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January — December, 1961

"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."

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Volume 44—January To December 1961

AUTHORS

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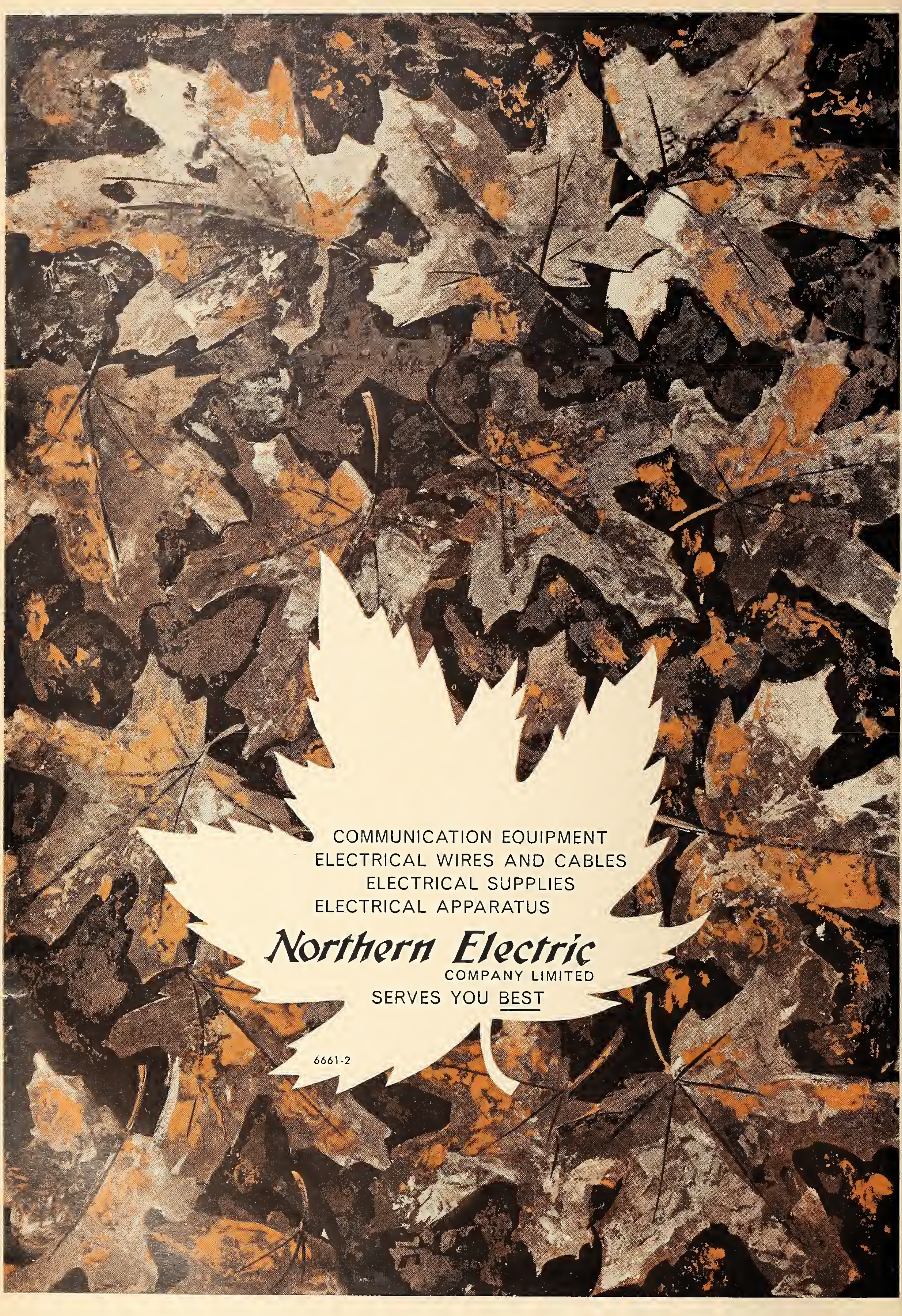

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IN THIS ISSUE

W. R. Schriever, M.E.I.C. and **W. G. Plewes**, M.E.I.C. are ideally suited as authors of their paper, *A New Canadian Structural Test Installation.* This installation for large-scale structural loading tests was installed recently in the Division of Building Research of the National Research Council in Ottawa. Mr. Schriever was born in Weggis, Switzerland and graduated as a civil engineer at the Swiss Federal Institute of Technology (E.T.H.) in Zurich in 1944. Following laboratory work in Switzerland he obtained an M.Sc. from Harvard. In 1948 Mr. Schriever joined the NRC's Building Research Division and five years later was named Head of the Building Structures Section.

Mr. Plewes, a native of Russell, Man., obtained his B.Sc. in civil engineering at University of Manitoba in 1949, and a post-graduate degree in civil engineering from Queen's in 1954. He joined the NRC in 1954 and now is an Associate Research Officer in the Building Structures Section.

Their paper describes the test installation which provides universal facility for loading tests on a variety of structural components such as beams, slabs, columns, roofs and walls.

Recent Advances in Experimental Stress Analysis, by **Professor J. B. Mantle**, M.E.I.C. deals with some new techniques. Described are some examples of their application as carried out in the author's laboratory at University of Saskatchewan where he is Head of the Department of Mechanical Engineering. Experimental stress analysis has become an increasingly important tool for designers, particularly since the advent of the space age. Prof. Mantle was born in London, England, in 1919. His family moved to the Canadian West and he attended primary and high school in Paynton, Sask., and Saskatoon. He obtained a degree in Mechanical Engineering at University of Saskatchewan in 1941 and an M.Sc. in Theoretical and Applied Mechanics at University of Illinois in 1947.

Interest in *Frazil Ice and Flow Temperature Under Ice Covers* comes naturally to co-authors **Ernest Pariset**, M.E.I.C. and **Rene Hausser**, M.E.I.C. Mr. Pariset, Director of LaSalle Hydraulic Laboratory in Montreal, holds degrees from Grenoble University in both electrical and hydraulic engineering. Following research and consultant work in France and in Canada, Mr. Pariset assumed his present position. Mr. Hausser also holds degrees from Grenoble in electrical and hydraulic engineering. He worked with SOGREAH as a research engineer from 1950 until 1956 when he came to Montreal to take charge of the St. Lawrence Seaway models. Mr. Hausser now is an engineer with LaSalle Hydraulic Laboratory.

Their paper on frazil ice, undertaken for the Quebec Hydro-Electric Power Commission, outlines a general study on ice problems in rivers. Problems include the formation of ice covers, hanging dams, ice jams and the rate of ice formation. Purpose of the study was to determine the effectiveness of an ice cover in stopping frazil ice transportation, to protect a downstream power station.

Harold O. Wilson, M.E.I.C. had the advantage of 23 years of engineering experience to draw on for his paper, *Braking of Hydro-Electric Generators.* After obtaining his degree in electrical engineering from Queen's University in 1937, Mr. Wilson worked with Shawinigan Engineering Company Limited and the English Electric Company of Canada Limited before spending four years in the Canadian Navy as an Electrical officer. After the war he rejoined English Electric. In 1947 he returned to Shawinigan Engineering and in February, 1960, was appointed Chief Engineer, Electrical Division. Mr. Wilson's paper has a special significance due to the widespread adoption of automatic braking for use with automatic units and remotely controlled generating stations. The scope of the paper is limited to Francis or Kaplan turbine driven generators of medium size and moderate speeds.

David Cass-Beggs, M.E.I.C. author of the *Economic Feasibility of Trans-Canada Electrical Interconnection,* is responsible for the redesign of Saskatchewan's power production system. In less than a decade he has brought electricity within reach of almost the entire agricultural area of his province. In the same period, virtually all power facilities in Saskatchewan have been tied in an integrated system. In his paper Mr. Cass-Beggs outlines the practical value of inter-connecting generating stations into large integrated electrical systems. Apart from the obvious economies arising from the optimum use of low cost resources the time zones into which Canada is divided offer important opportunities for improvement of load factor, while integration could also reduce the reserve capacity required for a larger system. Mr. Cass-Beggs, General Manager of the Saskatchewan Power Corporation since 1952 and president of the Canadian Electrical Association, is a former professor of electrical engineering. He was born in Manchester, England, in 1905 and holds a degree of M.Sc. Tech. from Manchester University. Mr. Cass-Beggs taught at University of Toronto, did development work for the RCAF, and returned to teaching in Canada and in Wales before joining Saskatchewan Power Corporation.

Probably no author could have described *Montreal's Jet Age Airport* with the authority of **Harold J. Connolly**, M.E.I.C. A native of Toronto, Mr. Connolly entered University of Toronto in 1915, but service in the First World War interrupted his education and it was not until 1924 that he graduated with a B.A. Sc. degree. After working with a consulting engineering firm in the field of municipal engineering for 11 years he joined the Department of Transport. He now is Director in charge of the Construction Branch of the Department's Air Services. As such Mr. Connolly is responsible for airport construction. His treatment of Montreal's newly-opened airport includes its history, the difficult engineering problems which had to be solved, description of passenger facilities, and the sustaining services.

Beaver Bill appears this month on page 115. Stan **Cassidy** has a membership reminder on page 100.

COVER ILLUSTRATION

Canada's highest structure, a television tower and antenna 1,003 feet high, recently was erected for station CJAY, Winnipeg. The structure consists of an 861-foot triangular mast topped by the antenna. Photo courtesy Dominion Bridge Company Limited.

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A New Canadian STRUCTURAL TEST INSTALLATION

W. R. Schriever, M.E.I.C.,
Head, Building Structures Section, Division of Building Research, National Research Council, Ottawa.

W. G. Plewes, M.E.I.C.,
Research Officer, Building Structures Section, Division of Building Research, National Research Council, Ottawa.

This installation provides universal facility for loading tests on such structural components as beams, slabs, columns, roofs and walls. It was installed in NRC's Division of Building Research.

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

Summary

The three main parts of this installation are (i) a strong reinforced concrete test floor, (ii) a set of steel frames to be assembled around the test object and anchored to the floor and (iii) portable hydraulic jacks for the application of the loads. The test floor, with a maximum length of 54 ft. provides 42 regularly spaced anchorage points for the structural steel frames and has been designed to withstand vertical or horizontal forces of up to 50 tons at each of these points. In resisting upward forces, use is made of the weight of the underlying bedrock through special pretensioned rock anchors. The structural steel reaction frames are connected to the slab and to each other by torqued high-strength steel bolts to provide maximum rigidity. The portable jacks range in capacity from 2½ to 50 tons and are suitable both for static and dynamic testing, are of the lapped-piston type and provide an accuracy in load measurement comparable to that of a universal testing machine. The Paper describes the design and construction of this installation and makes reference to installations in other countries.

* * *

THE behaviour of structures under actual loading and the interaction between various components of a structure have of recent years become the subject of increased interest to structural engineers. In the past, structural design has usually been based on assumptions of (i) elastic behaviour, (ii) homogeneous materials and (iii) an assemblage of elements acting independently. Research has shown that these assumptions frequently do not lead to an accurate assessment of the actual strength of a structure because of complicated interaction of components or because the behaviour changes significantly as the range of true elastic behaviour is exceeded.

To investigate this interaction of components and the behaviour of various structures under actual loading it is often desirable to observe structures in the field or to conduct loading tests on full scale structures or assemblages of components in order to develop a more complete understanding of structural behaviour up to and including failure. Loading tests to failure are particularly important since it is frequently difficult to predict the true margin of safety of a structure from stress calculations in the elastic range.

The Division of Building Research of the National Research Council, and particularly its Building Structures Section which is concerned with the strength and deformation characteristics of structures and the loads acting upon them, has frequently encountered the need for such loading tests. In the past this called for special equipment, often designed or improvised for a single test. Tests had to be made on structures such as house components, roof trusses, beams, floors and walls. With improvised equipment it was often difficult to develop the large forces and reactions necessary to reach failure. Ordinary universal testing machines were found to be very limited in their application to such testing because they were not sufficiently adaptable to the variety of shapes and sizes that occurred.

Consequently, it was decided that the Division should develop and construct a testing installation which would allow a wide variety of loading tests on relatively large scale structures.

Basic Design Considerations

Other installations: Several structural testing laboratories in North America and Europe were visited and studied. It was found that although the installations varied considerably in detail the common basic parts were:

(a) a reinforced concrete slab with a system of regularly spaced anchorage points,

(b) a set of structural steel members which could be assembled and bolted together in a variety of ways around the test object and anchored to the slab, and

(c) a number of portable hydraulic jacks for the application of the loads, together with load measuring equipment.

The installations studied were those of:

(1) Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pa., USA

(2) British Building Research Station in Watford near London, England

(3) The Cement and Concrete Association in Wexham Springs near London, England

(4) Association of the Industrials of Belgium (Grande Installation Mécanique Pour Essais de Durée, or briefly GIMED)

(5) University of Ghent, Belgium

(6) University of Liege, Belgium

(7) Division of Building Research of T.N.O. in Delft, Holland

(8) Materials Testing Laboratory of the Technical University of Munich, Germany

(9) National Civil Engineering La-

boratory at Lisbon, Portugal.

Some of these installations, particularly that of the GIMED in Belgium, are very elaborate and allow the application of very large forces. Some provide access to the underside of the test slab, allowing through-bolting of the test frames to the slab. The detail and spacing of anchorage points also varied considerably. In the Portuguese laboratory, prestressing was used to achieve a greater strength in the slab. Although the hydraulic loading equipment used in these laboratories varied it was found that the majority of the installations were equipped with Amsler jacks, pendulum dynamometers, and pulsators.

One of the most modern of these testing installations was found to be that of Lehigh University in Bethlehem, Pa. This installation incorporates some new ideas, one of which is the use of high strength bolts for rigid assembly of the reaction frames and of pretensioned bolts for anchoring the frames to the slab. This feature, particularly important in case of dynamic testing, eliminates slack in the reaction framework.

Anticipated Requirements: Some of the anticipated types of test were:

(a) vertical loading tests on beams, trusses, slabs, roofs and walls

(b) horizontal loading tests on walls and possibly columns

(c) combined vertical and horizontal loading tests on walls and entire building components

(d) miscellaneous tests including the application of loads in any desired direction.

This wide range of applications indicated a need for considerable flexibility in the arrangement of forces and reactions.

It was decided that the size of the installation should allow the testing of long members of lengths up to approximately 50 ft. and more or less square members such as slabs of the order of 20 ft. square. One of the main governing considerations in the choice of dimensions was the space available in the existing laboratory.

In making an estimate of the required loading capacity of the installation, it was thought that the application of a 100 ton load through two 50 ton jacks would be adequate and could be taken as a design criterion. In other words, each of the two columns of a portal frame was to be designed to resist a 50 ton force in an upward direction. A horizontal capacity of 50 tons was also considered desirable.

To produce the loading forces it was considered desirable to obtain a type of jack which would allow an accurate measurement of loads directly by the measurement of oil pressure, since this would eliminate the need for a separate load measuring system.

Available Space: The test installation had to be built within the confines of the existing structural testing laboratory of the Division of Building Research. This laboratory measures approximately 40 by 80 ft. in plan and extends to a height equivalent to three stories. It was realized that to arrive at the most economical type of test slab it would be better not to choose a rectangular type of slab but a combination of a long area for the testing of long members such as beams and an approximately square area for the testing of slabs, roofs, and similar items. Furthermore, it was desired to retain some of the existing floor, since it incorporates some light embedded I-beams for anchorage purposes which are useful for miscellaneous work in the Division. The test slab thus became T-shaped in plan, with the long area 54 by 8 ft. and the approximately square area 23 by 28 ft. (Fig. 1.)

Since the space between floor level and bedrock was rather shallow (3 to 4 ft.), it was soon realized that it would not be possible (without blast-

Fig. 1. Plan view of project laboratory.

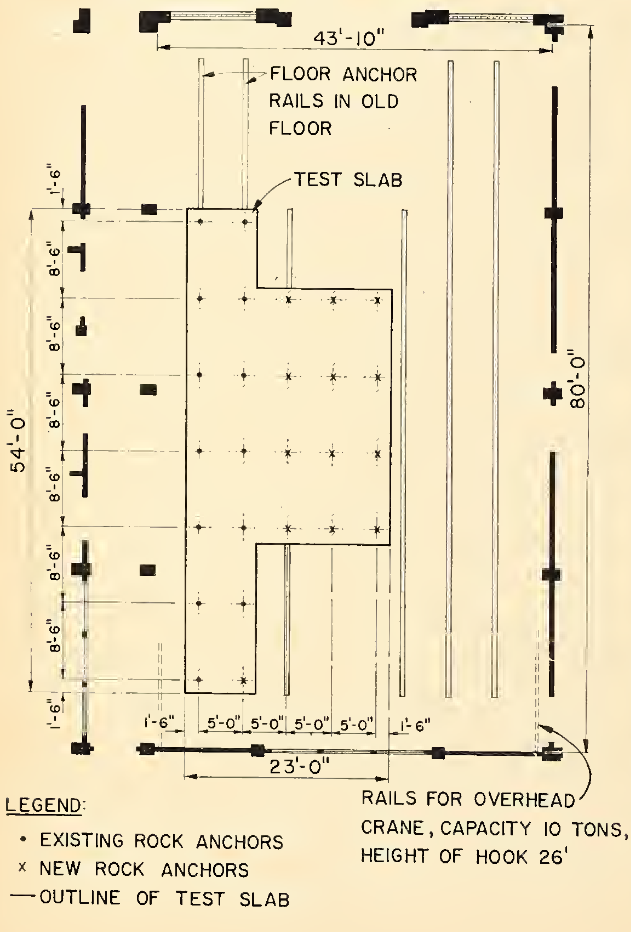
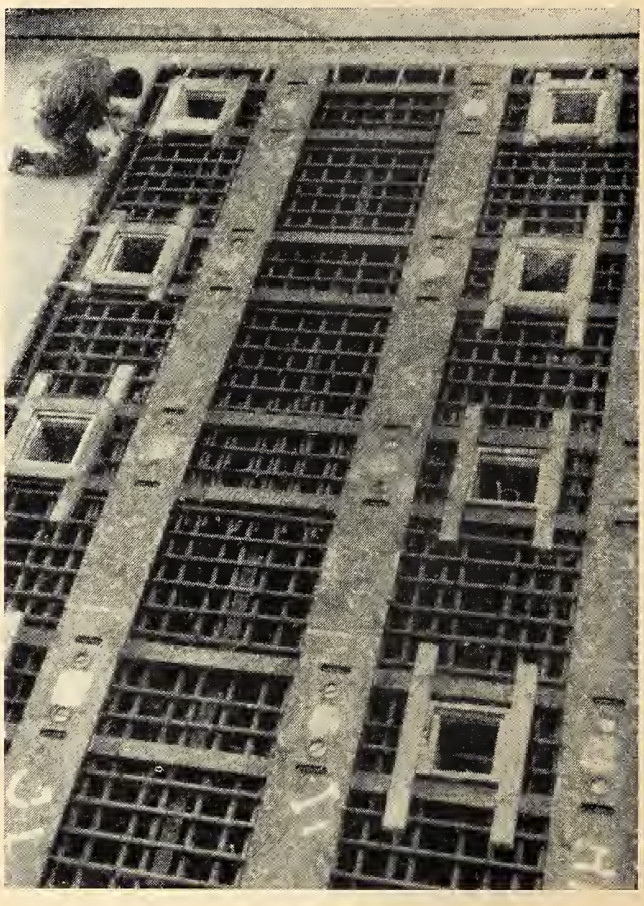


Fig. 2. Structural and reinforcing steel of test slab before concrete was placed.



ing) to install a slab thick enough to provide the necessary flexural resistance for a loading test on a long and heavy beam, as was done in the Lehigh University installation where the slab is 6½ ft. thick. It was therefore decided to use the weight of the underlying rock, by means of rock anchors, to resist upward forces. Blasting operations inside the building would have been difficult and expensive, and rock anchors had already been installed in the old floor along the west side which it was hoped could be used in the new test slab.

Description of the Installation

Slab: Existing rock anchors in the old floor were available in two parallel lines 5 ft. apart along the west side of the laboratory with a longitudinal spacing of 8½ ft. (See Fig. 1.) It proved possible to continue this pattern for the rest of the new slab and to arrange the spacing of the column anchors in a pattern fitting in with that of the rock anchors. The column anchors were placed 5 ft. in an east-west direction and 4½ ft. in a north-south direction, making the ratio of column to rock anchors two to one. The slab can thus be regarded, in a way, simply as a means of disturbing the upward force introduced by the columns to the nearest group of rock anchors.

To achieve complete interchangeability of parts in the test installation it was realized from the start that high accuracy in the spacing of the column anchorage points and in the vertical level of the slab surface would have to be achieved. It was decided to aim at a tolerance in the spacing and elevation of column anchorage points of ± 1/16 in. It was therefore imperative to develop a construction method which would achieve this accuracy. With this in mind a step by step construction procedure was prepared which allowed the complete assembly and welding of all the steel going into the slab prior to the placing of concrete.

Fig. 3. shows typical cross-sections through the floor. Steel embedded in the slab consists mainly of three groups:

(a) reinforcing steel providing flexural and shear strength in the slab

(b) structural steel providing for resistance to horizontal forces developed during tests

(c) additional structural steel provided merely for accurate positioning and support of steel members (b).

Two-way reinforcing (a) was designed for the bending moments and shears, under the assumption that the slab acts in strips and distributes upward forces introduced at the column bases to the nearest group of rock anchors.

The embedded structural steel listed as (b) consists of "floor plates" flush with the floor and of pairs of longitudinal I-beams which run directly beneath the floor surface and are welded to the floor plates. These I-beams were designed to take the horizontal forces produced by the horizontal application of a 50 ton jack at a column base.

As stated earlier the additional structural steel (c) in the slab served to achieve the required accurate positioning of the floor plates with a tolerance of ± 1/16 in. during construction. This steel consisted of six transverse I-beams supported by short steel posts. The beams supported the longitudinal I-beams and floor plates and held them rigidly in place during placing of concrete.

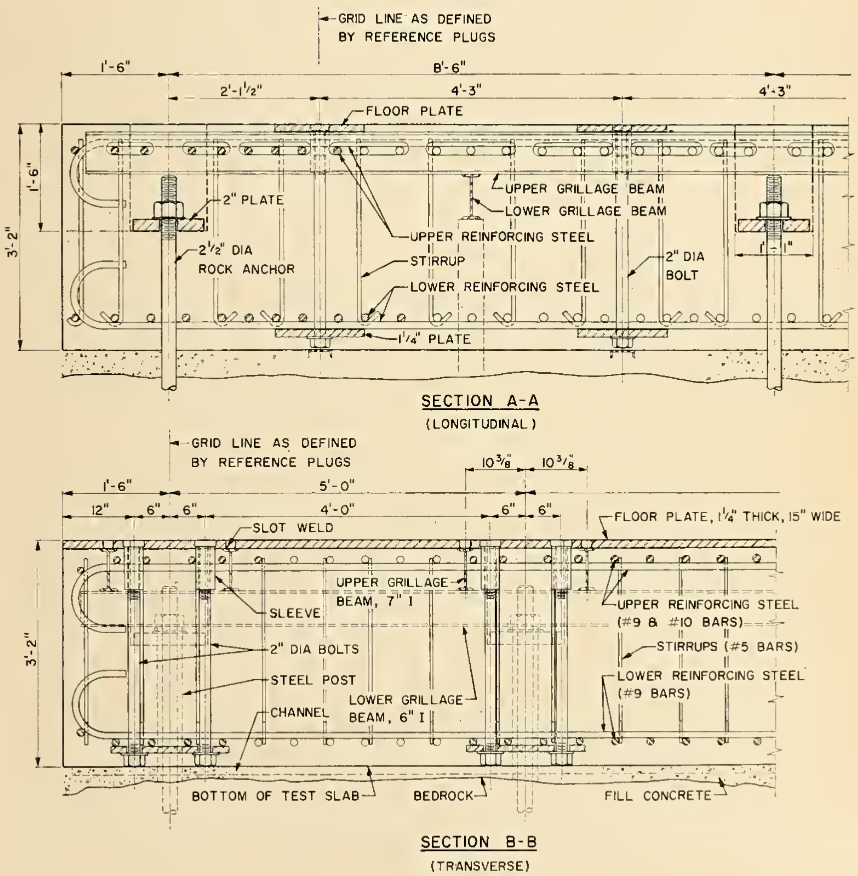
As assembly of the complete grillage progressed from bottom to top, more and more accurate positioning by shimming was possible, and after a complete check of dimensions the whole system was welded together into a strong unit capable of resisting all the pressures and vibrations resulting from placing and vibrating the concrete.

Rock Anchors: The test slab was "clamped" to the underlying bedrock by means of 26 pretensioned rock anchors. The rock anchors reached a depth of approximately 10 ft. below the floor surface, each anchor consisting of a 2½ in. diameter high strength steel rod designed to withstand an upward force of approximately 70 tons. It was not considered necessary to design the rock anchors to twice the capacity of the column anchors since it was unlikely that all rock anchors would be simultaneously loaded to capacity by the slab, which is intended to serve as a load sharing member.

The actual anchorage of the rods at the lower end was achieved by a system, devised for the purpose, which consisted of flaring the ends of the steel rods and grouting them into the bottom of the hole. This system was tested to a load of 100 tons in a rock outcrop in a nearby quarry. The flared end was produced by splitting the rock anchor rod crossways by two flame cuts and driving wedges from the bottom. The tops of the rods were threaded for pretensioning and bolting after completion of the slab.

Test Frames: The basic idea of test frames is to provide a system of reaction frames that can be assembled and bolted together in any desired manner around the test object and anchored to the slab. In some ways

Fig. 3. Sections through test slab.



these frames thus form a giant "meccano" set, to which the hydraulic jacks are bolted. A typical test set-up is shown in Fig. 4.

Since vertical downward loading is by far the most frequent requirement, particular attention was paid to the arrangement of the jacks to be used for this purpose. The combination of continuous adjustment in both directions in a horizontal plane makes it possible to position the jacks at any desired point over the structure, in spite of the fact that the frames themselves can only be positioned at discrete points. This can be achieved by sliding the jacks along the spreader to any desired point and sliding the spreader beam in the other direction under the cross beams joining the columns.

A main requirement of the test set-up is the provision of rigid joints in order to prevent slack, which would reduce the effective stroke of the jacks. This is achieved efficiently and inexpensively by the use of high tensile bolts rather than by accurate machining of parts as in some of the European installations. The anchorage of the frames to the slab is achieved by pairs of 2 in. diam. high-strength steel bolts which clamp the base plates of the columns to the floor. Details of a typical column anchorage are shown in Fig. 5. The system used provides a clear separation between the vertical and horizontal anchorage. Horizontal displacement of the column base plate, which would endanger the threaded anchor bolts, is prevented by two tightly fitting 3¼ in diam. collars which protrude through the column base plate into holes in the floor plates. Each column anchorage is designed to resist a static force of 50 tons in either upward or horizontal direction. After assembly of a column anchorage, the anchor bolts are pretensioned by means of a simple hydraulic jacking system (Fig. 6.) producing an upward force of approximately 30 tons while the nut on the bolt is tightened.

The test frames consist of ordinary structural steel members. As a first instalment intended to serve many of the anticipated ordinary needs, the following main members were acquired:

6 columns 12 WF 85, 16 ft. long;
2 cross beams, pairs of 18 ⌴ 58, 16 ft. long;
1 cross beam, pair of 18 ⌴ 58, 11 ft. long;
2 spreader beams, 12WF 106, 14 ft. 9 in. long;
5 supports for spreader beams or jacks;
4 diagonal struts, 10 WF 33 with stub columns.

These members are shown in Fig. 4, with the exception of the diagonal struts which serve to give horizontal support to the top of the columns when greater horizontal forces are involved.

Connections between the different members, with the exception of that between the spreader beam and the cross beam are made by 1 in. diam. high tensile bolts. This method offers the advantage of achieving complete joint rigidity without requiring accurately machined parts, ease of assembly and disassembly and better resistance to fatigue loading (in case such testing becomes necessary in the future). The bolts are tightened to the required 700 to 800 foot pounds by means of a special torque wrench or a pneumatic impact wrench.

The 1 3/16 in. diam. bolt holes are laid out in a 3 by 6 in. pattern on the members. One inch diameter high strength bolts are used in all ordinary work since the clamping force produced would eliminate any joint slippage up to working loads. Bolts 1⅛ in. diam. could, however, be used in case of exceptionally high loading where frame movement resulting from joint slippage might become a factor.

Load-Producing and Measuring Equipment: The hydraulic loading equipment consists essentially of portable hydraulic jacks fed from a pump in the pendulum dynamometer which serves to measure the load pressure applied with high accuracy. The loading equipment is made by a Swiss firm which has had extensive experience in the manufacture of this type of loading equipment.

The hydraulic compression jacks are of the lapped piston type in which the friction between the piston and the cylinder is reduced to a minimum so that the oil pressure can be used to indicate the load applied with considerable accuracy.

The hydraulic equipment available consists of the following main parts:

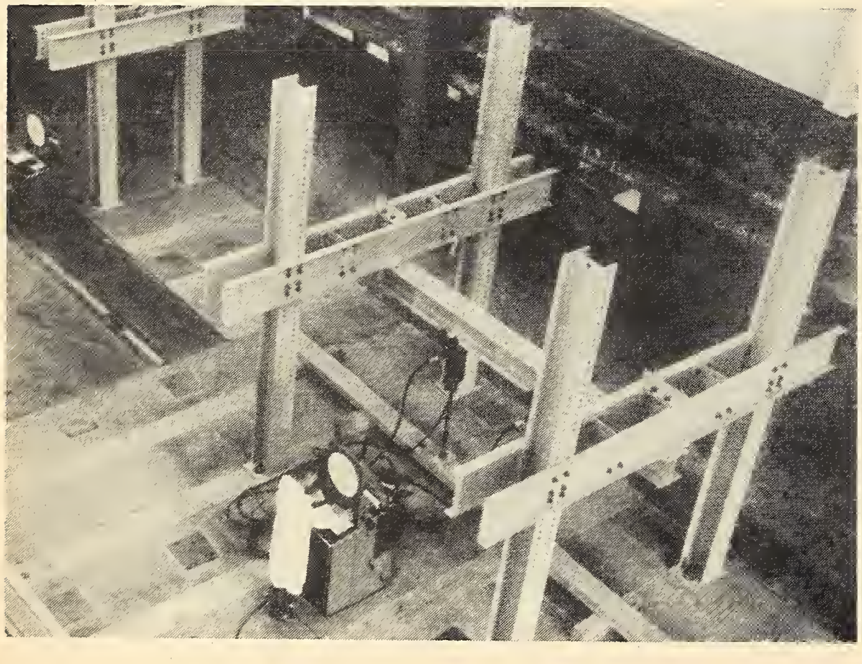
2 hydraulic jacks of 50 ton capacity;
2 hydraulic jacks of 10 ton capacity;
8 hydraulic jacks of 5 ton capacity;
4 hydraulic jacks of 2½ ton capacity;
2 pendulum dynamometers, both equipped with hydraulic load maintainers;
1 distributor used when necessary to distribute the oil from one pendulum dynamometer to a number of jacks;
Various high-pressure flexible hoses and miscellaneous accessories.

All jacks have a piston stroke of 5 in. The coil springs seen on the outside serve to compensate for the piston weight in the inverted position, and pull the piston back when unloading. Spherical seats are provided at both ends to ensure true axial loading through the jack. (Fig. 9.)

The same jacks can be used for dynamic or fatigue loading if fed from special pulsators which are made for this purpose. For the time being the installation is not equipped for dynamic testing.

The pendulum dynamometers have the double function of supplying oil pressure to the jacks and of measuring the load; this is done with the

Fig. 4. Over-all view of structural test installation.



same accuracy as in ordinary universal testing machines. The hydraulic pressure fed to the jacks acts on a measuring piston, which in turn pushes against the pendulum. A higher pressure on the piston is balanced by the higher swing of the pendulum, and the movement of the pendulum is transmitted to a large dial on the front of the cabinet. The measuring piston is constantly rotating about its own axis, thereby practically eliminating friction.

The pendulum dynamometer provides four load ranges for all jacks. The smallest gradation of the smallest jack in the smallest range is one pound. In contrast, the maximum capacity of the largest jack in the largest range is 112,000 lb. or 50 metric tons.

An automatic load maintainer allows application of constant loads over long periods of time, independent of the deformation of the structure. This feature is particularly valuable for creep tests on structures or when it is desired to maintain one load while varying another. The pendulum dynamometers can easily be moved and need not be bolted to the laboratory floor.

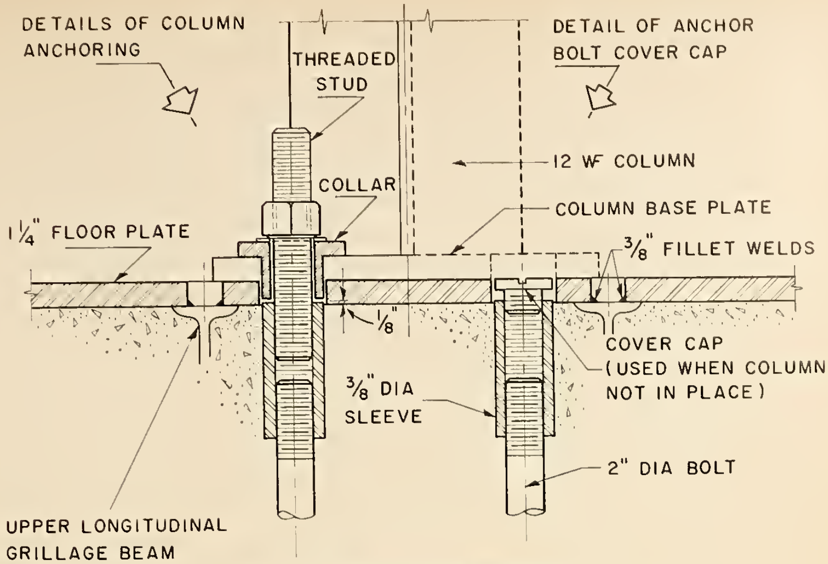


Fig. 5. Column anchorage detail.

Construction of Slab

It was realized at the outset that the complete interchangeability of component locations would require close control of dimensions during construction of the slab base. It was therefore decided to establish grid control points on brass plugs set in the floor along lines of a very accurate rectangular traverse established just outside the excavation area. Using precise triangulation and chaining methods along with careful scribing of the brass plugs, the grid control points were made sufficiently accurate to allow location of any point over the excavation area within ± 1/64 in. by means of a transit set up over the proper control points. The accuracy of the horizontal dimensional control system was therefore about twice that of the tolerance specified for drilling the anchor holes in the slab bed plates and four times that of the tolerance specified in the final location of the anchorage points.

The original laboratory floor was slightly sloped for drainage but it was decided to make the test slab surface as nearly horizontal as possible. The top elevation of the slab was set to be the same as the highest point of the surrounding floor adjacent to its perimeter. A rounded brass bench mark was set in concrete in a stable location for use in controlling the vertical location of the test slab.

As noted before, the plan of the slab was arranged to make use of some rock anchors already existing under the original laboratory floor. For convenience, the holes for additional new rock anchors were drilled through the existing floor down to the required level in the bedrock before any excavation for slab construction was started.

Construction of the new test slab was begun by sawing through the existing floor with a concrete saw on lines ½ in. outside the perimeter of the new slab location. The concrete removed was broken up with jack hammers and all material including crushed rock below the floor slab was excavated down to bare rock using a small backhoe and a conveyor for loading trucks.

The design depth of the test slab was 3 ft. 2 in. and the average depth of bedrock below the general laboratory floor proved to be 4 ft. 1 in. A layer of fill concrete was therefore cast over the whole floor of the excavation to bring the working level up to that assumed in the design and to provide a level working area.

Short steel posts were set vertically, with their lower ends embedded in the fill concrete and their top ends adjusted to an elevation slightly below that required to support six transverse I-beams, which in turn would carry the longitudinal I-beams and bed plates (Fig. 8). Small steel channels were also embedded in the top surface of the fill concrete to which the nuts and anchor plates for the column anchor bolts were later welded for accurate positioning.

Excavation of the slab area exposed the previously drilled rock anchor holes. Since the rock anchors were to be installed after the test slab was completed, short lengths of pipe were placed over the rock anchor holes to keep concrete from entering them and to enable the rock anchors to be lowered down through the slab at a later date (Fig. 8).

Following completion of the fill concrete, a low concrete block wall was built around the perimeter of the excavation beneath the exposed edges of the old floor slab to support them. To this low wall was nailed a layer of ½-in. asphalt-impregnated fibreboard which was placed to isolate the test slab from the general laboratory floor, so insulating it from the rest of the building. This was done in order to reduce vibrations in the rest of the building if and when the test installation was used for fatigue testing in the future.

The contractor then proceeded to place the transverse and longitudinal I-beams, the reinforcing steel, and the column anchor rods. The latter were greased and wrapped with tar paper to prevent bond with the concrete, so that when later pretensioning loads were applied they would be transmitted directly to the bottom anchor plates at the base of the slab. The rods were then screwed into the nuts below the plates, and after careful plumbing they were tack welded to the plates which in turn were tack welded to the small channels embedded in the fill concrete.

At this point the longitudinal I-beams were shimmed into proper position and the floor plates placed in approximate position. Members of the Division's staff then carefully set the plates for line and level and clamped them into position. The contractor proceeded to weld the several sections of the plates together and to weld the complete plates in turn to the longitudinal I-beams. Although a welding sequence was used that would minimize warping, it was necessary at this stage to check the levels of the plates constantly and to correct, by judicious shimming, changes in level caused by welding.

The final operation prior to concreting was to place small wooden forms over the top of the existing rock anchors and pipe openings left for new rock anchors. These were placed to form pits 15 by 15 in. by 1 ft. 6 in. in the test slab surface (Fig. 2). These extended down to a level just below the tops of the rock anchors, which were intended to have their tops about 8 in. below the slab surface.

Ready-mixed concrete with 4000 p.s.i. compressive strength at 28 days was specified for the main mass of the slab. The aggregates used were a local crushed rock aggregate and sand. Although the heavy slab reinforcement was rather closely spaced and the concrete mix rather stiff in consistency, the concrete was readily vibrated into place with very little segregation and, it is thought, very little if any honeycombing or voids. A 2 ± ½ in. slump was maintained by making tests of every truck load of concrete received and at least one compression test cylinder from every second load. After 28 days' standard curing the average strength of the test cylinders was 4080 p.s.i. with a minimum of 3810 p.s.i.

The top surface of the main body of the slab concrete was struck off about ¾ in. below the bottom of the steel base plates, and after 24 hr. members of the laboratory staff carefully dry-packed the space below the base plates with a dry mortar mix to make virtually certain that the plates would not be separated from the concrete by settlement of the slab but would have positive bearing. This was considered necessary as tests conducted before construction indicated that the 3 ft. depth of concrete could settle away from the plates by about 1/16 in. After this operation the contractor brought the slab concrete up to the level of the top of the base plates by placing a 2 in. layer of finish concrete containing ½ in. trap rock aggregate for hardness and abrasion resistance. Welded wire mesh was placed in the centre of the layer. A commercial curing compound was sprayed onto the concrete.

By careful checking and adjusting during all phases of construction a sensibly flat slab was achieved, so that with one minor exception, the deviation from the specified elevation of the anchor points was less than 1/16 in. Without this care the deviation would have been much greater owing to the natural variation of dimensions of all the slab components, workmanship errors, and the tendency for such grillage to warp when welded.

In the three years since construction, close inspection of the slab shows it to be in excellent condition and remarkably free of surface cracks. The latter is partly due to the fact that the finish concrete is divided into sections by the steel bed plates.

Installation and Tensioning of Rock Anchors

Three months after construction of the test slab, the flared end of an anchor rod was lowered through the pipe sleeves in the slab into bedrock. The lower end was about 7 ft. in the rock and the upper end approximately 8 in. below the slab surface and exposed in the small 15 by 15 in. access pit. A 20 ft. length of ½ in. O.D. copper tubing was lowered to the bottom of the rock anchor hole alongside the anchor rod. Clean, ⅜ in. traprock aggregate was dropped into the hole until a plug of stone 20 in. deep was formed around the flared end of the rod (extending about 12 inches above the top of the flare). Neat cement grout consisting of 5½ gal. of water per sack of high early strength cement plus 50 cc of Plastiment was then pumped through the copper tube until it completely filled the voids in the traprock plug. The amount of grout necessary was previously determined by calculation and experiment. In the grouting operation grout was poured into the copper tube through a funnel and pressure applied to it with a pump improvised from a caulking gun.

The rock anchors were pretensioned to about 65 tons, which was just below the yield point of the rods at the root of the threads. The prestressing operation was commenced four months after the rock anchors were installed. A 12 by 12 by 2 in. plate washer was placed over the top of each rock anchor and floated to even bearing on a bed of cement mortar at the bottom of the access pit (Fig. 3). When the bedding mortar had gained sufficient strength a nut was turned onto the rock anchor and tightened by hand against the plate washer. By means of a threaded sleeve, the lower end of an extension rod was then fastened to the top of the rock anchor and the upper end coupled to a 100

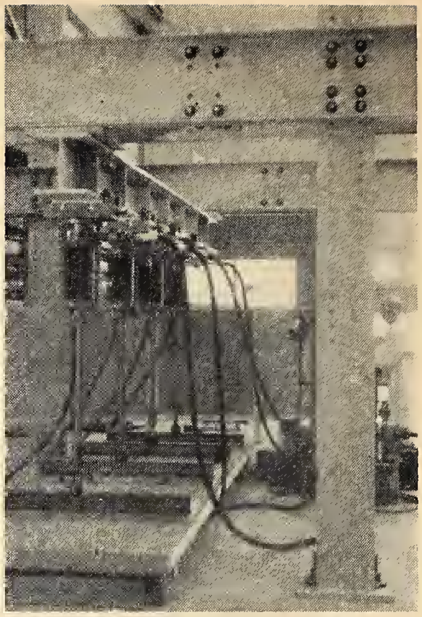
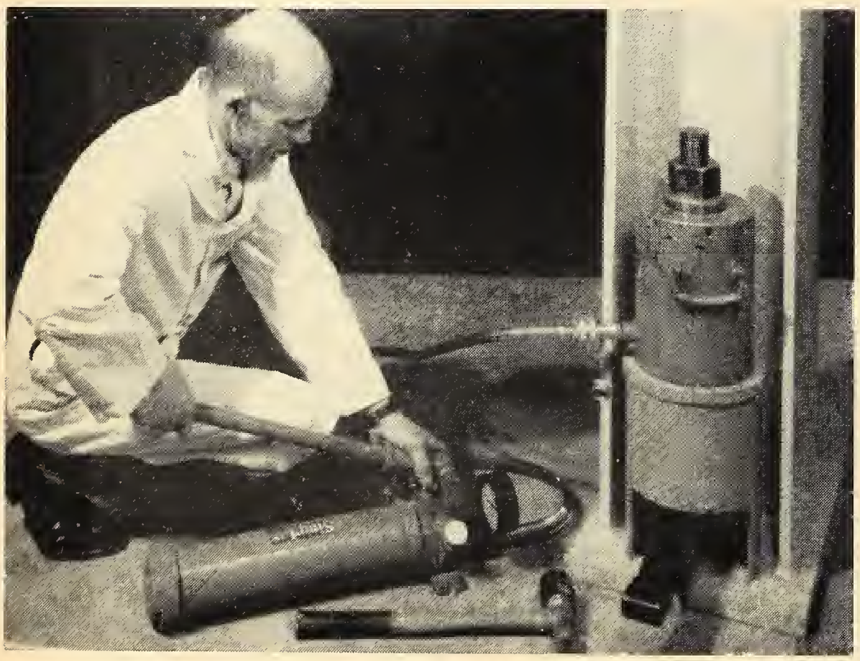


Fig. 7. Loading test on Arctic housing roof panel with four jacks.

Fig. 6. Pretensioning column anchor with centre-hole jack.



ton centre-hole jack supported by a small reaction frame. A 65 ton load was then applied to the rock anchor, the nut at the bottom of the access pit tightened by special socket wrench and the jack pressures released, leaving the rock anchor pretensioned.

As a final step, 4½ in. un-reinforced concrete slabs were cast in place to provide semipermanent covers over each pit. From time to time one or more of these slab covers will be broken out to check prestress losses.

Handling of Testing Equipment

Considerable attention was given in the design of the installation to the convenience of assembling and dismantling the components of test frames and of the hydraulic loading equipment. The members of the frame were equipped with holes for easy lifting by means of the 10 ton laboratory crane. Thanks to the accuracy of column anchorage points, it has been found possible to leave entire bents assembled while moving them to different locations.

Since the hydraulic jacks are most frequently used in their "hanging" position, it was decided to store them also in this way. All except the heavy 50 ton jacks are kept on a storage rack from which they can be transferred by sliding them onto a dolly which is then wheeled under the desired point on the test frame. From there the jacks are hoisted by means of a crane and double sling and attached by special bolts and brackets to the underside of the spreader beam. A similar arrangement is used for the 50 ton jacks, but because of their 1400 lb. weight, they are kept permanently on the dolly and are not transferred to a storage rack. (Fig. 9).

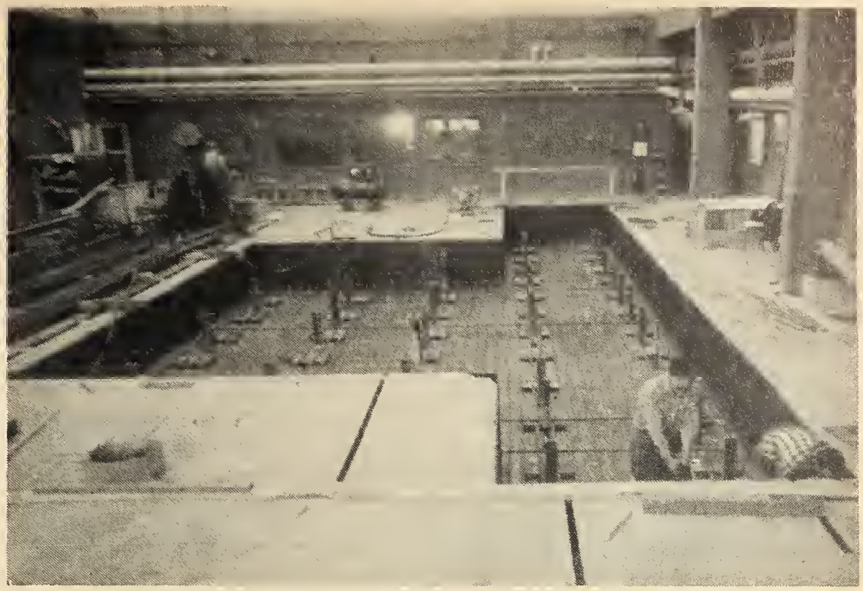
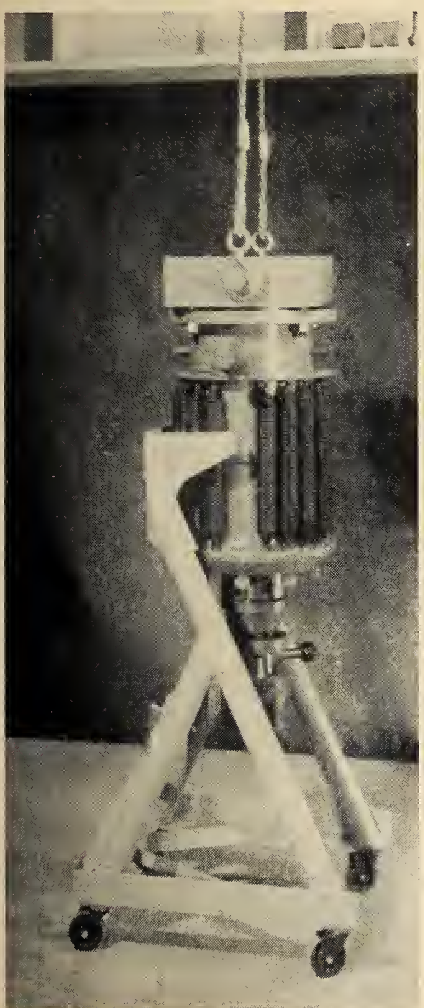


Fig. 8. Excavation for test slab after placing of steel posts, bottom plates for column anchorages and part of lower reinforcing steel.

Fig. 9. Fifty-ton jack being lifted from dolly to test frame.



When the jacks are used under a single bent, as shown on the left on Fig. 4, a different attachment is used. The saddle support which normally carries the spreader beams is provided with a special hanger plate with holes at appropriate places to support the jack.

Use of Installation and Final Remarks

The installation has been used for loading tests on a variety of structural items including timber bridge planks (Fig. 4), prefabricated Arctic housing panels (Fig. 7), sections of wooden roof trusses, concrete and masonry walls subjected to combined vertical and lateral loading. It will shortly be used for loading tests on an entire house roof.

It may be noted that during the test of masonry walls both pendulum dynamometers were used simultaneously, one to provide quarter-point horizontal loads on the face of the wall, the other to keep, with the aid of the built-in load maintainer, a constant vertical load on the wall.

In conclusion it can be stated that the system of structural testing equipment adopted, consisting of an anchorage slab, reaction frames and portable hydraulic jacks, has provided the Division of Building Research with an extremely versatile structural testing installation, suitable for full-scale loading tests on a wide variety of structural elements. Experience to date with the installation has been entirely satisfactory. It is expected that, as the work of the Building Structures Section expands, the installation will be used more and more. Further parts will be added to the test frames and the hydraulic loading equipment as the need arises. It is believed that this new installation of the Building Research Centre will fill an important role in making available for service to the Canadian construction industry the best possible building research facilities.

Acknowledgements

The authors wish to express their appreciation to the many persons who generously contributed their services and experience to the successful development of the installation, particularly to members of staff of the laboratories listed at the beginning of the paper and especially to Dr. Bruno Thürlimann of Lehigh University, Bethlehem, Pa., for information leading to the general scheme of the installation. The authors are indebted to Dr. Sheldon Cherry for valuable assistance with the structural design of the slab and test frames. This paper is a contribution from the Division of Building Research of the National Research Council of Canada and is published with the approval of the Director of the Division.

Recent Advances in
Experimental Stress Analysis

J. B. Mantle, M.E.I.C.,
Professor and Head, Department of Mechanical Engineering,
University of Saskatchewan, Saskatoon

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Space age demands for huge weight savings in missiles, rockets and satellites has resulted in growing interest in experimental stress analysis. This tool is of ever-increasing importance to designers. Particularly interesting are activities in three-dimensions.

A REVIEW is made here of recent advances in experimental stress analysis techniques with some examples of their application, as carried out in the author's laboratory being given. In respect of photoelastic stress analysis there is discussed the new Photostress technique, including the Photostress gauge, as well as some of the newer materials for three-dimensional work such as Hysol 6000 OP and photoelastic casting resin E.P.A. In the area of electrical resistance strain gauges the new metalfilm gauges are emphasized and in addition a description is given of some of the author's recent experiences with dynamic stress analysis in the milli-microsecond range using standard gauges.

With the advent of the space age experimental stress analysis has become an increasingly important tool for designers. All out weight saving is required for missiles, rockets, satellites and the like. This increased interest in experimental stress analysis has led to numerous developments that otherwise might not have occurred. In particular, three-dimensional work has moved into greater prominence. Three dimensional photoelastic stress analysis has received more attention with the result that materials having better properties have emerged. A teehnique has been evolved for attaching photoelastic materials directly to actual machines and structures and observing photoelastically strain variations when the loads are applied. Light weight electrical resistance strain gauges have been developed involving the printed circuit teehnique. With high energy transfer rates dynamic problems are increasingly facing the designer. Stress variations during time intervals of milliseconds and microseconds are now of vital importance. Refinements in recording and indicating equipment for dynamic applications are continually being announced.

At the University of Saskatchewan the author has attempted to keep abreast with these developments and has encouraged his students, both graduate and undergraduate, to do experimental work involving them. The purpose of this paper is to inform readers of the latest developments in experimental stress analysis and also to bring to their attention some of the projects that have been going on in the author's laboratory during the past year or two.

Fig. 1. Frozen Stress Patterns of Diametrically Loaded Discs after a Load-Thermal Cycle.

Three-Dimensional Stress Analysis by the Stress-Freezing Technique.

The most popular method of three-dimensional stress analysis is the stress-freezing procedure described in detail in several volumes.[1-2] In brief, the method involves preparing a model of the member from a sensitive plastic material, applying loads to it, heating to a critical temperature, soaking for a period and finally slowly cooling to room temperature. It will be found that a birefringent condition is locked into the model even with no load applied. The model may then be sliced and the stress condition in the slice examined quantitatively using a standard photoelastic polariscope. From the stress conditions found in the slices an overall evaluation of three-dimensional stresses may be made.

Photoelastic Material Properties: Several properties of photoelastic materials are of concern to those engaged in three-dimensional work. Especially, the photoelastician is interested in (a) critical temperature, (b) photoelastic sensitivity above critical temperature, (c) rigidity above critical temperature, (d) time-edge effect after the load-thermal cycle and (e) cost of material.

Critical temperatures vary from 170° to 320°F, depending on the material and batch. This value may be easily obtained by observing with polarized light a calibration member such as a diametrically loaded disc as it is being heated while under load. At the critical temperature one phase of the plastic softens and the remaining phase supporting the load is less rigid and much more photoelastically sensitive than formerly. Thus a certain amount of deformation occurs and a fringe pattern suddenly takes form. Upon cooling and removal of the load the new fringe pattern remains. Fig. 1 shows views of two discs originally carrying the same load; in one case cooling took place before the critical temperature was reached and in the other case the critical temperature was exceeded before cooling.

These same diametrically loaded discs make excellent members for calibration of the material, i.e. for determining its photoelastic sensitivity. Analytically it can be shown[3] that the relationship between fringe count at the centre of the disc (n), diameter (d-inches), load (P-pounds) and fringe value (f-pounds per inch per fringe-shear stress) is as follows:

$$f = \frac{4P}{\pi n d} \qquad (1)$$

For the disc shown on the right hand side of Fig. 1 the fringe count at the centre is 1.86 (fractional fringe order determined by Senarmont method[4]), the diameter is 0.750 in. and the load was 0.602 lb., so that one fringe is equivalent to a shear stress of 0.55 p.s.i. for material an inch thick (Absolute units: pounds per inch per fringe).

A small amount of distortion remaining after the load-thermal cycle can be tolerated but it must be remembered that the resulting distorted pattern is the one being analyzed and not the original shape. Rigidity (Young's modulus, E) may be evaluated by measuring the maximum deflection of a constant moment beam, after the load-thermal cycle, using the following relation which may be calculated from ordinary strength of materials:

$$E = \frac{Ml^2}{8I\Delta} \qquad (2)$$

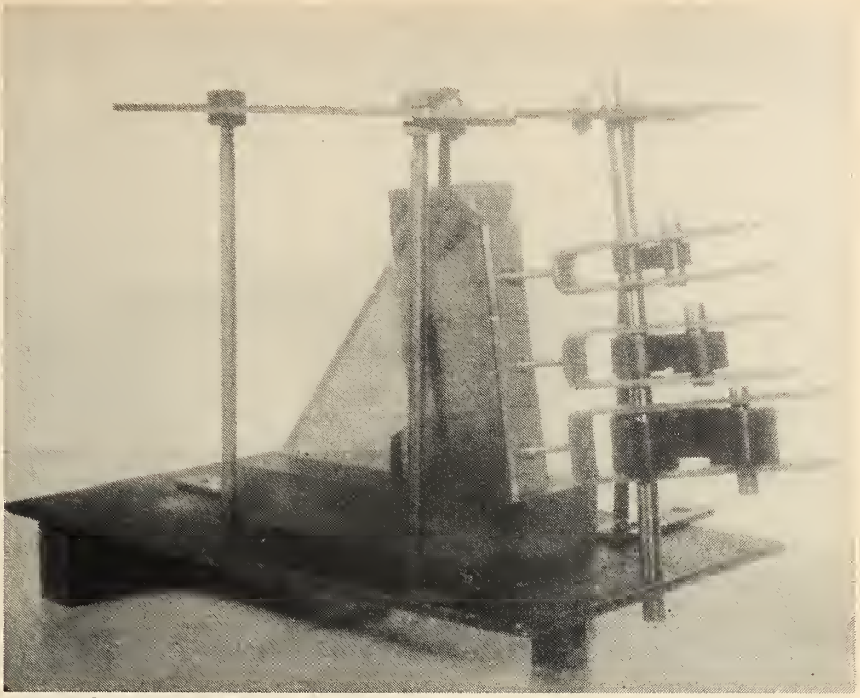


Fig. 2. Photoelastic Model of Diamond-Head Buttress Dam Mounted in Loading Rig and Having One Face Loaded.

where E = Young's Modulus—lb./in.^{2}
M = moment—lb. in.
l = length—in.
I = moment of inertia—in.^{4}
and Δ = maximum deflection—in.

Since the photoelastic worker is interested in maximum sensitivity with minimum distortion he uses a term "figure of merit"[5] for comparison purposes where:

$$\text{Figure of Merit} = \frac{E}{f} \qquad (3)$$

Time-edge effect is a constant threat to the accuracy of photoelastic results and must be avoided if at all possible. Freshly cut model edges tend to absorb moisture from the surrounding air resulting in swelling and in a matter of hours producing a stress system that will superpose on that due to external loads. There are a number of ways that may be employed to arrest this condition[6] but generally speaking each material has its own peculiarities in this regard. Quantitative measurements of the magnitude of time-edge stresses may be made by photoelastic observation of the edges of unloaded models.

Commercially Available Materials: Several materials are available commercially in the United States and Canada that are suitable for stress-freezing, each having its particular advantages and disadvantages in so far as their photoelastic properties are concerned. Catalin 61-893 is suitable but is not easily obtainable in sheets over one-quarter of an inch thick. Fosterite was used extensively during the past ten years but appears to be off the market now. Hysol 6000 OP having good characteristics is available in rods up to 5 in. in diameter and in sheets to 3 in. thick, but is expensive and delivery time is of the order of two months. The company formerly marketing Fosterite is supplying in its place a casting resin E.P.A. with hardener. This material has quite favourable properties but has been found by the author to be rather tricky to work with.

Table 1 shows comparative data for the above mentioned materials, the values having been obtained in the author's laboratory except where noted.

Some Experiences: The author has made use of Catalin 61-893, Hysol 6000 OP and E.P.A. photoelastic resin for various three-dimensional photoelastic investigations under his direc-

Table 1.
Photoelastic Properties of Some Three-Dimensional Materials.

Material	*Critical Temp. °F.*	*Fringe Value f lb./in./fringe shear stress*	*Figure of Merit Based on shear stress*	*Time-Edge Effect*	*Cost*
Catalin 61-893 ¼ in. sheet	240	1.65	668	Excessive	Approx. $15.00 per lb.
Fosterite (Fumeric)	250*	2.25*	1320*	Negligible*	Not Available
Hysol 6000 OP ½ in. sheet	220	0.55	1900	Negligible	$5.63 per lb.
Hysol 6000 OP 2 in. sheet	270	0.68	3540	Negligible	$5.43 per lb.
E.P.A. Casting Resin	320	1.04	2600	Excessive	$2.25 per lb.

*M. M. Leven, Westinghouse Co.

tion in recent years.

One of the earliest was that using 61-893 to investigate the most efficient cross-sectional shape for a reinforcing ring to be placed around a circular hole in a plate under tension.[7] Here the reinforcing ring was attached to the main plate by means of a special adhesive. Following the load-thermal cycle the material in the plate adjacent to the hole was sliced in order to get an evaluation of stress gradients through the plate.

This was followed up lately by Toronchuck[8] using Hysol and E.P.A. resin. In this case the effect of various shaped reinforcements around a circular hole in a plate subjected to plane shear was investigated. The reinforcement was made integral with the plate by two different methods. In one the plate and reinforcement were machined as a unit from a half-inch thick plate of Hysol (Fig. 6 shows a typical frozen stress pattern of the plate with attached reinforcement prior to slicing). In the other the whole model including reinforcement was cast from E.P.A. resin using a steel mould. Time-edge stresses were a definite problem with the E.P.A. models but examination of the models several weeks after casting and stress-freezing revealed substantial reduction in time-edge stresses.

Catalin 61-893 was utilized by North in his studies of hydrostatically loaded conduits.[9] He was examining the stress distribution in conduits having circular internal loaded boundaries and external boundaries varying from square, to octagonal and finally to sixteen-sided. The stress-freezing technique was employed to evaluate the pressure variation through the model being imposed by the loading device.

A three-dimensional photoelastic stress analysis of diamond-head buttresses for an earth fill dam[10] is nearing completion in the author's laboratory. Initially it was hoped to cast the models using E.P.A. resin and plaster of paris moulds. The fact that it takes almost 48 hr. for the model material to gel led to considerable difficulties with leaking moulds. This was finally overcome but shrinkage cracking and other problems forced abandonment of attempts to cast the models. They were finally made by building them up from machined sections of Hysol; in one case using ½ in. slabs and in the other three large machined pieces. The parts were put together with a Hysol adhesive. After a period of cure of seven days a very satisfactory bond for the stress-freezing technique could be obtained. A diametrically loaded disc made up from laminations and having a stress pattern frozen into it is shown in Fig. 5. Loading of the models to simulate water and earth loads was accomplished by using fourteen Negator clamps supported in a framework as shown in Fig. 2.

Photostress and Photostress Gauge.

Recent innovations in photoelastic stress analysis are "photostress" and the related "photostress gauge". In the photostress method developed by Zandman[10,11] a layer of sensitive plastic is attached to the actual structure (steel, iron, concrete, etc.). After loading, the critical area is examined with the aid of polarized light reflected from the structure surface after passing through the plastic. The simplest instrument for examination is a piece of polaroid with integral quarter-wave plate. This, together with the plastic sheet, provides all the elements of a simple polariscope. The stressed area will show color bands from which quantitative stress measurement may be made by color matching. Greater accuracy of readings is possible with more refined instruments available from the manufacturer. Johnson[13] successfully analyzed gear teeth stresses at the University of Saskatchewan by attaching photostress sheet to the teeth and then examining the resulting stress pattern with a P Q/Z hand viewer.

The latest development in this area is the photostress gauge which is still more or less in the experimental stage although available commercially. These gauges are made from a strip of photoelastic material with a fringe pattern of colored bands frozen into it, with a piece of polarizing material over this and having a reflective surface at the bottom. Indeed, all the elements mentioned for photostress have here been combined into the gauge itself! A scale is incorporated along the edge of the gauge and with it the amount of movement of the fringes resulting from strains in the members is observed. This amount of movement is proportional to strain and may be used in its quantitative evaluation. They may be attached to any structure with the aid of a suitable adhesive. In Fig. 3 is shown a photostress gauge attached to a constant stress steel beam. This installation was used by Koch[14] to compare the accuracy of this gauge with that of the standard bonded wire resistance strain gauge, under both static and dynamic loads. Remarkable accuracy was obtained under these ideal conditions but one must be skilled at identifying colours. The gauges are inexpensive considering that no auxiliary equipment is required to aid in the measurement. Their disadvantages in the present stage of development are (a) very sensitive to heat, (b) principal stress direction must be known, (c) gauge length excessive,—one inch, and (d) correction factors are necessary when bending is present.

Electrical Resistance Strain Gauges.

The principle of measuring strain by observing resistance change to a grid of fine wires bonded to a structure has long been utilized in experi-

Fig. 4. (right) Strain-Time Trace for Strain Gauges on a Shot Gun at Firing.

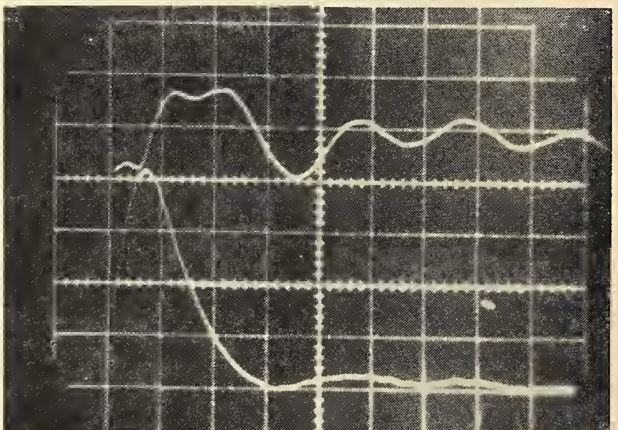


Fig. 3. (below) Photostress Gauge Installation.

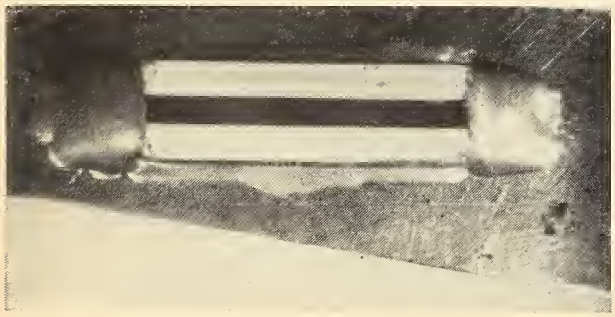


Fig. 5. Frozen Stress Pattern of Diametrically Loaded Laminated Disc.

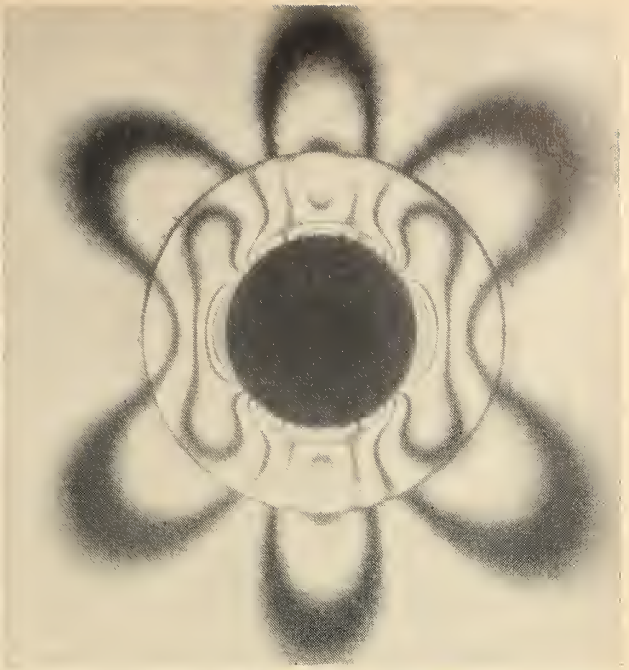
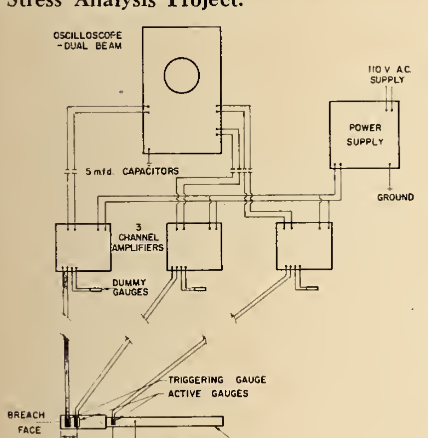


Fig. 6. Frozen Stress Pattern of Reinforced Circular Hole in a Plate under Tension.

mental stress analysis work. These bonded resistance strain gauges have had many applications in the past for both static and dynamic work.[15,16] Lately advances have been made in light weight temperature-compensated gauges and also a high stage of perfection has been reached in measurement and recording equipment for dynamic stress analysis.

Metalfilm Strain Gauges: A notable achievement in electrical resistance strain gauges is the metalfilm gauge.[17] These gauges are formed by photo-etching on a special alloy foil. The foil may be made from materials that give automatic temperature compensation. The result is an extremely useful design — one that can give great accuracy on thin sections under bending conditions, can readily conform to curved surfaces, can be used immediately after attachment and can be used under high temperature conditions as well as under high values of acceleration without loosening. Burke and Ens[18] used this installation for studying vibration characteristics of a square bar under torsion.

Fig. 7. Schematic Diagram for Dynamic Stress Analysis Project.



Dynamic Stress Analysis Project: Recently George,[19] at the University of Saskatchewan, carried out some comparative tests of the power of various shot gun shells by circumferential strain measurements on the barrel and breach at the instant of firing. (Fig. 7.) A Sanborn 150 oscillographic recording system formed the basic apparatus element. However, the oscillographs did not have sufficient response so amplifiers were hooked in to a dual beam oscilloscope. Recording was accomplished by using one gauge as a trigger for the beams and photographing with a Polaroid camera. A photograph of one set of strain curves is shown in Fig. 4. The lower curve is that for the gauge on the breach itself and the upper one for the gauge placed six inches out along the barrel. The first peaks occur approximately one millisecond after firing.

Conclusion

New techniques have emerged recently and advances have been made in three-dimensional photoelastie stress analysis. Despite the lack of literature on the newly introduced light weight strain gauges, experimental work utilizing them is going ahead.

Acknowledgement

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Frazil Ice and Flow Temperature Under Ice Covers

Ernest Pariset, M.E.I.C.
Director LaSalle Hydraulic Laboratory

René Hausser, M.E.I.C.
Engineer, LaSalle Hydraulic Laboratory

Frazil ice can present a serious clogging problem. This study is designed to probe the effectiveness of an ice cover in stopping the transportation of frazil ice, to protect a downstream power station.

FOLLOWING Mr. G. P. William's paper on frazil ice (Engineering Journal, November, 1959), we present here some new aspects of this subject. Our study on frazil ice was undertaken for the Quebec Hydro-Electric Power Commission and is part of a more general study on ice problems in rivers: formation of ice covers, hanging dams, ice jams, rate of ice formation. . . . This study, still in progress, has given interesting results, and probably will be published.

The fact that an ice cover will stop formation of frazil ice is well known, but sometimes it is not economically possible to have such a cover along the whole reach of a river. Therefore, a certain percentage of frazil ice generated upstream will be carried along under the ice cover to the power-station.

It was the aim of the study to determine this percentage, as a function of the flow characteristics and the length of the ice cover.

Frazil Ice Formation:

It is very probable that the formation of the frazil ice must be in close relation with the phenomenon of supercooling of water.

Classical theories assume that in running water at 0°C the heat loss of the exposed water surface generates localized masses of supercooled water which travel in the main flow until they meet some foreign particles in the water, or even existing frazil ice particles, which serve as nuclei for freezing of these masses of supercooled water. But we can also consider another possibility of frazil ice formation.

During cold weather, there is always a more or less thick layer of fog above the water. The convectional part of the water heat loss proceeds as usual by evaporating the water, which then forms the fog due to condensation of the vapor into very small droplets. These droplets are subject to cooling and supercooling and a certain percentage will drop back into the water.

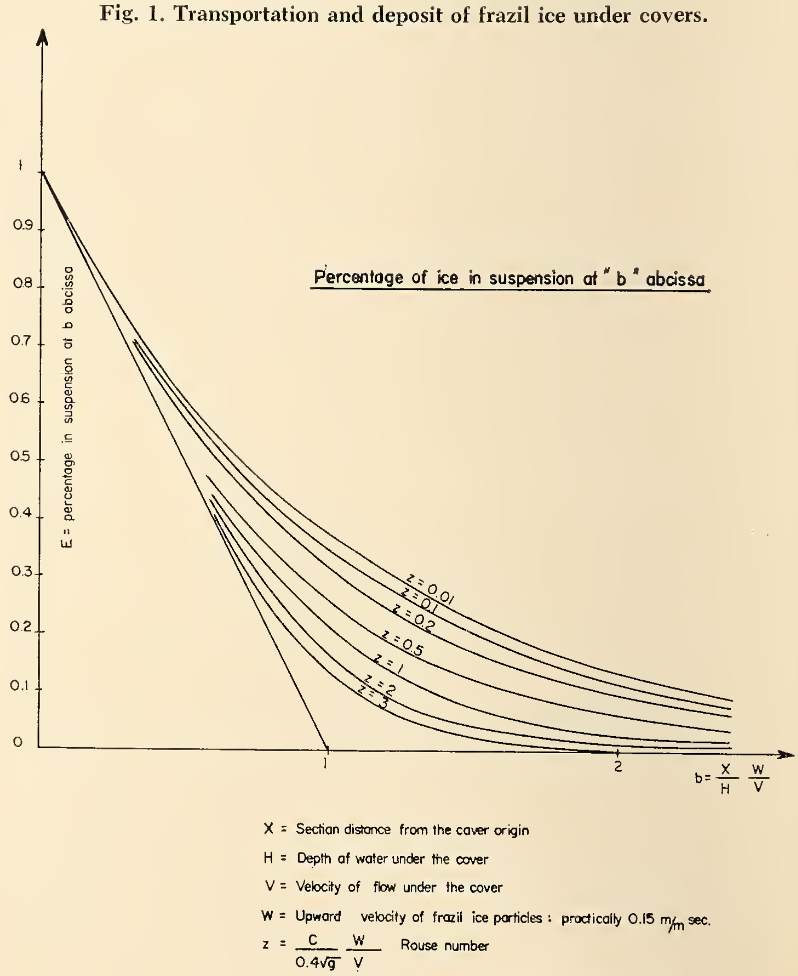
The supercooling of these droplets can be very extensive because of the pressure inside the droplets caused by surface tension (about 45 p.s.i. for droplets of a diameter of one micron). When these droplets fall back into the water, they flatten with a disk form. The release of surface tension forces will be sufficient to freeze them without the intervention of nucleating agents.

Transportation and Deposit of Frazil Ice

Frazil ice is, by definition, transported in suspension. Therefore turbulence phenomena play an important part and make its transportation study practically impossible on scale models. Thus we have tried to solve this problem by calculation, and have checked these results by field measurements on the deposit of frazil ice under ice covers.

Transportation under ice covers : Being less dense than water, frazil particles present an upward velocity similar to the settling velocity of the particles heavier than water. Then the problem of deposition of frazil ice under an ice cover is similar to that of a silting basin and we have solved it in the same manner. However, in order to simplify the study we assumed the following basic hypotheses :

Fig. 1. Transportation and deposit of frazil ice under covers.



1. The flow under the ice cover is uniform and influence of banks is negligible (this is practically true if the river is sufficiently wide);

2. At the front of the cover, all ice particles have the same upward velocity w and are uniformly distributed in the flow;

3. Deposited ice particles stick to the cover and cannot be removed by the flow;

4. We suppose also the mixture density is always close to unity, so that we can neglect density currents;

5. Finally, we suppose that the turbulence originating from the bed is smaller than that from the cover.

From the well-known mechanical equation of suspension (Dobbins)

$$\frac{\partial}{\partial Y}\left(\epsilon\frac{\partial c}{\partial Y}+wc\right) = V\frac{dc}{dX}$$

and by assuming that ϵ is given by:

$$\tau = \epsilon\rho\frac{\partial u}{\partial X}$$

(Rouse, experiment of Vanoni)

$$\frac{\partial u}{\partial Y} = \frac{1}{K}\cdot\frac{u*}{Y}$$

(Nikuradze, Von Karman)

We find:

$$\epsilon = \frac{Ku*}{H}Y(H-Y)$$

By taking into account the preceding physical hypotheses along, the integration of this equation gives:

$$E(b,z) = \sum_{n=0}^{\infty}\frac{(-1)^n(2z+2n+1)\Gamma(2z+n+1)}{(z+n)^2(z+n+1)^2\ n!_1\ (z)^2}\cdot e^{-(n+z)(n+z+1)(b/z)}$$

The general results of the integration are given on Fig. 1, but the direct application of the result is impossible because we do not know the upward velocity of frazil ice particles.

However, from the ice concentration variation and the ice discharge at the upstream edge of the cover, it is easy to calculate the shape of the ice deposit along the cover for various upward velocities. The comparison of the results so obtained with results of field measurements then will allow the determination of the upward velocity of frazil ice particles.

Application to the Beauharnois Canal: Application of this method of calculation to the Beauharnois Canal between 1953 and 1957 has furnished several interesting results.

(a) For the different years, ice particles appear to have constant upward velocity. The question is to know whether this constant velocity is independent of the site. If so, we would be in presence of a very particular ice which truly merits being called frazil ice. Future studies will probably provide verification of this point. From the velocity value and supposing ice particles as spheres of 0.92 density, we find that their mean diameter would be equal to 0.75 m/m. In fact ice particles are usually disk shaped.

(b) Theoretical and measured deposit profiles are reasonably close to each other (Figs. 2 and 3). This result constitutes an indirect verification of the theory.

The comparison of these profiles obviously shows some divergencies, especially at the beginning and at the end of the cover. However, we must point out that we have considered here only the action of frazil ice deposit and neglected all the other factors governing the thickness of the cover.

Some of the neglected factors, like erosion due to water flow or impact of ice floes can reduce the thickness of the upstream end of the cover. Others, like thrust of the cover tend to increase its thickness towards its downstream end.

Finally, we assumed that the initial ice cover was formed quickly with a uniform thickness. In fact this is not absolutely true, as there may be some frazil deposit during this formation. Also some growth in thickness can occur locally by ice crushing.

(c) Finally the study shows that in the Beauharnois Canal, even with an ice-cover of 60,000 ft. above the power-house, quantities of ice particles entering the turbines are of the order of three-quarters of the quantities produced by the ice free surface upstream of the cover. Therefore, it appears obvious that the use of covers to prevent frazil discharge through turbines is not very efficient.

In an effort to obtain a more precise verification of this theory, we have built and calibrated an electric probe to measure frazil ice concentration in rivers. This probe probably will be in operation this winter and we expect to do some measurements with it on frazil transportation in the city of Montreal water intake.

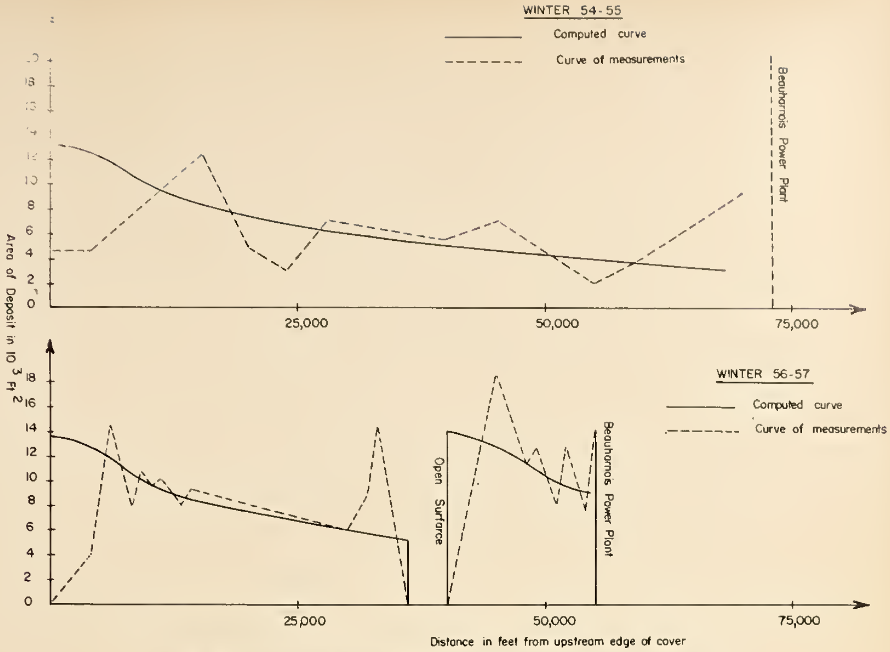


Fig. 2. Deposit of frazil ice under Beauharnois ice covers.

Frazil Ice Sticking

We have said that the use of ice covers to prevent frazil discharge through turbines does not seem very efficient. Otherwise the experiment has shown that ice covers in front of power-houses reduce greatly and sometimes even eliminate the troubles caused by frazil ice.

Consequently, these troubles do not seem due only to the presence of frazil, but rather to its sticking property. On this point, we think the adhesion of ice particles to objects in water probably depends greatly on the state of these crystals. The adhesion of these particles to the objects in water depends on whether they are growing or melting. On the other hand, studies have shown that the temperature of water tends to increase as it progresses under ice covers. We think, therefore, that after a sufficient journey under a cover, frazil ice is melting and cannot stick to objects, hence does not create troubles in power-house operation.

Water Temperature Variation Under River Ice Covers

We have said the temperature of water tends to increase as the flow progresses under an ice cover. This result can be determined by calculating heat balance between two sections.

If we consider a length of flow ΔX in meters under an ice cover and if discharge per unit width is q^{m^3}/sec/m and the energy line slope i, water temperature will increase or decrease by ΔT as a result of :

(a) a heat release or absorption by the water of :
$W_1 = \Delta T \cdot q \cdot 10^6$, in calories/sec.

(b) a heat release from head losses :
$W_2 = 2350 \cdot q \cdot i \cdot \Delta X$, in calories/sec.

(c) a heat transfer through the cover, since ice water boundary is always at 0°C :
$W_3 = hT \cdot \Delta X$, in calories/sec.
h being the coefficient of heat convexion.

(d) a heat release W_4 from the river bed to the water : this heat release is usually very small ($W_4 = 0.5$ to $I.$ 10^{-3}cal/m^2/sec. from some measurements) and negligible, except if springs or infiltration of warmer water occurs in the river bed.

Finally the heat balance between two sections distant ΔX is given by the equation :

$$+\Delta X \cdot h, T = -\Delta T \cdot q \cdot 10^6 + 2350 q \cdot i \cdot \Delta X$$

Whose the general integration shows that :

$$T°C = A e^{-(hx/10^6 q)} + \frac{2350}{h} iq$$

A being the constant of integration.

According to the conditions at the front of the cover, we may have the following cases :

(*a*) *Waters enters under the cover at 0°C :*

Mathematically we have at the front of the cover :

$$X = 0 \qquad T° = 0$$

then

$$A = -\frac{2350}{h} iq$$

and

$$T°C = \frac{2350}{h} iq(1 - e^{-(hx/10^6 q)})$$

In this case, the water temperature increases as the flow progresses under the ice-cover, up to the asymptotical value :

$$T°C = \frac{2350}{h} iq$$

practically reached a distance of :

$$X = 4.6 \frac{10^6}{h} q$$

(*b*) *Water enters under the ice cover temperature T_0 higher than 0°C :*

Following the general integration we have :

$$X = 0 \qquad T = T_0$$

and

$$A = T_0 - \frac{2350}{h} iq$$

In this case the water temperature X meters downstream of the ice cover edge is given by :

$$T = \frac{2350}{h} iq + \left(T_0 - \frac{2350}{h} iq\right) e^{-(hx/q10^6)}$$

Graph 4 shows the results of the different cases.

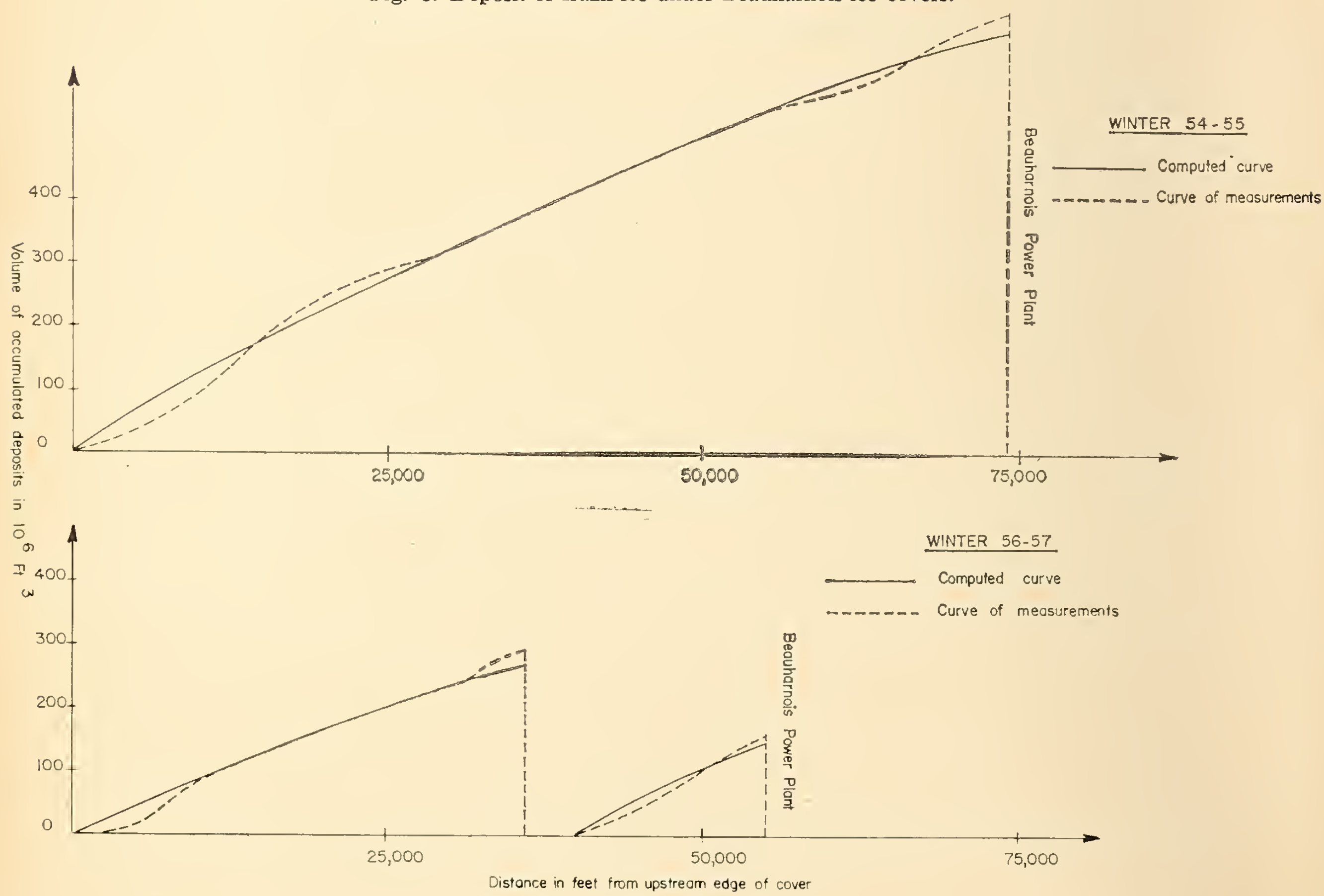
(*c*) *Water entering under the cover carrying ice particles in suspension :*

Part of these ice particles is deposited under the ice cover, another part is melted by the increase of heat of the flow during its travel under the cover, and a third part is carried downstream.

As long as the flow carries ice particles, its temperature remains at 0°C and there is no heat transfer through the cover. All heat produced by friction is hence used to melt ice particles so the quantity of ice melted per unit width is, in metric tons :

$$P = \frac{29.4}{10^6} i \cdot q \cdot X$$

Fig. 3. Deposit of frazil ice under Beauharnois ice covers.



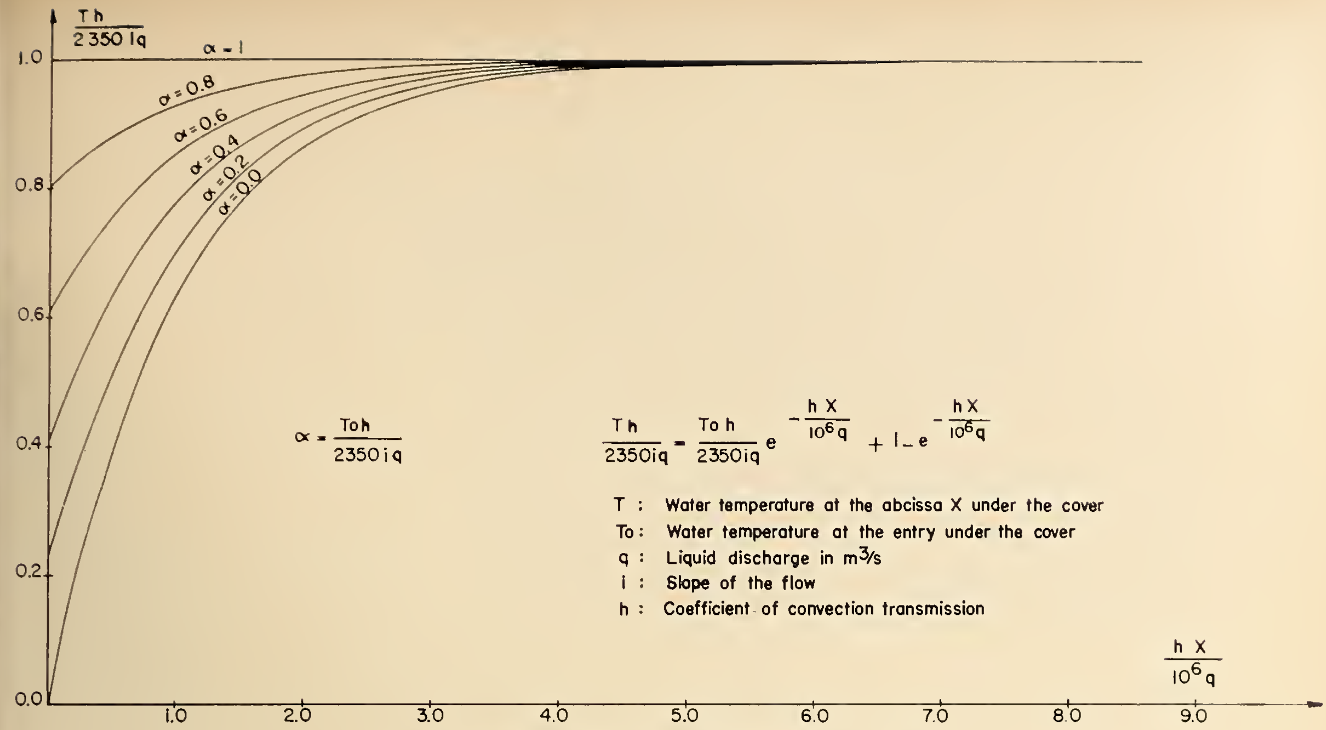


Fig. 4. Water temperature variation under an ice cover.

Application to Beauharnois Canal: The mean discharge is about 170,000 c.f.s. and the slope of the flow with an ice cover close to 0.6 10^{-4}. The width is about 4,000 ft. and the ice-cover reaches normally a mean length of 60,000 ft.

(a) Supporting that, near the front of the cover, water does not carry ice and its temperature is 0°C ; calculations show that, near the turbine intake the water temperature is :

$$+\frac{2.6}{1000}\ \text{C}$$

The rise of water temperature is hence very small and probably impossible to measure.

(b) Supposing that water enters under the cover with ice particles in suspension, we find by calculations that during its travel under this cover the flow can melt about 15,000 cubic yards of ice per day, and that independant of atmospheric conditions.

Atmospheric conditions will just govern the rate of melting or thickening of the ice cover ; the cover will thicken if the heat transfer from ice to atmosphere is higher than the heat transfer from water to ice cover ; it will melt in the opposite case.

Note the Coefficient h: The coefficient h may be written as :

$$h = k \cdot h_c$$

where : k is the correction index for the real surface of the ice cover in contact with the water ; it is therefore larger than one (1), and depends on the state of the bottom surface of the cover.

h_c is the convection transmission coefficient.

In the system we have chosen, it is approximately equal to :

$$h_c = 0.560(1 + 5V)\,\frac{\text{calories}}{m^2 \cdot {}^\circ\text{C} \cdot S}$$

where : V is the mean flow velocity in meters per second.

Finally,

$$h = k0.560(1 + 5V)$$

It is impossible to determine k without tests ; we know only that it is larger than unity, and may be taken as 1.57 if we consider the real surface as an agglomeration of hemispheres superimposed on the base of the ice cover.

Conclusion

Heat from losses of head is the main factor governing the temperature of flow under ice cover ;

If ice cover will stop local formation of frazil ice, it does not seem very effective in reducing the amount of frazil ice coming from upstream ; but it certainly is effective, by starting a certain melting of frazil ice and so greatly reducing its tendency to stick to trash screens and other equipment ;

Deposit of frazil ice under ice cover seems to follow closely the law governing settling basins, and field measurements check well enough theoretical calculations.

List of Symbols

Y, X	= coordinates.
H	= depth of water under the cover
ϵ	= coefficient of turbulent diffusion
w	= upward velocity of ice particles
C	= local concentration of frazil ice per volume
V	= velocity of water
E	= frazil ice concentration along the cover in relation to the ice concentration at the upstream edge of the cover
z	= the Rouse's number
Γ	= the gamma function
b	= the length from the upstream of the cover measured in units equal to the length that an ice particle coming from the bottom would travel to reach the cover in a non-turbulent flow
τ	= shearing strength
ρ	= specific weight of water
$K = 0.4$	= universal constant of Von Karman
$u*$	= shearing velocity
X	= distance in meters from the edge of the ice cover to the cross section considered
q	= discharge in m³/sec. per unit width
i	= the energy slope line
T°C	= temperature of water in degrees centigrade
W	= heat quantity in calories/second
h	= coefficient of heat convexion
P	= quantity of ice melted per unit width in metric tons

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Rouse: Elementary mechanics of fluids
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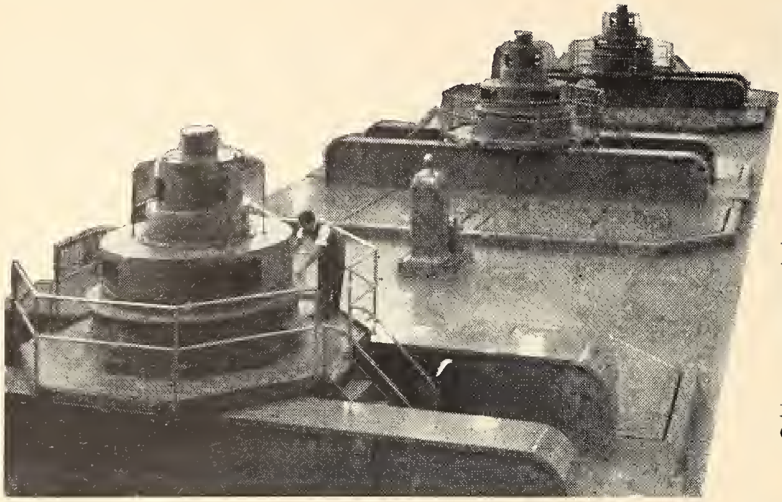
BRAKING OF HYDRO-ELECTRIC GENERATORS



H. O. Wilson, M.E.I.C.

Chief Engineer, Electrical Division, The Shawinigan Engineering Company Limited, Montreal

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May, 1960.

THE BRAKING of hydraulic turbine driven generators has assumed a new significance in recent years due to the widespread adoption of automatic braking for use with automatic units and remotely controlled generating stations. Also the increase in the number of units on the power systems has resulted in more braking operations being carried out than in the past.

The scope of the paper is limited to dealing with Francis or Kaplan turbine driven generators of medium size and moderate speeds.

Braking of a hydro-electric generator during a unit shutdown is required primarily to prevent slow deceleration of the unit in the critical period when the generator thrust bearing goes through the transition from the low friction of planing on an oil film through greased rubbing to static holding friction. If the bearing were left to linger in the rubbing friction area the babbit would heat up and eventually wipe.

Because bearing damage is to be avoided, a braking system supplied as part of the generator must be reliable, simple and easy to inspect and maintain.

Braking System

A generator braking system consists essentially of interconnected friction pad assemblies mounted on the lower bracket arms and a brake track attached to the under side of the rotor rim. To apply the brakes, air pressure is released through a solenoid-operated valve into the brake cylinders. The brake pistons, working against spring pressure, force the friction pads or brake shoes against the brake track.

To release the brakes, the solenoid of the air valve is de-energized, this shuts off the air supply and exhausts the air from the brake cylinders to atmosphere. The springs in the brake pad assemblies withdraw the shoes from the track.

A brake control switch, with *Hand-Auto* positions is usually located near the unit. For manual brake application the switch is turned to the *Hand* position and energizes the solenoid-operated valve. In the *Auto* position, the switch prepares the solenoid circuit for an automatic braking operation. The control switch is spring returned to neutral from the *Hand* position but is maintained in the *Auto* position.

The solenoid-operated valve is equipped usually with a hand lever for operating the valve mechanically to provide standby braking. A reliable source of air pressure, usually at 100 p.s i., can be obtained through a reducing valve from the air system supplying the governor accumulator tanks.

The braking system also serves as a means of jacking the rotor; a hand oil pump is used to apply relatively high oil pressure to the brake cylinders.

Design Considerations

The design of a braking system is determined by such items as:

Machine WR^2;

Peripheral speed of the brake track;

Turbine gate leakage torque;

Air pressure available;

Normal stopping time.

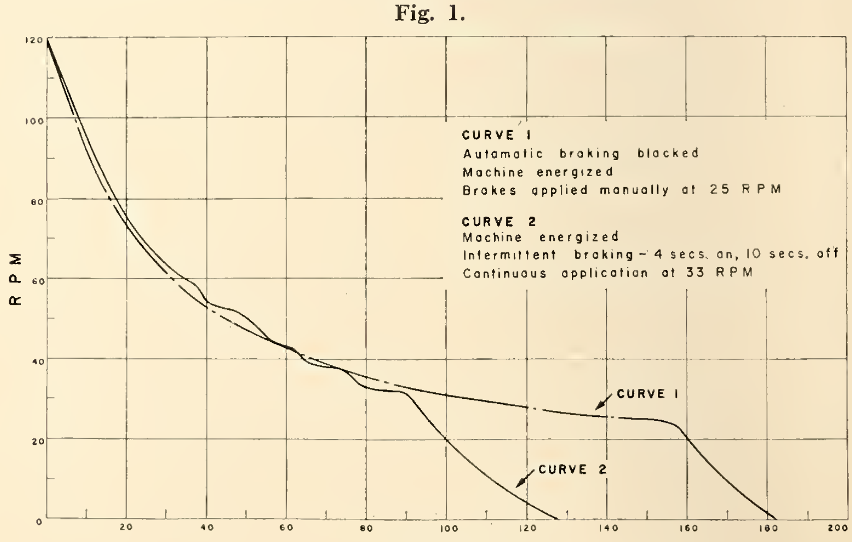
The torque of the unit which changes from a retarding torque initially on shutdown, to a driving torque as the speed decreases and the leakage torque becomes relatively more effective.

Governed by the above items, the designer must meet certain requirements such as:

Cracks in the track surface must not develop during normal braking;

Severe vibration of rotating and stationary members belonging to the brake assembly must be prevented in order to avoid fatigue in the highly stressed parts;

Fig. 1.



The pad lining material must not be allowed to score the track surface;

The brake pads must have a reasonable life and the replacement of worn pads must be a simple process.

The above requirements are met in general by:

Provision of the proper size and number of brake pads;

Specifying the speed at which normal braking should be initiated, thereby limiting the maximum rubbing velocity;

Designing the thickness of the brake plate to allow a temperature rise commensurate with the material used;

Erecting the track so as to eliminate waviness and obtain constant friction conditions;

Providing asbestos pad lining material without metallic particles or threads with the proper co-efficient of friction at a certain temperature and pressure.

Types of Braking and Shutdowns

Of the two classifications of braking, manual and automatic, only the latter will be discussed here in detail as it is considered that the methods used in automatic braking will apply as well to manual braking and can be incorporated into proper operating instructions.

Automatic braking is used with two types of unit shutdowns, normal and emergency. For this discussion a normal or planned shutdown is considered to be one in which the load is gradually dropped, the supply circuit breaker is opened and the unit brought to rest. An emergency shutdown is considered to be one in which the load is dumped by tripping the supply breaker, the generator field breaker is tripped and the unit brought to rest.

Emergency shutdowns are caused by either mechanical or electrical faults and usually result in a lockout of the unit involved. The unit cannot be started until the lockout relay is reset by hand.

Deceleration Curves

At this point it is of interest to examine the accompanying deceleration curves shown in Figs. 1, 2 and 3. These curves are the results of tests run on a modern 45 mva., 120 r.p.m. unit, the generator being driven by a Francis turbine.

Fig. 1:

Curves 1 and 2 illustrate the different characteristic deceleration curves of the machine for continuous and intermittent braking respectively. From a comparison of these curves it is evident that the intermittent application of the brakes produced very little effect on the rate of deceleration of the machine.

Fig. 2:

Fig. 2 illustrates the characteristic deceleration of the machine with and without the generator field energized. It can be seen that the deceleration is somewhat more rapid when the field is energized.

Fig. 3:

Fig. 3 compares the deceleration curves of a machine having gate leakage (Curve 5) and a machine having no gate leakage (Curve 7). (Incidentally, the gate leakage here was found to be due to a bent shear pin.) It should be noted that Curve 5 tends to flatten out at approximately 30 r.p.m. Curve 6 shows the result of applying the brakes continuously at 35 r.p.m. on the machine having gate leakage.

Observations

The following observations which can be made from a study of the deceleration curves are significant in the application of generator braking:

(a) In the intial stage of shutdown (i.e. above 60 r.p.m. or 50% speed) it makes little difference in the deceleration whether the field is energized or not (Curves 3 and 4).

(b) In the intial stage of shutdown it makes little difference whether or not the brakes are applied intermittently. (Curves 1 and 2).

(c) Gate leakage has little effect on the rate of deceleration in the initial stage of shutdown.

(d) The deceleration after the continuous application of the brakes below 40 r.p.m. or 33% speed is practically constant regardless of the actual speed at which the brakes are applied.

(e) Gate leakage could keep the machine in question running indefinitely at approximately 30 r.p.m. or 25% speed.

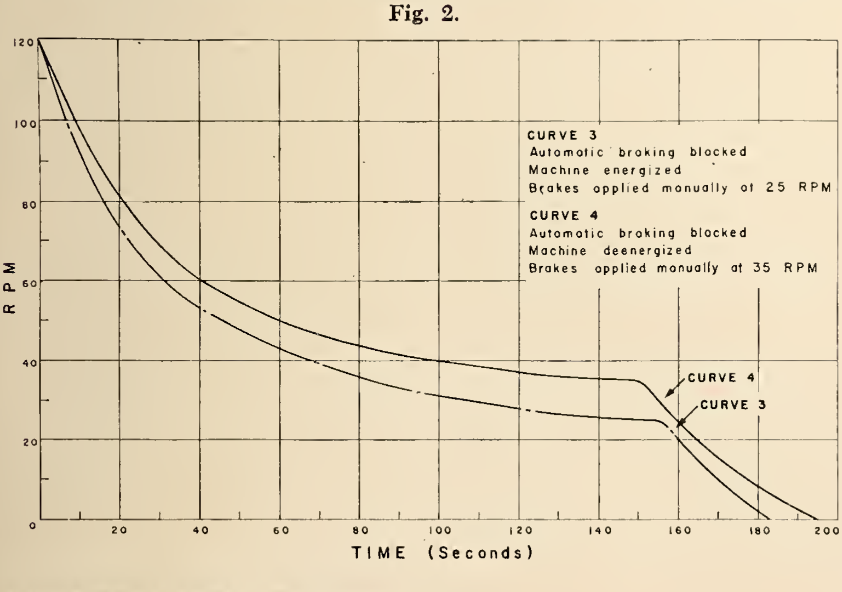
Proper Application of Brakes

From the above observations and in accordance with manufacturers' recommendations, the most suitable point on the deceleration curve for brake application is considered to be approximately at 40% of rated speed. Above this speed the turbine braking torque does an effective job of reducing the speed and, what is more important, brake application above this speed can cause destruction to the brake surfaces because of thermal fatigue caused by the high rate of heat generation.

Below 40% rated speed it is possible, due to gate leakage, to fall into the flat part of the unit's deceleration curve where the speed switch initiating brake application would not operate, and the machine would run indefinitely. While running at speeds just below 40% rated speed will not damage the generator bearing, this condition certainly will not shut down the unit.

Past braking practice in a great many cases has been to employ a braking timer which came into action at 50% rated speed and applied the brakes intermittently at first and then continuously and finally released the brakes a few minutes after the unit had come to rest. Present practice tends to eliminate intermittent braking and use continuous or maintained braking only. Intermittent braking is not considered advisable because the thermal cycles it produces cause more thermal fatigue in the brake surfaces than with continuous braking. In addition, intermittent braking accomplishes little or nothing in decelerating the unit. Also it is considered that with the elimination of a timer and its motor, simplicity is gained with maintained braking which could result in less maintenance. After the machine has stopped, oil oozes out from between the thrust bearing surfaces and in approximately four minutes the bearing static friction becomes greater

Fig. 2.



than the holding friction of the brakes and eventually overwhelms the brake friction. If the brakes are released too soon after shutdown and there is sufficient gate leakage there is a danger that the unit will start to creep, i.e. rotate very slowly, thus wiping the bearing, therefore it is considered safer to leave the brakes on continuously after shutdown. Monitor switches mounted on the brake pads and connected in series can be used to prevent a start-up of the unit until the brakes have been released.

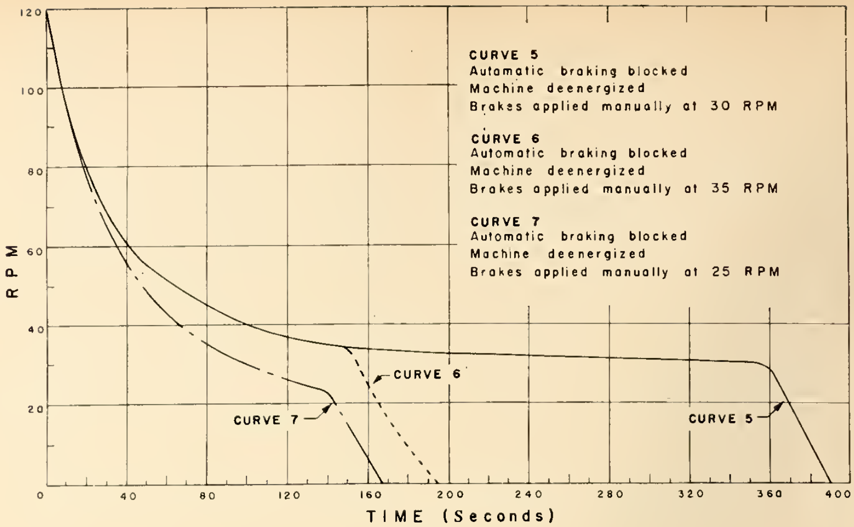


Fig. 3.

Braking in an Automatic Shutdown Sequence

For a normal or planned automatic shutdown, the "Unit Stop" switch or pushbutton is operated to set up a sequence such as follows:

1. The load is gradually removed from the unit;
2. The supply breaker is opened.
3. The wicket gates are closed by means of the governor shutdown solenoid;
4. A zero gate position switch closes when the gates are fully closed, thereby partially setting up a circuit to apply the brakes;
5. The unit decelerates due to the turbine braking torque;
6. At 40% rated speed a speed switch closes and completes the braking circuit to energize the solenoid-operated air valve and apply the brakes continuously;
7. The brakes remain on until the unit is required to start up again, when they are removed as part of the starting sequence.

For an emergency automatic shutdown the protective devices or the protection relays operate to trip the supply and field breakers and energize the governor shutdown solenoid. Thereafter the shutdown sequence would be similar to that shown above for a normal shutdown.

It is necessary for automatic shutdown to have the *Hand-Auto* brake switch in the *Auto* position so that the circuit is prepared for automatic braking. An alarm can be provided that will sound when this switch is not in the *Auto* position while the unit is running.

Various standby features can be added to the braking scheme depending upon circumstances and utility practice. Standby speed switches and standby solenoid-operated air valves have been used in some cases.

For larger machines it may be desirable to build up the brake pressure slowly as the unit decelerates so that the rate of heat generation will be approximately constant during the build up period.

It should always be kept in mind that an extra feature added in the interests of reliability should not be a source of hazard in itself.

Creep Indication

For units equipped for automatic braking it is suggested that a creep detector be provided to indicate rotation of the unit when there should be none.

There are different forms of creep detectors on the market but whichever type is chosen it is advisable that it should be capable of sounding a remote alarm and it should be used in such a way that false rotation alarms are avoided during the slow rotation periods that occur when starting or stopping a unit. Otherwise the value of a creep detector is lost.

A main cause of creeping could be the release of the brakes too soon after the unit has come to rest, when there is sufficient turning torque due to gate leakage to overcome the partially established bearing friction torque. Another cause could be the failure of a speed switch to initiate braking; under this circumstance when there is very little gate leakage the unit could slowly come to rest of its own accord.

Upon the occurrence of creeping, there are possibly two choices of action in the case of this with a normal shutdown. Another shutdown sequence may be initiated which will bring in the braking sequence again or a start up may be initiated which will bring the unit to speed-no-load and out of the dangerous low speed area. However, with an emergency shutdown the unit cannot be restarted due to the lockout feature of the shutdown relay.

Suggestions for a Braking System

In order to obtain a reliable braking system and make the best use of materials and facilities available:

The corresponding generator and turbine designers be requested to collaborate regarding the effects that the turbine torque can have on the unit braking;

The generator designer state the highest speed at which the brakes can be applied safely and the lowest speed at which the unit can be run without the danger of bearing damage;

A deceleration curve be obtained by actual test for each unit in order to determin the best speed during the shutdown at which to apply the brakes;

The brakes be applied at a speed below the highest safe speed given by the generator manufacturer and above the coasting speed that is due to gate leakage. Also it is suggested that allowance be made for an increase in gate leakage as the unit becomes older. A good average speed for brake application is considered to be 40% rated speed;

By means of a mechanical speed switch the brakes be applied continuously, not intermittently, and be left on until the unit is required to start up again;

The braking system be simple, easy to inspect and maintain. Careful consideration should be given to the addition of extra features or gadgets.

Conclusion

Reliable automatic braking systems can be and have been designed and it is considered that this factor has played an important part in the increasing use of automatic units and remote-control generating stations.

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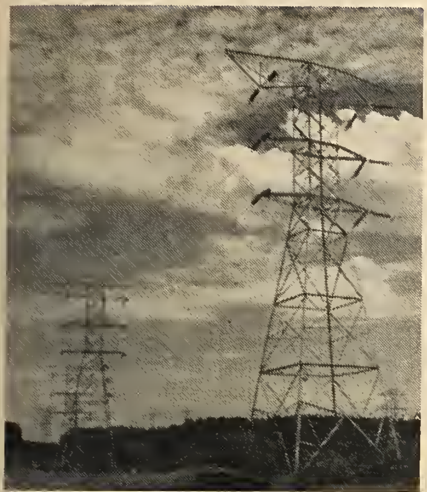
Economic Feasibility of TRANS-CANADA ELECTRICAL INTERCONNECTION



D. Cass-Beggs, M.E.I.C.,

General Manager, Saskatchewan Power Corporation

The possibility of a Trans-Canada interconnection of generating units is often discussed. Elsewhere such systems are common, but development here in Canada is principally on a provincial scale.

Paper presented to the E.I.C. Western Technical Conference, October 1959.

THE interconnection of generating units into large integrated systems is commonplace today. To a casual observer this process, in North America, might appear to have reached completion. It has been accompanied by the elimination of small and inefficient generating units, concentration of generation at plants with the lowest energy cost, and usually the transmission of relatively large blocks of power over the considerable distances that lie between low-cost resources and centres of population. Generally, Canadian development has been on a provincial scale, due largely to the fact that jurisdiction over the natural resources involved is vested in the governments of the provinces. While interconnections exist between adjacent provinces, notably between Ontario and Quebec where a common water resource forms the inter-provincial boundary, the concentration of load and the greatest capacity of the networks tend to be in the centre of the provinces. Facilities constructed towards the provincial boundaries are of little use for interconnection.

Connections presently contemplated between provincial systems such as the line under construction from Estevan, Sask., to Brandon, Man., are of limited capacity. They are generally for a specific purpose and cannot be considered to integrate the two systems.

The purpose of this paper is to examine the feasibility of a large-scale coast-to-coast interconnection. This interconnection would be such that a significant part of the power requirements of any province could be met from the facilities of others. Large amounts of energy would be moved from the region in which it naturally occurs, or not yet developed, to areas increasingly in need of new resources.

Obviously the studies involved in evaluating this question are both extensive and detailed. This paper does not attempt to do more than make a superficial examination of some of the factors in generalized terms and to indicate that it would appear that an a priori case for a trans-Canada electrical interconnection can be made.

Among necessary simplifications in a first study, attention should be drawn to the use of provincial systems as single units irrespective of the division of such units between separate utilities operating within the province. This is justified because separate utilities, whether they are private companies, municipal utilities or provincial commissions or corporations, are or will be largely interconnected within the particular province by 1965 and can be considered economically as single units. Further, Nova Scotia and New Brunswick have, for this purpose, been considered to be a single unit, and for geographical reasons, Prince Edward Island and Newfoundland have been omitted. Apologies are due to the individual utilities which have been arbitrarily merged or omitted, but some support for the action may be secured from the more readily available statistics on a provincial scale.

Other sweeping assumptions will be encountered as the argument proceeds. One of the first will be the allocation of a uniform price of $250 per kw. to new hydro developments, and $150 per kw. to new steam plants, wherever they may be.

For this analysis, 1965 loads have been estimated from trend curves indicated in Fig. 1. These are based on Dominion Bureau of Statistics figures with slight adjustments.

The economies that might be achieved by such an interconnection come from three main sources:

1. Reduction in the capacity that is held in reserve for contingencies, or that is constructed ahead of demand;

2. Reduction in peak demand due to increased diversity arising out of different consumption patterns in different regions, and particularly as a result of the displacement of peaks in the five time zones of Canada;

3. Savings due to the optimum use of minimum cost energy resources and the maximum use of available energy storage.

Reduction in Reserve Capacity

The reserve capacity maintained by utilities in Canada rarely has been that which they would consider most desirable. At times in the post-war period, reserves have been low due to war-time shortages combined with high post-war growth rates. At other times reserves have been individually high when new plants have been commissioned due to the justifiable decision to install very large units. However, a trend in the variation of reserves with the size of the system can be deduced by graphing the average reserve held by systems within certain size ranges.

The graph (Fig. 2) is based on average reserve capacity held by the nine provinces considered during a six-year period (1953-1958) as published in the Dominion Bureau of Statistics Annual Electric Power Survey of capability and load.

Points plotted represent the averages of systems which in any year fall within certain ranges of capacity, such as, 400 to 800, 800 to 1600 Mw. The smaller systems obviously have higher reserves compared with those in the region of 5000 Mw. (Ontario and Quebec). Some cases in the ranges between 1000 and 2000 appear to have abnormally high values which may be attributed to the effect of special isolated projects not integrated with the system. The points in question are for British Columbia.

Extrapolation of the graph to apply to single integrated systems of the order of 20,000 to 50,000 Mw. indicates that a reserve of 5% might reasonably be considered. For a fully integrated system of 20,000 Mw. (such as Canada by 1965) this would provide 1000 Mw. of reserve. The largest unit in operation might be 500 Mw. The simultaneous failure of two of these, or half a dozen or so units of smaller capacities would be covered. It should be noted too, that in a very large integrated system, indirect reserves in the form of overload capacities of steam units, interruptible loads, and the revision of despatching procedures to minimize losses rather than to minimize costs, would all be more easily mobilized.

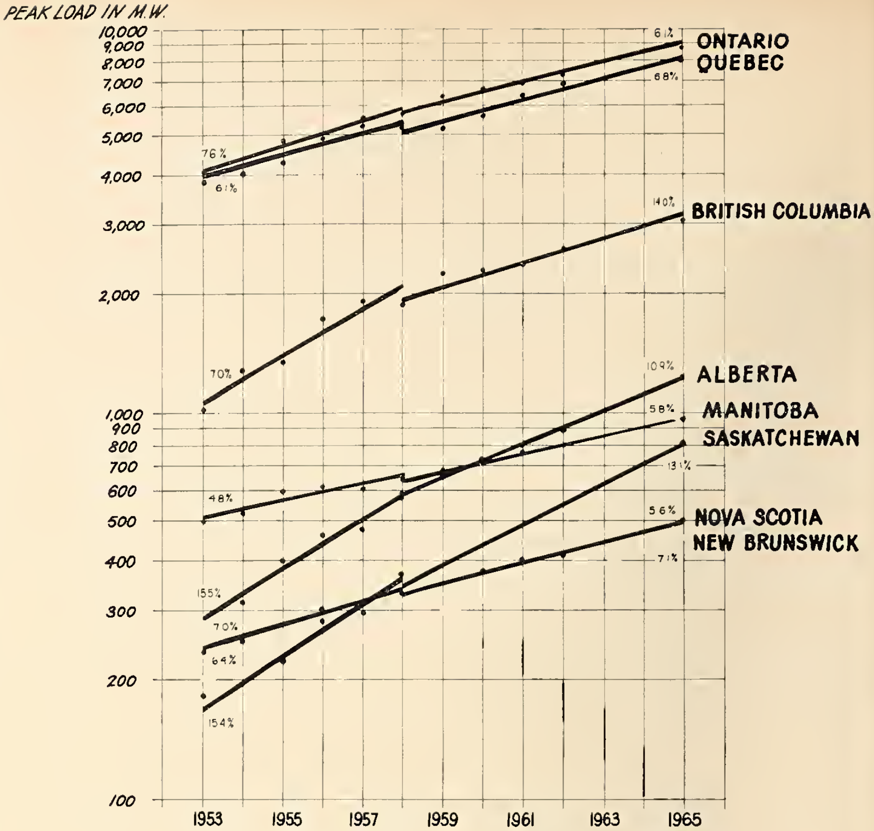
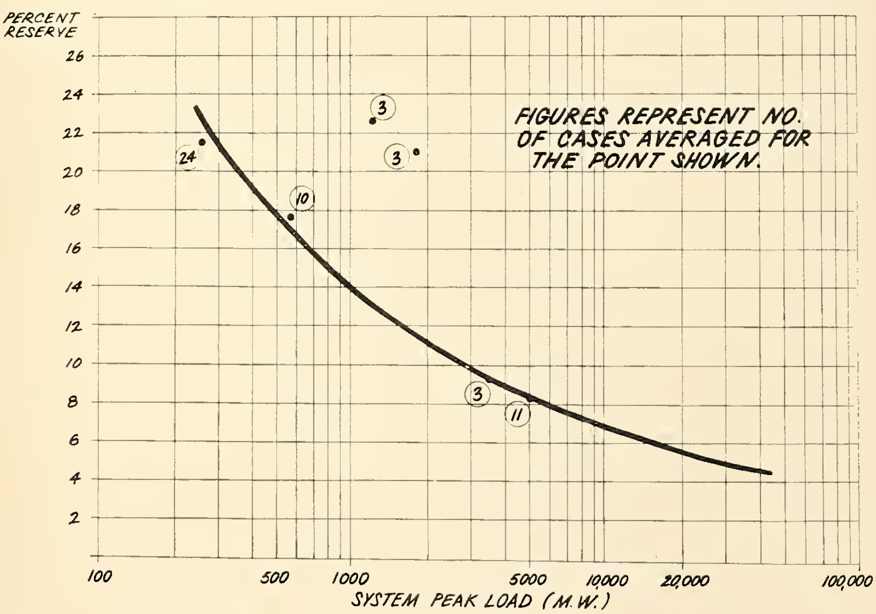


Fig. 1. Peak loads of Canadian Provinces 1953-65

To estimate the saving in reserve capacity, the individual provincial peak loads have been projected to 1965, and a reserve factor according to scale has been applied from the graph (Fig. 2). This involves values ranging from 15.2% for Saskatchewan to 6.9% for Ontario. Considering (for this purpose) the peak load of the integrated system to be the sum of the separate peaks, a system of 22,000 Mw. would have required 5.4% reserve. Reduced to capacities this represents a saving in installed capacity of 715 Mw.

To find the investment involved in this reserve capacity it has been necessary to assign it arbitrarily to hydro and steam capacity in the proportion in which these resources are represented in the total. Valuing the hydro at $250 and the steam at $150 per kw., we find that the saving in investment due to the reduction in reserve capacity would be approximately $150 million.

Fig. 2. System peak load and percentage of reserve capacity (derived from 1953-58 data of provincial totals.)



Effect of Diversity

The savings to be secured from the diversity arising from the various time zones would be much more impressive if the provinces with the largest systems, Ontario and Quebec, were not in the same time zone. However, if it be conceded that other parts of Canada, particularly British Columbia and the Prairie Provinces, may expect relatively more rapid growth than the older established provinces, any estimate of savings calculated, for example for 1965, will be increased as time passes. Fig. 3 illustrates the distribution of provincial areas between time zones.

Daily load curves for a number of utilities have been obtained from which, with reasonable assumptions, composite load curves for the provinces have been constructed for

1965. These are shown individually in Fig. 4. Quite obviously Ontario and Quebec dominate the picture, but the other loads in aggregate are by no means insignificant and will be increasingly important.

These curves have been plotted to a base of Atlantic Standard Time. It is easy to see that the morning and evening peaks of British Columbia, Alberta and Saskatchewan, fit nicely on either side of the evening peaks of Ontario and Quebec.

A series of composite load curves has been developed starting from the Atlantic Zone and successively adding provincial loads until the total is reached with the inclusion of British Columbia. The top curve (in Fig. 5) represents the estimated total Canadian load for the peak day of 1965. It has been assumed that the peak day for the largest system would determine the peak day for the whole, and the corresponding day for other systems has been used. A more thorough compilation of load curves with more historical background would be desirable for this analysis, but it is felt that economies calculated on this basis are not likely to be over-stated.

The peak load thus calculated for Canada (with the omissions noted earlier) is estimated to be 20.7 million kw., while a summation of provincial peaks, irrespective of time of occurrence, gives 22.01 million kw. It is therefore argued that if integration can be achieved without loss of capacity, a saving of 1,500,000 kw. can be secured. This would represent capacity that need not be installed immediately after integration. According to whether this is hydro or steam capacity, it could represent an investment in the neighbourhood of $300 million.

In combining the savings due to both the effect of diversity and the reduction in reserve capacity, the following tabulation can be made:

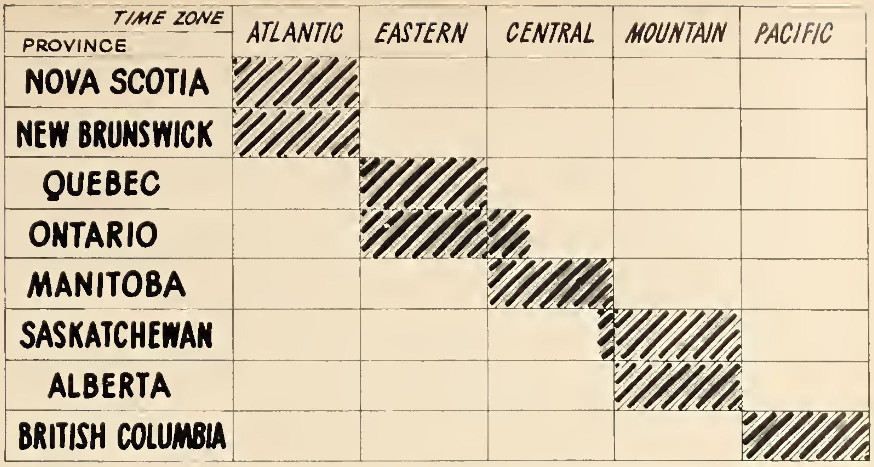


Fig. 3. Relationship between time zones and provinces in Canada

Necessary Capacity before Integration	
Sum of peak loads in each province:	22,007 Mw.
Sum of reserves separately required:	1,903
Total Capacity	23,910
Necessary Capacity after Integration	
Peak load for composite System	20,473
Reserve for composite system:	1,125
Total Capacity	21,598
Total Capacity Savings through Integration	2,132 Mw.

It is difficult to forecast what part of the capacity saved in this manner would be hydro and what part steam, or indeed nuclear energy at still greater capital cost. However, it is reasonable to assume it to be divided in the proportion for the presently planned increments of 36% hydro to 64% steam, which might apply between 1958 and 1965. Using the prices per kw. previously suggested for hydro ($250) and thermal generation ($150) the investment saved by a capacity saving of 2,312 Mw. is $430 million.

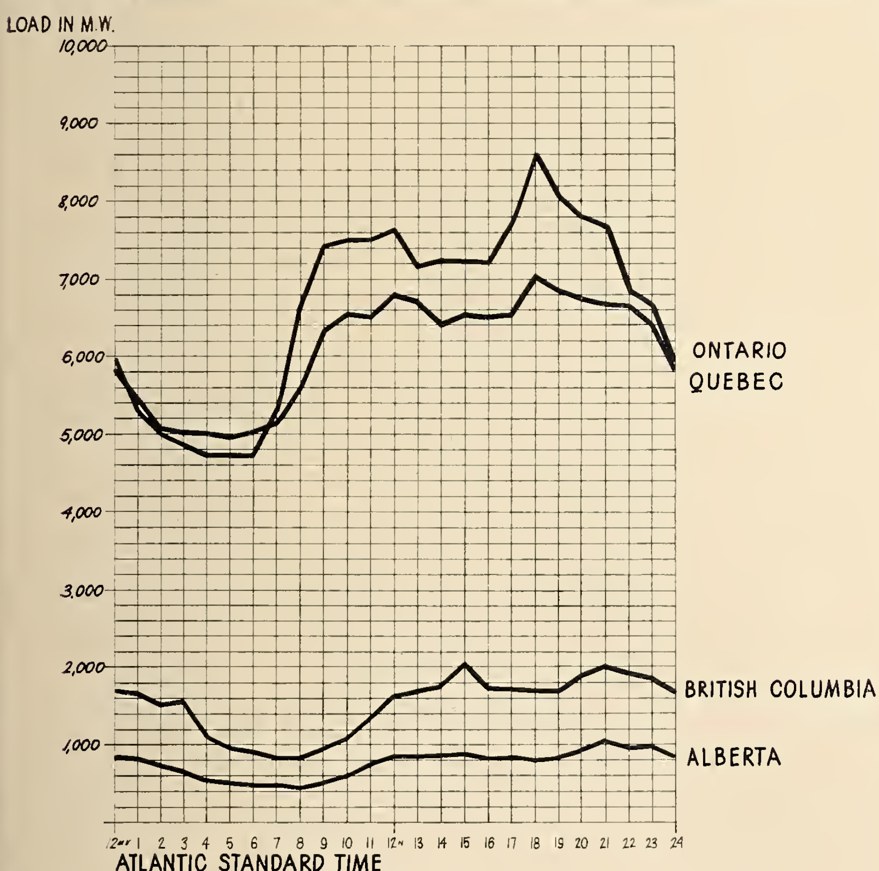
Optimum Use of Resources

The third possibility of significant savings, those arising from the optimum use of lowest-cost resources, is more obvious but still more difficult to evaluate.

The main resources capable of further development on a large scale (excluding nuclear energy) are coal in the Maritime Provinces, hydro in Labrador and Quebec and possibly in Northern Manitoba, coal in Saskatchewan and Alberta and hydro in British Columbia. Any development that would permit the flow of energy from east and west towards the centre of the country would be advantageous.

The analysis of the problem of matching resources to loads, and mak-

Fig. 4. Representative provincial load curves for peak day (estimated for 1965)



ing the most economical allocation within the limiting factors of availability and transmission capacity, is a task so large that it cannot be undertaken in this preliminary review. It is suited ideally to the techniques of operations research and with computing equipment is by no means insoluble. It would take into account the incremental cost of energy from various sources with plants of assumed efficiencies; the added cost of the losses involved in transmission; and the various limitations of capacity. It would produce ultimately a schedule for the loading of all major plants at all times, corresponding to all conditions of water supply and other variable factors. This could be done for an integrated system today, and indeed is a sine qua non of integration.

For the present purpose a skeleton-like sample of this analysis has been undertaken with greatly simplified assumptions.

Each province has been assumed to have two composite generating plants, one steam and one hydro. Composite costs based as far as possible on published information have been assigned to these plants. These incremental costs per kwh. have been increased as the power is assumed to move away from its source with a price assigned in each province. Thus British Columbia hydro priced at 1.5 mills in British Columbia increases to 1.62 in Alberta, 1.74 in Saskatchewan, 1.83 in Manitoba and 2.11 in Ontario. These increments are relatively large. They would cover more than the effect of transmission losses, but are not intended in this analysis to include the fixed costs of operating the transmission system. The relatively high incremental cost assumed for hydro (which excludes fixed charges) is intended to give a conservative approach to the savings involved.

The annual load in kwh. has been estimated for each province. The problem has been to assign this to local generation in the province, and to imports from adjacent or more distant provinces to secure maximum economy.

The methods of operations research have been applied to the problem and a logical and perhaps feasible solution developed for assumed conditions of 1965. The limitations of capacity of hydro and thermal installations and the degree of possible utilization, namely 100% for steam and 65% for hydro, were assumed for these dates.

The pattern that might be anticipated for 1965 is illustrated in Fig. 6. For example, Quebec would generate only with hydro, holding what steam capacity it might have in reserve. From its hydro it would meet all its own needs and export to Ontario, New Brunswick and a small amount to Nova Scotia. Ontario, on the other hand would use all its hydro and generate from coal for part of its own needs (with some of its steam capacity on stand-by), but would also import from Alberta, Saskatchewan and Manitoba as well as from Quebec. The middle portion of Fig. 6 shows the loads in the bus, which reach 1250 Mw. between Saskatchewan and Manitoba, and 1000 between Manitoba and Ontario. It should be noted that no new B.C. hydro power, such as the Columbia River, has been assumed to be available as soon as 1965. Consequently, British Columbia is importing power from Alberta in 1965.

The lowest diagram of Fig. 6 shows the energy and kw. fed into or taken from the bus, on an assumed load factor of 85%. The terminal equipment in Ontario must be capable of delivering 1500 Mw., while that in Alberta will handle an input to the bus of about 1000 Mw.

No claim is made that these tentative results are very reliable. An important assumption is that all steam plants in a province can be treated as a unit, with a weighted average incremental cost. In practice, consideration of individual plants would eliminate the higher cost units and increase the savings. The use of annual kwh. without reference to load factor is justifiable for 1965 in relation to the then existing excess of reserve capacity. At a later date, following integration, capacity would have been planned according to the optimum uses of resources, but allocation of energy would have to be related to daily load curves for the system.

The savings indicated by this analysis may be considered a minimum. Computing the savings for the hypothetical 1965 case, as compared with an extrapolated actual 1957 case, there appears to be a possible saving in annual operating costs of some $45 million. The saving in 1957 by a similar calculation would have been about $20 million.

Without looking further afield, these investments and operating savings are those that might be available to meet the initial and annual costs of a coast-to-coast interconnection.

It is preferable to reduce them all to an annual cost basis. For this purpose it will be assumed that the interest, depreciation and fixed part of operating cost for hydro is 8% of investment and for steam, 12%. These yield fixed costs per kilowatt of $20 and $18 respectively.

The annual saving due to the reduction in capacity secured by integration now appears to be:

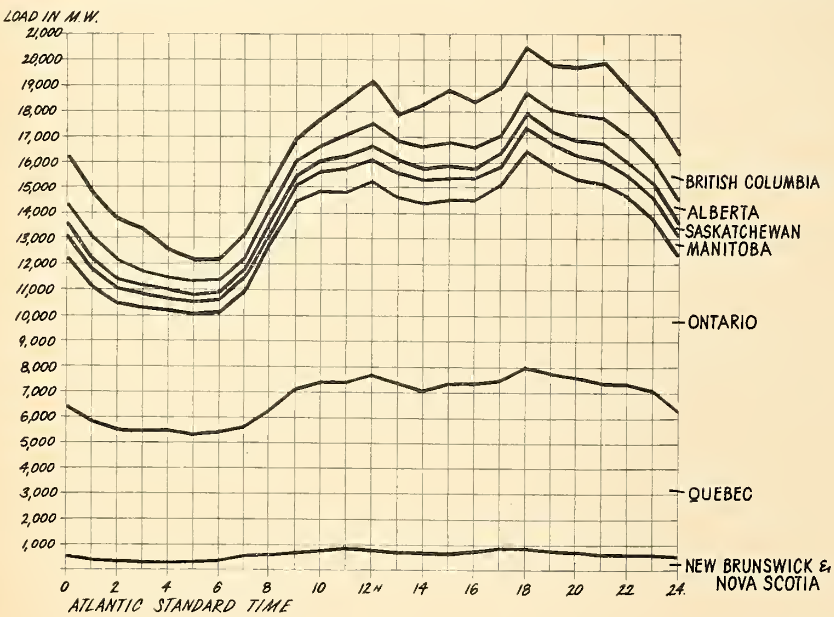
Hydro, $208 million at 8%	$16,640,000
Steam, $222 million at 12%	$26,640,000
Total	$43,280,000

Say $43 million per annum.

Adding the saving of $45 million through optimizing the use of resources, the total annual saving is some $88 million. The question remaining is whether this would pay for the facilities required.

It is hardly within the scope of

Fig. 5. Composition of daily load curve for peak day of integrated Canadian system (estimated for 1965)



this paper to propose the technical solution to the problem of interconnecting the major provincial systems in Canada. The proposal involves a transmission line or bus some 3000 miles long, capable of handling up to a million kw. at any point with taps connecting in each province with the locally integrated provincial system. The average distance between taps would be some 500 miles with the line starting in British Columbia, tapped in Alberta, Saskatchewan, Manitoba, Ontario and Quebec and terminating in New Brunswick. The location of the taps would be determined by the most suitable location in each provincial system. It would be anticipated that taps would be too expensive to allow more than one per province, although in particular cases, such as Ontario, a second tap might be justified, but will not be assumed for the present purpose.

The loading of the line will vary from point to point and it should be considered more as a bus than as a source to load transmission line.

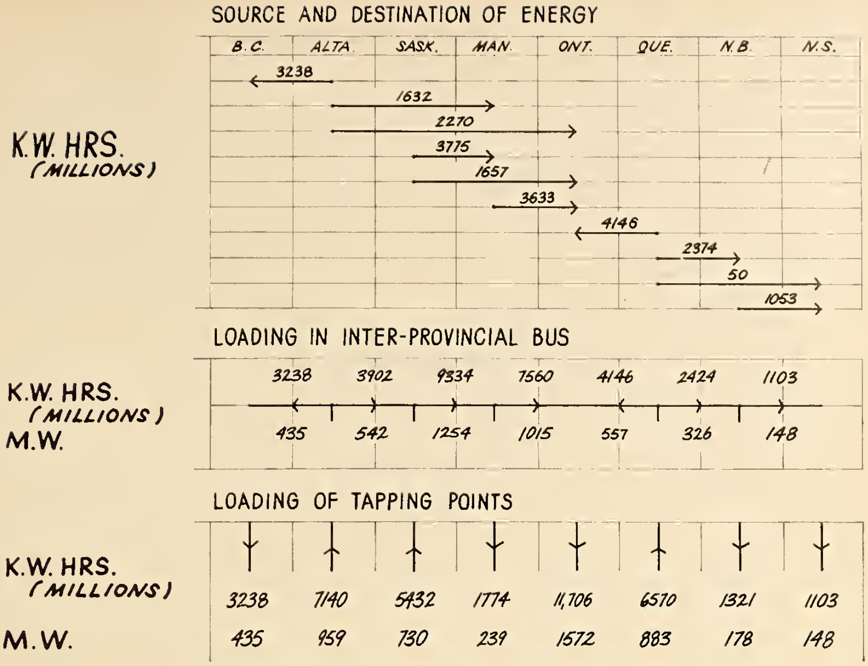


Fig. 6. Transfer of energy between provinces (1965 estimated)

Considerable discussion has taken place on the merits of DC transmission and the limits of AC transmission. There has been a tendency to argue that DC transmission is unlikely in the U.S.A. since the untapped distances are relatively small. It has been suggested that distances, of the order of 400 miles, and loads per circuit in excess of 750 Mw., are required for DC to prove the more economical. It would appear that this is precisely the case for the suggested trans Canada bus. A two-conductor circuit with lines operating at plus and minus 400 kv. DC could easily handle 1000 Mw. over the distances contemplated. Possibly lower voltages would be adequate. There would be no difficulty in arranging the end sections to operate on AC, if the loads at the ends were permanently lighter. There is probably no serious technical problem in the construction of such a system. Since the bus would interconnect large systems with considerable synchronous capacity, there is not likely to be much of a problem in providing the reactive kva. required for the operation of the inverters. However, costs quoted for terminal stations probably include the cost of static capacitors for this purpose. It is not suggested that an AC system might not be equally feasible but there appears to be sufficient justificiation for discussing the DC solution.

An outstanding advantage of DC for such interconnection is that it forms an asynchronous link between the systems, and provides a major measure of independence. The transfer of power to the bus, either into it, or out of it, at tapping points is easily secured by grid control or similar ignition control of the rectifiers or inverters. The entire control of loads into and out of the bus could be automatically handled in accordance with a schedule determined by suitable computers, which would continually take cognizance of the local loads and available resources.

The equipment required at a terminal station or tapping point, consisting of mercury vapour rectifiers, transformers and switchgear is expensive. There might be general agreement that for the large capacities involved an average cost of $30 per kw. would be adequate. There would be seven such taps with a total capacity of some 5 million kw.

The cost of the 800 kv. line (400 kv. to ground) would be somewhat less than the cost of an AC line of equivalent voltage class. An allowance of $50,000 per mile should be adequate for a first approximation.

The cost of the DC interconnection might thus be:

3,000 miles of line at $50,000 per mile	$150 million
7 taps totalling 5,000 Mw. at $30 per kw.	$150 million
Total	$300 million

It will be observed that this is considerably less than the investment saving estimated to be due to the reduction in plant capacity required, namely $430 million.

A better comparison may be secured in terms of annual cost. It is unlikely that the interest, depreciation and operating costs for the system would exceed the figure of 12% assumed for steam generating plants, and it might well be nearer 10%.

The total annual cost of the suggested trans-Canada interconnection may thus be of the order of $36 million compared with the estimated $88 million saving. If the net saving indicated was realized, it would amount to about a half a mill per kwh. throughout Canada.

Admittedly the estimates are crude but the margins appear sufficient to claim that an a priori case has been made, and to argue that further study is urgently required and fully justified.

It might be premature to discuss the administration of such a scheme. It is not difficult however to visualize an inter-provincial organization, co-operatively owned by the various utilities participating, which would own the facilities and buy and sell power from or to the utilities to secure their greatest advantage.

Alternatively, one can visualize the transmission line as a common carrier that would transmit, for a fee, the energy that would be bought and sold in deals between the utilities. A somewhat more orderly scheme might well be desired and would provide an interesting field for research in the organization on a national scale of the utilization of energy resources.

Acknowledgments

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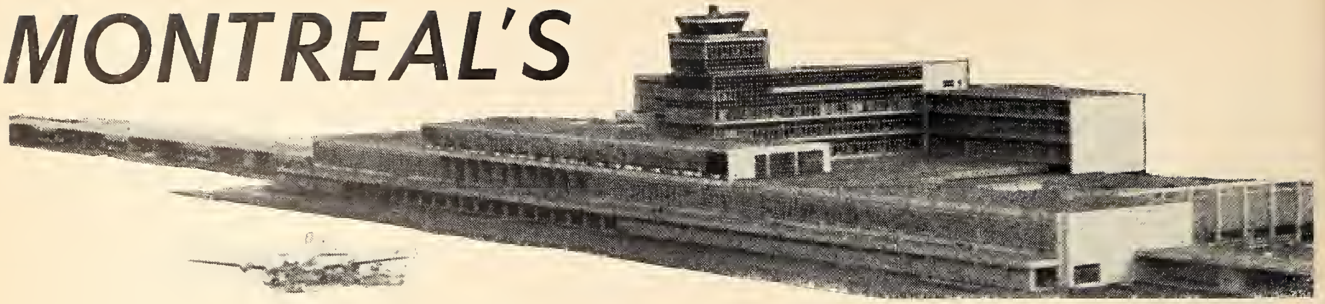
MONTREAL'S



JET AGE AIRPORT

Harold J. Connolly, M.E.I.C.,
Director, Air Services Construction Branch,
Department of Transport,
Ottawa

Montreal's Airport at Dorval was built hurriedly at the beginning of World War II. The massive rebuilding and rehabilitating job to accommodate the jet age started several years ago. The new airport was officially opened at ceremonies held in December.

THE entrance of Montreal's International Airport into the jet age is complete. After years of planning and frustration brought about by rapidly-changing needs and developments, the major new installations were opened late in 1960. These include a new terminal building, ancillary service buildings, runways and taxiways, navigational aids, refuelling systems, central heating plant, and runway and approach lighting systems.

The intent of this article is not to describe in detail, with technical data, the many aspects of the development. Rather, it is to give a broad description of what has been completed during the last five years at Dorval.

History

Before the Second World War the St. Hubert military airport was used by Trans-Canada Air Lines. TCA was incorporated in 1938 and when war was declared was operating about two flights a day with 12 passenger Lockheed aircraft. The state of war made essential a new site for civil operations, and the Montreal International Airport came into being.

Speed of construction was necessary and three runways, auxiliary taxiways and aprons complete with radio aids, runway and approach lights were built with the limited amount of engineering data available.

During this initial construction period Dorval was pressed into service as the base for the Royal Air Force Ferry Command. This shifted the emphasis from civil needs to military needs. One result was that the terminal building was inadequate despite many extensions and modifications.

Planning

Following the war the emphasis swung back to civil needs and the Department of Transport undertook a study to determine long-range needs. Included was a complete inventory of all Canadian airports to find what existing facilities could be used to meet the rapidly-increasing needs of commercial operations. Generally it was found that most facilities were obsolescent. Terminal buildings and runways were needed.

Budget considerations prompted a construction program to provide at least one heavy-duty runway at each major airport. When this phase was completed there began a phase of terminal building construction. As Montreal was one of the most important airports in Canada it was logical that runway construction should start there immediately.

Before 1939 pavement design as applied to airport construction in Canada generally paralled design methods then used by provincial Highways Departments. For aircraft with low tire pressures and which weighed less than 30,000 lb. the method was highly satisfactory. The development of heavier aircraft brought problems which could not be solved on the basis of existing information, and it was decided to seek further data.

In 1945, therefore, an intensive investigation of major airfields was undertaken by the Transport Department. The investigation, directed by Dr. N. W. McLeod, was planned to obtain data which would provide a design that would reflect more truly Canadian conditions than would the existing empirical systems.

Its primary objectives were: the making of a complete pedological soil survey including a study of the base course and subgrade materials beneath pavement structure; determination of load-carrying capacities of existing runways, taxiways and aircraft parking areas; the recommendation of a rational method for safe, economical pavement design following the evaluation of the numerous controversial designs criteria.

Thirteen airports were investigated during 1945-46. One of the fundamental conclusions indicated that the increase in load-carrying capacity provided by any given thickness of flexible base and surface varied directly with the load-supporting value of the subgrade and the pavement of the subgrade upon which it rested, provided both the bearing capacity of the subgrade and the pavement were measured at the same deflection by bearing plates of the same diameter.

This important conclusion has been approved mathematically for design purpose by the following empirical equation:

$$T. = K. \log \left(\frac{P}{S}\right)$$

In this formula, T. equals the total thickness of the pavement in inches; K. equals the base course constant; P. equals the applied load on a specific deflection; and S. equals the subgrade support at the same contact area and deflection as P.

Subsequent investigations conducted at more than 50 airports have verified the validity of this equation and have allowed constant expansion and refinements to the resultant design methods. Design and evaluation programs based on this initial research still are proceeding. This early design concept was the basis for runway construction at Dorval although increases in gross weight of aircraft and in tire pressures have been almost fivefold.

Runways

Fig. 1 shows runways already built and those proposed. The asphaltic concrete pavement now in use totals 156 acres and the portland cement concrete totals 203 acres. This is more than enough pavement to build a 24 ft. highway from Montreal to Ottawa. A storm drainage system was installed when the runways were built. This system consists of perforated pipe varying in size from 6 in. to 10 in. placed on each side of the runways and taxiways immediately below frost depth in graded granular material. Catch basins were placed at intervals of approximately 300 ft. These were connected by pipes up to 72 in. to four main drainage ditches which lead to Lake St. Louis. The amount of pipe in the system is approximately 166,000 ft.

Terminal Building

By 1955 all commercial airports in Canada had at least one runway capable of handling aircraft in use at that time, and the Transport Department turned its attention to a program of terminal building construction. The hope was that architects' plans would incorporate all known features and factors and that provision could be made for developments.

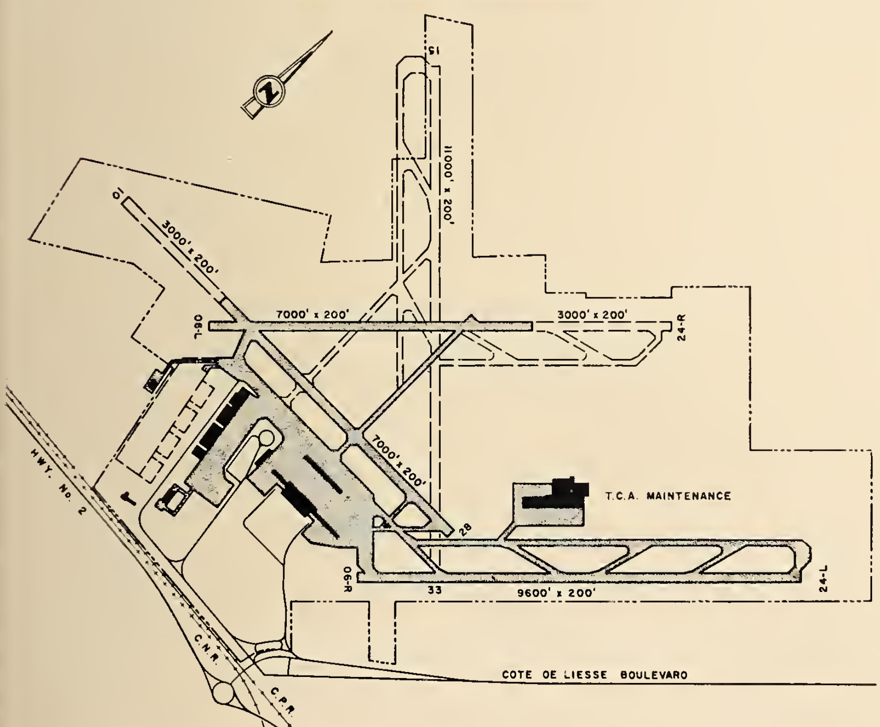
It was realized that auxiliary buildings and services would be required when the terminal building was finished. These includeed a central heating plant, power substation, control tower, navigational aids, refuelling system, water supply and sanitary sewerage lines.

Fig. 2 shows the perspective of the terminal building with the fingers and aeroquays.

The main terminal building is a rectangular, four-storey structure which rises to eight storeys in the control tower area. Two one-storey "fingers" project from each end of this main building. A one-storey aeroquay is located on the aircraft parking apron parallel to and some 600 feet from the main building to which it is connected by underground tunnels.

Total floor area exceeds 250,000 sq. ft. The principal dimensions in feet are: main building, 800 by 300; east finger, 850 by 55; west finger, 450 by 55; and aeroquay, 1160 by 55.

Fig. 1. Airport Development



All buildings have fully-developed basements. The main building encloses a large service court open from the ground floor up, and accessible to vehicular traffic by way of a tunnel through one of the end wings of the building. The main entrance is one floor up from the ground floor and is served by an elevated roadway along the face of the building.

Ice and snow will be kept from the ramp by a radiant heating system. A covered concourse runs the length of the building at ground floor level on the side bordering the aircraft parking apron.

Foundation

Soil investigations revealed a substrata of relatively level rock overlain by about 1 ft. of coarse gravel. Superimposed on this gravel is a tilted anticline of extremely hard boulder studded glacial till prevalent at the east end of the building site but running out on the gravel bed just west of the centre of the building. Laying against this glacial till at the west end of the site is a layer of marine clay. The entire area has an overlay of fine sand.

Because of these soil conditions a varied foundation design was selected. The easterly portion of the building was placed on poured concrete footings stepped in accordance with the glacial till. At the west end cast-in-place concrete piles were used for the interior columns. The outer walls were placed on poured concrete footing underlain by rock fill.

The Aeroquay and connecting tunnels were placed on "raft" foundations and the fingers varied between piling and "raft" foundation in accordance with the type of strata.

Shell and Services

The superstructure throughout is supported on steel framing. This framing follows a 20 ft. by 20 ft. modular grid in the main building and varies from these dimensions to meet the peculiar requirements of the fingers and aeroquay. More than 4000 tons of steel were used.

The outer walls are formed mainly with curtain walling sections relieved at suitable points by facings of brick, limestone and granite. All interior partitions are of fire-proof masonry except in the office areas where moveable steel partitions are used to permit maximum flexibility.

Most subflooring is of reinforced poured concrete. Exceptions are found in offices and other areas where extensive communications, telephone

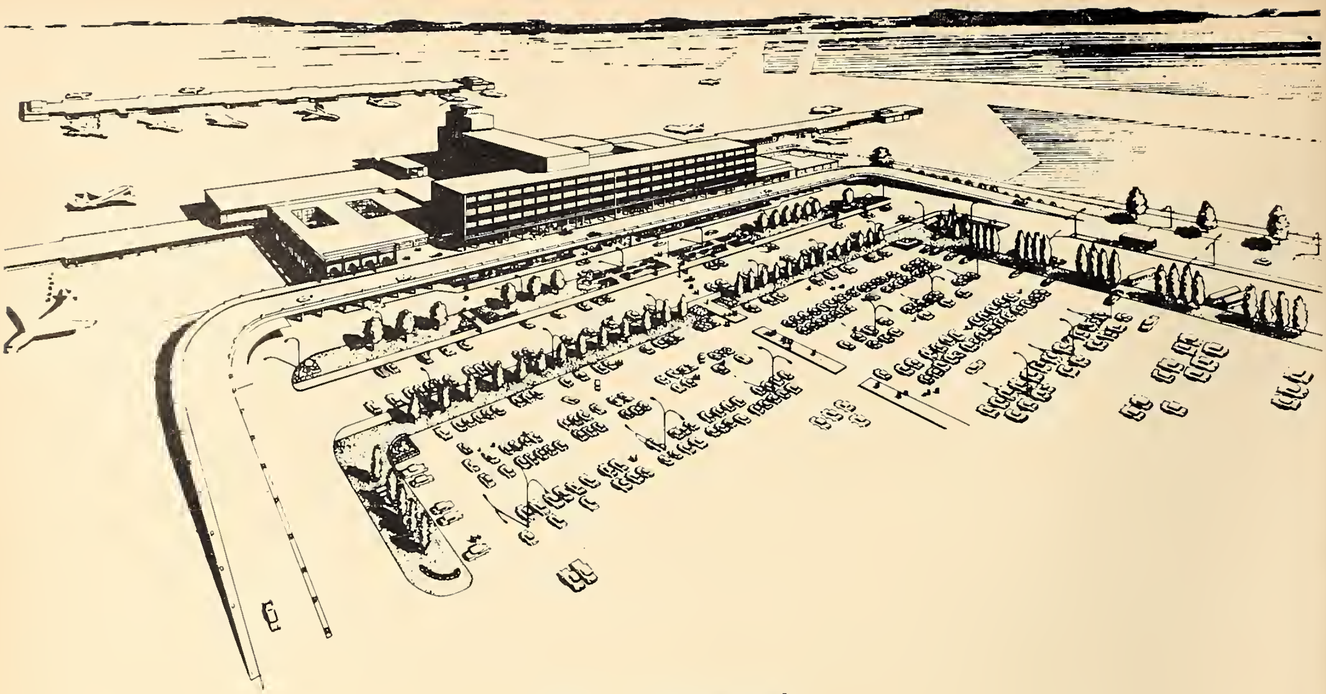


Fig. 2. Airport Terminal

and power cables are required. In these areas "Q flooring" has been used.

Pre-cast concrete is used for the main roof slab. Steel roof decking is used over office areas, aeroquay and fingers to facilitate grounding of antenna equipment. Suspended ceilings have been utilized extensively to provide concealment for ducting and to accommodate recessed lighting.

The general floor finish is terrazzo in a variety of patterns. A great variety of wall and ceiling finishes have been adopted appropriate to the use of individual sections. In the main public areas the emphasis is on the use of Italian marble.

The building is well equipped with escalator and elevator services. Special elevators are provided to accommodate wheel chairs and stretchers. Air conditioning is provided in all public areas and in all sectons where heat-producng equipment will be used. Further provision has been made for air conditioning units in rental areas, if required by the tenants.

Functions

Of necessity, the main building was designed, and construction started, before a decision had been made concerning the position of gates to serve individual aircraft. The need for a late decision was caused by rapid development in air travel.

Among the many alternates considered were long fingers projecting at right angles from each end of the main building.

The final decision, made in mid 1959, was based on established 1958 traffic of 1,077,500 inbound and outbound passengers, and an anticipated traffic density of 4 million persons in 1970. Influences were the desire to keep walking distances short while recognizing the noise factor involved in parking jet aircraft close to the main building.

The layout adopted provides a finger with seven gate positions for domestic traffic at the east end of the building. At the west end is a similar finger with four gate positions for trans-border traffic. This finger is convenient to customs inspection areas. There also is an island aeroquay with 12 gate positions for long distance foreign travel and for domestic jet flights. Each function is served by a separate passenger tunnel to the main building. The tunnel for foreign traffic leads directly to the inspection areas.

On a percentage basis, the functional space in the main building is distributed as follows: airlines ticketing, baggage handling, flight operation, 33; public areas, 35; health, immigration, and customs inspection facilities, 10; concessions, 8½; Department of Transport offices and equipment including weather, radar, radio and air traffic control facilities, 6½; rentable office space and storage, 7.

The basements of the buildings are used for mechanical, electrical and telephone equipment, and storage space. They also provide access to the basement-level tunnels connecting the aeroquay to the main building.

Primary functions of the ground floor are the complete accommodation of inbound passengers, and the handling of both inbound and outbound luggage. The first floor is designed for outbound passengers, and for the public.

The passenger accomodation on the ground floor is designed so an inbound passenger arriving from a foreign country can pass through the necessary inspection services without mingling with outbond passengers.

Of interest is the baggage pick-up system on this floor. Baggage from each flight is conveyed automatically to slowly-revolving 25 ft. turntables. The passenger claims his baggage as it moves past him and proceeds directly either to limousines parked beneath the elevated ramp which serves the floor above, or to the adjacent car parking area.

Also located on the ground floor are a well-equipped hospital, extensive cafeteria and commissary facilities for employees, and central food preparation areas to serve restaurants on the floors above and for in-flight catering.

The first floor provides the main entrance to the building from the elevated vehicular ramp served by the main entrance road. Along concourses leading to international departure points are ticket counters of more than a dozen airlines. Similarly grouped along the concourse leading to domestic departure points are the ticket counters of the various Canadian airlines.

Adjacent to these concourses are a variety of concessions including a barber shop with rentable showers, drug store, banks and flight insurance counters. Waiting rooms, a reading room and a quiet lounge extend the full length of the building overlooking the airport through a 16 ft. high wall of glass. Beyond this is an open deck for spectators.

A coffee shop, a lunch counter and a cocktail lounge also are on the first floor. Such pre-flight inspection services as necessary for international passengers are provided on this floor.

An in-transit waiting room for foreign passengers includes restaurant and refreshment facilities.

The second floor contains a spacious dining room, lounge and cocktail bar. An excellent view of the airport and the aircraft parking apron is provided through glazed walls. Extensive airlines offices are located on this floor. Succeeding floors are devoted to Departmental and rentable office space. The tower structure is designed to accomodate the Air Traffic Control functions and the complex equipment related to radio and radar.

Electric Power Supply

An electric power substation adjacent to the terminal building houses equipment for power distribution on the airport. Power requirements can be divied into three areas:

1. Normal supply of the most reliable type which can be offered by a commercial company.
2. Semi-essential supply for minimum operation and public comfort, usually achieved by manual switching operation in case of limited supply from the commercial source.
3. Emergency power for communications, air traffic control and air navigational aids during complete failure of the normal source of power. Usually this is achieved by a diesel generator unit which allows up to 25 seconds of power interruption.

The normal power supply to the terminal building is from two Quebec Hydro Electric Commission overhead transmission lines, with provision for a third line. Each is capable of delivering 8 mva. at 12 kv., 3 phase, 60 cycle. Two underground cable circuits take the power from the switching structure to the substation. For additional service reliability, each of the underground circuits is duplicated.

Each of the underground circuits terminates on a separate bus through a breaker. These two buses are interconnected through a tie breaker.

Power supply to the terminal building; is through four 3000 kva. 12 kv/575 v. transformers, to the main 600 v. secondary distribution board. This distribution board, consisting of two buses and a tie breaker between them, supplies 14 distribution centres at 575 v., located in the basement of the terminal building. Connected load for the terminal building is approximately 10 mva. with maximum demand estimated at 6 mva.

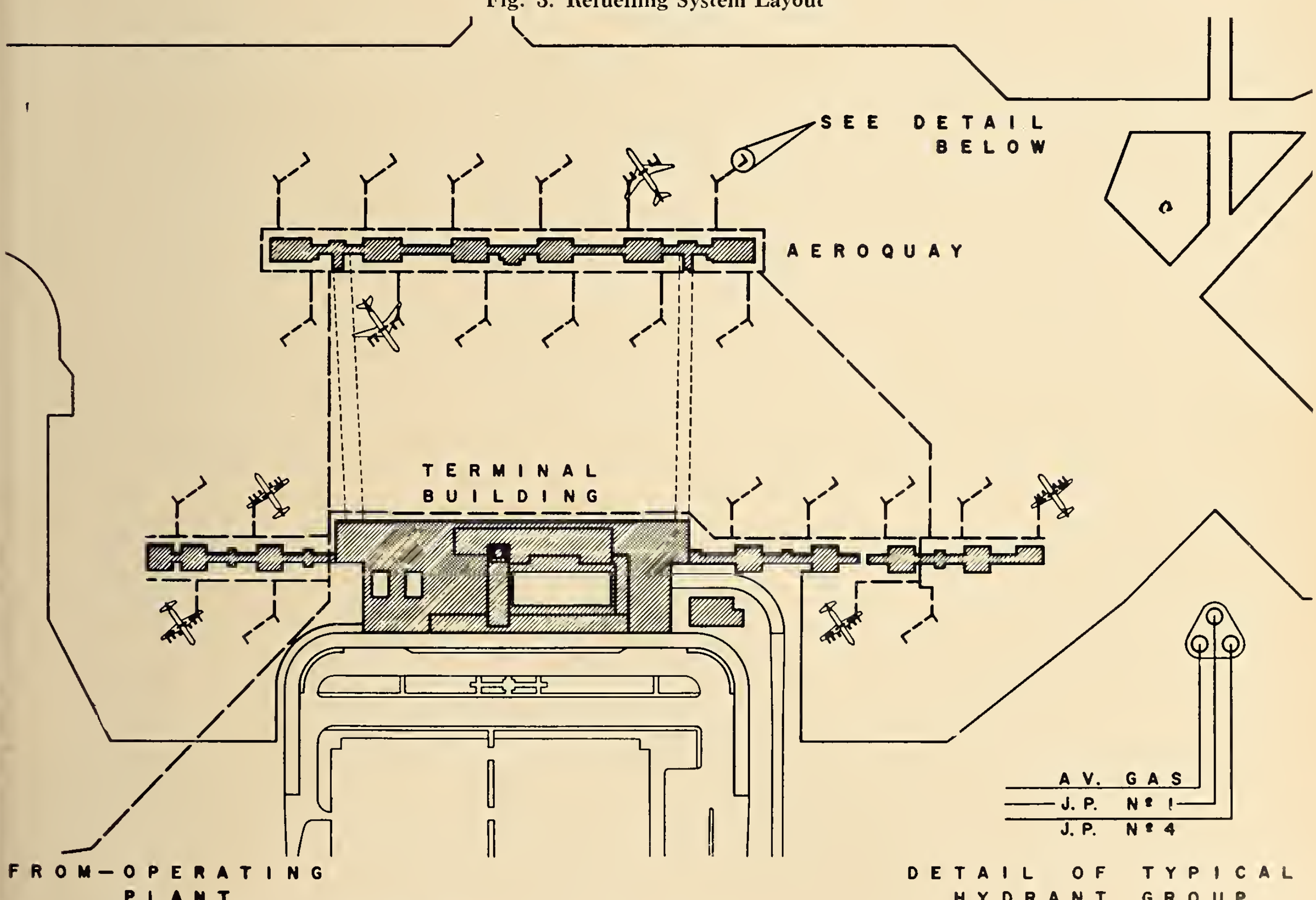
The substation is also designed to provide power to the other Department of Transport services in the area. For this purpose, two 4000 kva. 12 kv./4160 v. transformers have been provided. This circuit now provides service to the central heating plant, aeroquays and lighting for car parking area.

Power is supplied to the heating plant through two underground cable circuits at 2400/4160 v. and to two buses with an interconnecting tie breaker. A 1000 kva. distribution within the heating plant is 600 v. and 120/208 v. through various panels.

Each of the fingers and the aeroquay have a 1000 kva. substation. The substations are interconnected for alternate power supply. The distribution of power in the aeroquay and fingers is at 600 v. and 120/208 v.

The semi-essential power supply is from a separate 2000 kva. 12 Kv./575 v. transformer through a special distribution system. The cross-connec-

Fig. 3. Refuelling System Layout



tion between main secondary distribution board and this system allows power supply when commercial power supply is limited.

Emergency power supply is through a 500 kva. 12 kv./4160 v. transformer, an automatic transfer panel and a 500 kva. 4160 v./575 v. transformer to the emergency distribution system. Should the commercial power supply fail, the 500 kva. diesel-generator unit automatically would restore the power supply to emergency distribution system within 12 seconds. The cross-connection between main secondary distribution board and emergency distribution system allows the diesel-generator unit to be by-passed for maintenance on the emerbency plant and transformers. Provision is made for the establishment of a second unit.

A separate 300 kva. 600 v. diesel-generator unit installed in the heating plant allows partial supply of heat to the terminal building in case of commercial power supply failure. The switching operation and protection is from a remote control panel. All switchgear controls are operated by a 125 v. d.c. battery.

Design of the substation layout and electrical facilities was developed by the Construction Branch, Air Services, Department of Transport. (Fig. 7).

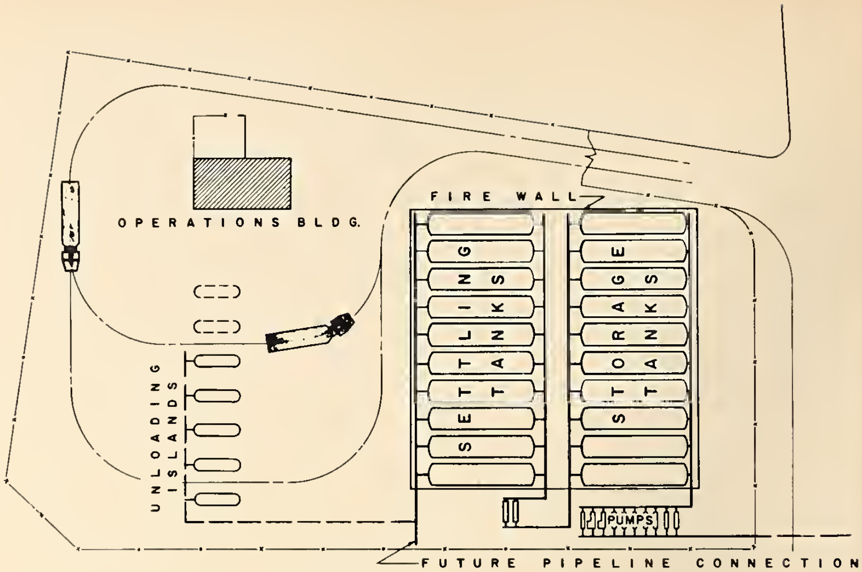


Fig. 4. Operating Plant

Heating Plant

It was decided that a central heating plant would best serve the terminal building and all other structures on the airport. The size of the plant, which is 3,808 ft. from the terminal building, was determined on the basis of ultimate development of the area.

The present summer load, which consists of heat for domestic hot water and for some kitchen services, is approximately 8 million B.t.u. per hour. The winter load is approximately 110 million B.t.u. per hour. The load for airports of this type grows at about 15% per year. A study of the available land and its probable ultimate use indicated that the final load should never exceed 300 million B.t.u. per hour.

On this basis it was decided the main heating units for the central heating plant should be two 40 million B.t.u. per hour boilers and two 70 million B.t.u. per hour boilers. Summer requirements can be accomodated by one 40 million B.t.u. boiler operating at 20% capacity. This equipment takes care of the needs for the next five years with at least 40 million B.t.u. per hour standby capacity available for emergencies. The plant can be extended to provide space for two 70 million B.t.u. per hour boilers for the ultimate load.

Studies indicated that for this installation, high temperature water would have owning and operating costs about 19% lower than a steam unit. The estimated capital cost of the steam system was approximately 17% higher than that of the high temperature water system.

The central heating plant is designed, therefore, to deliver water at 400°. Some existing heating plants could be abandoned and in these cases the equipment was replaced by steam vaporizers. These use high temperature water as the heating medium to generate the steam required. In some instances high temperature water was used in heat exchangers to heat domestic hot water on low temperature water heating systems. In the terminal building, high temperature water was used: in heating coils for air systems; in the heat exchangers for heating the anti-freeze for the snow-melting system; in heat exchangers for low temperature hot water heating systems; in heat exchangers for heating domestic hot water; and in the steam generators to provide steam at 75 p.s.i.g. where required for the kitchens and some air-conditioning services.

At 400° water will boil at a pressure of 233 p.s.i.g., and it is therefore necessary to keep the entire system pressurized above this point. At pump discharge points, pressures up to 350 p.s.i.g. are expected. This difference consists of the circulating pump heads, a margin due to elevation differences, plus the safety margin between the saturation pressure of 233 p.s.i.g. and a safe operating pressure. With the 350 p.s.i.g. maximum pressure and the 400° it is possible to use standard 300 p.s.i.g. class equipment.

The system is pressurized with a nitrogen cushion in a pressurizing tank. Nitrogen was chosen because of its non-corrosive properties. This tank has been sized to take the normal variations in water volume in the system from day to day. The larger variations found in the seasonal operation of the system are cared for by dumping the necessary volume of water into a secondary tank, and pumping back from that tank as more water is required. Therefore, the secondary tank can operate at lower pressures.

Tunnels run from the central heating plant to the new terminal building and along the road to a point near the old overseas terminal building. There are about 5,700 ft. of tunnels and approximately 2,300 ft. of buried conduit. More than 30,000 ft. of heating mains are included in the present installation.

Boilers in the central heating plant are of the gravity compensated forced circulation type. These are a variation of the forced circulation Lamont type which generally has been used on high temperature water systems. The boilers contain external downcomers from the upper headers which allow gravity circulation to take place. A much wider range of boiler capacity, without limitations in minimum flow, can be accomplished with this type of boiler.

The plant was designed to burn heavy oil and natural gas. The present competitive price of natural gas on an "interruptible rate" basis is such that gas probably will be burned for the next few years. The oil handling and storage system can use the heaviest residual oils with complete capability, but with an "interruptible gas" contract, lighter oils will be stored for use during gas interruptions. An allowance for future installation of an overhead coal bunker has been included in the design. Other provisions have been made to allow the plant to be converted, if necessary, to coal burning at some future date.

Boiler House Building

This is a structural steel frame building with corrugated insulated metal panels enclosing the upper walls. The front and sides, to a height of about 15 ft., are metal sash with opening sections, and are fully glazed. The opening sections are arranged to allow ventilation during summer. In the winter, the building is ventilated by heating units in the penthouse area. Air for combustion purposes, which also acts to ventilate the space, is introduced at high level and is drawn to the forced air fans and through the firing floor level.

The boilers are individually fitted with stub stacks which protrude to a minimum height above the roof of the building in conformity with good airport building design. A complete system of walkways and platforms provides access to all equipment above the firing floor level. All platforms are of the open grate type.

Central Heating Plant Features

a. Pumps — All water circulating, transfer, feed and booster pumps are of the vertical shaft type. They occupy less floor area and are suitable for more direct connection from the main headers located in the basement. These pumps are assembled in a row along the front of the boiler plant on a slightly depressed platform level. This allows a view from the exterior of the plant into the firing aisle, and easy observation of their operation from the firing floor level.

One of the main circulating pumps has been supplied with a variable speed motor with the speed controlled to maintain a constant differential head between the supply main and the return main at a remote point of the circulating system. This characteristic is required only during low load conditions where the reduced flow through the heating mains affects the available head at the remote points. The pressure loss through the mains is very small, thereby imposing, heavier duty on control valves at low loads to control the flow at the remote points. By reducing the available head at these remote points, the operation of the controls is improved. The speed control is electrically operated through a pneumatic electric servo mechanism.

b. Stand-By Diesel Electric Plant — A Stand-by diesel electric plant capable of operating the entire central heating plant under emergency conditions has been provided. This plant has a capacity of 300 kva.

c. Fuel Handling System — In the fuel oil handling system the oil burners are of a high pressure wide range mechanical atomizing type. In view of the high pressure required for this type of burner a two-stage oil pumping system is used to avoid excessive pressures in the oil heaters. On the oil heaters water pressure is higher than oil pressure. This avoids the serious consequences of oil leaks into the hot water system.

d. Combustion Controls and Safeguards — The burner control system consists of the normal combustion safeguards for the gas and oil firing systems. These are of the standard programming type with electronic flame detection equipment. The combustion control system on high temperature water installations differs somewhat from the orthodox "steam flow — air flow" system. In this installation the leaving water temperature controls the air flow to the burner with a correction being applied by the water flow through the boiler. The air flow, in turn, adjusts the fuel flow to the requirements of a characterized controller which has been provided with characterizing controls suitable for gas and for oil.

The entering water temperature is also measured and a B.t.u. calculating mechanism records and integrates the total heat delivered by each boiler. The water flow is also recorded on a chart which records B.t.u. flow. Other minor measurements indicated or recorded include draft conditions, exist gas temperature conditions, fuel flow and consumption, and fuel conditions.

e. Vacuum Cleaning System — The building is provided with a central vacuum cleaning system with outlets arranged for portable hoses for cleaning purposes.

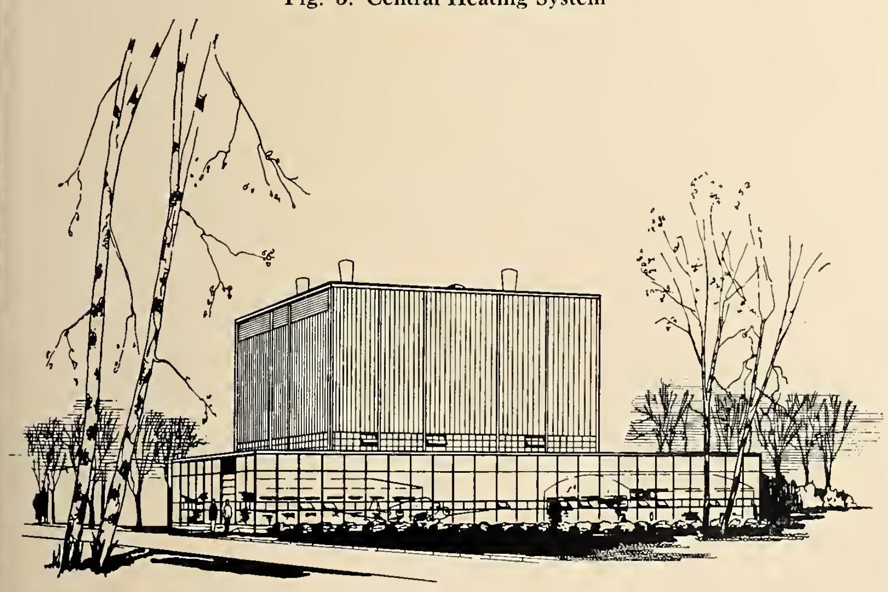
f. Workshops — A workshop has been included for maintenance and repairs of the building equipment, the distribution system and other heating equipment throughout the airport development. It includes a variety of power-operated tools and a well-stocked storeroom.

g. Water Treatment — While high temperature water plants require a minimum of water treatment, it is important that the original filling of the system and make-up to the system, which is very small, is treated properly. A water treatment plant included in the scheme provide water softeners and the equipment for the introduction of chemicals for control of oxygen and pH. The size of the plant is adequate to allow a minimum filling period, but onee the plant is in operation considerable spare capacity will be available.

Throughout the airport, high temperature water is used in many places. These include its use in vaporizers which generate steam at pressures suitable to replace the boilers which were removed. It also suits the steam requirements of new buildings. These steam systems require make-up water, and a water distribution system has been included to provide treated water to the vaporizers from the water treatment plant in the central heating plant.

h. Pipe Expansion Provisions — In the underground mains provision must be made for the normal expan-

Fig. 5. Central Heating System



sion and contraction of these lines through the range of temperatures which will exist. In the tunnels for heating mains it is normal practice to use either bellows type expansion joints or U-bends. However, it has been possible at Dorval to provide for the majority of thermal expansion in the elbows at changes in direction of the tunnel. The route of the tunnel to the new terminal building, for example, is parallel to building lines but diagonal from the location of the central heating plant to the terminal building. In this way, changes in direction of the tunnel have been co-ordinated with expansion requirements. Where this co-ordination has not been possible, and in underground conduits, U-bends have been used. An interesting feature of the tunnel piping is the support of the mains on insulated, integrally-lubricated metal plates. This allows free horizontal movement.

Hydrant Refuelling System

Modern jet airliners are voracious consumers of fuel. The modern intercontinental airliner of the DC8 or Boeing 707 class has a fuel capacity of about 20,000 imp. gal. compared with 1,900 imp. gal. for a Viscount. The large jet consumes fuel at the rate of approximately 50 gpm. at cruising speed. Refuellings for transatlantic flights average 14,000 to 16,000 imp. gal. The presence of such large quantities of fuel on the ramp in tankers is hazardous and an unnecessary obstruction to a long list of essential ground service equipment varying from baggage handling to aircraft sewage disposal wagons.

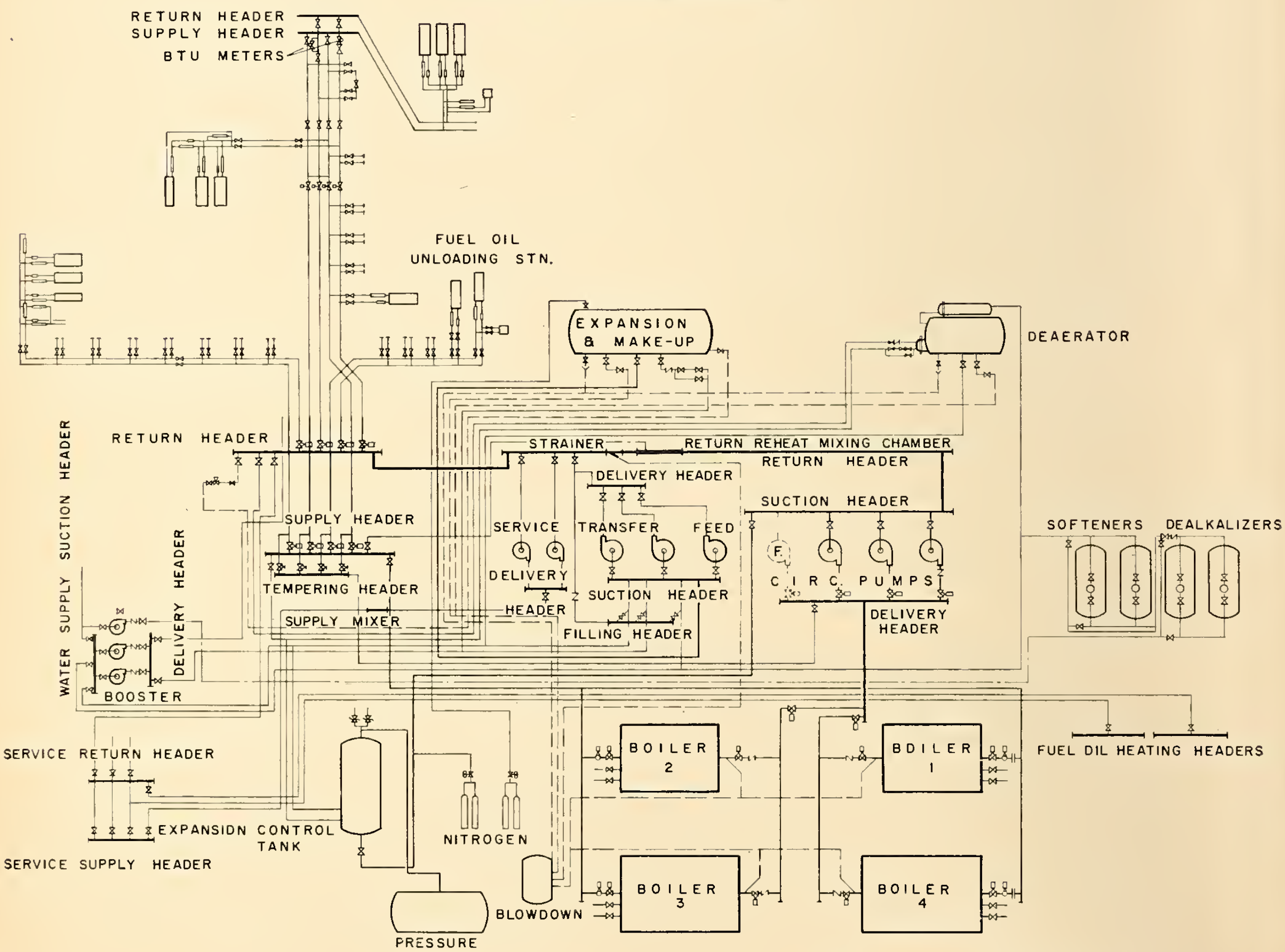
For these reasons the Department invited the major oil companies to participate in a common-usage hydrant system. Five companies expressed a willingness to make use of such a system and volunteered to supply the design and supervise the construction. The capital cost of the system was borne by the Department and ownership rests with the Crown.

The system is capable of dispensing three fuels; JP1, or kerosene; JP4, which is a wide cut distillation of kerosene; and aviation gasoline 115-145 grade. The first two turbine products can be delivered to the ramp at the rate of 2,000 igpm. which is sufficient to handle about three simultaneous refuellings. The aviation gas system will deliver 1,000 igpm. and will handle an equal or larger number of craft as the acceptance rate is lower than turbine powered aircraft. It is expected the usefulness of the third system to dispense gasoline will diminish within a few years. This third system will be used to supplement either of the existing turbine or be used for a third turbine fuel. This third fuel system can then be augmented with further pumping and attain a capacity of the two present turbine fuel systems.

The system may be divided into two distinct sections, the underground piping and the operating plant.

The under-ramp section (Fig. 3) consists generally of three 12 in. parallel pipes. Main lines from the plant and before loop supply is achieved are 16 in. At each gate, or parking position, an 8 in. lateral feeds the first hydrant and then diminishes to 6 in. for the hydrant farthest from the line. There are two groups of three outlets or hydrants at each position, each group being approximately under the wing of the aircraft. The hydrant valve is located in a 14 in. round box top of which is level with the apron. The box is covered when not in use. Within the box

Fig. 6. Central Heating System



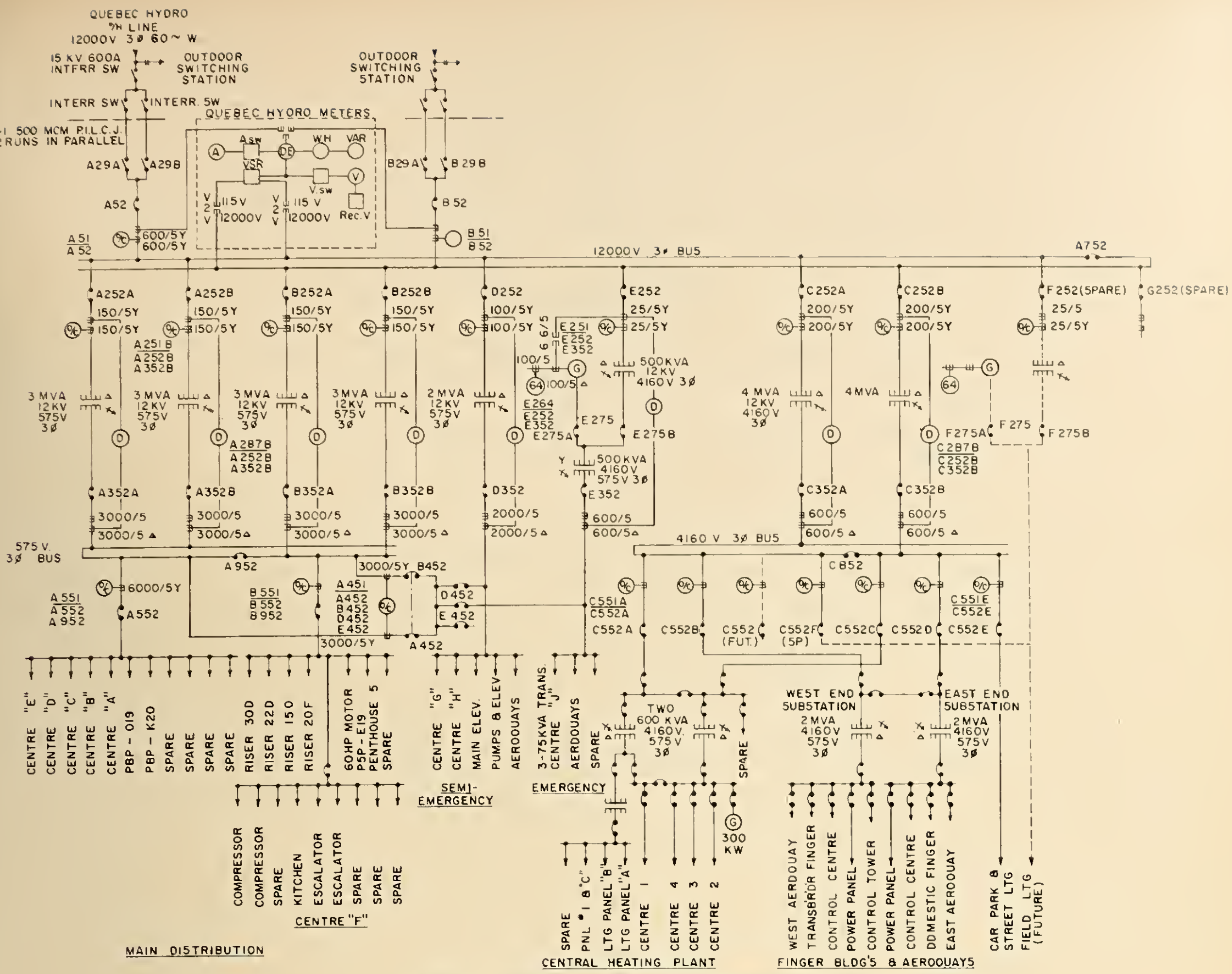


Fig. 7. Substation schematic diagram

there is a 4 in. hydrant valve, especially developed for this project. The largest size available prior to this development was 2½ in. The hydrant valve is operated by an air cylinder with remote "dead man" control which can be carried to the fuelling part of the plane by the operator. The valve has a bayonet-like top which will only accept hose of the correct hydrant cart and the dispensing hoses of the cart are similarly distinctive and can only be connected to a plane requiring that type of fuel.

Two hydrant carts are required for refuelling large jets of the DC8 or Boeing 707 type. These are positioned slightly forward of the leading edge of the wing. The hydrant cart is a short chassis truck and consists essentially of a filter, pressure relief valve, metres, piping and hoses. The 4 in. hose which connects to the hydrant is carried on a power operated reel on the truck. The 4 in. supply is then divided into two 2½ in. streams within the hydrant cart, each hose being connected to one of the two outlets in each wing. The 4 in. and 2½ in. end connectors on the hoses are self-sealing when disconnected, keeping the hydrant cart and hoses filled with fuel at all time.

A 4 in. butterfly isolation valve installed under each hydrant valve permits removal of any hydrant valve without interrupting service to any other hydrant.

All underground piping was wrapped with polyethylene tape and is cathodically protected with magnesium anodes. As the majority of the piping will be subject to full aircraft loading, backfilling was to 95% Proctor.

All laterals were graded downward to the mains and the mains are grated to low points, from which fuel can be removed by opening a valve on top of a vertical pipe or riser. This provision allows the removal of water or other contaminate. Minimum cover was set at 4 ft. at the hydrants, the balance of the piping is around 7-8 ft. deep and maximum cover is about 12 ft. Fluid flow will be about 3 f.p.s. at ultimate development of plant. Mains may be extended to serve additional gate positions should the aeroquay or fingers need additions.

The operating plant is located approximately 1,000 ft. from the terminal building. The plant (Fig. 4) is composed of unloading island, storage tanks, pumps and filtering equipment and a small operations building. The incoming fuel is removed from automotive tankers at the rate of 300 igpm. through a filter separator to a bank of settling tanks. Not less than 12 hours after the last delivery to the tank the fuel is transferred and again filtered to a bank of storage tanks. The fuel then is available for use. Fuel is removed from all tanks through floating suctions to insure cleanliness.

Once the fuel has entered the main pumping system it is under constant pressure (95 p.s.i. at the plant) out to the apron outlets. Withdrawal of fuel and the accompanying pressure drop actuates pumping. Rate of flow through instrumentation controls from one to four pumps (500 igpm. each) giving constant pressure over the entire range up to 2,000 igpm. in both ascending and descending order.

The plant can be expanded in any increment up to double its initial capacity with minimum interference to operations. The headers were designed so that any tank or pump can be connected to each of the three systems. EIC

Discussion

MORAN DAM AND THE FRASER RIVER

R. E. Potter, M.E.I.C.,
Consulting Engineer,
Victoria, B.C.
The Engineering Journal, December 1960, page 43.

Discussion by Mr. J. K. Sexton, M.E.I.C.

Mr. Potter is to be congratulated on having presented such a forceful picture of the "Fish versus Power" problem in British Columbia. It comes as a surprise to learn that almost 15 million kw out of an estimated total of 22 million kw of firm hydro potential will be lost to the Province if no power dams are allowed on salmon rivers.

(From the context it would appear that the term firm kw, indicates continuous kw of primary power.) This is indeed an enormous quantity of hydro potential to be eliminated from the nation's resources, and its loss will eventually attract widespread attention — even in a part of the country as well endowed with hydro resources as British Columbia. Surely a compromise must be found to permit the development of these resources to the best advantage of the community. Just as at Niagara where the conflict between power and aesthetic considerations has been so successfully solved, we must expect a solution to be found for the "Fish versus Power" problem of British Columbia.

As for the Fraser River, it is interesting to note that of the three alternative hydro schemes outlined by the Fraser River Board two contemplate the development of the total head by a number of dams of moderate height whereas one would combine several of these steps into a single dam at Moran with a record height of 720 feet. The company referred to by Mr. Potter has selected the Moran Dam alternative and raised its proposed height to 740 feet. This would result in a structure probably larger than any dam built to date, and the problem of financing such an undertaking to supply power to the Pacific Coast area would no doubt be very great. The time necessary for the construction of the project has not been mentioned by Mr. Potter but its size would indicate a period of say six to eight years. During all this time a large investment would be tied up. In 1956 Dr. J. L. Savage estimated the total cost at $512 million, and one wonders if this estimate made allowance for the interest charges that would be accumulated during such a long construction period.

There would also be the problem of finding a market big enough to absorb the output from the Moran Dam development after it were completed. Otherwise there would be a further accumulation of interest charges to add to capital costs, until the project could be fully utilized. Since the development would be one of the largest ever undertaken by private enterprise no doubt such financial considerations have received careful study, and it would be interesting to have Mr. Potter's comments on them.

Discussion by R. C. McMordie, M.E.I.C.

The author has outlined the problems facing early development of the power potential of the Fraser River in a manner compatible with maintaining existing anadromous fish runs. Based on the current status of fishery science, the author reaches the conclusion that, for early development, the river could support either fish or power, but not both. He supports the case for power.

Preliminary studies of potential hydro power sources in British Columbia indicate that, if the fish problem on the Fraser River System did not exist, the economic attractiveness of the power potential of this river is second only to that of the downstream benefits to be obtained by the development of Columbia River Storages. There can be little doubt that but for this fish problem, development of the Fraser sites would already be well under way, providing not only low cost power but also affording much needed flood protection.

With studies on some 11,000,000 kw of power potential already in progress on the Columbia, Clearwater, and Peace Rivers, none encumbered by fish problems, the development of the Fraser River sites, highly attractive as they are, could be deferred for some time. In the meantime, current fishery study is gradually accumulating basic research data and developing methods for transporting fish runs over dams or providing possible alternative solutions. The problem is complicated by the international aspect of interference with existing fish runs.

British Columbia is a young province with a vast potential of undeveloped natural resources. It has not yet reached the stage in its industrial growth where a sufficient proportion of diversified secondary industries has been established. Also, labour costs in the presently predominant primary industries are high relative to those in the rest of Canada. The availability of vast reserves of low cost power judiciously programmed, will do much to alleviate this imbalance which could tend to retard British Columbia's future expansion.

As a river with one of the largest remaining undeveloped power potentials on the continent, the Fraser must play an important role in the future of the province.

This paper serves to further focus attention on the unique power situation in British Columbia. It forcibly

(Continued on page 96)

Automation and Control Engineering in Canada

Conversion of the Jim Gray Hydro-Electric Plant

P. Kubilius, M.E.I.C.
Montreal Engineering Co. Ltd., Montreal

THE JIM GRAY hydro-electric plant was commissioned in 1953 as a manually-operated 60,000 kva. station of the system of Price Brothers and Company, Limited. In June, 1960, it became the first hydro-electric station in Quebec Province to be converted from manual to automatic radio control. It now is completely a remotely-operated station. It takes its commands from, and sends its conditions and information to a control centre in Kenogami, some 20 miles to the south. The transmission of the operating and telemetering data is accomplished by means of VHF broad band radio signals.

Four hydro-electric plants are owned and operated by Price Brothers and Company on the Shipshaw River in Central Quebec. They are the Jim Gray, the Adam Cunningham (7,500 kva.), Chute - aux - Galets (10,000 kva.), and Murdock-Wilson (70,000 kva.). Jim Gray is a double-unit plant, with each 30,000 kva. unit generating at 13.8 kv. 60 cycles and running at 277 r.p.m. under a head of 338 ft. The turbine is a Francis type waterwheel with a Woodward "A3" governor. The generator is equipped with a type "BJ" voltage regulator.

Chute-aux-Galets, the oldest of the three other plants, was commissioned as a manually-controlled plant in 1921 and still is operated manually. In 1953 the Adam Cunningham plant was built some three miles from Chute-aux-Galets and is under supervisory remote control from Chute-aux-Galets. Transmission of data is via a telephone cable. The Murdock-Wilson plant was added in 1957 and is under supervisory remote control from Kenogami with transmission via telephone cable. (Fig. 1).

Early in 1959 engineers began investigating the possibilities of converting the Jim Gray station from manual to remote automatic control. Two alternatives were studied for the power link between Jim Gray and Kenogami: power line carrier and VHF radio. The studies indicated that for equivalent installed cost, the VHF space radio with broad band capacities yielded a system which was more flexible, and which lent itself to more additional channels than the carrier. It was decided, therefore, that, if feasible, VHF space radio would be the means of communication. In April 1959, field tests proved the radio link was practical for remote control and telemetering. Following the tests it was decided the program would be started, with the Jim Gray plant as the first to be converted.

Economic Considerations

The plant was converted to reduce its operating cost. It was operated manually by eight men, two per shift. One man was the switchboard operator whose duties were confined mainly to the control room and generator floor. His helper operated the auxiliary equipment and supervised the operation of the mechanical equipment. Even though this plant was essentially manual, certain functions, such as synchronization, speed control, and centralization of some alarms were done automatically. This partial automation had already reduced the per-shift operating staff from three to two.

Price Brothers has a "roving" operator who visits the remote controlled plants for routine inspection. This "roving" operator now includes the Jim Gray in his rounds. The effect of total automation was the reduction in plant staff from eight to nil.

At a nominal $5,000 per annum per man, the operating cost will be reduced by about $40,000, with a capital expenditure of $80,000. The $40,000 annual saving is somewhat of a simplification. Plant operation costs such as housing, especially in remote areas, might easily exceed the actual labor cost. However, the initiation of such a program requires the upgrading and training of present personnel. There will be added costs involved in personnel turn-over to replace the existing staff, and to train new recruits. The likelihood of a costlier man/year is evident because of the need for men with increased technical abilities.

Automatic Controls and Protection

The main components to be controlled in the Jim Gray plant are shown in Fig. 2. To facilitate the remote control it was necessary to re-arrange the control and protection schemes. So the right maintenance personnel can be alerted in case of trouble, and so they can be provided with the necessary intelligence with a minimum number of indications, several protective functions are grouped for a single indication. (Fig. 3). The groups are:

- Non-lockout shutdown — Generator 1 & 2
- Lockout shutdown — Generator 1 & 2
- Transformer breaker trip 1 & 2
- Transformer alarms 1 & 2
- Urgent alarms
- Non-urgent alarms

The schematic drawing in Fig. 3 shows all protective gear and tripping and alarm points. The protective devices are shown in Fig. 2 and are described in Fig. 3. It was necessary to add a generator automatic control board consisting of three free standing panels complete with annunciator, speed matcher and auxiliary relays for automatic remote control of generators and associated equipment.

Supervisory, Signalling and Telemetering Equipment

The generators and auxiliary equipment are operated remotely under normal conditions but may be transferred to "local automatic" or "local manual" control by a transfer switch. There is one transfer switch for each unit and one for the station service and auxiliaries. The operator can call for: 1. generator start, stop; 2. close and trip the breakers (synchronizing is done automatically); 3. adjust loading; 4. raise, lower voltage.

In addition to the alarms shown on Fig. 3, the operator at the remote control centre is provided with indications of all breaker and butterfly valve positions, governor load limit, governor load, voltage adjustment rheostat travel limits, as well as master transfer switch position indications.

Circuitry

The remote control system used for this plant is of the frequency code type. Individual push buttons are provided for the necessary operations. Operate sequencies are transmitted and received by frequency shift equipment. When an operation is called for, the signal divider will operate the selected relays which key the frequency shift transmitter and an operating sequence of four radio tones is transmitted to the remote station. At the remote station, these tones are in turn detected by the frequency shift receivers. The sequence selector relay contacts energize the interposing relays. The latter contacts close and operate the device selected.

Immediate indications confirming operations such as air circuit breaker's closure while the push button is depressed, are obtained by transmitting a signal according to the position of the device. At the control centre, the decoding relays connected to the output of the frequency shift receiver operates the lamp selective relay. Contacts on the latter change the lamp configuration and confirm the completion of the operation.

The alarms at the remote station initiate an indication check cycle. During this cycle the position of each supervised device is checked and the control panel lamps are illuminated accordingly. For each alarm there is an interposing relay. A contact on these relays initiates driving of the stepping switch and keys the frequency shift transmitter. A signal is transmitted for each step. At the control centre this signal is decoded by the frequency shift receiver, which in turn drives the stepping switch and also picks up and drops out the interposing relays, controlling lamps. When an indication check cycle reports a trouble, it calls the attention of the operator by:

1. Illumination of a lamp.
2. Sounding of an alarm.
3. A change of lamp on the appropriate escutcheon.

A lamp will indicate which device operated to initiate the check (alarm). A push-button also is provided at the control centre for the supervisory station check.

Frequency shift equipment is used for the transmission of supervisory control impulses and telemetering signals over the VHF space radio. The transmitters located at the control centre are keyed by relays and a sequence of audio tones is transmitted. At the remote station these tones are detected by the frequency shift receivers and operate the designated relays.

The following operating frequencies for frequency shift equipment are used:

2295) CPS — signalling transmitter for supervisory control at Kenogami
and
2465) CPS — signalling receiver for supervisory control at Jim Gray
2635 CPS — Signalling receiver for indications at Kenogami
2635) CPS — Signalling transmitter for indications at Jim Gray
2805) CPS — Signalling receiver for telemetering at Kenogami
2975) CPS — and
3145) CPS — Signalling transmitter for telemetering at Jim Gray.

Fig. 1

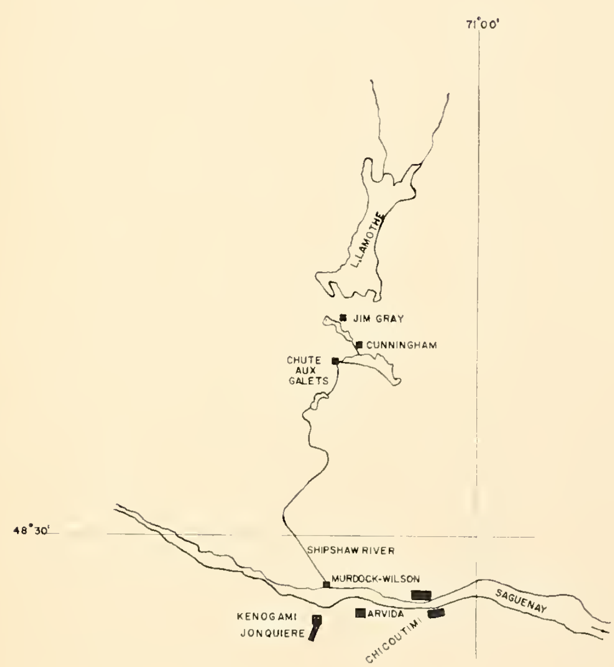
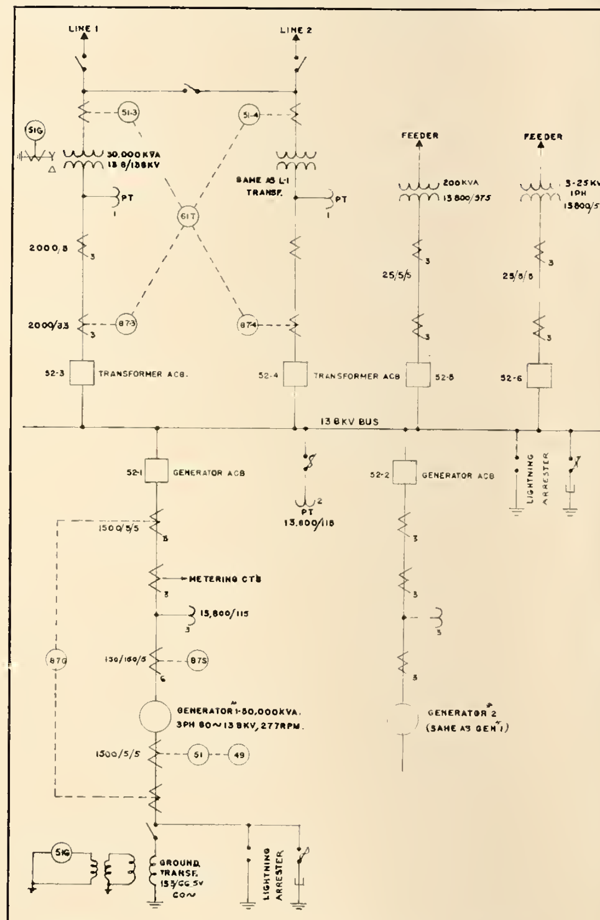


Fig. 2 (right)



Telemetering is of time-ratio principle. The transmitter converts the electrical values being measured into evenly spaced signals, the duration of which depends upon quantity to be measured. These signals are transmitted at the rate of 300 impulses per minute. They key the frequency shift transmitter and at the control centre this intelligence is detected by the frequency shift receiver which in turn operates the telemeter receiver. The telemeter receivers decode this intelligence, convert it into a direct current which varies in magnitude from zero to one ma., according to the signal duration. The receiver is connected to a standard 0-1 MA DC instrument. The receivers indicate 99% of full scale readings in less than 3 seconds.

Megawatts are transmitted continuously for each generator. Ten "as called for" telemeter functions are provided:

governor gate position (unit 1 & 2)
governor gate limit (unit 1 & 2)
exciter field current (unit 1 & 2)
megavars (unit 1 & 2)
forbay elevation and bus voltage.

Synchronizing

With the transfer switch in the "manual" position, the breakers will be closed from the plant, after synchronizing across them. With the transfer switch in the "local automatic" or "remote automatic" position the operator may call for either of the two generator breakers to close in any order. The breakers will close only if the generator is running at speed-no-load and preset voltage. The closing of the breaker(s) will take place under control of the automatic synchronizer in conjunction with speed matcher as well as synchronizing check and voltage selecting relays. The synchronizer will be bypassed when either or both sides of breaker(s) is/are dead. An interlocking system has been arranged so that only one breaker can be synchronized at a time.

Closure of the generator breaker will cause the governor partial shutdown solenoid to be energized through auxiliary contacts on the generator breaker. This will allow the gates to open beyond the "speed-no-load" position, thus the unit can take on load. It should be noted that when the generator breaker is tripped, the governor partial shut-down solenoid will be de-energized thus causing the wicket gates to be brought back to the "speed-no-load" position.

Radio and ancillaries

The radio relay transmitter is used for transmission of control, indication and telemetering signals between the Jim Gray plant and the control centre at Kenogami. The radio is a FM unit for operation on frequencies 162.09 MC to Jim Gray and 168.75 MC to Kenogami. It uses eight tubes with 12 tuned circuits. The r-f output of this unit is 40 W. minimum, continuous duty. However, the Department of Transport has asked for reduction to 20 W. The radio relay receiver is for FM reception on frequencies 168.75 MC from Kenogami and 162.09 MC from Jim Gray, with 19 tuned circuits.

The 45 ft. antenna structures have been erected at the Kenogami site and Jim Gray generating plant, complete with six element yagi antennae, one for operation on each of the following frequencies — 168.75 MC & 162.09 MC.

Because the station service voltage varies between 110 and 104 v. depending on the system loading, it was necessary to supply two constant voltage transformers, giving single phase output voltage within plus or minus 1% of 118 v. when operating under exacting conditions.

An automatic change-over panel was supplied to provide a stand-by power for the VHF radio equipment when the 115 v. lph 60 cycle station service power fails. A DC convertor, driven from the supervisory lead battery, will supply the emergency AC power to the radio.

Governor pressure system and auxiliaries

Originally the governor was operated manually. It had only one solenoid which when de-energized initiated a complete shut-down of the unit. To allow full automation it was necessary to add:

speed matching (load adjusting) motor
gate limit motor
gate position switches
speed switches
creep signal transmitter
generator brake valves and control.

Also it was necessary to add a partial shut-down solenoid which when de-energized closes the gates to a partial gate opening. To start the unit, the master control relay energizes the complete shut-down solenoid (provided the butterfly valve is completely open), allowing the wicket gates to open to a limit set by the partial shut-down solenoid. As the unit comes to speed-no-load, the breaker closes and its auxiliary contact energizes the partial shut-down solenoid, allowing load to be picked up on the unit.

To ensure that the governor pressure system is in operating condition it was necessary to add oil level switches for alarms and low pressure switch for tripping of the unit.

Butterfly valve control

The butterfly valve was manually operated. Due to the wear on the waterwheel wicket gates, the water leakage was sufficient to maintain a unit speed too high for continuous brake application. The valve closure was made automatic with each shutdown and the leakage was reduced, thus permitting the generator brake application at a lower speed. The field tests have shown that the butterfly valves will open against full unbalanced penstock pressure. Therefore, it was not necessary to motorize their by-pass valves. The opening of the butterfly valve is incorporated in

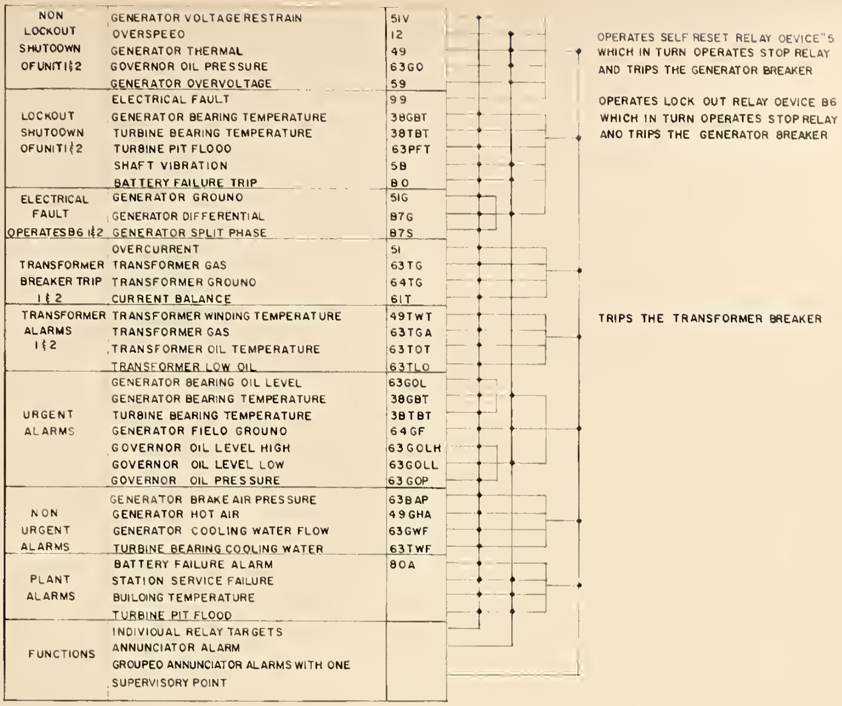


Fig. 3

the automatic starting sequence and is initiated by the master control relay.

Battery and charger

In addition to the existing lead acid, 60-cell control battery in the plant, a second lead acid supervisory 60-cell battery was supplied, complete with an automatic battery charger. Normally this battery supplies power to the supervisory equipment. In an emergency case it will supply the AC power for the VHF radio equipment through a DC-AC convertor.

Generator braking

Each generator has been supplied with a set of compressed air operated brakes. The brakes were applied manually, by means of a valve located on the generator floor. An additional electrically operated valve, timer and auxiliary relay have been supplied for each unit to provide an automatic braking cycle. The brakes will stop the generator in approximately 40 seconds with the gates closed and hold the rotor against turning. It is assumed that the field is left excited and utilizing the core loss and windage to reduce the speed to 25% of synchronous speed before the brakes are applied. Experience has shown that continuous application of the brakes at low speeds is more effective and causes less wear on the brake shoes and track than intermittent application at higher speeds. It was decided to apply brakes at 77 r.p.m. In case of emergency it might be desirable to apply the brakes continuously until the generator stops. But even then the length of time will not be considerably prolonged if the brakes are applied at 15% or 25% of synchronous speed. The continuous brake application simplified the brake control scheme. It was sufficient to add time delay and auxiliary relays to provide the required sequence. (Fig. 4). During the normal operation (the unit is running), auxiliary relay 20TX is energized and its contact 1-2 is closed. The transfer switch is on "automatic". As soon as the unit reaches 25% of synchronous speed, zero gate position (33-1 closes) and the generator breaker trips (52-b closes), the braking cycle commences. After a preset time interval, say 5 min., the time delay relay is de-energized and subsequently the auxiliary relay drops, thus the braking cycle is complete (solenoid 20 is de-energized).

After the generator has been stopped by the brakes, the oil film gradually squeezes out from between the rotating member of the thrust bearing and its stationary elements. After, say, 5 min. the brakes are released, since the friction exerted by the pressure on the thrust bearing is up to five times that obtained from the brakes. It is worthy of note that when the brakes were applied manually some smoke was produced (it means that the operator, though applying the brakes intermittently, commenced to apply them at too high speed). On the automatic brake application, the units were stopped very smoothly, without a trace of smoke.

Field Experience

Because of the already existing remote controlled hydro-electric plants in their system, Price Brothers was fortunate to have adequately trained personnel ready to take over the problems of Jim Gray. Some of their men were given special technical training which included technical courses, visits to various manufacturers to witness fabrication and testing of the various components.

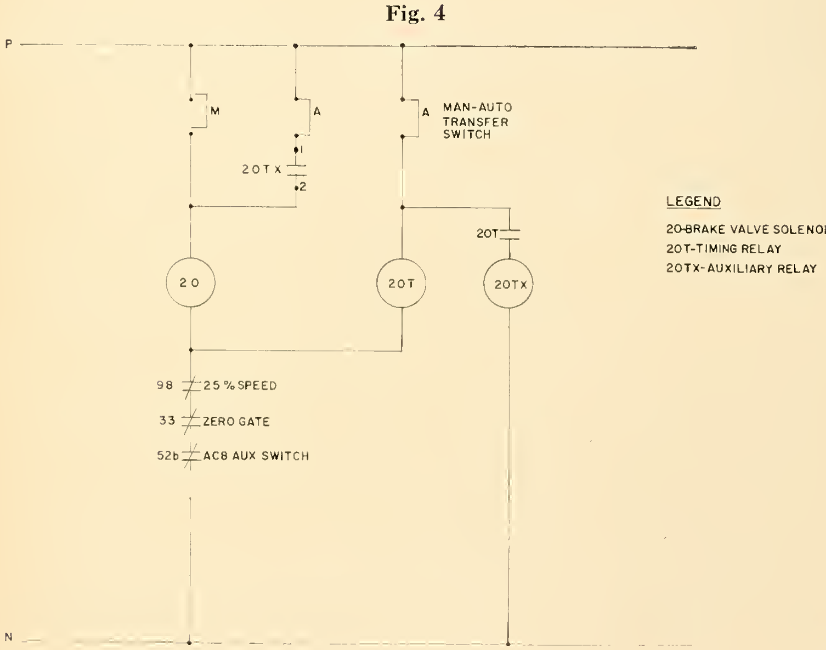
The revision of all wiring diagrams and the programming of the change-over was carried out in the field by the staff of Price Brothers with the assistance of a field engineer from the consultants.

It is worthy to note that the company engineers showed a great interest in this automation and the technicians devoted most of their time (working a seven-day week) and energy in performing the installation and wiring of the additional equipment.

The conversion to automatic took three months of the field work, starting in March, 1960. The modification of some 50 drawings, redrawing and preparation of interconnection diagrams took two months. The installation of all additional equipment and wiring, some of which had to be done while the units were stopped (scheduled weekend shut-down) took the additional month. There were four technicians on the job and four tradesmen available on a "call basis" who installed some 8,000 ft. of single conductor cable and made approximately 5,000 connections. When all additional equipment was installed and wired and all interconnections made the actual change-over from manual to remote automatic control was done during two weekends and involved no loss of production.

It is fully expected, that as time goes on more experience is gained in the operation and maintenance of remotely controlled plants, the Price Brothers system will eventually become fully controlled from the control centre in Kenogami. The ultimate phase, would, of course, be the installation of an automatic dispatching system. This system would control generation to match demand and select the combination of generators and the capacities at which they should operate to result in the most economical generation and transmission.

Fig. 4



Acknowledgements

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Canadian Developments

The Department of Public Works is making increasing use of hydraulic models as a planning aid for construction work on harbors and rivers. Models eliminate guess work in such construction and their use results in large financial savings and in increased efficiency of the installations. This article, prepared by Major-General H. A. Young, Deputy Minister of Public Works, outlines briefly the history of hydraulic models and the use being made by the Department of these studies.

Some 25 years ago in Rangoon, Burma, a huge sandbar was being formed by the movement of tides across the harbor mouth and threatening to block navigation. The British Government was about to spend several million pounds to have the sandbar removed, but decided before doing so to set up a miniature hydraulic model of the harbor to study the causes of the disturbance. Engineers found that the model showed that the same winds and tides which had caused the sandbar to form would also cause it to disappear in a few years. They decided on a period of "masterful inactivity" during which the sandbar disappeared as predicted, resulting in a great saving in public funds.

This example has become a bit of a classic to engineers of the Department of Public Works involved in hydraulic model studies which, in the past few years, have saved the country millions of dollars in dredging and other maintenance and construction costs.

The hydraulic scale models in the laboratory reproduce in miniature the harbor channels and river beds as they exist in nature. Then the water is allowed to flow and the waves are generated artificially with the result that years are telescoped into hours and miles reduced to inches. The behavior of a mighty river at full flow and shoal conditions far in the future can be predicted. Many complicated questions involving the action of water can be answered. The hydraulic model has become an accepted and necessary part of marine developments.

One of the largest models to be used by the Department is the model of the Fraser River-Delta below New Westminster, B.C. Between 1949 and 1954, the cost of maintaining the navigation channel through the Delta was running between $700,000 and $900,000 per year. In the last few years, expenditures have not been above $500,000 per year and have been as low as $300,000. The model has also made savings possible in the cost of work other than dredging. It has assisted in making improvements such as in the design and location of protection walls and other marine structures.

The first and largest model study of a harbor construction project undertaken by the Department, was begun in 1955 for Port aux Basques, Nfld. Port aux Basques is situated at the southwestern tip of Newfoundland and is the island terminus of the C.N.R.'s connecting service maintained by ferry between there and North Sydney, N.S. Following the Confederation with Canada in 1949, a larger ferry than was used previously, was built and new harbor structures were erected. With the completion of the ship and harbor terminal, it was found necessary to provide additional protection for the berthing area. Even moored at the quay side the big ships would pitch and toss dangerously during stormy weather. A reduction in the residual waves at the ferry dock was necessary. These waves resulted from frequent and severe storm action outside the harbor and, since there was no natural protection, the waves caused extremely rough water at quay side.

A further consideration was that the protecting structures had to be built so as not to affect the old terminal still being used by smaller ships. Also, the positioning of the breakwaters had to be such as to leave an approach channel for the ferry, the "William Carson".

Facing these problems, the Department of Public Works had a complete model of the harbor, to a scale of 1 to 128, built by the Hydraulic Dynamics Section of the National Research Council in Ottawa. An exact prototype of the ferry vessel was built to the same scale as the model. Many miniature breakwaters were tried out in different locations until it was found which offered the best protection. This was done by

Model of Chandler harbor on the southeast coast of Gaspé Bay. Various types of breakwaters are tested to provide protection for structures against rough water.

subjecting the various proposals to simulated gale and storm conditions of various intensities in the laboratory.

As a result, the Department in 1959 completed the construction of breakwaters which fulfilled all the predictions of the model and provided the inner harbor at Port aux Basques with good protection. The model study for Port aux Basques was the key to the solution of this most difficult harbor problem, and the right answers were found, thanks to a scale model half the size of a hockey rink.

Public Works engineers are most enthusiastic about a hydraulic model study carried out in co-operation with the National Research Council for the harbor at Dingwall, N.S. A model was designed which in effect, did its own maintenance dredging — the miniature breakwaters and other structures were so designed that the resulting action of the water kept the harbor model free of sand and silt. If the harbor is built according to the model and if the predictions turn out to be accurate, the saving to the taxpayer will be considerable. In the past five years, maintenance dredging for Dingwall has cost the Department an average of $55,000 a year in addition to large dredging expenditures by private firms.

The Department hopes to bring about more savings as the result of a new model on which construction is just beginning at Queen's University in Kingston. It is a model of the harbor and approaches at Cobourg, Ont. It can easily be redesigned into a miniature of other ports on Lake Ontario or Lake Erie. It is hoped the new model will form the basis of a study which will enable marine structures to be designed to greatly reduce siltation problems which are affecting the ports and harbors of the two lakes.

A study was made of the harbor at Chandler, Que., on the south-east coast of the Gaspe peninsula. This location was exposed to wave action from the open sea and there was inadequate protection for existing harbour structures. At Glace Bay, N.S., another harbor problem was studied by the Hydraulic Dynamics Section of the National Research Council for the Department of Public Works. Glace Bay harbor is used largely for fishing and the problem is to cut down the action of waves in the inner harbor.

Another study was carried out for the port of Baie Comeau on the north shore of the St. Lawrence in Quebec. Baie Comeau is one of the rapidly growing North Shore industrial communities, which taken as a whole, represents one of Canada's more important industrial developments. The harbor problem there involved a study of several miles of shoreline, which was necessary for the planning of extensions to harbor facilities.

Other studies undertaken were for small harbors at Etang du Cap, Que., Ingall's Head, N.B., Lunenburg, N.S., Kingsville, Ont., and Lockesport, N.S.

A model study now under construction by the National Research Council for the Department of Public Works is of a different nature. The problem is at Rustico, P.E.I. where consideration is being given to construction of a bridge over Rustico Bay as part of the Gulf Shore Road. The main problem here is to prevent damages by beach erosion to sections of the highway and the approaches to the bridge. The Gulf Shore Road runs through P.E.I. National Park where highway construction is entirely a Federal responsibility.

The use of hydraulic models is exerting a continuous and growing influence on harbours and rivers construction work in Canada. This is as it should be, because there is no doubt that the influence is a good one. Before the introduction of model studies, the design of structures was based more on trial and error, and in harbor projects which are often large, even minor errors can be expensive. Studies in the laboratory, and the intelligent use of the research data they reveal have made possible improvements in design and location with the result that our harbor and river works more efficiently serve the purpose for which they were built. EIC

Errata

An article in the November issue concerning Montreal's Place Ville Marie project contained erroneous figures for some of the construction and excavation work. An up-to-date report on construction highlights, released by Webb & Knapp (Canada) Ltd., lists the following figures. Amount of concrete poured, 59,528 cu. yd. Structural steel erected, up to and including Dec. 1, 1960, 17,206 tons. Excavation, 257,866 cu. yd.

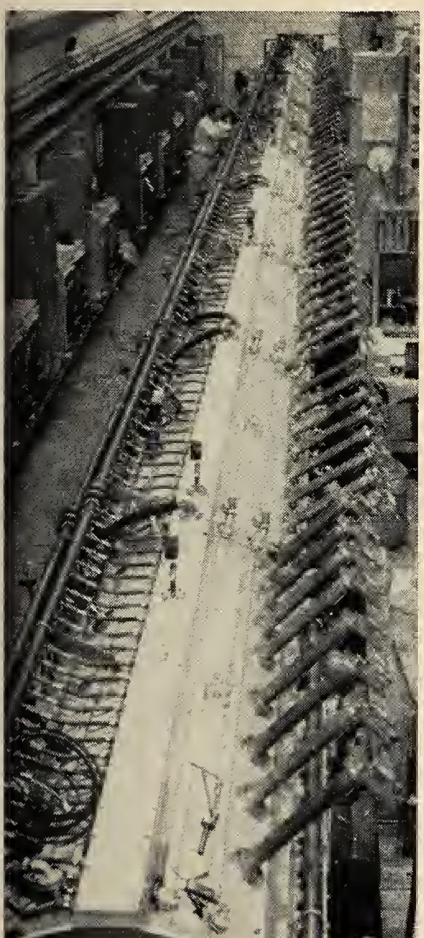
International News

World's Most Powerful Atom Smasher

A new atom smasher, the largest ever built in the United States, was recently put into operation at Brookhaven National Laboratory near New York City. One hour after its start-up, the big doughnut-shaped machine developed 30 billion electron volts of energy, setting a world record for power and accelerating nuclear particles to almost the speed of light, 186,000 miles per sec. The big device, known as an Alternating Gradient Synchrotron (AGS) is expected to attain even greater power levels, which will be used for investigations that are expected to yield new knowledge of the universe.

The Brookhaven synchroton will be used for several specific types of research; identification of the nuclear particles that make up atoms of ordinary matter; mass-production of little-understood particles such as mesons, hyperons, anti-protons and anti-neutrons; a search for hitherto undiscovered "strange particles" that physicists believe are in existence.

The 110-ft. long linac, composed of eleven 10-ft. sections coupled together, develops 50 million electron volts.

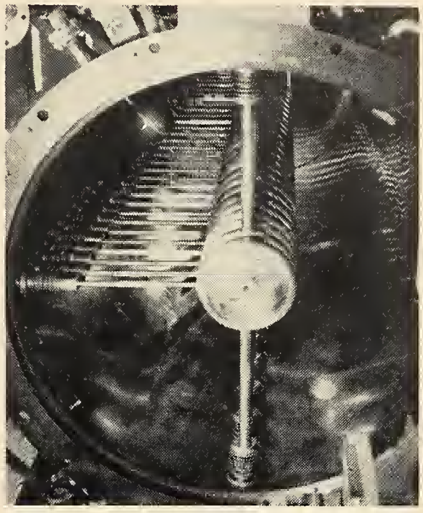


A good way to describe the operation of the synchrotron is to show how the machine increases the velocity of protons more than 30 times, to less than 0.1% of the speed of light.

The protons for use in the AGS are derived from hydrogen atoms, the lightest of the elements. The protons are acquired in a small chamber where an electrical arc tears away the electrons that revolve around protons. The resulting hydrogen nuclei are protons with positive charges. After the protons are made available, they are accelerated in three stages. First they pass through a Cockcroft-Walton generator, where they are accelerated to 750,000 electron volts. Next, the speeding particles are "shot" into a 110-ft.-long linear accelerator, called a linac, where they pick up 50 million volts of energy.

The final stage of acceleration is accomplished in the AGS, an "atomic racecourse" one half-mile in circumference and enclosed in a tunnel beneath 10 ft. of earth. The synchrotron is a vastly complex device. It consists essentially of a vacuum tube, which is a hoop of copper tubing about 7 in. wide and 3 in. high extending completely around the "racetrack" inside the circular tunnel. The copper tubing is contained by a circle of 240 magnets weighing 4,000 tons. As protons pass from the linac into the copper vacuum tube, the powerful magnets sweep them into a circular path. The magnet assembly is so arranged that it applies strong focusing forces to keep the protons in orbit and to prevent them from striking the walls of the vacuum tube.

The magnets do not increase the speed of the proton beam. This is done by 12 radiofrequency accelerating stations spaced at regular intervals around the circular vacuum tube. Each time the beam passes one of the stations, the protons are accelerated by 8,000 volts, which results in a total gain of 100,000 electron volts each time the beam completes its circular path. To reach the energy of more than 30 billion electron volts attained during the first trial of the synchrotron, the beam completes 300,000 revolutions, or 160,000 miles. The time required for this number of revolutions is only one second.



Interior of the linac showing drift tubes (centre) and vertical and horizontal supports inside tank. The proton beam enters the accelerator through the small hole in the centre of the first drift tube.

As the proton beam speeds around in the synchrontron, it passes through a target building constructed astride the "atomic racecourse". It is in this building that Brookhaven physicists will use the proton beam for experiments. By directing the beam at other atoms, reactions are produced which can be studied by means of emitted radiation. Many of the particles produced by atomic collisions exist for only a fraction of a millionth of a second before they decay into other particles or are converted into energy. These brief lifetimes, however, are long enough for the particles to be detected and recorded by instruments — counters, bubble chambers and photographic emulsions. A study of the records reveals the particles produced in the collisions.

Ultimately, it is planned to deflect the proton beam out of the AGS vacuum tube, which will enhance the usefulness of the machine by making possible many simultaneous experiments along the path of the beam. An 80 in. bubble chamber is now under construction for use with

(Continued on page 97)

Month to Month

Executive Committee Meeting

The Executive Committee of the E.I.C. Council met Nov. 19 in the Royal York Hotel, Toronto. President Dick was chairman. The following highlights of the meeting were taken from the minutes.

Oakville Branch Formed

Oakville, Ont., officially became the Institute's 51st Branch on the approval by the Executive Committee of a petition by Oakville Members. The Branch's charter will be presented by Dr. Dick during an official inauguration ceremony in February. Following are the officers of the Branch:

Chairman—A. A. Swinnerton
Vice-Chairman—H. J. Bexon
Secretary—J. W. Kirk
Committeemen—A. G. Ackerman, Program; C. F. Gross, Membership
Councillor—A. H. Thompson

Tariff Item 180 (e)

The General Secretary reported that the Committee appointed by Council Oct. 29, 1960, to receive the opinions of Council regarding the proposed amendment to Tariff Item 180 (e) was actively at work, and that councillors had been reminded to submit their opinions and the opinions of the Branches at the earliest opportunity.

Past President Tupper asked whether the text of the Institute's submission to the Tariff Board would be provided to Council. The General Secretary assured the meeting this would be done as soon as it has been prepared. He also reassured the meeting that consultations were being held with the Canadian Council of Professional Engineers regarding this matter.

Student Section at Loyola College

The Executive Committee heartily approved an application for permission to form a Student Section at Loyola College, Montreal. Loyola thus became the ninth Student Section, joining Assumption University, University of British Columbia, University of Manitoba, Ontario Agricultural College, Queen's University, University of Saskatchewan, University of Sherbrooke, and Waterloo University.

National Vocational Training Advisory Council

The General Secretary reported he attended a meeting of the National Vocational Training Advisory Council of the Federal Department of Labour in Ottawa, Nov. 3, 1960. He said he was present as liaison representative of the Labour Department's Advisory Committee on Professional Manpower, of which he has been a member for 15 years.

At this meeting Labour Minister Starr said there now is considerable unemployment in certain areas of the labour force. At the same time, Mr. Starr said, there are many vacant jobs which go unfilled because the required supply of technicians and workers with higher skills are not available. He noted the alarming drop-out rate from secondary schools, and urged an accelerated building and training program for the labor force.

The General Secretary reported that, in discussion during the meeting, he had stressed the importance of an adequate supply of technicians for industry, and for assisting the engineering profession in the performance of this work. A study will be made early in 1961 to attempt to find some general standard for technician training and related matters.

Canadian Conference on Education

The General Secretary reported that he participated in the Nov. 10 meeting in Ottawa of the National Committee of the Canadian Conference of Education. The Conference, sponsored by 64 national organizations, is planning the Second Canadian Conference on Education in Toronto, Feb. 18-22, 1962.

The objects of the Conference are to:

a. Focus the sentiments of citizens on the importance of education, and the need to take decisive action
b. Inform the public concerning the present state of education
c. State and examine new ideas about education

At this meeting the General Secretary had observed for the record and for the guidance of the program committee regarding the many technological developments which affect our lives and jobs have a definite impact on the aims, methods and scope of education. These, he said, should be considered when planning the program.

It was resolved that the General Sec-

Twenty-one Institute Members served as delegates or alternate delegates at the Sixth Congress of the Union Panamericana de Asociaciones de Ingeieros at Buenos Aires, Argentina, Sept. 18-22. One group is shown after its arrival in Buenos Aires. They are, from the left: Prof. Carson Morrison; Nicholas Fodor; W. N. Papove; A. T. Hurter; R. M. P. Hamilton; R. A. Frigon; Dr. James A. Vance; Paul Pelletier; C. C. Huston; G. R. Adams; W. H. Beaton; C. A. Dagenais; G. C. Hatch. Canadian participants not included in the photograph were: Dean H. G. Conn; Dean R. R. McLaughlin; Dr. K. F. Tupper; Leo Scharry; C. R. Vegh Garzon; Frank Athey; Harold Wright; H. B. Tafelmacher.

retary be instructed to keep the Engineering Education Division of the E.I.C.'s Committee on Technical Operations fully advised of the details of this Conference, so the Institute will be prepared to make a significant and appropriate contribution to the Second Canadian Conference on Education.

Relationships with provincial and territorial Associations and Corporation of Professional Engineers

President Dick reported that after numerous branch visits, and informal discussions with senior officers of several provincial associations, it has become evident to him that a relationship between the groups which will help attain what is best for all Canadian engineers must be achieved. With this common objective, there should be no effort wasted on competitive activities.

Past President Grant urged most strongly that the E.I.C. retain its identity at the branch level in advancing the well-being of engineers, with increased emphasis by the Institute on technical activities. Colonel Grant said serious problems would arise if, at the local level, non-members are able to obtain the same E.I.C. services as E.I.C. members. He said he could not reconcile himself to the Institute financing these services, or, in fact, to E.I.C. Branches retaining their charters under such circumstances. He also foresaw that E.I.C. Branches may lose their identity entirely if combined with local groups of provincial associations. He said he is opposed to the principle of confederation, and does not want to see the Institute lose its identity, prestige and functions by default.

Dr. Dick said the large majority of E.I.C. Branch officers concerned are intensely loyal to the Institute. But they now are faced with new conditions about which something constructive must be done in the best interests of the individual engineers in the localities concerned. He said the E.I.C. cannot instruct its branches not to co-operate with local groups of provincial associations if this appears an appropriate course of action at the local level; and that an organization which is not prepared to change its policies to meet changing circumstances will not flourish.

Past President Tupper suggested that the Institute should maintain a cordial relationship with the provincial associations, but should recognize them only as licensing bodies.

Vice-President Lawton said he was encouraged by the discussion. He emphasized the necessity for the E.I.C. to maintain a strong, virile and alert organization; to adhere to its objectives; and to render the types of service it should to its members. Mr. Lawton noted that steps were taken in the summer of 1960 to overcome long-standing problems vis-a-vis membership, and also to render all possible assistance to branch operations without detracting from the autonomy of the branches. He said many successful joint technical meetings have been held with sister societies. While there are many advantages of meeting jointly, he insisted the E.I.C. must not lose its own identity.

After considerable further discussion it was resolved that the following statement of policy be accepted by the meeting:

1. E.I.C. Branches must retain their identity and adhere to the approved system on government of the Institute.
2. The E.I.C. recognizes the associations and corporation of professional engineers in the provinces and territories of Canada as the sole licensing bodies of professional engineers in the respective provinces and territories of Canada.
3. E.I.C. Branches have the right to participate jointly in activities of mutual interest with any learned society or engineering organization, in conformity with the By-Laws of the Institute.

Committee on Membership

The first meeting of the Committee on Membership was held in Toronto Nov. 19 to chart a fresh and active course in E.I.C. membership promotion. Attendance of eight of the 11 committee members indicated the keen reaction to the work of the group. The extreme travel distances involved was responsible for the absence of the three other members.

With Fredericton Councillor Stan Cassidy as Chairman, the committee devoted most of the day to an examination of all phases of the Institute's organization and operation. Everything that might affect the attitudes of engineers — both members and non-members of the Institute — toward the E.I.C. was discussed with complete frankness. The best of the ideas and suggestions exchanged will be distributed to all concerned.

Included among the important conclusions reached at the meeting are:

A change is necessary in many of the former concepts concerning the running of the Institute. The Institute must be able to adapt to rapidly-changing times.

There is no substitute for personal contact, which creates interest on the individual level.

In many cases Branch organizations need overhauling, with new men put to work.

Large city Branches should consider dividing themselves into smaller Branches.

Many good customs and ideas to increase attendance at meetings and build interest can be adopted from other successful organizations.

Members of the committee will do all they can to assist Branches through personal contact.

In general terms, a three-point program emerged from the committee's discussions:

(Continued overleaf)

President's Column

BRANCH visits by the President during November included Hamilton, Ont., where more than 400 Engineers and wives gathered for their annual Ladies Night and Presidential Visit. Subsequent visits were made to Kitchener, Niagara, and Chatham. The latter included members and their wives from London, Sarnia, Border Cities and vicinity. At all these places, enthusiastic meetings were held.

The President also visited the Ontario Agricultural College at Guelph and Waterloo University at Waterloo, Ont. At both institutions the facilities for the teaching of engineering were inspected and suitable words of encouragement given to the students. There are active student groups at both institutions suitably sponsored by local E.I.C. Branches.

The Engineering Institute of Canada was officially represented by the President and Mrs. Dick at the "Bal du Genie" held by the Alumni and Students Association of Ecole Polytechnique in the Queen Elizabeth Hotel, Montreal on Saturday, November 26th.

A meeting of the Executive Committee of Council was held in Toronto on Saturday, November 19th when a number of Councillors from the Western Ontario area were also present. Concurrent with this event was a meeting of Council's Committee on Membership presided over by Councillor Stan Cassidy.

The Committee on Technical Operations is actively pursuing the development of increasing technical interest among all members, with particular accent on appropriate technical content of branch meetings.

A new Committee on Branch Operations has been appointed to study how branches operate, and to recommend to Council and the Branches regarding possible aids or techniques whereby the membership at large may benefit more widely from branch activities.

As the new year opens, may I take this opportunity to express, on behalf of the Institute, the very best wishes for 1961. This is the time when we should all take stock of our accomplishments during the year just closed, and suitably adjust our sights for the year that lies ahead. Our New Year's resolutions should include a sincere desire to improve our individual ability by some suitable augmentation of our technical knowledge, so that collectively we may enhance the technical accomplishments and ability of Canada's engineering fraternity, with the resultant improvement in Canada's national economy. EIC

1. To find from the Branches their membership problems.
2. To provide the Branches with as much guidance and assistance as possible.
3. To follow this with personal visits to the Branches.

The Engineers Confederation Commission

The third plenary meeting of the Engineers' Confederation Commission was held in Toronto, Nov. 25, 26 and 27, 1960.

The following delegates were present:

Newfoundland: J. B. Angel
Prince Edward Island: W. R. Brennan
Nova Scotia: G. F. Vail and G. F. Bennett
New Brunswick: T. C. Higginson and J. O. Dineen
Quebec: E. D. Gray-Donald, J. Lemieux, H. Gaudefroy and H. Cimon
Ontario: T. Foulkes, D. D. Whitson, C. T. Carson and L. D. Dougan
Manitoba: T. E. Storey and N. S. Bubbis
Saskatchewan: J. C. Traynor and J. B. Mantle
Alberta: J. McMillan and J. F. McDougall
British Columbia: F. A. Forward
Joint Secretaries: L. M. Nadeau and G. T. Page

John Clary, legal advisor of the Commission was also present during part of the meeting. W. K. Gwyer from British Columbia and E. W. King from the Yukon Territory had asked to be excused.

The meeting was under the chairmanship of John H. Fox, Chairman of the Engineers' Confederation Commission and Vice-Chairman J. E. L. Roy was also in attendance.

The Commission received for consideration the complete text of a proposed charter and proposed by-laws for a new national body combining the existing Canadian Council of Professional Engineers and the Engineering Institute of Canada as required under the Terms of Reference of the Commission, and preliminary proposals for the financing of this proposed body. Written legal opinions relative to these documents and to the procedure which would have to be followed for their implementation were tabled and the solicitor of the Commission attended part of the meeting to explain various legal aspects of the problems involved.

This, in effect was the culmination of a tremendous amount of work and study by a representative group of 25 engineers from all parts of Canada who have been given the responsibility, by their profession, of drafting a complete and detailed proposal for the confederation and unification of the engineering profession in Canada.

Since October, 1959, when the Commission and its eight committees became operative, a total of 68 recorded formal meetings and a large number of informal meetings were held, during which some 8,000 man-hours were spent by the 25 delegates who had to travel collectively an estimated total of 300,000 miles to attend these meetings.

After 13 months, during which each important aspect of the plan was carefully studied, both individually and in relation with other aspects, the Commission was finally in a position to consider a complete project and, as a result, several important decisions were taken although many details remain to be worked out.

Since the Commission is responsible and must report to the Councils of the Engineering Institute of Canada and the Canadian Council of Professional Engineers, it adopted as a policy that information relative to details of its work should not be made public until it was ready to take firm and definite decisions. The Commission is now in a position to release information on a number of points but feels that other aspects which have to be studied further before final decisions are taken should not be dealt with publicly at this time.

The major points concerning which the Commission has taken firm decisions may be outlined as follows:

1. Charter

After careful consideration of all possible alternatives and giving due consideration to the legal problems involved for all concerned, the Commission will recommend that the Charter of the Engineering Institute of Canada be used as a basis, with the necessary modifications to adapt it to the needs of the new organization.

2. Objects

In line with the terms of reference of the Commission, it was finally agreed to recommend that the objects of the new organization be as follows: (these

Miss Maudie Abraham was honored by officers and staff of the EIC on the occasion of her retirement from the staff after 41 years' service. Gifts were presented from the Montreal Branch and from Institute headquarters following a staff dinner. Madame Jacques Benoit, wife of the Chairman of Montreal Branch, is shown giving one of the gifts to Maudie. Looking on is EIC President Dr. Dick.

Engineers are the chancellors of four Canadian universities. This unique situation was marked recently in Montreal when a group of engineering friends honored them with a luncheon. From the left, they are: Dr. C. J. Mackenzie of Ottawa, Chancellor of Carleton University; Dr. R. E. Powell of Montreal, Chancellor of McGill; Dr. J. B. Stirling of Montreal, Chancellor of Queen's University; the Right Hon. C. D. Howe of Montreal, Chancellor of Dalhousie.

objects are incorporated in the proposed Charter):

(a) To develop and maintain high standards in the engineering profession.
(b) To facilitate the acquirement and interchange of professional knowledge among its members.
(c) To advance the professional, social and economic welfare of its members.
(d) To assist in the development throughout Canada of uniform registration requirements and examination standards for the engineering profession.
(e) To act in an advisory capacity in connection with legislative matters common to professional engineering bodies throughout Canada.
(f) To promote a knowledge and appreciation of engineering and of the engineering profession and to enhance the usefulness of the profession to the general public.
(g) To collaborate with universities and other educational institutions in the advancement of engineering education; to encourage original research and the study, development and conservation of the resources of Canada.
(h) To establish and maintain a bond between associations recognized by the Canadian Institute as Participating Associations and to promote the welfare of the engineering profession in Canada.
(i) To provide a forum for the discussion of problems common to all engineering bodies.
(j) To publish a national journal and such other technical and professional papers and transactions as may be of assistance to its members.
(k) To promote intercourse between engineers and members of allied professions.
(l) To co-operate with other societies for the advancement of mutual or national interests.
(m) To act as a national voice speaking on behalf of all the professional engineers of Canada.

3. Name

It will be recommended that the name of the organization be Canadian Institute of Professional Engineers and in French, Institut Canadien des Ingénieurs Professionnels.

4. Membership

The Commission will recommend that admission to membership in the Canadian Institute of Professional Engineers be obtained through registration as a Professional Engineer in a provincial or territorial association or corporation of professional engineers. Provision will also be made for admission to the proper grade of membership of engineers-in-training, junior professional engineers and students registered or recorded by these same bodies.

It will also be recommended that continuing membership in the proper grades be provided for all the present members of the Engineering Institute of Canada.

The Commission will recommend that there be five grades of membership as follows:

Fellow: This will be the highest grade of membership and will be used to recognize outstanding contributions to the engineering profession in technical or professional practice or in the fields of administration and teaching. It will be restricted to Members and the number of Fellows will be strictly limited.

Member: Will include only professional engineers registered in Canada.

Junior: Will be limited to engineers-in-training or junior professional engineers registered or recorded by the provincial associations.

Student: This grade will include only students recorded as such by the provincial associations.

Honorary Member: This grade will be used to honour persons who have attained eminence or have achieved great distinction in fields of endeavour allied to or asociated with the engineering profession, but who are not professional engineers registered in Canada. The number of Honorary Members will be very restricted.

• MONTH TO MONTH

5. Management

It will be recommended that the Canadian Institute be governed by a Council composed of the President, two Vice-Presidents, the immediate past President, one Councillor appointed by the Council of each of the provincial Associations and Councillors elected by the membership of the provincial Associations.

The number of elected Councillors shall be determined as follows: Associations with 301 to 5,000 members shall elect one Councillor. Those with 5,001 to 10,000 members shall elect two Councillors and those with over 10,000 members shall elect three Councillors.

The Commission further recommends that two Boards and four Standing Committees be formed under the Council as follows:

Board on Professional Interests — This Board will be composed of all the Councillors appointed by the provincial associations and will be responsible for the activities of the Canadian Institute in the field of professional interests including the co-ordination of the activities of the Associations in this field.

Board on Technical Services — This Board shall be responsible for the activities of the Canadian Institute in the field of technical services and for the co-ordination of the activities of the provincial associations in this field.

Committee on Finance
Committee on Branches
Committee on Publications
Committee on Honours and Awards

Provision will be made that under the administration of the two respective Boards, any number of committees may be established to allow for the implementation of the objects of the Canadian Institute of Professional Engineers.

6. Branches

Details of a program to provide the membership with an expanded program of branch activities are being developed. It is proposed that this program will make provision for the professional and technical aspects of the profession.

7. Student Chapters

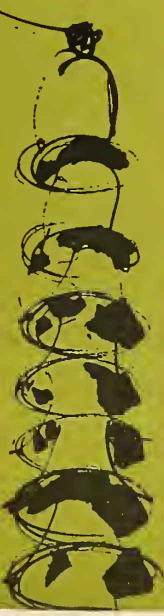
Provision will be made for an expanded program of student activities.

8. Membership Participation

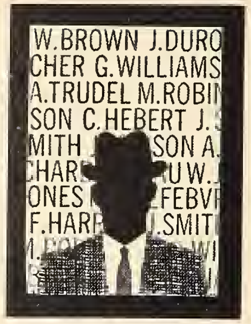
To provide for direct participation by each individual member in the basic activities of the Canadian Institute, it is proposed that at both the branch and national levels, members may participate in the activities of one or more technical and functional divisions. Each division will be concerned with a major area of technical or professional interest of the engineering profession.

9. Advance Schedule

It is hoped that at its next meeting scheduled for February, the Commission will be able to prepare a complete report for a submission to the Engineering Institute of Canada and the Canadian Council of Professional Engineers in advance of their 1961 annual meetings.

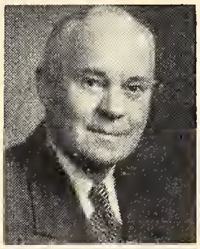


Personals



Dr. Richard L. Hearn, M.E.I.C. (Toronto '13), has been appointed President and a Director of C.B.A. Engineering Ltd., Vancouver, B.C. Dr. Hearn was General Manager and Chief Engineer, Hydro-Electric Power Commission 1947-55, and Chairman 1955-56.

R. L. Hearn, Hon. M.E.I.C.

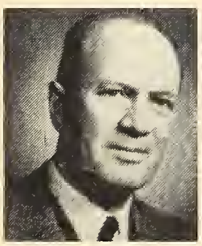


Dr. O. Holden, M.E.I.C.

Dr. Otto Holden, M.E.I.C. (Toronto '13), recently retired Chief Engineer of Ontario Hydro, was presented with a silver medal by the Engineering Alumni at the University of Toronto. The medal is awarded for outstanding achievements in the field of engineering.

Karl O. Elderkin, M.E.I.C. (McGill '20), has retired as President of Bowaters Engineering and Development Inc., in Calhoun, Tennessee. Mr. Elderkin joined the Bowater organization in 1952 and has been in charge of the design and construction of many of their mills.

W. J. W. Reid, M.E.I.C. (Toronto '24), has been appointed Senior Vice-President of the Otis Elevator Company, New York. Mr. Reid has also been elected a member of the Board of Directors.



W. J. W. Reid, M.E.I.C.

D. A. Barnum, M.E.I.C.

D. A. Barnum, M.E.I.C. (Michigan '29), was recently appointed Vice-President and Manager, engineering and sales, Corba Industries Inc., Quebec City.

Elzear N. Gougeon, M.E.I.C. (Mass. Inst. of Tech. '30), has been appointed Assistant Chief of the technical services division (Montreal area) of the Industrial Expansion Bureau of the Trade and Commerce Department.

Thomas A. Marshall, JR.E.I.C. (Georgia School of Tech. '32), has been appointed Executive Secretary of the American Society For Testing Materials, Philadelphia. Mr. Marshall was previously Senior Assistant Secretary of the ASME.

J. E. Laframboise, JR.E.I.C., an Athlone Fellow, has been studying at the Imperial College of Science and Technology, London, England where he was doing research work on flame quenching and flame traps operation. Mr. Laframboise is now working for Computing Devices of Canada, Valcartier, Que.

G. E. K. Dudman, M.E.I.C. (Alberta '54), has been appointed Chief Engineer for the Alberta Branch of the Dominion Bridge Company Limited. **A. Baxter,** M.E.I.C., has been appointed Manager, Mechanical Products of the same Branch.

G. E. Dudman, M.E.I.C.

D. Buckley, M.E.I.C.

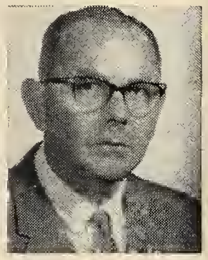
Donald C. Buckley, M.E.I.C. (McGill '49), was recently appointed assistant chief engineer in Wix Corporation Limited, Toronto, manufacturers and filtration specialists.

John W. Demcoe, M.E.I.C. (Manitoba '39), previously Acting General Manager of central region, Toronto, has been made General Manager of Canadian National Railways Atlantic region. Mr. Demcoe joined Canadian National in 1939.

A. C. Ridgers, M.E.I.C., has become chief design engineer in the engineering division of The Consolidated Mining and Smelting Company, B.C. Mr. Ridgers has been with the company since 1924.

R. T. Harland M.E.I.C. (Manitoba '38), formerly Chief Engineer, has been promoted Assistant General Manager of the City of Winnipeg Hydro-Electric System. **J. H. Benditt,** M.E.I.C. (Manitoba '27), succeeds Mr. Harland as Chief Engineer. Mr. Benditt joined the Winnipeg Hydro in 1927 and was previously General Superintendent of Distribution.

R. T. Harland, M.E.I.C.



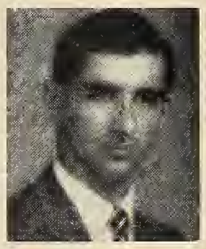
J. H. Benditt, M.E.I.C.

Alexander Baptist, M.E.I.C. (New Brunswick '47), has been appointed City Manager of Pointe Claire, Que. Mr. Baptist was formerly Town Manager and Industrial Commissioner of Hawkesbury, Ont.

Glen C. Riteey, M.E.I.C. (McGill '48), has been appointed Vice-President and General Manager of Rader Pneumatics (Eastern) Limited in eastern Canada. Mr. Ritcey was formerly Assistant Manager Pembroke division of Consolidated Paper Corporation, Pembroke, Ont.

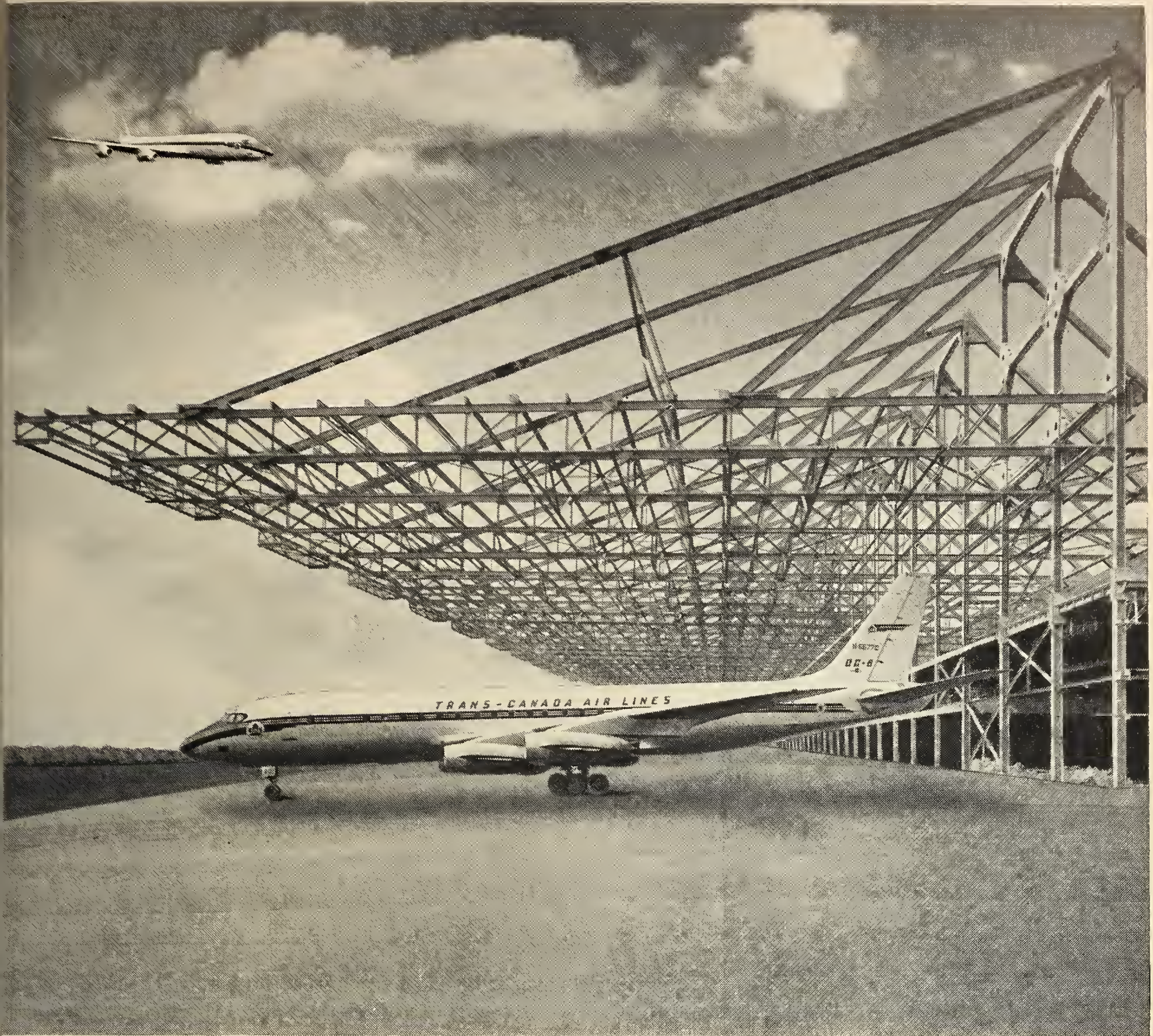
K. R. Fulton, M.E.I.C. (New Brunswick '48), has been appointed Vice-President (construction) of Canadian Engineering and Contracting Co. Ltd., Hamilton.

K. R. Fulton, M.E.I.C.



C. J. Gauvin, M.E.I.C.

C. Jacques Gauvin, JR.E.I.C. (Polytechnique '54), has been promoted to chief geologist for Steep Rock Iron Mines Limited, Steep Rock Lake, Ont.



Room to swing a jet

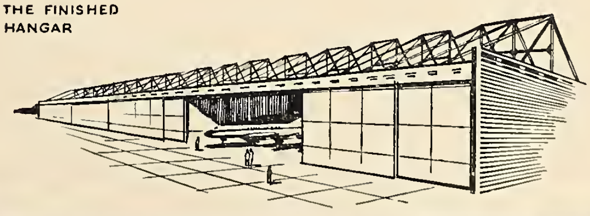
This huge steel frame is the backbone of a hangar for jetliners. It belongs to Trans-Canada Air Lines and is part of their new multimillion dollar base near Montreal designed solely for the maintenance of turbine aircraft.

Because of the size of modern aircraft vast covered areas free of all vertical supports are necessary to permit planes to manoeuver freely. In this building, structural steel, fabricated and erected by Dominion Bridge, is used to create the largest cantilever roof of its kind in North America. It projects 175 feet for a length of 836 feet and provides a post free area larger than two football fields.

The roof structure is suspended by diagonal members from anchored and braced steel columns. The design permits unobstructed entrance through 50 ft. high sliding doors for the whole length of the building. Five DC-8 jetliners can be accommodated. Architects and engineers were Ross, Fish, Duschenes and Barrett of Montreal and E. W. Sellors of T.C.A., and the general contractors, Pigott Construction Ltd.

This is an example of Dominion Bridge at work—five divisions—Structural, Mechanical, Platework, Boiler, Warehouse Steel. Fifteen plants coast-to-coast.

THE FINISHED HANGAR



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DOMINION BRIDGE

T. E. Harris, M.E.I.C. (McGill '50), has been elected chairman of the Montreal section of the Standards Engineers Society. Mr. Harris is Mechanical Engineer, Power Crane and Shovel Division, Dominion Engineering Works.

W. H. R. Gibney, JR. M.E.I.C. (British Columbia '50), has been appointed Planning Engineer, Mines Division at The Consolidated Mining and Smelting Company's Sullivan Mine at Kimberley, B.C.

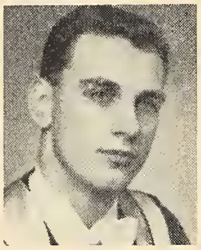
J. H. White, M.E.I.C. (New Brunswick '54) has been appointed Secretary, Gifco Limited, Moncton, N.B. Mr. White was previously Sales Engineer, Armco Drainage and Metal Products for Nova Scotia.

B. B. Kubow, JR.E.I.C. (McGill '56), has been promoted from Junior Engineer to Electrical Engineer in Southern Canada Power Co. Ltd., Montreal.

Lionel Simard, JR.E.I.C. (Ecole Polytech. '58), has been nominated Chief Engineer for the City of Jonquiere, Que. Mr. Simard was formerly employed by the City of St. Lambert, Que. as City Engineer.

S. D. Robertson, JR.E.I.C. (Queens '58), an Athlone Fellow, has returned from England where he studied at the Imperial College of Science and Technology, London, in the control systems field. Mr. Robertson has now taken a post at the University of Toronto as a Research Associate.

Louis Donolo, JR.E.I.C. (McGill '58, Harvard '60), has been appointed director and administrative assistant of Louis Donolo Inc.



R. Avery, JR.E.I.C.

Roland Avery, JR.E.I.C. (N.S.T.C. '60) is now junior design engineer for Foundation of Canada Engineering Corporation Limited.

John H. Duerksen, JR.E.I.C., has joined Atomic Energy of Canada, Limited as a Junior Research Officer in the Chemistry and Metallurgy Division. He has returned to Canada after two years of studying in Europe on an Athlone Fellowship. His first year was spent with W. J. Fraser & Co. Ltd., chemical contractors, as a graduate trainee, and in his second year he studied Nuclear Technology (Chemical) at the Imperial College of Science and Technology.

T. H. Welch JR.E.I.C. (Saskatchewan '60), has joined D. R. Rowe Engineering Services Limited and is now operating in the Tisdale, Sask. office.

Obituaries

Colonel William Herbert Magwood, M.E.I.C. (Royal Military College), former town engineer and building inspector of Cornwall, Ont., died Nov. 18. He was 91. Colonel Magwood was former commanding officer of the Stormont, Dundas and Glengarry Highlanders. He joined the Institute as an associate member in 1905, became a member in 1919 and was made a life member in 1947.

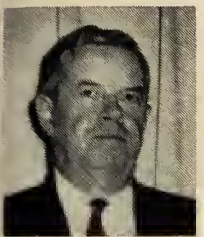
T. Dowsley Kennedy, M.E.I.C. (Berlin '05), past President of William Kennedy and Sons Ltd., died Nov. 9, at Owen Sound, Ont. He was 75. Mr. Kennedy entered the family firm in 1909 and became President in 1940. He joined the Institute as an affiliate member in 1911 and became a member in 1940.

Wesley Blaine Redfern, M.E.I.C. (Toronto '09), a partner in Proctor and Redfern, consulting engineers, Toronto, died September 17. He was 73. He was born and educated in Owen Sound, Ont. Mr. Redfern joined the Institute in 1920 as an affiliate member and became a life member in 1955.

(Continued on page 85)

(Continued from page 82)

Aubrey H. Perry, M.E.I.C. (Toronto '30), an internationally recognized authority on water and pollution problems, died Oct. 11, after a short illness. He was 54. Mr. Perry was with the Public Health Engineering Division, Department of National Health and Welfare, Vancouver. He became an affiliate member of the Institute in 1935 and a member in 1940.



A. H. Perry, M.E.I.C.

E. J. Blandford

E. J. (Ted) Blandford, Publication and Advertising Manager of the Engineering Institute of Canada, died Dec. 7, at the age of 59. Mr. Blandford was born in Kent, England and received his early education at the Colchester Grammar School. He served his apprenticeship in marine engineering on the Clyde. His first job was with the Dutch Shell Oil Company in Venezuela, where he spent three years. After settling in Montreal in 1927 Mr. Blandford worked as a space salesman for the publishing houses of Hugh C. MacLean and for Maclean-Hunter. He then worked for Vickers Shipbuilding, after which he opened his own business, Home Film Studios. Mr. Blandford became public relations manager for National Breweries Ltd. During part of his Second World War services with the R.C.N.V.R., he helped establish shipbuilding bases in the Maritimes. He ended his naval service with the rank of Lieutenant Commander. About 13 years ago he began working for the Institute and rendered excellent service throughout his association with the E.I.C. Mr. Blandford channelled his tremendous vitality into service and professional clubs and into his hobbies of painting, music, woodworking and photography. Survivors include his widow, the former Margaret Forrester, and sons John and George.

John E. Warner, M.E.I.C. (McGill '12), a prominent engineer in the paper industry, died Oct. 17, New York City. He was 69. Mr. Warner retired as chief plant engineer for the Robert Gair Paper Company, a subsidiary of the Continental Can Company, in 1957 after 21 years with the firm. He became an affiliate member of the Institute in 1920 and a member in 1940. He was made a life member in 1955.

Sheldon Byrne Clement, M.E.I.C. (McGill '01), Sarnia, Ont., died recently. Mr. Clement joined Ontario Northland Railway in 1906 and was made Chief Engineer in 1909. He retired in 1946. Mr. Clement joined the Institute as a student member in 1899, he became a member in 1911 and was made a life member in 1947.

Robert White, M.E.I.C., 76 yrs., a retired chief engineer of Williams and Wilson, Montreal, died Nov. 22. Mr. White emigrated from Scotland in 1911 and was in the employ of Canadian Pacific Railway for some years. He was associated for more than 35 years with Williams and Wilson, retiring in 1954. He joined the Institute as a Junior member in 1912 and became a member in 1940. He was made a life member in 1950.

Romeo Morrissette, M.E.I.C., former mayor of Cap-de-la-Madeleine, Que., has died. Mr. Morissette was 83. He joined the Institute in 1945 and became a life member in 1958.

T. H. Kirby, M.E.I.C. (McGill '13), chairman of the Winnipeg branch of the Institute in 1944, died Oct. 17. Mr. Kirby was 69. He was President of Filer-Smith Machinery Co. Ltd., Winnipeg, and had previously been with the Manitoba Power Commission. He joined the Institute as an associate member in 1919, transferring to member in 1940. He became a life member in 1954.

Other Societies

American Institute of Chemical Engineers

The 53rd Annual Meeting of the Society was held in Washington, D.C., Dec. 4-7. Thirty-four technical sessions were held and 11 plant trips arranged. Among the speakers were Fred Singer, University of Maryland, who spoke on "Scientific Exploration of Space", and Wallace Brode, Former Science Advisor, U.S. Department of State, who talked on "Scientific and Engineering Planning". Delegates also heard from the Dynamic Objectives Committee which has been working on a report on the future of chemical engineering.

Society for Experimental Stress Analysis

The second technical meeting of the season of the Hamilton Section of the S.E.S.A. was held Nov. 29. "Modern Strain Bridges, Scanners and Readouts" was the subject for the evening. George Kelk, President, George Kelk Limited, was the speaker.

Institute of Radio Engineers

The Toronto Section of the society visited Trans Canada Telemeter, Dec. 5. Following a description of the system, there was a conducted tour of the studios and facilities, from which programs are originated for the first pay-TV system in Canada.

The Society of Naval Architects and Marine Engineers

At the 68th Annual Meeting at New York, Nov. 19, John Rogers Newell was elected President for a two-year term. Mr. Newell succeeds Rear Admiral Albert G. Mumma.

American Society of Tool and Manufacturing Engineers

The A.S.T.M.E. held a meeting in Montreal, Nov. 16. Ed. Hanna, Chief Engineer, Landis Machine Company, gave an informative talk on "Thread Rolling".

American Society for Testing Materials

The Society has published their 1960 Annual Report of the Board of Directors. Of special significance in the report is mention of the creation of committees in new fields — sampling and analysis of metallic ores, the study of skid resistance of traffic surfaces, the standardization work in the field of ceramics for electronics, and the exploration of sensory testing.

The American Society of Mechanical Engineers

The Winter Annual Meeting of the A.S.M.E. was held in New York City Nov. 28-Dec. 2. Walker L. Cisler, President, headed the meeting during which more than 300 papers were presented at 123 sessions. Several outstanding engineers, executives and educators were honored through presentation of Society awards for their achievements. Among these was Henry Heald, President of the Ford Foundation, who was made an Honorary Member of the Society. The 1960 Power Show was held concurrently with the conference. Displayed was a variety of new equipment designed to supply the expanding power needs of all phases of American life.

Papers presented during the week included reports on such topics as aviation, management, railroad improvements, safety, professional practices, solar energy heating and atomic energy innovations.

The first day started with great excitement when delegates were told that May 4, 1964 might well be the day when a space capsule sets off to Mars. Some theories on the accomplishment of the mission were presented by Harold Brown of the Flight Propulsion Laboratory Dept., General Electric Company. The space ship would be powered by low-thrust electrical propulsion, a system some engineers are advocating as a lower weight substitute for chemically powered engines. Also featured that morning was a discussion by a Federal Flight Test Inspector on problems faced by pilots of new commercial jets. Charles L. Blake and Eric R. Woods, both of the Convair Corp., presented a paper in which they suggested a method by which passenger aircrafts could be checked and overhauled more quickly. They said that a computer, an electronic brain, built into each aircraft would permit the jet to be under constant check in the air and would enable quicker service to be carried out on the ground.

Paul C. Aebersold, Director of Isotopes Development for the U.S. Atomic Energy Commission, gave an interesting and informative paper about the radioisotope, on Tuesday. These radioactive forms of different chemicals, often man made, are "truly the success story of atomic energy," he said. He described the numerous uses they are being put to, including assisting in the discovery of cheaper fuels, processing food, keeping manufacturing processes at a standard tolerance and traeing oil in pipelines. At the same session, J. R. Mason, reviewed safety and regulatory controls for radioisotopes. Staying in the nuclear field, two engineers told a session about a new plant under consideration that uses sulphur to carry heat to the steam generator. Preliminary studies indicate that such a plant may be cheaper to construct and to operate than more conventional systems.

One of America's leading experts on solar energy, John I. Yellot, summarized sun-power developments during 1960. Another paper described experiments on solar-heated homes. An interesting discussion was held about photographic methods of studying combustion in rocket chambers.

(Continued on page 88)

The Associations and Corporation

The establishment of a province-wide network of chapters has been approved by the Executive Council of the Association of Professional Engineers of Ontario. The move is designed to bring about an improved system of communications between the Association and its membership. "Chapters will be formed in every large centre in Ontario in order that every member will be able to attend regular meetings without having to travel a great distance", says the President, Dwight S. Simmons. He added that between 35 and 40 chapters would be formed.

Included in Thursday's papers were observations by William M. Keller, Vice President of the Association of American Railroads, on his study trip to the U.S.S.R. At the same session, three other engineers supplied comments on mechanical engineering progress in other countries abroad.

During the last day of the meeting, Friday, William van der Sluys, Associate Director of Research for the Pullman Company, described a new train that can run with the locomotive at the back. Another railroad engineer described how railroads can compete successfully with trucks over the same route by means of a new train-truck car, a 'railvan'. Also among the highlights of the meeting was a paper presented by Charles M. Loucks, Consulting Chemist, Materials and Methods, Inc., on chemical cleaning of plant equipment.

Professional Survey

The Department of Labour's annual Survey of Scientific and Technical Professions is being carried out in the first quarter of this year with questionnaires being sent to some 25,000 engineers and scientists. This survey program provides the only comprehensive set of statistics covering all engineering and scientific groups. It is carried out with the co-operation of the principal professional associations.

Summaries of the results are sent to all who answer the survey. More detailed statistical reports are published by the Department as part of its professional manpower series. The present survey will provide employment and earnings data for 1960. In addition, for the first time, the Department is planning to publish data on salary rates to meet the demand from employers of professional personnel for this type of information.

The following taken from the 1959 survey, gives the median earnings in the main professional groups, with comparisons for 1958:

Field	1959	1958
Agriculture	$6,400	$5,900
Engineering	8,100	7,900
Forestry	6,900	6,700
Natural Science	7,650	7,400
Veterinary Medicine	7,350	7,000

Coming Events

54th Annual Meeting, The Canadian Institute of Surveying, Chateau Laurier, Ottawa, Feb. 8, 9, 10.

Winter meeting, The National Society of Professional Engineers, Des Moines, Iowa, Feb. 9-11.

Solid State Circuits Conference, Institute of Radio Engineers, American Institute of Electrical Engineers, Philadelphia, Feb. 15-17.

57th Annual Convention, American Concrete Institute, St. Louis, Feb. 20-23.

Annual Meeting, American Institute of Mining, Metallurgical and Petroleum Engineers Inc., St. Louis, Feb. 26-March 2. EIC

News of the Branches

Belleville

A. G. Tooth, M.E.I.C.
Correspondent

The atomic reactor installation in Bombay, India, was the subject of an address given the Branch at its Nov. 14 smorgasbord. Guest speaker at the meeting held at Tweed was G. R. Adams, Vice-President and General Manager, Foundation Overseas, Ltd. With the aid of excellent color slides, Mr. Adams outlined the difficulties of construction. These difficulties apparently were minor compared with the red tape which hampered operations with the Indian Government. Canada supplied all the material while India contributed the labor and the foundations. E. A. Cross, Regional Vice-President of the Institute, gave a short, excellent talk on the history of engineering.

Border Cities

Wallace A. Macdonald, JR.E.I.C.
Correspondent

Members of the Border Cities Branch, including Assumption University's student section, spent a constructive and enjoyable evening during the combined meeting of the Sarnia and London Branches at Chatham during the Nov. 18 visit by Institute President, Dr. G. McK. Dick. In the afternoon the executives of the three branches met with Dr. Dick and many interesting problems were discussed. This session was found very informative by the executives and it produced much incentive for future programs. In the evening, members and their ladies met for a reception and dinner. E.I.C. General Secretary Garnet T. Page outlined present and future plans and activities of the Institute. Dr. Dick, the speaker of the evening, discussed the importance of an engineer's wife's role in his life and duties. He continued his talk concerning the necessity of Canadian engineers' ingenuity. The Canadian engineer must continue his education after graduation, Dr. Dick said. Technical programs must be promoted to enable Canada and Canadian engineers to be recognized. In summarizing, the President advised engineers to raise their standards and to "keep on going."

The speakers were thanked by Art Worth of the Sarnia Branch.

Central B.C.

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

The annual meeting for presentation of reports and election of officers of the Central B.C. Branch took the form of a dinner get-together at Vernon, Nov. 25. Retiring Branch Chairman H. A. Price, Division Engineer for the C.P.R. at Penticton, presented his annual report summarizing the activities of the Branch during 1960. Mr. Price accepted the position of Branch member of the National Nominating Committee. Reports from Branch secretary W. M. Owen and the auditor's report received favorable consideration. Also discussed during the meeting were Tariff items 180 (e) and 180 (f) regarding the importation of engineering plans and specifications. Support was recorded for Council's action. Endorsed was the report by the Sub-Committee on Water Pollution which is of vital interest in the Okanagan. The following members were chosen to the executive: Branch Chairman—J. W. Nelson, Kamloops; Vice-Chairman—B. S. Harvey, Kelowna; Branch Councillors—T. Berger, Vernon; R. Wannop, Kelowna; M. Elston, Kamloops.

Special guests at the meeting were W. McKenzie, mining engineer and past president of Okanagan Helicopters, and G. Warren, mining engineer recently returned from five years in Peru.

Chalk River

R. O. Sochaski, JR.E.I.C.
Correspondent

Members of the Chalk River Branch participated in a field trip Nov. 19, to observe the NPD-2 nuclear power station. The three-hour tour was arranged by personnel of Ontario Hydro and Canadian General Electric and covered the complete power station. Items inspected included turbo-alternators, boilers, pumping stations, instrument panels, fuel assembly and storage bays, condensers, ventilation and electrical switch gear. The station is hoped to become critical late this year.

Kootenay

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

George Small, chief instrument engineer, Instrument Department, Cominco, discussed automation in process industries at the Branch's Oct. 24 meeting. After outlining the history and definition of automation, Mr. Small described a simple manual operation using instrumentation terms for the sequences. He then told how each of these sequences would be automated. Finally he touched briefly on computers, audio storage units, and taped sequences.

Loyola College

Richard Kind

The first meeting of the Loyola College Student Section was held Dec. 2. The formation of a student section had been approved at the Institute Headquarters less than two weeks previous to the meeting. The officers of the new section are: Chairman—Peter Mayers; Vice-Chairman—Ross Deegan; Sec. Treasurer—Richard Kind.

The speaker at the meeting was H. J. Racey, Vice-President, Racey, MacCallum and Associates Ltd., who gave a talk on "Microwave Construction in the Yukon". Mr. Racey's talk dealt mainly with the problems of constructing access roads from the Alaska Highway to the sites of microwave towers. His talk introduced the student members to some of the engineering problems encountered in the North, and was illustrated by slides.

University of Manitoba

Brian Grover, S.E.I.C.
Correspondent

Professor E. Kuiper, Hydraulics Professor at University of Manitoba, discussed harbor works in Harling, Holland, at the Nov. 24 meeting. Prof. Kuiper presented films showing the construction of the harbor dam in all stages, with emphasis on the protection of the slope of the dyke facing the sea by using asphaltic materials. He described the entire project and methods of construction with the aid of his own films. After his presentation, Prof. Kuiper answered questions from the audience of about 200 students.

Ottawa

H. P. Ristow, JR.E.I.C.
Correspondent

French hydraulics expert Pierre Danel

AIR TERMINAL BUILDING, DORVAL, P.Q.

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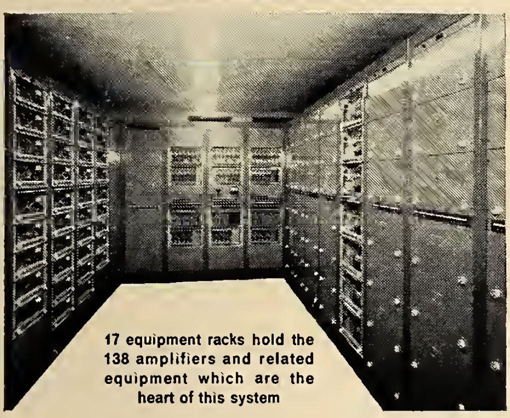
Paging System Engineered & Installed by: National Electronics Limited, Montreal, P.Q.
Consulting Engineers: Leblanc & Montpetit, Montreal, P.Q.


17 equipment racks hold the 138 amplifiers and related equipment which are the heart of this system

1,735 speakers will carry messages like this through the new Dorval Air Terminal Building, 24 hours a day, every day of the year. This will be one of the world's hardest working public address systems, and it has been designed for maximum clarity in speech and music reproduction.

Working to basic specifications laid down by the Department of Transport, Northern Electric Company Limited designed the overall system and manufactured its major components. The installation of the Northern Electric system was engineered by National Electronics Company of Montreal.

Northern Electric is proud indeed to have participated in the new Dorval Air Terminal Building.

Northern Electric
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was to have addressed the Ottawa Branch, Oct. 20. Due to illness, Mr. Danel's address was presented by Ernest Pariset of Montreal's LaSalle Hydraulic Laboratories. The advancement of hydraulic turbine development during the last 50 years as to efficiency and specific speeds was illustrated by slides. This was followed by details of different developments with which the author had been connected. The last part of the lecture was devoted to the feasibility of developing hydro power from tidal effects.

The Nov. 17 meeting heard Raymond Brunet of Ed. Brunet and Sons, General Contractors, Hull, Que., discuss construction and employment. Mr. Brunet had served as advisor to the Unemployment Insurance Commission and to the Canadian Construction Association, and thus was able to present both sides of the present unemployment problem. Statistics he employed emphasized the importance of the construction industry to the whole Canadian economy.

Peterborough

R. C. Johnston, JR.E.I.C.
Correspondent

A Northern Electric Company tape recording concerning Communism was heard at the Branch's Nov. 30 meeting. At the same meeting, 10 members were nominated for the Branch's 1961 executive. The Annual Gala Ball is scheduled for Jan. 29. This event has become one of Peterborough's main social functions.

Vancouver

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

The erection of steel bridges was the topic of an address given the Branch's civil-structural group Oct. 18 by R. C. Harris, Construction Manager for Dominion Bridge Company. Mr. Harris illustrated his talk with excellent slides of bridges in various stages of construction, both in North America and Europe. Seventy-five members were present. French hydraulics expert Pierre Danel, President of SOGREAH, addressed a joint meeting of the Vancouver Branches of the Institute and of the Professional Engineers of British Columbia. Mr. Danel traced the evolution of the turbine, and discussed hydraulic problems in canal and harbor works. About 100 engineers attended the address which was illustrated with slides and films. Seventy-five couples enjoyed a smorgasbord dinner and dance at the annual Ladies' Night, Nov. 5.

Vancouver Island

W. N. Tivy, M.E.I.C.
Correspondent

Pierre Danel, President annd General Director of SOGREAH, Grenoble, France, addressed the Oct. 26 meeting on the subject of hydraulic turbines and hydraulic structure laboratory practice. His talk covered hydraulic turbine manufacture and turbine efficiencies,

harbor layout and tidal energy. Also discussed was the design of the relatively new bulb type turbine unit.

Winnipeg

P. M. Abel, JR.E.I.C.
Correspondent

Pierre Danel, President and General Manager of SOGREAH, Grenoble, France, discussed hydraulic turbines and hydraulic structure laboratory practice at the Branch's Nov. 1 meeting. He was introduced by V. L. Dutton, professor of Civil Engineering at University of Manitoba, and was thanked by Ed Kuiper, also a Civil Engineering professor at U of M. The talk was aided by slides and a short documentary film. A lively question and answer period was enjoyed by the large audience.

Yukon

Capt. J. P. MacGowan, M.E.I.C.
Correspondent

Howard Truman, resident engineer for the Department of Public Works at Dawson City, described the Flat Creek Road at the Branch's Nov. 26 meeting. Mr. Truman summarized the construction practices, techniques and intentions of the Flat Creek Road by the use of slides and tape-recorded interviews with the general foreman and other men. The Flat Creek Road starts near Dawson City and is planned to terminate at Eagle Plains. During the past two seasons, construction has proceeded to approximately Mile 62, Chapman Lake, with 35.5 miles being constructed during the 1960 season. Because of the scarcity of road building materials on the hillsides, initial plans have been revised and building is being done in the river valleys. This is particularly the case in the Blackstone River area where gravel fill material was obtained from the river bottom. An area of scenic grandeur and a potential oil reservoir will be opened by this road.

Engineers' Wives

The Engineers' Wives' Associations, Clubs and Auxiliaries are continuing their active programs from St. John's, Nfld., to Victoria. These programs, which include social and sports events, lectures and industrial tours, are a valuable part of the Branch activities. The following wives' groups have mapped comprehensive plans for the current season: Border Cities; Calgary; Cape Breton; Corner Brook, Edmonton; Halifax and Area; Hamilton; Kingston; Kitchener, Waterloo, Galt and Preston; Lakehead; Lethbridge; London; Moncton; Montreal; Niagara Peninsula; Nipissing and Upper Ottawa; Ottawa; Peterborough; Port Hope and Cobourg; Regina and Area; St. John's, Nfld., Sarnia; Saskatoon; Sault Ste. Marie; Toronto; Vancouver and Lower Mainland; Victoria; Winnipeg.

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

Address all information to: *The Engineering Journal*, Editorial, 2050 Mansfield Street, Montreal 2, Que.

• DISCUSSION

(Continued from page 66)

points out the importance and urgency of continuing fishery research to resolve fish problems before the potential of economic power on non-fish rivers has been exhausted.

Discussion by G. Douglas Sauer, M.E.I.C.

Mr. Potter is to be complimented for his paper on a highly controversial subject — power vs. fish. His approach and conclusion — that the only answer is a choice between them — is somewhat novel and will no doubt arouse considerable discussion from both sides of the picture.

However, I believe there is still room for compromise and would like to suggest an approach to this.

Mr. Potter has noted that Moran Dam itself will not affect the Adams River run of Sockeye salmon, since it is located on the main stem of the Fraser above the confluence with the Thompson. As the Adams River run contributes by far the greatest percentage of Sockeyes, particularly during the so-called Adams River run, it is apparent that Moran would have little effect on the overall production of this valuable species of salmon.

It would therefore seem practical to proceed with further thoughts about Moran.

On the Columbia River at McNary Dam, an interesting experiment has been in process for the past three years and is still continuing. An artificial spawning station has been constructed downstream from the dam in an effort to explore the feasibility of diverting adult Chinook salmon from returning to their home spawning beds. Like the Sockeyes, the Chinooks are predominately a 4-year cycle fish, and it is not yet possible to determine the success of this experiment.

Many other experimental and research investigations have taken place in regard to determining the effect of stream blockage on migrant fish. One of the most interesting outlines is contained in the investigations at Baker Dam by the International Pacific Salmon Fisheries Commission by Messrs. J. A. R. Hamilton and F. J. Andrew in 1954. The results are quite devastating — about 63.5% of those which passed through the spillway over the dam and about 37% of those which went through the turbines were lost. The head is about 250 feet. The report also states that the subsequent reduction in catch

This large loss certainly suggests is roughly proportional to the mortality.
that the fisheries interests have a large stake in the problem of stream blocking by power or other interests.

On the other hand, the delay in development of the large hydro-electric power sites in these streams, particularly the more economical ones located relatively close to large load centers, is most frustrating and a wasting of a natural resource whose commercial value far outweighs that of the fish.

It is therefore recommended that the experimental work at McNary Dam be closely watched, and when possible, similar or related research be carried on or continued to achieve a compromise answer, rather than an aye or nay to the choice presented by Mr. Potter.

This need not delay Moran.

Discussion by J. H. Steede

I note that the figures you have used regarding the production of salmon from the Fraser River are taken from recent reports which include two very good years for the Adams River Run, at a time when salmon was bringing a very good price on the local market.

Your comments on the economic advantages of the large block of low-cost power which might be available if it should be feasible to dam the Fraser River are provocative.

We are watching with interest the efforts of the Canadian and American fisheries people to increase the productivity of barren streams below potential hydroelectric sites. If these experiments meet with the success which is hoped for, the whole economic picture of salmon production may be due for a change.

Author's reply

The time to construct the Moran Dam was calculated at five years. The financing was apparently going to be one of the easier phases even though over $42 million had to be included for interest during construction. The Company had plans worked out for a load of some two million horsepower when the plant was completed. This included exporting power to the United States. The Company believed it would be possible to arrange this with the Canadian Government although no agreements had been made.

Mr. McMordie points out the great amount of power available in the Columbia, Clearwater and Peace Rivers all unencumbered by fish.

These sources are all five mill to twelve mill power at the present load centre of British Columbia and not in the low cost primary power field that the Moran Development Company could reach.

The hope of the commentators seems to lie in fisheries research coming up with a solution. The development of artificial spawning beds below the dams at fish farms would appear to offer some hope. To the fisheries people this appears not as an alternative but as an adjunct to their resource.

With such a colossal amount of power at stake it would appear reasonable to be spending vast sums of money on research and experimentation to find the answers. The sums being spent are less than insignificant.

• INTERNATIONAL NEWS

(Continued from page 73)

the synchrotron. Until it is completed the 6 smaller bubble chambers at Brookhaven will be used for AGS research.

This new Brookhaven synchrotron represents an important advance toward the long-range goal of world physicists—discovery of the ultimate indivisible piece of matter. This machine is expected to reveal new basic knowledge since it can probe more deeply than other accelerators. However, it may pose new problems, as its predecessors have, that will require more powerful accelerators. Plans for such machines are already being made in the United States and other countries. To aid in their development, Brookhaven physicists will reveal the results of their research and will cooperate with interested physicists in other countries.

More than 1,000 persons attended last year's Annual General and Professional Meeting.

PLAN NOW
to attend the 1961 meeting
at Vancouver
May 31 - June 2

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.

*ELEMENTARE SCHALENSTATIK, 3rd. ed.

An introductory treatise on the statics of shells. Originally published as a textbook, the new edition has been enlarged and revised so as to be useful to the practicing engineer as well. After a brief explanation of the shell concept, the author discusses in detail the membrane theory of rotation shells, the bending theory of rotation shells, and specifically, the membrane theory of cylindrical shells. There are also notes on the states of stress and a tabular summary of membrane theory solutions for shells of various forms. (Alf. Pflüger. Berlin, Springer-Verlag, 1960. 112p., DM 19.50.)

*CONSTRUCTION CONTRACTING.

This book discusses the five basic management functions of organizing, staffing, directing, planning, and controlling, as they are applied to the conduct of a construction contracting business. Each area is developed from fundamentals. Typical topics covered are construction insurance, contract bonds, labor legislation, business forms, personnel and labor relations, fiscal records, safety, and bidding and estimating. (R. H. Clough. New York, Wiley, 1960. 382p., $9.75.)

*SYMPOSIUM ON AIR POLLUTION CONTROL

At the Third Pacific Area National Meeting of the ASTM in San Francisco, October, 1959, the following papers were presented and here are published:— Air pollution potential of California coastal climate; Wind and weather summaries for chemical plant design and air pollution control; Fluorescent dyes as airborne tracer materials; Colorimetric determination of formaldehyde and methanol from combustion source; determination of gaseous and particulate inorganic fluorides in the atmosphere. (Philadelphia, American Society for Testing Materials, 1960. 44p., $1.50. s.t.p. no. 281.)

*TRANSPORT PHENOMENA

An introduction to the field of transport phenomena for students of engineering and applied science. It is a parallel, systematic treatment of the three transport processes: momentum transport, or viscous flow; energy transport, or heat conduction, convection, and radiation; and mass transport, or diffusion. The media in which transport phenomena are occurring are regarded as continua, and very little is said about the molecular explanation of these processes, the continuum approach being considered by the authors as of more immediate interest to engineering students. (R. B. Bird and others. New York, Wiley, 1960. 780p., $13.75.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*INDUSTRIAL ARCHITECTURE.

This book is an attempt to capture the essence of the modern factory. Particular emphasis has been placed on current practice in the U.S., Great Britain, and Germany. The four major types of industry — heavy, light, utility, and process — are analysed in terms of the various ways in which the units for each are enclosed, serviced, and operated. Also included is a study of industrial parks, estates and districts. The text is amply illustrated by photographs, line drawings and sketches. (J. F. Munce. New York, Dodge, 1960. 232p., $14.75.)

*MATERIALS IN NUCLEAR APPLICATIONS.

This volume contains papers presented at four symposia held during the Third Pacific Area National Meeting ASTM in San Francisco, October 1959, and a literature survey of the title subject — "Radiation effects in steels." The symposia fields are: radiation effects and dosimetry (14 papers); postirradiation effects in polymers (5 papers); technical developments in the handling and utilization of water and industrial waste water; industrial water for reactor use (2 papers); ceramics in nuclear energy (6 papers). (Philadelphia, American Society for Testing Materials, 1960. 344p., $8.25. s.t.p. no. 276.)

*SYMPOSIUM ON BITUMINOUS WATERPROOFING AND ROOFING MATERIALS.

Eight papers presented at the Third Pacific Area National Meeting of ASTM at San Francisco, October, 1959, plus a paper on weatherometer data on coating-grade asphalts from a June meeting in Atlantic City. Five of the eight papers cover aspects of manufacture, inspection, applications and service requirements of asphalt and coal tar materials; the remaining three are of specialized experimental or theoretical interest. (Philadelphia, American Society for Testing Materials, 1960. 81p., $2.50. s.t.p. no. 280.)

*PRINCIPLES OF GEOCHEMICAL PROSPECTING.

Hydrochemical, biogeochemical, and geobotanical methods of prospecting for the various kinds of ore deposits in igneous, metamorphic, and sedimentary rock, and in surficial (residual) blankets, are discussed, preceded by a history of the development and a generalized treatment of the principles of geochemical indicators. Two chapters are devoted to haloes and other anomalies in overburden and soils. There is a lengthy bibliography, mainly Russian publications. (I. I. Ginsburg. New York, Pergamon Press, 1960. 311p., $10.00.)

*FROM THEORY TO PRACTICE IN SOIL MECHANICS; SELECTIONS FROM THE WRITING OF KARL TERZAGHI.

A detailed account of the personality, professional achievements and method of working of Karl Terzaghi, composed mainly of his own words through selection from his writings, with some explanatory comment. Clearly demonstrated in this manner is the way in which he established the fundamental principles of soil mechanics and then used them as powerful tools in his engineering practice. Also included is a bibliography, and contributions describ-

ing his life, achievements, and their significance. (L. Bjerrum and others. New York, Wiley, 1960. 425p., $12.00.)

*KRANKHEITEN ELEKTRISCHER MASCHINEN, TRANSFORMATOREN UND APPARATE, 2nd. ed.

The need for collected information on electrical plant troubles has inspired this German treatise on causes, results, cure and prevention of faults and failures in heavy current machines, apparatus, and plant. The book covers installation and operational faults of electrical machines, transformers and auxiliary apparatus, with particular reference to the materials employed and the troubles directly resulting from them. (R. Spieser. Berlin, Springer-Verlag, 1960. 376p., DM 48.00.)

*GRUNDBAU-DYNAMIK.

A treatise on foundation dynamics intended both for the student in civil engineering and for the practicing or research engineer. After a general introduction, vibrating systems with concentrated masses are considered, introducing the civil engineer to the theory of forced oscillation. A chapter devoted to homogenous systems follows, and the final chapter goes into the fairly unknown area of the dynamics of soil. There is a bibliography of 115 German and English references. (Hans Lorenz. Berlin, Springer-Verlag, 1960. 308p., DM 46.50.)

*STATISTICAL THEORY AND METHODOLOGY IN SCIENCE AND ENGINEERING.

An elementary text involving simple college algebra and little calculus, with the balance between theory and practice weighed towards the understanding of principles. Topic selection for inclusion was made on the basis of the "interesting and useful", and length limitations imposed by the number of course hours available. Among those selected are binomial, multinomial, hypergeometric, Poisson, and bivarite normal distributions; variance analysis and tests; nonparametric tests; linear regression; hierarchial situations; and design of experiments. (K. A. Brownlee. New York, Wiley, 1960. 570p., $16.75.)

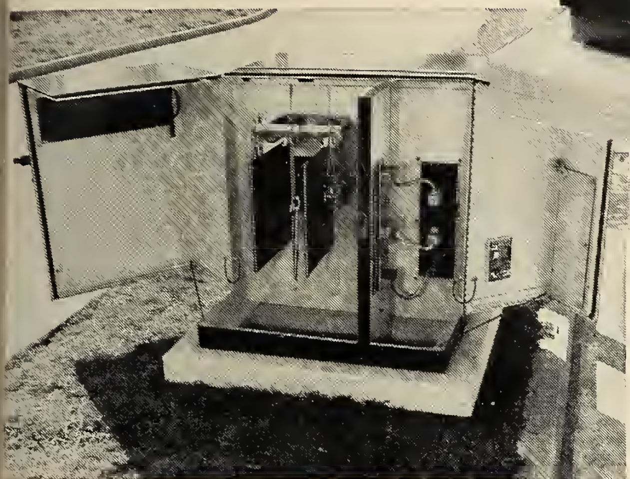
*COUPLED MODE AND PARAMETRIC ELECTRONICS.

This introduction to the theory of coupled modes shows how the use of the theory simplifies the study of coupled systems. From this point of view, it also presents a unified theory of travelling, wave tubes, backward wave oscillators, and similar microwave devices, and discusses the theory of parametric amplifiers, oscillators, and frequency converters. (W. H. Louissell. New York, Wiley, 1960. 268p., $11.50.)

*ELECTRICAL DESIGN DETAILS.

This book was developed as a quick and practical reference file of ideas for electrical design. The diagrammatic material, adapted from the magazine "Electrical Construction and Maintenance", represents all phases of electrical distribution and circuitry in industrial plants, commercial building including airports, tunnels, bridges, streets, and highways, and residential elements including private houses, farms, hotels and trailer parks. (J. F. McPartland and W. J. Novak. Toronto, McGraw-Hill, 1960. 231p., $9.75.)

For residential underground systems



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INSTITUTION OF STRUCTURAL ENGINEERS, FIFTIETH ANNIVERSARY CONFERENCE, 1958. PROCEEDINGS.

The Institution marked its golden jubilee by holding a conference, which covered the whole field of structural engineering, and was attended by delegates from all over the world.

There were ten technical sessions, at most of which four or five papers were discussed. The themes of the sessions were: the production of electric power; bridge design; composite construction, flat slabs and skin structures; various phases of structural engineering research; structural analysis; light-weight structures; precast concrete and lift slab construction; foundations and site engineering; airports and docks; mine structures, moving buildings; reinforced plastics, concrete testing, and structural engineering in the U.S. The discussion which took place on each paper is also included. (London, Institution of Structural Engineers, 1960. 404p., £5.)

***REINFORCED CONCRETE COLUMN TABLES.**

These tables have been specially prepared for practising structural engineers, architects, and designers. Special features include the extreme range of values for each column design, the wide range of rectangular column sizes, and the inclusion of values for eccentrically loaded columns both with reinforcing on all four faces and with extra reinforcing on the tension face alone. The tables are arranged in two groups — rectangular tied columns, covering 63 sizes, and spirally reinforced round columns, covering 12 sizes. (H. F. Fenlon. New York, Dodge, 1960. Various pagings, $15.00.)

ENGLISH-POLISH DICTIONARY OF BUILDING AND CIVIL ENGINEERING.

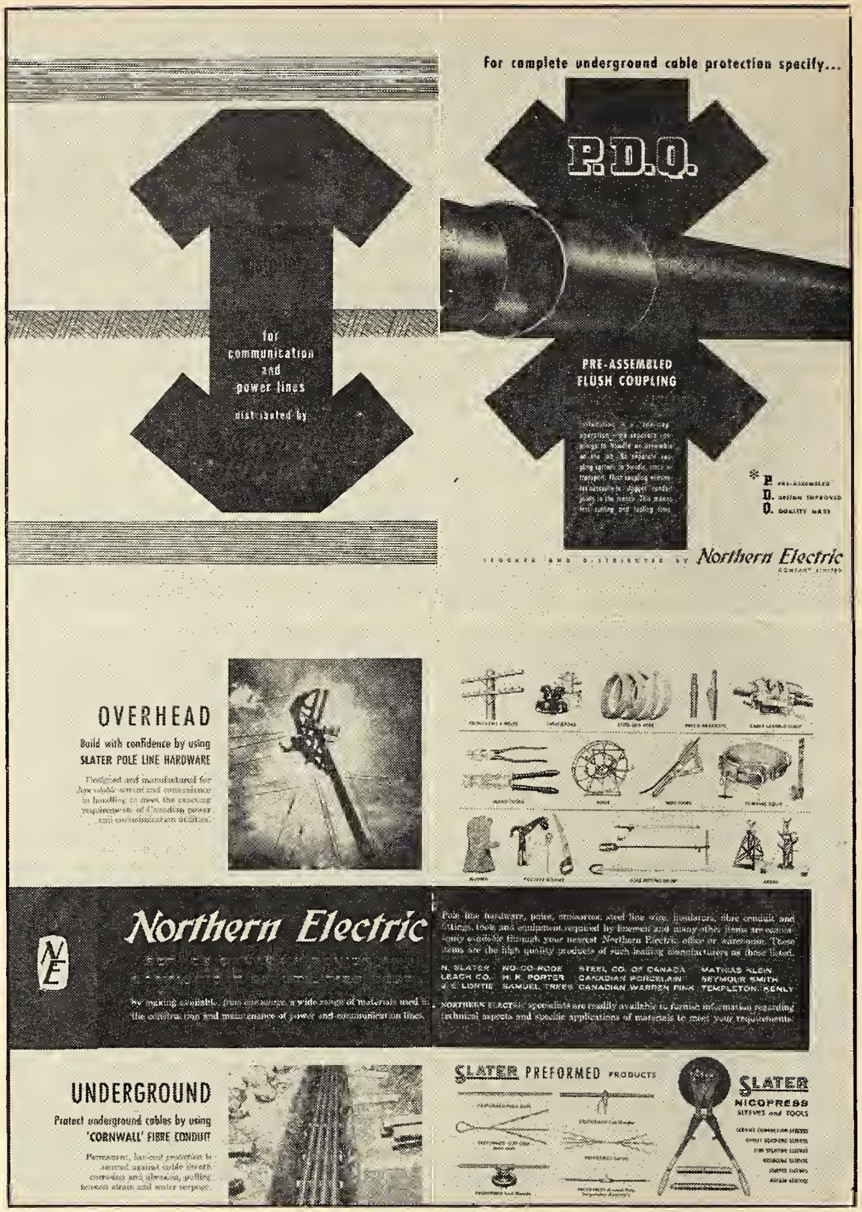
The dictionary contains over 37,000 British and American terms, with their Polish equivalents. The English terms have been taken from recent books, encyclopedias and periodicals, and cover engineering materials, architecture, town planning, all phases of civil engineering, hydraulic engineering, timber, and management. A list of English abbreviations is included, as is an index of Polish terms, keyed to the English terms, so that this volume can also be used as a Polish-English dictionary. (Ed. by A. Zboinski. Warsaw, Panstwowe Wydawnictwa Techniczne, 1959. 833p.)

ENGLISH-POLISH DICTIONARY OF MECHANICAL ENGINEERING.

There are over 38,000 technical terms in this dictionary, compiled from British and U.S. sources. The terms cover mechanics, metallurgy, foundry practice, welding, metal cutting, machine tools, automation, power, refrigeration, materials handling, transportation, missiles, etc. A list of common abbreviations is included, but there is no index of Polish terms, as there is in the previous dictionary. (Ed. by S. Czerni. Warsaw, Panstwowe Wydawnictwa Techniczne, 1960. 606p.)

(more Library Notes page 115)

Front *Back*



Centre Spread

NORTHERN ELECTRIC COMPANY LIMITED WINNING INSERT

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

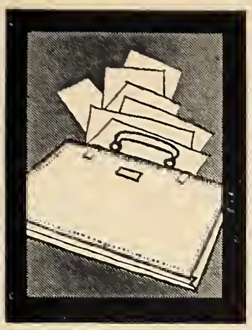
E.I.C. CERTIFICATE OF ADVERTISING MERIT

Northern Electric Company Limited has won the E.I.C. Certificate of Advertising Merit for the third time since the inauguration of the certificates in January 1959. The winning advertisement appeared in the October issue. It is a 4-page, two-colour, insert, black and orange, titled "OVERHEAD AND UNDERGROUND MATERIAL FOR COMMUNICATION AND POWER LINES DISTRIBUTED BY NORTHERN ELECTRIC".

The insert covers a variety of services and products made available to engineers through the company and lists some of the firms Northern Electric represents. The advertisement occupies pages 33, 34, 35 & 36.

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

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



Business and Industrial Briefs

Appointments and Transfers

James N. Landis, Vice President of the Bechtel Corporation of San Francisco, has been elected President of the Engineers Joint Council, New York.

J. **Hector LeBlanc** has been named President of Freezmart Co. Ltd., Toronto. In addition to his new duties, he will continue to manage the packinghouse design division of the corporation. Bertrand **England** has been promoted from Senior Sales Engineer to Vice-President in charge of engineering, development and design.

The Canadian Fairbanks-Morse Co., Ltd., Montreal, have announced the appointment of **L. A. Weom** as Assistant to the President.

E. Jack Sheare, formerly General Manager of Taylor Instrument Companies of Canada Limited, has recently been elected President of the Company.

New appointments in the Chemicals Division of Canadian Industries Limited, Montreal, include the promotion of **Dr. R. W. Allgood** to Production Manager and **J. D. Crichton** as Specialty Chemicals Sales Manager.

The new Vice President of the Shell Oil Company of Canada, Limited is **Paul L. Kartzke.**

The appointments of **George Ditchfield** to the field sales staff of the Central Ontario District and **John E. Hales** to the Montreal District have been announced by Leland Electric Company Limited.

Canadian Ingersoll-Rand Co. Limited have appointed **George J. Prew** Manager, Merchandising Division with headquarters in Montreal.

The two companies Farrington Manufacturing Company Limited and Bradma of Canada Limited recently merged to form the organization now known as Farrington-Bradma Limited, Toronto. **V. B. Gale** is the Executive Vice President and General Manager of the new company.

The Canada Cement Company Limited have changed the address of their Toronto District Sales Office to The Manufacturer's Life Building, 200 Bloor St. E., Toronto 5.

K. W. Brown, who has been Vice President and General Manager of Avro Aircraft Limited during the past year, has returned to the Boeing Airplane Company in a senior executive capacity.

Dr. R. F. Knott has been appointed research manager of the explosives division of Canadian Industries Limited. He succeeds **Dr. J. F. C. Dixon** who is now technical manager of C-I-L's chemicals division.

A. C. Martinsen has been appointed Executive Vice President and General Manager of Catalytic Construction of Canada, Limited, Sarnia, Ont.

R. B. **Lanskail** has been appointed Manager, Technical Products Marketing, RCA Victor Company, Ltd. In his new position Mr. Lanskail will be based in Calgary.

Leon Simard succeeds the late J. Edouard Simard as a director of Sicard Inc., Montreal.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

HYDRAULIC RESEARCH in the United States, has been published for the United States National Bureau of Standards. This publication, the latest in a series of annual publications dating back to 1951, contains reports on hydraulic research conducted within the past year by various hydraulic and hydrologic laboratories in the United States and Canada. Nearly 200 subjects in the field are covered.

ULTRASONIC WELDING is the title of a new booklet published by the American Welding Society. It contains 38 pages and 29 illustrations and is designed to meet a growing demand for authoritative technical literature on new developments in the welding industry.

THE BOARD OF DIRECTORS of the Shawinigan Water and Power Company has declared a dividend of 20 cents a share on the no par value common shares of the Company for the quarter which ended September 30, payable November 25 to shareholders of record October 14. A quarterly dividend of 33⅓ cents a share also was declared on the Company's Class "A" common shares, payable November 15 to shareholders of record October 19.

ATLAS COPCO AB, of Stockholm, has announced the purchase of Svenska Diamantberg Borrnings AB, a company specializing in drilling operations for testing soil, rock strata, mines and ore deposits. Svenska Diamantberg, with headquarters in Stockholm is an international company with operations in many parts of the world. Atlas Corpo, the international firm of compressed air engineers with interests in 90 countries, manufactures rock drills, air compressors, mine loaders, pumps, hoists, pneumatic tools and similar equipment.

ULTRA-THIN stainless steel now is being bonded to a variety of back-up materials which can be used in anything from skyscrapers to a homemade shower stall. Stainless steel has been bonded to various materials in the past, but it has never been done in such light gauges. Costs are cut in some cases more than half by using the new product. Much of the secret of the success of the new product lies in the bonding agent.

TWO LIVE STEAM REHEATERS to be built by the Dominion Bridge Company Limited will be employed in Canada's first large scale nuclear power plant, now being built at Douglas Point on Lake Huron. The reactor-boiler produces saturated steam at 560 p.s.i. In order to reduce the moisture content of the steam in the late stages of the turbine the steam cycle equipment includes moisture separators and live steam reheaters between the high pressure and low pressure cylinders of the turbine. Because of limited application of live steam reheaters in central power plants anywhere, no precedents or standards were available to guide bidders.

TIRE NEGLECT costs Canadian truckers thousands of dollars a year and endangers the lives of drivers, warns the Canadian Highway Safety Council. The Rubber Association of Canada reports a major cause of premature tire failure is overloading. Although the weight placed on an automobile tire is important to the motorist, too, the heavier weights and greater variations of load on trucks makes overloading a much more serious problem for truckers.

A BOOKLET has been prepared by Imperial Oil Limited to put into proper perspective statements made about Canadian oil policy and about a major oil pipeline from Edmonton to Montreal. The booklet outlines what the company feels is a sound national oil policy — one which is in the best interests of all phases of this major industry — marketing, manufacturing, transportation and production.

A FURTHER PRICE REDUCTION in the price of copper has been announced by The International Nickel Company of Canada, Limited. The new price is 28.5 cents Canadian per pound delivered Toronto. Its price had been reduced Aug. 30 to 30 from 31 cents per pound.

A NEW PLANT to manufacture PETN, an explosive material with the chemical name "pentaerythritrol tetranitrate" has been completed by Canadian Industries Limited at its Beloeil, Que. works and now is in production. The $500,000 plant consists of two detached buildings somewhat resembling sod-covered pyramids.

SCREW THREAD STANDARDS have been given a common denominator of comparison in a volume published recently. More than 2,000 standards are listed. These cover the 33 countries which have National Standards for screw threads. There are 108 illustrations of screw thread forms, together with self-tapping screws.

ABSTRACTS have been published of 188 theses accepted for the Doctor's degree at the Massachusetts Institute of Technology in the 1958-59 academic year. The 288-page paper-bound book also lists the titles of theses presented for Engineer's and Master's degrees during the year.

PLASTIC BOATS primarily for export to the United States will be made by a subsidiary formed recently by Albin Motor AB, Sweden, large manufacturers of boat engines. The new plant is scheduled to go into operation early in the spring. Concentration in the first stage will be on building sailing craft with auxiliary engines.

AN ECONOMIC ATLAS of the Soviet Union has been published by the University of Michigan Press. The atlas, by George Kish, is the first of its type published in the Western world. Based on primary sources, the 60 colored maps picture the structure of Soviet economy in terms of its 15 major regions.

THE HEILAND DIVISION of Honeywell Controls Limited has introduced a low-cost direct recording oscillograph designed for use in normal laboratory testing and evaluation. Known as the 1406 Visicorder, the new model produces instantly readable records of up to six channels of scientific and test data simultaneously. It is the fourth member of the firm's Visicorder family of direct recording oscillographs. Previously introduced models have recording capacities of 14, 24 and 36 channels.

PROPERTIES, APPLICATIONS AND STORAGE of ultra-high purity gases are discussed in a new 16-page booklet offered by Union Carbide Canada Limited, Linde Gases Division. In addition to information about several gases the booklet contains charts and graphs showing the results of extensive testing including the areas of heat conductivity, excitation potentials, and discharge characteristics.

THE NEW LONDON WORKS of Northern Electric Company Limited were formally opened this autumn. The London Works will be an entirely self-contained manufacturing operation, producing telephone and outside plant apparatus all the way from raw materials to the finished product.

THE DIVISION OF BUILDING RESEARCH of the National Research Council has started a new series of mimeographed publications in order to make publicity available in finished form the results of its fire research work. The first of these studies describes the fire research furnaces that have been installed in the fire research building which was open for use in October, 1958. The furnaces were commissioned some time ago and now are in regular operation. They will be used primarily for research purposes, but since they are the only such furnaces in Canada a limited amount of actual test work for manufacturers also will be carried out.

CONSTRUCTION has started on a new, 40,000 sq. ft. plant near Toronto for Canadian Broomwade Ltd., specialists in the manufacture and distribution of compressed air and allied equipment. The parent company is Broom & Wade of High Wycombe, Buckinghamshire, England, established in 1898.

THE BRISTOL COMPANY now is offering a single-case time-program recorder-controller in its series 500 instrument line. The incorporation of the recorder and controller into a single unit affords a 50 per cent reduction in panel-space requirements.

A PRODUCTION LINE is being moved to Saskatchewan to facilitate building part of the South Saskatchewan Dam power project. At a cost of $250,000, Sparling Tank & Mfg. Co., of Oakville, Ont., is setting up a temporary shop to make penstock liners for the Coteau Creek electric power and irrigation project of the Saskatchewan Power Commission. The plant will be dismantled after the company contract has been filled late this year.

A SERIES OF split-body valves interchangeable on a "mix and match" basis with other valves and actuators it now produces, has been introduced by Honeywell Controls Limited. The company said the addition of the new valve as well as a cylinder actuator to its product line "makes possible an intermix of diaphragm and cylinder actuators with split bodies and globe bodies to match specific applications at the lowest possible combination price."

HIGH-PRECISION deep hole drilling by a revolutionary method has been introduced to Canada by Montreal Locomotive Works, Limited. MLW says it is the first and only heavy equipment manufacturer in Canada to use a tape-controlled automatic target drill. Company officials say the new installation offers outstanding advantages over the conventional method, the most important of which are precision, reliability and repeatability.

NODULAR IRON ROLLS (type 80-60-03) manufactured for the first time in Canada, are being supplied to two of Canada's major steel companies for their galvanizing lines. The rolls were made by Canada Iron Foundries, Ltd. Diameters in inches were 60, 48, 36, and 27, with widths from 58 in. to 72 in. The rolls are normalized and stress relived with a surface finish of 16 micro.

A NEW BULLETIN concerning air line oilers is available from Gardner-Denver Company. It gives operational and specification data on oilers with half pint to five gallon capacities. Bulletin LO-2 describes the company's various size oiler models and lists the data on care and operation of pipe lines, hoses and lubrication.

FASTER ASSEMBLY of structural steel, both in shop fabrication and field connections, is made possible by a new structural bolt now produced by the Steel Company of Canada, Limited. This bolt has been designated the Stelco Heavy Hex Structural (High-Strength) Bolt, conforming to A.S.T.M. Specification A 325.

TRIPLE CAPACITY of its iron ore recovery plant at Copper Cliff, Ont., will result from an expansion program announced by the International Nickel Company of Canada, Limited. Board Chairman Henry S. Wingate said that "using a process invented by the company's research staff and successfully established in its existing iron ore recovery unit, the expanded plant will treat 1,200,000 short tons per year of nickeliferous pyrrhotite high in iron content."

THE "CENTRI-PRIME" motorpump is the newest addition to Canadian Ingersoll-Rand's line of centrifugals. This unique pump combines the lifting capabilities of a self-priming pump and the high efficiency of a standard centrifugal pump. The "centri-prime" is a compact, single-stage, single-suction, centrifugal pump with a built-in positive displacement type priming unit.

IMPROVED PERFORMANCE and uprated capacity are featured in a new four-way solenoid controlled, pilot operated directional valve announced recently by Vickers-Sperry of Canada, Ltd., a division of Vickers Incorporated. Although price and envelope size have remained virtually the same, the valve's nominal capacity of 30 gpm is 50 per cent greater than that of previous models.

IMMEDIATE AVAILABILITY of 11 new, lighter-weight, wide flange steel sections has been announced by Bethlehem Steel Export Co., Canada. The new sections are the result of a continuing experimental and research program designed to provide the construction industry with better products.

TWO BLOWERS, each capable of delivering more than 8,000 c.f.m. at a pressure of 4 p.s.i.g., have been shipped recently to the British American Oil Company gas processing plant at Rimbey, Alta. They were the first blowers produced in Canada by James Howden & Co., of Canada Ltd., at the firm's plant in Scarborough, Ont.

A $500,000 Formation-Finishing plant for the Hart Battery Company Limited has been opened in suburban Toronto. Eventually the plant, which can be expanded to triple capacity, will not only finish and to store batteries, but also will manufacture the company's complete line from the automotive to the custom-made industrial battery.

UNION CARBIDE Canada Limited has opened its new head office building in Toronto. The 11-storey building is built in two sections with a main structure and an elevator tower in the rear. It will serve as head office for the company and its six divisions — Bakelite, Chemicals and Plastics, Consumer Products, Linde Gases, Metals and Carbon, and Visking.

THE 1960 SERIES of addresses on industrial relations has been published by the University of Michigan. This is a collection of 17 talks on personnel and industrial problems ranging in subjects from employee compensation to supervisory training.

THE 10TH EDITION, completely revised, of the Diesel Engineering Handbook, now is available. This is a comprehensive reference work on diesel, dual fuel, gas-burning engines, components, accessories and maintenance procedures. EIC

Beaver Bill says —

Dear Jim,

We were pleased to receive your letter last week and to hear the new job is going so well. You must find it different after the big city, but it's like meeting an old friend though, isn't it, to find a Branch of the Institute near at hand? Remember, Jim, wherever you are, the objects of the Institute are the same.

In a nut shell, the prime object of the Institute is to develop and maintain high standards in the engineering profession. It's there to advance the professional, social and economic welfare of our members, and to enhance the usefulness of the profession to the public.

The Institute makes it easier for members to acquire professional knowledge, and to exchange it. One way this is done is to work with universities and other educational institutions to advance engineering education.

Engineers should mingle with other professionals and with members of other technical societies—and the Institute helps here too.

Another point, and this is basic, is the encouragement of original research, and the study, development and conservation of Canada's resources.

Best of luck to you and the family. Write again soon.

Sincerely,

• LIBRARY NOTES

(Continued from page 102)

*PHOTOGRAMMETRY AND PHOTO-INTERPRETATION, 2ND. ED.

This is the second edition of "Aerial Photographs in Forestry," the title change indicating broadening of the scope to serve all who can use aerial photographs as a professional tool — geologists, soil scientists, botanists, geographers and engineers, as well as foresters. The five parts of the book discuss in detail aerial photographs, photogrammetry, mapping, photo-interpretation, and finally the special applications in forestry. (S. H. Spurr. New York, Ronald Press, 1960. 472p., $12.00.)

DESIGN AND CONSTRUCTION OF SANITARY AND STORM SEWERS.

The latest of the A.S.C.E. Manuals of Engineering Practice, this volume was prepared by a joint committee of the A.S.C.E. and the Water Pollution Control Federation. It covers all phases of the subject, commencing with a chapter on the organization and administration of sewer projects. Other topics covered are preliminary surveys, calculation of the quantities of sanitary sewage and storm water to be handled, hydraulics, special structures, design of sewer systems, structural requirements, materials, construction plans, specifications and methods, and sewage and storm water pumping stations. Useful bibliographies are included. (B. H. Swab, Committee Chairman. New York, American Society of Civil Engineers, 1960. 283p., $7.00.)

*DIGITAL COMPUTERS AND NUCLEAR REACTOR CALCULATIONS.

A primary objective of this book is to present to the nuclear engineer or scientist an introduction to high-speed nuclear-reactor calculations. One small reactor calculation is discussed thoroughly and a number of representative types of calculations is considered briefly. The first four chapters deal with an introduction to reactor problems, digital computers, programming, and numerical analysis, and the last four with considerations involved in actual reactor calculations. (W. C. Sangren. New York, Wiley, 1960. 208p., $8.50.)

*THE SURFACE CHEMISTRY OF METALS AND SEMI-CONDUCTORS.

This volume contains the papers presented at the 1959 symposium co-sponsored by the Electrochemical Society and the Office of Naval Research. Contributors from France, Germany, Australia and the U.S. are represented. All twenty-two papers are in English. The material is grouped in five parts — chemistry and physics of surfaces; imperfections and surface behaviour; electrode behaviour of metals and semiconductors; surface reactions in liquid media; and, surface reactions in gaseous media. (Ed. by H. C. Gatos, New York, Wiley, 1960. 526p., $12.50.)

*THERMOELECTRICITY.

Much of the material in this book is from the 1958 Conference on Thermoelectricity sponsored by the U.S. Naval Research Laboratory. Section two deals with basic parameters, examining the physics of the properties which determine thermoelectric performance and discussing thermal conduction and electronic transport in terms applicable to thermoelectric materials. Section three studies the chemical and physical properties of materials at high temperatures. Section four discusses the measurement of material properties, emphasizing high temperatures, and examining the relative merits of static and transient methods of measuring thermal conductivity. (Ed. by P. H. Egli. New York, Wiley, 1960. 407p., $10.00.)

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CONTENTS

IN THIS ISSUE

Test Buildings in Building Research is discussed with authority by two executive staff engineers of the National Research Council's Division of Building Research. Dr. **Neil B. Hutcheon,** M.E.I.C., is Assistant Director of the Division in Ottawa. **G. O. Handegord,** M.E.I.C., is Officer in Charge of the Division's Prairie Regional Station. Both are Saskatchewan natives. Dr. Hutcheon was born in Rosetown and received his Bachelor's and Master's degrees from University of Saskatchewan and his Ph.D. from University of London. Mr. Handegord was raised in Regina. After receiving his B.Sc. in Mechanical Engineering from University of Saskatchewan he went on to University of Illinois where he earned his Master's degree. In their paper they point out that test buildings are by no means a consistently good approach in research into building problems. Certain phases of performance studies are investigated with profit by test buildings, but many difficulties are encountered.

William B. Rice, M.E.I.C., Associate Professor in the Department of Mechanical Engineering at Queen's University, presents the results of an experimental investigation in his paper, *The Formation of Continuous Chips in Metal Cutting.* Described is a mechanism, quite different from those assumed in the classical analyses, which was observed during orthogonal cutting. Mr. Rice obtained his B.Sc. from Sir George Williams College, Montreal, in 1950 and four years later received his B.Eng. from McGill. He earned post graduate degrees from McGill and l'Ecole Polytechnique in Montreal.

Carson Templeton, M.E.I.C., is the senior partner of a Winnipeg consulting engineering firm which conducted studies for a Royal Commission on Flood Cost Benefits. The Commission was established by the Manitoba government to assess which of a number of flood protection schemes proposed for the province were economically feasible. It is on that work that his paper, *Benefit-Cost Analysis of the Greater Winnipeg Floodway,* is based. Mr. Templeton, a graduate of University of Alberta, had extensive experience in similar work before establishing his own consulting firm in 1955.

A life line vital to the economic well-being of northern Ontario is being provided by a bridge which will link the twin cities of Sault Ste. Marie, Ont., with Sault Ste. Marie, Mich. *Sault Ste. Marie Bridge Design* is described with authority by **Carl H. Gronquist,** a partner in the New York consulting engineering firm of Steinman, Boynton, Gronquist and London. A native New Yorker, Mr. Gronquist received his graduate and post-graduate education in engineering at Rutgers University. He has extensive experience as a project engineer in charge of design and construction, and in charge of preliminary design and report on numerous bridges. In his paper, Mr. Gronquist deals not only with the design of the Sault Ste. Marie Bridge. He also puts the entire project in its proper perspective with details concerning need, history, geography and services.

Glacial-lake clay deposits in some areas of the Great Lakes were, at one time, up to 100 feet thicker than they now are. **G. T. Hughes,** M.E.I.C., explains this in his paper, *Glacial-Lake Deposits — the determination of their original depth in the Great Lakes region.* Mr. Hughes is an Associate Professor of Civil Engineering at the Royal Military College of Canada, Kingston. After graduating from University of Alberta where he obtained his M.Sc. in 1953 he taught at University of Saskatchewan. Mr. Hughes then worked in British Columbia for a firm of consulting engineers in soil mechanics and foundation engineering, and four years ago joined the R.M.C. staff.

H. R. Wright, M.E.I.C., points out that in most instances the cost of power in an industrial operation is not a major part of the total product cost. *Economic Aspects of Industrial Power Plants* deals with the alternatives of investing capital in a generating plant or of buying power from an outside source. Mr. Wright, a graduate of University of British Columbia, brings 29 years of experience to bear on the problem. He started as a design engineer on hydroelectric plant construction and now is Vice-President of Swanson Wright & Co., Engineers Ltd. — a consulting firm in Vancouver.

The purpose of *Trends in Electrical Engineering Education* is to collate some of the current trends in one place and under one title. **Dr. B. R. Myers,** M.E.I.C., has attempted to give the situation a useful perspective in guiding the engineering educator's thinking in matters of curriculum planning. Dr. Myers is Professor and Chairman, Department of Electrical Engineering, University of Waterloo. He previously was a member of the technical staff of Bell Telephone Laboratories, Inc., Murray Hill, N.J., and was with the Circuit Theory Research Group, Electrical Research Laboratory, University of Illinois.

Robert F. Legget, M.E.I.C., in his paper, *Early Ottawa and Engineering,* treats with nostalgia and admiration the emergence of an early construction camp to the bustling community of Bytown, and finally to the proud capital of Canada. Engineering played a vital role in the growth of Ottawa, and Mr. Legget expresses disappointment that some of these engineering landmarks soon may vanish. Mr. Legget earned an M.Sc. in Civil Engineering at University of Liverpool in 1925, and four years later came to Canada. After serving on the staff of Queen's University and University of Toronto he moved to Ottawa where he started the Division of Building Research of the National Research Council. He has been Division Director since 1947.

Beaver Bill appears this month on pages 98 and 134. **Stan Cassidy** has a membership reminder on page 118.

COVER ILLUSTRATION

The raising of the flag marks the placing of the last beam in the thirty-four storey CIL House, at present Montreal's tallest building. The beam weighs two tons and is forty-two feet long.

Test Buildings in BUILDING RESEARCH

G. O. Handegord, M.E.I.C.,
Research Officer, Prairie Regional Station, Division of Building Research, National Research Council, Saskatoon.

N. B. Hutcheon, M.E.I.C.,
Assistant Director, Division of Building Research, National Research Council, Ottawa.

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

THE USE of test buildings is by no means a consistently good approach in research into building problems. Test buildings may be useful for certain phases of performance studies, but as in most experiments, the difficulties in arriving at sound and useful conclusions increase with the number of variables introduced. The kinds of building research studies for which test buildings are most useful are discussed, and examples given. Test buildings used in various projects of the Division of Building Research are described.

Many people conceive a building research program as requiring full-scale test buildings, specially designed and instrumented for experimental purposes. In the housing field particularly, the concept of the "research house" appeals to the layman. He is likely to regard this as being at once the minimum and the maximum experiment required to prove a point. He is unlikely to differentiate between the use of an individual house, incorporating a variety of new materials and ideas, and the more realistic use of groups of houses incorporating certain specific variations. The common view appears to be that investigation of actual houses under actual conditions is a useful method of obtaining practical answers in a short period of time.

The scientist has never found this approach fully acceptable, preferring to conduct laboratory experiments under controlled conditions, followed by field application and observation. This apparent obsession of the scientist with controlled experiment is often difficult for the layman to understand, particularly in such a practical field as building. This paper suggests reasons for this attitude and discusses the philosophy of test buildings on the basis of experience gained in the building research field over the past ten years. Particular reference will be made to the Canadian use of test buildings and to the approach followed by the Division of Building Research of the National Research Council in the use of small test huts.

Tests on Full-Scale Houses

A full-scale house is, by itself, a complex arrangement of materials and components that can be described accurately only by means of a set of fairly detailed plans and specifications. The possible differences that may exist between houses, in materials, structural details, window arrangements, over-all shape and size, to name but a few variables, are almost without limit. Some of these differences may have little or no influence on the particular performance features to be investigated, but even if some factors can be ruled out on this basis, the number of features having possible influence on the result to be studied will still be large.

The variables inherent in house construction are only part of the problem; the complex effects of the exterior environment must also be considered. Wind, temperature, humidity, radiation, precipitation, and other factors that make up the weather, are all uncontrolled variables, acting sometimes separately and sometimes in combination. Some features of house performance may be related to one particular factor, but more often the combined effects of two or three factors are significant. Daily average values of outside temperature, for example, may represent a primary variable in one instance, but if freeze-thaw action is involved the related fluctuations of temperature and solar radiation become important. On the one hand the transient behaviour of weather factors may affect performance; in other cases the cyclical aspects over longer time intervals may be the important influence. Even annual weather cycles may change significantly at any one location, requiring a study to be continued over a period of several years. The weather thus not only increases the number of variables involved, but may introduce a time factor which requires the duration of studies on actual buildings extended to cover long periods, with corresponding increased cost.

There is yet another characteristic of full-scale house testing that complicates the situation, the question of occupancy. Occupants are normally necessary, both to simulate the actual case and for economic reasons. Although it is conceivable that the influence of the occupants on the interior environment could be duplicated artificially for certain studies, to do so in all other respects would be difficult and costly. Certainly from the economic point of view, the use of unoccupied houses in large numbers can seldom be justified. In any case, the variables introduced must still be contended with and in the majority of cases using real occupants, the differences between the various families involved must be recognized.

Two examples will serve to illustrate the marked influence which differences in the habits of occupants can have on studies in actual houses. An attempt to compare the summer comfort conditions in two occupied houses of widely different constructions failed because the differences attributable to the houses themselves were effectively masked by the uncontrolled opening and closing of

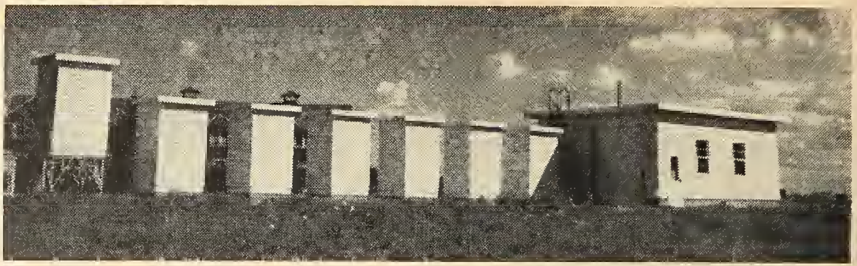
Fig. 1. Early test hut in Norway.

windows. In another case two houses were fitted with aluminum windows and frames on an experimental basis and were to be observed over one winter. The tenants in one house reported no difficulties with the windows. They did, however, ventilate the house extensively by opening windows, and dried all washing outdoors, so that the indoor humidity in winter was so low as to cause no condensation on the aluminum frames. The tenants in the second house said the windows were satisfactory but on examination after a period of cold weather a coating of as much as one inch of ice had accumulated on the warm side of the window sills, a condition that would have been quite unacceptable to many tenants. These tenants never opened windows in winter and dried washing indoors, thus maintaining a high moisture condition in the house.

Very few planned, large-scale house performance studies have been carried out in Canada. There have been, and probably will continue to be, studies on groups of a few "experimental" houses designed to demonstrate or evaluate some specific characteristics, but the results from such experiments are often of limited value. This approach was tried initially by the Division of Building Research in its early formative years, before its laboratory and other research facilities were available.

Two similar houses were built in 1947 at the Montreal Road site, as part of a staff rental housing program. These houses incorporated a variety of new materials and equipment, as well as involving one or two departures from conventional structural features. The observations made and the reports of the tenants were interesting and informative, but any conclusions that could be drawn had very limited application. Many of the features could have been studied to greater advantage in the laboratory had such facilities been available at the time. Perhaps the most significant results were to be found in the experience gained by the research workers involved.

On rare occasions an opportunity is provided in which the number of variables within a group of buildings may be reduced so as to make possible a designed experiment with a small number of samples. When such situations are recognized by interested people, useful results may be obtained with a minimum of expense. A notable example in Canada was the work of F. L. Lawton at Arvida, Quebec, in 1930 to 1935.[1, 2] The main study conducted by Lawton involved eight houses of identical plan and construction in which different insulation arrangements were employed. The houses were electrically heated, with the energy input metered accurately; the householders were co-operative to the extent of maintaining records of interior conditions. The nature of the experiment permitted the author to draw some fairly definite conclusions regarding the comparative thermal performance of the houses and to relate these to previous, less complete, investigations in a roughly quantitative manner. Even with close similarities within a group of houses, however, there were still many variable factors to complicate the analysis.



(Photo: National Film Board of Canada).

Fig. 2. Outdoor test station at Saskatoon showing the service building, six wood-frame test huts constructed over a service tunnel, and a standard hut on the left.

The need for statistically sound evidence from a large number of houses, under the wide range of climatic conditions and with the large number of variables to be contended with, is normally recognized by manufacturers of building products. Development departments in such organizations are continually producing new materials that must be tested to determine their suitability for use in houses across Canada. These products are tried out on a field basis in as many cases as the manufacturer can afford. When their performance has been tentatively established, they are released for sale. They therefore come to be used in a large number of houses across the country with their expected performance being confirmed or questioned through the medium of reports to the supplier. The manufacturer inevitably experiments to some degree with his customers in this way, using the information he gains to improve the performance of his product in future production.

This is the only economic method that he can utilize for no matter how much money is available for testing, it is not enough to enable him to cover all conditions to which his product will be exposed. The manufacturer's problem is really the same as the research worker's problem — he must do what it is possible to do, having in mind the requirements of the situation. The manufacturer, like the researcher, utilizes the scientific method. Observations of the performance of the product, isolation of the factors causing the effect, the development of hypothesis explaining the effect, and subsequent testing to confirm the hypothesis, summarises the procedure followed. The objective is the accurate prediction of performance, achieved through synthesis of the available information and experience.

The Use of Small Test Huts

Apart from the broad, all-inclusive field observation approach used by the manufacturer and the costly, planned statistical study of groups of experimental houses, there is another research technique that has been used with considerable success. This method involves the use of small, simple test buildings exposed to actual weather conditions. It has been used occasionally in studies of the thermal and moisture performance of building sections in North America and in the Scandinavian countries.

The first use of small test buildings for thermal studies on walls occurred in Canada in the period from 1920 to 1925, and in Norway at about the same time. Professor A. R. Greig, at the University of Saskatchewan in Saskatoon[3] compared the heating requirements of several huts of identical size, constructed of different materials. Initial measurements of electrical heat input were made, with interior conditions under manual control, but the following year automatic control was utilized. Because of the simplicity of the hut construction, not only were relative thermal values obtained but reasonable estimates of thermal coefficients of walls were possible.

Dr. Andreas Bugge[4] utilized the same basic approach at Trondheim, Norway (Fig. 1), with over 27 test huts of different construction. He later employed a technique similar in principle to the guarded hot box, which permitted the evaluation of the thermal properties of individual walls or roofs in these test structures.

Small test huts have the obvious advantage over full-scale test buildings of low cost, permitting a much larger number of units to be considered in an experiment. They need not conform to any particular shape or configuration, and may be as simple in construction as is possible while still in keeping with the design of the experiment. The variables associated with occupancy are eliminated and the restrictions imposed by the safety and health requirements of building codes are not applicable. Changes in construction features are more readily made to suit the changing demands of the experiment. Simpler structures permit simpler instrumentation. Measurement of mass and energy flow are more readily obtained and can be more easily analyzed than in complex, occupied buildings. Simpler, standardized shapes may considerably reduce the complications associated with wind and other weather phenomena.

Studies involving variations in construction, where the behaviour of individual panels under predictable exposure conditions alone is of interest, may be adequately handled in multi-panel test buildings. The test building in this case can be a simple single structure with exterior walls, roof, or floor, made up of different components or combinations of materials. The various panels are subjected to the same indoor and outdoor environment when similarly orientated and direct comparison becomes possible. Certain advantages of the "separate hut" approach in the heat and moisture flow aspect are lost, but a great deal is gained by the ease of panel removal for observation and measurement. The multiple panel test building has been used very successfully in the United States, notably at Pennsylvania State College and at the National Bureau of Standards. The method has particular advantages in the moisture performance field, representing a materials exposure approach, the test building serving only as an enclosure in which representative conditions may be maintained.

The smaller test huts are not without their disadvantages and limitations. Important characteristics of the simulated full-scale buildings are lost in size reduction. Aerodynamic simulation is impossible under actual conditions and over-all thermal and moisture storage capacity cannot be duplicated. In many fields the small test building is entirely unsuitable, such as in heating system performance studies, structural testing, foundation performance, and architectural planning, to name a few. In the materials field, however, particularly in the performance of building enclosures, the test hut has great potential, the basic problems with the method being in the selection of exposure conditions, internal and external, and in the instrumentation and processing of results.

The Use of Test Huts by the Division of Building Research

Test huts for studies in the field of thermal performance of walls were first erected by the Division of Building Research in 1950 in Ottawa and Saskatoon. At that time the Division had no laboratory facilities for thermal testing of walls and there was need for some information on the performance of newly developed materials and wall designs. In Ontario, insulated masonry construction was being proposed, and in the Prairie Provinces various new types of insulation and insulation arrangement for wood-frame construction were being introduced.

Preliminary planning for a test hut installation had been underway at Saskatoon by the University of Saskatchewan. This work led to the establishment of the Prairie Regional Station of the Division in Saskatoon, and the design and construction of an Outdoor Test Station on the campus of the university there (Fig. 2). This outdoor test facility provided an underground tunnel to permit access to six individual test huts from below (Fig. 3).

The thinking of the Saskatoon group influenced the design of the huts in Ottawa in so far as instrumentation and basic design were concerned. The huts were heated electrically to maintain constant interior air temperatures, with air circulation maintained using a fan. Initially, control of temperature only was employed, but in subsequent studies controlled humidification was added. In all cases the total energy input was measured on a daily basis and became the primary parameter of performance.

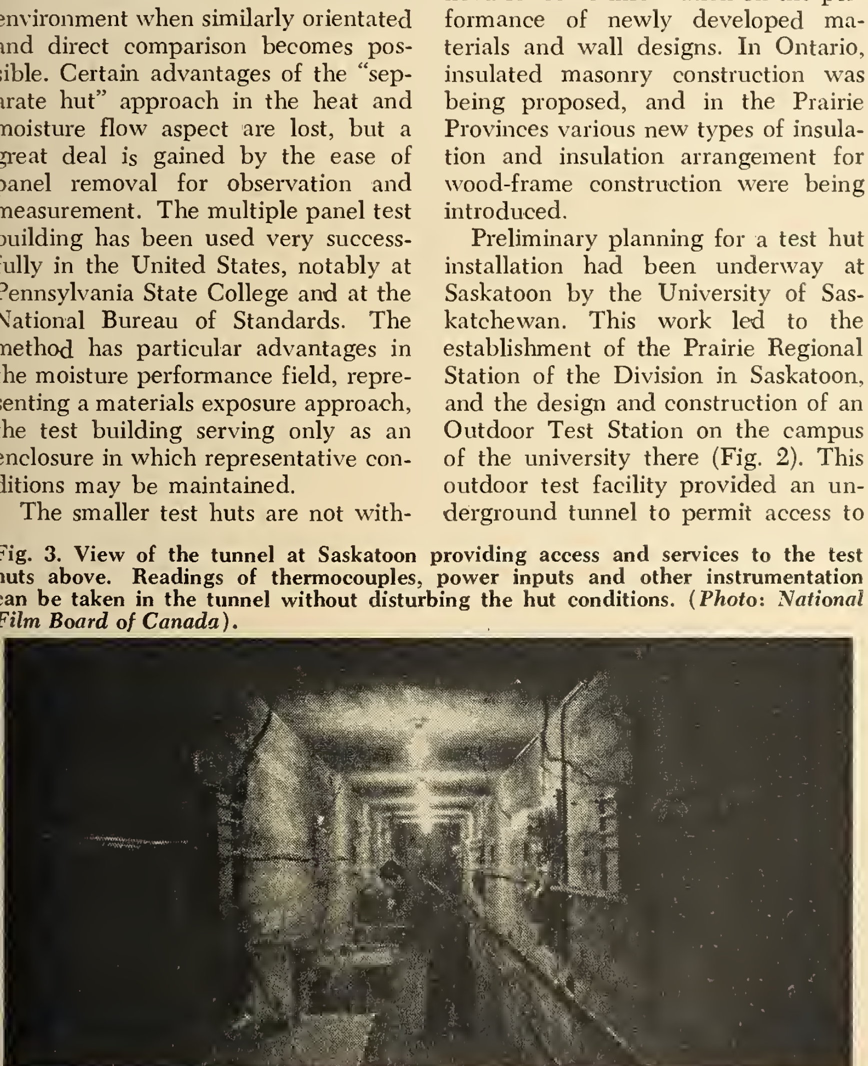
The Ottawa huts, involving unit masonry walls and incorporating variations having more significance from the moisture point of view, came to be regarded with somewhat different emphasis than those in Saskatoon. The influence of rain water absorption by masonry, coupled with the temperature-induced migration of moisture, led to studies which overshadowed the original relative thermal performance concept. Ottawa huts came to be regarded, quite naturally, as providing a means for exposure of walls to climatic conditions of Central Canada.

The Saskatoon installation had been specifically designed for thermal performance studies of variously insulated wood-frame walls. It had been anticipated that, in addition to overall thermal comparison between huts, correlations between heating requirements per unit temperature difference and wind velocity, as well as solar radiation, would be attempted. The north and south walls of each hut were also well instrumented for temperature and moisture content measurement in preparation for studies of transient conditions and solar radiation effects.

Enthusiasm for the test hut approach within the Division led to another development, that of using a "standard hut" as a type of calorimeter to be used in establishing climatic differences between various regions (Fig. 4). The thought was that the heat input to the test hut would be a measure of the combined effects of wind, outside temperature and solar gain on a small structure and, as such, would be indicative of the heating requirements for a particular area. Four such standard huts were erected, one at Saskatoon, Fort Churchill, Manitoba, Ottawa and State College, Pennsylvania. These huts were of insulated frame construction raised above grade level on a light metal stand, and heated electrically to maintain a constant inside air temperature (Figs. 2 and 4).

A useful comparison of the huts at Fort Churchill and Saskatoon was

Fig. 3. View of the tunnel at Saskatoon providing access and services to the test huts above. Readings of thermocouples, power inputs and other instrumentation can be taken in the tunnel without disturbing the hut conditions. (*Photo: National Film Board of Canada*).



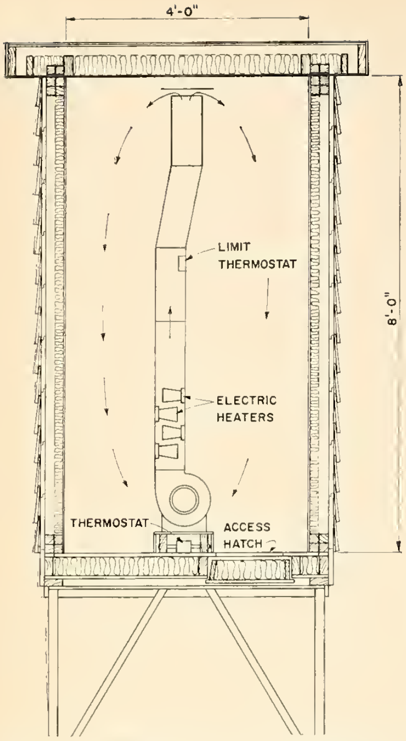


Fig. 4. Cross-section of the standard hut of the type exposed at Saskatoon, Churchill, Pennsylvania State College, and Ottawa.

made during the first year of operation in 1951, and interest was stimulated by the correlation found of heat input with wind velocity. A similar analysis of records from the six Saskatoon huts was undertaken but yielded rather disturbing results. It became apparent that the Saskatoon-Churchill hut agreement was largely fortuitous, and that the effects of variable air leakage between huts made useful comparison quite difficult. Correlation of daily heating requirements with wind velocity showed not only discrepancies between huts, but for the same hut from season to season. Disturbing though this was, the magnitude of the effect on average seasonal values for the individual huts was small.

Attempts were made to determine the air leakage characteristics of the huts directly, using a pressurization technique, and later employing tracer gas methods. These tests, admittedly incomplete, failed to establish any definite relation between measured leakage and heat input versus wind characteristics. It could be concluded only that the leakage of the individual huts changed with time and resulted in a thermal loss dependent on wind direction, velocity, and temperature difference.

The gradual development of laboratory facilities for steady-state thermal studies on built-up wall sections, both in Saskatoon and Ottawa, brought the test hut approach into new perspective. At best, it appeared that the hut technique offered only relative evaluation of wall thermal properties, and this only after a considerable time. A proper average value was obtained only after one year's operation; verification might require one to two more years of operation. It thus became clear to those concerned that the huts were of value in two particular fields:

(1) Studies of the performance of components under weather conditions that could not be easily reproduced or defined in the laboratory; and

(2) Performance studies involving periodic effects, dependent as to source and cycle on natural weather conditions and seasonal frequency.

These principles guided subsequent work at the two test locations. Studies at Saskatoon concentrated on the thermal effects produced by natural ventilation of the wall cavity. The investigations in Ottawa, concerned with cyclical effects, were concentrated on the summer-winter moisture migration reversal in insulated masonry construction.

Discussion

Test buildings for use in building research may range from existing structures, built for the usual purposes without thought for research, to small simple enclosures designed for the exposure to the weather, of building materials or components. Between these two extremes there may be individual houses of unique design, groups of buildings having certain similarities, intentional or unintentional, full-scale houses differing in some singular predetermined respect, or unoccupied huts designed to obtain information on one particular aspect of performance. The main difference in each case lies in the number of variables essential in evaluating the results obtained.

The vast number of existing houses that have been built in recent years provide a statistical "population" which can be "sampled" to obtain information describing the conditions of exposure of building materials and components. Records of temperature and humidity conditions indoors, fuel consumption, and foundation measurements can usually be accumulated with simple instrumentation and with the co-operation of the homeowner. In some cases, more detailed observations can be made. This information, obtained on an organized basis, can be used to define the conditions or to determine procedures for studies with small test buildings so that they may simulate the actual cases. Significant results can then be obtained with only a limited number of samples.

The utilization of these two types of "test" buildings, complementing each other, relegates the use of full-scale experimental houses to a few special cases only. It is indeed fortunate that this possibility exists, for the limited-number, full-scale experimental-house approach exhibits the disadvantages of both extremes. Almost as many of the primary variables as are involved in actual houses must be accounted for with only a token number of samples. The instrumentation and analytical techniques must be far more complex than with small-scale huts. Much more careful and extensive experimental design procedures must be followed, with little chance of subsequent changes being made except at considerable cost.

The concept of using actual buildings in conjunction with small test buildings and laboratory studies is not new, since the three progressive steps — from laboratory to pilot scale to full scale—have long been recognized as desirable in the development of industrial processes. The application to buildings is not, however, always so straightforward as in industry because of the number and complexity of the variables entering into the full-scale building situation, thus complicating the full-scale experiment.

Information relating to actual exposure conditions and to the performance of materials may be discovered either by design or by accident, in both actual buildings and in test structures. In the latter case, certain unexpected factors come to light more frequently because of concentrated and repeated observation, but information obtained through reports of problems from the field are still of great value.

Contrary to popular view, an experimental building is not always particularly useful in building research. For some purposes a building may represent but a single case from which little can be learned. In certain other cases a complete building may be the most suitable means for establishing realistically the conditions desired for study, but will seldom provide by itself an entirely satisfactory basis for experiment. Most problems can at some stage be handled best in the laboratory. There is a continuing challenge in building research to learn how best to combine laboratory and full-scale experiments in the solution of particular building problems.

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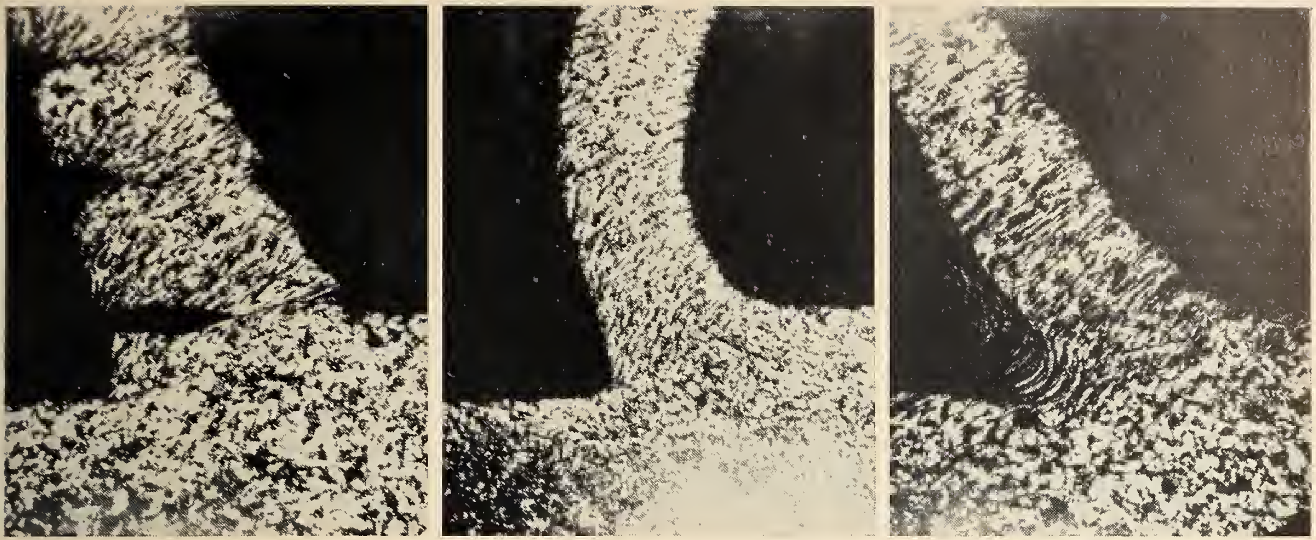


Basic Chip Types — Ernst.

THE FORMATION OF
Continuous Chips in Metal Cutting

Results of experimental investigations into the formation of continuous chips in metal cutting are presented. Observation of these chips using high speed photography is also described.

W. B. Rice, M.E.I.C.,

Associate Professor, Department of Mechanical Engineering, Queen's University, Kingston, Ontario.

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

CLASSICAL ANALYSES of chip formation are based on the assumption that a continuous chip is formed by a process of simple shear.[1, 2] In general the results of these analyses cannot be justified experimentally.[3, 4] The suspicion that the assumption of a process of simple shear represented an oversimplification prompted the experimental investigation reported here.

The results showed clearly that, in general, the process is quite different from that usually assumed. Further, the mechanism of chip formation observed provides an explanation for two important phenomena which could not be satisfactorily explained in terms of a process of simple shear. These phenomena are:

Chip curl, and
Cratering wear.

Orthogonal Cutting: The investigation was limited to the case of orthogonal cutting, that is, to the case of a straight-edged cutting tool moving relative to the workpiece in a direction perpendicular to the cutting edge. Experiments disclosed that the lateral flow is negligible. That is, the process is essentially two-dimensional. It is emphasized that the chip is not peeled off, as the chip thickness is usually greater than the depth of cut.

Chip Classification—Ernst

Ernst[5] described three fundamental types of chip which he observed in orthogonal cutting. Shown above, they are:

- Type 1—Discontinuous;
- Type 2—Continuous (ribbon-like);
- Type 3—Continuous with built-up edge. That is, with a more-or-less stable deposit of workpiece material on the tool tip.

The author is responsible for the extra designation "ribbon-like" for the Type 2 chip. The reasons are presented below.

Classical analyses of Chip Formation

Merchant[1] proceeded to a mathematical analysis of the mechanics of formation of the Type 2 chip. He assumed that the process was one of simple shear characterized by a shear plane extending from the tool tip to the intersection of the free surfaces of the chip and workpiece. To illustrate the process Merchant devised a simple model, the progressive displacement of cards in a stack. As shown in Fig. 2 the cards are inclined at an angle, ϕ, called the shear angle, to the workpiece surface.

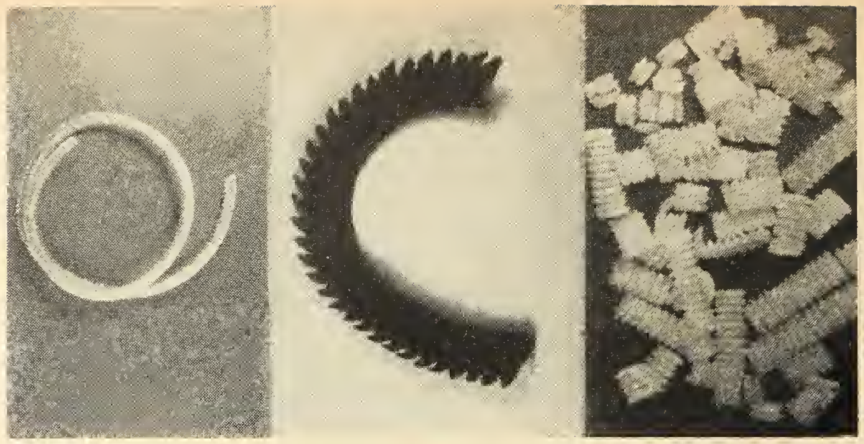


Fig. 4. "Segmented" Continuous Chips — Aluminum, Steel, and Wax.

Using this model, and invoking the minimum energy principle, Merchant obtained an expession for the shear angle in terms of

α = the rake angle

β = the *nominal* friction angle at the tool-chip interface, and

τ = the *nominal* shear stress on the shear plane

namely $\phi = (\pi/4) - (\beta/2) + (\alpha/2)$

Lee and Shaffer[2] argued that the solution for the shear angle is found in the configuration which gives:

1. Minimum machining force, *and*
2. Satisfactory stress distribution. Stresses induced within the chip are considered *satisfactory* as long as the yield stress is not exceeded.

The analysis is based on the assumption that the process may be represented by a *particular*, extremely simple, uniform stress field.

They concluded that Merchant's expression for ϕ is satisfactory when the rake angle α is greater than the friction angle β; but that in the reverse situation, which is more common

$$\phi = (\pi/4) - \beta + \alpha$$

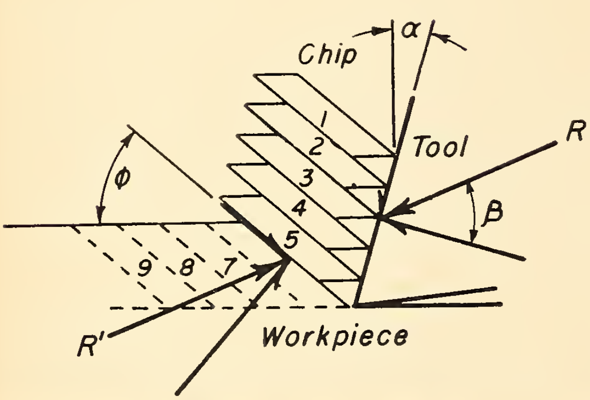
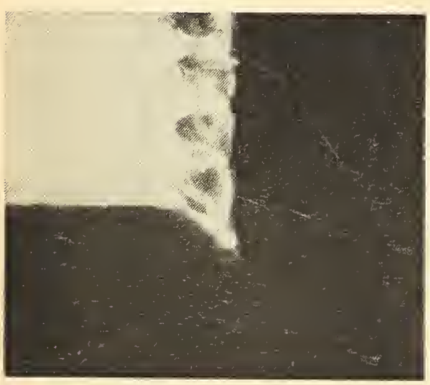
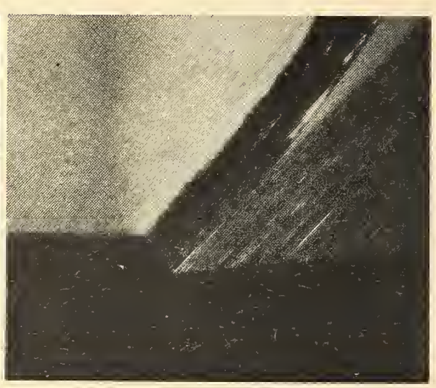


Fig. 2. (left) Schematic Representation of Cutting Process — Merchant.



α = 0 degrees



α = 45 degrees

Fig. 3. (below) "Segmented" and "Ribbon-like" Continuous Chips.

They recognized that for small values of α or large values of β, ϕ could be zero or negative — an impossibility. They noted that under these conditions a built-up-edge may be observed. For these conditions they assumed that *another* simple stress field represents the process, and deduced the expression

$$\phi = (\pi/4) - \beta + \alpha + \Theta$$

where Θ is a measure of the built-up edge.

Experimental Results

The fact that in general these expressions cannot be substantiated experimentally led to the suspicion that the classical model represented an over-simplification, and prompted the experimental investigation utilizing high-speed photography as the major research tool.

The workpiece was specially extruded 26 ST Aluminum, and the tools were 18:4:1 high speed steel.

Ribbon-like and Segmented Continuous Chips: As shown in Fig 3, two types of *continuous* chips were observed. These were the Type 2 chip of the classical analyses, herein designated "Ribbon-like" to distinguish it from a new type of continuous chip consisting of definite segments firmly attached together, hence designated "Segmented".

Fig. 4 consists of photos of continuous segmented aluminum, steel and wax chips. The similarity of chips despite the dissimilarity of materials indicates the generality of the conclusions drawn from the data for 26 ST Aluminum.

Segmented Chip Formation: Fig. 5 illustrates the mode of segment formation.

Each segment was formed in less than .0004 second. Thus with the apparatus available, it was impossible to obtain a sequence of pictures of the same segment at various stages in its development. However, pictures were taken under the same conditions: their similarity justifies their use and necessitates this remark.

Fig. 5(b) is a sketch derived from the photographs of Fig. 5(a) to facilitate the explanation of segmented chip formation.

1) The material is compressed in front of the tool, bulging upward, as shown at the left of Fig. 5(b), until rupture occurs.

2) Rupture occurs when the slip-line field has the appropriate configuration. That is, it occurs when a) the direction of the maximum shearing *stress*, b) the direction of the minimum area subjected to shearing stress, and c) the direction of minimum shearing *strength* of the material are optimum.

3) As the segment is being displaced along the rupture surface, the formation of the next segment begins.

4) Subsequently, the newly formed segment, and the rest of the chip, consisting of previously formed segments, are forced upwards by the bulging of the material of the segment being formed.

Transition from Segmented to Ribbon-like: For smaller values of rake angle, the chips are segmented whereas for larger values they are ribbon-like.

The upper part of Fig. 6 illustrates the fact that the frictional force necessary to prevent a wedge from moving up an inclined surface increases as the incline decreases, that is, as the angle α increases. At the same time the normal force between the wedge and the inclined surface decreases, and consequently the frictional force decreases, and, eventually, the wedge will slip.

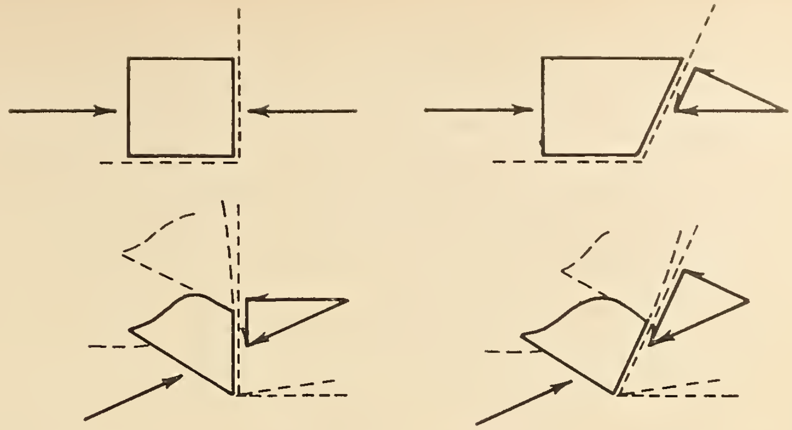
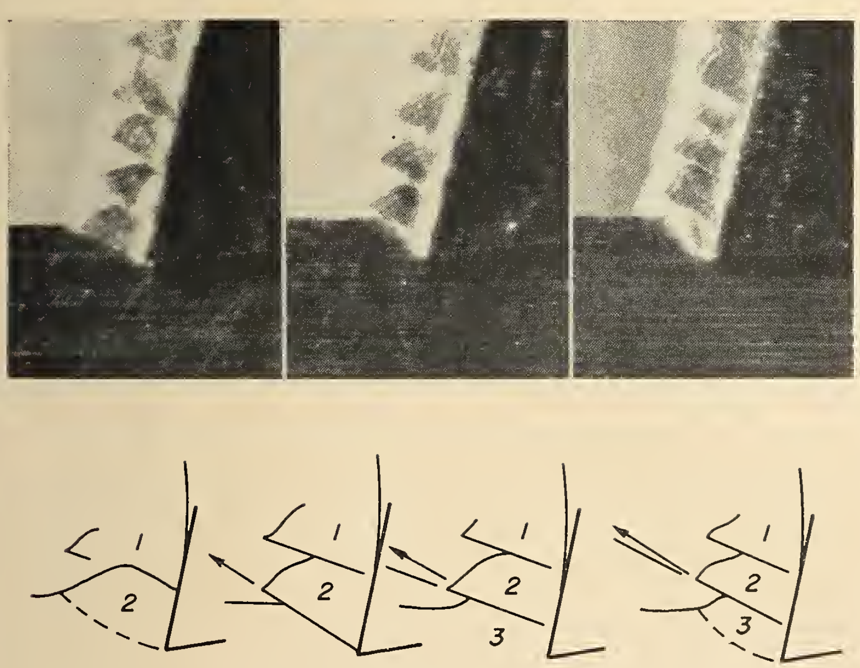


Fig. 6. Illustration of Effect of Rake Angle Upon Frictional Force.

The lower part of Fig. 6 illustrates comparable conditions in chip formation. Therefore it is not surprising that at large rake angles the chip is radically different from that obtained at smaller rake angles. Thus, it appears that the ribbon-like or Type 2 chip is a limiting case of the segmented.

Fig. 5. Illustration of "Segment" Formation in a "Segmented" Chip. Material — 26S Aluminum; rake angle — 14½°; cutting speed — 228 f.p.m.; feed — 0.018 in. per revolution; chip width — 0.125 in.



Explanation of Chip-Curl Phenomena

In interrupted cutting under steady state conditions a sequence of similar spiral chips is produced. The chips are tightly curled at the beginning of the chips, and become less curled eventually reaching a more-or-less uniform curvature.

Hahn[6] conducted an ingenious experimental investigation of this transient chip-curl phenomenon. A tube was cut orthogonally as shown in Fig. 7. The cylinder was advanced when the tool was opposite the "window" and retracted when the tool was again opposite the "window". Thus only one uniformly deep cut was made in one revolution of the cylinder.

In order to get a comparison between chips which were formed at the beginning of cutting and those which were formed when equilibrium was established, an interruption in the form of a narrow strip of workpiece material was inserted in the cylinder approximately 20% of the distance from the "start".

A variable reluctance type dynamometer was used to detect tool forces. The data obtained from a tool-work thermocouple were considered as representative of the tool-chip interface temperature.

He discovered the same spiralling effect in both chips.

He rejected interface temperature as a controlling factor because the distance necessary to establish temperature equilibrium was small compared to that necessary for chip-curl equilibrium. He also rejected the effect of built-up-edge in that there was evidence of it in the first chip only after temperature equilibrium was established, but there was evidence of it throughout the *whole* of the second chip. There was no change

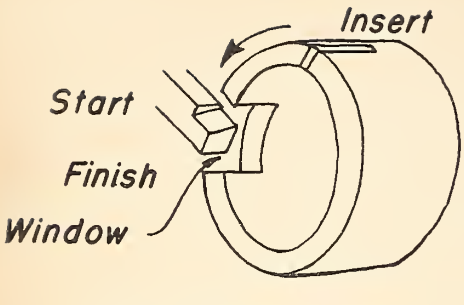


Fig. 7. Chip Curvature—Hahn.

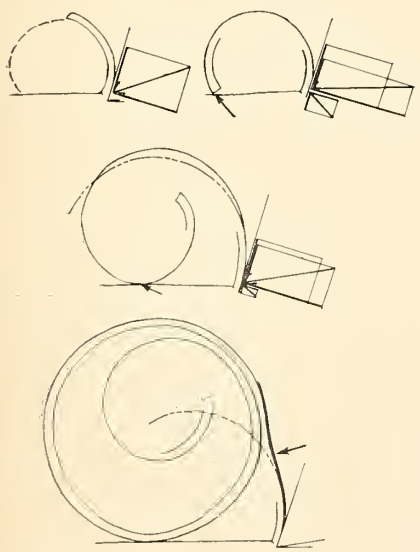
in temperature or tool forces at the insert yet the spiralling effect was the same in both chips. This led Hahn to conclude that the chip-curl phenomena are associated with the shear region, or as he so aptly phrased it, the chip is "born curled".

The mechanism of chip formation described in this paper provides an explanation of: 1) why the chip is "born curled", and 2) why successive coils are similar.

1) From the schematic representation of segmented chip formation, Fig. 5(a), it is evident that the plastic deformation of the segment being formed rotates the previous segment counterclockwise imparting curvature to the chip. Thus, the chip is "born curled".

When the tool face is limited to a fraction of the depth of cut as shown in Fig. 8 the bulging of the segment being formed rotates the previous segment clockwise and the chip is curled in the opposite direction. The length of the tool face shown is extremely small, approximately equal to the width of the letters on this page.

Fig. 9. Illustration of Formation of Chip Coil.



2) In the case of orthogonal cutting the chip eventually comes into contact with the surface of the work, as shown in Fig. 9(b), causing the chip to bend, and consequently changing the curvature by:

a) Permanently deforming the chip which is at a high temperature and hence susceptible to permanent set; or by

b) Changing the pressure distribution at the tool-chip interface, thus changing the frictional force, and hence the mode of chip formation. Evidence of the latter phenomenon is shown in Fig. 10 where ribbon-like sections occur in an otherwise segmented chip.

Fig. 9 illustrates the probable action during formation of a coil.

The force due to the interference between the chip and the workpiece causes a reduction in the frictional force (as does an increase in the rake angle). As a result a ribbon-like section is produced. Almost immediately the chip assumes the configuration of Fig. 9(c) causing an increase in the frictional force, and as a result a reversion to segmented chip formation. When the chip assumes a configuration similar to that shown in Fig. 9(d), the radius of curvature as the chip is "born" is as shown by the broken line (- . -). The forces on the coil cause the chip to bend in the region indicated by the arrow, eventually causing the chip to snarl or break. Then the process is repeated. It is therefore not surprising that successive coils are similar.

Explanation of Cratering Wear

A characteristic of tool wear is the development of a crater which starts at some distance from the tool tip, and grows, weakening the tool until the tool tip breaks off.

This phenomenon may be explained in terms of the segment formation illustrated schematically in Fig. 5(b).

Just prior to rupture there appears to be no *sliding* of the segment being formed relative to the tool face. The friction in the region of the tool tip is *static*. The previously formed segment **does** move relative to the tool face at some distance from the tool tip. The friction in that region is *dynamic*. At rupture the friction is wholly dynamic. It is therefore apparent that most sliding between the chip and the work occurs at some distance from the tool tip. Wear is the inevitable consequence of sliding. Thus most wear occurs at some distance from the tool tip—hence cratering wear.

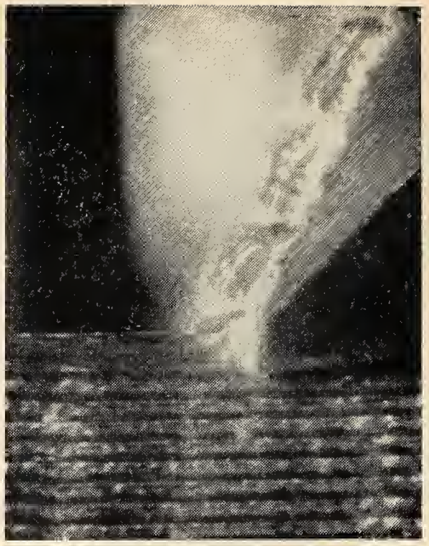


Fig. 8. Effect of Limited Tool Face on Chip Formation.

material — 26S aluminum
rake angle — 7½°
cutting speed — 211 f.p.m.
depth of cut — 0.17 in.
tool face length — .0210 in.

Apparatus

The general arrangement of the apparatus used in orthogonal machining experiments is shown in Fig. 11.

The principle components were a lathe, a tool force dynamometer and associated recording equipment, and the optical apparatus used to photograph the chip formation.

The dynamometer consisted of a tool holder clamped cantilever fashion in a supporting block. The tool holder had an offset square hole for the tool at the overhanging end, and a reduced rectangular measuring section between the overhanging end and the clamped section. Two strain gauges were attached to each of the faces of the measuring section. The gauges on the top and bottom faces formed a Wheatstone Bridge circuit for sensing vertical forces; while those on the sides formed a bridge for sensing horizontal forces. Each bridge was connected to a Universal Analyzer which in turn, was connected to a Two-channel Direct Writing Oscillograph.

The arrangement of the optical

apparatus is shown schematically in Fig. 12. An 83 mm. f 1.9 lens and a 35 mm. single-lens reflex camera and bellows were attached to opposite ends of a 19½ in. extension tube. A 45° prism was located between the lens and the subject. The image at the film was approximately 5 times actual size. The entire optical apparatus was carried on a camera support which rested on the ways of the lathe and was connected to, and thus moved with, the lathe saddle.

The brief exposure was obtained by flash illuminating the tool tip during the time that the camera shutter was open. The flash of 40 microseconds duration was produced by a Strobolume. The resulting blur in the photograph at a cutting speed of 228 f.p.m. was less than .002 in.

The Strobolume and Oscillograph Event Marker were both actuated by the opening of the camera shutter. Film used was Plus X and the lens opening was f6.

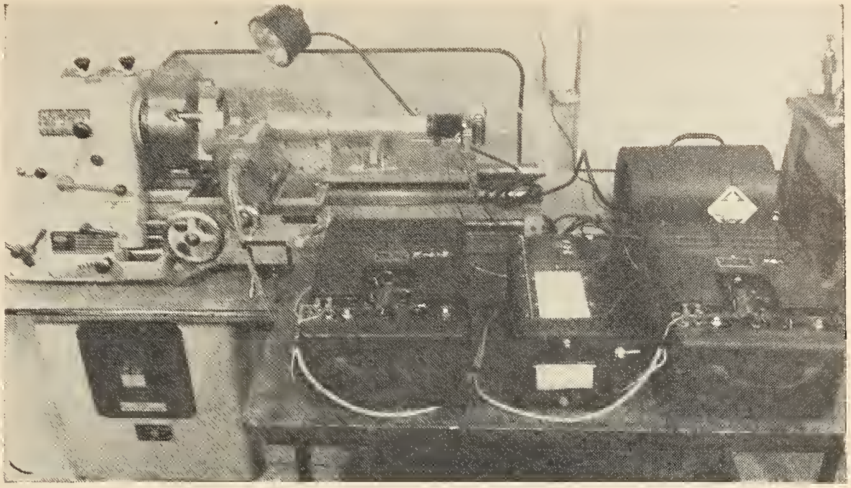


Fig. 11. General Arrangement of Apparatus.

Conclusions

The mechanism of *continuous* chip formation is quite different from those assumed in classical cutting analyses. It is a periodic process of plastic deformation and rupture in which, generally, a "segmented" chip is produced.

The Type 2 chip of Ernst's classification herein designated "ribbon-like" is a limiting case of the "segmented" chip. The transition from segmented to ribbon-like is the result of a reduction in frictional force with increase in rake angle.

The mechanism of segmented chip formation provides an explanation for chip-curl and cratering wear.

The rotation of the previously formed segment due to the plastic deformation of that being formed imparts curl to the chip. Interference between the chip and the workpiece, and the resultant changes in chip forces cause the chip to coil in a fashion peculiar to the cutting conditions.

Cratering wear occurs because most of the rubbing between the chip and the tool is at some distance from the tool tip.

Acknowledgements

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Fig. 10. Change in Chip Formation When the Chip Comes Into Contact With the Surface of the Workpiece Ahead of the Tool.

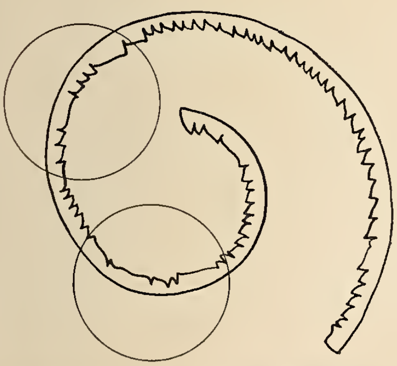
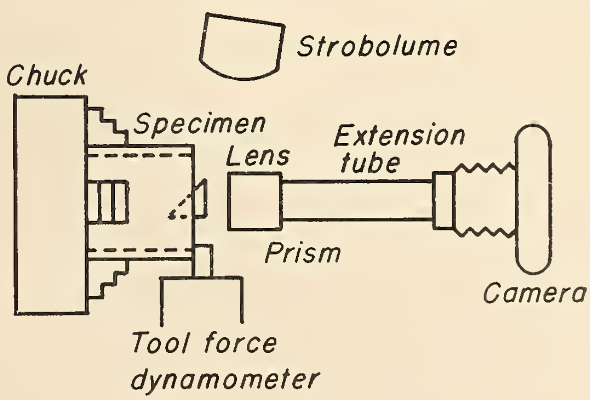


Fig. 12. Schematic of Arrangement of Optical Apparatus.



GREATER WINNIPEG FLOODWAY

Carson Templeton, M.E.I.C.
Consulting Engineer, Winnipeg

Spring flooding in Winnipeg is a recurring problem. Some years the city escapes with negligible inconvenience; at other times damage approaches disaster proportions. This paper outlines a method of determining benefit-cost of a diversionary floodway.

TO ILLUSTRATE the method of making the analysis, let us follow through the studies of a Royal Commission which was set up by the Manitoba Government to determine what, if any, projects were economically feasible to reduce the flood hazard in Manitoba, or whether it would be cheaper to accept the damages as they occurred.

A benefit-cost analysis is the comparison of the dollar benefits which a project would produce for each and every year of the life of the project versus the dollar costs per year of the project. If everything is brought down to an average annual benefit versus an average annual cost, there is no problem in determining whether the project is economically feasible.

The history of flooding in Winnipeg is fairly well documented for 150 years. Most Canadians remember the 1950 flood. Although it was not as serious as it might have appeared in the newspapers, it was very close to being disastrous. As it was, it covered entire municipalities, some of which were mainly urban in character. It was only a few feet below the level of most of the houses in Greater Winnipeg where half of Manitoba's population lives. It was only a few feet below the level of the industries from where well over half the industrial taxation of the Province comes. It was only a few feet from closing off both major railways of Canada. Winnipeg has had floods before. In fact, in 1948, only two years before, there was some flooding which at that time was considered quite serious. It is easy to say that some of the low lying areas were improvidently settled — people should have known better, this is true. However, the whole area is almost flat. Thus when the river rises above the level of its banks, it is not very far below the buildings in the whole metropolitan area.

After the 1950 flood, steps were taken immediately to prevent such a recurrence. An immediate step was taken by the Dominion and Provincial Governments to construct a series of dykes along both sides of the rivers in Winnipeg to reduce a flood hazard. No attempt was made to contain the highest known flood, which is usually the prime requisite in designing any dyke or dam. The dykes were designed only to reduce the frequency of flooding. The reason for this emergency work was so the whole problem of flooding could be studied in detail without the governments being pressured into hasty action.

While the dykes were being built, the Dominion Government set up the Red River Basin Investigation, whose terms of reference included methods of flood protection for the whole Red River basin.

This investigation was under Mr. Gordon MacKenzie, who is now Director of the Prairie Farm Rehabilitation Administration. The Hydraulic studies were conducted under him by Mr. Robert Clarke, now Chief Hydraulic Engineer with the Water Resources Branch of the Department of Northern Affairs and National Resources. Mr. Clarke conducted the studies on the Red River and Mr. E. Kuiper who is now Professor at the University of Manitoba conducted the studies on the Assiniboine. In the course of the Commission's work, this report was reviewed in detail and found of particularly high calibre. It is well documented and thorough.

The Red River Basin Investigation compiled the history of flooding and computed discharges on the Red River and all of the Tributaries. It outlined a number of different methods of reducing the flood hazard. These methods included small and large dams, diversions, dyking and channel improvements comprising more than 20 different projects in all.

The Royal Commission on Flood Cost Benefit was set up to determine the most economically feasible combination of the projects.

When the Red River Basin Investigation was started, its first study was to determine the magnitude of past floods, which had been recorded in diaries, but never correlated to today's Geodetic datum. Incidentally, this study of determining the high water elevations proved to be a very interesting history of Winnipeg, and, in fact, most of the chronicles of various events were referenced to past floods. In 1880, Sir Sanford Fleming, who was then Chief Engineer of the C.P.R., wrote a very complete, well documented history of past floods. His information was obtained from the records and diaries of clergy, traders and other early settlers. The reason for making his complete study was that he was trying to have the C.P.R. crossing over the Red River put some 20 miles north of here, where there was no danger of flooding. However, as sometimes happens in the best engineered works, he did not have the final say, the crossing was put here and the City grew.

The 1950 flood did not materially disrupt the economic life of the City beyond the time that the flood was in process. The historic records, however, have proved very conclusively that in 1826, the water was some six ft. above the level of what it was in 1950. Such a flood would put the City out of commission completely and it is estimated that it would not be fully operative for over a year. In 1852, there was a flood 4 ft. higher than the 1950 flood and in 1861 it was 2 ft. higher than the 1950 flood. Between 1861 and 1950 there have been parts of Winnipeg flooded, but nothing of a very serious nature, except in 1916 and 1948 when things looked fairly serious, but these were soon forgotten when the 1950 flood occurred.

In the Red River Valley in the 1948, 1950, 1826 and 1852 floods, the whole valley was flooded and storage reservoirs would have had little use in preventing flooding. They would tremendously increase the flooded area above the dam to give limited protection below the dam. The lake formed in the 1826 flood would be about 25 miles wide.

Fig. 1 shows the area flooded in Greater Winnipeg. The Red flows North from bottom to top and the Assiniboine River comes in from the West. The darker colour indicates the probable extent of the 1826 flood and the lighter colours in the centre indicate lesser historic floods. This photograph covers the entire area of Metropolitan Winnipeg, except part of St. James and Charleswood, and Tuxedo. Thus, in a flood of the 1826 magnitude, of the present 400,000 population, some 370,000 would have been flooded out.

Fig. 2 shows the type of dyking which has been constructed throughout the Metropolitan Area. The dykes, as a rule, are 50 ft. wide and are used as regular streets, but the top of them is some 4 ft. below the level of the 1950 flood. It is possible, in an emergency, to build a temporary dyke on the river side as shown on the photograph. This emergency dyke would be built by equipment rather than sand-bags and would still leave room for two-way traffic on the land side. There are some 26 miles of dykes and line of flood defence in Greater Winnipeg.

Fig. 3 shows a diagrammatic view of a pumping station used to pump out the sewers in time of flood. The older sections of the City use combined sewers which have an outfall to the river. In times of flood, the river backs up these, into the basements and floods the low lying land behind the dykes. The sketch shows a cast iron gate, which closes off the sewer to prevent the river backing up. The pumps lift the water over the top of the dykes. There are some 25 of these stations in Greater Winnipeg with pumping capacities of between 35 c.f.s. and 275 c.f.s., depending on the size of the area protected.

Fig. 4 shows a Flood Frequency Curve. The dots on the curve all represent past floods and their frequencies computed. The curve itself was drawn by judgment. You will note that the 1950 flood has a frequency of once in 37 years, 1861 a frequency of once in 60 years and the 1826 flood a frequency of once in about 426 years. It should be remembered that floods do not occur at regular intervals. The climate follows cycles and so do floods. For example, the three largest floods in the last 150 years in Manitoba occurred during a 35 year period from 1826 to 1861.

Fig. 1. Areas flooded in 1950, 1852 and 1826 in the Greater Winnipeg area. (Legend: 1950-light area, 1852-grey and light areas, 1826-dark, grey and light areas.)

The second highest flood in the Fraser Valley was in 1948 and the third highest flood was only two years later in 1950.

Flood Protection Projects Considered

The main projects considered by the Red River Basin Investigation are:

(1) The Greater Winnipeg Floodways of a number of different sizes, varying from 20,000 c.f.s. to 145,000 c.f.s.

(2) Portage Diversions. Alternate routes are shown on each side of the City of Portage la Prairie.

(3) Russell Reservoir on the Assiniboine at Russell, Manitoba.

(4) A dam on the Pembina River.

(5) The Ste. Agathe Detention Basin.

(6) A diversion of the flood waters of the Rat, Rosseau and Seine Rivers and Joubert's Creek into an Eastern Tributaries Diversion.

(7) Omand's Creek Diversion.

(8) Dyking of the present river banks.

(9) Widening and deepening of the present channel.

Channel Improvements

When studying methods of flood prevention where the capacity of the river channel is not large enough, the logical solution would be to increase the channel capacity by widening and if possible, deepening. However, making it wider and deeper presents difficulties and tremendous expense in the heart of the City. When you consider that the present channel, filled right up to the top of the dyke, passes only 80,000 c.f.s. and the 1826 flood had 225,000 c.f.s., it can be seen that the channel needs to be 2 to 3 times its present size. Such an increase in size would mean complete revision of all the bridges and approaches and removal of streets, houses, industries, railways, etc.

A knotty problem would be the decision of whether to widen the river on the West side in the downtown area, thereby removing the C.N.R. Yards, coming right up to Portage & Main, or widen it on the East side and take out the St. Boniface Hospital. Such a scheme would have tremendous other costs in addition to cost of the removal of earth.

A floodway can do the same thing, but since it goes through undeveloped land, the costs are less and the excess earth can be placed alongside, rather than hauling it some distance.

An improved channel which would pass 140,000 c.f.s., which is about the same as the present channel plus a 60,000 floodway, would cost $120 million, a little over double the cost of the floodway.

Dyking

The conventional method of flood protection is to construct dykes up to at least the elevation of the highest known flood. However, they tend to give a sense of false security and if they fail for any reason, they cause a terrific rush of water which can cause a very serious loss of life and damages far beyond what they would have been had there not been any dykes.

Consider raising a street about 14

ft. and you could imagine the problems involved with intersecting streets, bridges, railways, buildings, etc., to say nothing of the threat of the wall of water if it should burst. In a City as old as Winnipeg, there are literally dozens of underground culverts, pipes and other structures of which there are no records. If one of these were to fail, it could cause the whole dyking system to fail. The present dykes are fine and are doing the job for which they were designed, which was providing a partial degree of protection, but to find more complete protection, a completely different scheme must be adopted.

The Ohman's Creek Diversion involved pumping of the flood waters over a height of land and then running it north by gravity to Lake Winnipeg. The pumping problem seemed insurmountable when one was talking about the intermittent use of pumps to handle, say 60,000 c.f.s.

The Ste. Agathe Detention Basin involved the placing of a dam across the Red River Valley which could give Greater Winnipeg a considerable help in levelling off the flood crests. It would have reduced the 1950 flood by about 4½ ft. in Winnipeg. Floods of larger magnitude would be reduced by lesser amounts and thus this scheme does not provide a satisfactory degree of protection.

Eastern Tributaries Diversion would provide less than a foot reduction in Winnipeg and thereby could not provide the protection needed for either the Red River Valley or Winnipeg.

Pembina Dam has substantial benefits in water supply and sewage dilution and if it could supply the Pembina Triangle with the potable water and irrigation water it needs, would be a very valuable project. However, to determine this value was considered beyond the terms of reference of the Commission and it computed the flood protection value and suggested further studies be made of the other benefits. The benefits of flood protection alone were not enough to justify the cost.

Russell Reservoir

The benefits of this are substantial in reducing the flooding between Portage and Winnipeg and in providing a more constant flow of water at Brandon, Portage and Winnipeg. This dry weather flow gives an adequate water supply and reduces the degree of sewage treatment. It has a Benefit-Cost Ratio of 6 and was recommended by the Commission.

The chief disadvantage of this project is that the dam is on a branch of a tributary considerably remote from Winnipeg, where most of the benefits are to be had. Its effect therefore is not as certain. For example, the whole Assiniboine flow in 1950 was 8,000 c.f.s. and therefore the Assiniboine projects alone would not have been much help. Ordinarily the flow would have been over double that amount.

Portage Diversion

In the location of the High Bluff Diversion with respect to the City of Portage la Prairie and Lake Manitoba there is some 25 ft. drop between the City and the lake, and in fact, the drainage for the City is to the lake rather than to the river.

This floodway would carry floodwaters from the Assiniboine to Lake Manitoba and would have a 25,000 c.f.s. capacity. It would not dry up the Assiniboine — it would only divert some water in flood time. Any of the water diverted would go out of the Red River drainage basin.

An interesting possibility would be the storage of the freshet waters from the Assiniboine in Lake Manitoba and then diverting them back into the Assiniboine farther east. In the late summer, this would dilute the sewage pollution in Winnipeg.

Greater Winnipeg Floodway

The location of the floodway around Greater Winnipeg would leave in the vicinity of St. Norbert and be about 26 miles long and would re-enter the river at Lockport. A floodway has a particular advantage in this location because immediately downstream from the City is Listers Rapids, where there is a fall of 10 ft. in 4 miles. Because of this drop, the backwater effects of the floodway re-entering the channel at Lockport are minimized. The channel is designed to have a 6 to 1 side slope on the southern section where the wet

Fig. 3. (right) Diagrammatic view of a pumping station used to pump out the sewers in time of flood.

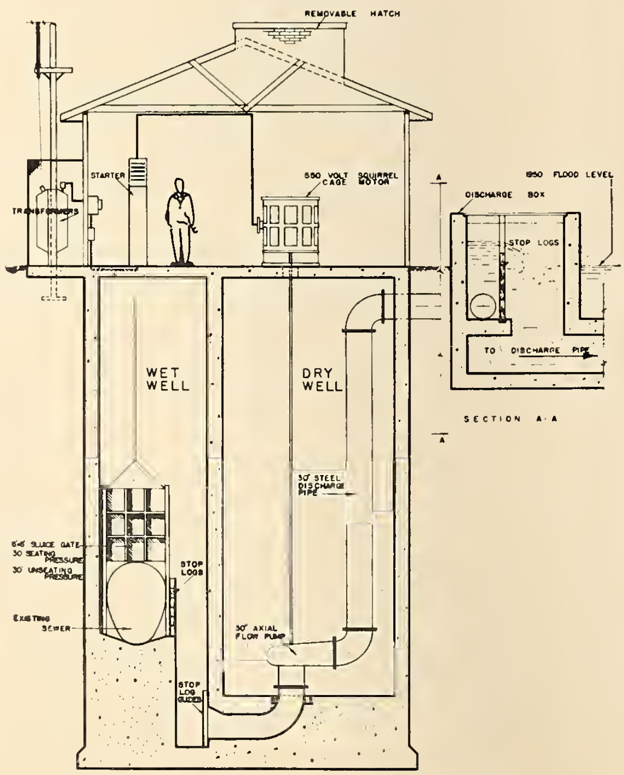


Fig. 2. (below) Photograph of a finished boulevard showing the type of dyking constructed throughout the Metropolitan area.

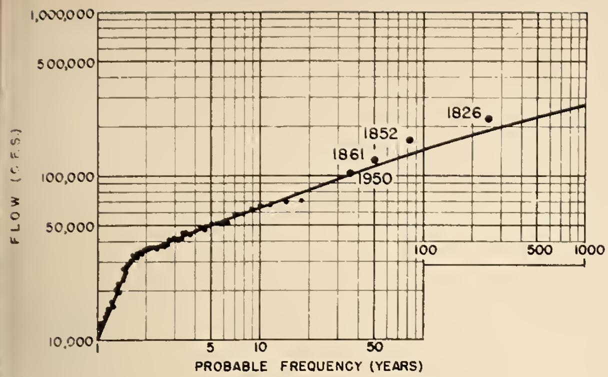


Fig. 4. Flood Frequency Curve

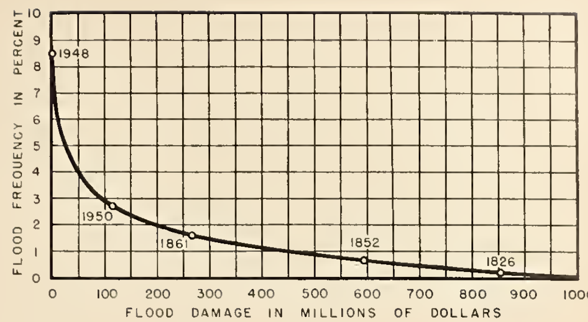


Fig. 5. Frequency Damage Curve

clay occurs and 3 to 1 side in the northern section where the soil is stiffer.

The control structure across the river downstream from the floodway intake would be used to control the flow in the river through the City in times of flood, thereby forcing more water down the floodway channel. (see Fig. 7.) The spoil from the excavation would be placed on each side. Floodwaters would enter the floodway channel on an average of every two years. Normal drainage from the East would be intercepted by the floodway which would carry it around the City.

Benefit—Cost Analysis

In making any benefit cost analysis, it is necessary to express the benefits and costs in terms of dollars per year. Benefits generally include flood protection, recreation, water supply, sewage dilution and any other applicable features. In this case, the Commission considered only the benefits of flood protection. Costs include not only capital costs, but amortization, interest on the money during the construction period before the project is useful, maintenance and repairs.

The entire study is to break these down to average annual benefits and average annual costs.

If a project has a benefit cost ratio of 2, it means that the average annual benefits are twice the average annual costs.

The balance of the study is to compute these annual benefits and costs.

Benefits

The benefits in these flood protection schemes are the reduction of damages that any project would bring about.

To find the average annual damage, it is necessary to estimate the damages which any flood would cause along with the frequency with which that flood would occur. For example, the losses caused by the 1950 flood amounted to some $110 millions. The frequency of this flood was once in 37 years or 2.7%. A flood of the 1826 magnitude in 1957 would have caused an estimated $850 million damages, but the frequency is only .2 and therefore, because of the infrequent nature, the average annual damage caused by the 1826 flood is about one half of the average annual damage of the 1950 flood.

To find the average annual damage, it is necessary to add together the damages from an infinite number of floods multiplied by their corresponding frequencies. This is most easily expressed by plotting a frequency-damage curve. The area beneath which gives the average annual damage for all floods.

Fig. 5 shows such a curve for Greater Winnipeg.

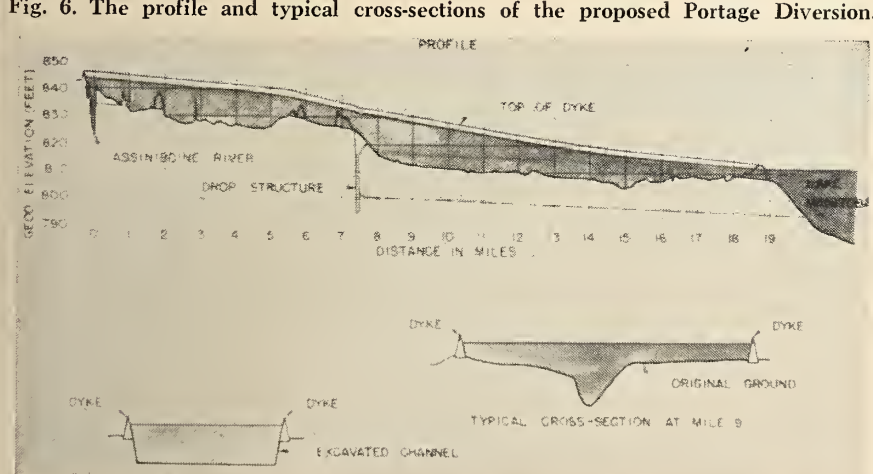
Damages

Fig. 8 shows the relationship of damages to the market values of a house as the flood waters rise. The records of the 1950 flood were used and it was found by observing several hundred of these, that the damage to the homes were related to the depth of water to which they were flooded. Immediately the water got over the main floor, which spoiled the floor and much of the furniture, the damages rose very rapidly.

The relationship between the market value of the home and the damages to the dwelling and personal property were related. The damage, once the water gets into the basements, starts at about 3.8% and rises only to about 7.3% until it gets over the main floor of the house. By the time it reaches 2 ft. above the main floor, the damages are about 42.7% of the value of the house. Having established this relationship, it was found necessary to obtain the elevation of each block in the city and put the market value of all the houses in that block on I.B.M. punch cards. Then, when each project was studied, it was only necessary to run the cards through the computer to determine the damages on that block for various heights of water.

To find the damages to commercial areas, a survey of the commercial buildings which were flooded in 1950 was conducted and the results tabulated on a sq. ft. basis for different types of commercial and industrial buildings. When industries are flooded out, there is a loss of income. In some cases, the workers are laid off without pay; in other cases salaried employees may continue on the payroll, whereby the loss is accepted by the employer rather than the employee. Nevertheless, there is a loss of income. In very major

Fig. 6. The profile and typical cross-sections of the proposed Portage Diversion.



floods, when the entire city would be inundated, most all industry and business would shut down for a time and would gradually open up again as their establishments were rehabilitated and their workers again had a place to live. For very major floods such as the 1826 flood, this amounts to a considerable amount of money because all bridges would be damaged or washed out and the main portion of the city would be disrupted. The loss of income was obtained from the Dominion Bureau of Statistics for income in Greater Winnipeg and this was correlated to the location in which the industries are situated.

In Fig. 9 these damages are totalled for all floods. The loss of income for a flood equal to the 1950 flood is fairly minor but for major floods, becomes increasingly significant.

From this chart you can read that the 1950 flood cost somewhere over $100 million, the 1861 flood would have cost $267 million, the 1852 flood would have cost $600 million and the 1826 flood would have cost $850 million. These are all direct costs — there is no allowance made in this study for intangibles such as the effect to the rest of Canada of cutting off the major railways. There is no allowance made for a possible loss of life. There is no value set on the effect of a flood threat hanging over the lives of people here, wondering if next spring there will be a flood. These and other intangibles were recognized by the Commission, but they were not taken into the computation of the damages.

Each project must be considered singly and in combination with other projects to find out what reduction in damages can be attributed to that project. To do so, the lowering of water levels for the various projects were calculated.

This has the same effect as reducing the frequency of all floods and thereby lowers the frequency damage curve. Thus, the area between the frequency damage curve under natural conditions and the newer frequency damage curve represents the average annual benefit.

Costs

The computation of the Costs are comparatively simple.

The capital costs are estimated in the usual way. However, since the floodway alone has close to 100 million cu. yd. of excavation in it, the unit prices are extremely significant. The Red River Basin, drawing on Mr. McKenzie's wide experience with the P.F.R.A., set a price of 30c per cu. yd. for common excavation. The Royal Commission studied this unit price in some detail. Local contractors thought that if anything, the price was too high. The Commission brought General La Rue, recently retired from the U.S. Army Corps of Engineers and who has a very wide experience in similar large projects, to discuss the problem. He thought the price of 30c was about right. The Commission also had a dredging company prepare a detailed cost estimate on the cost of excavation using floating suction dredges. Its estimate was 23c per cu. yd.

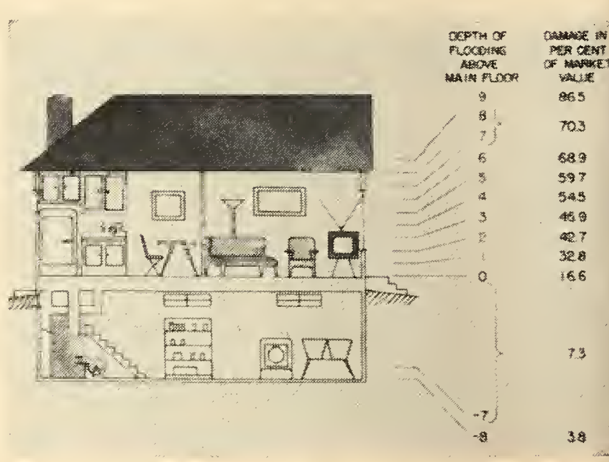
All things considered, the unit price for common excavation was left at 30c, but in its final report, the Commission inserted the sentences "There is some reason to believe that if the works were undertaken today, the actual cost might be less than the Commission used in its calculations. This would result in even more favourable benefit-cost ratios." This price may seem low to engineers from other parts of Canada, but Manitoba road jobs usually cost only 12-15c per cu. yd.

Table 1.
Estimated Cost of 60,000 c.f.s. Floodway

Right of Way	$ 3,520,000
Excavation	35,246,000
Aqueduct Crossing	260,000
Highway Bridges	5,639,000
Railway Bridges	6,762,000
Outlet Drop Structure	762,000
Control Structure and Dyke	4,537,000
Miscellaneous	635,000
Total	$57,361,000

Fig. 7. (left) An artist's sketch of the floodway as it leaves the river.

Fig. 8. (below) Flood damage to dwellings and personal property.



To illustrate the importance of this unit cost:

A difference of 1c in the cost of common excavation means a total difference in cost of $1,000,000.

In computing the average annual cost, it is necessary to amortize the capital cost over the life of the project. In this case, the life of the projects were assumed to be 50 years. One might say that the life of the projects should be more than this, but when the interest is taken into account, it makes little difference in the average annual cost whether a 50 or 60 year life is assumed.

In addition to the amortization is the interest charges. The Commission used an interest rate of 4%. In the light of today's high financing costs, one might argue that this figure is too low; however, the Commission studied interest rates over the past 50 years and came to the conclusion that in the next 50 years, an interest rate of 4% would be reasonable and conservative.

The maintenance of the floodway and the structures crossing it was also taken into the average annual cost. Maintenance included removal of silt deposited in low flows, side slope maintenance, mowing and weed control. Annual Bridge maintenance was taken as 1% of the capital cost.

The average annual costs of the three recommended projects amounted to $4 million. This figure is made up of $3,159,000 interest, $517,300 amortization and $325,500 maintenance.

In Fig. 10, the benefit cost ratio is shown diagrammatically. The floodway, with a benefit-cost ratio of 2.89, means that the benefits are 2.89 times the costs. The Portage Diversion benefits are 9.06 times the costs.

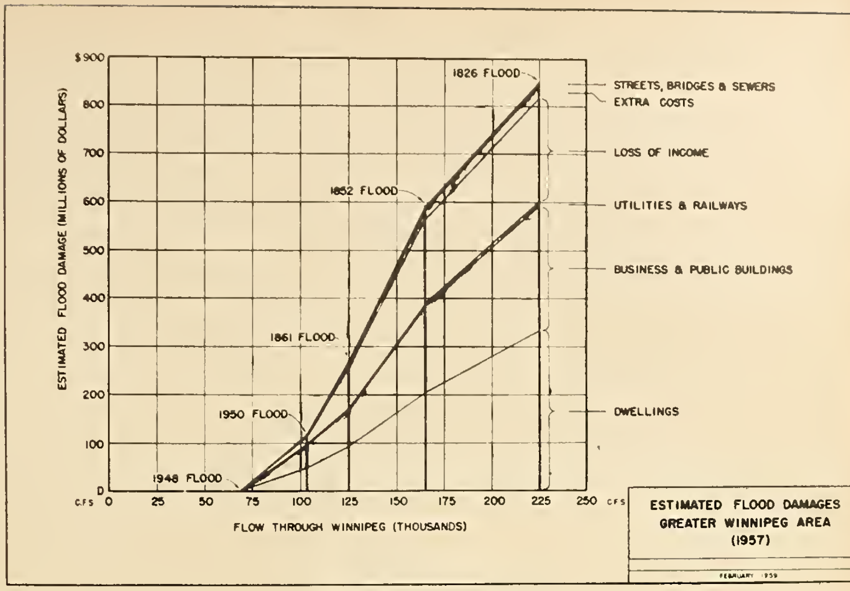


Fig. 9. Flood Damages

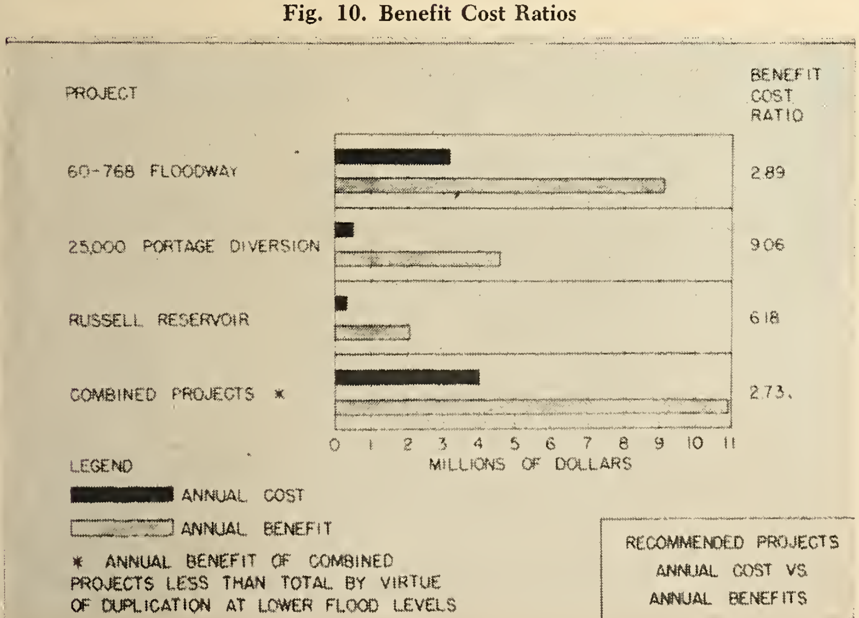
It should be noted that the benefit cost ratios of a combination of projects are less than any single project. The reason for this is because there is a duplication of protection for small floods. For all, except extreme floods, the floodway would prevent most of the damages from occurring and therefore the projects on the tributary would not be fully realized.

Even if an interest rate of 5% were used, the combination of projects would have a benefit cost ratio of 2.30.

These figures are computed on a 1957 Winnipeg. As the City grows larger, the benefits and costs will increase.

By 1981, it is estimated that the growth of the City will have increased by 71% and the damages of the various floods would be increased. The benefit-cost ratio of the three projects was estimated to be 4.1 in 1981.

Fig. 10. Benefit Cost Ratios



Comments

The Royal Commission on Flood-Cost Benefit contemplated trying to find out what degree of flood protection had been provided for other cities. In other words, should one try to provide flood protection against a 50 year flood, a 100 year flood, or 1,000 year flood. The Commission was not successful in determining the degree of the protection that other cities enjoyed. Not having a yardstick, it had to rely completely in the benefit-cost ratios.

No doubt the Greater Winnipeg Floodway will be an active issue again soon, as the Provincial Government is committed to building it and the Federal Government is committed to helping. This is a big project, but since the benefits are 2.7 times the costs, it is economically justified.

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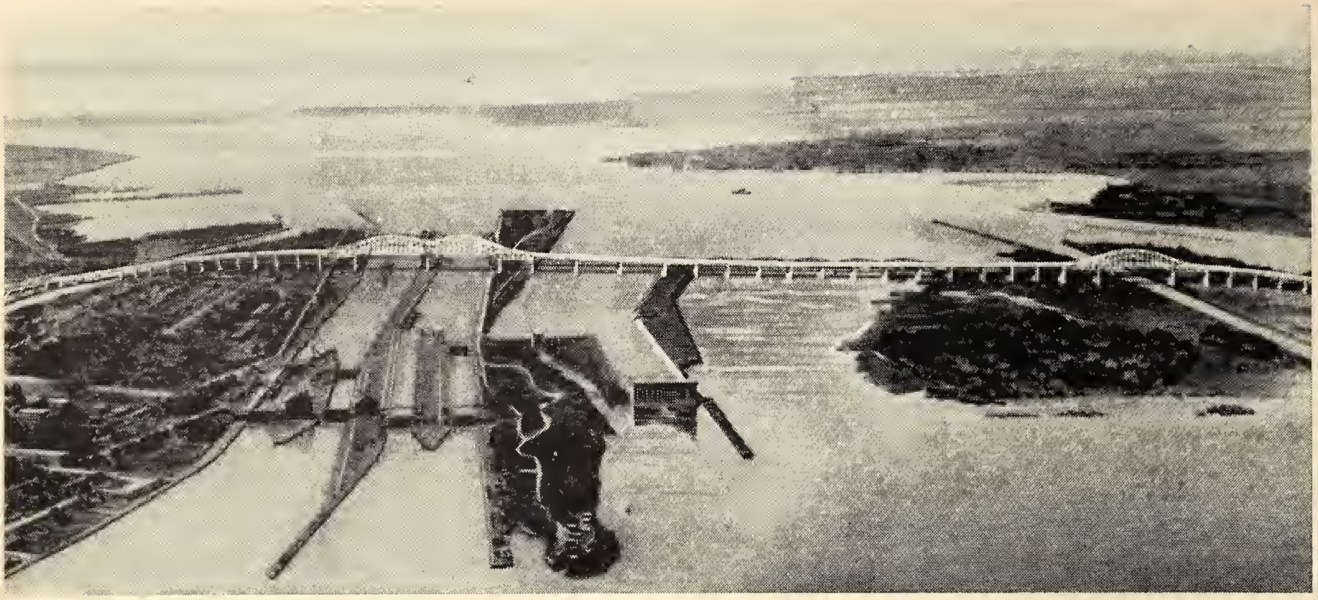


SAULT STE. MARIE BRIDGE DESIGN

C. H. Gronquist

Steinman, Boynton, Gronquist & London, Consulting Engineers, New York

A VEHICULAR BRIDGE to join the cities of Sault Ste. Marie, Mich., and Sault Ste. Marie, Ont., has for many years been a pressing need, for the continued growth and development of the region which depends on the construction of a span across the turbulent St. Marys River.

The St. Marys, which marks the International Boundary between Michigan and Ontario, drops between 18 and 24 ft. as it tumbles from Lake Superior into Lake Huron. The cities are divided by the river and the 100-year-old Soo locks and ship canals. These locks and canals, built to pass shipping around the falls, have been maintained and reconstructed as necessary during the intervening years so the waterway now is capable of handling the largest ships which can use the St. Lawrence Seaway.

Location

Sault Ste. Marie, Mich. is the northern terminus of U.S. Route 2, and the terminus of State Route 28 from the west, and State Route 129 from the south. U.S. Interstate Route 75 from Detroit will pass over the Mackinac Bridge, and, as a relocation of U.S. Route 2, will also have its northern terminus at Sault Ste. Marie. Portions of this interstate route are already under construction in both the Lower and the Upper Peninsulas of Michigan; the portion to be built at Sault Ste. Marie will connect directly with the Sault Ste. Marie International Bridge, and will be finished at the same time as the opening of the bridge.

The Canadian Pacific Railway, the Duluth, South Shore and Atlantic Railroad, and the Minneapolis, St. Paul and Sault Ste. Marie Railroad supply rail service to the city.

A low-level railroad bridge with swing and bascule openings has connected the twin cities, but the railroad swing span has recently been replaced with a new lift span bridge. The lift span was constructed in the raised position over the present railroad bridge, and now that the lift bridge is completed, the swing span, together with its supporting island in the south canal is being removed. Railway traffic was maintained during the construction of the new lift span.

Sault Ste. Marie, Ont. is reached from the east by King's Highway No. 17 which at present as part of the Trans-Canada Highway is being further extended northward and to the west around Lake Superior to Port Arthur and Fort William. This scenic highway should become a major tourist attraction. The Canadian Soo is served by the Canadian Pacific Railway and the Algoma Central and Hudson Bay Railway.

The Soo area has many important industries, including the Union Carbide Company on the Michigan side, the Algoma Steel Company and the Abitibi Power and Paper Company on the Canadian side, and extensive uranium mining installations which have been recently developed to the east in Ontario. The city ports handle a large amount of lake traffic in coal, limestone and lumber, and numerous firms dealing in these and other products have been established in the area.

In addition, the Soo is a popular recreation area, with excellent hunting, fishing and boating readily available.

With the recently completed Mackinac Bridge joining the Upper and Lower Peninsulas of Michigan, the proposed Sault Ste. Marie International Bridge will be the last link in the chain connecting the midwest and lower Michigan with the vast recreational and rapidly-growing industrial area of northwestern Ontario. Moreover, it has long been recognized that a vehicular bridge connecting the two cities of Sault Ste. Marie is needed for the continued growth of the twin cities, and that it is of prime importance for National Defence.

Legislation approving the construction of this bridge has been passed in the Michigan Legislature and the U.S. Congress, and in the Ontario Legislature and the Canadian Parliament.

The International Bridge Authority, an agency of the State of Michigan, is authorized to construct, maintain and operate the International Bridge. The St. Marys River Bridge Company is a corporate body created by the Senate of Canada in 1955 for a similar purpose. The rights and powers of the latter were assigned to the International Bridge Authority of Michigan to enable it to proceed with the financing and construction of the project.

Applications for approval of clearances and other details of the construction have been approved by the following agencies: U.S. Department of the Army, the Governor-in-Council of Canada, and the Canadian St. Lawrence Seaway Authority.

Conditions at Site

The St. Marys River drops approximately 21 ft. in the St. Marys Falls, and there is a similar difference in water level between the head and the foot of the several locks. At the head of the Falls a compensating works consisting of a series of sluice gates regulates the flow of water to maintain necessary depth of water in the power canals and for navigation in the ship canals. The United States power canal with the new powerhouse directly south of the Falls, delivers a maximum of 18,000 hp. of electrical energy. South of the U.S. power canal there are the two U.S. ship canals and their four locks through which pass the heaviest tonnage of shipping in the world, at a maximum rate of 75 ships a day. The Union Carbide Company power canal, Sault Ste. Marie, Mich., south of the ship canals, can deliver 40,000 hp. North of the Falls on the Canadian side, the Canadian ship canal and lock are located. The Great Lakes Power Company canal to the north of the ship canal delivers a maximum electrical energy of 27,500 hp.

The locks are ice-bound every winter for approximately three to four months, during which time navigation is suspended. The ice thickness varies from year to year to a maximum thickness of 30 in.

Bridge Location

This site, with its complex network of canals and various shipping requirements both above and below the locks, presents many problems in the determination of the most suitable location for a crossing. Numerous locations have been studied for the bridge crossing of the St. Marys River, as well as a proposed tunnel in the vicinity of Johnstone St. in the Michigan Soo and East St. in the Canadian Soo. It has been determined that the location which will meet all requirements at minimum cost is a line crossing the ship canals immediately east of the existing railroad bridge. The reasons are:

1. The recommended location will be the most economical that will satisfy all governing objectives. The bridge will have relatively short spans and will be located over shallow water and at shallow depth to rock;

2. The proposed location is as far above the locks as possible, to equate any hazard to the locks from the proposed bridge to that of the existing railroad bridge;

3. The bridge location is within the cities to best serve inter-city traffic in order to realize the maximum toll revenue for the project;

4. The bridge plazas are readily accessible to local traffic from either city;

5. The recommended location will connect directly with the proposed Interstate Highway System through Interstate Route 75 in Michigan which will be located at the west edge of the city and will have interchanges for connections to the city at Easterday Ave. near the toll plaza and at the south edge of Sault Ste. Marie, Mich. In Sault Ste. Marie, Ont. the bridge plaza at Huron St. will connect by one-way city streets to King's Highway No. 17 and the Trans-Canada Highway.

The recommended route runs just east of the railroads on both sides of the river and along the west edge of the Abitibi Power and Paper Company property on the Canadian side. The location will minimize any interference with the railroads or the Paper Company operations.

Construction Contracts

Except for the Michigan approach spans and the Easterday Ave. Inter-

Fig. 1. Highway Connections

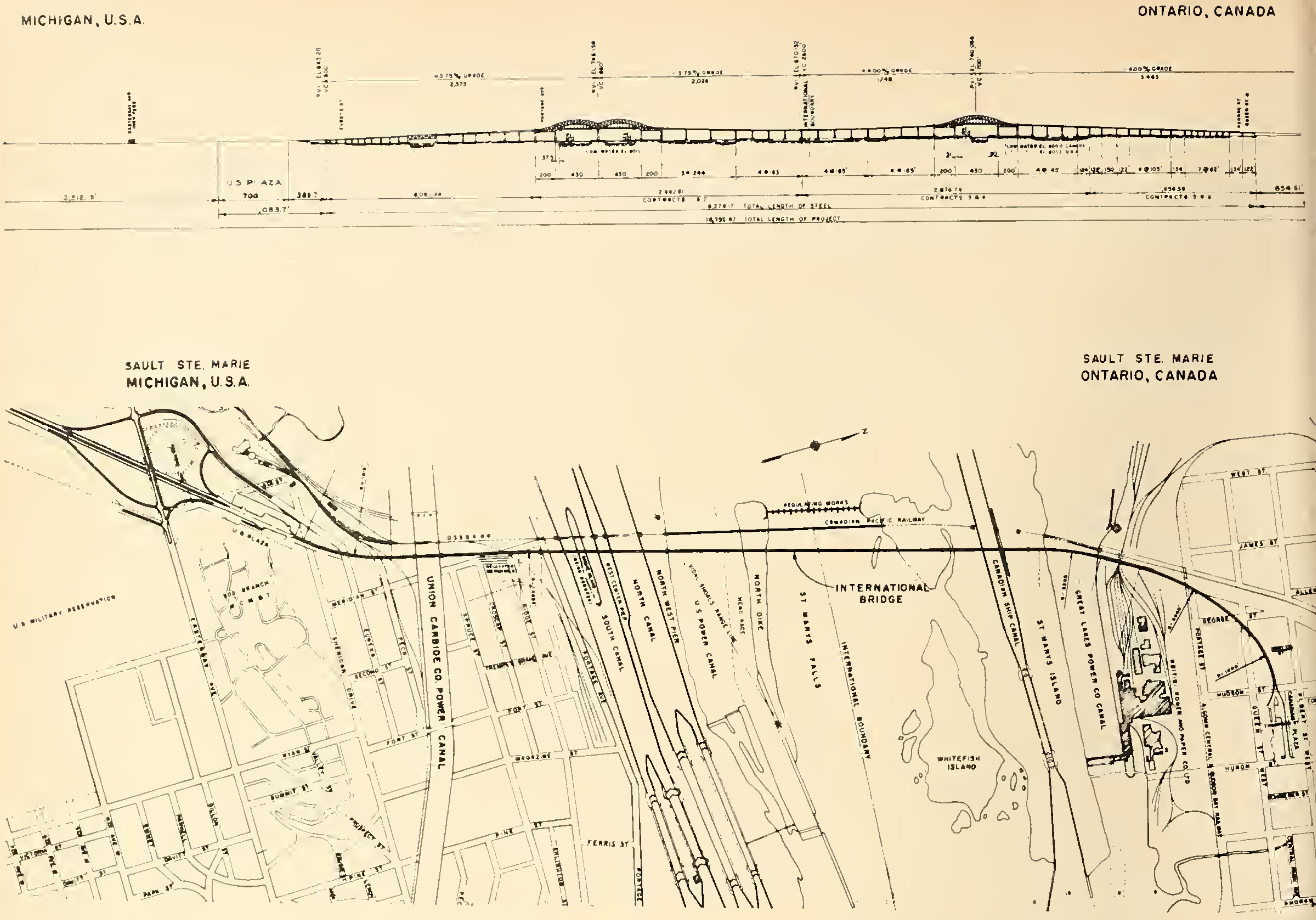


Fig. 2. General Plan and Elevation

change on Interstate Route 75, all of which will be built by the Michigan State Highway Department with the use of Federal funds, the American toll plaza and the remainder of the project from Portage Ave. near the south bank of the river in Sault Ste. Marie, Mich. to and including the plaza in Sault Ste. Marie, Ont. has been financed by the International Bridge Authority by means of a revenue bond program.

The Michigan approach spans will be constructed in two contracts, one for the substructure and one for the superstructure, including the deck and roadway lighting. South of the toll plaza on the Michigan side, the Easterday Ave. interchange consisting of a four-span bridge to carry Easterday Ave. over Interstate Route 75, together with a section of Route 75 and four interchange ramps, will be built under separate contract. The two-mile long section of Interstate Route 75 extending from the Easterday Ave. interchange to an interchange at the south edge of the city will be constructed by the Michigan Highway Department in conjunction with the bridge project, and will be opened to traffic on completion of the latter.

Bids were received in June 1960 by the International Bridge Authority on a total of six contracts for the substructure and steel superstructure for each of three divisions of the project, namely, the American river spans, the Canadian river spans and the Canadian approach spans. Contract drawings will be completed and bids will be received for the remainder of the work, including the concrete roadway, the lighting, and the plazas.

Subsurface Exploration

Borings along the proposed centre line of the bridge and approaches were made during September and October, 1958, and on the Michigan approach in the fall of 1959.

Rock was found generally at a shallow depth, ranging from 2 to 10 ft. below ground except in a few locations, mainly near the American plaza where rock was found to be 30 to 40 ft. below the surface. The overburden in general consists of sand, gravel and sandstone fragments. The rock is sandstone, with sand or clay seams in some locations.

The maximum foundation pressure on sandstone rock will be 6 tons per sq. ft. and the maximum foundation pressure on soil will be 3 tons per sq. ft.

Design of Bridge

The cost of construction of this project has been kept to a minimum consistent with adequate capacity, safety of traffic and conservative design. Structural details will facilitate fabrication and erection and will be conductive to economical maintenance.

The bridge geometric design is in compliance with the Interstate Standards of the U.S. Bureau of Public Roads.

The preliminary traffic study indicates that a two-lane highway bridge will have sufficient capacity for the anticipated traffic.

The above considerations have led to the adoption of an overall width of 28 ft. between curbs, providing 14-ft. lanes in each direction. In addition a 2-ft. emergency walkway is provided on each side of the bridge.

The roadway consists of a reinforced concrete slab with a 1½-in. asphalt wearing surface. The curb has been designed to facilitate snow removal and to permit snow to blow off the bridge.

Design Specifications

The specifications for materials, loads and permissible stresses which have been used as a basis for the design of the Sault Ste. Marie International Bridge follow general practice for modern structures of this type and magnitude.

The current specifications of the American Association of State Highway Officials have been followed, using the basic standard loading H20-S16-44 as generally applied to the design of bridges on major highways. The new vertical clearance of 16 ft. 3 ins. for structures overpassing Interstate Routes has been used throughout the project.

These specifications require design for a static wind pressure of 75 p.s.f. on the area of the structure as seen in elevation. This corresponds to a wind velocity of more than 100 m.p.h., far greater than any recorded velocity in that vicinity.

After careful consideration of the latest information on ice pressure on engineering structures, it was decided to adopt the very severe assumption of a transverse ice pressure for circular surfaces of 65,000 lb. per lineal ft. of pier width at the water line, similar to that used for the Mackinac Bridge. A longitudinal ice pressure of 5,750 lb. per linear ft. was taken simultaneously with the transverse pressure. The resulting forces are considerably greater than those generally assumed for engineering structures under comparable climatic conditions, and it is confidently expected that these forces are generously in excess of those to which the piers will ever be subjected.

General Description of Bridge

The bridge with its approaches is approximately 10,324 ft. long, exclusive of the bridge plazas, and the total length of structure is 9,280 ft. Including the plazas and the interchange south of the American plaza, the total length of project is 14,595 ft. or 2.76 miles. A 124-ft. minimum vertical clearance above low water is provided over the U.S. and Canadian ship canals, and the maximum grades are 3.75% on the U.S. side and 4% on the Canadian side.

The American plaza is located adjacent to Eureka St. between Easterday Ave. and Sheridan Drive for a distance of approximately 700 ft. South of the plaza the interchange between Interstate Route 75 and Easterday Ave. is located, including an overpass structure for Easterday Ave. The American approach runs north from the plaza to the River spans for a distance of approximately 2,471 ft., of which 2,081 ft. are on structure.

The River spans, comprising the two main structures over the American and Canadian ship canals and the crossings over the U.S. and Canadian power canals and rapids, have a total length of about 5,540 ft., of which the American spans are 2,663 ft. in length and the Canadian spans are 2,877 ft. long.

The Canadian approach, which is approximately 2,313 ft. in length, 1,659 ft. of which are on structure, extends north and east from the Canadian ship canal in a gentle curve to the Canadian plaza. This plaza lies between Queen St. W. and Albert St., and extends from Hudson St. to Huron St., a distance of approximately 660 ft.

TABLE I

Length of Project

Michigan State Highway Department		
Easterday Avenue Interchange......	2,911 ft.	
Roadway on Fill (North of Plaza)..	390	
Approach Spans.....	2,081	
Total............		5,382 ft.
International Bridge Authority		
American Side		
Toll Plaza........	700 ft.	
River Spans......	2,663	
Total............	3,363 ft.	
Canadian Side		
River Spans........	2,877 ft.	
Approach Spans.....	1,659	
Roadway on Fill....	654	
Plaza..............	660	
	5,850 ft.	
Total............		9,213 ft.
Total Length of Structure.........	9,280 ft.	
Total Length of Project..........		14,595 ft.

Substructure

The layout of the bridge including both approaches, provides for a total of 62 piers, of which 38 are two-legged bents having a single top strut. Eighteen are hammer-head piers for economy near the ends of the approaches where the pier heights are less. Six are pylon piers at the outer ends of the continuous truss units over the Ship canals and at the ends of the 275-ft. simple span truss over the Carbide Company power canal, in addition to the two abutments.

All the water piers are in relatively shallow water with a maximum depth of about 20 ft. in the U.S. power canal, 6 ft. in the rapids, and 17 ft. in the Great Lakes Power Company canal. Rock generally is close to the surface and all water pier footings will be founded in sandstone rock, placed as tremie concrete in steel sheet-pile cofferdams. The tremie seal footings in the rapids will be steel reinforced.

The piers in the U.S. power canal will be placed at a depth great enough to accommodate the widening of the canal for the future 20-ft. depth. The surrounding rock for an area of approximately 100 ft. by 100 ft. at each pier will also be excavated to this depth. The piers in this canal will be placed to align with the existing railroad bridge piers.

The truss span piers on the banks of the ship canals will be carried well into rock and will be constructed in the dry. Sealing of seams in the sandstone will be done as necessary to exclude water from the excavation, and to consolidate the seams.

The land piers also will be founded in sandstone rock except for the piers near the American abutment where the rock is fairly deep. These piers will bear on soil. The retaining walls and the Canadian abutment will also be founded on soil with a maximum soil pressure of 3 tons per square ft., and the American abutment will be founded on piles.

The total estimated volume of concrete in the substructure for the project, including the American approach spans, is 60,000 cu. yds.

Superstructure

The River spans include the American and Canadian main truss spans and the continuous girders spanning the U.S. Power canal and the St. Marys Falls.

The U.S. main truss spans consist of a four-span continuous truss unit with arch-form top and bottom chords and a suspended roadway over the American north and south ship canals. The two main spans are each 430 ft. long and the end spans are 200 ft. long. The design of the main spans has been planned to permit truss steel erection by cantilevering from the shore spans over the ship canals with materials being carried over the completed steel. The superstructure steel may be erected on either side of the west centre pier island by balanced cantilever erection about the pier and falsework bents on that pier island. With proper scheduling of construction operations it will be possible to avoid obstruction to navigation during the construction period.

A similar three-span continuous unit with arch-form top and bottom chords and a suspended roadway will span the Canadian ship canal. The main span is 430 ft. to permit construction of a future second canal, and the end spans are each 200 ft.

long, with the top chord at centre of main span 210 ft. above low water. The location of the north main pier has been placed on a line between the Canadian Pacific Railway swing bridge and the movable dam swing bridge, and 90 ft. north of the canal bank. Thus, when the bridges are swung, they will clear the pier, and sufficient space will be provided for pier construction.

Over both the U.S. power canal and the rapids, continuous girders are used. A three-span unit with equal 244-ft. spans is employed over the power canal, and three, four-span units with equal spans of 165 ft. are used over the rapids and south of the Canadian truss spans.

North of the Canadian truss spans, four 145-ft. simple span girders with one 124-ft. simple span girder are used on the horizontal curve over the Great Lakes Power Company canal.

Approach Spans

Since use of a pier in the Carbide Company power canal would have required widening of the canal for a considerable distance at substantial expense, a 275-ft. simple span deck truss will span this canal on the Michigan side.

Multiple beam spans approximately 30 ft., 63 ft. and 90 ft. in length are used in the 2,081-ft. Michigan approach south of the Carbide Company power canal where the alignment is on a 3-degree horizontal curve. North of the power canal a four-span continuous girder unit is employed with equal spans of 132 ft. on tangent, and three simple span girders with equal spans of 150 ft. are used south of Portage Ave. where the alignment is on a slight curve.

The Canadian approach consists of 1,659 ft. of beam and girder spans. Continuous girders with spans of 122 ft., 150 ft. and 122 ft. are employed for the three-span unit along the west edge of the Abitibi Power and Paper Company property adjacent to the pulpwood stacker and north of the power canal. Multiple girders are used for the four 105-ft. simple spans and for the two 134-ft. simple spans over the Algoma Central and Hudson Bay Railway and over George St. A skew span with multiple girders varying in length from 110 to 140 ft. is used over Queen St. The remaining spans are beam spans of 64-ft. length.

Carbon structural steel is used throughout for the superstructure, except that certain highly stressed members of the truss spans will be of low-alloy steel in conformance with the A.S.T.M. 242 Specification. The truss members are in general built up of 15-in. channels and cover plates, and lacing is avoided for any member of the bridge for economy of construction and maintenance, as well as better appearance.

The continuous trusses were analyzed with the moments over the piers as the redundants. The influence line computations for the continuous girders were performed by electronic computer. The stresses from lateral wind on the continuous truss spans were computed considering the effect of the curved chords. Lateral participation in dead and live load chord stresses was included in computing total lateral stresses.

Riveted construction is employed throughout, except for the composite beam spans, but the use of high strength bolts in place of field rivets will be permitted at the option of the contractor.

Muliple girders are used for the simple span girders of 105 ft. to 134 ft. span, which vary in depth from 6.5 ft. to 7.5 ft. Pairs of girders are used for the continuous spans which are from 132 ft. to 244 ft. in length and from 7 ft. to 12 ft. in depth. Pairs of girders are also used for the 9½ ft. deep 145 ft. long simple span girders.

The beam spans are of composite construction, generally 36 in. deep and vary from an abutment span of 30 ft. to a maximum span of 90 ft. on the American approach.

The stringers for truss and girder spans are set on top of the floorbeams and will be continuous in length of from 114 ft. to 368 ft. in order to reduce the number of joints in the roadway slab. The floorbeams, which are from 25 ft. to 30 ft. apart, are indicated to be 36 in. wide flange beams, but the contractor may elect to substitute deeper built-up girders where available depth permits.

In general the roadway slab will be of 7 in. ordinary concrete, but in order to reduce weight in the main spans of the continuous trusses, a 6-in. slab of lightweight concrete will be used. Bituminous surfacing 1½ in. thick will be used on all roadway slabs.

A 3-in. high curb with open sidewalk and curb guard railings will be employed to permit the snow to blow readily off the bridge. Favorable results have been obtained with this type of railing construction on the suspended spans of the Mackinac Bridge, but where high concrete curbs were employed, it was found that snow collected for a distance out from the curb equal to 12 times the curb height.

The total estimated tonnage of structural steel in the project, including the American approach spans, is 11,000 tons. Beyond the abutments the roadway is placed on fill extending to the plazas for a distance of 390 ft. on the Michigan side and for a distance of 654 ft. on the Canadian side.

Toll and Inspection Plazas

The toll plaza is located on the U.S. side adjacent to Eureka St. and

Fig. 3. View of Canadian Canal Crossing

ies between Easterday Ave. and Sheridan Drive. It is convenient of access to city traffic via Easterday Ave. or Eureka St. and will be directly connected to the proposed limited access Interstate Route 75. Property values in this area are comparatively low. This plaza will contain the toll booths, the U.S. Customs and Immigration building and inspection booths, the administration building and the garage and maintenance building. Ample provision has been made for future expansion to accommodate increased traffic. The plaza is approximately 225 ft. wide by 700 ft. long and will be paved with concrete.

The Canadian plaza is located between Queen St. W. and Albert St. W. and extends from Huron St. to Hudson St., but it will be unnecessary to take the frontage along Albert St. W. The plaza has been located in the city for convenience to the local traffic, while still providing connections to the major route via one-way streets. It is in an area of comparatively low-cost property. The plaza will contain the Canadian Customs and Immigration building and inspection booths, as well as a bus terminal and examination warehouse building. The plaza dimensions are approximately 270 ft. wide by 660 ft. long, providing ample capacity for future expansion to accommodate increased traffic. Approval of this layout has been received from the Chief of Accommodation, Department of National Revenue, Customs and Excise Division, Ottawa.

Lighting

A mercury vapor lighting series system will be used for the lighting of the roadway of the bridge. The roadway lights will be spaced 150 ft. apart, staggered about the centre line of the roadway, and will be at a maximum elevation over the ship canals of about 160 ft. above low water. This will greatly minimize, if it does not eliminate, the possibility of confusion between the much-lower existing lights of the canal area and the lights of the proposed bridge. However, it will be possible to use special shielded roadway lights to reduce glare and to confine the light to the bridge roadway.

Electric power will be supplied separately to each end of the project. Substations will be provided at each plaza and at other points to furnish power to the bridge, and emergency power for operation of toll recording equipment will be available in case of power failure at one of the stations. A telephone system will be provided on the bridge for maintenance and emergency use.

Estimated Cost of Construction

The estimated cost of construction of the project is $3.3 million for the Michigan approach, including the Easterday Ave. interchange; $5.8 million for the American plaza and American river spans; and $6.4 million for the Canadian river spans, Canadian approach and Canadian plaza; for a total of $15.5 million.

Construction Schedule

Financing was completed in September 1960. Assuming that all Right-of-Way for approaches can be obtained by March 1961, the following schedule of construction can be met. The construction of the foundations was started September 1, 1960, and based on the schedule below the bridge will be open for traffic on September 1, 1962.

Contracts for the substructure of the American and Canadian River Spans and for the American and Canadian Approach Spans were awarded September 13, 1960. Work was started September 13, 1960 and will be completed by November 1, 1961.

Contracts for fabrication and erection of superstructure steel for the American and Canadian River Spans were awarded September 13, 1960. Steel erection will begin June 1, 1961 and will be completed March 1, 1962. The contract for the American Approach Spans superstructure, including paving and lighting, was awarded in September 1960. Steel erection will start March 1, 1962, and all work will be completed October 1, 1962. The contract for the Canadian Approach Spans superstructure steel was awarded September 13, 1960. Steel erection will begin May 1, 1961 with completion January 1, 1962.

Paving operations will generally follow steel erection. Award deck paving contracts for the River Spans and for the Canadian Approach Spans April 1, 1961, begin paving August 1, 1961 and complete work August 1, 1962. Award Plazas and approach on fill contracts May 1, 1961, begin paving July 1, 1961 and complete work November 1, 1961.

Award contracts for the Easterday Avenue Interchange and American Approach on fill December 15, 1960, start work April 1, 1961 and complete work July 1, 1962.

Award Lighting and Electrical Contracts March 1, 1961 and complete this work by September 1, 1962.

Award Toll Booth Contract March 1, 1961. The erection of the booths would start on September 1, 1961 and all work would be completed by July 1, 1962.

Award Plaza Building Contracts April 1, 1961, start construction by May 1, 1961 and complete the buildings and Inspection Booths by July 1, 1962. EIC

Fig. 4. View of American Canals Crossing

GLACIAL LAKE CLAY DEPOSITS

Determination of their Original Depth in the Great Lakes Region

G. T. Hughes, M.E.I.C.
Associate Professor,
Dept. of Civil Engineering,
Royal Military College of Canada,
Kingston

When the glaciers retreated following the last ice age, large glacial lakes were formed. Clay sediments settled on the bottom of these lakes, sometimes to great depths. The original depths are found by consideration of sedimentation and consolidation.

WHEN THE glaciers which occupied the Great Lakes region during the Peistocene period retreated to the north, large glacial lakes were formed. Sediments accumulated at the bottom of these lakes—or this lake—to depths equal to or much greater than what exists now.

Portions of these deposits have been eroded by various forces, some of which are still active. It is of valuable interest to the civil engineer and to the geologist to determine the maximum depth of the glacial lake deposits, and the depth which has been removed since their deposition.

In some parts of the Great Lakes the amount of these clay deposits which have been removed from their surface since deposition ranges from nil to 10 ft. However, in areas of Lake Ontario deposits of glacial lake clay have had great depths of soil removed from the existing surfaces. An example of this is found at Kingston where it has been estimated by the consolidation test that clay deposits at one time were as much as 100 ft. thicker than they are now.

The correlation of total depth of deposition of glacial lake clays in one region compared with another since a given time can be obtained. The original depth of the clay deposits can be determined from the process of sedimentation, and the analysis of consolidation.

Glacial-Lake Clay Deposits

During the Pleistocene period the whole Great Lakes area including certain portions to the south, was occupied by the glacier. This continental glacier disrupted the previous drainage of the region, carved new channels in some cases and left various types of surface and lake deposits to later erosional forces. The St. Lawrence valley was dammed early in the movements of the glacier. The ice dam forced water from the glaciers to rise until it found an outlet to the Mississippi or eastward through the Mohawk valley in New York State.[1]

As the glacial front retreated to the north a lake was formed. The glacial lake was deeper and covered a much greater area than the present lakes. For instance, the Lake Ontario basin was occupied by Lake Iroquois which left shore lines to the north of Lake Ontario, and on the south extended into the Finger Lakes and other areas.[6]

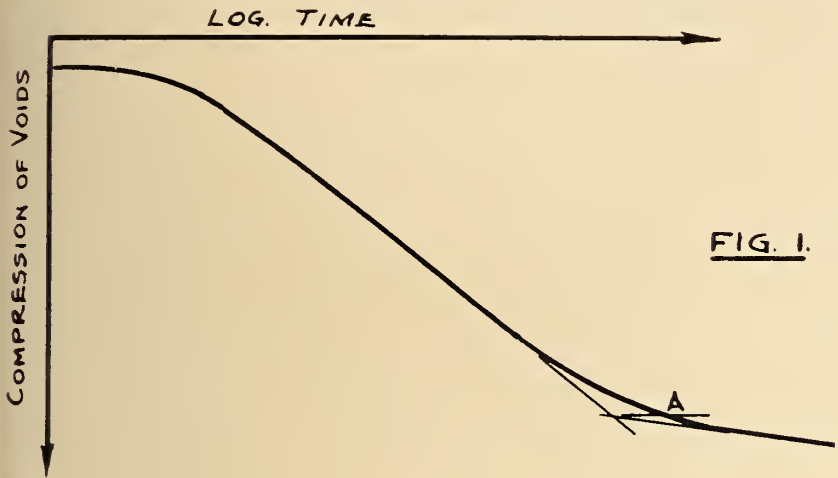
The formation of the lakes allowed the free seimentation of soil to the bottom of the lakes. The type of material deposited depended of course, on the type of material available in suspension and the season of the year. However, the net result was the formation of a clay deposit which in many cases is of a relatively weak nature.

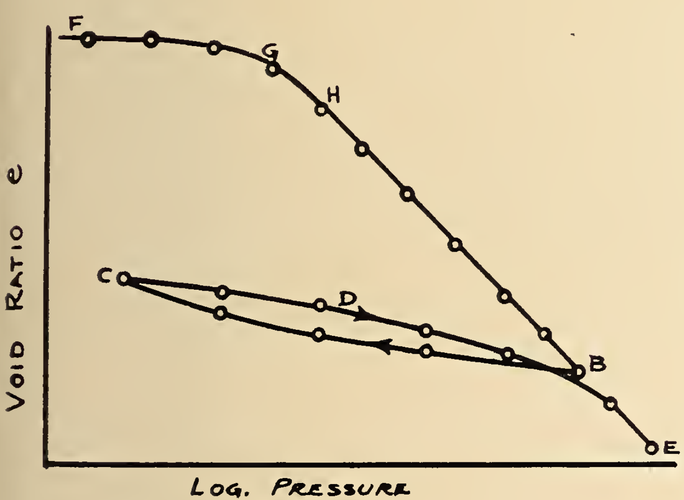
Glacial-lake deposits can be found today above the present water levels. Some of the deepest exposed deposits are found south of Lake Ontario. However, they have been almost completely removed from the higher lands on the north shore in Canada.

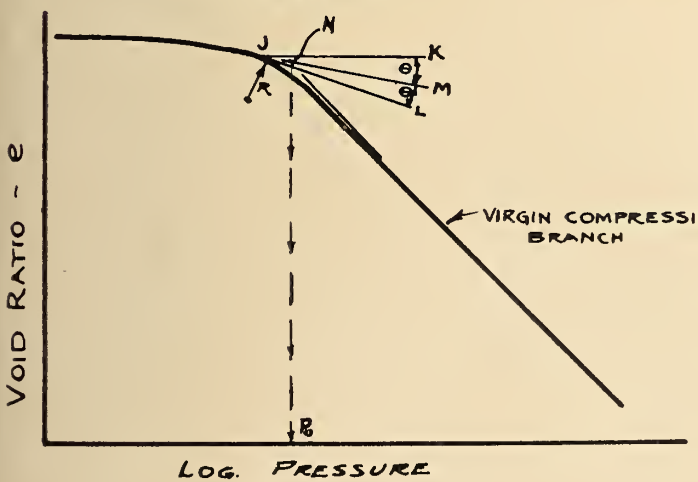
The seasonal variations which occurred in the pro-glacial lakes in the fresh, cold glacial water commonly experienced a summer and winter alternation in the type of material composing the glacial-lake clay deposits. In the summer relatively coarse, light grey material settled out in a layer, compared to a distinctly dark, finer grained layer deposited in winter. This alternate pair constitutes a varve. The transition from summer to winter is gradual, whereas that from the winter to summer is a sharply defined line or plane. The thicknesses of the varves vary with differences in melting rate in successive years. Therefore, it is possible to identify at different places the varve made in a particular year. When the unlike thicknesses of the varves for a series of years are plotted as an enlarged, jagged curve, the distinctive pattern of certain sequences is quite apparent. It has, therefore, been found possible to count thousands of years in succession where series of varve deposits permits the matching of such recognizable sequences from place to place. Together with this information, the determination of the maximum depth of glacial-lake deposits (even with undisturbed soil samples taken from drill holes) a correlation of total deposition in time in one locality compared with another, or with respect to surface elevation can be estimated.

As the glacier receded north, the St. Lawrence channel was reopened and the water level of Lake Iroquois was lowered to the present level of Lake Ontario which is 246.7 ft. above sea level.[2] The lowering of the water level caused the formation of streams in the Finger Lake and other regions which eroded channels in the glacial beds. One excellent example of this is the exposed varved clays at Mink Brook, Connecticut River Valley.

Figs. 1, 2, 3







Sedimentation or Consolidation

The formation of the glacial-lake clays is best described by the process of sedimentation and partly by consolidation. When the first seasonal or thickness of soil is deposited on the bottom of a lake it is considered to be normally loaded. It is exerted upon only by the forces of its own weight; that is, no greater forces have ever acted upon it in geological history. It is soft and any given volume of this deposit would consist of soil particles, which resemble a porous mass, with the pores completely filled with dater. The total load is taken by the soil skeleton. As another depth of soil or clay is deposited on the former layer, the former layer is not only subjected to the forces of its own weight but also the buoyant weight of the newly deposited layer of soil. As soon as this has occurred, the former layer begins to compress or consolidate under the new forces imposed upon it. The pore spaces, which can be referred to as voids, decrease under these loads. The compression or consolidation will continue until the load is no longer carried by the water phase but becomes completely supported by the soil skeleton. A characteristic curve for this process is shown in Fig. 1. When an additional layer of soil is deposited on the original soil layer, the original layer once again experiences the same pattern of consolidation as had occurred before. In each case the soil reaches 100% consolidation under the new load as represented by point A. However, it can be appreciated that the voids also have decreased during the successively larger loads to which it has been subjected.

The consolidation process which occurs in nature can be simulated in the laboratory by a consolidation test. Only the basic fundamentals of the test will be discussed here. However more details may be found elsewhere.[4] If the void ratio at A for each increment of load as indicated in Fig. 1, is plotted vs the log of the pressure due to the depth of soil, a definite characteristic type of curve is obtained as in Fig. 2. Each circle of the curve represents a point A of Fig. 1 for successively greater increments of load.

If we consider a soil sample from the glacial lake deposits which has been tested in the laboratory under increments of load which constitute the consolidation test, we will get the same type of result. However, let us load it to point B (Fig. 2) and then release the loads in small increments and in each case allow the soil sample to come to equilibrium before reducing the load further. Under these conditions we would obtain a curve BC. Then if we once again apply increments of load to the sample, and allow complete consolidation under each load, we will obtain the curve CDE. This curve represents a recompression branch of the consolidation or e log P curve. Point B represents what is called preconsolidation load point on the curve. The curve CDE is very similar to the original part of the e log P curve FGH. A point in the region of G represents a preconsolidation load in the same way as does point B. The preconsolidation load is the maximum load which has acted on the sample in its previous geological history; in our case the depth of overburdened or soil deposit.

The determinization of the location of G or the preconsolidation curve has a method which has been suggested by A. Casagrande. The graphical construction to locate the preconsolidation load is as follows. (See Fig. 3). Locate the shortest radius of curve in the region of the recompression curve as indicated by J. Next extend a horizontal line from this point and also construct a tangent to the curve at this point as represented by lines JK and JL respectively. Bisect the angle formed by KJL with a line JM. Next extend the tangent to the straight portion or the virgin compression branch of the curve until it intersects the line JM as represented by point N. Point N represents the preconsolidation load or maximum pressure that has acted on the sample of clay before in its geological history. The preconsolidation pressure is represented by pressure po. This pressure was caused in the case of our soil by the effective unit weight of the overburden multiplied times the depth of the deposit. The effective unit weight of the natural soil deposit is relatively simple to obtain and therefore the depth of deposit which existed over the sample in its geological history can be computed.

Fig. 4. Great Lakes Area

Maximum Depths of Overburden

A large percentage of the glacial lake clays in the Lake Superior, Lake Huron, Lake Michigan and Lake Erie areas are normally loaded. That is they have at present the greatest, or almost the greatest, overburden pressure acting on them that has acted on them in previous geological history. This is borne out by test results on glacial lake clays from Chicago. Sault Ste. Marie, Saginaw, Detroit Toledo, Fremont, Cleveland, as reported by others.[7,3] (Fig. 4). In some localities of these Great Lakes no overburden to a maximum of about 10 ft. has been removed in geological time.

However, in the Lake Ontario area, there are large deposits of glacial lake clays which indicate clearly that great depths of clay have been removed from the existing surfaces. An example of this occurs in the Kingston area. (Fig. 3). Consolidation tests performed on samples located below the present lake level indicate that at one time the soil had been subjected to pressures greater than those which exist today. These pressures were equivalent to a depth of about 100 ft of overburden greater than which exist today, or to an elevation of 347 ft. approximately.[8]

It is obvious that a similar case exists in such areas as the Finger Lakes and Mink Brook to the south and in other locations around the shores of Lake Ontario. With the determination of the age of a specific varve of glacial clay and the total pressure of depth of overburden in one locality compared with another it is possible to determine the respective amounts of total deposition or sedimentation in one area compared with another with respect to age or time.

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Economic Aspects of
INDUSTRIAL POWER PLANTS

H. R. Wright, M.E.I.C.
Swanson Wright & Co. Engineers Ltd.,
Consulting Engineers, Vancouver.

The cost of power in industrial operations is generally a minor part of the total product cost. Even though the percentages are not high, a reduction or increase in the cost of power can be significant in maintaining adequate operating profit margins.

IT IS sometimes surprising to find that, with the possible exception of the metal refining industry, the cost of power in an industrial operation is not a major component of total product cost. It varies from about 1% in the lumber industry, 4% to 8% for pulp and paper, to 12% to 15% in some chemical plants. While these percentages do not appear to be high in themselves, a reduction or increase in cost of power can be a significant factor in maintaining satisfactory operating profit margins.

In the planning stages for a new plant or expansion of an existing plant, it is important to know whether or not serious consideration should be given to investment of capital in generating plant as opposed to purchase of power from an outside source.

Many of our pulp and paper and metallurgical plants obtain power from hydroelectric developments which are operated by the plant management or by wholly owned subsidiaries. The calculation of power costs is a relatively straightforward addition of fixed charges on capital, operating and maintenance labor and supplies, charges for water consumption, taxes and insurance. In certain cases it is possible to prorate some of the supervision and maintenance charges, and, where water is re-used for process, to prorate charges for water, but these are adjustments of secondary magnitude and calculations are similar in other respects to those for a separate hydro-electric utility system.

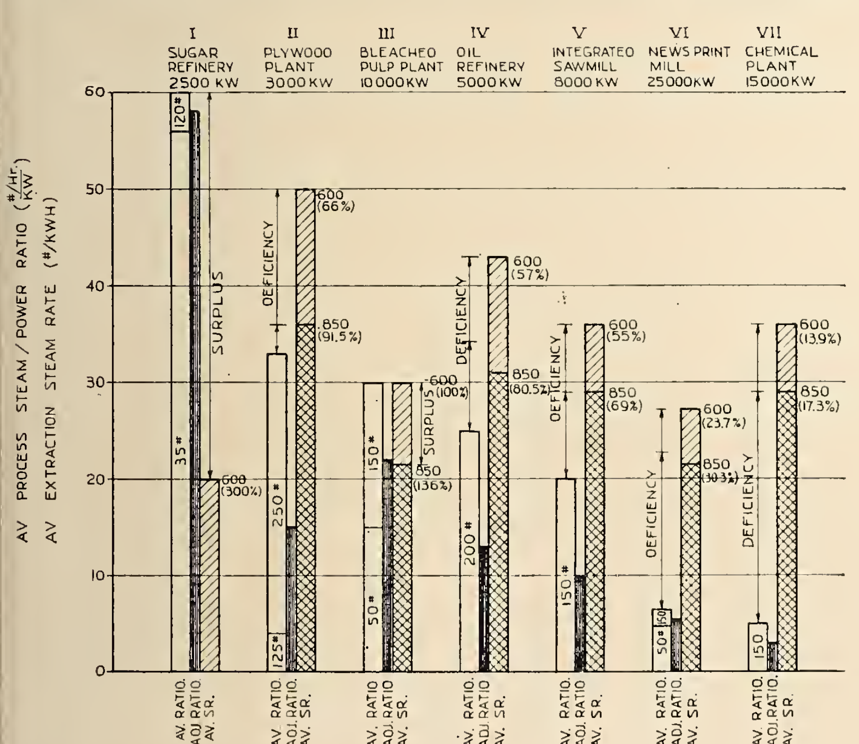
The calculation of power cost for a diesel electric plant is also comparatively straightforward except that prorated costs and possible credits for heat recovery may be of greater relative magnitude.

Steam electric plants, on the other hand, are often integrated closely into requirements for process steam, and the prorating of capital charges and operating costs can be complex.

It is of value in these cases to make rapid preliminary calculations of approximate cost. This paper has been prepared to provide a means of approximate determination of probable costs for steam power generation where the boiler plant is a necessary part of the process plant.

In general it can be stated that the diversion of capital for construction of an industrial steam power plant be-

Fig. 1. Variation in process steam/power ratios for a number of industrial plants.



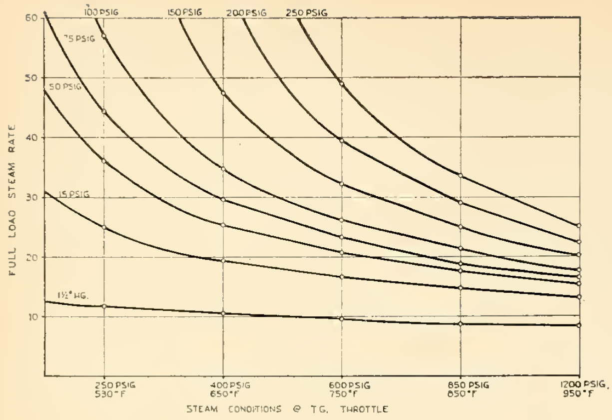


Fig. 2. Steam Rates for extraction turbines at different throttle and extraction pressures.

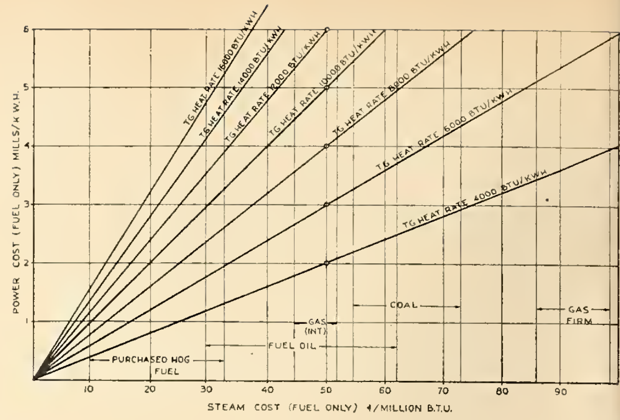


Fig. 3. Steam cost in cents/MKB against power costs in mills/kwh. for various turbogenerator heat rates.

comes increasingly attractive with: (a) an increase in the ratio of process steam demand to process power demand; (b) a decrease in the process steam pressure; (c) an increase in required power plant rating; (d) an increase in plant load factor; (e) a decrease in fuel cost.

Fig. 1. is a vertical bar diagram in which the first illustrates the wide variation in process steam/power ratios for a number of representative industrial plants.

For the sugar refinery the ratio is 60/1 with the greater part of the process steam requirements at 30 psig.

For the plywood plant the ratio is 33/1 and the main process pressure 250 psig. For the bleached pulp mill the ratio is 30/1 and the process flow divided equally between 50 psig and 150 psig. Similarly for the integrated sawmill the ratio is 20/1; for the newsprint mill, 6.6/1; for the chemical plant, 5.7/1, and for the oil refinery the ratio is .7/1.

These ratios may vary for specific plants in the same industry but can be taken as typical of the wide variation between industries.

The second bar in the chart shows the relative steam/power ratios after adjustment to a common 30 psig level by multiplying by the ratio of extraction steam rates from a common high-pressure base. The relative positions of the plywood plant and the bleached pulp mill are reversed by this adjustment.

The third bar in the chart shows the weighted average extraction steam rates for high-pressure steam conditions of 600 psig, 750° F., and 850 psig, 850° F., and the approximate surplus or deficiency of potential power generation from process steam in each case.

When the surplus is large, as in the case of the sugar refinery, and the variation in steam and power demands relatively small, it is possible to operate the plant without using a turbine condensing section. When the margin is small or where there is a deficiency, it is necessary to provide a condensing section, a separate condensing turbogenerator, or the equivalent in an outside power connection for frequency stabilization.

Fig. 2. is a chart showing aproximate steam rates for extraction turbines at different throttle and extraction pressures. The steam rates shown are full-load rates for a 5000 kw. unit and require adjustment for turbine rating and for part-load and extraction losses.

From the steam/power ratio in Fig. 1. and the curves in Fig. 2., the percentage of total process power which can be generated from process steam can be calculated for standard throttle steam conditions. Using this percentage the average turbine heat rate can be read from the chart in Fig. 8.

When the cost of fuel and the probable boiler plant efficiency is known, the calculation of the fuel component of process power cost component can be completed by reference to the chart in Fig. 3., which plots steam costs (fuel only) in cents/MKB against power costs (fuel only) in mills/kwh. for various turbogenerator heat rates.

The calculation of capital and operating cost components is more complex.

In most industrial plants where

Table 1

PLANT	I Sugar Ref.		II Plywood		III Bl. Pulp		IV Oil Ref.		V Sawmill		VI Newsprint		VII Chemical	
Maximum Demand kw	2500		3500		12000		5000		8000		25000		15000	
Load Factor %	80		70		85		90		52		90		90	
KWH/yr.	17,500,000		21,400,000		89,300,000		39,400,000		36,300,000		197,000,000		118,000,000	
Fuel	Oil/Gas		Wood		Wood/Oil		Oil		Wood		Wood/Oil		Oil/Gas	
Operating Pressure psig	600	850	600	850	600	850	600	850	600	850	600	850	600	850
Power Cond. %	100	100	66	92	95	100	57	80	55	69	24	30	14	17
Turbine type	NC	NC	EC	EC	EC	NC	EC	EC	EC	EC	EC	EC	EC	EC
Fixed Charges	2.75	2.95	3.95	4.00	1.61	1.31	2.50	2.60	3.85	3.90	1.60	1.70	1.80	1.90
Operating Lab. and Supp.	0.56	0.57	0.59	0.60	0.20	0.18	0.35	0.36	0.36	0.37	0.13	0.14	0.15	0.16
Maintenance Lab. and Mat'l.	0.56	0.57	0.59	0.60	0.20	0.18	0.35	0.36	0.36	0.37	0.13	0.14	0.15	0.16
Total exc. Fuel	3.87	4.09	5.13	5.20	2.01	1.67	3.20	3.32	4.57	4.64	1.86	1.98	2.10	2.22
**Fuel	2.00	2.00	1.20	1.00	2.10	2.00	4.00	2.50	1.70	1.25	5.15	4.95	6.15	5.65
Total	5.87	6.09	6.33	6.20	4.11	3.67	7.20	5.82	6.27	5.89	7.01	6.93	8.25	7.87

**Oil at 50 cents/MKB and Wood at 20 cents/MKB as steam.

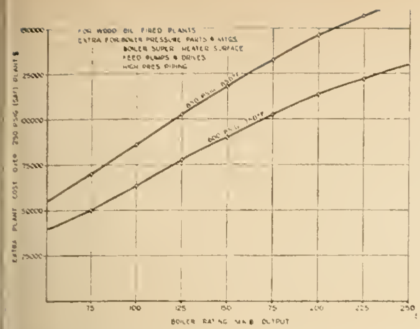


Fig. 4. Approximate additional cost of changing boiler plant steam conditions.

steam is required for the process in relatively large amounts, it is usual to assume that the capital investment required for generation of this steam is a basic charge against process equipment and only the additional cost due to increased operating pressure, increased boiler capacity, increased fuel storage, additional operating and maintenance charges, etc., are chargeable to the cost of power generation. Sometimes the segregation of these costs is a difficult task. For preliminary studies the charts which follow may be used with some discretion, bearing in mind that adjustments should be made throughout the preliminary calculation phase for any specific set of circumstances.

Fig. 4. shows the approximate additional cost of changing boiler plant steam conditions from 250 psig saturated to 600 psig, 750° F., and to 850 psig, 850° F. Costs include the extra for boiler pressure parts and super-heater, feed pump and drive, and high pressure piping, plus a moderate increase in boiler rating for plants where the majority of process power can be produced from process steam.

Fig. 5. gives preliminary estimating figures for the basic turbogenerator plant for non-condensing and extraction-condensing operation. It follows that any plant which shows a heat rate greater than 4000 B.t.u./kwh. must include the extraction-condensing turbogenerator or its equivalent unless an external source of power is available to make up the difference between non-condensing turbine output and plant demand.

In Fig. 6. the costs taken from Fig. 4. and 5. are combined to show the total capital cost in dollars chargeable to power generation and this same cost on a basis of dollars/kw. of plant capacity.

For extraction-condensing operation where there is more than minimum flow to the turbine condenser, it is necessary to add to the capital costs shown in Fig. 6. to reflect the cost of the necessary increase in boiler plant capacity. The amount of this adjustment can be obtained from the curves of incremental cost in Fig. 9.

The curves in Fig. 7. show approximate unit values of fixed charges corresponding to capital costs in the preceding curves for plant load factors of 50, 70, and 90%.

The slope of the preceding curves indicates why it is often difficult to justify power generation for smaller industrial plants even when fuel has a negligible or even a negative value, and at this point it is possible in many cases to form an opinion of feasibility without further study.

Typical unit costs for the plants listed in Fig. 1. are tabulated for comparison in Table 1. Charges include operating labour and supplies, and maintenance labour and materials, as incremental to those required for process steam generation alone. Fuel

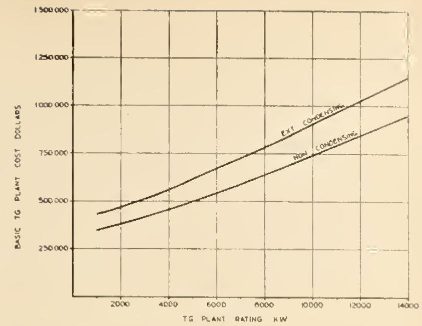


Fig. 5. Preliminary estimating figures for the basic turbogenerator plant.

charges are also based on incremental fuel values so that power generation in the wood/oil-fired plant is charged with the higher cost fuel. The totals are representative of costs actually experienced in similar plants.

As suggested, the principal value of the charts and the comment in the foregoing is to permit a fast preliminary appraisal of the economic feasibility of a project and to point out the areas which justify further detailed analysis, and for this reason they have been found to be a useful addition to engineering reference files.

As may have been gathered from the subject matter of this paper, one of the author's principal interests is in the study of power generation in the forest products industries.

In the lower mainland of British Columbia there is available an annual surplus of 600,000 units of hogged wood waste. In spite of conversion of most or all suitable solid waste to pulp chips, and diversion of some bark to production of bark extractives, the total surplus increases each year due to increased mill production. In urban areas where operation of burners is prohibited by air pollution by-laws,

Fig. 6. Costs from Fig. 4 and Fig. 5 combined to show total capital cost.

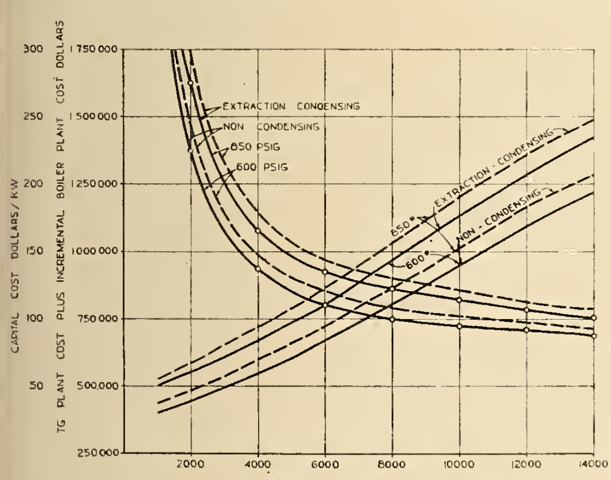
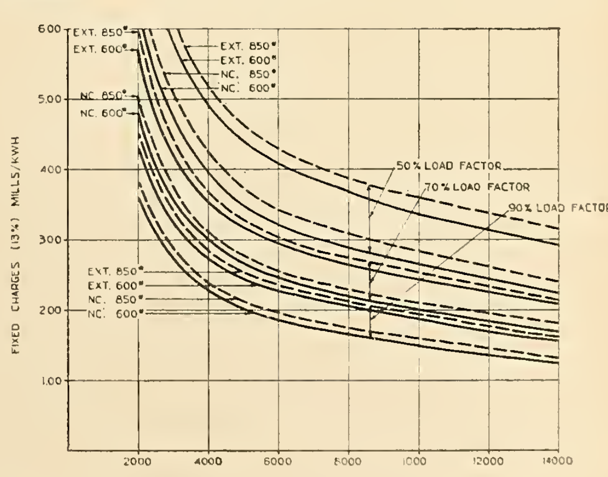


Fig. 7. Unit values of fixed charges corresponding to capital costs in the preceding curves for varying plant load factors.



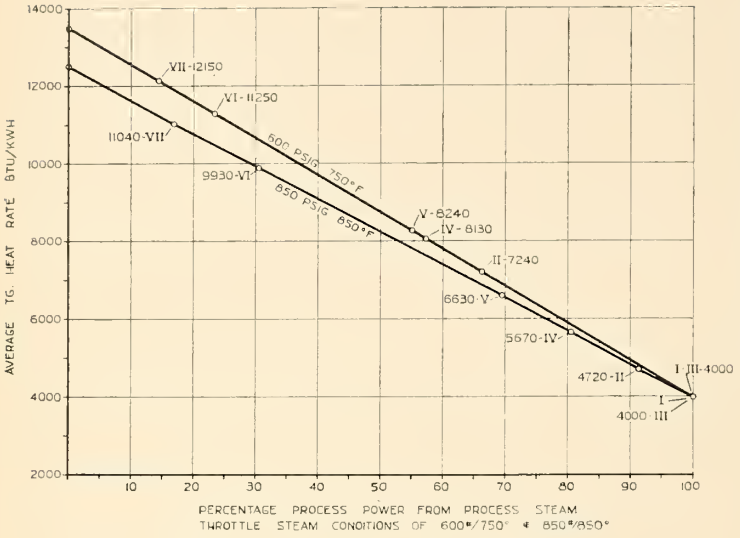


Fig. 8. Average Turbine Heat Rate

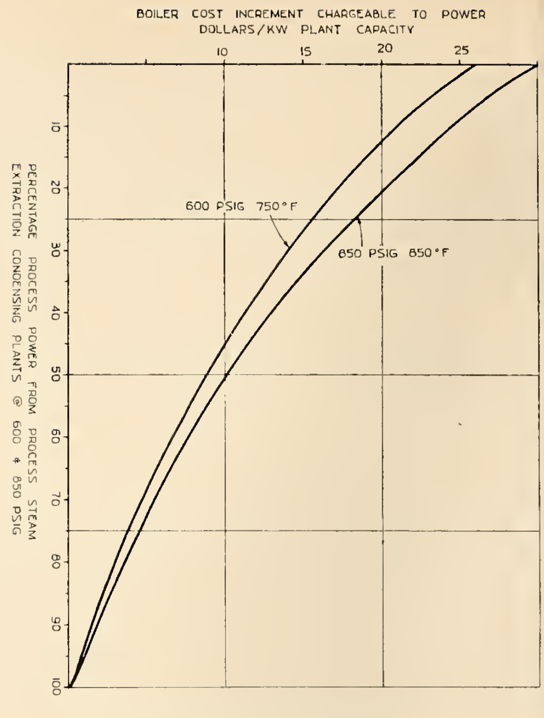


Fig. 9. Curves of Incremental Cost

disposal expense is a very real problem to mill operators.

Some time ago a study was made to determine the feasibility of construction and operation of a 150 MW, 60% load factor, utility type steam power plant to provide an outlet for disposal.

This study indicated that the industrial type power plant where the power plant is combined with process steam plant, as outlined here, is possibly a more profitable method of utilizing the available wood waste. This is especially true if the waste originates in the same plant, and the power plant fuel system is integrated with the mill waste system.

Consideration of the power generation project is prompted by necessity for replacement or expansion of existing power steam generating plant, by pressure from air pollution authorities, by a sudden increase in rates for purchased power, or by a combination of these factors, and where the power load is appreciable, the generation of power can show a satisfactory return from savings in purchased power and reduction in waste disposal expense.

In the selection of equipment for such a plant the specification for the boiler is a major item for thorough study.

The term 'hogged wood waste', or 'hog fuel', does not describe fuel characteristics any more than the term 'coal' describes the characteristics of lignite or bug dust. The range of variation is in some ways similar to coal. For comparison, coals vary in moisture content from under 5% to possibly 30% (or a ratio of 6/1), with higher heating values varying from under 8000 B.t.u./# to over 13,000, a ratio of 1.6/1. Wood waste may vary from 10% moisture content for plywood plant sander dust to over 60% moisture content for hemlock bark, a ratio of 6/1, and higher heating values from 7150 B.t.u./# for the true firs to over 10,150 for Douglas fir bark, a range of 1.42/1. The variation in fuel quality during actual operation is also probably greater and more rapid than in any coal-fired plant. Many operating problems are due to this sudden change from wet to dry fuel and back again to wet.

In recent years most of the large wood-fired boilers have been designed for pulp mill use to burn wet bark and refuse from the woodroom, augmented usually with oil, coal or gas fuels, or in a few cases by solid wood waste from outside sawmills: a somewhat different application from the normal sawmill or plywood plant application.

It may be of interest to examine some boiler designs offered recently for sawmill, plywood or shingle mill application.

These include a unit for pile burning of wood waste in a grateless cell at the bottom of a furnace designed for supplementary coal or oil fuel; a unit for optional thin bed or low pile burning of sawmill/shingle mill waste; and a somewhat larger unit for thin bed or pile burning of sawmill/plywood waste.

Each of these units provides for air preheating to approximately 500° F. to improve furnace stability with wet and variable moisture fuels and to improve boiler efficiency for possible future firing of purchased fuels; a baffle-free boiler bank to minimize erosion; from 20 to 50% of preheated high-pressure overfire air for increased furnace turbulence, to burn out light fuel particles; and a cinder return system using spent gas as a conveying medium to reduce fire hazard in collector hoppers. Sander dust where available is introduced with a minimum of conveying air below the feed spouts.

Incorporating improvements of this kind, a power plant just commissioned will replace two old HRT dutch oven process steam plants, and generate approximately 8000 kw. of process power requirements.

Our industrial plant management groups are continually striving for increased uitlization of raw materials and reduction of even minor items of operating expense. Where power generation can be shown to provide a satisfactory return on investment, there is little hesitation in providing necessary capital for quality equipment. The engineer can be of real value to these groups in preparation of feasibility studies, design, and in the solution of the many problems which accompany the development project. EIC

TRENDS IN ELECTRICAL ENGINEERING EDUCATION

B. R. Myers, M.E.I.C.

Professor of Electrical Engineering and Chairman of the Department, The University of Waterloo, Waterloo, Ontario.

In this age of rapid development it is recognized that many of the professions, engineering included, require instruction in greater depth than now is available during a four year course at university. Traditional teaching concepts must be revised.

THE SCOPE and procedures of engineering education are in a state of rapid evolution. More and more, it is being recognized that engineering as the other professions—requires education well beyond the bachelor's degree, and that a period of internship is required before a truly professional status is attained.

The traditional concepts of engineering education are therefore fast disappearing. Predominant in this trend is abandonment of the teaching of detailed engineering practice. The "know-how" type of course has been relegated from the university to either on-the-job training in industry after graduation or to the vocational school or technical institute, whose job it is to train rather than educate. In particular, non-technical courses on such matters as industrial processes, industrial management, which at one time, and not too long ago, were found in every engineering curriculum—no longer have a place in the university, since they tend to be descriptive and qualitative in nature and contribute little or nothing to the analytical and philosophical education of the individual. Similarly, the course content and teaching procedures of the technical courses are changing. The emphasis is towards more scientific disciplines, and away from practical engineering skills and manipulative procedures.

In short, the function of a university engineering curriculum is no longer to match the graduate to the industrial job market, but rather to give him a potential for creative activity in his chosen field. The onus for acquainting him with the clutteria of practical engineering procedures and the industrial climate must rest with industry in his internship after graduation, at the same time recognizing the potential which he has accrued in his university years and which he must be given the opportunity to develop further in his professional career.

The reasons for these trends are not hard to find. In contrast with earlier times, the spectrum of technological activity which now falls under the aegis of the professional engineer is almost without bound. Practising engineers are constantly confronted with problems for which their past training and experience is inadequate. Thus, training for a specific job is neither possible nor desirable. One manifestation of the trend in the last decade has been the vast increase in the industrial demand for engineers with advanced degrees. Another manifestation has been the introduction of post-graduate training programs by many large industrial organizations, offering purely academic courses of the type given in university graduate schools. Still another manifestation has been in the converse direction—the tendency for new graduate engineers to seek employment in the larger industrial organizations which can afford to offer further education and which also encourage research activity and scholarly pursuits.

These trends are particularly true in electrical engineering. Electrical engineering education is moving away from the traditional concepts of engineering more rapidly than any of the other disciplines*. The traditional simplifications formerly used in the teaching of many subjects are now clumsy and both practically and philosophically inadequate. Electronic devices are appearing, particularly semiconductor devices, which cannot be treated by classical physics; classical circuit theory is inadequate at frequencies which are now common; the teaching of "heavy" electrical engineering—heavy rotating electromechanical machinery courses and electric power systems analysis—and which used to occupy a major portion of the electrical engineering curriculum—now occupies but a small part of the academic spectrum. Indeed, modern electromechanical problems have become much more so-

*The author includes those electrical engineering subjects which are taught in Canada under the guise of "Engineering Physics"; for example, much of electromagnetic engineering, control system work, and so on.

phisticated—extending, for instance, into the subject of magneto-hydro-dynamics.

By virtue of the unique inter-disciplinary nature of electrical engineering, electrical engineers are rapidly assuming a dominant role in such fields as physiology and psychology —fields which are diverse in their pursuits. Experimental psychology in particular might almost be regarded today as a branch of electrical engineering which has sprung up on the wrong side of the campus. Another field in which electrical engineers have played a significant lead is that of information theory, due to the obvious connotation with signal communication theory. The electrical engineer finds himself intimately able to contribute in these various fields because he is disciplined in circuit theory, communication systems and control systems. These disciplines find ready application in physiology in studying neural responses and biological control systems; and in experimental psychology in studying muscular responses to electrical impulse trains, i.e. an application of data processing techniques—the analysis, storing and processing of digital data.

Reactions to these trends in different educational institutions have been many and varied. In fact, the academic scene is in a turbulent state of flux, not only in North America, but also in most other countries. A quick survey of existing curricula is enough to reveal that there is no such thing as a "typical" curriculum. Some curricula (particularly some of those offered as "Engineering Physics" in Canadian institutions) have a predominantly theoretical and scientific content; at the other extreme, some schools still offer a traditional curriculum, with a heavy content of classical rotating machinery, power, and industrial engineering courses.

The only significant common factor seems to be the turbulence and activity which exists in academic circles. Educators are searching for an optimal curriculum. An indication of this activity is the increasing number of conferences and meetings being held in North America for the specific purpose of discussing electrical engineering education. Some particularly well-attended meetings were the Summer 1957 Curriculum Workshop held at the Massachusetts Institute of Technology, the 1958 Sagamore Conference on Electrical Engineering Education, the Symposium on Electrical Energy Conversion and Control held at M.I.T. during the summer of 1958, the Spring 1959 Laboratory Workshop at Syracuse University, and the Conference at the Case Institute of Technology in 1959 which was devoted to the place of materials in the curriculum.

The purpose of the present article is to collate some of the current aspects of technical trends in one place and under one title, and thus give the situation a perspective which may be useful in guiding the electrical engineering educator's thinking in matters of curriculum planning. No pretense is made in the article of presenting, or even suggesting, a solution to the problem of optimizing a curriculum. Such a solution can only come after considerable deliberation and mutual exchange and assimilation of ideas over the years; even then it must be one of compromise.

Selected topics will be considered one at a time, and attention will be confined primarily with the undergraduate curriculum in mind.

The Basic Science Content of the Curriculum

The demand for more scientifically mature engineers has lead to a re-examination of the physics, mathematics and chemistry content of the engineering curricula. Although the reader can no doubt think of many others, some of the more popular questions being asked are:

Should classical physics precede the teaching of modern physics?

At what level, i.e. in which year, should modern physics be introduced?

Is enough mathematical preparation given to ensure an adequately quantitative level of presentation of the physics material in early years?

Might not some of the early mathematics and classical physics be better taught by members of the engineering faculty?

What provision should be made for advanced courses in physics and mathematics?

Should physical chemistry be a required course for engineers?

To what extent can numerical analysis, probability and statistics be introduced into the curriculum?

In physics, the main topics required in the freshman and sophomore years are Mechanics, Modern Physics, Electricity and Magnetism. In addition, there is usually some coverage of Heat and Light.

There is little doubt that these topics must be retained in the early part of the curriculum since they are basic to engineering. Mechanics is the most basic of all, and should be a substantial course spread over a whole academic year in order to permit assimilation of the material. It should be taught in the freshman year in order not to retard the rest of the curriculum. This brings up an important difficulty, however: namely, that the freshman is normally only just being exposed to the calculus which the mechanics course really requires. To postpone the mechanics course to sophomore year, that is until after freshman calculus has been completed, does not seem to be the answer because the same difficulty would arise in connection with whatever physics course was given in place of mechanics in first year.

The most tenable answer to the problem at the present time seems merely to require that the freshman physics instructor be made fully aware of it and hence prepare his lectures carefully to make up for the students' deficiency in mathematics at this stage. Hopefully, it may eventually be possible to enhance the level of preparation in high school prior to entering university, and thus eliminate the problem.

A similar difficulty is encountered with the modern physics course. If given at an early level, the student's mathematical maturity is inadequate to permit other than a qualitative survey course. Nevertheless, it is generally believed that it should indeed be given prior to the professional courses, to lay the groundwork for such courses as semiconductor electronics and a modern presentation of the properties of materials in the professional part of the curriculum.

Should the engineering faculty teach the early classical physics and mathematics courses? This is a debatable question, and one which has not yet been resolved. One school of thought is adamant in their "physics-by-the-physicists" and "mathematics-by-the-mathematicians" beliefs. Another school of thought believes that it would make for a better academic whole to have the engineers teach these early courses. Thus there would be less unnecessary duplication of material in the later professional courses, and the psychological effect on the student would be to improve, or even eliminate, his attitude to these early courses. This attitude now is generally one of intolerance and impatience due simply to the fact that the courses are given outside of the engineering departments.

As to what provision can be made for advanced courses in physics and mathematics in the later part of the curriculum, this is very much a local matter, depending on the size and facilities of the particular institution.

Presumably the most convenient method is to offer such courses as technical electives in the professional years; for example, a selection from courses in atomic and solid-state physics, experimental nuclear physics, quantum mechanics, physical chemistry, group theory, the calculus of matrices, advanced complex variable function theory, and so on, in addition to the more conventional sequence of electives in engineering. Thus, the full spectrum of student ability and engineering could safely be accommodated within a single curriculum, and much of what is taught in Canada under the title of "Engineering Physics" would be moved into the engineering curricula proper—which is where, in this author's opinion, it belongs. While there was a need many years ago for curricula which, as it were, bridged the gap between engineering and physics, that bridge has now been crossed by the engineers so that "Engineering Physics" as a title is rapidly becoming obsolescent.

Incidentally, it may be noted that physical chemistry was listed above as a possible advanced or elective course. This essentially answers an earlier question as to whether physical chemistry should be a required course. It seems to be generally agreed that it is not a necessary part of the curriculum for electrical engineering.

How about the last of the questions listed earlier—to what extent can numerical analysis, probability and statistics be introduced into the curriculum? Here, some definitive answers have cemented in the last two or three years. Due to the increasing complexity of modern technological systems, these topics have become essential to the training of the engineer. The increasing number of variables and the magnitude of the problems which he now has to solve calls for formal education in the methods of numerical analysis—leading in his professional years into the use of digital computers. The increasing complexity of modern systems and the continual tightening of performance margins, calls for some training in probability and statistics.

It is therefore felt that these topics should be seeped down into the undergraduate curriculum. *Numerical methods* and *numerical analysis* should be given in each of the professional years. Furthermore, they should be given by the mathematics department, since the mathematicians are best able to separate the problems and techniques into classes and thus maintain an orderly perspective which the professor of engineering may not have. Ultimately, in senior year, a course in digital computer programming may be given as an elective by the mathematics department. Computer aspects proper are dealt with in a later section of this article. Suffice it to say that numerical methods and numerical analysis courses are essential to the preparation and support of the computery work which the engineer will get in his professional courses.

The situation with *probability* and *statistics* is not quite so definitive. Past practice has been for the engineers to teach this material as and when they need it, in communication theory courses, for instance, rather than run it as a separate entity given by the mathematics curriculum. Since engineers are usually well-versed in the applications of probability theory it might be as well, in these days of crowding curricula, to continue the existing pattern.

So much for the basic sciences in the engineering curriculum. While the venue of this article is directed specifically towards the *electrical* engineering curriculum, many of the remarks made in this section apply also, of course, to the other engineering disciplines such as mechanical, civil and chemical.

Field Theory

All naturally-occurring electrical phenomena are basically three-dimensional. They are explainable in terms of field theory. The seemingly logical approach to the electrical engineer's professional education would therefore be to start with field theory. It might be said that this is in fact done to some extent in the early physics courses, when fields of force and other phenomena are studied. In the professional courses, however, it is an unfortunate fact that electrical engineering has traditionally relegated field theory to the background.

The reason for the traditional approach is not hard to find. Phenomena have been handled in the guise of circuits, with the circuit parameters defined on the basis of mathematical, not physical, concepts. The field concepts involved in the definition of circuit parameters have been given very little attention; for example, the convenient mathematical description of lumped resistance, capacitance and inductance is well approximated by the physical behavior of practical elements in the frequency ranges which have been in common use in the earlier development of electrical technology. The extension of frequency usage into the microwave region and beyond brought courses in electromagnetic engineering which were simply tacked on to the curriculum in the senior undergraduate years. Much of the associated theory merely extended the undimensional, linear, low-frequency concepts.

This approach does not always serve modern needs, however. Electrical engineering research activity in recent years has been directed in areas such as molecular engineering, microwave computers, cryogenic devices, solid-state devices, magnetohydrodynamics, parametric devices, scatter propagation, plasmas, beta-ray spectroscopy, nuclear blast simulation, biological computers, neurology studies—an infinity of applications requiring a more fundamental understanding of basic phenomena. These researches have made, and are still making, their impact on industrial technology. It is therefore becoming increasingly important that the undergraduate student be prepared, at least psychologically, to contribute in these areas if called upon to do so in his professional activities after graduation.

Many schools are doing this by giving an electrical science course immediately following the early physics courses, in which an engineering interpretation of basic field phenomena is developed and in which a thorough appraisal of field concepts is involved in defining circuit parameters. In addition, the early properties of materials courses are now being treated as much from their internal microstructure as from their handling and external working properties. In the solid-state area, modern electronic courses now include appreciable solid-state theory. In electromagnetic engineering, there is a welcome tendency to introduce elementary waveguide and antenna theory more thoroughly into the curriculum.

All this has been made possible by elimination of what used to be traditional courses such as economics and industrial processes, as well as by more efficient use of the time available in those courses which have been retained. Even so, there still is a tendency in many institutions to leave field theory until the later years, rather than seeping it down throughout the curriculum in conceptual and other forms. The issue is one which is constantly being evaluated by electrical engineering educators in searching for a well-balanced modern curriculum.

Circuit Theory

It is difficult to divorce circuit theory entirely from field theory in talking about the curriculum since the two disciplines are fundamentally inter-related and the ideal curriculum would presumably develop the two aspects simultaneously. There are, however, some distinct trends in the presentation of circuit theory, per se, which are worthy of note.

First and foremost, tradition has developed a large body of circuit *analysis* for strictly *linear* systems. The pattern has been to first introduce the student to elementary steady-rate analysis of simple passive circuits in his early physics electricity and magnetism course. This pattern continued in the electrical engineering courses with sinusoidal and cisoidal analysis of linear circuits. No attention was paid to non-linear and time-variant circuits. The pattern has changed considerably in the last few years, however, in that pole-zero concepts are now fairly general and the Laplace transformation has been almost exclusively adopted. The emphasis is more towards pulse techniques, and away from the old sinusoidal and steady-state influence. One manifestation has been that it is no longer philosophically desirable to have the student introduced to circuit theory from the sinusoidal steady-state point of view in the early physics course. Another manifestation is that certain aspects of network *synthesis* material are creeping into the undergraduate curriculum.

A more significant trend has been the incorporation of *signal theory* into what used to be exclusively circuit theory courses. The feeling is that signals and circuits cannot justifiably be divorced. A particularly important philosophical aspect is that this joint pattern lays a sound basis for bringing in some non-linear and time-variant circuit theory, by virtue of the student's introduction to integral transformations. In addition, it has become obligatory for the student to be exposed to the theory of functions of a complex variable—though many schools still teach this within the engineering courses proper, as and when they need it, rather than having a separate course in the subject given by the mathematics department.

Another function of the circuit theory courses is, of course, to generate the disciplines on which most servomechanism and control system theory depends. In this age of automation, it is highly desirable that the student of electrical engineering be required to take one course or another in control or servo systems in his senior year. This is rapidly becoming the case in mechanical engineering as well.

Energy Conversion

One of the most active areas of academic interest, that which used to be called "electrical machinery", is being redefined. The modern aim is to provide the students with a unified treatment of the theory of electrical machinery by approaching it from the standpoint of the underlying principles of electromechanical energy conversion. The steady-state performance of machines has traditionally been studied by phasor and equivalent-circuit methods. More attention is now being paid to transient analysis by generalization of the impedances through impedance transformations. Laplace transform methods are finding favour over the conventional use of Heaviside's calculus.

Thus, the modern approach to machinery exactly parallels that in circuit theory and communication. In conjunction with a more rigorous alliance to basic field phenomena, "machinery" thus presents the area of most radical change. It is extending even into magnetohydrodynamic conversion studies (the motion of an electrically conducting fluid in the presence of a magnetic field).

In short, energy conversion is appearing as the most important concept in electrical engineering education; it facilitates the cohesion of circuit theory, field theory, linear and non-linear systems. It presents the greatest threat to the older pattern of curriculum, which involved rotating machinery and power system courses.

System Analysis

One of the distinctive features in engineering which distinguishes it from other fields is the emergence of the *system concept*—the engineer's interest in whole systems, as opposed to the lone and separated components which comprise a particular system. Examples include transmission systems, electronic systems and control systems. The behavior of a vacuum tube, for instance, is of little interest as a physically isolated device; rather, it is its behavior when the device is embedded in its applicatory environment that is of most interest—specifically, the dynamic behavior of the system as a whole; for example, an electronic feedback amplifier is more properly viewed as a system, rather than as a collection of discrete components.

This systems-oriented bent, like the concept of the principle of energy conversion, has made a particular impact in very recent times on the rotating machinery area of the electrical engineering curriculum. The earliest electrical engineering curricula evolved primarily from a study of the theory, design and operation of rotating machines. The several types of machines were dealt with both separately and one at a time. Early courses dealt with the characteristics of each machine on its own.

With the advent of control systems and servomechanisms, however, a unification of curriculum planning has appeared possible. Just as with the vacuum tube in electronic applications, the rotating machine is now being treated as a component of an electromechanical system. This approach may well prove to be significant in achieving an optimal and efficient curriculum, in keeping with the increasing demands of the times.

Computery

The spectacular growth of technological achievement in recent years has been made possible primarily because of the even more spectacular growth of the computer field—a field which was not in existence twenty years ago. Both analogue and digital computers have become necessary tools of the practising engineer. The undergraduate student must therefore be exposed to their operation and use. While electrical engineers are interested in the design of computers as well as in their use, this section will be confined only to their use as a problem-solving tool.

The techniques needed to solve a problem on the *analogue* machine do not differ too greatly from those conventionally used in engineering analysis. Thus, little formal instruction is required for most educational purposes. One simple answer is to have a small analogue computer, for instance a desk-top machine, located permanently in each of the undergraduate laboratories. The machines should be accessible not only during their regularly scheduled laboratory sessions, but also at other times, to encourage the students to resort to them in solving homework problems as well as laboratory assignments. An alternative possibility to having a small analogue machine located in each laboratory would be to have a pool of several of them in a central location, with free access for students at all times.

The important thing is that it is of little use having computers available only at restricted times. Just like the slide rule or desk calculator, the computer must be available and ready for use essentially at the very instant that the individual requires it. This is particularly important so far as a student is concerned, since his time is limited by rigorous class schedules. If the computer is not available when he wants it, that is, when he is both free to use it and at the same time is motivated to do so, the danger is that he may never get to use it at all. This would constitute an educational failure for which the faculty would be, surely, as culpable as the student.

Concerning the *digital* computer, the common methods of solving engineering problems are no longer satisfactory. It calls for formal courses in numerical methods and some instruction in programming. These topics were discussed earlier in the section on the scope of the basic sciences in the engineering curriculum. Briefly, it was stated that numerical methods and analysis should be introduced and taught by the mathematics department in the professional years. A course entity in computer programming is not necessarily desirable, however, for programming is the professional prerogative of the mathematician.

Accordingly, it is believed that the best way to introduce the student to the digital computer as a problem-solving tool is through the medium of a small machine, to be used in regular course work rather than as a separate course on its own. Each electrical engineering department should have its own small digital computer, and program library. The students should be given enough instruction so that they can write elementary programs and gain some feeling for the potentiality of computery. It is not necessary that they be able to write the programs for all the problems which they may be called upon to solve by computer in their work. Library programs should be made available for the more complex problems.

A major objective in introducing computery into the undergraduate work is, of course, to eliminate the drudgery of long-hand computations. It is generally accepted that long-hand methods contribute almost nothing to the individual's education. In this day and age, no efficient engineering industry would fail to take advantage of computer facilities— either owned, rented or through a service bureau. Thus, most engineering graduates will have computers available for their work.

In addition to the small computer as a campus facility, there is also the question of establishing a large on-campus computing centre. Such a centre would house a large digital machine and would be staffed by professional full-time staff. Its function, however, would be more in the graduate and faculty research areas, rather than in undergraduate teaching. This author is firmly convinced that all universities should aim at establishing such a facility, though the question is not immediately germane to this article and will not therefore be discussed further.

Laboratories

Laboratory experience has always been, and still is, an essential ingredient of engineering education. With the increasing level of abstractness and unification of the classroom material, several questions arise in connection with the laboratory sessions.

First, is it now preferable to aim towards a more general type of laboratory, rather than the more prevalent fashion of running separate laboratories to accompany the corresponding lecture courses? Secondly, there is the impact of computery, discussed in the previous section, which permits more time for truly educational work by virtue of the elimination of long-hand and point-by-point computation.

These are probably the two main aspects, though the reader can no doubt think of many others. Suffice it to say that this is another of the most turbulent areas of interest. Some positive reorientation seems to have been effected at many schools. For example, the classical approach to heavy rotating machinery laboratories is disappearing in favour of the systems approach to machinery. It has finally been acknowledged in many areas that it is not necessary to employ huge, multi-horsepower machines; small, fractional-horsepower machines do the job just as well. Furthermore, the small machine is readily integrated into a control system, thus unifying the field and making for a better overall offering. In the electronics area, pulsed and digital experimentation is replacing a lot of the older sinusoidal work. Switching circuits are finding a place in the undergraduate laboratory — with an increasing element of logical design, rather than the more usual type of cut-and-dried experiment which had an accompanying set of purely manipulative instructions.

The basic problem in organizing a modern laboratory seems primarily one of faculty time available for preparation and supervision. It is much less time-consuming, and therefore also more economically feasible in terms of operating budget, to prepare and supervise the discrete, cut-and-dried type of experiment than the type of experiment involving design and interpretive work.

Concluding Remarks

The primary purpose of this article has been to list the major trends which are occurring in electrical engineering education and at the undergraduate level, and some of the reasons and manifestations associated with these trends.

Briefly, present reorientation of the undergraduate curriculum is towards truly scientific fundamentals, with a strong, almost total, de-emphasis of current engineering practice in industry. Due to the increasing complexity and size of modern technological systems and the continually accelerating pace of technology, the function of a university engineering education is no longer to match the graduate engineer to the immediate industrial market; rather, it is to give him the analytical and philosophical depth which means that, after a subsequent period of internship in industry, he has the creative potential which the present day calls for, as well as the potential for professional leadership.

No attempt has been made in this article to present a solution to the problem of drawing up a composite curriculum. It is felt that it would be unreasonable and uninformative to do so; for not only does so much depend upon local conditions, but also the national and international academic scene is still one of turmoil and indecision in searching for common agreement on what should be done.

Robert F. Legget, M.E.I.C.,

Director, Division of Building Research, National Research Council, Ottawa.

Early Ottawa and Engineering

OTTAWA is a charming city. To both residents and visitors alike the nation's capital with its waterways, its parks and parkways, and its steadily growing collection of stately buildings crowned by the noble group of buildings on Parliament Hill, must often appear to be a perfectly located city, an expanding municipality utilizing an area specially chosen as a desirable site for a capital city. But all who know anything of the history of Ottawa know that this superficial impression of its beginnings is far from correct. The city does occupy a lovely location but the city of today stands where it does mainly because it occupies the site of an early construction camp, built on a clearing in the virgin forest, its location determined by the start of a military canal that is still a notable engineering undertaking. This is but one of the close links between early Ottawa and early engineering work. Today under the co-operative guidance of the National Capital Commission and local municipal councils it is slowly being transformed from a rather nondescript town into a capital district of which the nation may well be proud.

There are many major cities of the world located on the banks of one river, some at the junction of two. There are but few cities, however, that have the good fortune to have three important rivers within their bounds. If the residents of Hull and Gatineau Point will permit such a slight geographical inexactitude, for the purpose of this paper only, then it can be said of Ottawa that its immediate area does include the confluence of three important rivers, the Ottawa, the Rideau and the Gatineau, all of which have had their influence upon its development. First and foremost is the Ottawa, one of the truly historic waterways of North America, providing the main route to the interior of most of this continent for almost all of the early explorers.

It was in 1613 that Champlain saw and described the lovely falls of the Rideau River, as he approached the Chaudière, there to disembark and follow the two short portages on the north bank of the river, long used by the Indians. As the continent was explored, he was followed by a steadily increasing stream of travellers, the Ottawa being used in preference to the St. Lawrence as the more direct route to the upper lakes and to the north. Brûlé and Nicolet, Le Caron and Brébeuf, Radisson and Groseilliers, and LaSalle in the 17th century; Lavérendrye, Alexander Henry and Alexander Mackenzie in the 18th; and a great number, including David Thomson and Simon Fraser, as recently as the last century — all these pioneers came up the Ottawa and portaged to the Chaudière. And in the very early use of this famous portage, unknown voyageurs, anxious to make their traverse a little easier, constructed what can accurately be described as the first Ottawa engineering project — four or five sets of stone steps and a small stone causeway near the upstream end of the Second (or Little) Chaudière Portage. Largely through the efforts of the two Canadian Clubs of Ottawa, these historic relics have been preserved in place, as a national historic site, just as they were used through the years; they may be seen today near the east end of Brébeuf Park in Val Tétreau (in Hull). What Canadian, and in particular what Canadian engineer, can stand on these ancient steps — looking at the wonderful panorama presented by the modern city — without being moved by thoughts of all the pioneers who have trudged up and down that same portage path, by reflections upon the the inevitability of some sort of settlement being formed adjacent to the great falls, now harnessed so completely for modern convenience.

Philemon Wright, a shrewd and energetic Yankee from Woburn, Mass., saw this possibility on his third journey north of his border with the result that in February 1800 he left his home town with his family and some associates, arriving in March at the Chaudière, there to settle on the north bank, thus founding what is today the modern city of Hull. The first settlers in the Ottawa valley had come

Photograph in the article heading is of a Bartlett print, published in London in 1842, in the possession of the author. It shows the entrance locks of the Rideau Canal as they appeared in 1839.

in a few years before, starting in 1791, but they were still scattered and isolated when Wright, with the aid of his sons, set about clearing his land. His fame spread and so he was soon followed by other pioneers who were attracted by the possibilities of business at the portage, including the redoubtable Miss Dalmahoy of Edinburgh (whose story all engineers should know even though it can not be classified as engineering). Caleb Bellows was one such settler; it is recorded that in 1809 he built not only a store but also a small dock on the south side of the river at what soon came to be known as Bellows Landing, the location from which the Rideau Canal might have started had it not been for a strange chapter of accidents. Nearby, another pioneer (Ralph Smith) built, in addition to his cabin, a still which might thus be classed as the first industry of the area.

By 1826, Philemon Wright had cleared 3,000 acres; Hull was a thriving little community. The south side of the river, however, was still almost untouched virgin forest, magnificent stands of trees extending right to the water's edge as travellers' accounts of the time vividly record. In the whole of Nepean township there were only two stores, one stone building, three squared timber houses and a few small log cabins. Such was the site of the modern city, when early in September of that year, the Earl of Dalhousie, Governor-in-Chief, accompanied by a middle-aged officer of the Royal Engineers, and their aides, sailed up the river from Montreal, to be greeted warmly by Wright. They had come to select the site for the entrance to the Rideau Canal, the British Government having finally decided that this vital link in the alternative route between Montreal and the fortress of Kingston must be built, even though the government of Upper Canada had declared itself too poor to contribute to the cost. Fear of renewed war was in the air. Military authorities knew that, if hostilities did break out again with the United States, Kingston could not be supplied (as it had been throughout the war of 1812) by way of the St. Lawrence, since American ambushes along the international reach of the river would be a certainty. The Rideau River had to be canalized, the Rideau Lakes linked by navigable channels, and the Cataraqui River transformed from a rushing stream into a chain of navigable lakes in order to permit the passage of supply vessels from Montreal, up the Ottawa and so to Kingston.

The Engineer officer was Lieut. Col. John By, selected almost certainly by the Duke of Wellington himself to be the Superintending Engineer on this great work. By and the Earl of Dalhousie inspected the site proposed by the Governor for the canal entrance, and agreed upon the first steps to be taken towards construction. Before they left to return to Montreal, the Governor wrote and gave to By a letter which was, in effect, the charter of Ottawa for in it he said: "I take the opportunity of meeting you here to place in your hands a sketch Plan of several lots of land, which I thought it advantageous to purchase for the use of Government. . . . These not only contain the site for the head locks, but they offer a valuable locality for a considerable village or town for the lodging of Artificers, and other necessary assistants in so great a work . . ." the letter proceeding to explain how some of the land was to be subdivided, even going so far as to detail how buildings should be located on the lots — the start of local town planning. One year later, the "corner stone" for the locks was laid by the Countess of Dalhousie in a small but pleasant ceremony held on Sept. 29, 1827. Less than five years later, on May 29, 1832, Colonel By now accompanied by his wife and two daughters and fellow officers came back to the same spot, but this time on board the little steamer *Pumper*, (renamed *Rideau* for the occasion) at the conclusion of the first voyage through the completed canal, starting at Kingston Mills. The achievements of John By during those five years, in design, construction and in local administration, constitute an epic of North American engineering.

Faithfully indeed did the Superintending Engineer carry out his assigned tasks — and the citizens of today benefit therefrom in innumerable ways. He reserved for the use of government the site now known as Parliament Hill. He laid out unusually broad streets, with the co-operation of Nicholas Sparks; Wellington and Rideau Streets are the legacy. He aided the establishment of local churches; he initiated local education; he started essential municipal services. His construction work is seen in the canal of today, with its flight of entrance locks and those at Hartwells and at Hog's Back, where By's great dam is now the core of the modern structure. He flooded Dow's great swamp in a singularly bold piece of engineering, thus bequeathing to the modern city the pleasure of Dow's Lake, constructing one of the first large earth dams in North America for this purpose, a dam still to be seen to the east side of Colonel By Drive. One of his construction buildings still stands, most fortunately, a fine example of old masonry work now happily used by the Ottawa His-

Fig. 1. The Second Union Bridge, designed by Samuel Keefer, having a clear span of 243 ft. 6 in.; opened in 1844 (From a water colour in the Public Archives of Canada, Ottawa; reproduced by permission).

Fig. 2. Entrance Locks to the Rideau Canal as they appeared in 1860; the Sappers' Bridge is on the extreme right, the arch obscured by the wooden sidewalk; the Chateau Laurier now occupies the cleared area on the far side of the Canal, originally used as the construction work yard for the Canal (From a photograph by S. McLoughlin in the Public Archives of Canada; reproduced by permission).

torical Society and maintained by them as the Bytown Museum. Containing much interesting local historical material, it is so much under the shadow of the Chateau Laurier that all too few visitors (and citizens too) ever notice its existence. And on the site of his construction yard and main workshops stands the Chateau Laurier. Rarely has the construction of one engineering project been so directly responsible for the start of a city as was the Rideau Canal for Ottawa. It is good indeed to think that the Canal has become so central a feature of the city, that it has been so well maintained through the years, and that it has been so beautified by its surrounding gardens and parkways. Long may it remain so vital a part of this city.

Even before construction of the Canal was complete, the little construction camp had become a small town. At a dinner held in 1827, it had been suggested almost jocularly that the settlement, officially first called Rideau Canal, should be named Bytown. The name was quickly adopted for official use; as Bytown the city was incorporated and remained as such until 1855 when Ottawa was adopted as the new official name. Wharves and warehouses had been built on the River, adjacent to the canal entrance; these were very quickly put to full use. The canal did serve its intended purpose of conveying troops and military supplies, even though most fortunately these were not needed for actual warfare. But civilian traffic on the Canal increased rapidly; the merchants of Montreal were not slow to see the advantages of shipping their goods to Upper Canada by the new route, with the result that within a few years there was a regular and frequent service on what became known as the "Triangle Route" — Montreal, up the Ottawa, the Rideau Canal to Kingston, and back to Montreal down the St. Lawrence. Only when the first steamer reached Kingston by way of the finally completed St. Lawrence Canals, in 1855, did the Rideau route cease to be in fact, if not in name, the first St. Lawrence Seaway.

This canal traffic led not only to good business for Bytown but also to the erection of additional wharves, warehouses and service buildings, thus having an appreciable effect upon the physical development of Ottawa. So also did the corresponding traffic on the Ottawa River itself, between Montreal and Hull and Bytown. Towards the end of the century there was an express river passenger service by which it was possible to leave Ottawa at 7:30 in the morning and arrive in Montreal by 6:30 the same evening, making use of the once famous Carillon and Greenville Railway to circumvent the rapids below Hawkesbury without the delay of using the Ottawa River Canals. The first class fare for this splendid trip, including shooting the Lachine Rapids, was $2.50, meals being 50 cents each. The future of these picturesque and historic waterways, as old as the Rideau Canal, is now in grave doubt, in view of the start on the Carillon power project. Once before the old canals had been threatened, when the Georgian Bay Ship Canal project was under active consideration early in the present century. It was not built, but the Carillon project has already started. Some part of the old canals should be preserved.

Passengers on the Ottawa River steamers would see not only river traffic provided by other steamers and barges, but the special Ottawa River traffic consisting of rafts of squared timbers. The magnificent stands of white pine throughout the Ottawa Valley attracted early attention, to such an extent that they soon became a major source of supply for the British Navy in its great days of wooden warships. Philemon Wright was responsible for the first raft of timber to go down the Ottawa; it left Hull June 11, 1806. Almost a century later, June 18, 1904, the last raft made the same journey, the owner being another famous local figure—J. R. Booth. The rise and fall of this great industry within the hundred years is a fascinating story, the character of the Ottawa Valley being virtually transformed as the great trees were steadily cut down to be replaced — if at all — by smaller species. The great rafts were engineering structures of note, statically indeterminate without doubt, but sturdy and stable as built with all the skill of Ottawa rivermen, who became famous throughout the continent.

Rafts could not pass over the Chaudière and so had to be dismantled above, the timbers being passed down separately at first, to be re-assembled in the quiet water below the falls. Hardwood had actually to be carted around the falls, as much as 20 days being taken to transfer a full raft. It was no wonder, therefore, that during his first visit, in September 1826, Colonel By was approached for aid with this problem. He persuaded the Earl of Dalhousie to grant £2,000 for the dredging of a channel on the south side of the falls and this made some improvement. It was Ruggles Wright, Philemon's son, who first suggested the possibility of constructing timber slides as a solution to the continuing problem, following a visit he had paid to Sweden and Norway to study Scandinavian methods of handling large timber. The first slide was built in 1829; two more were soon added and competition became keen. They were most successful; rafts had merely to be disarticulated at the head of the falls, sent down the slide in sections, and re-assembled below.

Old photographs show clearly what an exciting venture was the "navigation" of a timber slide, but the river men were adept and sure of themselves, so sure indeed that when King Edward VII as the Prince of Wales visited Ottawa in 1860, he was taken down one of the slides on a small raft of squared timber, greatly to the concern of some in his entourage. One of the last "official" uses of the slides was in 1901 when the Duke and Duchess of Cornwall (later to be King George V and Queen Mary) were taken down during their Canadian visit of that year. The slides were splendid engineering structures, themselves solidly built of squared timbers. Remains of the slides are still to be seen, the upper part of the Wright slide within a stone's throw of the busy rue Principale of Hull, immediately behind the old Anglican Church of St. James. One, at least, of these old slides should be retained, restored and preserved as a reminder of one of the most colourful aspects of Ottawa's early history.

With the steady development of Bytown a local demand for sawn lumber arose, to meet which two firms established saw mills using water power derived from the use of a small amount of the water flowing over the Chaudière. Harris and Bronson, and Pattee and Perley, were proprietors of tow companies having original grants (issued in 1861) – names which include two well known in Ottawa in more recent years. Earlier, in 1851, Ezra Eddy of Vermont rented a small building in Hull and started to make wooden clothes pins, wash boards, bowls and pails, thus starting the great industry which occupies so dominant a place in the local economy today. John R. Booth came to the district shortly after from his home in the eastern townships; he worked at first for the Wrights but in 1858 rented a small shop of his own in Ottawa (with Robert Dollar) to manufacture split shingles. So started another great local industry, the development of which has involved so much plant engineering, as the power available at the Chaudière has been harnessed for use.

There were other mills in Bytown in those early days, the first a small one operated by the Bywash, a stream which ran down near what are now Cumberland and York Streets. The owner, Jean-Baptiste St-Louis, was leased a mill site at the Rideau Falls April 30, 1830; he was soon cutting wood along the Rideau for his new mill. Thomas McKay eventually came to own this mill; he had been operating a grist mill since 1833 on the other branch of the Rideau. W. C. Edwards and Company were later owners, operating the mills until the early years of this century. There is still a "mill" at the Rideau Falls, the National Research Council today operating a small water power plant, recently rebuilt in connection with the rehabilitation of Green Island, in which about 1,500 h.p. are generated. Small in comparison with developments at the Chaudière, the Rideau Falls mills and power plants provide an unbroken example of local engineering endeavour from the earliest days of settlement.

Thomas McKay

Thomas McKay's name is an honored one in Ottawa; the city owes much to him. A masonry contractor who had earned an enviable reputation in Montreal before the start of the Rideau Canals works, he was entrusted by Colonel By with the masonry work for the great entrance flight of locks, now so familiar a feature of the Ottawa scene. Testimony to the excellence of his workmanship can be obtained by going and looking at the masonry in the locks, so close to this hotel. Colonel By's satisfaction was shown by his gift to McKay, at the end of the work, of a silver loving cup, specially wrought in London. McKay was a successful as well as a capable contractor, with the result that he made a good profit on his Rideau contracts. Alone of all the major canal contractors, he chose to stay in Bytown, making this district his home for the rest of his life. Some of his money he invested in the mill already mentioned. Another use to which he put his profits was to build for himself a stone mansion, using the skilled Scottish masons he had employed on the locks. This great house was located so far from the centre of the settlement that it was called, derisively, McKay's Castle. McKay purchased the land on which he built, and 1,000 acres around, another act of folly in the view of the local inhabitants of the time. The 1,000 acres eventually included much of the village of Rockcliffe Park. McKay's Castle is known today as Rideau Hall, another legacy of engineering to the nation.

It was in 1868 that McKay's Castle, and 90 acres of land around it, were purchased by the nation (after being rented for two years) for the use of the Governor General of the newly-formed Dominion, after it had been decided not to build a new "Government House" on Nepean Point, as had been originally planned and strongly urged. Sir John A. Macdonald was overruled by his cabinet colleagues on this matter for he is reported to have said, at a later date: "I also wished to acquire all that property" (pointing to the direction of Nepean Point) "and to build Government House there; but some of my colleagues would not hear of it . . . the consequence is that . . . we have spent more money patching up Rideau Hall than a palace would have cost at Nepean Point." The patching up process still continues but the old house now has become such a national monument that any alternative to it as the Canadian home of Her Majesty and of her Canadian representative is unthinkable.

Parliament Buildings

An associated building must be briefly mentioned, even though engineers can claim no share in its design; its construction, however, was at the time an unprecedented feat of "engineering construction". This was the original block of Parliament Buildings, started as early as 1859. In 1860, the Prince of Wales made his special journey to the little settlement of Bytown in order to lay the foundation stone. The East and West Blocks of today give a good idea of what the original group of three

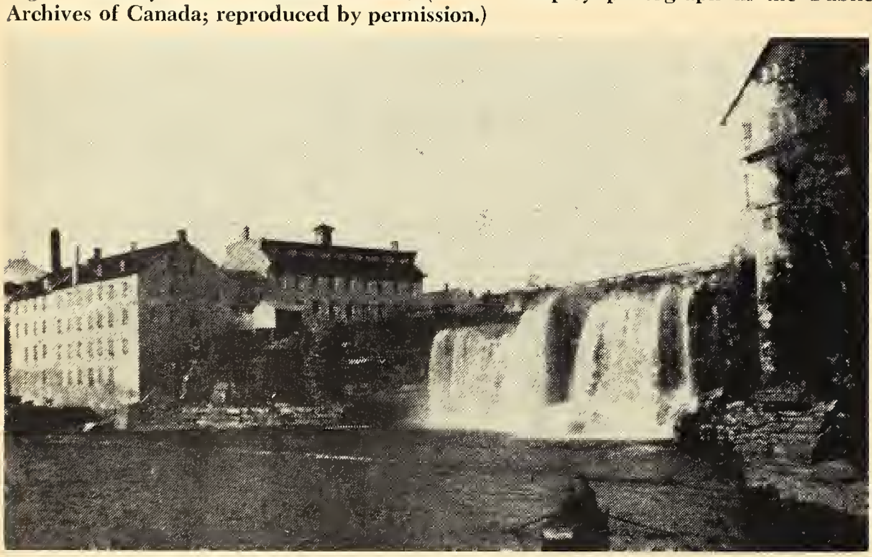
Fig. 3. Part of a timber raft going down one of the Chaudiere timber slides towards the end of the nineteenth century. (From a Tapley photograph in the Public Archives of Canada; reproduced by permission.)

buildings must have looked like. Destruction of the main building by fire in February, 1916 was a national tragedy, but the noble building replacing it after the war years now forms a most fitting centre to the lovely grouping on "The Hill". Writing in 1864 to John A. Macdonald, George Brown had this to say: "The buildings are magnificent; the style, the extent, the site, the workmanship are all surpassingly fine. But they are just 500 years in advance of the time. It will cost half the revenue of the province to light them and heat them and keep them clean. Such monstrous folly was not perpetrated in this world before. But we are in for it, I do think the idea of stopping short of completion is out of the question . . . I go in for such a superb folly that will bring visitors from all countries to see a work they can't see elsewhere. To say the truth, there is nothing in London, Paris, or Washington approaching it." Engineers can share with their architectural colleagues the pleasure which these old words may bring, even as they can share also in the responsibility for some of the interesting, if unusual, older buildings of the city such as the old "tin house" on Guigues Street at the corner of Dalhousie which shows how engineering skill, of a peculiar variety, can be applied to architecture.

An architectural friend suggests that the men capable of producing such work in the past were the predecessors of those who provide the air conditioning systems of today. Throughout the years, engineering and architecture have been closely linked in Ottawa. Today, it will take the united efforts of both professions, working with other citizens, to preserve for posterity at least some of the remaining links with the past.

Buildings are peripheral to engineering activity; bridges are not, their design being a major branch of civil engineering. The first major civil engineering undertaking in Canada west of Montreal was the construction of a bridge of which every Ottawa engineer may be justly proud, parts of which are still in daily use by heavy traffic, although unknown and unrecognized by all but the few. Reverting again to that busy visit to Hull in 1826 of The Earl of Dalhousie and Colonel By, the two men saw clearly that access from the north to the south bank of the Ottawa River would be an essential preliminary to the start of the Canal works. Another result of their short visit was therefore a decision that the river must be bridged, Colonel By noting that this could readily be done by a series of short bridges linking together the several islands that made the Chaudière a fall of such beauty. His Clerk of Works for the Canal, a Scot named John McTaggart, was therefore sent up from Montreal together with Thomas McKay, with instructions to get the bridge started; they arrived in Hull early in October, 1826. Undaunted by all the tales he had heard of the Canadian winter, McTaggart decided to build the first stone arch immediately; McKay loyally supported him, as his master mason. So started Canada's first winter construction job, a dry-stone arch with a span of 57 feet being completed by February, work proceeding through what must have been a particularly cold winter. McTaggart has left a graphic account, noting that he froze one of his hands one morning while shaving in an unheated room. It is this same arch that is still in use as an integral part of the modern Chaudière Bridge, located just north of the gateway to the Hull plant of the Gatineau Power Company but naturally unseen from automobiles; one has to be a humble pedestrian to see clearly this splendid piece of masonry work, still serving after 130 years.

Fig. 4. McKay's Mill at Rideau Falls. (From a Tapley photograph in the Public Archives of Canada; reproduced by permission.)



Work on the remaining arches proceeded throughout the early months of 1827; Colonel By himself is credited with the way in which connection was made across the Big Kettle, where a span of 200 feet had to be bridged. He had a small cannon brought to the edge of the gorge (probably borrowed from Philemon Wright for the occasion) and a shot was fired with a light cord attached across the rushing waters. This was used to pull successively heavy ropes over, until finally it was possible to haul across strong "iron cables" obtained for the purpose from the naval stores at Kingston. With this connection made, cables were strung from which was supported a remarkable 200-foot span wooden truss that can better be illustrated rather than described. The bridge was opened for use in 1827. It provided a 30-foot roadway and is said to have cost only £2,500. Appropriately named the Union Bridge, it was the first connection between Upper and Lower Canada, and served well throughout the busy Canal construction period. But in the spring of 1836 the truss collapsed, fortunately without loss of life.

A ferry service was quickly instituted. Operated by John Perkins, the main ferry boat was one of the early engineering wonders of the Valley for it was one horse power in fact, a horse walking in the boat on a treadle geared to a shaft on which were two paddle wheels. It was not until May 23, 1843 that the foundation stone for a replacement of the ill-fated timber truss was laid, a suspension bridge having been designed by Samuel Keefer under the supervision of H. H. Killaly, Chairman of the Board of Works of Upper and Lower Canada, predecessor of the Federal Department of Public Works. The new span of 243 ft. 6 in. was opened Sept. 17, 1844; it served for many years, until the construction of mills began to obscure the great falls from sight.

Colonel By was responsible for two other bridges, a small structure initially built of unpeeled logs to span a gully near the north end of the Union Bridge, dubbed "Pooley's Bridge" by Colonel By since it was constructed by one of his trusted assistants, Lieu-

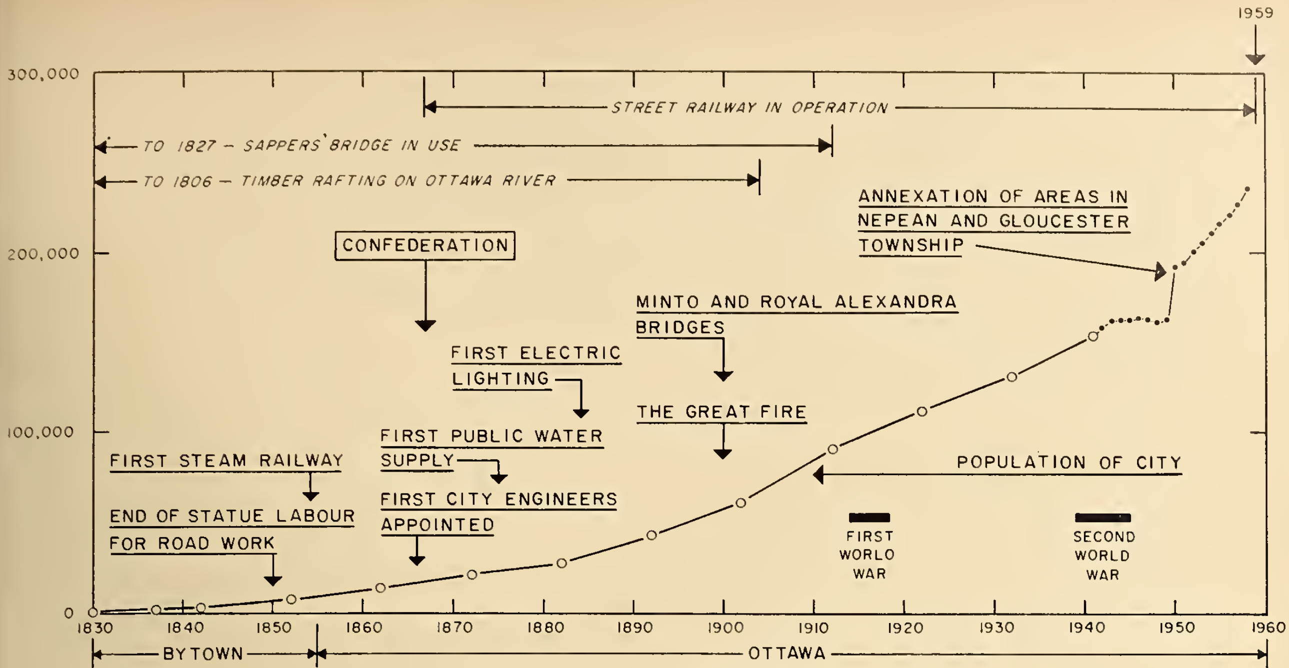


Fig. 5. The Growth of Ottawa.

tenant Pooley, R.E. Much more important, however, was the bridge necessary to span the valley in which the entrance locks were to be constructed. Clearly necessary if construction operations in the narrow valley were to be co-ordinated, it was the first major canal work to be undertaken under Colonel By's immediate direction by the Royal Sappers and Miners, two companies of which were raised in England in March, 1827 especially for service on the Canal. The bridge, known down the years as the "Sappers' Bridge", was a graceful arched structure occupying part of the site now used for the much larger Confederation Bridge. Built of cut limestone blocks, it was of such massive construction that its eventual demolition in 1912 was an unusually difficult operation, as older residents of Ottawa still recall. Although the bridge probably had to go in the march of progress, two stones from it were saved. They now form the monument in Major's Hill Park that marks the site of Colonel By's own residence (also destroyed), the stones fortunately still showing some of the carving with which the Sappers adorned this first piece of bridge building in the "wilderness".

It was not until the turn of the century that bridge building again became a major engineering activity in Ottawa. It was in 1900 that the still graceful Minto Bridges were built across the Rideau, and the great Interprovincial Bridge (more kindly named the Royal Alexandra Bridge) was opened Feb. 21, 1901. (Robert Surtess and Guy C. Dunn were the respective engineers.) Both structures were constructed by the Dominion Bridge Company, the Royal Alexandra Bridge (despite the horror with which it is now viewed by town planners) being still a notable structure and in its day the greatest bridge of the Dominion. Ottawa still has in use one of the first reinforced concrete bridges in Canada, this being the original Hurdman's Bridge built in 1906 by Emil Wahlberg. Engineers of the capital should keep a watchful eye on plans for the future of this interesting old structure. This gap in the history of bridge building in Ottawa is not surprising when one considers the slow growth of the little city throughout the nineteenth century. This is illustrated in an accompanying chart. It is true that railways had come to Bytown as early as 1854 but it was not until the twentieth century that they really displaced water transport.

It was on Christmas day, 1854 that a small train was pulled into the first railway station of Bytown, located in New Edinburgh through Thomas McKay's influence. The train ran on rails improvised from maple scantlings since there were no funds left to purchase iron rails. This was the northern terminal of the Bytown and Prescott Railway Company, for many years the only rail connection that Ottawa had. Until 1855, when the Rideau was bridged, passengers for Ottawa had to be taken across the river by boat after leaving their train. Walter Shanley was the engineer; his letters describing his work on the construction make fascinating reading. He found Bytown "a fast place (but) a snobbish town" too. He complained that he "was disturbed (in his office) half a dozen times one day by the President (of his Company) rushing in to try to force me to play cricket". It was not until the close of the century that the effects of the "railway mania" were seen in Ottawa. These were the years of the Quebec, Montreal and Occidental Railway; the Canada-Atlantic Railway; the Pontiac Pacific Railway Company and others with names almost as pretentious, but their development, construction and eventual incorporation into the C.N.R. and C.P.R. of today, with some disappearing completely, is a tale of this century.

The development of municipal engineering services was, correspondingly if surprisingly, also a feature of the later years of the last century. There is still so much to see of the origins of Ottawa that it is easy to forget that even when the Parliament Buildings were completed, Ottawa was still a rather grubby little town. The first road in the district had been built by Philemon Wright in 1818, from Hull to what is now Aylmer. It was operated for many years as the Aylmer toll road. Colonel By laid out some of the main streets of what is now the city and built a few other roads to give access to the canal works at Hartwells and Hog's Back. Statute labour was, however, still in use for road maintenance until 1850 so that it is perhaps not surprising that the streets of Bytown had the reputation of being impassable in the spring and fall because of mud, and in the summer on account of dust. It was not until 1862 that the city got permission to issue $40,000 worth of debentures for the drainage and macadamizing of its streets, the first city engineers being appointed in 1866. And it was not until 1895 that the first paving was laid, this being on Sparks Street, between the Canal and Bank Street, specially provided for the holding of a bicycle race. It is therefore not surprising that, in view of the slow development of good streets, Ottawa should have had one of the earliest street railway systems in Canada, the Ottawa City Passenger Railway Company being incorporated in 1866. It provided a service of one-man horse-drawn trams until its amalgamation with the newly formed Ottawa Electric Street Railway Company in 1893. The latter had operated its first electric streetcar in June, 1891. Residents of Ottawa saw the last operating streetcar May 1, 1959, electricity having had to give way here also to the claims of gasoline.

With abundant water power so close, it was natural that Ottawa should have been one of the first of Canadian cities to use electricity for lighting, even before it was used for power. It was first used for street lighting Nov. 4, 1884. Pembroke beat its neighbour city by merely a month and thus lays claim to be the first electrically-lit city in Canada. Oil lamps had been used for such public lighting from the earliest days, superseded by gas lamps about 1854. It is an interesting turn of the wheel of fortune to find gas again taking its place in the public service although now brought from the west and not made from coal, and used for heating rather than for light.

It will be surprising to many to find municipal engineering services relatively so recent a development in Ottawa. Nothing need be said about sanitary services, particularly with papers being given at this meeting about the design of Ottawa's first sewage treatment plant. But brief reference to the long and tangled story of Ottawa's public water supply must bring this record of early engineering in Ottawa to its conclusion. After the Royal Engineers had found it impossible to find well water on Parliament Hill, they initiated a system of carting water from the Ottawa River. Although some public pumps were provided at strategic points in the little town, water carriers soon came to be an important group in the local economy. So keen did competition between them become that in 1866 they had to be licensed. The first report recommending a proper public water supply was made to the City Council in July, 1859 by Thomas C. Keefer. Incredible though it may seem today, the lobbying of the water carriers was so successful that it was not until 1875 that the first City Water Commissioners were actually appointed. Perhaps the delay was fortunate since Keefer's original plan included the use of Parliament Hill as the location for a reservoir for a gravity supply. The first water was delivered in 1875, Thomas Keefer having been the engineer for a simple supply system that was the start of the fine public water service enjoyed by the citizens of today. As is so often the case, it took a tragedy — in this case the awful conflagration of 1900 — to bring home fully to the citizens of Ottawa the vital character of their water supply system. The legacy of the water-carriers' opposition to a public water supply certainly contributed to the great loss in that fire which in many ways marked a turning point in the history of the city.

Impersonal though such a summary record as this has had to be, it cannot conclude without brief tribute to the early engineers who were responsible for all the works described. John By will forever be honored as the founder-engineer of this city. His able young assistants were to make their names in many of the far places of the world, at least three becoming full Generals in the British Army. Many works were carried out by engineers whose names are lost, but Killaly, Shanley and Samuel Keefer have been mentioned even in this brief survey, as has also Thomas Coltrin Keefer, possibly Canada's greatest consulting engineer. He was the only man to hold office twice as President of the Canadian Society of Civil Engineers, the second time while he was President also of the American Society of Civil Engineers, the only Canadian (it is believed) ever to hold that high office. When the A.S.C.E. held the only meeting that it has held in Ottawa, in 1913, a highlight was a garden party reception in the lovely grounds of Thomas Keefer's home, the old gentleman — then in his ninety-second year — seated in the middle of his garden, receiving the greetings of his fellow engineers from all over the continent. He could then look back to a boyhod memory of seeing the first vessels sail up the original Welland Canal to mark its opening in 1829. There are living in Ottawa today engineers who have spoken with Thomas Keefer; thus can the whole history of engineering in Canada be bridged by two lifetimes. In one of the local hospitals lives a very old man who has told the writer that he can remember hearing from his grandmother how she stood on the banks of the Rideau River, watching Colonel By and his family go by in the *Pumper* on that memorable day in 1832. Thus can the engineering history of Ottawa be bridged by two lives.

It is a challenging history, a vital part of the warp and weft of the wonderful tapestry of the Ottawa story. Significant as have been many of the contributions of the engineer to the development of this capital city, let it also be remembered that some of his works have been a disfigurement of the local scene. This brief review started at the Chaudière; there must it come to its close — but with a glance at a "Chaudière" where one has to look hard between a conglomeration of singularly undistinguished buildings even to see the waters of the great river as they come over the falls. This used to be one of the beauty spots of the region, one of the focal points of local development. Should not engineers be in the van of those who have concern for the future of the Chaudière — for the restoration of what is left of at least one timber slide, for the marking and preservation of the arches of the old Union Bridge, for the restoration of some, at least, of the inherent natural beauty of these historic falls? Thus could honor be paid to the pioneers, service given to the citizens of today, and a further legacy provided for the citizens of tomorrow to remind them for all time of the vital connection between this capital of the North and its engineers.

Acknowledgments:

All who prepare such historical papers such as this record of Early Ottawa and Engineering are indebted to innumerable other writers and students who have rescued and recorded details of the past. It would, therefore, be invidious for the writer to attempt to record even those to whom he knows he is in debt in this way, but he does wish to acknowledge his indebtedness to his fellow members of the Advisory Historical Committee of the National Capital Commission (Anthony Adamson, Chairman) who have shared with him their interest in and expert knowledge of early Ottawa. Further information on the subjects touched upon in this paper may be obtained from the following books which the writer consulted freely in its preparation:

Brault, Lucien. **Ottawa Old and New**, 349 pp., ill., 1946, Ottawa.
Davies, Blodwen. **Ottawa; Portrait of a Capital**, 186 pp., ill., 1954, McGraw Hill, Toronto.
Legget, Robert. **Rideau Waterway**, 249 pp., ill., 1955, University of Toronto Press, Toronto.
Walker, Frank. (Ed) **Daylight through the Mountain**, 350 pp., ill., 1956, Engineering Institute of Canada, Montreal. EIC

Canadian Developments

One and a Half Million Dollar Fredericton Terminal Station

The recently constructed Fredericton Terminal Station has been built to accommodate 138 kv, 69 kv and 12.47 kv circuits with ease of interconnection between voltage levels. The layout is also suitable for future addition of circuits and transforming capacity. The new 138 kv network will in some instances parallel the existing 69 kv system. As part of the new grid, five terminal stations were designed with three already completed and in operation. Frank L. Newson, Design Engineer at The New Brunswick Electric Power Commission covers some of the major engineering features of the Station in his paper.

A modified one-and-a-half circuit breaker per element scheme was selected for the Station. It is modified because the tie transformers are part of the 69 kv and 138 kv buses. These transformers provide the interconnection between the buses. The first is a three-winding transformer connected star-delta-star. The Delta winding has sufficient capacity to connect a 10,000 kva capacitor bank in the future.

The protective equipment includes the grounding system, sky screening, lightning arresters, insulation levels, relay equipment and interlocking. Forty-three copper-covered grounding rods were driven to a depth of 16 ft. at a varying spacing of 30-60 ft. The ground rods are interconnected with a 500 mcm soft-drawn stranded copper conductor. The station steel, circuit breakers, switches, transformers, lightning arresters and steel buildings were connected to this grounding mat, in the majority of cases with 2/0 stranded copper conductor. The safety fence is grounded to a separate grounding-rod system which follows the fence line. Sky screening in the 69 kv section is achieved by raising the steel columns with steel rods to a height of 16 ft. above the nearest bus. The 138 kv section has sky wires that are 25 ft. above the bus to compensate for the greater spacing of the tower columns. Lightning arresters have been used at all voltage levels at power transformers with discharge counters on 69 kv and 138 kv levels.

The 138 kv-69 kv-12.47 kv tie transformer has standard gas relay protection, oil and winding temperature indications and expansion tank oil level alarm. The transformer has a percentage differential relay system with current transformers in the 12.47 kv tie transformer delta switchgear and in the 69 kv and 138 kv transformer bushings. The three-case relay equipment has harmonic-current restraint that keeps the tripping function inoperative during magnetizing inrush surges that are initiated by voltage changes on the power system. The arrangement of operating and biasing relay coils also keeps the relays inoperative during heavy through fault currents.

The distribution circuits, 12.47 kv 4-wire circuits supply unbalanced loads in the local areas around the Terminal Station. Each circuit has an inverse time overcurrent relay per phase with another in the residual circuit of the cur-

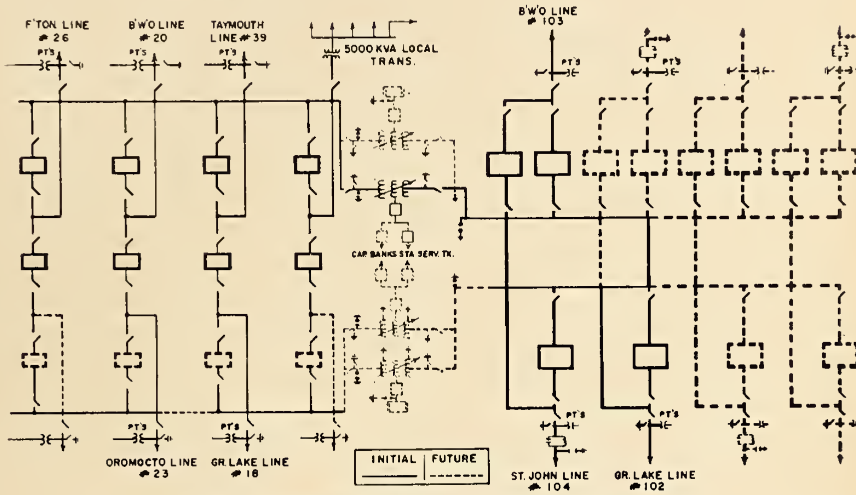
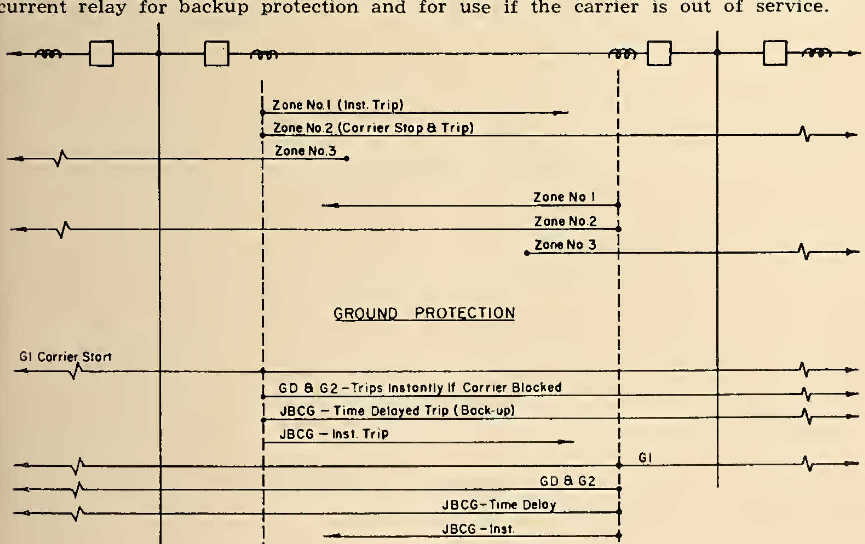


Fig. 1. One line diagram of primary equipment.

Fig. 2. 138 kv. Line Distance Impedance Relaying Phase Protection.

Zone 1 covers 90% of the distance of line section and trips instantly. **Zone 2** covers 125% of the line length and trips instantly if the carrier is blocked, otherwise 15-25 cycles. **Zone 3** covers adjacent line sections as backup and reaches further than Zone 2 from the remote opposite end of the line to act as a carrier starting device. Zone 3 trips in approximately 1 sec. G1 is a sensitive ground relay used to start the carrier only. GD plus G2 is a sensitive ground directional ground relaying used to stop the carrier and trip instantly if the carrier is blocked. JBCG is a ground directional overcurrent relay for backup protection and for use if the carrier is out of service.



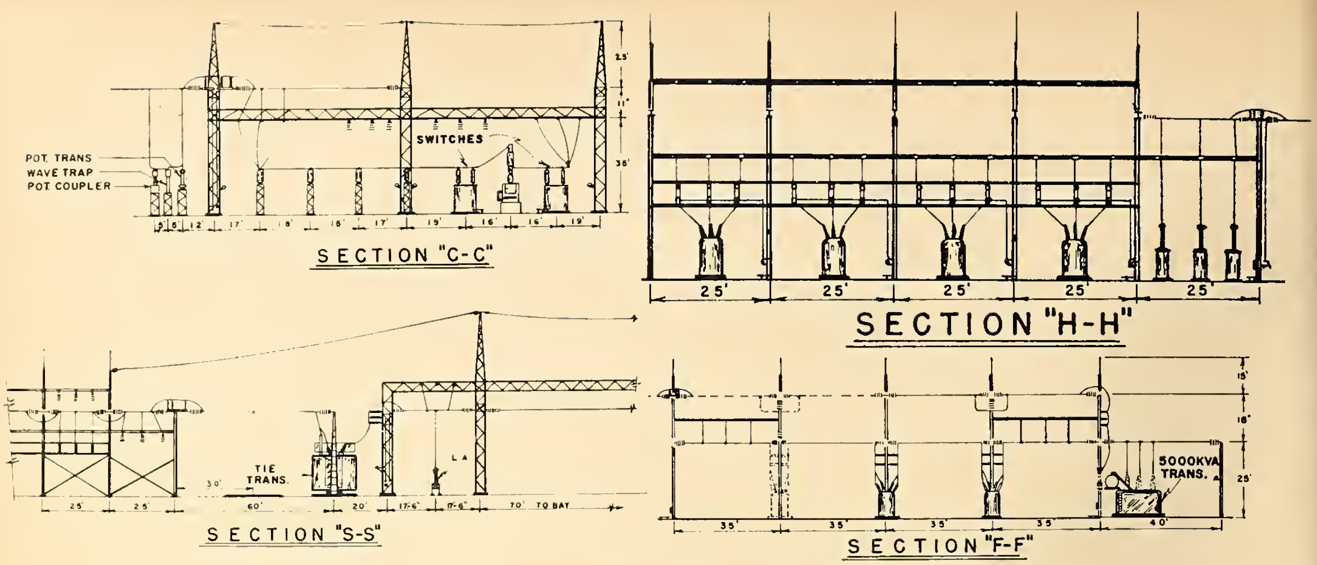


Fig. 3. Elevation sections of terminal plan view.

rent transformer system. There is a 12.47 kv ground fault back-up relay on the local transformer neutral. Each circuit breaker has a three shot reclosing relay.

The system operating center is a single story structure with basement and is electrically heated. The building has 10.4 kw of fluorescent lighting plus 3.75 kw of incandescent lighting in the control and shift dispatching section that is automatically switched to the station battery in an emergency.

The Moncton Terminal Station is to be remotely controlled from this Station over the power line carrier. Forty points are provided with seventeen to be operating initially. The supervisory equipment provides selective control and automatic indication of the remote terminal station. Continuous visual indication is provided for each supervised unit. The tap changer is controlled automatically from the 69 kv bus potential transformers, which keeps this bus at a fairly steady voltage level.

Each line has a single side band and audio shift carrier current equipment. Its primary function is to give the Commission its own telephone communication system and includes the Nova Scotia Utilities. Secondary functions are: remote supervisory control of generating switching and transforming stations, telemetered power quantities for system control for the dispatching centre and line relay control.

More and more the practice in Canada has moved to air blast circuit breakers for switching control of high voltage circuits. Oil circuit breakers are still being supplied but require special considerations when temperatures drop to 30-40° below zero. The 12.47 kv distribution oil circuit breakers are contained in a heated switchhouse supplied as a complete metal clad unit. The 69 kv and 138 kv ABCB's operate at different air pressures but have a common air storage system comprising 14-4.8 cu. ft. cylinders at 900 psi. The 69 kv circuit breakers have a conventional bulk oil circuit breaker appearance of the round tank design. Six interrupters are mounted in the single tank. The breaker is rated at 2500 mva. The 138 kv circuit breakers are a comparatively recent Canadian design particularly suitable for the high voltages and ratings that are developing in Canada. The interrupting capsule supplied has a rating of 5000 mva at an air operating pressure of 350 p.s.i. which surrounds the interrupting parts. Both these circuit breakers are a practical application of Paschen's law of gases, with the high pressure air preventing restriking of the arc and holding the contacts open. Series isolating switches are not required.

The ground fault current at the Station can be as high as 3 kv and, as additional generation is added to the system, this will increase. With a ground resistance of one ohm, a 3 ka ground potential rise will be reflected momentarily into the telephone circuits. The New Brunswick Telephone Company requires that neutralizing transformer equipment be applied if the ground potential should exceed 600 volts. The neutralizing transformer prevents the damage described and possible shock to telephone personnel and equipment.

The source of station service supply will be from the delta-tertiary 12.47 kv winding of the tie transformer, with an alternative supply from the distribution switchgear. This alternative supply will be transferred to the second tie transformer as soon as it is installed. The 12.47 kv source is transformed to 600 volts for the three-phase undergrounded delta system.

The 60 kv and 138 potential transformers are single phase to ground units of an oil minimum type. Three units are used on tie lines and bus potential requirements, and a single unit for radial feeders.

International News

£40,000,000 Nuclear Power Station for Scotland

The major portion of the civil engineering work on the two reactor structures and the turbine hall of the £40 million nuclear generating station at Hunterston, on the Ayrshire coast of Scotland, has now been completed. Around these main structures the various subsidiary buildings are now taking shape. The station is being built for the South of Scotland Electricity Board, and the first reactor is expected to be on load for the winter of 1962/63, the second towards the end of 1963. Concerned in the construction are the General Electric Company Ltd. and the Simon-Carves Atomic Energy Group, both of London.

The last sections of the concrete biological shield of the first reactor having been lifted into position, a start has been made on the erection of the structure to house the service machine. A "rehearsal" shaft for the charge-machine has been included in the first reactor structure. This will be able to test every function of the charge-machine and is expected to be used daily when the station is in operation.

The circumferential welding between the various courses of the reactor pressure vessel is nearly finished, and the welding in and non-destructive testing of the charge nozzles and control rod nozzles is progressing well. Therefore, the time for stress relief of the whole structure is approaching. Electrical resistance heating will be employed for this operation, which then will be followed by final installation work and a pneumatic pressure test. Closing in of the reactor structure, with precast concrete units which form the soffit of the roof biological shield, has begun.

If reactor performance is not to suffer, clean conditioning of the gas ducting, blowers and other plant directly in contact with the circulating cooling gas is necessary. Some of this cleaning is carried out on site, but the majority is performed in the works of the makers. The first gas circulator drive has undergone a satisfactory test of continuous running under load conditions and under simulated conditions of misalignment. A shock load test has also been successfully carried out.

The first steam-raising unit shell has been internally cleaned and is in position on its plinth, ready for the erection of the main gas ducts and installation of the internal tube banks. The shells of the other 15 steam-raising units, for both reactors, are in process of assembly.

Construction of the circulating waterworks is well advanced. The penstocks and all eight bandscreens inside the pumphouse have been erected, together with four of the six main circulating-water pumps and three of their 800 h.p. motors and associated pipework and valves.

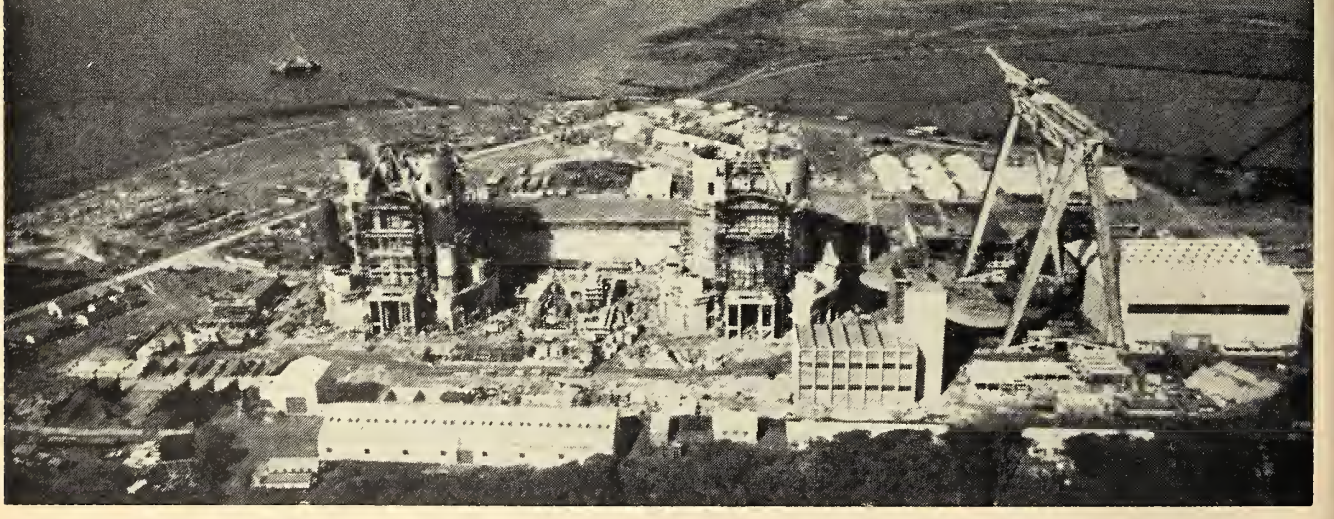
Externally, the turbine hall, with transformers in their stone-filled bays on the north side, presents a finished appearance. Reinforced concrete blast walls have been constructed to prevent accidental damage to the cabling which will eventually be run over the pipe bridge linking each reactor to the turbine hall. The first of three 1,000 kw. emergency diesel generators is to be erected in the basement of the turbine hall. These sets will be used to supply the essential power station auxiliaries in the event of a failure of the incoming supply to the station.

The charge-machine maintenance building, to the south of the second reactor, is linked to both reactor structures by means of rail tracks, which serve to bring the charge-machines (which are at ground level) into the building for servicing.

Between the two reactors is the cartridge cooling pond. The capacity is such that the complete fuel charge of one reactor can be dumped into it in the case of emergency. The pond is divided into two unequal sections. Under normal conditions the larger section will store the discharged cartridges and the smaller one cartridges from channels in which a burst has occurred.

The weight of each reactor, including pressure vessel and contents, will be 80,000 tons. Preparation of the site has involved the excavation of 174,000 cu. yd. of rock.

An aerial view of Hunterston Nuclear Generating Station which is being built for the South of Scotland Electricity Board. The first steam-raising unit of reactor A can be seen on its plinth. The weight of each reactor will be 80,000 tons.



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Eastern Field Office

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(Continued overleaf)

President's Column

THE Presidential program for branch visits for 1960 concluded with meetings of the Cornwall, Kingston, Belleville and Port Hope Branches. Successful gatherings were held at each of these places. Opportunities were provided during the afternoon in each case for branch executives to meet the President.

The President and Mrs. Dick, accompanied by the General Secretary and Mrs. Page represented the Engineering Institute of Canada at the Annual Meeting of the American Society of Mechanical Engineers, recently held in New York City. The fine relationship which has existed between these two sister Societies was emphasized by both the retiring President, Walker Cisler, and the incoming President, William Byrne. Our A.S.M.E. friends did everything to make the visit pleasant for the Canadians, and the experience is one which will long be remembered.

To explore the possibilities of the numerous potentials of branch operation, a Committee has been set up with Mr. Fred L. Lawton, Montreal Vice-President, as Chairman to study this situation. Branch operation and its significance in the eyes of each member would appear to be one of the most important phases of the Institute's activities, and a thorough study of the branch situation is to be made to be sure that this contract is being suitably developed. It is also hoped that in the near future time will be available for the General Secretary to make even more branch visits, so that he may by personal contact with the present and future officers of the branches, be increasingly available to them for consultation and discussion of the types of programs most suitable for the various branches and for the development of technical activities wherever these can be fostered. While many branches continued to put on wonderfully successful programs, there are others which, by virtue of local circumstances and geographical restrictions, have problems in selecting program structures. It is felt that closer contact with the General Secretary in these cases may help the Branch Executives gain a fuller appreciation of what can be done.

In closing the President's column for this month we would like to pay tribute to a faithful member of the E.I.C. Staff who passed away suddenly early in December. We refer to Mr. E. J. Blandford who was for many years responsible for the advertising section of the Journal. Mr. Blandford worked well and faithfully for E.I.C. Deepest sympathy is extended to the bereaved wife and family. EIC

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E.I.C.-C.I.S.S Committee

A national committee has been formed by the Engineering Institute of Canada and the Canadian Institute on Sewage and Sanitation who have joined forces to conduct a study of all phases of the use, conservation and pollution-control of Canada's water resources.

The official name of the committee is "E.I.C.-C.I.S.S. Committee on the Use, Conservation and Pollution-Control of Water Resources" consisting of 16 prominent engineers and scientists as follows:

Chairman—A. L. Van Luven, M.E.I.C., Montreal.

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W. L. Wardrop, M.E.I.C., Winnipeg.

All are recognized as leaders in the broad field of water resources, water conservation, and the treatment of domestic and industrial sewage.

The Committee will become familiar with the work now being done by many organizations that are concerned with water resources, and will solicit and analyze views of all Canadian organizations concerned. It will ask pertinent questions of the national executive of some 200 Canadian organizations including such groups as agriculturists, architects, business and industrialists, educationalits, engineers and scientists, game and conservationists, service groups, women's clubs and government organizations, as well as those interested in forestry, labour aspects, medical and legal aspects, political, civil and recreational aspects.

If justified by the factual data received from participating organizations, a report reflecting their collective reactions will be prepared and presented to governments and industry. It is hoped that useful information relating to such things as the need for a national research program will be obtained.

This report will provide the various governments and industry with an objective, scientific and unbiased analysis of the use, conservation and pollution-control of water resources in Canada which can be used by the federal and provincial governments as a comparison with their own work.

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 Dcember 20, 1960.

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O'Keefe, Rosemere; J. W. O'Neill, Kingston; C. H. Osborne, London; H. J. Ostapovitch, Montreal; W. Ozust, Edmonton; F. G. Pack, Ottawa; H. A. Pageau, Montreal; G. S. Peach, Toronto; W. T. S. Pearce, Castlegar; D. Pearson, Arvida; H. W. Percival, Arvida; E. W. Petzold, Rexdale; J. F. Pilon, Montreal; J. F. Preston, Montreal; M. H. Rapp, Toronto; K. B. Rasmussen, Sarnia; C. R. Reany, Dryden; J. G. Relich, California; C. L. G. Robinson, Sarnia; G. A. Robinson, Ajax; H. J. Rolph, Hamilton; B. M. Ross, Goderich; J. M. Ross, Toronto; S. Roth, Montreal; F. Sampson, N. Burnaby; A. W. Samson, Edmonton; W. A. Scott, Toronto; J. H. C. Scrimgeour, Peterborough; A. Sernyk, Sarnia; S. Shisko, Toronto; E. H. Shum, Montreal; P. C. Slinn, Montreal; D. E. Smith, Calgary; D. T. Smith, Ottawa; G. E. Smith, Toronto; J. C. Smith, Dalhousie; R. N. Smith, Toronto; R. W. Smith, Montreal; D. R. Snider, Waterloo, Ont.; J. T. Sniezek, Kenora; J. A. Soicher, Montreal; J. M. Spencer, Montreal; K. J. Steele, Thompson; J. W. Stephen, Hamilton; H. Stoller, Montreal; J. C. Strang, Toronto; G. R. Stunden, Montreal; H. M. Sullivan, Saskatoon; A. H. Sunley, Edmonton; T. J. Szkolnicki, Winnipeg; B. Tait, Nanimo; H. S. Tamaki, Toronto; M. Tammako, Roxboro; G. C. Tanner, Roxboro; F. A. Tayelor, Vancouver; A. G. Taylor, Caledon East; J. R. Taylor, Toronto; J. H. Thorne, Toronto; P. L. J. Tillson, Toronto; O. A. Timm, Hamilton; A. E. Toole, Ottawa; J. F. Trant, Welland; W. J. L. Tyler, Montreal; J. C. Underhill, Dawson Creek; C. E. F. Underwood, Ottawa; W. A. Vallance, Windsor; P. W. Walkinshaw, Shawinigan; J. W. Wallace, Burlington, Ont.; J. H. Walsh, Ottawa; R. B. Warren, Ancaster; H. M. Watson, Toronto; L. C. Webster, Montreal; L. A. Whitman, Montreal; G. Wilkinson, Toronto; C. F. Williams, Toronto; N. L. Williams, Vancouver; C. E. Williamson, Toronto; R. Williamson, Port Arthur; L. G. Wong-Buckley, Ottawa; R. J. Wood, Montreal; J. G. Woodcock, Ottawa; J. M. Young, Edmonton; J. M. Zaback, Montreal.

Student to Junior: A. J. W. Bate, England; L. L. Davidoff, Moose Jaw.

STUDENTS ADMITTED

University of Manitoba: K. M. Adam, J. L. Allan, L. P. Arliez, S. E. Attersley, H. C. Avery, W. G. Badger, W. H. Bailey, T. E. Bates, D. H. Bishop, L. Boily, M. H. Bolt, A. J. Bomford, R. H. Buchanan, R. R. Buss, R. K. Bryam, G. M. Calder, D. B. Chalcroft, D. W. Charleson, D. A. Chivers, J. T. Christison, R. Christiuk, R. W. Coley, I. Cooper, K. B. Copeland, D. M. Deagle, K. J. Dedrick, J. P. de Graaf, I. G. Deme, J. C. Dempsey, W. W. Dolhun, N. J. Fenwick, G. A. Filmon, R. R. Foster, R. T. E. Fowler, W. Friesen, R. W. Galatiuk, F. R. Garland, L. E. Geoffrey, R. V. Gilmore, B. A. Gordon, M. C. Griffith, R. R. Haas, J. K. Halsall, R. J. Hamlin, W. M. Harricott, J. V. Hebert, A. E. Heinrichs, B. C. Hepworth, L. Hiley, M. Hirt, J. M. Hobbs, D. A. Hobson, G. J. Hodgins, J. K. Holland, C. P. Honeyman, G. L. Hood, H. H. James, J. D. Johnson, J. D. Johnson, G. K. Jor-

genson, E I. Jurgens, R. M. Karpiak S. J. Kawalee, J. M. Keelty, P. T. Keenie J. V. Kelly, W. Kepron, R. L. Kester D. B. Kilpatrick, A. V. Kohuska, J. A Kopec, G. E. Koreen, G. K. Kwong, R. F. Laffin, C. Lambert, C. T. Larway, D. J. Laurence, R. B. LeBleu, G. A. Lewis, J. F. Liska, P. B. Loewen, B. Luffman, R. D. Lynch, A. F. Macatavish, G. J. MacDonald A. K. MacKenzie, J. W. Mackintosh, H. E. Martel, E. R. McComb, D. R. McCreath, B. H. McDonald, B. A. McFarlane, J. R. McIntosh, D. T. McKay, B. McLauchlin, W. G. McLean, K. W. McLellan, R. J. McPhail, T. W. McPherson, M. E. Melnyk, H. Mielke, R. L. Milburn, R. G. Miller, R. J. Mitchosky, J. L. Moskalyk, G. T. Mroz, K. E. Nixon, E. J. Nych, P. F. Osted, J. B. Park, D. A. Pashniak, E. O. Pauch, N. M. Peitsch, E. R. Pentland, R. L. Pentland, M. J. Penuita, H. R. Plenert, A. J. Poetker, R. W. Pollock, B. W. Purdy, D. W. Randell, R. E. Ray, B. C. Robinson, C. M. Robinson, M. C. Romas, R. J. Roscoe, R. Russell, E. Rymek, J. Rzonca, R. E. Sandalack, D. E. Saramaga, H. Schettler, M. J. Schjerning, W. B. Schumacher, D. J. Scott, S. P. Seniuk, A. H. P. Shaw, D. T. Shimozawa, C. E. Shoemaker, B. L. Shulakewych, O. Sideris, D. R. Simpson, R. G. Skinner, K. E. Snidal, H. D. Spenst, V. J. Steciuk, Z. Stepchuk, K. R. Stevens, A. L. Strang, R. F. Stromberg, S. Swereda, H. R. Taylor, M. D. Thomas, J. E. Thompson, J. S. Thomson, D. G. Toole, J. Toye, M. E. Trethart, M. Trusewych, T. D. Underwood, D. H. Van Dusen, W. C. Wagner, D. I. Waldman, R. A. Watt, H. B. Wattis, K. J. Wiebe, R. B. Williams, C. D. Wilson, D. J. Wilson, J. E. Witherspoon, A. Wittenberg, R. F. Wright, E. A. Yells, T. H. Young, M. Yunik.

University of British Columbia: H. Arndt, D. G. Black, G. F. Bondaroff, D. S. Chalmers, R. D. Christie, D. G. Creelman, D. A. Dame, T. A. Davidson, H. R. Davis, G. E. Dawson, R. J. R. Dee, J. C. Dill, I. J. D. Dowdeswell, V. L. Dupres, W. H. Dutcher, W. L. Elsdon, R. A. Embley, J. H. Engweiler, M. Fillipoff, R. S. Hallisey, E. C. Hamre, J. C. Hannah, G. C. Harlos, E. H. Harper, R. B. Hayter, W. Heine, G. Heinrichs, E. J. Hemmes, C. A. Heuckendorff, G. C. Howard, E. Y. Inouye, S. A. Jones, S. Kadarisman, T. Kobayachi, B. P. Le Clair, V. P. Lesiuk, G. A. Lewis, J. S. K. Li, G. C. Lok, A. G. Longmuir, A. K. Lum, G. M. Luy, M. K. MacDonald, R. H. McIlwaine, T. G. McSpadden, E. J. Mellander, J. C. Menu, J. S. R. Montgomery, S. B. Mould, R. A. Myllymaki, E. G. Neudorf, S. Ontowirjo, R. G. Orr, E. R. Ould, R. R. Parsons, H. S. Paulger, W. D. Peacock, R. K. Peterson, B. Poplack, D. A. Powell, E. H. H. Pun, T. Randsalu, E. Rankin, A. J. Reed, N. A. Ross, W. D. Ross, E. A. Sadler, H. H. Sato, W. J. Serediak, J. C. H. Shaw, P. W. M. Shibley, J. A. Simpson, T. H. Skupa, A. E. I. Tackoor, P. Thiesson, G. W. Tovell, G. R. Towgood, B. A. Van Snellenberg, J. F. Watson, R. A. Wood, D. R. Young.

University of Alberta: B. L. Bury, W. N. Cherniwchan, J. G. Culliton, M. R. De Leeuw, K. M. Dixon, K. U. Driedger, W. W. Evans, W. E. Germaniuk, W. K. Good, W. J. Hamilton, M. J. Hannah, W. C. Harrison, A. G. Herron, E. R. Hoeght D. E. Holroyd, V. L. Humaniuk, D. L. Johnson, R. M. Kachman, M. D. M. Krupa, F. P. Mannix, G. Martin, L. L. McClennon, T. B. McFadzean, I. J. McGillis, G. D. Montgomery, S. R. Newson, E. T. Overbo, R. M. Painter, R. L. Patterson, G. M. Pottinger, J. R. A. Proctor, D. B. Rhyason, C. B. Rolfson, G. E. Salsauler, K. R. Schrag, J. D. Scott, J. B. Seale, F. A. Seyer, T. C. Slimmon, J. J. Sparling, R. K. Stagg, B. L. Steblecki, W. C. Stenton, D. E. Wagner, E. Watamaniuk, M. W. Weber, W. G. Webster, C. D. Westcott, M. W. Wilson, M. Yerichuk.

Queen's University: J. F. Adams, J. W. Alsop, L. E. Anderson, J. K. Armstrong, J. Bobak, A. P. G. Brown, R. R. Cowell, O. W. D. Daub, G. D. Dougall, W. J. Dunker, F. J. Durdan, S. R. Easson, J. L. Gibson, E. Haag, A. H. J. Hagedoorn, M. D. Harmelink, C. C. Hung, J. W. Kamphuis, W. P. Kangas, R. Lepp, J. G. MacRae, C. R. Mallette, P. G. Mayor, G. E. Murison, B. F. O'Malley, E. A. O'Neil, R. A. Poaps, C. F. Pullen, W. G. Raffan, G. C. Reid, J. A. Reynolds, J. R. Richardson, R. G. Ryan, J. F. Scott, P. S. Smith, R. S. Soetadji, S. M. Theodoulou, R. Voyer, W. A. Westcott, J. B. White, G. G. Whybourne, R. A. Wilkinson, J. H. Wilson, T. M. A. Wilson, L. R. Windover, C. C. A. Wong, W. M. Zuk.

University of Sherbrooke: M. Baudet, J. G. Beaudoin, R. Bolduc, J. P. Brunelle, J. G. W. Christman, G. Cloveau, M. Co-

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Royal Military College: F. A. Archibald, A. G. Blaikie, C. Blais, J. A. R. Blanchette, R. E. J. Drouin, G. A. Griffith, W. S. Hammond, G. L. Hodgson, R. J. G. A. Houston, J. A. Hunter, J. W. Joynt, C. H. Kristjansen, D. A. J. P. Langlois, J. P. Lawlor, J. C. Lejeune, J. A. M. Leroux, R. A. McLean, K. C. Mitchell, E. G. Mosher, G. E. Ostiguy, J. R. Y. Paquette, J. Y. J. J. De Pin, O. Poirier, A. F. Robb, S. Rolsky, J. M. Ross, K. H. Scott, D. J. V. Springate.
Assumption University: P. Arber, L. M. Bontront, R. Burn, P. J. D'Angelo, A. J. Brobitch, R. I. C. Finley, M. Hamzeh, C. R. Heward, H. W. Johnson, C. R. Kerr, R. J. Lanza, K. R. Long, G. P. Medina, M. L. Melconian, R. A. Pawelek, A. Polmac, I. G. Reilly, E. J. Rembish, R. E. Shiner, B. Y. Tam, K. T. Wright.
Saint Mary's University: G. H. Baker, S. K. Chua, J. P. Currie, J. D. Dornan, C. D. Feeley, L. J. Irving, C. J. Jakobszen, R. J. Le Clerc, E. H. Lee, R. B. Lloyd, S. B. McCluskey, J. H. Saulnier, D. A. Shay, M. K. N. Ting.
Sir George Williams University: B. J. Beauchamp, P. Braun, J. G. Fleming, G. R. Huberdeau, S. J. Labreche, R. N. Lucas, W. D. Shewan, H. O. F. Weber.
Carleton University: G. B. Andrews, G. H. Argue, D. C. McCredit.
University of Toronto: R. L. Fetterman, R. W. Lowden, W. A. Urie.
Canadian Services College (Royal Roads): J. M. Hannah, A. W. Horne.
McGill University: G. B. MacArthur.
Ontario Agricultural College: W. R. Marshall.
University of Idaho: K. E. Fenton.
Student — Corp. of Prof. Engrs. Que: V. G. Snaibeck.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective December 20, 1960.

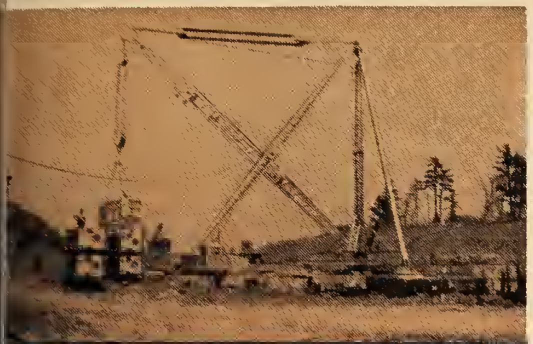
ALBERTA

Junior: R. E. McLennan.
Junior to Member: K. D. Adams, W. D. Allen, J. D. Balfour, B. G. Bartlett, H. T. Beare, E. W. Brooker, B. A. Burgess, E. I. Carefoot, P. H. Davies, H. J. Dawe, D. A. de Wolff, H. C. Duguid, R. E. Ellestad, D. Farrugia, C. M. Fryer, J. H. Geddes, W. E. Gillespie, J. W. Grainge, W. R. Hardcastle, J. F. Hlavay, J. H Hogg, J. F. Hole, M. A. Jackson, K. C. Johnstone, R. W. Keir, W. D. Kennedy, D. W. E. Kenney, W. G. Lancaster, B. G. Lawlor, W. A. Lawrence, C. A. Marteinson, K. A. McCaskill, R. C. McMordie, J. L. Milner, J. L. Mitchell, A. J. Neilsen, V. W. Osbaldeston, D. A. Peterson, H. S. Ragan, G. Schotch, G. Stefanick, M. S. Tempest, R. C. Wharton.
Student to Junior: N. E. Anderson.

SASKATCHEWAN

Members: L. Domaschuk, G. E. Evens, G. F. Fordyce, G. N. Hedges, D. M. Henderson, A. J. Kyle, N. F. Moody, J. A. Peden, V. J. Pittson, S. Romansky, L. C. Sevick, C. G. Troyer, M. A. Upham, L. T. Wilkinson.
Junior: G. W. Salberg.
Junior to Member: A. A. Allart, F. P. Buchanan, R. A. Cheney, M. Cherney, R. A. Fox, W. A. Hinz, H. M. Hleck, D. A. Hodgkinson, T. H. Lackie, W. F. Maguire, G. D. McKenzie, V. K. Pedscalny, W. E. Randall, E. C. Sherwin, J. J. Syrnyk, D. W. Tutt.
Student to Junior: P. E. Brown, F. R. Hill, G. C. Koch, N. W. Ledray, A. I. Massier, W. J. McDonald, L. K. McMillan, F. B. McPherson, H. J. Murzyn, J. E. Richert, P. P. Steinhubl, P. K. Symborski, H. T. Welch, J. G. Zbeetnoff.
Student: M. W. Alary, R. Arndt, O. Babichuk, H. A. Bachelu, A. F. Balasch, R. P. Baldwin, P. Barbonoff, A. C. Beaulieu, G. T. Beck, E. J. Bedard, A. R. Bens, M. Berezowski, R. E. Bergen, A. T. Bergan, P. E. Bert, G. M. Bohajski, W. L. Borbely, J. Borsa, R. B. Bowker, W. M. Brehaut, M. G. Britton, T. M. Brock, R. L. Buckley, W. R. Burton, H. W. Causier, A. P. Chadney, G. L. Chee, E. Chez, R. H. A. Christianson, W. E. Cripps, J. C. Crocker, M. R. Crozon, M. J. E. Demaine, A. M. Dolan, J. A. Dunlop, H. J. Dunbury, F. B.

(Continued on page 104)



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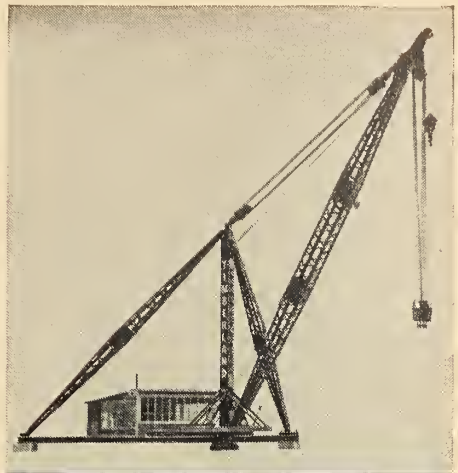

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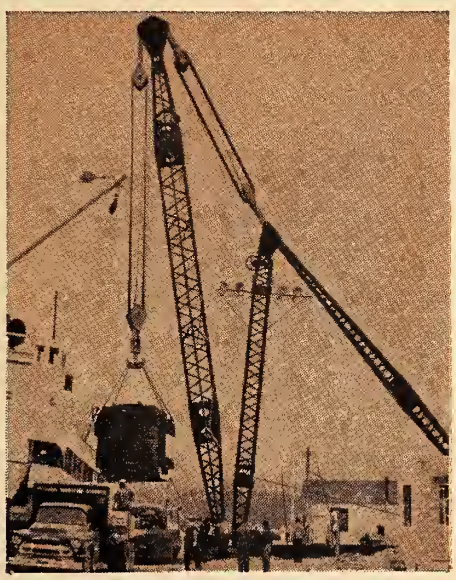

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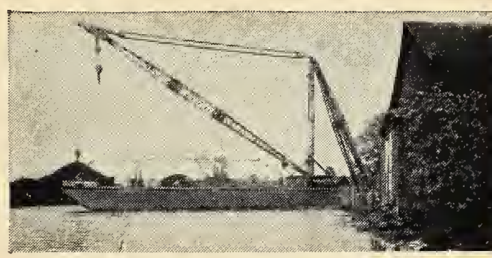

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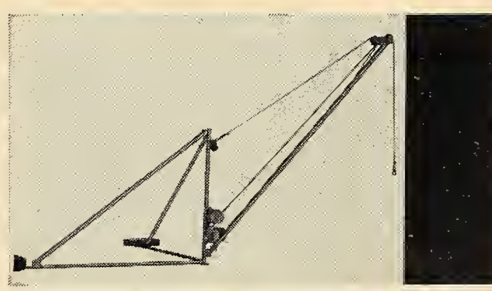

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3rd Southern Ontario Regional Conference

Niagara Falls

March 25

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PROGRAM

11 A.M.—Registration

Noon—Men's Luncheon

1 P.M.—Keynote Address

2:15 P.M.—Technical Program

6 P.M.—Reception

7 P.M.—Conference Banquet

9 P.M.—Conference Ball

Keynote Address

— "The Challenge Facing the Engineer"
The Hon. Robert Winters, President,
Rio Tinto Mining Co. of Canada, Ltd.

Technical Program

2:15 p.m. — **The Big Bounce** — *Alec G. Lester, M.E.I.C., Vice-President, Engineering, the Bell Telephone Company of Canada.* Mr. Lester will describe, with the aid of a film, the use of satellites for intercontinental telephone calls. The film shows how the first such call was made using Echo I, a 100-foot balloon orbiting 1,000 miles above the earth.

2:15 p.m. — **Underwater Engineering** — *Rod Martin, Regional Manager, Western Division, International Underwater Contractors.* The training of divers for underwater construction work will be described with the aid of films. Mr. Martin will also describe important projects including surveys, soundings, concrete work, blasting, cutting operations, woodwork and raising sunken vessels.

3:15 p.m. — **Polystyrene Foam — Its Production and Applications** — *Brian Palmer, Technical Services Representative, Dow Chemical of Canada Ltd.* Outlined by Mr. Palmer will be techniques employed in producing Polystyrene, and some of its uses which include low temperature insulation, building material, prefabricated panel construction and buoyancy material.

3:15 p.m. — **Engineering as Training for Management** — *R. Ross Service, Director of Engineering, O'Keefe Brewing Company.* Mr. Service will analyze the various qualities required in management and will assess the extent to which they are developed through engineering.

4:15 p.m. — **Can Industry Generate Electric Power Economically?** — *E. W. Hill, Utility Sales Manager, Canadian Westinghouse Co. Ltd.* The increasing price of power has prompted many companies to consider generating their own power. Mr. Hill will discuss the important factors bearing on such a decision.

4:15 p.m. — **A New Look at Structural Steels** — *W. C. Kimball, Assistant Chief Metallurgist, Algoma Steel Corporation.* A review of the history and development of structural steels since 1920, with special emphasis on the first of a new series of steels C.S.A. G 40.8.

Ladies' Program

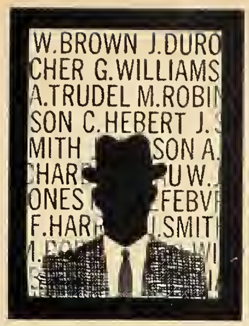
11 A.M.—Registration and Coffee Hour

12:30 P.M.—Luncheon

2:15 P.M.—Niagara Falls Parks Commission Tour

3:15 P.M.—Madame Tussaud's Waxworks

6 P.M.—Join the Men



Personals

Keith P. Gould, M.E.I.C. (McGill '48), has been appointed Hamilton District Manager of the Otis Elevator Company Limited. Mr. Gould joined the Company in 1948.

M. E. Stewart, M.E.I.C. (Alta. '47), has been appointed to the Board of Northwestern Utilities, Limited. Mr. Stewart is General Manager and has been with the gas company since 1949.

Dr. Donald Charles Rose, M.E.I.C. (Queens' '23), has been appointed Associate Director of the Division of Pure Physics, National Research Council of Canada, Ottawa. Dr. Rose will continue to head the cosmic ray section of the division and to represent Canada on various committees concerned with space research. He is chairman of the Associate Committee on Space Research and in 1959 was Chairman of the United Nations Technical Committee on outer space.

T. R. McLagan, M.E.I.C. (McGill '23) has been elected a director of the U.S. owned Sperry Gyroscope Company of Canada, Ltd. Mr. McLagan is leader of the Canadian Manufacturers Association and also President of Canada Steamship Lines Ltd.

W. E. Adkins, M.E.I.C. (Alta. '37), has been appointed Vice-President of Howard Smith Paper Mills Limited. He will continue to serve as Vice-President of Dominion Tar and Chemical Company, Limited.

W. E. Adkins, M.E.I.C.

C. B. Woodley, M.E.I.C.

C. B. Woodley, M.E.I.C., has been appointed Manager of Northern Electric Company's London works. Formerly chief engineer of the communications equipment division, Mr. Woodley is replacing **J. R. Houghton**, M.E.I.C., who has been appointed assistant general manager of the telephone contract division in Montreal.

W. D. Hurst, M.E.I.C. (Man. '30), has had Winnipeg's new 60 mpd. unattended automatic pumping station named after him by the Winnipeg City Council. Mr. Hurst is City Engineer and Commissioner of Buildings and played a predominant part in the success of the project.

R. E. Evans, M.E.I.C. (U.N.B. '45), is Manager of the newly formed Hydraulic and Thermal Power Department, Canadian Allis-Chalmers Limited. **J. R. Mainprize**, JR.E.I.C. (Toronto '50), is Chief Engineer of the new department.

L. J. Hammerschmid, M.E.I.C., (McGill '46), has been appointed Terminal Equipment Engineer with the Bell Telephone Company of Canada, Montreal.

J. F. Godsell, M.E.I.C.

C. K. Hurst, M.E.I.C.

Jack F. Godsell, M.E.I.C. (Cambridge '48), is one of three engineers who have received senior promotions in the Department of Public Works, Harbors and Rivers Engineering Branch. Mr. Godsell has been promoted from District Engineer at St. John, N.B., to Chief of the Marine Excavation Division in Ottawa. He replaces **Charles K. Hurst**, M.E.I.C. (Iowa '40), who becomes Chief of Maintenance and Operations Division. Mr. Hurst is replacing **John Eric Bright**, M.E.I.C. (Queens '38) who becomes Chief of the Planning and Construction Division.

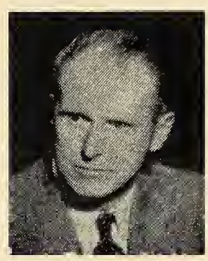
John R. Ogilvie, M.E.I.C. (McGill '54), has been appointed General Manager of Keele Buildings and Services Limited. This company has been established to service the industrial and commercial trades with warehousing and manufacturing buildings.

Jack Alton, M.E.I.C. has been named Bridge Engineer, Department of Highways, Victoria. Mr. Alton was formerly Assistant Bridge Engineer.

M. J. P. Gleeson, JR.E.I.C. (Queen's '51), has been appointed Manager, Sales Engineering, Canadian Locomotive Company Limited. This newly created position will consolidate administration of sales for all divisions of the company and includes development of new product lines.

Gordon Gracie, JR.E.I.C. (Toronto '52), has been elected Secretary-Treasurer of the Great Lakes Region of the American Society of Photogrammetry for 1961.

Stephen F. Angus, JR.E.I.C. (McGill '55), has been appointed Sales Engineer, Mechanical Division, Dominion Bridge Company Limited, Montreal. Mr. Angus has been a design engineer in the Mechanical Division since joining the Company five years ago.



J. E. Bright, M.E.I.C.

J. A. Pihlainen, M.E.I.C.

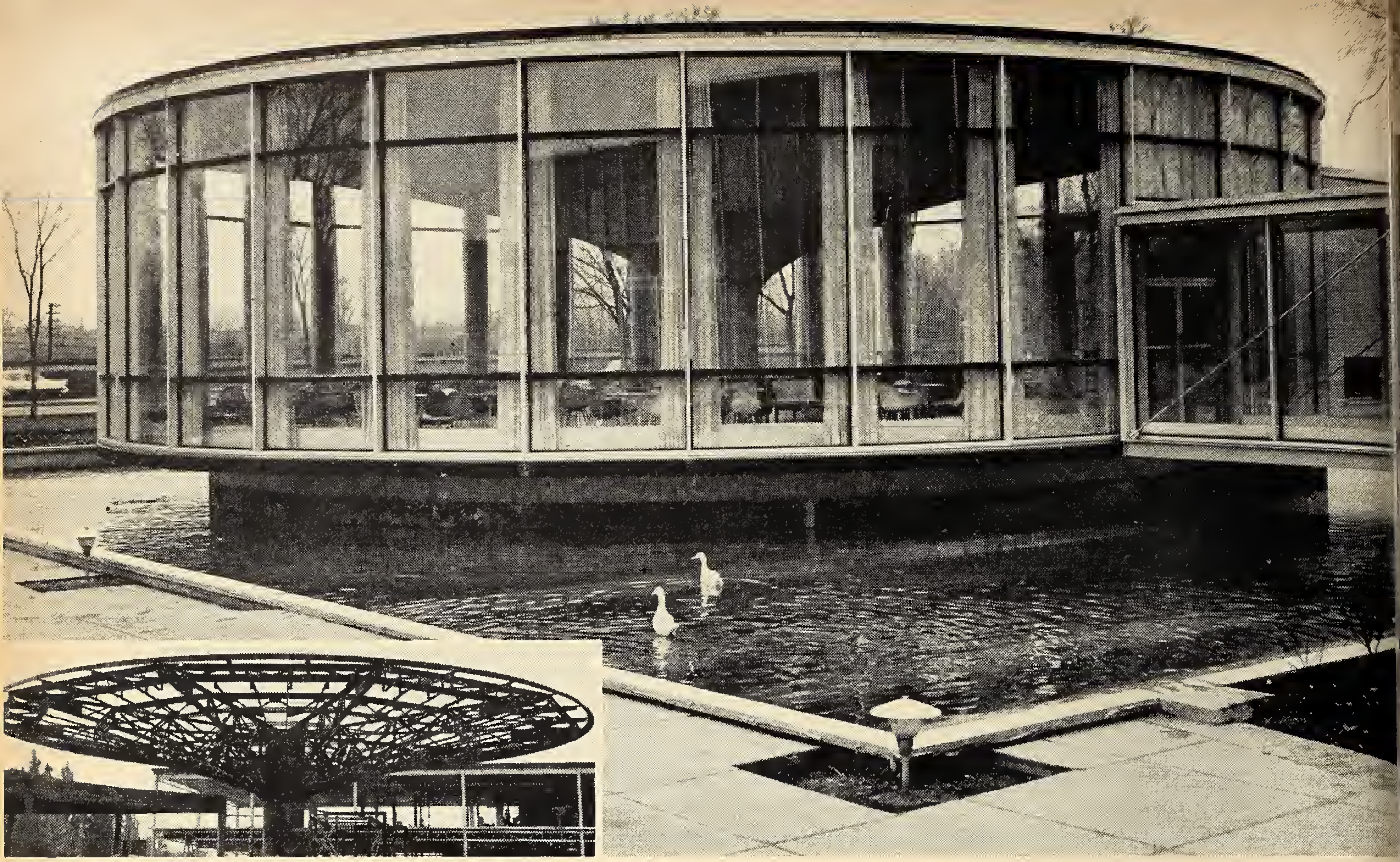
John A. Pihlainen, M.E.I.C. (McGill '50), has established an Arctic Consultant Service in Ottawa. Mr. Pihlainen also represents J. D. Mollard and Associates of Regina, Consulting Engineers specializing in air photo interpretation for civil engineering and geological purposes.

R. R. Real, JR.E.I.C. (Sask. '53), is one of four radio engineers of the National Research Council at Ottawa, who have won the 1959 Brabazon Award. The award was made by the British Institution of Radio Engineers, who offer it each year for the most outstanding paper on aircraft safety to be published in their journal.

Joseph H. G. Howard, JR. E.I.C. (R.M.C. '55, Queen's '56), has returned from Birmingham, England, where he was studying under an Athlone Fellowship and a N.R.C. scholarship. He is now with Pratt and Whitney Aircraft Co., Montreal.

Albert Hopkins, M.E.I.C., Hopkins Mining Consultants Ltd., Toronto, has been in-

(Continued on page 98)



Beauty—This striking cafeteria on the CIBA building employs a steel umbrella-like cantilever roof structure. (See inset). The characteristics of steel offer great scope to the imaginative architect.

Why you shoul

Better Economy—This merry-go-round building is the kindergarten of a new school in Regina. Close co-operation between the architect and the steel fabricator made the best use of materials and helped cut costs.

● PERSONALS

vestigating, surveying, and mapping trap rock deposits occuring on a chain of islands in the North Channel of Lake Huron, Ont. for Poly Ores Mining Co. Ltd. and Tough Rock Quarries Ltd.

John Douglas Fowler, M.E.I.C. (Queen's '55), has been appointed Development Engineer in the Marketing Division of Inland Cement Company Limited, Edmonton. In his new capacity, Mr. Fowler will provide up-to-date information and assistance on new uses of cement and concrete in the Prairies.

J. D. Fowler,
M.E.I.C.

R. L. Berggren,
M.E.I.C.

R. L. Berggren, JR.E.I.C. (U.N.B. '56), has been appointed Production Manager, Building Materials and Insulation Departments, Atlas Asbestos Co. Ltd., Montreal. Mr. Berggren was formerly Merchandising Manager, Building Materials Dept.

Obituaries

James Murdock Wyllie, M.E.I.C., 49, chief contractor of structural steel at Canadian Bridge Works, died Sept. 15. Mr. Wyllie had been with the company for 32 yrs. and played a prominent role in obtaining and processing such large contracts as the structural steel for the Rainbow Bridge, Niagara Falls; numerous bridges for the Department of Highways and local manufacturing plants. He was a resident of Riverside, Ont.

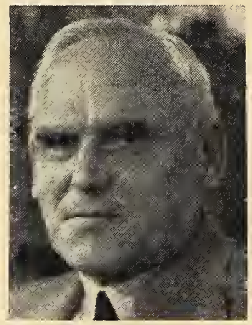
J. M. Wyllie,
M.E.I.C.

W. A. Mather,
HON. M.E.I.C.

William Allan Mather, HON. M.E.I.C. (McGill '08), Chairman and former President of the CPR, died Jan. 2. He was 75. Mr. Mather joined the company when he was 19 and was President from 1948 to 1955 when he became Chairman. Among the many honors which Mr. Mather received were an honorary degree of Doctor of Civil Law from Bishops University, 1951, Doctor of Laws University of Western Ontario and honorary degree of Doctor of Laws from McGill, 1956. He joined the Institute in 1911 as an associate member and became a member in 1920. He was made a life member in 1947 and in 1951 was awarded an honorary membership in the Institute.

Rt. Hon. C. D. Howe, HON. M.E.I.C. (M.I.T. '07) outstanding engineer and a major influence on government policy for a quarter of a century, died New Year's Eve at his Montreal home. He was 74. Mr. Howe held vital portfolios in the cabinet of Prime Ministers King and St. Laurent. He suffered personal defeat when the Liberals were swept from power in 1957.

His engineering skill brought Mr. Howe wealth and honors, including numerous honorary degrees from universities. Other recognition included the American Daniel Guggenheim Medal in 1954, and the Julian C. Smith Medal from the Engineering Institute of Canada in 1960. Mr. Howe, Chancellor of Dalhousie, was one of four engineers serving as Chancellor of a Canadian university



Rt. Hon. C. D. Howe,
HON. M.E.I.C.

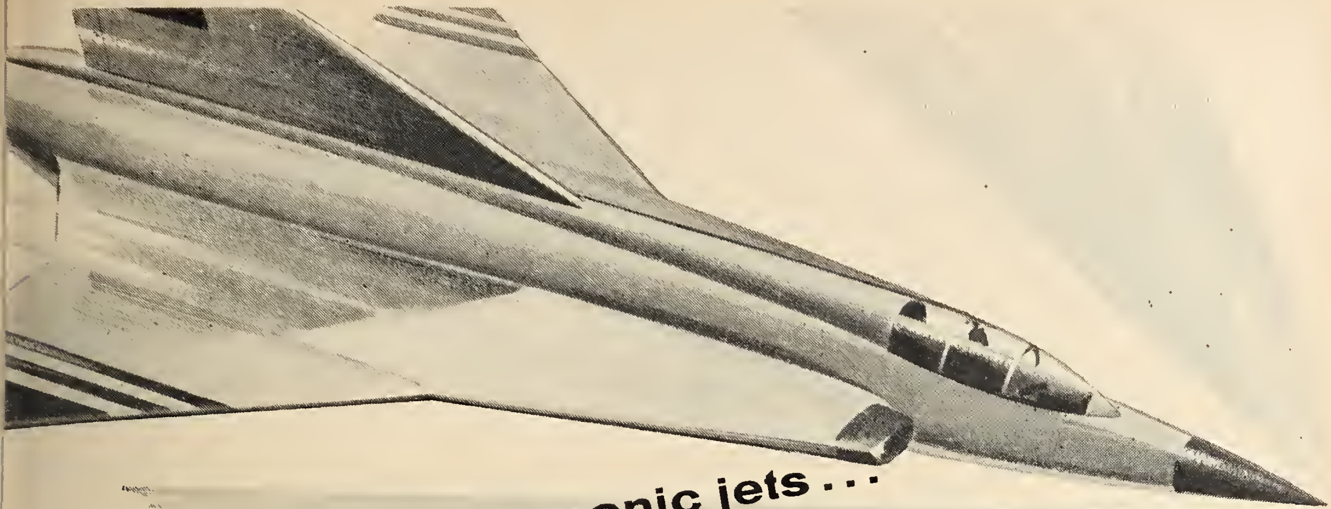
last year. He joined the Institute in 1922 and was made an honorary member in 1937. He became a life member in 1957.

Beaver Bill Says —

Dear Bob,

Well, you're out of University, with a sheepskin and a job.

One bit of counsel, if I may call it that, from an old friend. Graduation is just the start. If you're going to become a fine engineer, and I know you have it in you, you should continue broadening your outlook, enhancing your professional background and experience, and improving your ability to talk in public, all your life. How? Participate in the activities of the Engineering Institute of Canada, a university for life for engineers.



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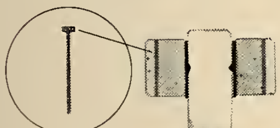
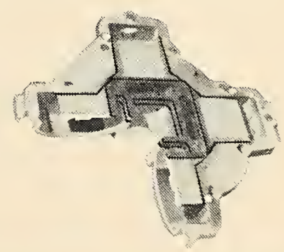
This amazing new "chemical welding" process enables you to fabricate without welds or rivets, solve design problems, and reduce parts assembly costs

Adhesive bonding of thin metal aircraft skins, metal braces, stiffeners and other parts was pioneered by the aircraft industry to develop stronger yet lighter, faster, higher flying planes. Certainly, if "Scotch-weld" Structural Adhesives are used to advantage in assembling multi-million dollar high-speed aircraft, they can also be used to advantage in load-bearing applications in many other industries. This modern, high strength method of joining metals, reinforced plastics and other materials, permits improved design and production techniques, cuts costs and offers many unique benefits . . . smoother contours . . . lighter gauge materials . . . reduced inspection . . . unusual combinations of materials, and so forth. Already, "Scotch-weld" Structural Adhesives have solved design and production problems for manufacturers of appliances, metal shipping containers, pneumatic tools, pumps, motors, scaffolding and many other items. They may be able to do the same for you. Mail the coupon and let us show you how.



Adhesive bonding small pinion gears to rotor shafts provided savings of $56.37 per thousand by reducing rejects, and eliminating secondary operations and the necessity for 100% inspection.

A pump manufacturer reduced rejection rates from a high of 25% to nearly zero by adhesive bonding three separate die castings to form a single part.



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Please send me complete information about the new "Scotch-weld" Brand Structural Adhesives.

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102302

Other Societies

National Association of Corrosion Engineers

New officers have been elected for 1961-62. E. C. Greco, senior research chemist for the United Gas Corp., Shreveport, La., has been elected President; Rolland McFarland, secretary and technical director of Hills-McCanna Co., Chicago, — vice-president; and G. G. Gribble, Jr., district manager for the Metal Goods Corp., Houston — re-elected treasurer. All officers are to be installed March 17, the last day of the Association's 17th Annual Conference and 1961 Corrosion Show, New York.

Canadian Institute of Steel Construction, Inc.

Structural steel draughting apprentices completing a twelve-week course at the provincial Institute of Trades were guests at a luncheon held at the Board of Trade Dec. 2, given by The Canadian Institute of Steel Construction, Inc. The course is Part I of a two-part six-month course which each apprentice takes during his three-year indentureship. The boys are sponsored by structural steel fabricating companies located in Ontario.

The C.I.S.C. has opened a new regional office in Winnipeg which is under the management of Hugh Krentz. He will service Manitoba, Saskatchewan and the Lakehead. This now puts C.I.S.C. regional facilities in Montreal, Winnipeg, Vancouver in addition to those available at the Toronto headquarters.

American Association of Cost Engineers

The "Soaring or Souring Sixties" was the subject of a talk given by Cecil H. Chilton to the Montreal Group of the American Association of Cost Engineers, Jan. 16.

Since 1956 when the Cost Engineers became organized into an international association, it has grown to a membership of more than a thousand. With so many active members in the Montreal area they are now feeling the need of a Regional Section.

Institute of Radio Engineers

The Toronto Section of the I.R.E. met Jan. 9 when C. J. McReynolds, Canadian Westinghouse Company Limited, presented a paper entitled "Ultrasonic Cleaning". He talked on the principles of ultrasonic cleaning, the systems available and their applications in industry.

The Chemical Institute of Canada

Dr. W. M. Campbell has been elected National Chairman of the Chemical Engineering Division, The Chemical Institute of Canada. Dr. Campbell, who is research director of the chemistry and metallurgy division, Atomic Energy of Canada Limited, takes over from Dr. W. H. Gauvin of the Pulp and Paper Research Institute of Canada and of McGill University. Other officers elected were: Viee-Chairman — Dr. J. W. Hodgins, McMaster University, Hamilton; Secretary-Treasurer — Dr. W. J. M. Douglas, McGill University.

The Society of Naval Architects and Marine Engineers

The Society has announced that it will continue, in 1961, the award of scholarships for undergraduate and graduate study. Accordingly, the Society is receiving, at this time, nominations for the four scholarships for graduate study which it has been offering each year in the past.

Society of Automotive Engineers, Inc.

The First International Congress and Exposition of Automotive Engineering, staged by the Society of Automotive Engineers, Inc., was held Jan. 9-13, Cobo Hall, Detroit. More than 100,000 engineers, including 25,000 SAE members from the United States and foreign countries had been invited.

At the Congress 70 sessions were held presenting more than 180 papers on topics ranging from new knock-testing methods, advances in truck tires, and equipment for clearing snow from jet runways, to vehicles for carrying explorers to the moon. More than 200 companies exhibited their latest developments in engines, materials, fasteners, mechanical components, hydraulic and pneumatic devices, and production equipment. The theme of the Science Pavilion was "Science Applied to Automotive Engineering". One area of the Pavilion depicted new powerplants such as the fuel cell, the rotating-combustion engine, the solar cell, and small nuclear reactors. Another area showed how physics and chemistry have provided clues to new materials and new ways to strengthen old ones. Committee meetings were held and work was done on

(Continued on page 104)

The Associations and Corporation

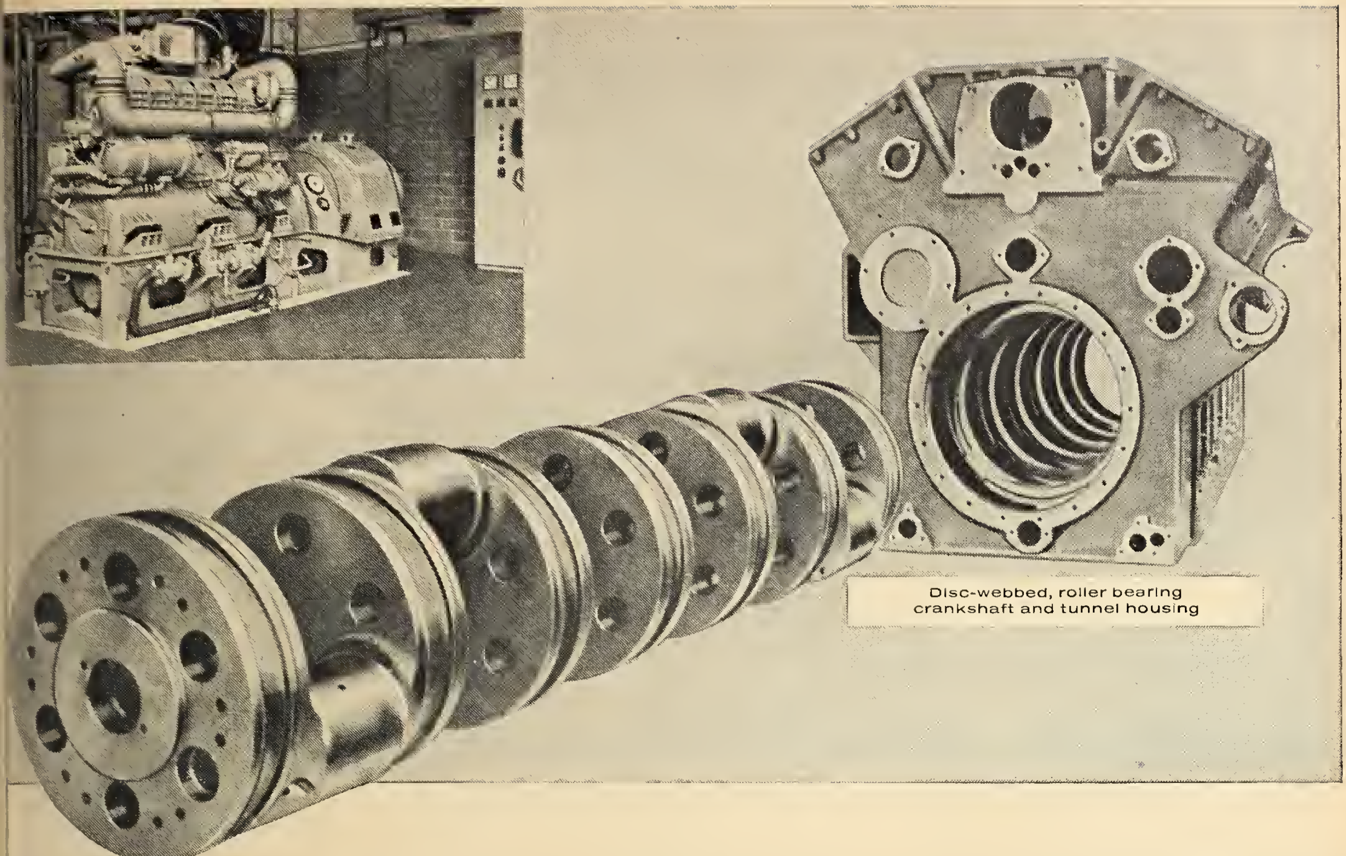
Ontario

Newly-elected President of the Association of Professional Engineers of Ontario is Lawrence C. Sentance, Manager, Defence Apparatus Division, Canadian Westinghouse Ltd., Hamilton. First vice-president — John W. Holmes, Niagara Falls, chief electrical engineer of H. G. Acres Co. Ltd.; 2nd vice-president — Robert L. Hicks, Toronto, who is with the Toronto Hydro-Electric System. Executive director of the Association is T. M. Medland; field secretary — T. C. Keefer; secretary-treasurer — David L. Turner, and field representative — Blake H. Goodings.

British Columbia

The annual meeting of the Association of Professional Engineers of B.C. was held in Vancouver, Dec. 9 and 10. William Hall, Victoria, was elected President of the Association and succeeds H. P. J. Moorhead. A. B. Sanderson was elected vice-president. The councillors elected, by classifications, were: R. H. Richmond — chemical; J. S. Kendrick — civil; H. R. Wright — electrical; P. N. Bland — mechanical; W. M. Armstrong — mining, geological and metallurgical.

Dr. O. M. Solandt, vice-president, research, Canadian National Railways, was the Guest Speaker at the annual luncheon. Dr. Solandt's topic was "Railway Research". Three members were granted Life Membership status. They were Dr. W. F. Sayer, C. C. Ryan and W. R. Curror. Another highlight of the meeting was the report of a special committee on Technical Education which stated that "there is a definite need for technical training facilities to fill the presently existing gap between vocational schools and the University". The meeting concluded with a banquet and a dance.



Disc-webbed, roller bearing crankshaft and tunnel housing

● OTHER SOCIETIES

standards and other co-operative engineering projects.

Coming Events

Gas Turbine Power Conference and Exhibition, The American Society of Mechanical Engineers, Washington, D.C., March 5-9.

Aviation Conference, American Society of Mechanical Engineers, Los Angeles, March 12-16.

17th Annual Conference, National Association of Corrosion Engineers, Buffalo, March 13-17.

National Convention, Institute of Radio Engineers, New York City, March 20-23.

National Aeronautic Meeting, Society of Automotive Engineers, Inc., New York, April 4-7.

Management Engineering Conference, Society for Advancement of Management, A.S.M.E., New York, April 6-7.

● ELECTIONS AND TRANSFERS

(Continued from page 90)

Dyck, R. E. Eliason, D. G. Eyre, P. B. Farley, A. W. Fennell, A. A. Finlay, R. H. Fisher, D. G. Fredlund, E. K. Friesen, M. Friesen, M. M. Frith, M. A. Gaudet, H. W. Goliath, D. A. Grasley, L. A. Haase, R. W. Haid, R. D. Hamilton, A. R. Hanson, T. E. Harras, G. H. Hartt, D. E. Harvey, W. H. Heimlick, D. G. Hemstad, G. M. Hillis, R. D. Hills, A. F. Hinderks, B. M. Hlady, C. H. N. Hodgson, A. L. Hoffert, L. A. R. Hoffman, Z. Hojnal, M. E. Holter, D. J. Horbay, L. A. Ingham, G. A. Jelinski, E. E. Johnson, H. L. Johnson, D. G. Johnston, E. P. Juneau, B. H. Ketcheson, M. V. Klein, K. W. Korchinski, J. H. Kostka, W. S. Kowal, A. E. Krause, G. R. W. Kurtz, J. M. Lainsbury, B. Lampman, D. A. Latham, A. Lau, H. R. Lemcke, D. F. Lemna, G. M. Levangie, D. E. Lobb, R. G. Mack, F. V. Majocha, D. G. Malcolm, R. A. Martinson, W. R. Masson, D. N. P. Matthews, R. G. McFadyen, G. McGibney, W. G. McIndoe, A. W. McIsaac, K. A. McKeen, A. T. McPhail, K. D. Meek, M. G. Merlyn, E. V. Miller, A. R. Minty, L. F. Mish, J. Montain, C. E. Morton, E. F. W. Mueller, J. Nabozniak, R. G. Newman, Y. S. Ng, W. Nicholaichuk, R. V. Nordlund, D. W. Ochitwa, W. Ohochinsky, B. J. Osiowy, E. J. Pacholko, W. H. Palmer, A. L. Pawlovich, H. R. Pelzer, D. T. Peters, R. W. Peterson, B. R. Pluhator, D. T. Pollock, W. B. Powell, M. D. Prosko, A. Protz, E. A. Radwanski, J. A. Remai, B. R. Renwick, G. R. Riddell, V. C. Rogne, T. D. Rokosh, K. G. Rooney, D. Ruse, M. J. Rutherford, B. P. Scott, G. E. E. Sedgwick, J. D. Selinger, E. M. Shantz, R. B. Skene, P. S. Skorsgard, L. H. Smith, H. M. Sochan, D. N. Southam, W. S. Stachuk, G. N. Stan, M. A. Stevens, E. Suchoboki, F. Vigneron, G. Wacker, J. D. Walmsley, D. F. Weisner, M. J. Welch, W. H. Wendel, G. N. Werezak, D. R. Westlund, D. A. White, V. H. Wiebe, W. L. Wiggins, L. A. Wildeman, B. J. Wormworth, M. N. Young, D. C. Zelmer, O. H. Zerebeski, M. C. Zoerb, N. Zrymiak, L. J. Zurowski, H. S. Zuzak, G. A. Zypchen.

MANITOBA

Junior to Member: T. W. Algeo, F. P. Y. Arseneault, H. A. Baragar, M. H. Bayne, T. W. Cable, D. G. Curiston, M. Dimentberg, A. G. Grant, H. W. Grant, S. Hayden, A. A. Hayman, F. M. Henry, E. C. Lamb, C. R. Langer, R. F. MacMillan, L. E. Marrin, V. A. McGregor, D. Panisko, H. Penner, C. E. Pontifex, G. R. Reshaur, W. N. Venables, E. L. Weiss, J. E. Whenham.

NEW BRUNSWICK

Student to Junior: G. C. Harper.

PRINCE EDWARD ISLAND

Junior to Member: N. N. MacLean.

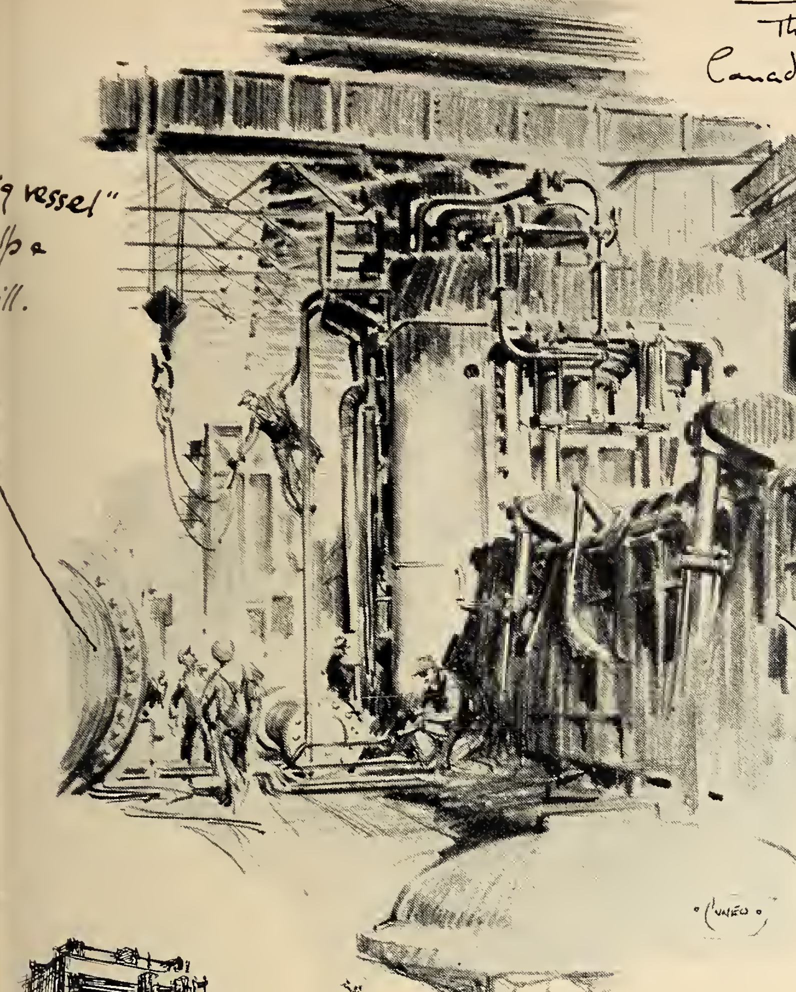
EIC

"g vessel"
-/p a
ill.

750 TON HYDRAULIC "SCRAP SHEAR"

This monster is to be installed in the Canadian National Railroad Yards, London Ontario. Its job is to crush, actually, bite up old steam locomotives. Its great guillotine blades can sever 6 inch steel with ease. For this I hate it. Yesterday I toured the C.P.R yards at St Luc, & saw the endless rows of proud rusty locomotives silently waiting their call to this modern madame Guillotine

"Vive le Progrès"



The hopper for loading.

Yesterday I was taken over a number of the locks of the St Lawrence Seaway & saw the massive gates that were made here in Canadian Vickers. Remarkable place this. It seems that they can take on anything from a ship to a "candy cooker".

This is a Vertical Boring Mill

It is turning a ball & socket expansion joint for the HUMBER RIVER SEWAGE TREATMENT PLANT (Romantic!) The reason for such a joint is to compensate for ground movement in the area. In other words the pipe may shift under the ground after its installation.

commission:-
ERT BOBY LTD.
ury St. Edmunds.

Overseas Companies make a vital contribution to the world-wide engineering resources of the Vickers Group. Whilst in Canada last year, Terence Cuneo paid a visit to Canadian Vickers Limited in Montreal, and these drawings give some idea of the part the company plays in Canada's shipbuilding and heavy engineering industries. The artist is shown in a typical sketching position

TGA OV62R

News of the Branches

Assumption University

Dean Morrison, M.E.I.C.,
Correspondent

A General Meeting was held Nov. 15 to present the budget for the school year 1960-61. The main position of the budget was delegated to subsidies. It was felt that this should be the main financial outlay since the students are not well off financially and were unable to attend some of the important functions of the Border Cities Branch. An example of results of this subsidy is the fact that 17 students were able to attend the Presidents Dinner Meeting in Chatham, Ont. The rest of the budget was set aside for current expenses.

Baie Comeau

G. W. Scott, M.E.I.C.,
Correspondent

The Annual General Meeting was held Dec. 1. S. J. Simons, Assistant Divisional Manager, Quebec North Shore Paper Company, was elected Chairman. In his report the retiring Chairman, G. W. Scott, gave a resume of the year's activities. Louise Tellier, Branch Secretary, stated that the Branch Membership was 59. There had been a slight decrease during the year resulting from the departure of engineers engaged on the Bersimis II Project at Labrieville but it was anticipated that membership would increase during 1961 with increased activity by Quebec Hydro on the Manicouagan River. The meeting concluded with the showing of the film "Quebec Winter Service" covering the winter navigation of the Lauritzen Line in the St. Lawrence River.

Corner Brook

Robert G. Scott, JR.E.I.C.,
Correspondent

The first meeting to be held in Newfoundland dealing specifically with prestressed concrete was held by the Corner Brook Branch Nov. 29. H. B. Carter, M.E.I.C., Assistant Resident Engineer, Bowater's Newfoundland Pulp and Paper Mills Limited, introduced the speakers, E. Leja, M.E.I.C., Managing Director, Lundrigan's Concrete Limited, and Harold Lundrigan, Jr. E.I.C., Manager, Lundrigan's Construction Limited.

Mr. Leja defined the title of their talk, "Prestressed Concrete", and went briefly into the history of this relatively new construction material. He discussed its advantages over reinforced concrete and its tremendous potential in the building field. He then gave a description of the various methods of actually producing prestressed concrete. Mr. Lundrigan followed up Mr. Leja's remarks by going into the theory of prestressed beams using actual numerical examples.

Liberal use was made of films, slides and scale models throughout the session. Especially interesting were films showing the actual making and placing of prestressed concrete on various projects throughout Newfoundland by Lundrigan's Concrete and Construction. Approximately 40 members and guests agreed that this was a most successful technical meeting. Refreshments were provided by the members of the Engineer's Wives Club. A vote of thanks was given by T. Rose, Jr. E.I.C., City Engineer.

An Executive Meeting was held Nov. 22 to draw up a schedule of winter activities. M. G. Green, M.E.I.C., Manager of Bowater Power Company Limited, Deer Lake, Nfld., was elected to the National Nominating Committee Headquarters.

A meeting was held Dec. 13 when P. Cupitts spoke on "Construction of Dokan Dam on the Lesser Zab River, Iraq". Mr. Cupitts is a Civil Engineer with Coode, Binnie and Preece, Consulting Firm.

Mr. Cupitts combined a film and lecture on the construction of the $40 million concrete arch dam. He noted that engineers from England, France, Austria and Germany took part in the project. For the design of the dam a new technique involving intensive mathematical and model experiments was developed at Imperial College, London University. From instruments incorporated in the dam structure it is eventually hoped to correlate theoretical and practical results. Shade temperatures ranging from 17° to 123° caused some difficulties. Artificial cooling means were employed before grouting contraction joints and after construction was complete to speed up removal of heat of hydration. Feature of the dam was one of the most extensive grout curtains ever constructed extending about one mile on either side of the dam itself. The film lasted some 20 min. and showed most of the important phases of construction. Following the film an interesting question and answer period was held and refreshments served.

Halifax

H. F. Peters,
Correspondent

The annual meeting was held Dec. 22 at the Nova Scotia Hotel. Refreshments and a light dinner preceeded the meeting. Attendance was below the usual number due to the imminent holiday season.

Committee chairmen reported on their activities during the year. The report of the representatives on the Committee on Confederation was received with great interest and was discussed at length.

Other reports at the meeting indicated success in the branch's policy of having monthly meetings, more social events and making the activities of the branch more widely known. Chairman of the recently-formed program committee, W. T. Windeler, reported on events arranged during the year and commented on the large attendance they attracted. Reports of the ballots for chairman and new members of the executive were received.

Hamitlon

Glyn T. Rees, M.E.I.C.,
Correspondent

The Eleventh Annual Professional Engineer's Ball was held Nov. 5 at Fischer's Hotel. Nearly 400 attended and President Dick was the guest of the night. President Dick spoke briefly to the engineers and their wives and stressed the importance of a high degree of technical proficiency in the engineering profession, in Canada, as a necessary adjunct to industrial growth and the development of the country's mineral resources. With this end in view the engineers present were urged to keep abreast of current advances in engineering technology and support professional development classes sponsored by the Hamilton Branch. Turning to the ladies, President Dick suggested that the engineers' wives had much to contribute to their husbands' careers, in some cases by encouragement, in others by advocating moderation.

Twenty Hamilton Branch engineers and their sons toured the City of Hamilton Water Purification Plant Nov. 26. The tour included the old "walking beam" type steam pump installed in 1856 which, although not now in service, is still preserved as a monument to those able engineers of 100 years ago.

Kitchener

A. R. LeFeuvre, M.E.I.C.,
Correspondent

A tour of engineering educational facilities at the University of Waterloo highlighted the visit of President Diek and General Secretary C. T. Page to the Kitchener area Nov. 6. During the visit at the University, the officials met with engineering faculty members and the student executive. In the evening the visitors were entertained by the executive members at a dinner meeting held at the Walper Hotel.

The meeting of Nov. 25 was held in the amphitheater of the University of Waterloo. It was the first time that the Institute had made use of these facilities. The members were welcomed to the University by Dr. D. T. Wright, Dean of Engineering. Cash prizes were awarded that evening to two engineering students at the University for technical essays submitted in a contest. These awards were presented by Vice-President Cross.

Professor J. W. Graham, Assistant Professor of Mathematics, was the guest speaker at this meeting and his talk was based on "The Anatomy of Modern Computers". Professor Graham illustrated his talk by means of slides and samples of computer components. He explained the fundamental logic and some of the circuitry of the computer, and made interesting analogies to the speed of these machines. A simple accounting procedure was used to illustrate the method of programming the computer.

Sixty-five members and student members were present and after the talk part of the audience asked Professor Graham to demonstrate the IBM 610 Computer, which the University is using at the present time.

Kootenay

I. Waterlow, M.E.I.C.,
Correspondent

At a meeting Dec. 12, Tom Brett, B.C. Telephone, Trail, B.C., gave a talk entitled "Canadian Microwave System". Mr. Brett described the Canadian microwave system with particular reference to the British Columbia section for which his company was responsible. He also showed the film "Waves of Sound", which described this construction.

Newfoundland

Anthony O. Nemec, JR.E.I.C.,
Correspondent

A meeting was held Dec. 12 in the auditorium of the Imperial Oil Building and was well attended by the members. A paper was given by Mr. Gordon MacDonald, M.E.I.C., Chief Highway Engineer, Dept. of Highways, Province of Nfld., entitled "Trans Canada Highway Construction in Newfoundland". This paper dealt with:

1. History of negotiotions having to do with Trans Canada Highway because of the special circumstances of New-

foundland becoming the 10th province of Canada.

2. The circumstances concerned with the general route and alignment problems.

3. The road system existing before confederation.

4. The special design specifications approved for Newfoundland.

5. The general construction methods employed in construction and problems presented by certain conditions in the field.

6. The paving program: a. specifications, b. plant and methods.

7. Soil conditions: a. geological areas, b. types of soils.

An extremely interesting question and answer period was held afterwards and coffee and sandwiches followed.

The Chief Bridge Engineer, Dr. E. Jacobsen is giving a paper on "Trans Canada Highway Bridges" at the next meeting.

Nipissing and Upper Ottawa

James W. Millar, M.E.I.C.,
Correspondent

Neil J. McMurtrie, Senior Design Engineer, Ontario Hydro Electric Commission, was the speaker at the Dec. 7 meeting. H. R. D. Graham, Manager, North Eastern Region, Ontario Hydro, introduced the speaker whose address was entitled "Research and Design Features of Extra High Voltage Transmission at Coldwater Project".

The Coldwater Project is a test facility near Waubaushene, Ont. It consists of two experimental transmission line sections each approx. ½ mile long with an instrument station between them. The purpose of the tests is to determine the minimum permissable conductor size for new EHV lines. Mr. McMurtrie stated that EHV transmission was not new, having been used in Western Europe, the United States and Russia but that sufficiently accurate data is not available to determine the size of the conductor with the exactness required by Hydro. It is proposed that eventually an EHV transmission line will extend from Abitibi Canyon into the Southern Ontario area involving ultimately two circuits over a distance of 450 miles. A slight reduction in the size of the conductor can mean tremendous reduction in cost.

Mr. McMurtrie said that with the completion of the St. Lawrence Seaway project the last big hydro development in Ontario was completed. The last remaining sources of hydro power in Ontario were being developed in the Northern part of the Province and it was in order to transmit this power over long distances that the EHV transmission lines were necessary. The lines will be designed to operate at 460,000 volts. The talk was accompanied by a film illustrating the construction and design features of the project.

North Shore Lower St. Lawrence

L. E. Fischer, M.E.I.C.,
Correspondent

At a meeting Dec. 1 Mr. R. E. Grout, Vice-President Shawinigan Engineering Co., Montreal, gave his impressions of his recent visit to Russian hydro-electric stations. His talk was mainly based on a series of slides. Mr. Grout said that he was impressed by the size of some of their undertakings in this field which are now under construction. He was also impressed by the effort that was put into research.

At a meeting at Sept Iles, Que. Dec. 7, D. Sellick, M.E.I.C. gave a paper entitled "Basic Research in Blasting Cherty Metallic Iron Formations".

Oakville

J. W. Kirk, M.E.I.C.,
Secretary

An organizational meeting was held Nov. 28 and 20 members attended. The 1961 Executive was elected:

A. A. Swinnerton—Chairman
H. J. Bexon—Vice Chairman
J. W. Kirk—Secretary
A. H. Thompson—Councillor
A. G. Ackerman, C. F. Grass—Committee men

Bylaws were drawn up and adopted. Plans were also discussed for the President's visit on Feb. 8 when he is to present their charter.

Saskatoon

F. W. Fossey, M.E.I.C.,
Correspondent

At a meeting on Dec. 15 Certificates of Membership were presented to new members. A discussion was held about the joint E.I.C. and A.P.E.S. A short film was shown concerning the Tennessee Valley soil and water conservation program.

Toronto

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

Toronto Branch members were the guests of the Ontario Water Resources Commission for an afternoon and evening session on "Urban Environment and the Engineer", Dec. 1.

Dr. A. E. Berry, General Manager of OWRC welcomed the members of the Branch and he and his staff outlined the activities of the Commission. The second part of the afternoon session covered modern practices in sewage treatment. Dr. J. F. MacLaren, Consulting Engineer, Toronto, outlined the Humber sewage Treatment works as an example of a large, modern plant while D. S. Caverly of the OWRC staff used coloured slides to illustrate progress in small treatment plants. After an enjoyable dinner, the members toured the facilities of the newly completed OWRC labs.

The evening meeting took the form of a symposium on Air Pollution. A. H. Cowling, Chairman of the Select Committee of the Ontario Legislature on Air Pollution outlined the work and findings of his committee. The Toronto Program was outlined by R. L. Clark, Commissioner of Works for Metropolitan Toronto. The Hamilton Program was reviewed by Mr. D. H. Matheson, Director of Hamilton's Municipal Laboratories.

The session wound up with a discussion on "Urban Environment and the Engineer" led by a panel chaired by W. H. M. Laughlin.

Vancouver

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

J. S. Shakespeare, General Manager, and Mr. J. F. Pine, Chief Engineer, Peace River Power Development Co. Ltd., gave a talk on the "Peace River Hydro Development Including Some Engineering Aspects", Nov. 30. The talk was illustrated by colored slides. The speakers described their Company's findings and future plans in great detail. The respective role of the Peace River Development to the other existing and potential hydro developments in the Pacific Northwest was particularly enlightening.

On Nov. 17, the Civil-Structural Section heard a well prepared paper on "Fire in Buildings" by John Wheeler. Mr. Wheeler discussed all aspects of fire in buildings and covered protection, safety and fire statistics.

University of Waterloo

Carl Hamacher, M.E.I.C.,
Correspondent

The October-December quarter was highlighted by the presentation of awards to the winners of the technical paper contest sponsored by the Student Section. Mr. E. A. Cross, M.E.I.C, Vice President, presented the cash awards at a meeting of the Kitchener Branch, Nov. 25. Gordon Sterline, S.E.I.C., 3rd yr. Civil Eng., was awarded 1st prize for his paper "Open Stope Mining". Wallace Fletcher, S.E.I.C., Chemical Eng., was 2nd. with "Radiation Chemistry of Cycloherane; Iodine Mixtures".

A series of movies, courtesy of various industries, has been presented during the three month academic period and the films have been well received by the students.

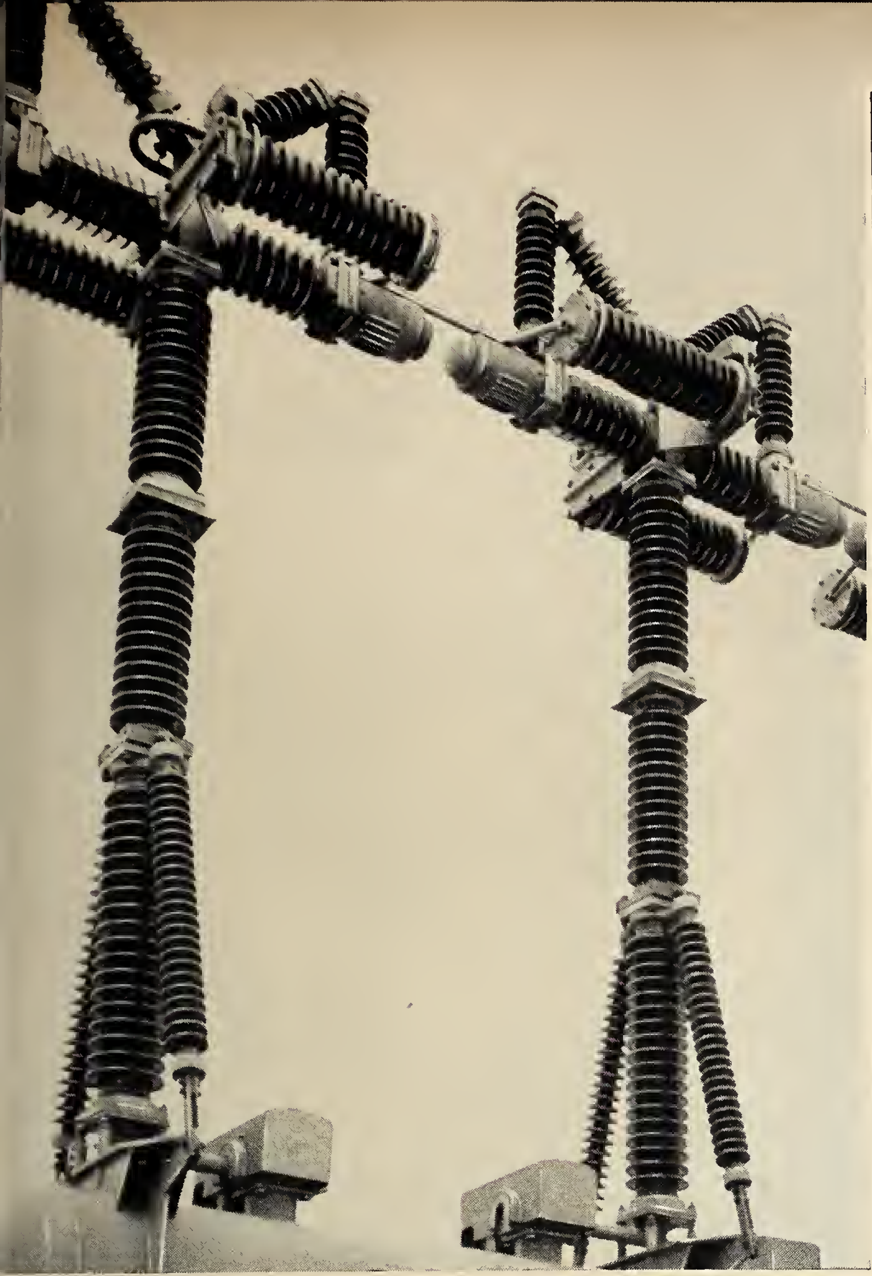
Fifty-five new student members have been enrolled, bringing the total student membership on Waterloo campus up to 125.

University of Western Ontario

John Westeinde, S.E.I.C.,
Chairman

During the past years, the Undergraduate Engineering Society at The University of Western Ontario has undertaken to direct the cultural, social and athletic activities of the Engineering student body. A need was felt for the establishment of a professional engineering society for the technical betterment of the student. With this in mind an E.I.C. student branch was formed and an executive elected. Present membership is 70.

Events planned include a film meeting, a joint meeting with the London Branch, a joint U.E.S.-E.I.C. dinner meeting. EIC



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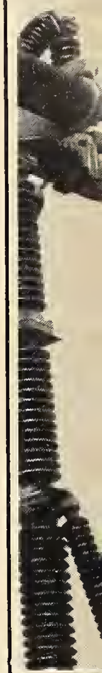

Late in 1960, numerous field tests on Hydro-Québec's Bersimis Power Transmission System were made with Brown Boveri 300 KV Airblast Circuit-Breakers. Completely successful results were achieved in the following line-dropping operations:

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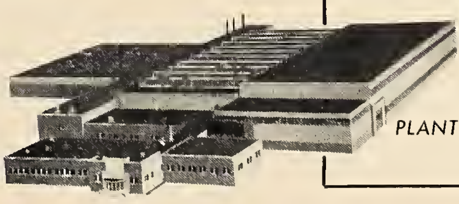

PLANT: St. Johns, Que.

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Library Notes

Prepared by the Library, The Engineering Institute of Canada

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

*THEORY OF INERTIAL GUIDANCE.

This volume is devoted to a systematized development of the basic theory and elemental configuration of inertial systems as employed in stabilization, navigation, and guidance. The pertinent features of classical mechanics are reviewed through an evolutionary establishment of systematic configurations of Cartesian transformations, vector quantities, kinematic fundamentals, rigid body dynamics; gyrodynamics; and stabilized platforms. The author appraises the vertical coplanar dynamics of the levelling and indicating mechanisms, and then gives the spatial analytical description and simulation of inertial systems. (C. L. McClure. Englewood Cliffs, N.J., Prentice-Hall, 1960. 340p., $12.00.)

*BESTIMMUNGEN DES DEUTSCHEN AUSSCHUSSES FUR STAHLBETON, 7th. ed.

A compilation of German specifications and standards in the field of reinforced concrete covering materials, test methods, structural elements, and construction details. There is an extensive subject index. (Berlin, Verlag von Wilhelm Ernst & Sohn, 1960. 543p., DM 19.80.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*THE TESTING OF ELECTRICAL MACHINES.

This book covers not only the actual techniques of testing, but also the purposes of the tests, the subsequent treatment of the data obtained, and the principles underlying the actions of the standard classes of machines concerned. Single-phase and three-phase commutator machines are not included. British testing practice and British Standard Specifications are referred to only. (L. H. A. Carr. London, England, Macdonald & Co., Ltd., 1960. 299p., 50/-.)

*ORGANIZATIONAL SYSTEMS AND ENGINEERING GROUPS.

The research here reported consisted of identifying and describing the organizational systems of each of two technical groups and of their individual parent companies, and then exploring and comparing the relationship between each system, and the background, behavior, performance, and satisfaction of each group's members. As well as reporting the findings of his research, the author indicates implifications the study may have for business administration and research in the behavioral sciences. (L. B. Barnes. Boston, Harvard Business School, Division of Research, 1960. 190p., $3.50.)

*THEORY OF MACHINES, 3rd. ed.

Intended for the engineering student, but also helpful for the draftsman and designer, this third edition has additional matter on gyroscopic motion, velocity and acceleration, toothed gearing, epicyclic trains, inertia forces in mechanisms, and vibrations. There are also chapters on balancing, dimensions, and dynamical similarity, governors, analysis of cams, and friction, including clutches. The analytical theory of five types of brakes is given, including brakes with external-contracting pivoted shoes; special attention has also been paid to the inertia effect of a connecting rod, to creep of belts, and to helical, spiral, and epicyclic gears. (B. B. Low. Toronto, Longmans, Green, 1958. 621p., $5.00.)

*SOILS ENGINEERING, 2nd. ed.

With a notable foreword by Karl Terzaghi, this is a practical introduction of the subject on the undergraduate level. It describes the origin, properties and classification of soils, all aspects of water, frost, and stress distribution in soil, and soil practice in connection with dams and levees, retaining walls, underground conduits, piles and pile-driving; and the consolidation and settlement of structures. This new edition incorporates improvements and additions reflecting advances in the science since 1951. (M. G. Spangler. Pennsylvania, International Textbook, 1960. 483p., no price given.)

*HEAT TRANSFER AND FLUID MECHANICS INSTITUTE—PROCEEDINGS, 1960.

This volume contains eighteen papers reporting completed investigations presented at the 13th meeting of the Institute, all American save for one from England and one from Belgium. The papers deal with research in vortex motion, boundary layer flows, origins of turbulence, flows not in thermodynamic equilibrium, separated flows, two phase flow systems, and thermal radiation problems in space technology. (Stanford, California, Stanford University Press, 1960. 259p., $8.75.)

*DICTIONARY OF AUTOMATIC CONTROL.

A unique feature of this book is an index arranged under the five major subject divisions the book covers—control theory and basic concepts, computers and data processing, industrial machine and process control, aircraft and missile control and telemetering, and control components and design features—which assists in the location of a particular term, as in a thesaurus. In the main text the terms are dealt with alphabetically by means of a brief discussion rather than just a definition. Extensive cross-referencing permits discussion of related terms or concepts under one heading in a unified essay, rather than in alphabetically-separated explanations. A chief engineer at Bulova Research Laboratories, Consulting Editor of the magazine "Automatic Control", and member of AIEE, IRE and AAS, the author has spent five years collecting, editing and interpolating the material. (R. J. Bibbero. New York, Reinhold Publ. Corp. 1960. 282p., $6.00.)

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*KINEMATICS AND DYNAMICS OF MACHINERY.

This text was developed for use in undergraduate machine design courses. The first ten chapters discuss kinematics, emphasizing acceleration analysis, comparing various methods of kinematic analysis, and demonstrating its role in the complete dynamics analysis of mechanisms. The next nine chapters cover static force analysis, and dynamic analysis; involving kinematic analysis as a tool, and covering in detail the speeds and static and dynamic balancing of rotating and reciprocating members, and forces imposed by gyroscopic effects. The final three chapters discuss cams, gearing and gear trains, using the principles of kinematics and dynamics in the process. (R. L. Maxwell. Englewood Cliffs, New Jersey, Prentice-Hall, 1960. 477p., $9.75.)

*MOTION AND TIME STUDY, 3rd. ed.

This edition reflects the extensive industrial applications made during the past five years, and includes new topics on work sampling and sampling standards, motion economy, statistical analysis and mathematical models, verified by first-hand observation in this and other countries. This is a practical book, presenting the basic principles of successful work and developing them through detailed description and extensive illustration from a wide variety of industry and types of work into the final time and motion study procedures. (M. E. Mundel. Englewood Cliffs, New Jersey, Prentice-Hall, 1960. 690p., $11.95.)

*THE RELAY PROTECTION OF HIGH VOLTAGE NETWORKS.

The English edition of a Russian work dealing with the theoretical aspects of the subject for specialists in the field. Relevant aspects of sequence networks, the vector locus method, symmetrical component filters, power directional devices, and the principles of construction and methods of theoretical analysis of systems of transmission line and bus-bar protection are discussed. Also included is consideration of the principles of auxiliary devices which serve for the selection of the faulty phase and for preventing the incorrect operation of protective gear during swings and for faulty conditions in the secondary windings of voltage transformers. (G. I. Atabekov. New York, Pergamon Press, 1960. 564p., $14.00.)

*THE NEW PRODUCT.

This guide to successful product development is presented from the point of view of general management. The basic concepts of top management planning and new product development are covered, as well as each major area of the business enterprise concerned with the successful development and marketing of a new product. Includes chapters on sources of new ideas, pricing, patenting, costing, and sales and advertising methods. (D. W. Karger. New York, Industrial Press, 1960. 234p., $5.00.)

*SYMPOSIUM ON HIGH-VOLTAGE CABLE INSULATION.

Three papers are included in this volume: "Paper for high-voltage cables"; "The Why and the How of Cable Oil Tests", and "The Utility Viewpoint on Cable Oils". (Philadelphia, American Society for Testing Materials, 1960. 39p., $1.50. s.t.p. no. 253.)

*THE CHEMISTRY OF PROPELLANTS.

The topics covered by papers in this volume include propellant sources and costs, liquid propellants, solid propellants, propellants for air-breathing engines, and basic studies on reactions during nozzle flow and jet engine deposits. High-energy propellants and basic propulsion problems are presented and discussed in five papers given at round table discussions. Papers are in French or English; some have extensive bibliographies. (S. S. Penner and J. Ducarme, eds. New York, Pergamon, 1960. 651p., $10.00.)

*SYMPOSIUM ON TREATED WOOD FOR MARINE USE.

This volume contains the seven papers presented at the Third Pacific Area National Meeting of ASTM in San Francisco, October, 1959. Topics covered include methods of evaluation of potential wood preservatives and of chemicals poisonous to the marine borer, the analysis of creosote, studies on wood piles in sea water, and tests on preservatives and specific woods used in piling. (Philadelphia, American Society for Testing Materials, 1960. 69p., $2.50. s.t.p. no. 275.)

*INTRODUCTION TO CONGESTION THEORY IN TELEPHONE SYSTEMS.

The purpose of this book is to present the study of stochastic processes describing the passage of telephone traffic through a switching system, and to introduce to telephone engineers recent mathematical developments in the general congestion theory applicable to telephone traffic. Strong emphasis is placed on the variety of the mathematical methods employed for the solution of congestion problems. Considerable use is made of such recent developments in general congestion theory as queueing theory, Markov chains, and renewal processes. (R. Syski. Toronto, Clarke Irwin, 1960. 742p., $23.00.)

*PROCESSES IN CRYOGENICS, VOLUME 2.

Volume 2 of the series summarizing articles on the whole field of low-temperature methods and techniques, as distinguished from low-temperature physics or chemistry. This volume presents papers on the storage and handling of cryogenic liquids; the gas refrigerating machine; bubble chambers; resistance thermometers; the three level solid state maser; methods of nuclear orientation; the 1958 scale of temperatures for the liquid Helium-4 region; and industrial low-temperature distillation for Deuterium. (Ed. by K. Mendelssohn. New York, Academic Press, 1960. 280p., $11.50.)

*PHYSICS OF THE UPPER ATMOSPHERE.

Eleven chapters of this book are detailed monographs on particular topics by specialists, all concerned with that part of the atmosphere above the height of 60 km. These deal with the thermosphere, the ionosphere, the properties and constitution of the upper atmosphere and its study by rockets and satellites, the airglow, general characteristics of auroras and their study by means of radar, interpretation of the auroral spectrum, and consideration of geomagnetism and meteors in the upper

*THE THEORY OF THIN ELASTIC SHELLS.

The proceedings of a symposium of the International Union of Theoretical and Applied Mechanics, held in Delft in 1959. The 23 papers presented at this symposium (5 in German, 1 in French) discuss two aspects of shell theory-non-linear theory and problems lacking axial symmetry. Frequently papers from two or more sources deal with the same topic, indicating simultaneous investigations in different countries, but these present different points of view and collectively, a broad perspective of each problem. (Ed. by W. T. Koiter. New York, Interscience Publishers, 1960. 496p., $9.00.)

*GRAPHITE AND ITS CRYSTAL COMPOUNDS.

This survey includes description of current lines of research without attempting definitive treatment where these are considered to be premature. It covers crystallographic models and structure of graphite, its physical, thermal, and electronic properties, and its crystal compounds and their electrical and chemical properties and chemical physics. The final two chapters discuss graphite oxide, and the chemical transformation of graphite to volatile products. There is a 28-page bibliography. (A. R. Ubbelohde and F. A. Lewis. Toronto, Oxford University Press, 1960. 217p., $5.25.)

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Air travel.

World air transport statistics, 1959. Montreal, International Air Transport Association, 1960. 47p. 50c.

Bridges. India.

Bridging India's rivers; an account of some of the bridges built during the first and second five-year plans. New Delhi, Indian Roads Congress. 256p.

Bridges, Wooden.

Glued laminated timber for bridge beams, by K. O. Tamberg and M. W. Huggins. Toronto, University of Toronto, 1960. 30p. (Report no. 11).

Canada. Dept. of Mines and Technical Surveys.

Mineral Resources Division. Operators lists.

List 1, Pt. 2—Metallurgical works in Canada—non-ferrous and precious metals. 1960. 24p. 25c.

List 7—Natural gas processing plants in Canada. 1960. 16p. 25c.

Canada. Dept. of Northern Affairs and National Resources. Water Resources Branch. Bulletins.

Principal hydro-electric and hydraulic developments in Canada at 31 December 1959 with total installed capacities not less than 2,000 hp. Ottawa, 1960. 30p.

Cement.

Quantitative determination of the four major phases in portland cement, by Stephen Brunauer and others. Skokie, Ill., Portland Cement Association, 1959. 10p.

Composite construction.

Proceedings of the composite construction design seminar held November 10, 1960, in Toronto. Sponsored by Joint Area Committee—Engineering Institute of Canada (Toronto Branch), American Society of Civil Engineers, Institution of Civil Engineers. 30p.

Computers.

Computer abstracts, v.4, no.6, June 1960. London, Chancery House. 19p.

Electrical engineering.

Electrical Research Association. Technical reports.

D/T112—Intrinsically safe electrical apparatus—relation of igniting current to circuit inductance for a mixture of buta-1: 3-diene with air, by P. B. Smith and N. L. Heathcote. 1959. 4p. 4/6.

D/T113—Intrinsically safe electrical apparatus—relation of igniting current to circuit inductance for a mixture of carbon disulphide vapour with air, by P. B. Smith and N. L. Heathcote. 1959. 5p. 6/-.

D/T114—Flameproof enclosures: effect of internal pressure on the flange gap width at the time of ignition of an external mixture, by T. J. A. Brown and N. Simpson. 1960. 27p. 15/-.

G/T312—Restriking voltage 33 kV survey—East Cornwall network, by J. S. Vosper. 1958. 13p. 10/6.

N/T86—The effect of temperatures of 650 C and 700 C on the magnetization and properties of Alcomax magnets, by A. G. Clegg and M. McCaig. 1960. 4p. 4/6.

S/T97—Line and neutral currents in multi-limb transformers under impulse-test conditions, by E. L. White. 1959. 28p. 15/-.

Executives.

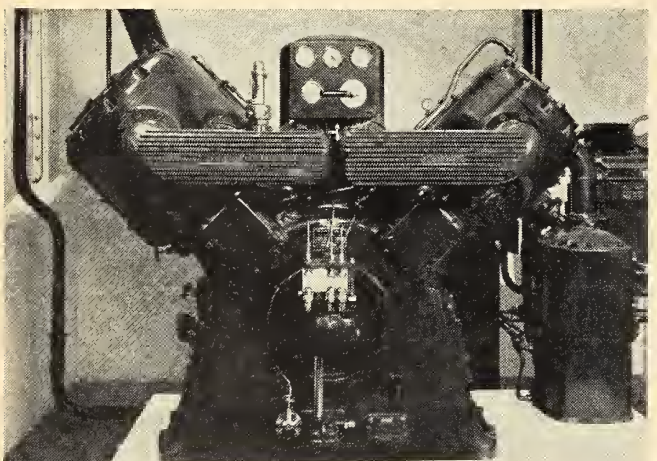
Princeton University. Industrial Relations Section.

The appraisal of executive performance. Selected references. 1960. 4p.

Industrial wastes.

Proceedings of the Fourteenth Industrial Waste Conference, May 5, 6, and 7, 1959. Lafayette, Ind., Purdue University, 1960. 831p. (Engineering extension series no. 104).

(Continued on page 135)



CAREER OPPORTUNITY FOR MECHANI-CAL ENGINEER in New Alumina Plant. Harvey Aluminum, a dynamic, fast growing producer of primary aluminum and mill products is engineering a new alumina plant.. The following challenging position is now open: Senior mechanical engineer, minimum 4 years plant experience in the maintenance department of a Bayer ore process or alternatively, minimum 6 years' plant experience in the maintenance department of other extractive metallurgical or chemical processes. Candidates having experience with the operation of boilerhouses will enjoy preference. This permanent position offers excellent career opportunity with a strong growth company. Send complete resume of education to: Harvey Aluminum (Incorporated). Attention: Mr. Ron Howard, Director of Professional Personnel, 19200 South Western Avenue, Torrance, California. File No. 7210-V.

MISCELLANEOUS

ENGINEERS FOR SALES, PROJECT, design, research, development, control and management. Graduates of all types and ages required by clients of The Technical Service Council, a non-profit industry sponsored placement service. Write 2 Homewood Avenue, Toronto 5, for an application. There is no charge for work done on your behalf. File No. 6648-V.

TEACHING VACANCIES exist for undergraduate courses in Mechanics, Thermodynamics, Materials, in young Engineering Department. Minimum requirement — Masters Degree. Rank and salary dependent on qualifications. Write — Jack Bordan, Head, Department of Engineering, Sir George Williams University, Montreal 25, Canada. File No. 7180-V.

ENGINEER REQUIRED. Must be bilingual with 5 to 7 years' industrial experience in preferably production planning. To act as assistant to plant manager. Please apply directly to Mr. Jean Moreau, P.Eng., Eagle Pencil Co., Drummondville, Quebec. File No. 7187-V.

HYDRAULIC SYSTEMS DESIGN ENGINEER. A vacancy exists for a design engineer with North American experience in high pressure hydraulic systems and components for industrial applications. Apply Vice-President, Engineering, Jarry Hydraulics Limited, 4384 St. Denis St., Montreal 18, Quebec. File No. 7190-V.

A MOST UNUSUAL OPPORTUNITY for a competent technical man, thoroughly experienced in the complete operation of vertical stud Soderberg anode cells. The man selected must have an outstanding engineering record, a theoretical knowledge of this electro-chemical process, and extensive operational experience producing primary aluminum. Must be capable of quality inspection of actual operations. Excellent salary, major benefits. Detail your background and experience in strict confidence. File No. 7201-V.

WE REQUIRE TWO JUNIOR GRADUATE Engineers with from one to three years' experience. One mechanical or electrical engineer for our instrument department, preferably with some experience in automatic controls, and a mechanical engineer for general work in design and maintenance. Good opportunity for advancement with excellent salary and fringe benefits. File No. 7203-V.

ENGINEERING FIELD REPRESENTATIVES required to assume responsibilities for field operations in London, Ontario immediately and in Maritime Provinces. Maritime position opens only in June. Duties involve promotional work (not sales) with engineers, architects, contractors, and government officials, on an individual basis and through meetings with professional groups. Complete training in all aspects of the work will be provided. These positions are suitagle for recent engineering graduates interested in public relations work and limited structural design. Salary commensurate with qualifications and experience in $5,000 to $6,000 range. Reply in writing to Plywood Manufacturers Association of B.C., 27 Goulbourn Ave., Ottawa, Ontario. File No. 7207-V.

E.I.C. CERTIFICATE OF ADVERTISING MERIT

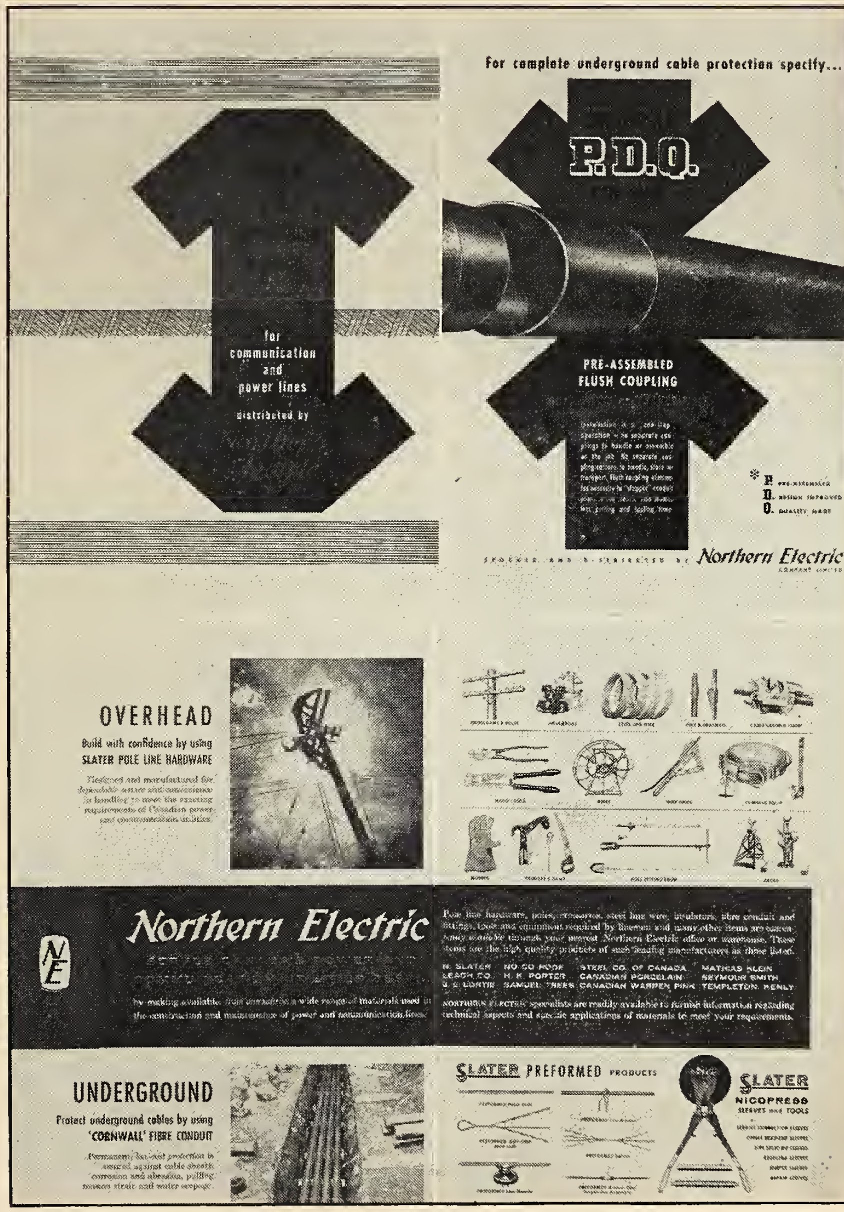
The E.I.C. Certificate of Advertising Merit for the month of November 1960 has been awarded to Northern Electric Company Limited. This is the fourth time, since the inauguration of the certificates in January 1959, that Northern Electric has been presented with this certificate. The winning advertisement appears on pages 33, 34, 35, & 36 of the November issue. It is a 4-page, two colour, insert, black and orange, titled "OVERHEAD AND UNDERGROUND MATERIAL FOR COMMUNICATION AND POWER LINES DISTRIBUTED BY NORTHERN ELECTRIC."

The insert covers a variety of services and products made available to engineers through the company and lists some of the firms Northern Electric represents. This same insert won the E.I.C. Certificate of Advertising Merit for the month of October.

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

The judging of the advertisements was done by fifty readers of the "Journal" — five from each province — who made their selection from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

Front *Back*



Centre Spread

NORTHERN ELECTRIC COMPANY LIMITED WINNING INSERT

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

Business and Industrial Briefs

Appointments and Transfers

The Foxboro Company, Foxboro, Mass., has formed a marketing division. Mr. C. **Schwarzler** has been appointed Vice-president of the new division.

Syntron (Canada) Limited has appointed **Walter O. Middleton** District Manager of British Columba and the Yukon Territory.

John J. Huggard, Assistant to the President of Continue-Flo Products Ltd., Hamilton, is spending one to two years in England. Mr. Huggard is assisting in the selling of the firm's products in the U.K. and Ireland. He will be in charge of sales and promotion co-ordination.

Otis Elevator Company Limited have appointed **Edmund M. Tuff** Construction Manager for Canada succeeding **George A. Thomas** who has retired.

R. Roy Ellis has joined The Indiana Steel Products Company, Ltd., Kitchener, Ont., as a sales engineer.

In addition to his duties as Executive Vice-President and General Manager of Howard Smith Paper Mills Ltd., **H. E. Mason** has been appointed Vice-president of Dominion Tar and Chemical Company, Ltd.

The Consolidated Mining and Smelting Company of Canada Limited has appointed **T. S. Campbell,** Mines Engineer, Benson Lake Property, Vancouver Island.

The appointment of **John F. Redmond** as Vice-President, exploration and production, has been announced by Shell Oil Company of Canada, Limited. Mr. Redmond will have his headquarters in Calgary.

G. J. Jackson has been appointed District Sales Manager, Dominion Structural Steel Limited, Toronto Division. Mr. Jackson was formerly Assistant Sales Manager, Montreal Division.

Canadian Petrofina Limited has appointed **J. C. Vezeau** Manager of asphalt sales. He will be organizing the marketing of asphalt products and co-ordinate the sales program with the refinery.

The A C and R Products Limited is to act as agents for the distribution of all Alco Valve Company products for air conditioning, refrigeration and industrial processing in Canada with the exclusion of British Columbia and Alberta. **W. G. Woodcock** is President and General Manager of A C and R Products Ltd.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A MILLION DOLLAR carbon monoxide boiler and extraction steam turbine is being installed by British American Oil Company Limited at its Clarkson refinery, 20 miles west of Toronto. The boiler is designed to aid in heat recovery and disposal of waste gas by burning carbon monoxide and unburned hydrocarbons produced in the refinery's catalytic cracking operation. It will provide steam power for the recently completed alkylation unit and complement the high pressure steam boiler at present supplying the catalytic cracking unit. It will be capable of generating 165,000 lb. of steam per hr. at 600 p.s.i.g. at 750°F.

THE WATER RESOURCES BRANCH of the Department of Northern Affairs and National Resources has issued its annual review of current water power development throughout Canada, and of other construction pertaining to electric power supply and distribution. During 1960, a net total of 1,741,820 hp. of new hydro-electric capacity was added in Canada after allowing for 4,680 hp. which was dismantled or destroyed. Quebec's total of 1,176,500 hp. of new capacity installed during 1960 surpassed the combined total of the other provinces. The total installed capacity of new water power plants in Canada is now listed at 26,372,444 hp. New capacity to be added in Canada during 1961 is limited to about 243,000 hp.; however construction is proceeding at other developments where 4.5 million hp. are expected to be installed and where provision will be made for installation of an additional 1 million hp. in later years.

TO FAMILIARIZE the construction industry with shell roofs is the aim of a new booklet produced by Portland Cement Association, Chicago. The publication gives basic information on several aspects of shell design and construction. The lead article by a noted architect deals with some of the esthetic considerations encountered in this work. Also dealt with are characteristics of shells, including explanations of their action and suggestions for best realization of their potential plan layouts. The final article gives details on six American projects that illustrate the versatility of barrels, folded plates and hyperbolic paraboloids.

CONTRACT for design, manufacture and installation of the largest single solids contact water treatment plant in North America has been awarded to Graver Water Conditioning Co., Toronto, by St. Lawrence Corporation Limited. The plant, to be installed at St. Lawrence's Three Rivers, Que., newsprint plant, will provide clarified process water to ensure maximum brightness of paper. The plant will consist of an all steel reactivator 150 ft. diam. and 24 ft. high, chemical feeds and flow control equipment. Flow capacity will be 20,000 gal. per min. The plant is planned to be in operation by the end of March, 1961.

A NEW LINE of high intensity infrared heaters recently announced by Canadian General Electric Company Limited are claimed to eliminate snow removal problems. These heaters are installed so as to radiate heat over a particular area. The heat rays pass through the air without heating it, but warm objects which they strike. For the duration of a snow storm the heaters are switched on and the snow melts as it falls, thus eliminating snow removal chores.

A NEW ALLOY has been announced by Union Carbide Canada Limited, Metals and Carbon Division. The metal, "Haynes" alloy No. 56, is said to capitalize on the best characteristics of nickel, cobalt, chromium, molybdenum and iron. These ingredients are blended to give the alloy high-temperature strength and oxidation resistance. It is

(more Briefs on page 135)

• MORE BRIEFS

available in the form of sheet, plate, bar, wire and coated welding electrodes. Parts can also be produced by sand-, investment-, and resin shell-mould casting.

ULTRASONIC CLEANING SYSTEMS for industries, designed to clean any product from machine castings, gears and shafts to delicate instruments, have been introduced by Canadian Westinghouse. This method makes use of high-frequency sound waves to remove foreign matter from metals, plastics, ceramics and glass. A generator produces high-frequency electrical energy, which a transducer converts to high frequency sound waves that travel through the liquid cleaning agent. These waves cause "cavitation", the formation of countless microscopic bubbles that grow in size and then violently collapse, thus setting up a scrubbing action that blasts the contaminant from the substance being cleaned. The equipment is claimed to provide a fast, economical method of removing oil, grease, buffing compound, chips, dirt and foreign substances from recesses, small holes or crevices. It will also remove flux residue, scale formed on metal surfaces during heat treatment, and decontaminate radioactive parts.

A VISUAL SYSTEM for selecting tool steels has been created by Atlas Steels Limited. This company claims that the new system will enable users of high speed and tool steels to make correct specifying decisions based on their shop needs, without extensive metallurgical or engineering knowledge. The "Select-o-Graph" is made up of a wall chart with full-colour graphs that show at a glance the chief characteristics of 23 tool steels; and a brochure that repeats the graphs along with technical information.

WESTINGHOUSE ELECTRIC International Company has appointed Liquid Carbonic Canadian Corporation as exclusive Canadian distributors of its line of electric welding equipment.

THE FORMATION OF a subsidiary company to commercially develop an asbestos deposit at Coalinga, Calif., has been announced by Canadian Johns-Manville Co., Limited and The Kern County Land Company of San Francisco. The new operating compnay will be known as the Coalinga Asbestos Company. Johns-Manville Corporation owns a majority interest in it.

SMALL AIR COOLED ENGINE WELDERS with engine idler and self-starter, introduced by the Lincoln Electric Company of Canada Limited, are said to have added convenience and improved economy. The welder will accelerate to operating speed instantaneously when the arc is struck and slow to idling speed 8 to 10 sec. after the arc is broken. EIC

• LIBRARY NOTES

(Continued from page 120)

Patents and inventions.

A proposal for Canadian provisional patent specifications, by C. C. Kent. Reprinted from Canadian Patent Reporter, v. 30, sect. 1. 10p.

Road materials. Bituminous.

Reflection cracks in bituminous resurfacing, by M. M. Davis. Toronto, University of Toronto, 1960. 46p. (Report no. 12).

Toronto.

The face of Toronto, by Ralph Greenhill. Toronto, Oxford University Press, 1960. 58p. $3.00.

Welding Research Council.

Bulletin series.
Welded interior beam-to-column connections, by J. D. Graham and others.
Transfer of stresses in welded cover plates, by A. M. Ozell and A. L. Conyers.
A survey of literature on the lateral instability of beams, by G. C. Lee.
(All in Bulletin no. 63)

STANDARDS RECEIVED

CSA standards. Canadian Standards Association, 235 Montreal Road, Ottawa 2.

B54.1—1960—Specification for determination of non-combustibility in building materials. $1.25.

B71.5—1960—Specification for tubular rivets. $1.50.

C22.2, No. 78—1960—Construction and test of varnished-cloth insulated wires and cables. $2.50.

C22.2, No. 124—1960—Construction and test of mineral-insulated copper-sheathed cables. $1.50.

G40.8—1960—Specification for structural steels with improved resistance to brittle fracture. 35c.

Canadian Institute of Steel Construction, Inc.

Tentative specification for high-strength low alloy structural manganese vanadium steel. Approved by the American Society for Testing Materials. 21p.

Canadian Underwriters' Association.

Standards . . . for the installation of sprinkler systems. Montreal, 1960. 157p. EIC

INDEX TO ADVERTISERS

February 1961

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Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

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EUROPE H. A. Mockenzie, 4A Bloomsbury Squore, London W.C. 1, England. Phone: HOlborn 3779

UNITED STATES R. G. Melendy, 17 Mougus Avenue, Wellesley Hills 81, Mass. Phone: CEdor 5-6503

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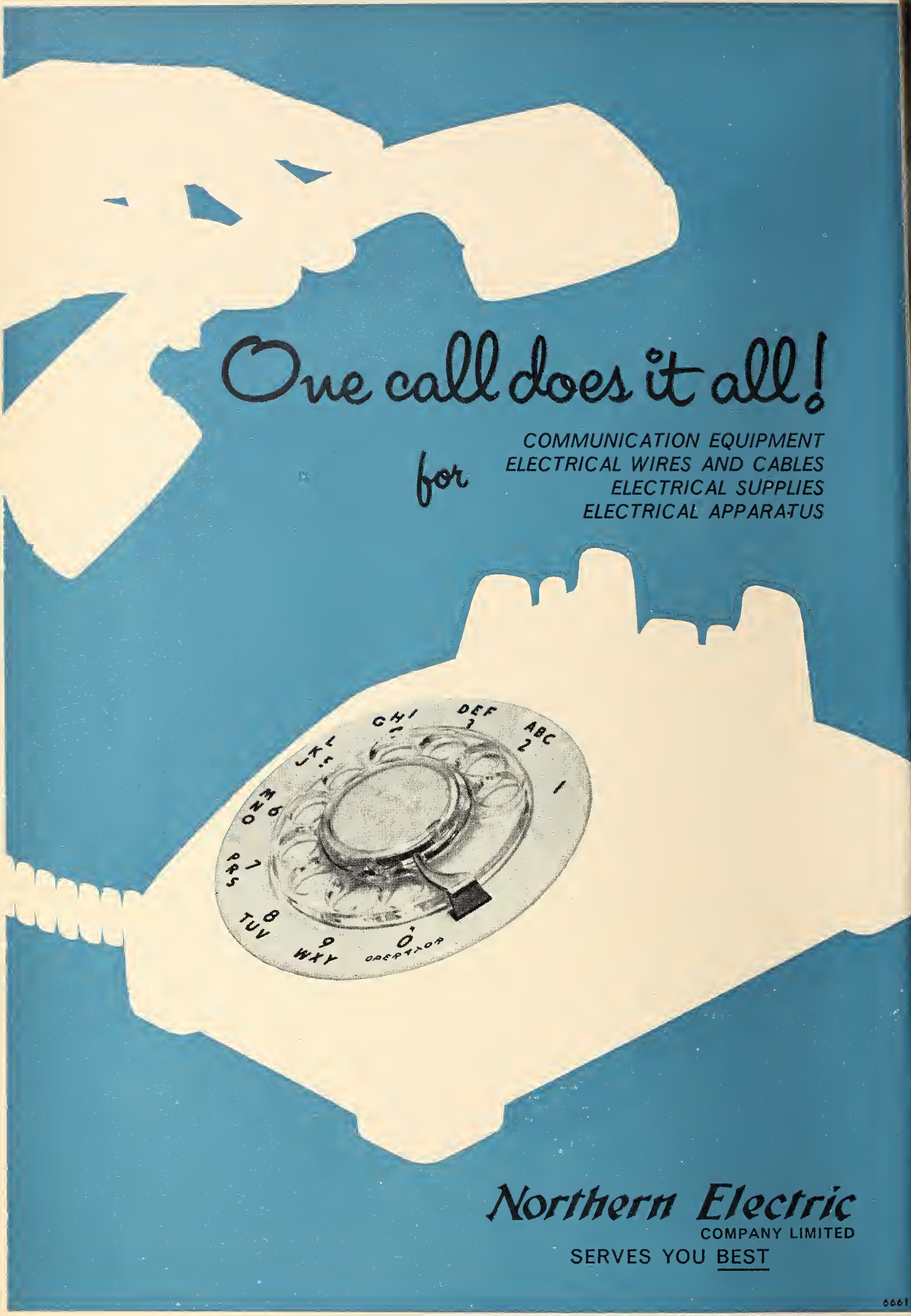
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IN THIS ISSUE

Technical Control of Ready Mixed Concrete by **M. F. Macnaughton,** M.E.I.C., covers some of the more important aspects of quality control. It also discusses some of the present problems relating to concrete quality — whether ready mixed or job mixed — and gives a brief review of some recent investigations which suggest at least a partial solution to some of these problems. Mr. Macnaughton, a native Montrealer, served overseas with the Canadian Expeditionary Force during the First World War after which he entered McGill University where he obtained a B.Sc. in Chemical Engineering. He received his master's degree from University of Michigan in 1924. After 28 years with Milton Hersey Co. Ltd., Montreal, Consulting Engineers and Inspectors, he joined Mount Royal Paving & Supplies Ltd., where he is Vice-President, Technical Control.

Harvey E. Martin, M.E.I.C., author of *The GM Portager Piggyback System*, joined General Motors Diesel Limited, London, Ont., 10 years ago as a Project Engineer. He was promoted successively to Supervisor of Project Engineering, Chief Project Engineer, and, in late 1960 to New Product Development Engineer. In his paper Mr. Martin outlines the rationale of piggyback systems and describes a different approach developed by his company. In the GM system the rubber-tired highway trailer rear tandems may be removed, and the trailer can be side loaded onto the rail vehicle. This allows a more simplified rail vehicle than now in general use for piggybacking. Mr. Martin was born in Napanee, Ont. After serving four years as an apprentice draftsman for Canadian General Electric Company he joined the Royal Canadian Navy. He obtained his B.Sc. degree from Queen's University in 1949.

Leo A. Leeyus, M.E.I.C., could call upon 12 years of experience in hydro electric projects for his paper, *Silver Falls Tunnel and Surge Tank Design.* Mr. Leeyus is a native Manitoban and received a degree in Civil Engineering from University of Manitoba in 1947. After graduation he joined the Hydro Electric Power Commission of Ontario where he now is Assistant Civil Design Engineer, Generation Design Department. Projects on which he has worked include Des Joachims, Niagara G.S. #2, Niagara River Remedial Works Control Structure, Pumping Generating Station (Niagara) and the Silver Falls project. Mr. Leeyus explains that the Silver Falls site is a typical example of an area where a hydraulic pressure tunnel is the most effective method of developing maximum power potential. The two basic requirements for the use of natural rock are that the topography lend itself to such an arrangement and that the rock be of satisfactory quality.

A tight schedule in the tunnel driving and concreting at Silver Falls made it necessary for the concrete operation to start while the tunnel driving was in progress. This is one of the problems outlined in *Concrete Tunnel Lining at Silver Falls Generating Station* written by **H. A. Jackson,** M.E.I.C., and **C. T. Bath.** The authors' qualifications include extensive experience in hydro electric projects. Mr. Jackson, Construction Manager for Northwestern Ontario of the Hydro Electric Power Commission of Ontario, joined the H.E.P.C. after obtaining a B.A.Sc. degree from University of Toronto in 1946. He has served as Construction Engineer at Otto Holden G.S. and as General Construction Superintendent at Manitou Falls G.S. Mr. Bath, a native Australian, came to Canada in 1953 and worked at the Kitimat and other hydro projects before joining Ontario Hydro in 1957. He now is Office Engineer of the Thunder Bay G.S. at Fort William. At Silver Falls, a 10,000 foot horizontal tunnel was driven between two lakes. Associated with the tunnel are two vertical shafts, and a surge tank joined to the tunnel by a reinforced concrete "T" section.

". . . for sheer presumptuousness at least, my title can hardly be surpassed," says **Dean J. W. Hodgins,** M.E.I.C., in his paper, *Technological Horizons*. The author, who is Dean of Engineering at McMaster University, Hamilton, first presented Technological Horizons as a talk before the Hamilton Association last year. Dean Hodgins points out that engineers spend their entire careers as custodians and purveyors of materials, energy, and information, "and that these three topics may very well serve as the basis for this discussion, for contemplation of them has suggested some rather strange inconsistencies." His thought-provoking paper reminds us of the past, reviews the present, and brings into sharp focus the responsibilities of the future.

A Study of *Winter Water Temperatures and Ice Prevention by Air Bubbling,* by **G. P. Williams,** M.E.I.C., presents water temperature data and the essential technical information that is available on air bubbling systems. Typical water temperature profiles under ice covers are given. Design considerations for air bubbling systems include a summary of design values which have been used at specific locations. The paper also reviews several experimental investigations on air bubbling techniques, both in the laboratory and under field conditions. Mr. Williams graduated in 1949 with a B.A.Sc. from University of British Columbia, and obtained an M.Sc. degree from Utah State University in 1951. He worked with P.F.R.A., Department of Agriculture, as field engineer on irrigations and drainage problems in British Columbia until 1952 when he joined the Aluminum Company of Canada as hydrology engineer at Arvida, Que. Three years later he joined the Division of Building Research of the National Research Council as a research officer with the Snow and Ice Section. During the past five years Mr. Williams has been involved in research projects involving the energy exchange from natural surfaces.

Beaver Bill appears this month on page 114, **Stan Cassidy** has a membership reminder on page 162.

COVER ILLUSTRATION

Arch form showing inspection doors and invert anchorage, Silver Falls Generating Station.
(Photo courtesy Ontario Hydro)

where to save refining dollars

WITH

ROCKWELL-Nordstrom **VALVES**

Technical Control of Ready Mixed Concrete

About $5000 would cover the cost to a small operator of equipment required to take daily samples of ready-mix concrete he supplies. This paper is intended to present information from the point of view of the supplier, as well as the user, of ready-mix concrete.

M. F. Macnaughton, M.E.I.C.
Vice-President, Technical Control,
Mount Royal Paving & Supplies Limited, Montreal.

QUALITY CONTROL of concrete is a broad subject. To devote the space available to best advantage much detail pertaining to many of the essential requirements for the production of controlled concrete will be omitted. Cement and aggregates must conform to certain specific requirements as to physical and chemical quality, must be reasonably uniform as regards grading, and the equipment used in proportioning, mixing, and delivering the concrete must be accurate and efficient. Most of this will be ignored in this presentation.

In Montreal about 95% of all concrete used is premixed or transit mixed. Accordingly, this paper is intended to present information from the point of view of the supplier, as well as the user, of premixed or transit mixed concrete. At the same time much of the information developed is equally applicable to concrete mixed on the job.

Basic Test Facilities

In any ready mix operation it is desirable that the supplier be in a position to carry out systematic tests on concrete supplied. How extensive this schedule of testing should be depends on the size of the operation, the control over uniformity and quality of materials used, and whether the services of capable commercial test laboratories are available in the area.

The ready mix supplier may feel that he can dispense with this cost and rely on tests carried out by his customers to keep him advised of the quality of his concrete. Our experience has been that this is not the case. Quite frequently we have found that our own test results were in serious conflict with those of commercial testing laboratories. In dealing with such cases we have found our own laboratory testing to be of great worth. In a large number of cases the customer has accepted our results. In many other cases tests on cores taken from the structure indicated that the concrete was in accordance with the specified requirements, regardless of the adverse results reported by the commercial laboratory. In two cases, where the argument went to arbitration, the decision was in our favour and in no case did the complaint go to litigation.

Even the smallest ready mix company should be in a position to take daily samples of their product to check on performance. The equipment required for this is quite simple, and, for a small operator, costs about $5,000.

For a major supplier, something more is necessary. His technical control department should be in a position not only to test concrete, but to proportion mixtures to meet specification requirements with maximum efficiency and economy.

The text books, the hand compendiums, and the technical journals are full of presentations of methods of proportioning concrete. In this connection the term "method of proportioning" is preferable to the word "design".

Basic Principles

In the early days each author laid down hard and fast rules—the original Lewis Institute water/cement ratio theory[1] was an outstanding example of this school of thought—as to how concrete mixtures should be proportioned for specific results.

In addition to the water/cement ratio theory there were many other methods of proportioning suggested. A few of these were:

(1) Maximum density method of Fuller & Thompson[2]

(2) Fineness modulus method of the Lewis Institute[1]

(3) Surface area method of Edwards & Young[3]

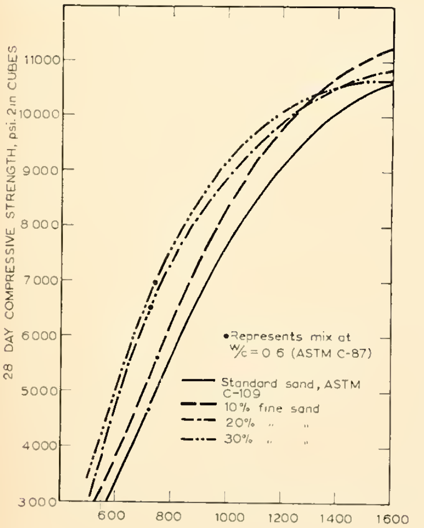
(4) Cement-space method of Talbot & Richart[4]

Other methods, as well as many variations of those mentioned, have been suggested.

In all cases the proponents of the various methods eventually retracted a large part of their pragmatic claims, and retreated behind a defence hedge with the suggestion that, prior to making any final decision as to the validity of the method presented for consideration, proof of the method would be desirable by actually making up trial mixtures with varying cement content, using the specific cement and the specific aggregates actually to be employed in the work, and subjecting test cylinders of the trial mixes to 28-day compressive strength tests before any concrete was delivered to the job.

Under these circumstances it seems useless to take you on a long review of the many methods of proportioning of concrete mixtures which have been suggested in the last 50 years. For a consideration of the situation as it was 27 years ago the reader is referred to an article published in the E.I.C. Journal for August, 1933, on "The Structure of Concrete Mixtures".[5] If you read this paper, please remember that, at that time, nothing was known about air entrainment in concrete mixtures, and very little about retarders. With these exceptions, the conclusions arrived at in this paper are still valid, and this method of determining optimum mixture proportions is again recommended.

Fig. 1—Results of compressive strength tests from cubes made with mortar of normal consistency.



Preliminary Studies

Prior to embarking on any considerable effort in the preparation of trial mixtures it is desirable to have some knowledge of the general problem, and a study of the literature on the subject will prove extremely beneficial.

In any such study the question of optimum grading is a matter of prime importance. While attainment of maximum density, per se, is not always beneficial in the overall problem of concrete mixture proportioning, as will be shown later, it exercises a considerable effect on the economical aspects of concrete proportioning in general. Therefore, prior to any attempt at proportioning concrete mixtures the grading of aggregates available for the work should be examined, to see if any improvement in this respect can be obtained.

Curiously, the classic work on grading of aggregates was carried out by a mining engineer, C. C. Furnas,[6] employed by the U.S. Bureau of Mines in Denver, Colorado. His problem was to develop gradings for rock mixtures used in backfilling mine stopes so as to minimize future shrinkage and settlement. His method of analysis was purely mathematical. It is interesting to note, that, while his analysis is mathematical, he had to determine, in advance, by trial, the density value of each individual aggregate size contained within the range of sizes.

It is interesting to note also, that, in this analysis, he had no particular interest in concrete mixtures, as such. However, a concrete technician, F. O. Anderegg,[7] adopted the grading methods outlined by Furnas, and adapted them to proportioning of concrete mixtures, with necessary adjustments because of the fact that the cement content was an added component, occupying space in the mixture as a binding material.

Shortly after this, C. A. G. Weymouth, working in California, published a report[8] covering optimum gradings for aggregates in concrete mixtures. He also submitted a mathematical formula for the optimum grading of aggregates for concrete. He also, like Furnas, had to rely for his basic constants, on results of tests for packing properties on individual sized aggregate fractions.

Furnas used calculus as a mathematical method in his analysis; Weymouth used analytical geometry in his approach. Both of them arrived at the same answer: that for proportioning of mixtures for maximum density the factor r, representing the quantity of each successively larger screen size, compared with the next smaller screen size, where the relation between screen sizes is 2.0 to 1.0, should be between 1.10 and 1.25, depending on the aggregate particle shape and packing properties.

Weymouth lays particular stress on avoiding "particle interference" in aggregate grading. His theory is that no particle size should be present in the mix in such proportion as to interfere with the free circulation of these particles in the matrix composed of all the constituents smaller than that size. If particle interference occurs the excessive amount of any single size interferes with the mobility of the mix, and with normal consolidation as the mixture sets and shrinks in volume.

Since the original work of Furnas and Weymouth the majority of searchers in the field of grading have accepted their conclusions, whether related to material for backfilling of mine stopes, fill for consolidation, Portland cement and bituminous concrete mixtures, as well as in many other fields.

Practical Application of Grading Studies

To the average producer of ready mixed concrete the grading of the coarse aggregate portions presents no great problem. The coarse aggregate, ranging in size from ¼ in. up, is delivered to the plant in shipments separate as to size, stored in separate bins, and weighed out in the required amounts.

The sand portion, usually ranging from ⅜ in. in size to -100 mesh, presents a greater problem. Here grading is perhaps even more important than in the coarse aggregate portion of the aggregate, and alteration of that basic grading presents more difficulties.

Theoretically, as cement content is increased from a minimum of, perhaps, 300 lb. per cu. yd. to a maximum of 900 lb. per cu. yd., very considerable changes should be made in the grading of the sand fraction to produce maximum economy in cement requirement.

For very lean mixtures, with low cement content, a high proportion of -100 mesh sand is desirable, in order to occupy space in the mixture, act as a void filler, and reduce the amount of mixing water required to induce plasticity. As the cement content is increased, with additional cement replacing water in the void spaces, the necessity for the presence of a part of the finest sand particles in the mix disappears, and they should be progressively eliminated as the cement increases in quantity. Finally, with very rich mixes, due to the void filling properties of the large amount of cement, only a small percentage of sand particles, below 50 mesh in size are required at all.

This means, of course, that, for optimum strength, for variable cement content, the supplier should be prepared to change the sand grading, as required, for the type of concrete to be produced. This is often done on large mass concrete projects, where a single, or a dual, class of concrete is desired, and where the grading of the sand fraction can be adjusted to that most suitable for the mix required.

For the average ready mix concrete operator such finesse is impossible. Unless he is prepared to install three bins in the plant to supply fine, medium and coarse sand in varying quantities, his only recourse is to arrange for a supply of sand of uniform median grading which will represent the optimum grading for mixtures between 2500 and 4000 p.s.i. in strength at 28 days. Mixtures leaner than 2500 p.s.i. in strength will tend to be harsh and unworkable. For these mixes air entrainment will assist greatly in remedying the effects of the too harsh sand. For mixes above 4000 p.s.i. in strength the use of dispersing agents will, to some extent, offset the disadvantageous sand grading, and increase the strength by 500 to 1000 p.s.i.

A limited amount of testing on mortar mixes, prior to general actual development of proportions for the concrete mixtures, can often afford useful information regarding the optimum grading of the sand fraction. As an illustration, in our Ottawa operations we use, as aggregate, sand and gravel from a deposit at Shawville, Que. The sand in this deposit, with an average F.M. of 3.10 for the fraction passing the 4 mesh sieve, is too coarse for optimum results in normal concrete mixtures, so it is blended with a proportion of fine sand, with a F.M. of about 1.60, obtained locally in the Ottawa area.

Since our Ottawa plants are equipped with only a single bin for batching fine aggregate, these two sands are pre-blended prior to depositing the mixture in the plant bin.

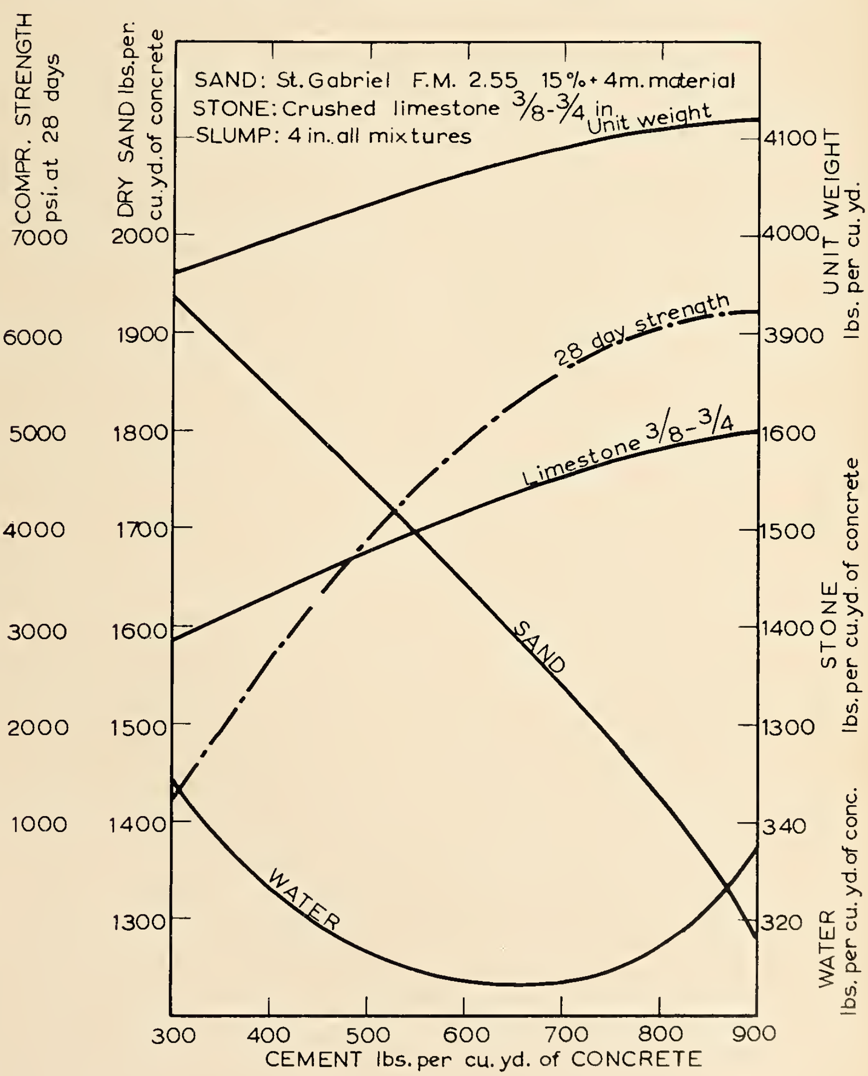
Fig. 1 shows the results of compressive strength tests obtained from 2 in. cubes at 28 days, on mortar mixtures of normal consistency, made in accordance with the method of A.S.T.M. Specification C87-58T, with a cement which is widely used in Ottawa. The specification calls for preparation and compressive strength tests of 2 in. cubes made from mixtures with a flow of 100±5 and a w/c ratio of 0.60. A comparison such as this leaves much to be desired, from the point of view of the concrete producer. The water requirements of different sands to produce a flow of 100±5 may be quite different, and the results obtained are not directly comparable, since the cement requirement, in pounds per cubic yard, is not taken into consideration. Cement is the most expensive ingredient in mortar or concrete, and the matter of cement cost per cubic yard is of vital importance to any concrete producer.

To obtain a broader view of the behaviour of different sands we make up four series of mortar mixes in the proportions 1:5, 1:3, 1:2 and 1:1.25 by weight, all with a flow of 100±5. The cement contents vary from about 480 to about 1450 lb. per cu. yd. The w/c ratios range from approximately 0.90 to approximately 0.30.

The information shown in Fig. 1 was derived from tests on such mixtures. The individual points designated on the curves indicate the results which would be obtained from mixtures with w/c ratios of 0.60.

The test results show quite clearly

Fig. 2—Typical graph covering proportions obtained from trial mixtures.



that the optimum percentage of the fine sand, over the greater range of normal mixtures, is about 20% to 30%. Accordingly, in our Ottawa plants, we are presently blending these sands in the proportion of 75% coarse and 25% fine.

Laboratory Trial Mixes

Once the problems relating to aggregate grading have been settled, the procedure then is to make up a series of trial mixes with the aggregates selected, and with cement factors of 300 to 900 lbs. per cu. yd. The exact proportions of fine and coarse aggregate are determined, on an empirical basis, by visual examination of the mixture.

A recommended method is to hold out, in the initial weighing, for the first mix, about 10% of each aggregate size, and make the final adjustment of aggregate quantities after visual inspection of the initial result. With an inexperienced operator this may mean undue delay and, perhaps, overmixing. The remedy, of course, is to discard this batch and make another under more uniform procedure.

The unit weight of the fresh concrete for each batch is determined, the slump and air content measured, and test cylinders cast from the batch. It is desirable to have at least six cylinders cast from each batch, three to be tested at 1, 3 and 7 days, two at 28 days, and one at 90 days.

The actual mix proportions, in pounds per cubic yard, are determined from the sum of the weights of the batch constituents, using the unit weight of the fresh concrete to determine yield.

Application of Basic Trial Mix Results

All of the information obtained from the trial mixes can be shown graphically, and Fig. 2 covers results of a series of trial mixes using a specific cement, coarse aggregate consisting of ¾-⅜ in. crushed limestone, and natural sand graded from ⅜ in. to -100 msh. All mixtures are made up with a slump of 4 in. It should be remembered that these are the quantities developed for the trial mixes. These should be increased by 1% because of some extra consolidation effect in truck mixer operation, as compared to laboratory trial mix tests, and by an additional 1% to compensate for shrinkage effects. For both weight adjustments, the required additional weight should be added to the aggregate weight only, without change in the cement or water proportion of the trial mixes.

The 28-day strength test results are plotted on the graph together with all of the rest of the information. With this it is a simple matter to develop mix proportions for concrete mixtures in this class for any specified strength.

Similar trial mix series can be made up for maximum aggregate sizes other than ¾ in. Our own schedule of standard mixes covers maximum nominal coarse aggregate sizes of ¼, ½, ¾, 1, and 1½ inches, as well as grouts, with no coarse aggregate at all.

We do not deliver concrete with aggregate coarser than 1½ in. nominal size, since handling aggregate larger than this presents some problems in operation, particularly in unloading the concrete from the trucks, and since, in normal ready mix operations, there is seldom any call for concrete with aggregate size larger than 1½ in.

Each test series represents a minimum of five samples of 6 cylinders each, or 30 test cylinders per series. With six aggregate sizes this represents 180 test cylinders. Extend this to several types of concrete, including plain, air-entrained, concrete with one or more types of dispersant material, concrete with retarders or accelerators, and the number of test cylinders required for even a preliminary look at the mix proportions will be between 1000 and 2000, for a single cement.

A.S.T.M. and A.C.I. both recommend proportioning for 15% above specified strength. We have decided, from our experience with variation in cement strength in the Montreal area, that this is not an adequate factor of safety, and we proportion for 20% above specified strength.

Since the strength-making property of the cement is probably the major source of variation in any well controlled ready mix operation, it is desirable to have fairly complete information about the properties of the cement used in making up the trial mixes.

For proper evaluation of the quality of the cement used in the trial mixes tests for mortar-making properties of the cement used should be carried out at the same time as the trial mixes are made. Then when the 28-day test results of the trial mixes become available the 28-day test results of the standard mortar mixes are also available for evaluation of the cement quality.

This, of course, does not help very much for the first series since there is no background of information about cement quality. However, after three or four sets of trial mixes the background will be available, and the operator will then know what factor of safety should be applied to this particular series of trial mixes in order to ensure that the required average safety factor will prevail.

Even from the same mill there will be fairly wide variations in the strength characteristics of the cement, and differences in the behaviour of cement from different sources may be even greater.

Fig. 3 gives an illustration of the variation of strength making properties of Type I Portland cement from the same mill, as well as results obtained from a different source. Here again, as in Fig. 1, test results obtained from a single mix of 1 part cement to 2.75 parts by weight of standard Ottawa sand, do not adequately disclose the behaviour of the cement over a wide range of mixtures. One might conclude, from the results of tests carried out on mixtures of 1 part cement to 2.75 parts of standard sand, that both cements from mill B were substantially the same. However, the results obtained from the two cements in rich, high strength mixtures are quite different.

Fig. 4 illustrates the variation in strength obtained from two series of trial mixtures, using similar aggregates together with cement delivered at different times from the same source. The two curves shown represent the highest and lowest strengths obtained from similar concrete trial mixes, using cement delivered from this source during the past three years. Between these curves could be shown 16 other curves occupying median positions which represent more closely the quality of the average cement delivered from this source.

Control of Concrete at Delivery Point

Having carried out the preliminary investigation it remains to see that the concrete delivered to the work meets the requirements. We check this by two methods:

(a) We have samplers who visit jobs to which we are delivering concrete. These men take periodic samples of concrete delivered to the work. These samples are taken to the nearest plant supplying concrete, where the test cylinders are cast, and later the cylinders are taken to the central control laboratory for storage and test.

(b) On work carried out by our own companies as prime contractors, and on some major projects carried out by other clients to whom we are delivering concrete, we have our own field inspectors on the job. These men run constant slump, weight and air content determinations on concrete supplied to the work, keep dispatch office and the central control laboratory advised of their findings, and also make adjustments to the concrete as required.

Limitation of Mixing Time

One of the greatest problems in the supply of ready mixed concrete, and particularly in the supply of pre-mixed concrete, is the matter of mixing time. All our Montreal plants are pre-mix plants, and we are more interested in the performance of this type of ready mixed concrete than in the so-called dry batch type, where the dry, or semi-dry, aggregate is loaded into the truck with the dry cement, and the truck is dispatched to the job, the driver adding water to the load either in transit or on arrival at the job site.

With a pre-mix plant more accurate control over slump is possible. The batcher can see the quality of the concrete that he produces; if it is slightly too wet or too dry he can adjust the next batch to correct the error and can orient himself for future batches. In a dry batch plant the operator does not have this advantage. He never sees the concrete that he is batching, and he might ship 10 loads to a job, either too wet or too dry, before any word got back from the job as to what the consistency was on arrival.

With all of our plants in Montreal pre-mix plants, we are interested only in pre-mixed concrete. Here the component parts of the mixture are weighed out, delivered to the pre-mixer, and finally, the mixed concrete is delivered to the truck. This concrete is completely mixed, except that it may have only about 90% of its potential air entrainment, if it is an air entrained concrete.

This concrete goes into the truck, and the truck proceeds to the job with the mixer revolving at agitation speed, or about 4 r.p.m. If the delivery interval between the plant and the job is 15-25 minutes the air content, on arrival, will be about the maximum.

On arrival at the site, if the job is not ready to take delivery of the concrete, the truck mixer is stopped, and the concrete in the truck allowed to remain quiescent. Every 30 minutes the truck mixer is turned over for 10-12 revolutions at full speed to overcome any mechanical segregation which may have occurred. No more mixing than this is required, or desirable.

It is obvious that, if mixing is 90% complete on discharge from the pre-mixer, any extended further mixing, even at agitation speed, might prove to be detrimental. In effect, with extended mixing time, the mixer operates as a grinding mill, degrading the aggregate particles, and producing more fines. Part of the energy input required to do this is translated into heat. This speeds up the chemical reaction and results in more rapid setting of the concrete. If air entrainment is specified, the increased production of fines, particularly if the aggregate materials are calcareous, results in a very rapid decrease in the air retention capacity of the mixture. Three effects are:

(1) Production of additional fine material;

(2) Development of additional heat;

(3) Elimination of air content.

These operate to make the mix drier and reduce the workability. It is obviously desirable to limit mixing time in the truck.

Even when delay in unloading has resulted in excessive loss of air means can be taken to correct this. All our trucks carry additional double strength A.E.A. in 5 oz. baby food cans. If part of the air content of the load has been lost the situation can be remedied by adding one or more cans of the A.E.A. and remixing the load. The drivers may not do this on their own initiative, but only on instructions from:

(a) One of our service inspectors;

(b) A representative of technical control;

(c) Central dispatch office, by radio.

Similarly, our drivers may add water only on direct instructions from some responsible person, either on our own staff, or on the staff of the customer. In all cases the person authorizing the addition of water has to sign the load ticket for the added water. In cases where the addition of water is requested verbally, and signature on the ticket is later refused, the driver has to state on the back of the ticket the circumstances relating to the case.

Temperature Rise

From past experience, winter or summer, we surmise that when concrete begins to set a significant increase in temperature is recorded. What this significant increase in temperature is we are not prepared to state, unequivocally, but, from some observations made it would seem that when a temperature increase of 6° to 8° F. is recorded in the concrete setting action is well in progress.

Consequently, when the temperature of the concrete in the truck has risen by this amount, the ultimate quality of that concrete is suspect unless it can be placed in position in the form within a few minutes. Depending upon individual conditions, a wide variation in behaviour of the concrete might result.

We periodically take samples of returned concrete which is to be dumped in order to have an adequate background of information about the behaviour of such concrete.

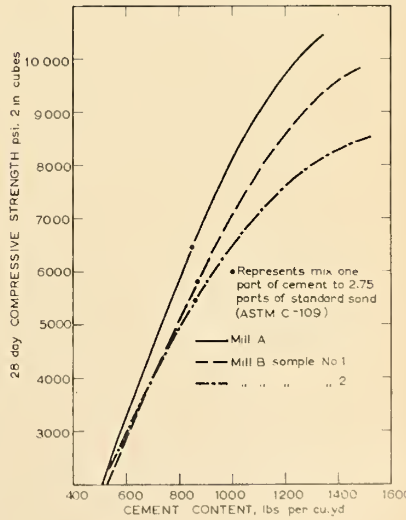
A very significant difference is noted between the behaviour of concrete in winter and in summer, as a result of basic differences in temperature conditions. In cold winter weather, with concrete leaving the plant at 60° to 70° F. we have had cases where the concrete was in the truck for up to five hours, with no significant temperature rise, only a slight decrease in slump, and no measurable loss in strength.

Use of Retarders

In winter in Montreal no problems are afforded by premature setting of our concrete. It is possible, by judicious control of aggregate temperature, to keep the temperature of the concrete loaded into the trucks between 60° and 70° F. No serious problems arise in connection with supply of concrete in winter except in relation to the customer who thinks that, because he specifies 2% calcium chloride in his concrete he can conveniently forget about heating and protecting his concrete in place in the form. This type of customer is becoming less numerous.

The situation is quite different in

Fig. 3—Compressive strength test results obtained from mortar mixtures (Flow 100±5) with different cements.



summer. Summer temperatures in Montreal reach a 90° to 100° F. maximum. With aggregates having an average temperature of 70° F., water at 65° F., and cement at 170° F., the temperature of a mix with a cement content of six Canadian bags per cu. yd., on discharge from the pre-mixer, will be 78.5° F. With eight bags per cu. yd. the temperature will be 81.5° F.

If the cement temperature is in the neighbourhood of 250° F., as was once the case, the temperature of the 6-bag mix, on delivery from the pre-mixer, will be 86° F., and the temperature of the 8-bag mix 92° F. With temperature conditions such as these the concrete sets while you look at it.

During the period of the "hot cement" frequent protests were made to the cement supplier, but to no avail. Precooling of aggregate materials and/or the use of ice in place of water was impractical, from both the mechanical and economic aspects. The only solution seemed to be in the use of a chemical retarder which would delay the setting action long enough to get the concrete to the job, unloaded, and placed in the forms.

During the winter of 1956-57 materials of this type, from a number of sources, were investigated. The majority of these were calcium lignosulphonates; by-products obtained in the manufacture of newspulp by the sulphite process. These materials varied very widely in their effect on concrete mixtures, but we were fortunate in finding several that reacted favourably with the cement and aggregates which we were using, and which we could use to control the rate of setting of our concrete. We have been using one of these for the past three years with very satisfactory results.

In addition to the tests with the lignosulphonates some tests were carried out with retarding agents of the hydroxylated carboxylic acid type. These also were satisfactory in their action, and, for some purposes, are probably better than lignosulphonates.

Overall Effect of Retarders

Before the trial tests had proceeded very far it became apparent that materials of both types produced results in concrete far beyond the immediate retardation effects which we were seeking. In addition to being retarders these materials were dispersants, reducing materially the amount of water required to induce plasticity. The lignosulphonates, in addition, possessed some air-entraining properties, in varying degree. The materials of the hydroxylated carboxylic acid type possessed no air entraining characteristics at all. In fact, they tended to act as densifiers. Whether the air-entraining retarders or the non air-entraining retarders are preferable depends, to a considerable degree, on the strength required for the concrete, as will be shown later.

The net result of all this was that in both cases, for equal cement content, the strengths of the mixtures in which the retarders were used were materially increased. Part of this increase in strength is derived, undoubtedly, from the decrease in water requirements; part of it is related, probably, in the leaner mixes at least, to the air-entraining properties of the admixtures; and part stems from the retardation effect itself.

It has long been known that the setting temperature of concrete greatly affects the ultimate strength. Prior tests have indicated that if the setting temperature is the normal 70° F., and the 28-day strength under these conditions is taken at 100%, concrete which is maintained at 40° F. for the first 24 hours after mixing may reach a strength of 120%, while concrete kept at 100° F. for the first 24 hours after mixing may reach only 80% of the normal strength. Chemical retarders apparently behave in similar manner, so that some part of the strength gain which is derived from the use of such additives is related directly to the retardation effect.

It is obvious that maximum benefit is derived from such admixtures in hot weather: in cold weather additional retardation, other than that afforded by the prevailing low temperatures, is likely to be undesirable. Even in warm weather, for special projects such as sliding form work, retardation may be undesirable.

Many commercial dispersants now on the market have integrated with them an accelerator to offset part, if not all, of the retardation effect. Where the accelerator is present in sufficient amount to completely offset the retardation effect, the benefits of retardation are lost, though the strength gain resulting from the dispersion and air-entraining effects may be retained.

Fig. 5 shows strength relationships for a number of series of trial mixes covering plain concrete, concrete with a retarder, concrete with a widely used air-entraining agent, and concrete in which both the retarder and the air-entraining agent were used. The wide differences exhibited by these mixtures, in relation to compressive strengths attained, will be referred to later.

Effect of Retarder on Retention Time

A comparison of the behaviour of similar mixtures, with and without a retarder, carried out in truck mixtures under normal summer conditions in Montreal, is shown in Fig. 6. Both mixtures contained, at the start of the tests, six Canadian bags (525 lb.) of Type I Portland cement per cu. yd., both were discharged from the pre-mixer to the truck with a slump of 4 in., both were subjected to similar temperature conditions and equal degree of additional mixing subsequent to their deposition in the trucks. The procedure, broadly, was as follows:

(1) After loading, the hatch was closed, and the mixer rotated at agitation speed for 25 minutes, to simulate the mixing operation in transit. Thirty minutes after the original mixing in the premixer a sample was drawn off, the slump, unit weight and air content of the concrete determined, and four cylinders were cast for determination of compressive strength.

(2) After the first sample was obtained the hatch was closed, and the mixer allowed to stand. After 40 minutes the load was remixed at agitation speed for one minute; the hatch was opened, and an estimate made of the slump of the concrete and the amount of water required to restore the concrete to the original slump. The estimated amount of water was then added, the load remixed, at full mixing speed for 12 revolutions in each direction, and another sample taken, 75 minutes after the original mixing.

(3) This procedure was repeated at two hours, and repeated at intervals of one hour thereafter until the completion of the test run seven hours after the original batching.

Fig. 6 shows the alteration in some of the characteristics of the concrete as a result of this treatment. The compressive strength is reduced with increase of retention time, and with the addition of water to maintain the original slump. The unit weight is decreased with increase of water. The temperature of the concrete rises with time, and, towards the end of the test, quite rapidly, indicating that setting action is well in progress.

Some of the results obtained appear to be inconsistent with the normal expected behaviour of concrete. This applies particularly to the results derived from the strengths obtained as compared to the original w/c ratios. After examining these

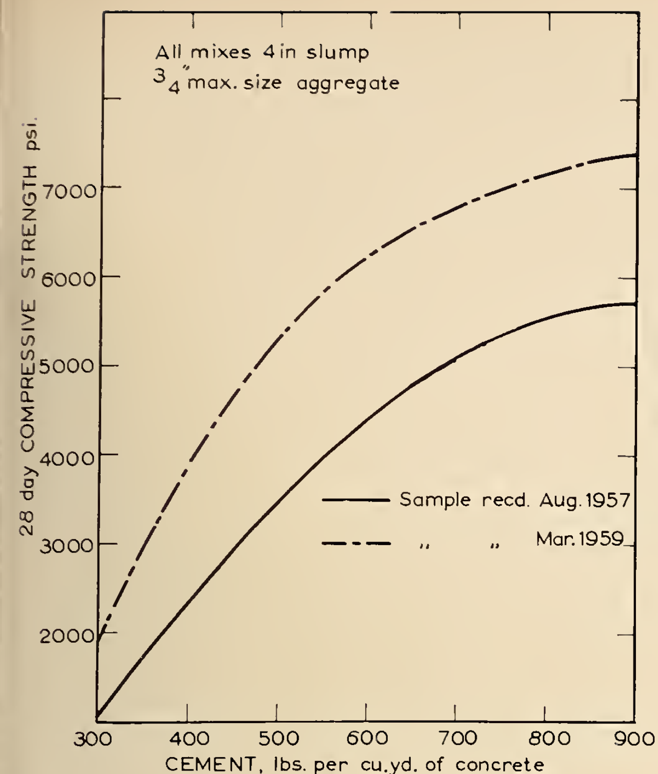


Fig. 4—Results from two typical series of trial mixes made with different samples of cement from the same mill.

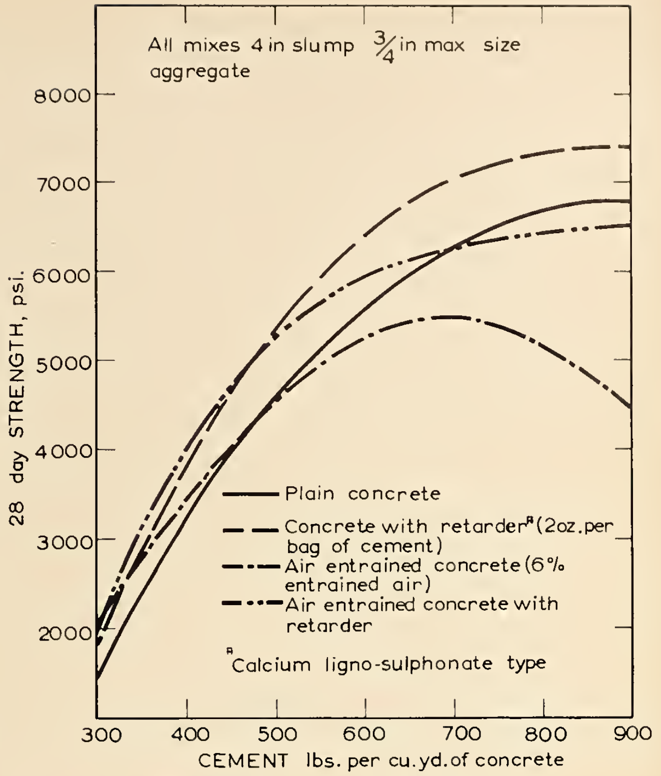


Fig. 5—Compressive strengths at 28 days obtained from trial mixes containing various admixtures.

closely it appeared that the true w/c ratio might be that existing in the concrete at the time it changed from a plastic mass to a solid.

Prior experience with the vacuum method of processing concrete,[9] where a large proportion of the original mixing water is removed by suction before the concrete sets, indicated that the true w/c ratio, affecting the compressive strength, was probably that represented by the relationship of water to cement in the mix after the excess water was removed.

Accordingly, density tests were carried out on samples of the concrete which had been moist cured in the damp room for seven days. In all cases the 7-day unit weights were appreciably higher than the wet weights for the corresponding mixtures. This would occur as a result of loss of water by bleeding, and subsequent shrinkage. From the unit weight determinations it was possible to calculate the apparent w/c ratio at the time of setting. Results of these calculations are shown in Fig. 7.

The surprising feature of this is the large difference between the w/c ratio of the wet concrete compared with the apparent w/c ratio of the same concrete at the time of setting. No explanation is readily apparent for the fact that, in both cases, the two pairs of curves cross. Some further exploration along these lines would seem to be desirable.

Revibration of Concrete

An interesting feature in the handling of concrete, which has recently returned to prominence, is the matter of revibration of the concrete some time after placing. In its present application it is closely associated with retardation.

A good illustration of this relationship is afforded by the practice followed in concreting some of the spandrel beams and deck spans of the Tappan-Zee Bridge on the New York Throughway, where a retarder of the hydroxylated carboxylic acid type was used to delay the set of the concrete in place until all of the concrete in the section in question had been placed, and settlement of the form, as a result of compression in the shoring, was complete. Then, while the concrete was still plastic it was revibrated to eliminate incipient internal strains and to minimize possibility of tension cracks. The method is described in an article,[10] "Setting Time of Concrete Controlled by the Use of Admixtures", by Raymond J. Schutz, in the Journal of the A.C.I., Vol. 55, January, 1959.

Nearer to home was the use of a lignosulphonate retarder for the concrete in the beams and slab of the reinforced concrete bridge supporting the steel cantilevers for the roof of the new T.C.A. hangar at Dorval Airport. Even though the work was done in winter time a retarder was used to delay the set for from six to seven hours until the first lift of concrete to the neutral axis of the beams was completed: a matter of about 350 cu. yd. This was revibrated with the concrete of the second lift, to the tops of the webs of the beams. At this stage there was a delay to permit as much settlement as possible to occur, and the concrete in the upper part of the webs was revibrated prior to placing the concrete for the roof slab. The work was successfully completed without development of shrinkage cracks.

Perhaps even more interesting was the information obtained from tests on samples of concrete representing the mix delivered for the construction of the base slab for a new test machine for Ecole Polytechnique in Montreal in September, 1958.

Here a high strength concrete was required. The slab was 59 x 20 x 4.5 ft. in dimension and required about 190 cu. yd. of concrete. Embedded in the concrete was a miscellany of steel anchorages for the holding down bolts. In addition, high tensile strength wire strands were carried in ducts for post compression of the slab in both horizontal directions, so as to develop maximum rigidity. Clearance between the various members embedded in the concrete was minimal, and it was decided to use a mix with a maximum aggregate size of ½ in., and a slump of 5 in., to facilitate placing of the concrete. A retarder of the hydroxylated carboxylic acid type was used to delay the set of the concrete in place for 10 to 12 hours, and the concrete in place was revibrated prior to setting. For very high strength concrete this type of retarder is preferable to the lignosulphonate type, since it entrains no air, and facilitates extrusion of surplus water while the concrete remains plastic.

The results were quite satisfactory. Compression tests on standard 6 x 12 in. cylinders, which were not vibrated, indicated an average strength at 28 days of 8300 p.s.i., and a strength at 18 months of 11,200 p.s.i.

Mr. B. A. Hesketh, in charge of the physical test laboratory at Ecole Polytechnique, carried out a fatigue test on a cylinder of this concrete at an age of 20 months. Details of the test were as follows:

Loading Range	*No. of Cycles*
1200-4500 psi	10,000,000
2200-5500 psi	10,000,000
3200-6500 psi	1,000,000
4200-7500 psi	40,000

After 40,000 cycles of test at 4200-7500 p.s.i. the test cylinder failed, exhibiting a normal double cone fracture.

The procedure followed in the three instances recorded will probably be used much more generally in the future.

Effect of Aggregate Size

Some of the questions that have developed as a result of observations of the behaviour of mixtures in which retarders have been used are rather puzzling. Some of the strength increases developed from the use of retarders are quite surprising. Some observers feel that these strength increases are brought about by the formation of a stronger gel as a result of the slowing down of the chemical reaction. Such a situation does develop in the case of the setting of some of the thermo-plastic resins, but the extension of this to the field of Portland cement chemistry is, possibly, a bit of wishful thinking.

Fortunately, some information developed from an investigation of an entirely different phase of concrete behaviour suggests a logical answer to this problem.

The classic water-cement ratio theory offered the premise that the strength of concrete is governed by the volume relationship of water and cement in the mix. Subsequent investigations have narrowed the application of this theory very materially, and it would seem that other investigations now in progress will narrow it still more.

For example, it has generally been accepted, as a corollary to the w/c ratio theory, that with increasing maximum aggregate size, for equal cement content and equal plasticity, the water requirement would be lower, and the compressive strength correspondingly higher.

Investigations carried out by Stanton Walker, Delmar Bloem and their associates in the National Ready Mixed Concrete Association,[11,12,13] and by our own Technical Control Laboratory in Montreal,[14] indicate that this is not the case, particularly in connection with high strength mixtures.

Fig. 8 shows compressive strength test results on three series of trial mixes using cement and aggregates from the same sources, but with varying maximum size of aggregate particles. The curves indicate that the theory of increasing strength with decreasing w/c ratio does not always hold good when aggregates of different maximum size are under consideration.

For a more direct comparison the data from which Fig. 8 was derived has been plotted in Fig. 9 to show the w/c ratio-strength curves for the three series of trial mixes in question. These show quite clearly that, for equal w/c ratio, the mixes with the smallest size aggregate, at least in the high strength range, are the strongest.

This was very puzzling, but a possible explanation was that the deleterious effects of water gain might be more pronounced with increasing

Fig. 6—Changes in properties of concrete resulting from long time retention in truck mixers

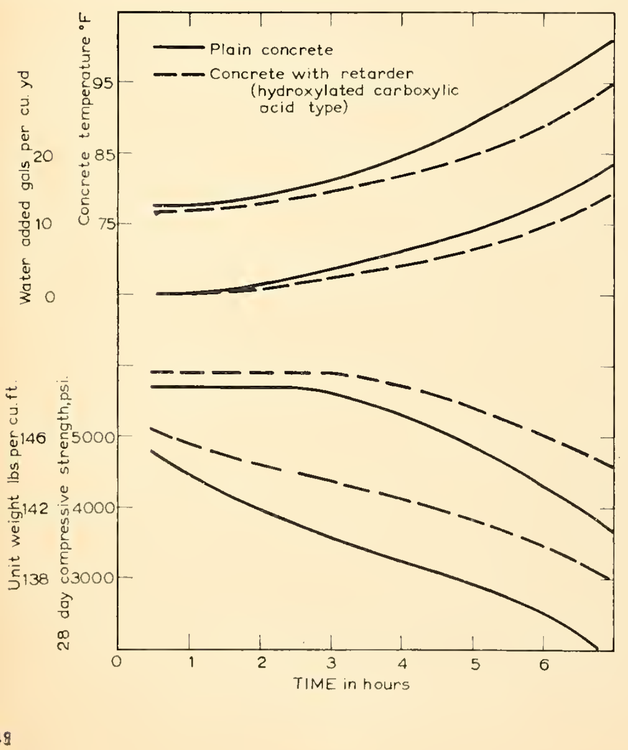
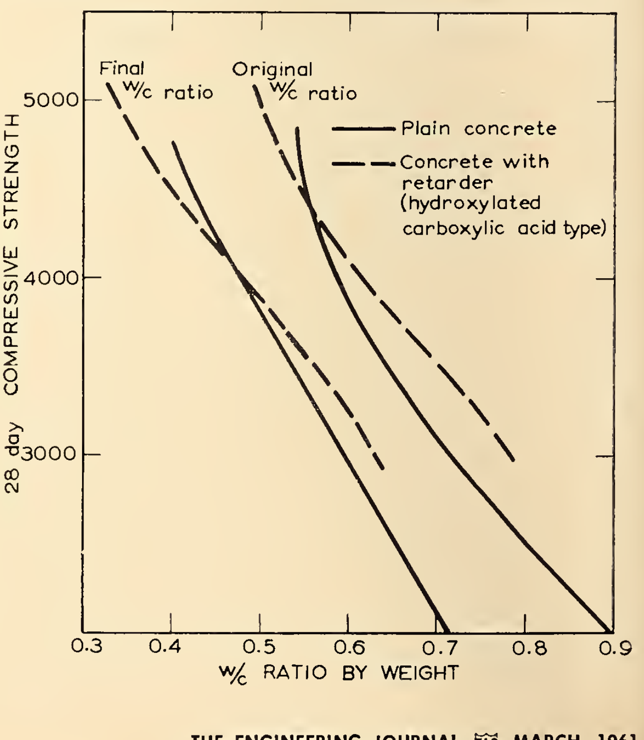


Fig. 7—W/C—Compressive strength relationship for mixtures shown in Fig. 6.



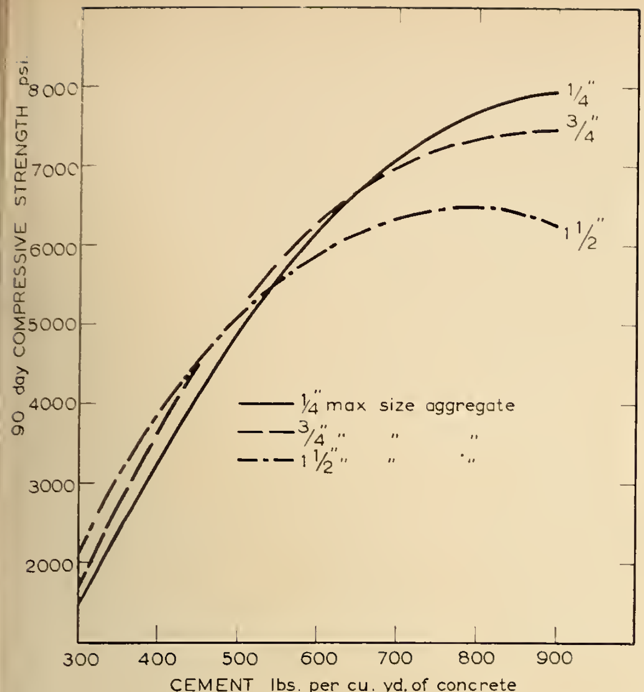


Fig. 8—Compressive strengths at 90 days from three series of trial mixtures with varying maximum size of aggregate.

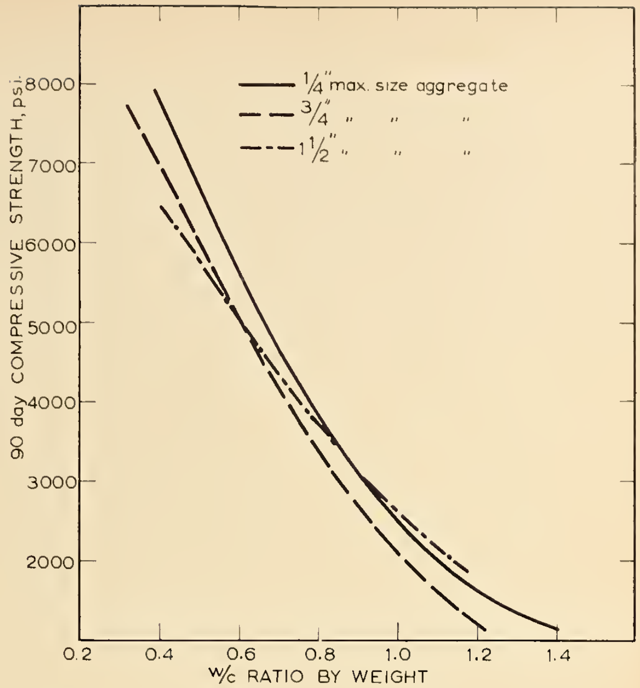


Fig. 9—W/C—90 day strength relationships for mixtures in Fig. 8.

size of aggregate, and the problem was dismissed without too much consideration.

Three years ago, when we began to carry out strength tests at very early ages—8 to 12 hours—to determine the effects of retardation, we found that this theory of water-gain being responsible for the lower strength of the concrete with the coarse aggregate was quite untenable. Water gain is, of course, complete as soon as the concrete begins to stiffen, and long before any measurable strength is developed. Yet the strengths at early ages, 24 hours or less, were quite normal, and did not exhibit any of the aberrations which develop at later ages, and which become more and more pronounced as the concrete ages and increases in strength.

Obviously, the cause of these effects is something which develops in the concrete after it passes from the plastic to the solid state, and it is equally obvious that the most logical explanation is internal shrinkage. Nearly all of the shrinkage which occurs in concrete develops in the cement-water phase, and the aggregate is comparatively unaffected. This applies, of course, to the samples under discussion here, which were kept in a saturated condition until tested. Where drying shrinkage also occurs a porous aggregate may contribute appreciably to the overall shrinkage of the concrete.[15]

While the concrete is still plastic, shrinkage of the cement-water phase will result in some movement of the aggregate particles, with subsequent shrinkage of the concrete as a whole. If we visualize a concrete consisting of only one size of coarse aggregate embedded in a matrix of cement-water paste, plastic shrinkage of the mixture as a whole may take place while the concrete is still plastic, as a result of extrusion of some of the water by gravity and evaporation effects. Once the matrix has set overall shrinkage of the concrete as a whole is no longer generally possible, but shrinkage of the cement water sandwiches between the aggregate particles still continues, and induces internal stresses which, in magnitude, are a function of the dimension of the aggregate particles.

The greater the proportion of cement and the greater the amount of water in the mix, the greater will be the ultimate shrinkage, and the greater will be the magnitude of the locked up stresses developed in the cement-paste sandwiches between the aggregate particles. Eventually, with very high cement content, and very large aggregate, these locked up stresses may become so great that the concrete may fail under the application of an external force which is actually less than that required to produce failure of a similar concrete made with

(a) Less cement per unit of volume, or,

(b) Smaller sized aggregate.

There is a very considerable volume of evidence being gathered to indicate that the above is probably the true explanation for some of the abnormalities observed in the behaviour of high strength concrete with varying sizes of aggregate.

Modulus of Rupture vs Compressive Strength

If there is any reason at all in the above argument we should expect that since shrinkage of the concrete after setting results in contraction of the cement-water phase, with development, generally, of internal tensile stresses, this tendency might be more apparent in modulus of rupture tests of the concrete, compared with compressive strength tests.

The modulus of rupture test, for concrete, determines the strength of the concrete in flexure, and to some degree is a measure of the tensile strength, since failure is induced by tension in the outermost fibres of the matrix at the lower face of the specimen.

In the compressive strength test, with shrinkage effects and stress development in all directions, some of the internal stresses, when the sample is loaded in compression, may cancel out. With the modulus of rupture test there is no possibility of relief of any of the internal stresses in that part of the beam which is being subjected to additional tensile stress, since all of the internal stresses, according to this theory, are originally in tension.

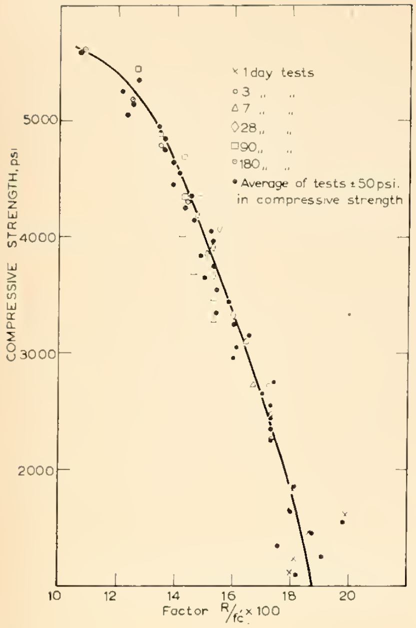


Fig. 10—Modulus of rupture—Compressive strength relationship derived from samples of concrete from Dorval Airport.

This is confirmed by a rather extensive investigation which was carried out in 1959 on samples from 135,000 cu. yd. of concrete which was used for the construction of a jet runway and accompanying taxi strips, for D.O.T. at Dorval Airport.

In this investigation samples were tested for compressive strengths and comparable modulus strengths, the two sets of samples being taken from the same batch, with test results determined at 1, 3, 7, 28, 90 and 180 days.

Mix proportions for this concrete were as follows:

		lb. per cu. yd.
Cement		475
Sand		1285
Crushed Limestone,	½ in.	600
	¾ in.	605
	1 in.	800
Water, (total)		250
Weight per cubic yard		4015
Slump		2½ in.
Air Content		4.0-6.0%

The sand contained 10% pea gravel between 4 mesh and ⅜ in size, which would be classed as coar. aggregate. The F.M. of the fraction passing the 4 mesh sieve was 2.60.

It was expected that as the concrete aged, the relationship between the strength of the concrete in compression, and the modulus of rupture test results, would change materially, depending on the age of the concrete.

A summary of the test results, covering 99 samples, of three cylinders and three beams each, is shown in Fig. 10. This shows quite clearly that age in time has nothing to do with the relationship $R/_{fc}{}^1$. The controlling factor in this relationship is the actual compressive strength of the concrete at the time of test, and, more probably, the extent of the internal shrinkage stresses which govern the strength of the concrete when tested, whether in compression or in tension. This, alone, determines what the flexural strength of the concrete shall be, for the specific aggregate and specific cement used, without regard to age of the concrete in terms of time.

As can be seen, test results at 1, 3, 7, 28, 90 and 180 days fall into a general pattern in which the value of $R/_{fc}{}^1$ decreases progressively as the compressive strength increases, regardless of the age of the sample. This would seem to support the premise that, as a result of internal shrinkage effects developed in the cement-water paste after the concrete hardens, internal tensile stresses are developed, and that these are reflected more vividly in modulus of rupture tests than in standard compression tests.

In Fig. 10 the results of all tests are plotted, firstly, as an average of results obtained from groups of three or more samples within a limited strength range for each age. These average results are identified by the legend. Secondly, all results, regardless of age of specimen, are segregated into groups with compressive strength falling within a range of ± 50 p.s.i. These are also plotted as single points on the graph. It is illuminating to note that the divergence from the mean, for the average result, regardless of age, is perhaps less than the divergence of the individual groups of test results at stated ages.

Special mention should be made of the results of the tests at 24 hours. These are all below 2000 p.s.i., and because of the difficulty of maintaining these samples under standard curing conditions in the field, little attention should be given to the comparatively wide scatter of results, compared with the results at later ages.

The graph shows quite clearly that the modulus of rupture strength of the concrete tested, and probably any other concrete, is a function of the compressive strength of the concrete, and varies with the compressive strength at any age.

Returning to the original premise, if increase in maximum size of aggregate is going to result in reduction of strength in flexure, which may occur before any indication of reduction in the compressive strength, it behooves the designers of pavements and airport runways, who are interested in the flexural strength rather than in the compressive strength of concrete, to consider the behaviour effects of aggregates of different maximum size in the concrete mixture. The Department of Transport, two years ago, reduced the maximum aggregate size in concrete, for paving on airfields, from 1½ in. to 1 in. Whether they did this as a result of prescience of these modern developments in the technology of concrete, or whether they adopted it as a result of the fact that, in many areas of Canada, aggregates coarser than 1" in size are difficult to obtain, will probably never be known. However, in adopting this attitude, they are anticipating current progress in concrete technology.

If we examine Fig. 10 closely it is apparent that, in the range of the lower compressive strengths, below 1000 p.s.i., which are of slight importance in any event, the factor $R/_{fc}{}^1$ x 100 may reach a value of 19.0 to 20.0. In the higher strength range the curve seems to be tending towards progressively lower values of the above relationship, and probably, with increase of cement content and compressive strength, will show even sharper reduction of values than indicated in this series of tests, which reached a maximum compressive strength of only about 5600 p.s.i. with a comparatively low cement factor of 475 lb. per. cu. yd.

At the maximum strength of 5600 p.s.i. obtained from this series of tests at 180 days the curve representing the relationship between the compressive strength and the modulus of rupture strength is veering sharply towards increasingly lower values of this relationship with increased compressive strength of the concrete. From an analysis of the results obtained it would seem that the modulus strength, even for this mix with comparatively low cement factor, and a maximum nominal aggregate size of only 1 in., reached a ceiling at a compressive strength of about 5000 p.s.i. Attainment of compressive strength greater than this, whether from the use of more cement in the mix, or increased aging of the concrete, probably will result in an actual decrease in the modulus strength.

It would be desirable to carry out further tests on high strength mixtures, with compressive strengths ranging up to 8,000 to 9,000 p.s.i. Perhaps, from the results of tests on such mixtures, with varying maximum size of aggregates, some interesting information might be developed.

Conclusions

If we now return to a consideration of the behaviour of retarders, applying the criteria outlined above, a reasonable explanation of the strength gains obtained as a result of their use is suggested. The retardation effect results in maintenance of the concrete for a longer period in a plastic or semi-plastic state. Extrusion of water, by evaporation or gravity effects, can be carried to a much greater extent. Post-vibration during this period may assist greatly in eliminating incipient strains in the semi-plastic mass by re-orienting the aggregate particles so as to fit more closely together. Consequently, if a greater part of the overall shrinkage in the concrete is effected while the concrete is still plastic and capable of adjusting itself, or being adjusted, to these shrinkage effects as they develop, the residual shrinkage which will take place in the cement-water paste after the concrete has changed to the solid state will be materially reduced. Internal stresses will also be reduced, and the strength ceiling of the concrete will be materially increased.

If we return to Fig. 5, and analyse the results shown in light of these later revelations, we can surmise, in relation to the A.E.A. mixtures, that they may exhibit, in high strength mixes, lower strengths because of greater internal shrinkage effects after setting. Such a condition is not only possible, but also highly probable.

One of the immediate effects of air entrainment, in fresh or old concrete, is to make the concrete less permeable. It is this characteristic, in fact, which affords A.E.A. concrete increased resistance against freezing effects. Obviously, if concrete resists entrance of water, because of the presence of multitudinous discrete air cells, it will also equally resist the loss of water, by gravity effects, evaporation or for any other reason.

Fig. 11—T.C.A. Maintenance Hangar, Dorval Airport, Montreal, where lignosulphonate retarder was used. *(photo Scherbi)*

For low strength concrete, air entrainment may be advantageous. For high strength concrete, where it is desirable to eliminate as much of the excess water as rapidly as possible before the concrete actually sets, it may prove to be an actual detriment towards the development of maximum strength in the concrete.

There is a very wide school of thought which feels that "bleeding" in concrete is undesirable, and that any appreciable degree of bleeding in a mix is conducive to segregation and possible loss in strength. For high strength mixes our test results indicate the direct opposite. For development of maximum strength in high strength mixes bleeding of concrete, provided it does not result from improperly graded aggregates, should be encouraged and assisted, by the use of suitable cements, suitable retarders and post vibration, if possible; and by the avoidance, as far as possible, of air-entraining agents in the mix.

These are some of the most interesting developments in concrete technology to-day, which offer very great promise in the production of materially better concrete in the near future.

Acknowledgement

The author wishes to record his deep feeling of gratitude to the late Mr. James Franceschini, who, as a result of his interest in modern developments, authorized and provided the facilities for carrying out these investigations.

Thanks are due also to Mr. R. A. Lapinas, Jr.E.I.C., concrete engineer for Mount Royal Paving & Supplies Limited, who organized and supervised the whole of the test programme.

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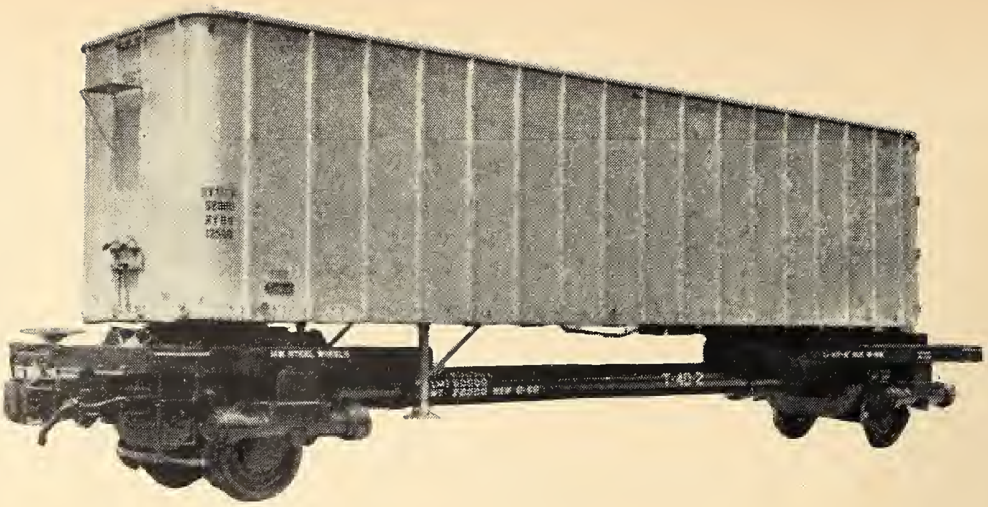


GM Portager Piggyback System

H. E. Martin, M.E.I.C.,
New Product Development Engineer, General Motors Diesel Limited, London, Ont.

RAILROAD interest in *piggyback* stems from transportation competition which diverted premium, heavy-density traffic from the railways to the highways. Under certain conditions, highway transportation possesses flexibility which cannot be matched by conventional railway methods. The cost of conventional freight movement by rail is low between terminals, but relatively high at the terminal.

The costs are opposite on the highway: high between terminals but low at terminals compared with railroad operations. Piggyback, which combines the most efficient features of both highway and rail operations, has a vital role to play in the economy as a more economical method of transporting goods.

With new product development in mind, our company's representatives approached Canada's two major railroads regarding areas where available engineering talent might best be utilized. It was in answer to a transportation concept outlined by the Canadian Pacific Railway Company that a quite different side-loading piggyback rail vehicle was designed and developed.

A concentrated engineering effort was launched immediately to expedite this new product through its several phases. The following is a progress report on the development of the GM Portager which incorporates the advantages of containerization.

Current System

The CPR, one of the largest piggybackers in North America, is always striving to improve its system and equipment. Its current system involves the use of flat cars with special adaptions and railway terminal facilities consisting of ramps and walkways which allow highway trailers to be end-loaded "circus fashion". Trains are broken into modules of 10 to 15 cars for loading and unloading. A conventional highway tractor with elevating fifth wheel is utilized to move the trailers. After the trailer has been positioned, the retracted king pin pedestal on the flat car deck is elevated to secure the trailer king pin during transit.

This system, while it achieves the basic requirements of piggyback and produces satisfactory loading and unloading cycle times, has a number of shortcomings. Consideration of these shortcomings promoted investigation of other systems by the CPR and led to the conclusion that side-loading and its many apparent advantages should be fully explored. Prior to participation by our company, a side-loading rail vehicle was designed and constructed by the CPR from a conventional flat car. This confirmed certain principles and indicated that the design of a new system of side-loading should be pursued.

Side Loading

Side-loading offers advantages to both railroad and trucker.

The rubber-tired highway trailer rear tandems that are currently transported may be left behind at the terminal. This localizes licensing, maintenance and records and can reduce the number of tandems required in a trucking operation as none are "tied up" in transit.

The absence of the trailer tandem contributes to the over-the-railroad economy. A sizeable portion of dead weight is eliminated. The consequent lowering of the load provides a more favourable centre of gravity for stability and better tracking, brings the height within all system clearances and reduces train windage losses. As piggyback trains run at passenger train speeds, windage is a significant component of total train resistance.

The rail vehicle can be simplified. Aprons, guide rails, decking and other special requirements to provide a path on the rail vehicle for the highway trailer are no longer required.

The potential exists for shorter loading and unloading cycles with fewer manual operations to improve terminal economy and provide for faster delivery of goods to the customer.

The rail vehicle can be loaded and unloaded facing either way, from either side and in any order. This will eliminate some directional and sequential restrictions which exist with the current system.

Design Criteria

Other original design objectives of the side-loading rail vehicle were established:

1. The first cost of the vehicle should be significantly less than existing equipment;
2. Maintenance should be minimized;
3. The vehicle must be capable of running satisfactorily at speeds up to 75 m.p.h.;
4. The vertical and lateral accelerations to which the container is subject must be of the same order as those experienced in normal highway service. This defines the ride requirements;
5. Transmittal of railroad handling impacts to the container and lading must be such that no damage to either will occur;
6. Containers must have no attachments or modifications that would increase significantly the trucker's expense;
7. The vehicle must be compatible with existing railway equipment to the extent that it must run in the same train;
8. The vehicle should accommodate containers from 35 to 40 ft. long and should be able to carry a load of 60,000 lbs.

It should be noted that no restrictions or standardization of components with existing conventional car equipment were imposed on the design at this stage. This is contrary to the traditional approach and allows the design to be radical if it is necessary to best achieve the desired results.

Thus, the design of the side-loading system was started with a large degree of freedom but with quite stringent requirements. Early design considerations established a rail vehicle with a single centre sill member, single axle trucks and a container mounting that utilized the trailer king pin and rear guide angles. Trailers with these guide angles, which provide for tandem shifting or removal, are in common use. These sliding tandems are utilized by truckers to meet varied wheel base requirements of certain areas relative to axle loading. A concept of a loader to raise these containers from underneath was also established at this time.

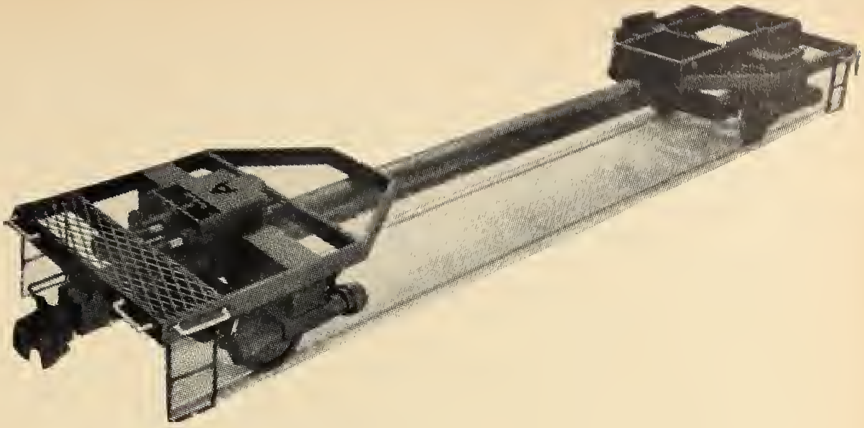


Fig. 1.

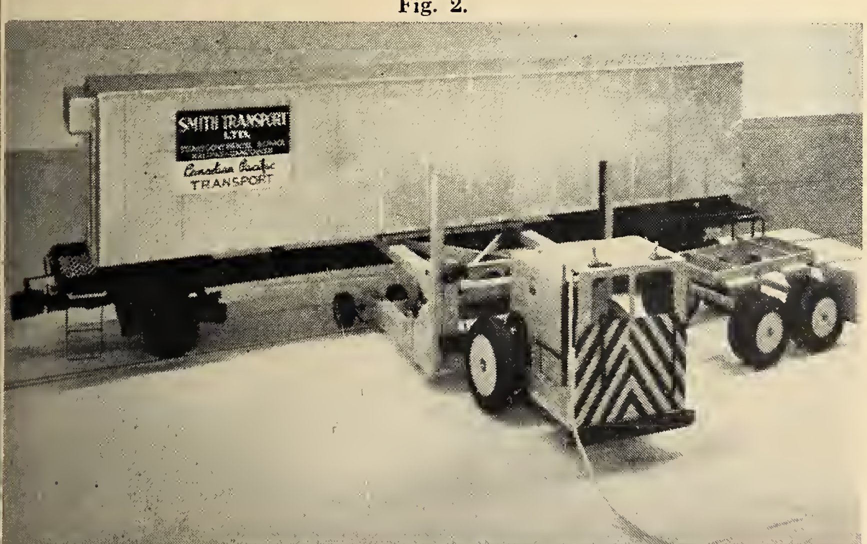
As soon as preliminary layouts were completed, ⅛ scale working models of the highway trailer, the loader and the rail vehicle were built. These models were of significant aid in visualizing improvements, overcoming restrictions and demonstrating the design of the new piggyback system. Fig. 1. shows the rail vehicle model and Fig. 2 shows the three models together.

Figs. 3a, 3b and 3c sketch three sequential positions of the equipment during a loading operation. Fig. 3a shows the highway trailer parked, ready for loading. In Fig. 3b, the loader has manoeuvered into position under the trailer, lifted the container off its rear tandem and is in transit with the load toward the vehicle. In Fig. 3c, the container has been positioned and lowered onto the rail vehicle. The rail vehicle's king pin hitch or fifth wheel has been locked on the king pin and the loader has departed. Unloading is accomplished by a similar procedure in reverse sequence.

The open centre section of the rail vehicle allows the loader table jack to be almost at the load centre to lessen the table structural requirements. The small diameter front wheels of the loader pass under the rail vehicle's centre sill eliminating any requirement for overhung counter balancing weight to provide stability when loaded. Quick and accurate spotting of the load can be achieved through four-wheel steering. Besides providing a short turning radius, four-wheel steering makes two additional loading manoeuvres possible. The loader can approach at an angle and aim the container king pin at the rail vehicle hitch. In other words, the loader can progress sideways while moving forward holding the container parallel to the rail vehicle. Furthermore, with the container king pin held in position over the hitch, four-wheel steering makes it possible for the container to be rotated about the king pin centre until its rear rails are lined up. These two manoeuvres eliminate the need for precise spotting and parallel locating requirements. The rail vehicle design allows a number of alternative loading methods.

Two prototype rail vehicles were built and tested to evaluate the unique features of the design. For identification, a model designation T-40 (Transporter for 40 ft. trailers) was assigned and the name "GM Portager" was added later. Progress on

Fig. 2.



some of the principal design features of the GM Portager components and their testing follows:

Underframe: A 16 in. diam. single tubular centre sill was selected to give high buff and drag strength and relatively low torsional resistance to keep all four wheels on the rails. No significant beam strength to support the vertical load of the container was required since it was supported directly above the trucks at each end. Rubber draft gears were used with standard couplers at each end of this sill member which, based on locomotive experience, had sufficient capacity to protect the GM Portager from road and yard railroad impacts. Air brake piping was routed through the centre sill tube. Other details of the underframe involved bolster structure for truck suspension, container mounting, air brake equipment mounting and the attachment of various other minor but essential equipment such as the uncoupling rods and the handbrake.

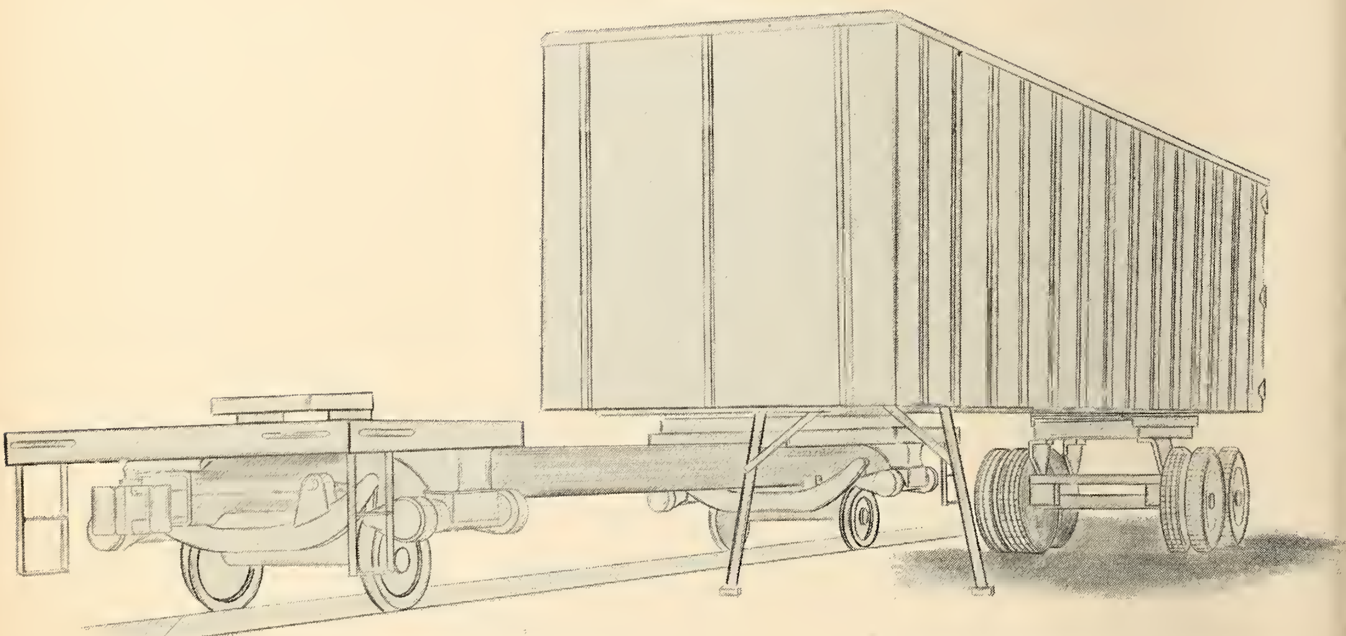
Truck Suspension: The two-wheeled design was selected because the maximum loading was within the capacity of four wheels per vehicle, using standard 33 in. diameter wheels. A swing hanger suspension was chosen to give easy lateral action—a requirement for high speed operation. A swing hanger length of 10 in. was selected arbitrarily. To develop high roll stability, a four-point swing link attachment to the underframe was used. The geometry for this arrangement was determined by calculations based on comparing the resistive force at the wheel flange against the rail to the maximum simultaneous overturning force that could be developed on a curve by a loaded vehicle. The four swing links were connected to the arms of the underframe mounted torsion springs. The flexible torsion-resisting elements of each spring consisted of two large preloaded rubber bushings. This spring design was chosen to provide a simple swing link connection and to act as a structural member, as well as giving a degree of vertical impact dampening. The idea of using rubber as a torsion spring element was conceived when, in an attempt to remove metal wearing bushings from a previously designed metal rod torsion spring design, it was found that the rubber bushings loaded in shear would provide most of the required torque reaction. The truck frame was fabricated, using two longitudinal box sections welded to a traverse flamecut member at each end. On one test vehicle, the axle was fixed and each wheel rotated on tapered roller bearings mounted in the wheel hub. This was done to assess any benefit that the differential action of free wheels might give to a four-wheel vehicle on a curve. The other test vehicle had wheels pressed on a rotating axle and inboard roller bearings. Other features of the truck were rubber-bushed stabilizing links to transmit braking and acceleration reactions to the underframe, automotive-type diaphragm single-acting brake cylinders and rubber-block bolster lateral stops mounted on an angle to also act as cushion seats in the event of the failure of any vertical suspension member.

Container Mounting: In order to use standard removable tandem trailers, the mountings on top of the underframe were designed to duplicate the manner in which this container is carried on a highway tractor and rear tandem. At the rear, support was provided by rails with the same spacing as highway tandem support rails which fit the container mounted tandem retaining angles. At the front, a highway tractor king pin hitch or fifth wheel was used. This hitch was conneeted to the underframe through a dual high-capacity rubber element arrestor gear. This gear allowed up to 10 in. of container "slosh" or restrained movement each way from centre to cushion the container and lading from railroad impacts. Frictional forces at the arrestor and rear rails add dampening capacity and prevent fore-and-aft jostling of the container in transit. Fig. 5 shows the king pin hitch mounting and the arrestor gear.

Testing and Evaluation

Structural Testing: Prior to vehicle assembly, the underframe was completely tested structurally. The method used involved the application of dynamic values of all loads separately and in combination, and measuring stress level at all critical locations with these loads applied to the structure. The results were analyzed graphically for fatigue using empirical formulae which have been proven by experience to yield reproducible and predictable results. This was accomplished by mounting the structure on a very rigid test fixture and applying the loads with hydraulic jacks. The fixture used for this test weighed

Fig. 3a.



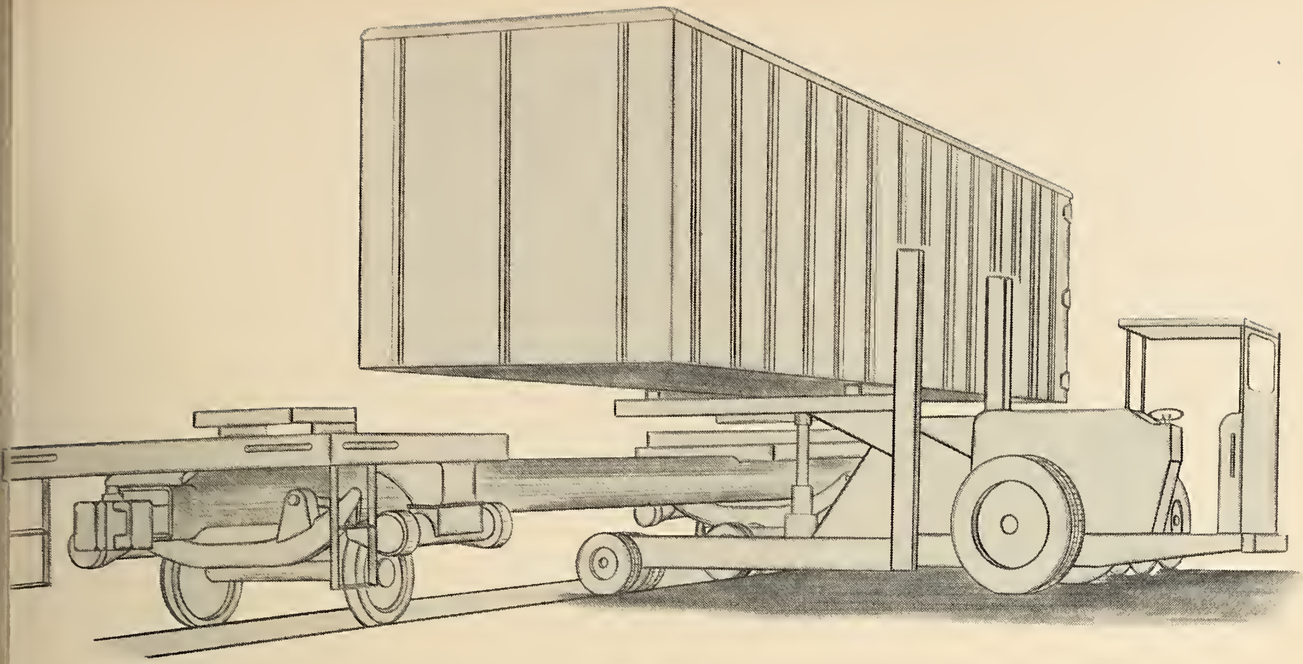


Fig. 3b.

ver 70,000 lb. The areas of high ress were generally known from the esign calculations. In order to precisely locate stress concentrations and ake certain none were missed, stress oat (a special paint that will "craze" areas of high stress) was applied the structure and loads were aplied. The locations for strain gauge pplication were thus established and nce the stress coat sensitivity was librated from samples the aproximate stress levels were also nown. Direct reading resistance wire rain gauges were then applied and ress values were measured for all esired load combinations.

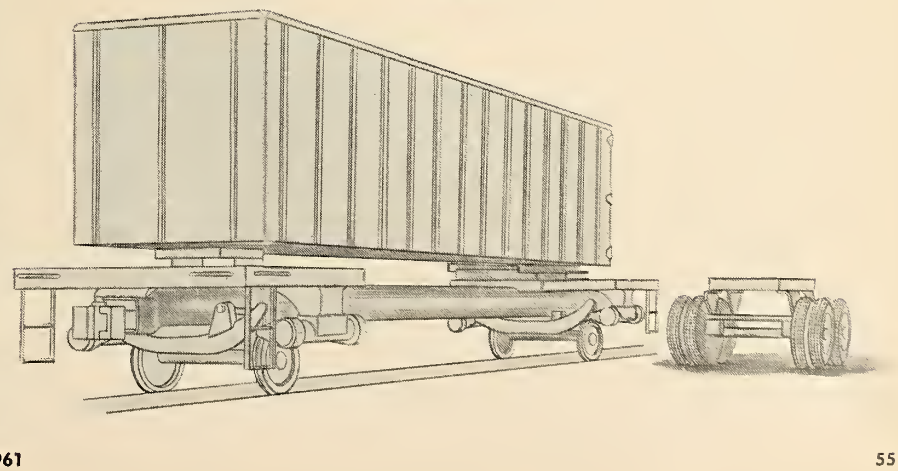
For this underframe test, 185 strain auges were used. Vertical, buff, impact at arrestor and twist loads were pplied separately and in desired ombinations. The results indicated ne area requiring major change due overstress and necessitated some inor revisions to eliminate localized resses. The underframe bolster section, that is the box section that ipports the outboard torsion springs, as overstressed in bending. Rebuildig to provide increased section and etesting was carried out and the ress level in these members was rought within acceptable limits. The visting test indicated an underframe exibility that, for a fully loaded ehicle, would allow one axle to be ver 2° out of parallel with the other xle with negligible underframe stress. was felt that this flexibility would ake a marked contribution to this ehicle's ability to "hold" the rail nder adverse conditions.

The frame for the truck was also ructurally tested in a similar manner using 50 strain gauges. No overstressed areas were found. Minor modifications were made to reduce two stress concentrations.

Running Tests: Railroad test runs were started on existing CPR piggyback rail vehicles before construction of the two prototype GM Portagers was complete. The total test program consisted of more than 300 different instrumented tests. Some of the variables were: four different railroad locations, three different vehicles, a number of loading variations, numerous running speeds up to 75 m.p.h. and vehicle modifications. Also included in these instrumented tests were impact tests at our London plant and tractor-trailer test runs on local highways using the same container and load as used on the railroad. Other tests and demonstrations involving only observation such as loader elevation and adverse buff conditions were also completed. In all, one prototype GM Portager accumulated over 11,000 test miles. All tests were prescribed and conducted jointly with Canadian Pacific's Mechanical Engineering, Piggyback and Research Departments. A caboose was provided by the CPR to be used as a test car. Power supply, instrumentation, communication equipment and signalling devices were installed in this vehicle.

The road testing instrumentation was selected to record ride accelerations, suspension and container movement, significant stresses and loadings and speed. Three four-channel ride recorders were used. Motions, stresses and loads were plotted by a multi-channel recording oscillograph. A recording calibrated tachometer maintained accurate speed records. Signalling pens on these recorders provided synchronization as well as a running record of such road conditions as curves, crossings, switches

Fig. 3c.



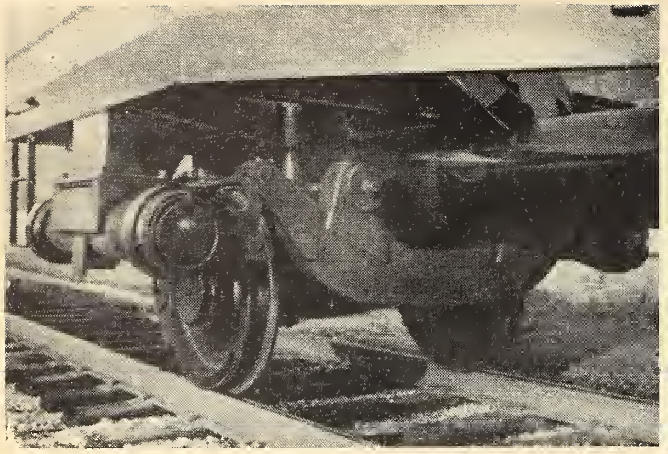


Fig. 4.

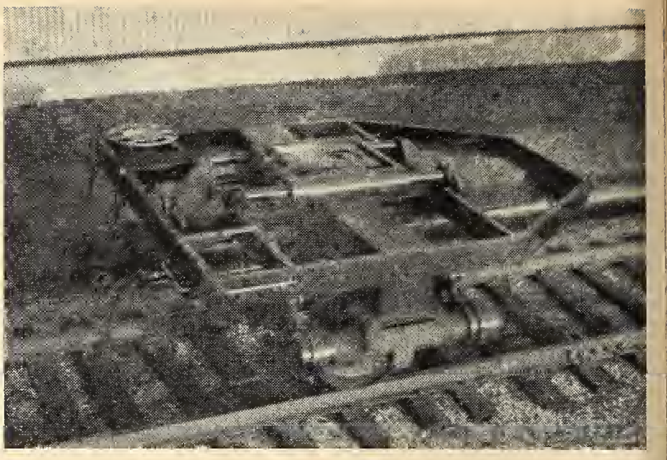


Fig. 5.

and bridges by using signalling keys operated by an observer in the test car cupola. Periodic observations and measurement provided records of wheel wear, torsion spring angular location, lading behaviour and other similar noteworthy conditions.

A base line for ride requirements was established from test runs on the highway using the same container and common lading in a conventional highway consist. Preliminary comparative records were established from railroad test runs and impact tests on a conventional "piggyback" loaded vehicle. This vehicle was included in the railroad test consist along with the prototype vehicles on a number of test runs for further direct comparison.

Prototype GM Portager evaluation started on a local branch line where light weight rail, sharp curves and the opportunity to aggravate the track conditions artificially were available. Trackability and general roadworthiness were assessed on this branch line. Then, higher speed runs were carried out on a section of mainline where curves were sharper and more numerous than normal. Final tests were conducted in revenue service in scheduled Toronto - Montreal CPR piggyback trains.

Impact Tests: Two series of impact tests were conducted. The first test consisted of impacting a conventional CPR piggyback car carrying a loaded trailer against several box cars with the brakes set. At 7½ m.p.h. the trailer king pin was pushed back about 6 in. with consequent structural damage to the trailer. This test indicated the necessity of accurate speed control, instrumentation and other aids to record stresses, deflections, relative movements, accelerations and speeds at impact in order to allow gradual impact increase to the point of damage and to provide a record of results. Consequently, an improved procedure was adopted when testing a loaded prototype GM Portager. A loaded coal car was coasted down an incline to impact against the test vehicle. Data was recorded on a multi-channel high-speed photographic type oscillograph and high-speed movies were taken. Motion, stress and speed transducers were engineered by our company and instrumentation, movie camera and technical assistance was provided by the National Research Council. Impacts were gradually increased to a value obtained from a fully-loaded coal car at 8 m.p h. at which speed the king pin hitch failed. The trailer was loaded with steel shot in 100 lb. bags to a gross weight of 49,000 lb.

Modifications: Prototype GM Portager modifications were made and evaluated during the test program as test results indicated their necessity in order to attain the design requirements. Noteworthy among these were:

(i) Lengthening of the truck suspension swing links to reduce both frequency and restoring force in order to slow down the lateral accelerations imposed on the container and lading:

(ii) Reduction of the rate of the torsion springs to reduce vertical accelerations;

(iii) Provision for secondary springing between the rail vehicle underframe and the container mounting to further reduce vertical accelerations. This was necessary because close limits on coupler heights did not allow enough primary spring deflection to achieve a sufficiently soft vertical ride for the container. Variable secondary springing to select the required spring rate was achieved by using a special test air suspension on which different air pressures and volumes could be selected;

(iv) Application of a different king pin hitch.

Test Results: The suspension proved to be very stable from the beginning. Roll was negligible, even after springing modifications, and with a heavy high centre of gravity load in the container. The modified suspensions achieved a vertical ride equivalent to that obtained on an average new highway. Excellent high speed trackability was obtained from the primary suspension. This suspension was *lively* in absorbing track irregularities without producing any tendency to sustained oscillation or vibration. The vehicle ran straight and true over the full range of load and speed conditions. Derailment did not occur under aggravated conditions. One test to evaluate track holding ability involved pushing a light vehicle without container on an 11½° curve with the full available starting tractive effort of four diesel-electric road locomotives. The combined shock absorption capacity of the draft gear and king pin hitch arrestor gear indicated a capability of protecting the GM Portager, the container and lading at impacts approaching 8 m.p.h.

Loader: A United States manufacturer has developed and built two prototype loaders for the CPR. These loaders were utilized in conjunction with the revenue test runs of the GM Portagers. Fig. 6 shows one of these loaders in the process of loading a container. The unit utilizes a standard highway tractor for motive power and achieves additional manoeuverability of the container by a hydraulically-actuated table shifting feature. A choice of fork spacing is an additional feature.

In Fig. 6, the container has been lifted clear of the tandem and moved into position over the GM Portager. The container has been elevated high enough for the landing gear to clear the centre sill of the GM Portager.

The forks, of course, pass above the centre sill while the wheels of the loader pass under it. Very encouraging loading and unloading times have been achieved.

If desired, the GM Portager can be moved from one track to another by lifting under the sill with the loader forks.

Conclusion

The foregoing has described the development of a container car to the completion of the test prototype stage. This program, although indicating a number of changes to improve standardization, reliability and adaptability, has proven the vehicle and the system to be sound. The accumulated experience has been used in the design of two production prototype GM Portagers. Standard wheels and axles with outboard bearings, reduced frame stresses, reduced manufacturing cost and a softer suspension, are the most significant changes from the test prototype design.

The differences between the test prototype and the production prototype cars have been evaluated. Structural tests confirm the increased strength and lower stress levels in the underframe. The truck changes have had no measurable detrimental effect on trackability. An improved vertical ride has been achieved due to the suspension modification.

A number of additional tests, mostly prescribed by the CPR, have been completed with satisfactory results utilizing the production prototype cars. One of these tests was the assessment of the derailing tendency of an unloaded GM Portager at the head end of a 3500 ton, 55-car freight train hauled by four road diesel units. Repeated pull and train "run-in" tests were conducted with this train on a railroad line which has grades up to 2% and curves up to 9°. "Run-ins" were produced by applying maximum dynamic brakes on all locomotive units with a stretched train. This produced an instantaneous head-end retarding force of 160,000 to 170,000 lb. at 20 to 25 m.p.h. and extremely severe impacts occurred due to the "run-in" of the train. This test relieved concern of possible derailment due to positioning of empty GM Portagers at the head end of trains. Signal tests determined a light, single GM Portager's ability to safely function all three types of signalling equipment — AC, DC and Coded (DC pulse).

Fig. 6.

During this series of tests two measurements were taken that are noteworthy:

(i) The maximum shocks due to normal "run-in" and "run-out" in high speed freight train operation were found to be in the order of 2½ m.p.h. impacts;

(ii) The dampening of the GM Portager rubber torsion springs was found to reduce peak road shocks by a factor of eight

In Fig. 7, a prototype GM Portager and a current piggyback car, carrying identical loads, are shown coupled together. The economics of complete GM Portager revenue trains are apparent although not determined. Because of weight reduction, less windage loss due to the lower, more streamlined profile and half as many wheels and bearings, significantly less horsepower will be required to pull these trains. It is felt that sizeable savings in loading and unloading man-hours can be realized. Potential savings also exist in the areas of rolling stock investment, trailer tandem investment and maintenance due to fewer wearing parts, stable high speed tracking and impact protection features.

Development efforts are continuing. However, the GM Portager has already demonstrated that it is a signicant step forward with resultant benefits to railroads, truckers and shippers alike.

Fig. 7.

Acknowledgements

The extensive contribution of the Canadian Pacific Railway and Smith Transport Companies for their guidance, joint participation, road-testing of the container car and highway test of the trucks is acknowledged. Credit as well goes to the National Research Council of Canada for their equipment and technical assistance and to Yale & Towne Manufacturing Company for their efforts in building the two loaders for the Canadian Pacific Railway. EIC

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

SILVER FALLS

L. A. Leeyus, M.E.I.C.
Assistant Civil Design Engineer, Hydro Electric Power Commission of Ontario, Toronto

Tunnel and Surge Tank Design

At the Silver Falls site a pressure tunnel in natural rock was used to convey water to a powerhouse and surge tank situated to the best advantage at the surface. Discussed by Mr. Leeyus are considerations of design for both the tunnel and the surge tank.

IN AREAS favored with suitable rock conditions, the hydraulic pressure tunnel has often been found to be the most effective method of developing the maximum potential from a given hydro-electric site. Silver Falls is a typical example in this regard of the use of a pressure tunnel in natural rock for conveying water to a powerhouse and surge tank situated to best advantage on the surface.

Although pressure tunnels have been successfully used for this purpose in conjunction with both surface and underground hydro-electric schemes in a wide variety of different arrangements since the turn of the century, the last two decades in particular have witnessed an increasing emphasis on this mode of development. In some degree this is a natural consequence of the more favorable sites found as the pursuit for power progressively extends into more remote and rugged areas. The trend may, however, be more directly attributed to recent advances in tunnel driving and concreting techniques as reflected in lower costs and faster construction. Many projects which might otherwise have used surface conduits or some alternative form of installation have as a result found it more economical to use the pressure tunnel. In addition, improved methods of analysis and experience gained with successful installations have done much to increase the confidence of designers in the use of natural rock for structural purposes.

While the choice between a pressure tunnel and competitive surface alternatives can usually be resolved on the basis of economics, certain features of the former tend to make it the more attractive alternative. Among its advantages one might mention freedom from extremes of weather and climate, laek of foundation and anchorage problems, reduced maintenance requirements, flexibility of arrangement and year round construction possibilities. In special cases, the greater security of the underground installation from wilful damage, or the preservation of existing surface features may be considerations of significance.

The two basic requirements for the use of the natural rock for these purposes are firstly, that the topography lend itself to such an arrangement and secondly, that the rock be of satisfactory quality. Although the topography of Ontario is liberally endowed with good rock, its disposition relative to potential sites has rarely been suitable to the use of pressure tunnels. Excluding the twin 45 ft. diam. 5½ mile long water supply tunnels built at Niagara for Sir Adam Beck G.S. No. 2, the only pressure tunnel installation built by the Commission prior to Silver Falls was the Aguasabon development. Completed in 1948, this plant is located on the north shore of Lake Superior in the same general area as Silver Falls and, being very similar to it in tunnel size, arrangement and rock conditions, provided a number of useful design precedents.

A tunnel and a surge tank usually present a number of interesting problems not encountered in the design of conventional river plants. This paper will attempt in a general way to discuss some of the more significant considerations involved in the design of these items at Silver Falls. The term "tunnel" is used in an all inclusive sense and is assumed for purposes of this paper to include the entire pressure conduit from headworks to powerhouse, including both the intake and surge shafts as well as the steel lined section and penstock adjacent to the powerhouse. For information on other aspects of this project the reader might refer to companion papers on the tunnelling,[1] tunnel concreting,[2] and the project as a whole,[3] the last giving a general description and history of the project.

General Arrangement

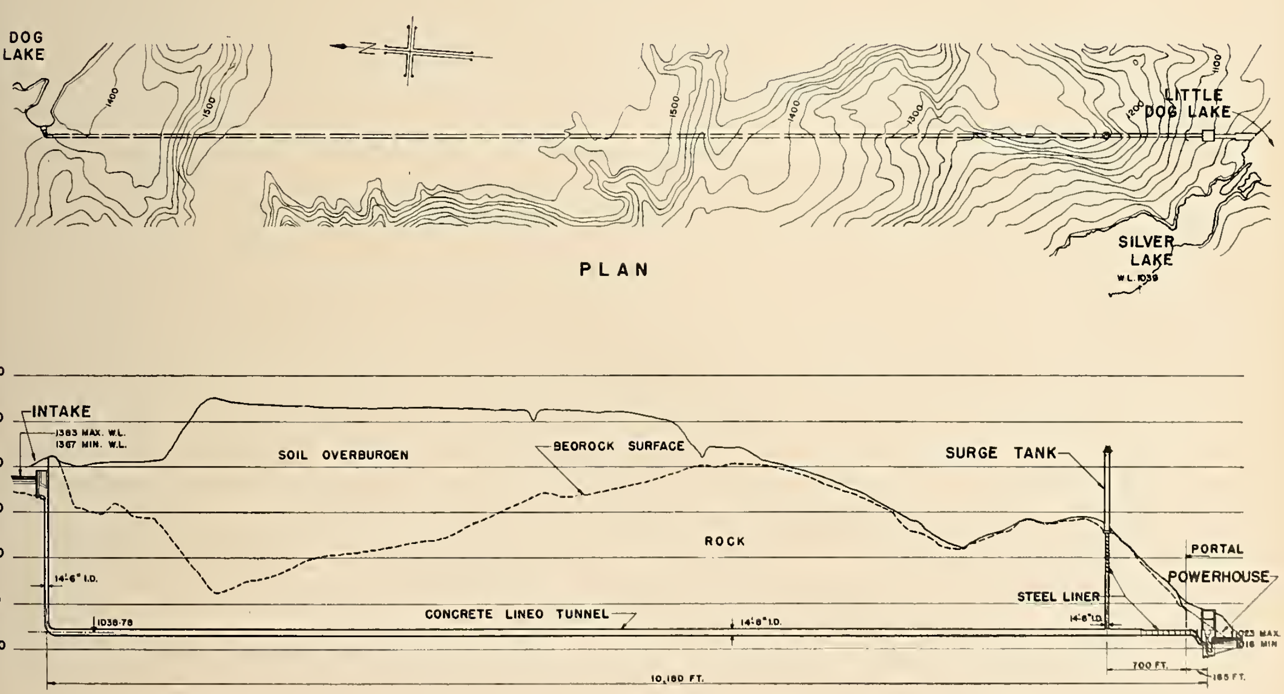
Preliminary studies encompassing multi-staged river plants, open-cut power canal and surface conduit alternatives had clearly established the economic superiority of a tunnel scheme. After site investigation had confirmed the existence of suitable rock conditions, further studies were required to determine the most advantageous final arrangement. From a fixed intake position on Dog Lake dictated by the nature of the bedrock, a number of tunnel alignments to different points downstream along the Kaministikia were possible, the two most promising being to outlets on either Silver Lake or a little farther downstream on Little Dog Lake.

An analysis of these indicated that the most favorable arrangement in either case would be a full length pressure tunnel running directly to a surge tank and powerhouse located on the surface at the downstream end. Despite a longer tunnel, the Little Dog Lake alternative was found to be economically preferable mainly because of its higher head. A further increase in head was possible by means of downstream river improvements which would lower the level of Little Dog Lake. This site in addition provided a steeper rock profile for improved surge tank and portal conditions as well as more favorable rock conditions for powerhouse and tailrace. The possibility of an underground installation was investigated, but did not prove to be economically attractive. A general idea of the topography encountered with this scheme may be obtained from Fig. 1.

A source of concern common to all the tunnel schemes was the problem of obtaining adequate roof cover for the tunnel at the bedrock depression near the intake. This took the form of a shallow saddle in the bedrock connecting the gently rounded rock knob centred on the intake with the ridge overlying the downstream part of the tunnel. The topography was such that a straight line alignment of tunnel from intake to powerhouse allowed maximum advantage to be taken of rock conditions in the powerhouse and surge tank area without appreciable sacrifice of roof cover at the depression. The need for adequate cover at this point, however, could not be satisfied without conflicting with tunnel grade and the elevation of the portal where it was desirable to keep the invert above high water levels in Little Dog Lake to avoid flooding during the construction period. This would later also permit drainage of the tunnel at all times without the necessity of pumping or of dewatering the powerhouse. Therefore, while it would have been desirable to provide a slight slope to facilitate tunnel drainage, a horizontal grade was used in conjunction with the raised portal elevation to retain the maximum possible cover at the depression.

A vertical shaft was used to connect from the intake structure to the tunnel proper in preference to a sloping shaft because it was felt that the maximum possible saving of approximately 250 ft. in length of conduit would not justify the additional costs and delays involved in changing equipment and methods to accommodate slope construction. With the intake shaft scheduled for excavation last, on the other hand, techniques

Fig. 1—Tunnel Profile (scale ratio 4:1).



used previously for the surge shaft could be used again to advantage, and the tunnelling could proceed uninterrupted on the horizontal grade already used of necessity along 80% of tunnel length.

At the surge shaft and portal, steel-lined sections are used through areas of diminishing rock cover where the conduit emerges to the surface. From the portal, the steel liner continues in the form of a sloping penstock down through an open rock cut to convey water the remainder of the distance down to a single unit powerhouse with a capacity of 60,000 hp. The final result, as shown in Fig. 1, is a rather conventional arrangement with a 10,000 ft. long tunnel developing the maximum possible head of approximately 350 ft. from the site.

Geological Factors

The bedrock of the Kaministikwia valley in the vicinity of the project is composed mainly of the massive paragneisses and granites typical of this portion of the Canadian Shield. This is covered except for scattered outcrops with varying depths of overburden consisting of terminal moraine and post glacial sedimentary deposits. The geological structure of the rock is rather complex, having resulted from a folding of the paragneisses by major intrusions of grey granite followed by faulting and numerous lesser intrusions of red granites and more basic rocks.

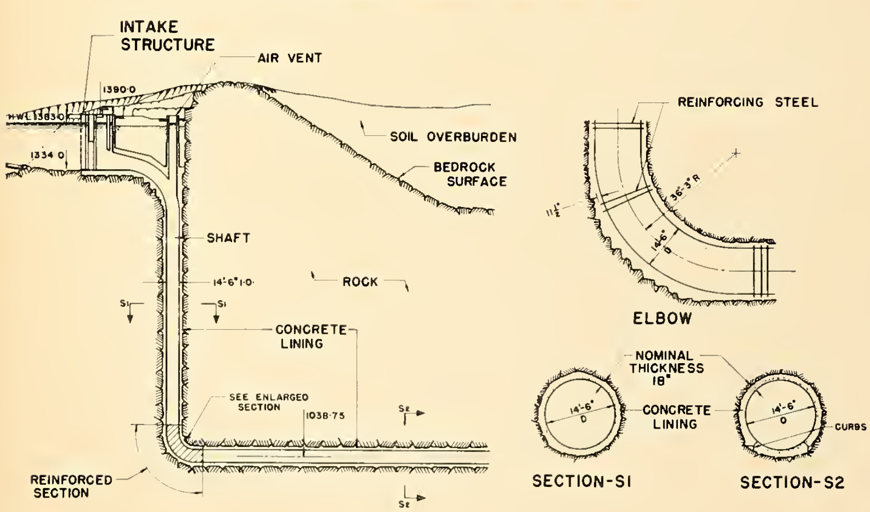
Metamorphic processes have healed most of the lines of primary weakness in the gneisses with the result that they are structurally sound at depth, and not unlike the granites in quality. Along its length, the tunnel passes through alternating areas of paragneiss and granite, the two constituents being encountered in about roughly equal proportions. The areas vary considerably in length, the alternations tending to become shorter and more frequent toward the depression and intake area. The rock structure in the intake area was particularly complex because of the numerous dikes and small intrusives of basic rocks in addition to the normal paragneiss and granite.

Slip planes and fractures were numerous throughout and rather irregular in pattern resulting in fairly prominent rock jointing. The majority of these were tight, however, and none appeared to be severe enough to have an appreciable effect on tunnel or liner safety. Sheared and brecciated zones which were found at the portal, near the depression and at the intake were found to be well cemented by secondary minerals and sound in character. The different rocks as a whole were hard and competent, and well suited for tunnelling and pressure conduit purposes. The specific gravity of the rock ranged from 2.63 for the granites to 2.78 for the paragneisses, suggesting an average value of approximately 2.7 or 170 lb. per cu. ft. for design purposes.

Tunnel diameter measurements which were made at various points following its excavation to determine rock squeeze showed only very small movements which ceased well before the pouring of the liner. While the measurements showed some variation, it was found that the major initial movements which were realized within the first 20 days, were all less than 0.10 in. Subsequent movements were all within the range of an additional 0.05 in. In addition to dispelling any concern about the effect of future rock squeeze on a liner, these measurements offered a general indication of the soundness and strength of the rock.

The material overlying the bedrock depression forms part of a ridge which acts as a natural dam separating Dog Lake from the Kaministikwia River. This consists of dense stratified layers of sand, gravel and boulders with bands and lenses of silt and clay, overlain by loosely packed surface deposits of sand, gravel and boulders. A zone of broken rock and gravel occurs at the bedrock surface. Continuous seepage from Dog Lake through the pervious strata has resulted in high ground water levels over the tunnel and in the existence of springs and erosion on the exposed downstream side of the slope. Owing to the presence of the silt and clay bands, however, it is possible that ground water pressures in underlying pervious strata close to the tunnel may vary considerably from a uniform gradient through lateral relief at the exposed slope. These conditions indicated the necessity of a tight tunnel in this area to prevent leakage which might alter ground water conditions to the detriment of the slope.

Fig. 2—Profile and sections intake shaft area.



Tunnel—Concrete—Lined Section

A concrete lining was adopted for the tunnel primarily on the basis of studies which indicated that the lined conduit would be less expensive than a larger unlined tunnel of equivalent hydraulic performance. The existence of certain blocky areas in the tunnel made it also desirable as a protection against possible rockfalls and the consequent expensive outages for repairs. It was further desirable in any case to have a liner in the depression area to reduce the possibility of tunnel leakage at this point in order to safeguard the stability of the natural ridge above. Losses due to leakage from an unlined tunnel nearly two miles long could easily be substantial even with careful grouting in the type of jointing present, whereas the lined tunnel would reduce this possibility and at the same time contribute further to the effectiveness of the grouting.

The final tunnel size was selected as a result of economic studies which indicated the optimum inside diameter to be 14 ft. 6 in., the circular cross-section being preferred for its hydraulic efficiency and its structural resistance to external pressures. The tunnel bore, however, was slightly out of round to accommodate the concrete curbs required on either side of the invert for construction purposes. Average flow velocities in the tunnel would reach a maximum of approximately 12 fps. under full discharge conditions.

The liner in the dewatered condition was assumed to act as thick-walled cylinder under the influence

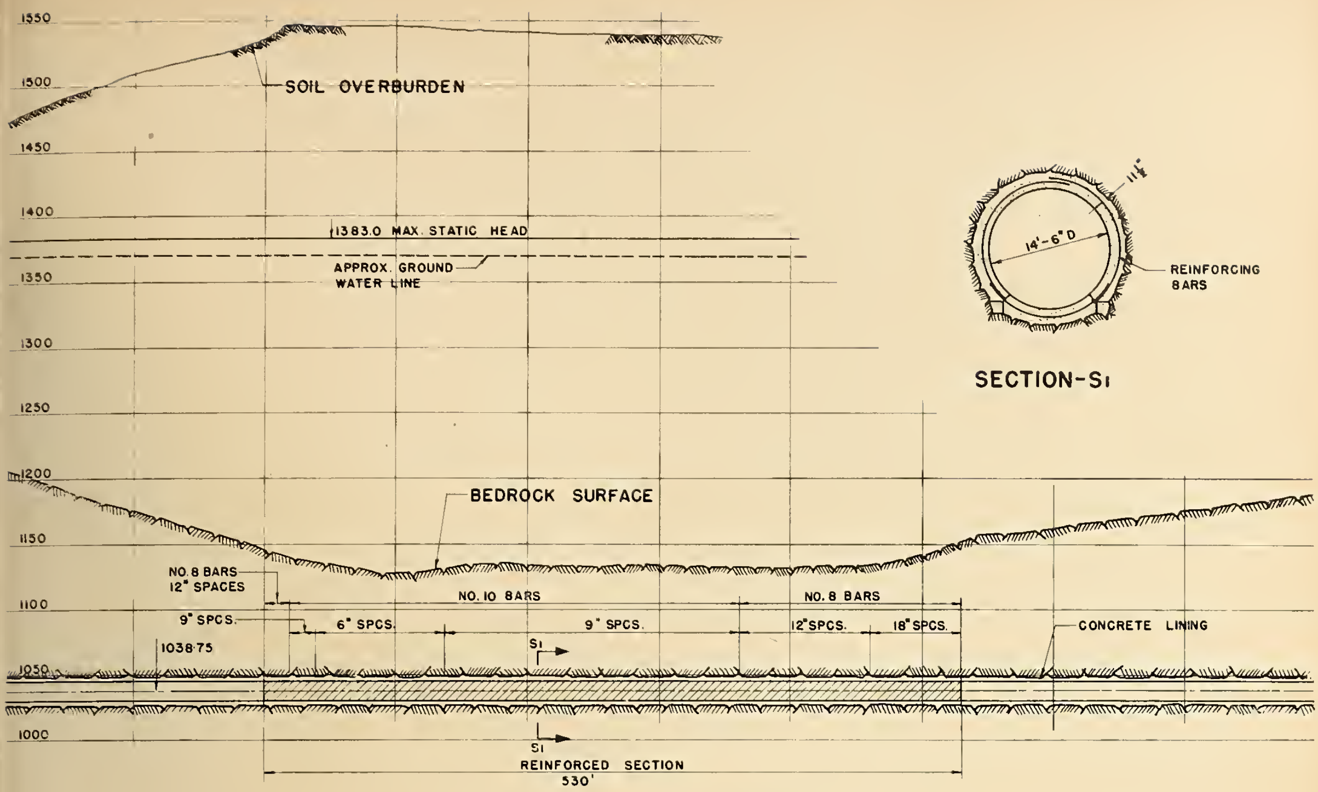


Fig. 3—Profile rock depression area.

of a uniform external ground water pressure. Where the surface profile fell below the internal pressure gradient, as when nearing the downstream end of the tunnel, the external pressure could reasonably be expected to conform to the usual assumption of being equivalent to the head to ground level. Tests conducted at Aguasabon had generally confirmed the validity of this approach. It also appeared reasonable where the ground profile was above the internal pressure gradient, to use the head to actual ground water level. While this condition prevailed over a considerable distance near the middle of the tunnel, the generally pervious nature of the overburden and the fact that the tunnel follows along the edge of the river valley suggested that the effective ground water levels would be considerably below surface grade. Under the circumstances it appeared probable that the external pressure would not exceed the internal pressure in the tunnel. This condition was known to occur at the intake by virtue of lake levels and by actual measurement of ground water levels at the depression area. An equivalent external pressure condition could occur at any point along the tunnel where the surrounding rock was tight enough to prevent relief of pressure resulting from long term seepage through the liner.

This assumption was accordingly used, resulting in the selection of an average liner thickness of 18 in., with a minimum allowable thickness of any point of 13 in. Average compressive stresses in the liner would be in the order of 1100 p.s.i. under the conditions assumed, reaching a possible maximum of approximately 1500 p.s.i. in the unlikely event of extreme ground water levels. A liner of this thickness would be adequate to carry any rock loads likely to result from local loosening of the rock at the soffit in severely jointed areas.[4]

This thickness agrees closely with existing tunnel installations of similar size and offered the prospect of convenient concrete placing. It also permitted the use of reasonable grouting pressures and appeared to provide sufficient depth for the installation of hoop reinforcing steel wherever required without unduly upsetting concreting methods, although later experience proved this expectation to be somewhat optimistic. Since the same considerations applied to virtually the entire length of tunnel, as well as the intake and surge shafts, it was convenient to use the same thickness throughout.

The plain concrete liner, while satisfactory for external pressures, could only be used where the depth of rock cover was adequate to fully resist internal tunnel pressures. The design of the tunnel for internal pressure was essentially a matter of assessing the degree to which the rock could be relied upon to fulfill this function.

Use of Cover—Theoretical Considerations

Various theories have been advanced over the years in an effort to explain the behavior of rock around open tunnels and pressure conduits under different conditions of loading. Recent trends in this respect which are described in a comprehensive survey by Jaeger[5] illustrate the increasing importance being attached to the state of stress naturally existing in the rock. Terzaghi and Richart[6], for example, have shown that the ratio between the vertical and horizontal compressive stresses which exist in the rock by virtue of its weight and geological origin have a major effect on the distribution of stresses around the empty tunnel opening. Their analysis indicates that where the natural horizontal stresses are less than 1/3 of the vertical in magnitude, tensile tangential stresses will be induced at the soffit.

A number of methods based on theoretical elasticity have been proposed for the analysis of rock behavior in conjunction with steel lined pressure conduits [7, 8, 9]. The generally favored approach consists of treating the rock surrounding a circular tunnel as a thick-walled cylinder concentric with the tunnel, its internal radius that of the bore and its outside radius equal to the shortest distance to rock surface. Hydraulic pressure inside the tunnel induces compressive radial and tensile tangential stresses in the surrounding rock which, according to theory, are a maximum and equal in magnitude to the pressure at the inside face, and which decrease radially in proportion to some function of their distance from the centre of the tunnel. These superimpose on the natural compressive stress field in the rock and its altered local distribution around the bore to establish the final stress pattern. This usually results in the existence of a tensile or "cracked" zone immediately around the opening, the extent of which is determined by the relative magnitude of the stresses involved.

Providing sufficient depth of cover is available, this zone will be enclosed within an area in which all stresses are compressive and which may be assumed to behave elastically as a thick-walled cylinder of somewhat increased internal radius.

Varying results are possible, depending on the ability of the rock to take tension. Rock tensile strengths are low, however, and frequently assumed to be nil because of jointing. In such cases its ability to take tension is limited to the amount of compressive prestress present. A plain concrete liner is commonly assumed to behave in the same manner as the rock by virtue of the similarity in their properties.

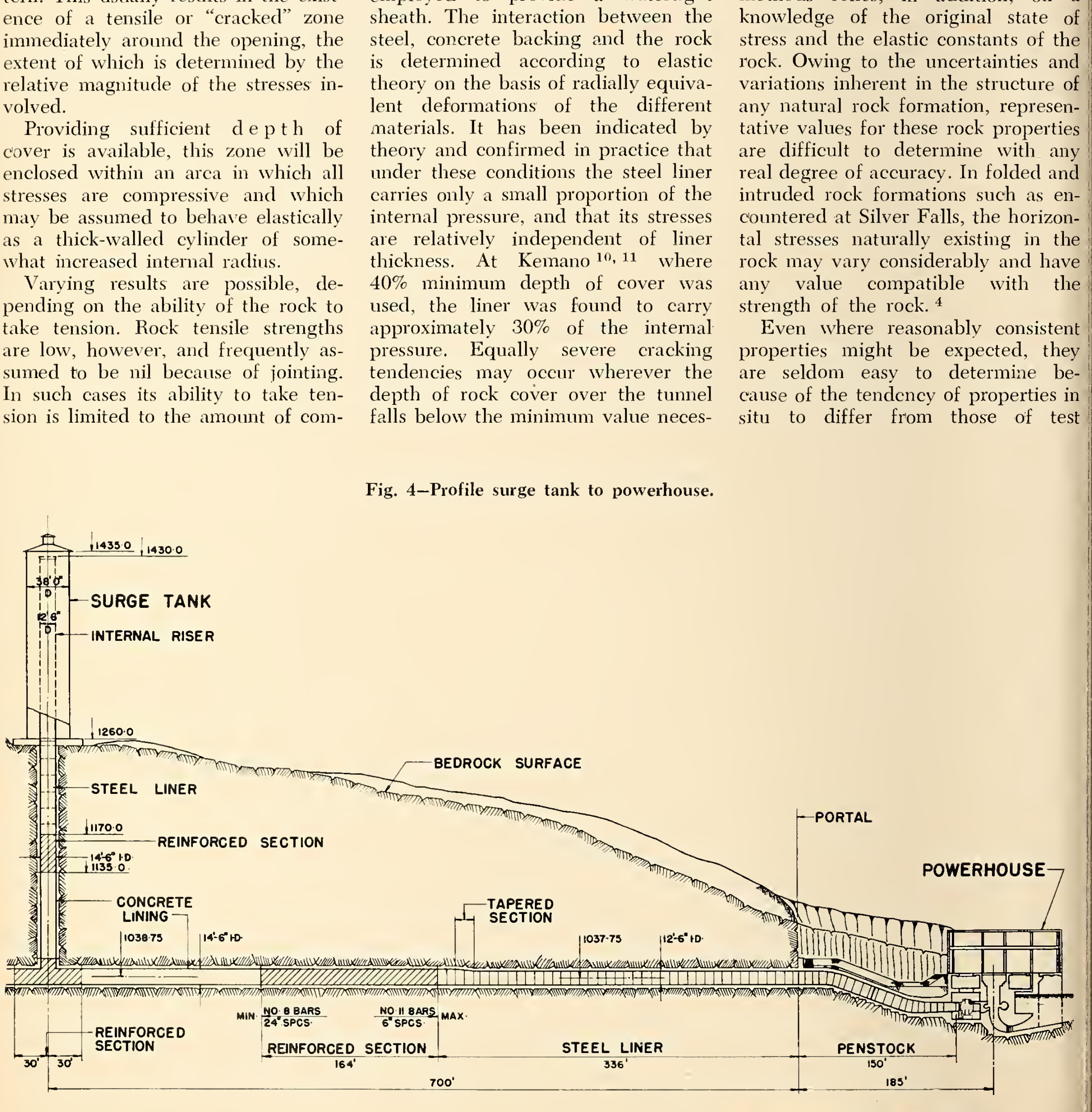
Where the resultant tangential stresses around the circumference of the tunnel are only slightly tensile or entirely compressive, and the rock is tight and otherwise of good quality, an unlined or plain concrete lined tunnel would appear to be satisfactory. With higher heads, however, even where adequate depth of cover to resist heave is present, the cracking tendency induced by the tensile stresses around the opening may be severe enough to warrant concern about leakage, particularly if the rock is of poorer quality or heavily jointed. In such cases a steel liner is usually employed to provide a watertight sheath. The interaction between the steel, concrete backing and the rock is determined according to elastic theory on the basis of radially equivalent deformations of the different materials. It has been indicated by theory and confirmed in practice that under these conditions the steel liner carries only a small proportion of the internal pressure, and that its stresses are relatively independent of liner thickness. At Kemano [10, 11] where 40% minimum depth of cover was used, the liner was found to carry approximately 30% of the internal pressure. Equally severe cracking tendencies may occur wherever the depth of rock cover over the tunnel falls below the minimum value necessary to prevent heaving. the steel liner in such cases being used to augment the strength of the rock as well as to prevent leakage. Assuming normal conditions wherein the natural horizontal stresses are usually less than the vertical stresses in the rock, the cracking tendency will be most pronounced at the tunnel roof.

While the theoretical methods are helpful in offering an improved understanding of rock behavior, there does not as yet appear to be sufficient knowledge available to accurately relate them to reliable safety factors in actual practice. There is reason to believe, for instance, that the cracking tendencies suggested by the theoretical tensile stresses might not be as critical as originally expected.

The successful application of these methods relies, in addition, on a knowledge of the original state of stress and the elastic constants of the rock. Owing to the uncertainties and variations inherent in the structure of any natural rock formation, representative values for these rock properties are difficult to determine with any real degree of accuracy. In folded and intruded rock formations such as encountered at Silver Falls, the horizontal stresses naturally existing in the rock may vary considerably and have any value compatible with the strength of the rock. [4]

Even where reasonably consistent properties might be expected, they are seldom easy to determine because of the tendency of properties in situ to differ from those of test

Fig. 4—Profile surge tank to powerhouse.



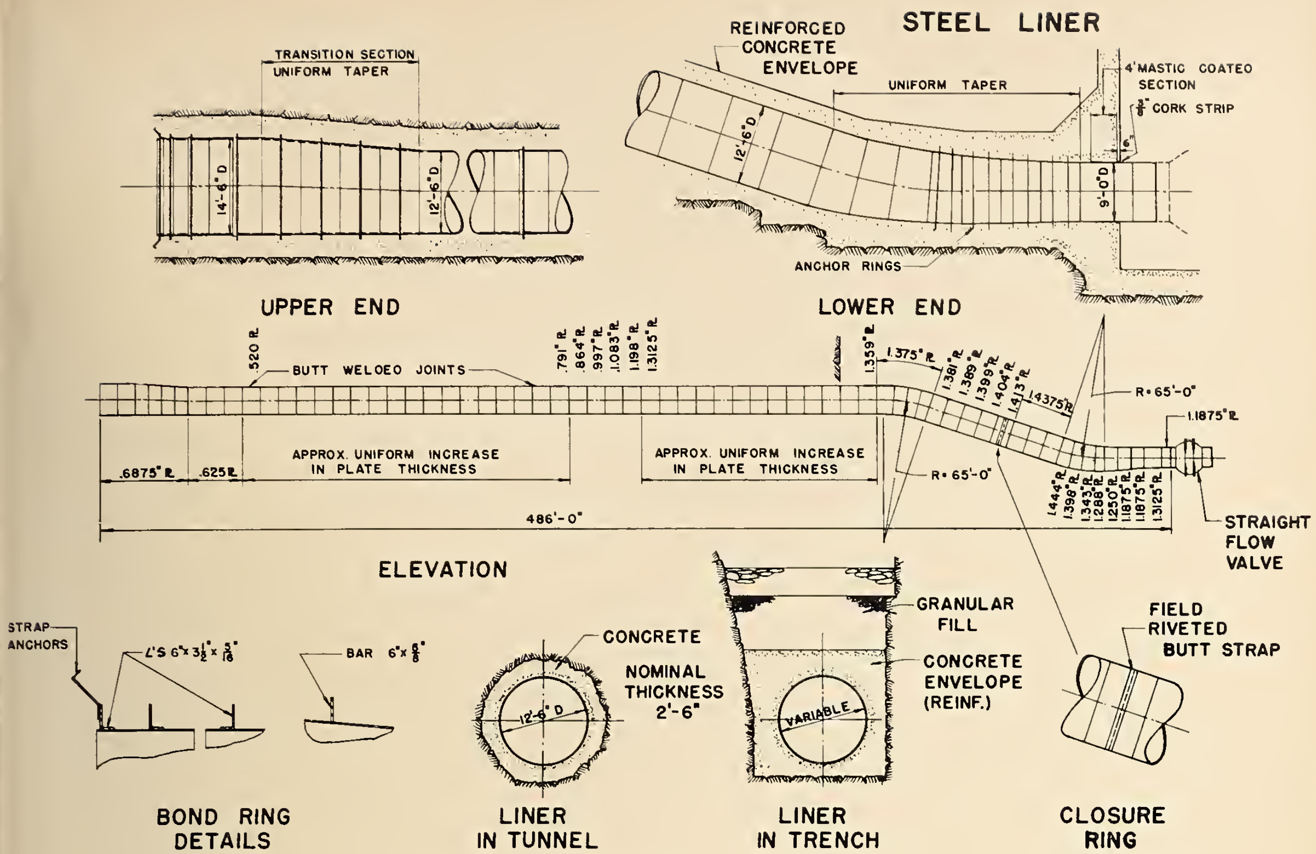


Fig. 5.

samples. The modulus of elasticity of rock in situ, for example, is invariably lower than that obtained from core tests, the elastic behavior usually also being preceded by a range of plastic deformation. These elastic properties can only be satisfactorily determined by conducting field tests in situ. A steel test cylinder or sphere grouted into an opening excavated at the desired test location is usually used for this purpose.

As a result of such limitations, it is usually necessary in tunnel design to resort to empirical rules and criteria derived from past experience. In addition to the scheduling difficulties which would have ensued, the use of elaborate test procedures were felt to be economically impractical for a project as small in scope as Silver Falls, particularly when directly comparable and proven empirical relationships were available from previous experience at the Aguasabon development.

Use of Cover—Empirical Methods

Values used for the minimum depth of cover necessary to safely resist internal pressures in unlined or plain concrete lined tunnels have shown a considerable variation in practice. One authority [12] recommends the general rule that the minimum depth of cover to ground surface should not be less than 70% of the maximum internal pressure head. Minimum cover of 50% has been frequently used, in some cases being assumed to apply to the combined depth of rock and overburden [13], and in others to the rock cover alone. In some instances even lower values have been used with success. [14]

It is generally agreed, however, that the depth of rock overlying the tunnel should be at least equal in weight to the maximum internal pressure. This is most commonly taken in the form of a vertical prism extending from the roof of the tunnel to the rock surface, its base equal to the tunnel bore in width. With this concept the shearing resistance offered by the rock at the sides of the prism is assumed to provide the necessary safety factor against rock heave. Variations of this have been obtained by flaring the sides of the prism outward to either side of vertical from the base. The minimum cover requirement at Aquasabon, for example, was established using a flare of 7°, and flare values as high as 30° are believed to have been successfully used in sound rock.

The depth of cover obtained by this means will vary with the amount of flare used, the specific gravity of the rock, and with such allowances as may be judged necessary by virtue of its character and quality. In view of the satisfactory results obtained using this method at Aguasabon under comparable conditions of rock, tunnel size and head, a similar approach appeared to be suitable for Silver Falls. Assuming an average weight of 170 lb. cu. ft. for the typical paragneiss and granite at Silver Falls, use of the vertical prism would result in a minimum cover requirement of 37%.

Concrete Lined Tunnel—Internal Pressure

When compared with existing pressure tunnel installations which range in head anywhere from an undetermined minimum to a maximum of 2600 ft., the 350 ft. head at Silver Falls may be considered to be fairly low. Although steel liners have been used with even lower heads, particularly in Europe, past experience with heads of this order has indicated that where a good quality of rock is available, a plain concrete liner is usually satisfactory. The plain concrete liner used at Aguasabon, for instance, has shown no sign of distress or leakage under similar conditions during its 12 years of service.

This would indicate that the theoretical tangential tensile stress of approximately 150 p.s.i. which would be induced at the inside face of the liner by an internal pressure of the same magnitude (max. static head), is not sufficient when taken in conjunction with the previously existing stresses to cause cracking severe enough to permit leakage of any consequence. This is no doubt due in part to the effect of pressure grouting which, in addition to applying an initial compressive pre-stress to the liner, also increases the modulus of elasticity of the surrounding rock, thereby reducing the radial deformations and cracking tendencies caused by internal pressure. The grouting would also help to counteract the formation of transverse cracks resulting from Poisson's ratio effect under internal pressure. With the use of proper grouting, there was little need to hesitate, therefore, in using the plain concrete liner to resist internal pressures wherever adequate depth of cover was available.

At the intake shaft and immediately adjacent sections of tunnel as shown in Fig. 2, external ground water pressures would likely be equal or nearly so to the internal pressure head at all times by reason of their position so close to the lake, barring the unlikely existence of local pervious or drainage zones in the rock which would provide relief. The conduit is, therefore, virtually in a state of hydraulic equilibrium with the rock stresses essentially those resulting from excavation of the opening. Ignoring the dewatered state, this condition is, in a sense, ideal for a hydraulic conduit since the internal pressure does not impose additional stresses on the rock, and the small differential between internal and external pressures gives little incentive for leakage.

The depth of rock cover along the tunnel is well in excess of the adopted minimum requirement of 37% except at the depression area and when approaching the portal. At the depression area, there was some concern that despite the generous amount of overburden, alternate filling and dewatering of the tunnel over a period of time might result in the formation of sufficient cracks and fissures in the liner and rock to create a leakage hazard, particularly in view of the low ground water levels possible at this point. The ability of the overburden to resist heave at its line of contact with the rock was likely to be uncertain due to local variations in the nature of the material and the very irregular nature of the rock surface. In order to protect against this possibility the liner was provided with reinforcing in the area where the rock cover fell below the minimum depth requirement as shown in Fig. 3. This was nominally proportioned to carry the balance of internal pressure remaining after deducting the weight of rock cover obtained with 7° flare from the maximum static pressure head. This rationalization resulted in a single layer of hoop steel varying in approximate inverse proportion to the amount of rock cover. The use of reinforcing at this point was felt to be preferable to a steel liner since it would not be subject to the same excessive external pressure requirements, and would be easier to install. While not watertight in the sense of a steel liner, it would reduce the amount of load carried by the rock and help to prevent leakage by resisting the tendency of the liner to form open tensile cracks under pressure. It could also be expected to increase the ability of the liner to resist point failure in small local areas of inadequate rock support.

As a result of the gentle bedrock slopes prevailing over the entire length of the tunnel, there was no need for concern about the depth of rock cover in directions other than vertical.

Tunnel—Steel Lined Section

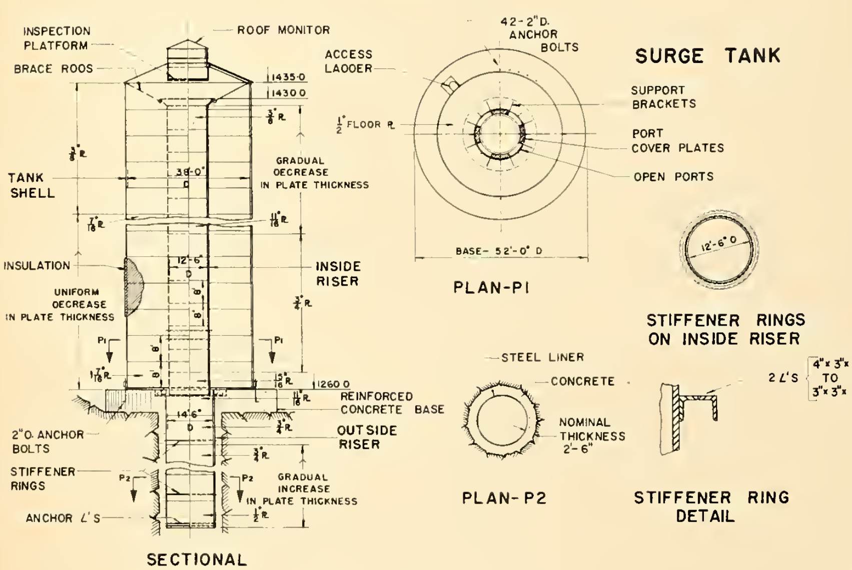
Where the diminishing rock cover approaching the portal fell below the minimum value estimated necessary to sustain full internal pressure, a welded steel liner was used in conjunction with hoop reinforcing to effect a progressive transition to the surface. In addition to carrying internal pressure loads, the liner serves as a waterproof membrane to prevent leakage through joints in the shallow cover near the portal, and for this reason alone, would be extended far enough into the tunnel to ensure fairly tight rock conditions. A liberal factor of safety was desirable in this area in order to avoid seepage which might have an unstabilizing effect on sidehill overburden adjacent to the powerhouse and transformer area.

There is some question as to the proper hydraulic load to use for the design of a pressure conduit in rock. It is felt in some quarters that because of the inertial effect of the rock cover, the pressure rise due to water hammer may be ignored in view of its short duration. This consideration would also apply, although with less justification, to the pressures resulting from mass oscillations of the surge system. The design in such cases would be based on the maximum sustained load represented by the maximum static head. Owing to the critical nature of the portal area, however it was decided to adopt the more conservative approach and to use the maximum internal pressure head including water hammer effect as shown on Fig. 7.

In the absence of reliable information on the elastic properties of the rock, the steel liner and reinforcing were proportioned on an empirical basis using normal working stresses in the steel. It was assumed that the reduced rock cover would contribute toward the support of internal pressure in proportion to its weight as determined by vertical prism, the steel being assumed to carry the balance.

No support was considered from the rock for the first 80 ft. upstream from the portal because of possible weakening effects from heavy blasting at the portal face. The steel liner

Fig. 6.



n this area was accordingly propor-ioned to carry the full internal pres-ure head. This was followed by a ransition zone 40 ft. long in which teel liner thickness could be de-reased in convenient increments to he value required after full allow-ance for rock support. From this point he internal pressure design head for he steel liner and reinforcing was ssumed to decrease in inverse pro-portion to the depth of cover, be-coming nil at the point where rock cover reached the 37% minimum lepth requirement of the concrete ined tunnel. The steel liner was ex-ended with decreasing thickness up o a point where buckling require-ments due to increasing external pres-ure began to dictate an increase, the xternal pressure head being taken equal to the head to ground surface. As the liner at this point had ex-ended into sound rock far enough to provide adequate seepage protection, hoop reinforcing steel was used in its place for the remainder of the dis-tance in order to avoid the additional requirements of external pressure. The resulting arrangement is shown n Fig. 4.

Using yield stresses and ignoring he pressure rise due to water ham-mer effect, the liner as determined would be capable of carrying the in-ernal pressure head due to mass oscillations of the surge system with-out assistance from rock cover in the area where it dropped below 37% of the assumed internal pressure head.

The liner was checked for buckling under external pressure in accordance with the revised theory of Amstutz,[15] assuming a gap between liner and concrete backing equal to three ten thousandths of the radius. For the 12 ft. 6 in. diameter of liner this would be equivalent to .022 in. The gap would occur initially as a result of the temperature and shrinkage effects due to concrete curing, and would be later increased by the cool-ing effect of the water on the liner and the subsequent plastic deforma-ion of the concrete and rock under oad.

While pressure relief drains, liner stiffeners, and anchors of various kinds have been used with thin plate iners to counteract the effects of external pressure, none of these alter-natives were felt to be particularly suitable for use at Silver Falls. Past experience with relief drains has shown them in many cases to be un-reliable, and the liner anchors and stiffeners invariably present difficul-ties during erection and concreting. Where the liner was not required for watertightness, therefore, the use of reinforcing appeared to be the most attractive alternative.

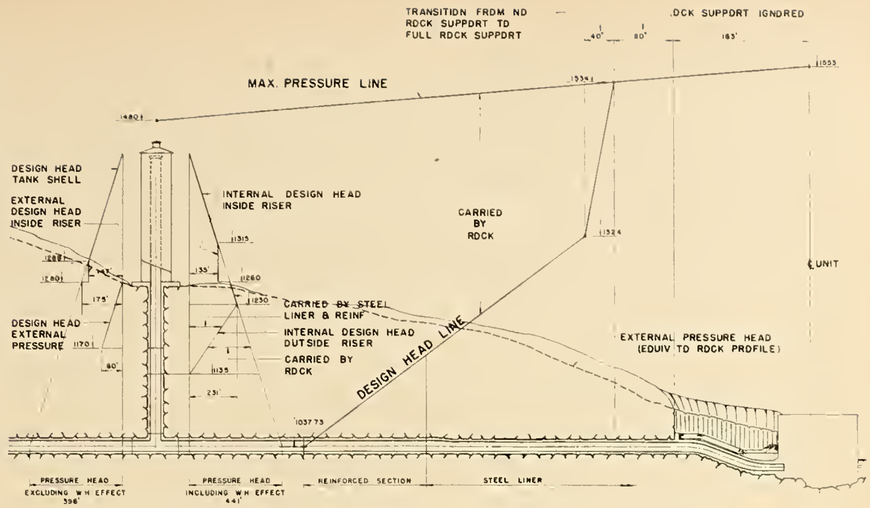


Fig. 7—Design Load assumptions; surge tank, tunnel liner, penstock.

The reinforcing was provided in a single layer of hoop steel in a manner similar to the depression area. This varied in spacing from a minimum of 6 in. at the liner to 24 in. at its termination. At the junction with the liner, fairly heavy longitudinal rein-forcement was used in conjunction with the hoop steel to provide a suit-able transition and overlap with the steel liner in order to reduce the danger of transverse cracking at this point. The steel for each hoop was provided in three lengths with lap splices on either side of the invert and at the crown.

Economic studies had resulted in the selection of a uniform 12 ft. 6 in. diameter for the steel liner and pen-stock. The change from the 14 ft. 6 in. diameter of the concrete lined tunnel to the 12 ft. 6 in. steel liner was accomplished by means of a tapered steel section incorporated into the upstream end of the liner, the in-vert being kept at the same level as that of the tunnel for drainage pur-poses as indicated on Fig. 5. The steel plate thickness varies from a maximum of 1.35 in. at the portal to a minimum thickness of .625 in. near the upstream end. Circumferential bond rings formed from 6 in. by 3 in. angles were located in the middle of each liner ring to provide better in-tegration of the liner with the 30 in. thick concrete backing. At the up-stream end, two anchor rings of similar material were attached to strengthen and anchor the end of the liner plate into the concrete assisted by strap anchors. Screw type counter-sunk plugs 2½ in. in diameter were provided at the crown in a pattern suitable for later use for pressure grouting.

Penstock

Being essentially a continuation of the steel liner in the tunnel, the pen-stock design was based on the same hydraulic requirements (Fig. 7) and was proportioned to resist the full maximum internal pressure at normal working stresses. As shown in Fig. 5, the uniform 12 ft. 6 in. diameter is continued from the portal around a 65 ft. radius upper elbow and down the slope to the beginning of a tapered lower elbow of the same radius, re-ducing to 9 ft. diameter at the up-stream wall of the powerhouse where connection is made to a straight flow valve of the same diameter. The tapered elbow was preferred because of its lower head losses and the im-proved flow characteristics which would be provided at the entry to the scroll case. Elbow radii were similarly selected with a view to minimizing hydraulic losses.

Since construction schedule require-ments dictated the erection of the penstock and liner from both ends toward the middle, a riveted closure section was provided in the sloping section to permit final adjustment of alignment and a stress-free final closure. This consisted of two sec-tions joined together by a butt strap which was field riveted after both sections had been welded to the ad-jacent sections of penstock.

At its downstream end the penstock is used to carry the full thrust result-ing from valve closure, a dresser coupling being used to provide the connection between the valve and the scroll case. This was preferable to transmitting valve forces into the scroll case because of the more favor-able combined stresses obtained by a tension connection. In addition to internal pressure and thrust loads, the penstock section immediately upstream of the valve was called upon to absorb residual eccentric forces from valve operating equipment which could not be completely absorbed by the anchor bolts securing the valve to its slip plate foundation. The effect of the thrust and eccentric loads due to valve operation was fortunately mitigated by the fact that the pressure rise which would result during its slow rate of closure would not be as severe as the maximum pressure rise resulting from rapid unit shut down shown on Fig. 7.

In the case either of valve operation, or of unit closure, the stresses resulting therefrom would be further aggravated by the behaviour of the penstock at its point of emergence from the concrete wall into the valve chamber. The tendency of the liner to expand upon release at the face induces additional stresses which often dictate the use of a thicker plate.[16] At Silver Falls, an effort was made to reduce the severity of this phenomenon by encouraging a more gradual or "two stage" transition from the fully confined to the unconfined state. This was done by coating a 4 ft. length of the penstock with a thickness of compressible ground cork mastic calculated to permit one half of the total expansion as illustrated on Fig. 5. A 6 in. cork band at the wall face was used both as a plug and a cushion to prevent failure and spalling of concrete at the face.

Stress analyses based on the foregoing resulted in the selection of a penstock section 1.312 in. thick extending a short distance upstream beyond the affected area. The remainder of the plate thicknesses in the penstock area range from a maximum of 1.444 in. to a minimum of 1.187 in. depending on variations in head and diameter. Anchor rings welded to the horizontal tapering penstock section downstream of the lower elbow were designed to transfer the maximum value of valve thrust into the surrounding concrete envelope, which in turn was longitudinally reinforced to recruit enough mass to prevent the possibility of movement.

The exposed penstock between the powerhouse and the portal was enclosed in a nominally reinforced concrete envelope following normal practice. In view of the possibility of rockfalls from the high vertical faces of the penstock trench and portal, the envelope was provided with a granular cover of 8 ft. minimum thickness designed to act as cushion against impact. At the downstream end this was fashioned in the form of a trap to prevent damage to the powerhouse from runaway boulders.

Surge Tank

Because of the length of the hydraulic conduit, it was essential to provide some means for the relief of excessive pressures which would result from sudden changes in load on the unit. While a pressure regulator might have served this purpose, the operating requirements of this station in the power network dictated the use of a differential surge tank which would allow full load rejection and full load demand based on an effective governor time of 4 sec. for both closure and opening over the full range of gate movement. With this type of arrangement, it was axiomatic that the surge tank should be as close to the powerhouse as possible in order to keep transient values of pressure rise in the turbine spiral casing and adjoining steel conduit down to a minimum.

Using preliminary tank dimensions obtained by Johnson's equations, economic comparisons were made of a range of tank positions taking into account the effect of consequent pressure rise changes on the steel liner and penstock. These comparisons indicated that optimum economic advantage of the various factors involved would be provided by a position 885 ft. upstream from the powerhouse as indicated on Fig. 4.

With the location fixed, final tank dimensions and operation were confirmed by the arithmetic integration method using an electronic computor. Design studies indicated that both the standpipe and elevated types of tank were equally feasible at this location. It appeared possible, however, that although the elevated tank would require a lesser quantity of steel than the standpipe, its greater complexity of fabrication and use of structural shapes might make it the more expensive alternative. This was later proved to be the case, the standpipe tank eventually being selected on the basis of its cost advantage.

The tank is an all welded structure and in its final form, as indicated on Figs. 4 and 6, has a 38 ft. diameter outer shell enclosing a 12 ft. 6 in. diameter inside riser. A 14 ft. 6 in. outside riser or steel liner extends 90 ft. down into the surge shaft. The tank bottom follows standard standpipe practice in the use of a 1 in. sand cushion under the ½ in. floor plate. This is enclosed around the outer edge by a ring of drypack which also serves to provide firm support for the tank shell.

The annular ring between the inside and outside risers provides a total port area equal to approximately 25% of conduit area which is divided into eight equal sections by the vertical steel plate brackets supporting the inside riser. The use of removable port covers in these sections permits any necessary adjustments of the port area. Initial computations indicated that a port area of approximately 14% was desirable.

A wind load of 35 p.s.f. was assumed to act on the projected area of the tank, but was not found to have a serious effect on stability. Around its perimeter the tank shell is anchored into the 7 ft. reinforced concrete base by anchor bolts attaching to brackets welded to the tank shell near the bottom. The entire weight of the inside riser is carried by the support brackets into the concrete base. A careful construction sequence was followed during erection to prevent damage to the final seal weld at the junction of the tank floor and the brackets. It was assumed that the rotational forces produced by bracket eccentricity would be fully carried by the bottom ring of the riser, vertical stiffener beams being provided on the inside opposite each bracket as additional reinforcement for this purpose.

The hydraulic loads used for the design of the tank are shown on Fig. 7. The inside riser is subjected to both internal and external loads as a result of the differential levels occurring during operation. Maximum differentials for both conditions were obtained assuming the worst combination of port area and operating sequence. In view of its high slenderness ratio of approximately 14:1 and the unknown effects of vibration encountered under certain conditions, somewhat higher differentials were arbitrarily assumed for design, and as an added safety factor, were assumed to occur from the top of the tank. As shown on Fig. 6, circular stiffeners were used along the riser to provide the necessary resistance to external pressures. The internal design head on the inside and outside risers included the effect of pressure rise due to water hammer which was assumed to diminish uniformly in its course along the conduit and up the surge shaft from a maximum at the unit to zero at the top of the tank.

The outside riser and reinforcing were extended 125 ft. down the shaft to El. 1135 where the weight of the rock cover would equal the internal pressure in order to reduce the possibility of rock uplift due to seepage. In view of the relatively flat slopes of the surrounding surface, it was estimated that, the rock below this point would be adequate to sustain the horizontal forces from internal pressure without assistance. Horizontal rock support was ignored for a distance of 30 ft. below tank bottom due to excavation effect in the more heavily jointed surface layers. Below this point the rock was assumed to contribute lateral support directly in proportion to its depth until wholly sustaining at the 1135 elevation. Reinforcing was substituted for the liner at the 90 ft. point where external pressure began to govern liner thickness. The junction of the surge shaft with the tunnel required substantial reinforcement against external pressure owing to its unsymmetrical shape.

Steel Design & Fabrication

The surge tank together with the steel liner and penstock were designed and fabricated to virtually identical requirements and specifications using ASTM A201 Grade A Flange Quality steel plate throughout for all load bearing plate surfaces. This steel was selected because of its ductility and good weld-ability as confirmed by satisfactory experience with previous penstock installations, and because of its favorable brittle fracture characteristics at low temperatures.

Normal working stresses of 15,000 p.s.i. in tension and 20,000 p.s.i. in compression were used for the plate, the former in conjunction with an allowable joint efficiency of 85% for all butt welded joints. A corrosion allowance of 1/16 in. was included in the thickness of all water containing plate except the floor plate of the tank and where stipulated minimum thickness values exceeded design requirements.

Welding in the field was carried out using the shielded metal arc process and in the shop by the automatic submerged arc process. Plates in excess of 1 in. thickness were preheated to 300-400° F before welding. All butt welded joints were stress relieved by the Linde Low Temperature stress relieving process and radiographed 100% to check for defects.

The penstock and liner and the surge tank outside and inside risers were shop welded into rings for shipment to the site, some rings of the inside riser also being shop welded together for shipment. The remainder of the joints were welded in the field. The 30 in. thickness of concrete backing in the steel lined sections of the tunnel and surge shaft originated mainly from the need to allow the necessary access for welding and radiographing of the circumferential joints.

Grouting

The grouting of the concrete-lined sections of the tunnel and shafts was carried out in two stages, the first being a low pressure operation at pressures up to 100 p.s.i. intended mainly to fill the voids left around the lining during concreting and the second later at higher pressures of 150 p.s.i. or over for the purpose of filling smaller voids and any fissures or cracks occurring in the rock and concrete liner.

The magnitude of the compressive stresses produced in the concrete lining by the final grouting will depend to some extent on the distribution of the grouting pressures around the outside of the liner and in particular on the amount of pressure release or drop following disconnection of the pump. The creep of the grout would also contribute to a reduction. It is usually considered therefore that final compressive stresses would be reduced to about 50% of those occurring during grouting. In the present case, ideal grouting at 150 p.s.i. would produce initial compressive stresses in the liner of approximately 900 p.s.i. which, according to this assumption, would provide final compressive stresses of approximately 400 p.s.i. This being considerably in excess of the theoretical tensile tangential stresses likely to be induced at the inside face of the liner, it may be concluded that the grouting pressures used would offer reasonable assurance against the possibility of tensile cracks in the liner.

In the steel lined section of the surge shaft as well as that of the tunnel, grouting behind the steel liner was carried out by means of the screw type plugs previously mentioned, using reduced pressures well below the buckling capacity of the liner. Grouting pressures in the surge shaft were further reduced approaching the surface to prevent uplift of surface layers of rock.

Conclusions

It is likely that pressure tunnel design will continue to rely heavily on empirical relationships from past experience until such time as some of the present obstacles in the way of more rigorous theoretical analysis are overcome. Due to the uncertainties involved in dealing with geological factors, the methods must of necessity be fairly conservative. The design at Silver Falls illustrates the application of one such approach to the conditions of a particular project site with satisfactory results.

Acknowledgement

The author would like to express his appreciation to those responsible for being given the opportunity of preparing this paper, and to acknowledge with thanks the valuable assistance received during its preparation from the different design groups and individual engineers with whom the author participated in the design of this project.

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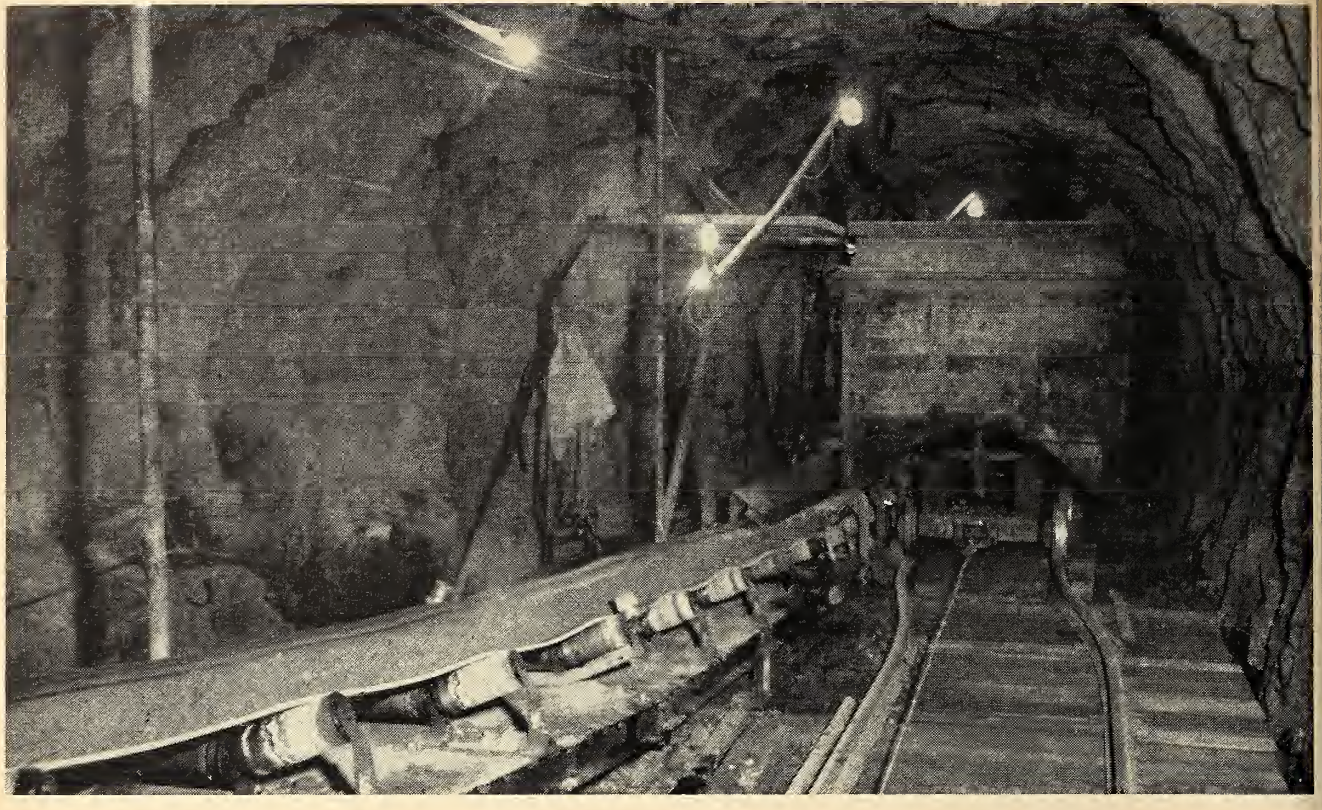


AT SILVER FALLS GENERATING STATION

Concrete Tunnel Lining

Little Dog Lake and Big Dog Lake were connected by a 10,000 foot horizontal tunnel to take advantage of the elevation difference. Associated with the tunnel were two vertical shafts, and a surge shaft joined to the tunnel. Discussed are the concreting problems.

H. A. Jackson, M.E.I.C.,
Construction Manager, Thunder Bay Generating Station, Hydro-Electric Power Commission of Ontario, Fort William.

C. T. Bath,
Office Engineer, Thunder Bay G.S. Hydro-Electrical Power Commission of Ontario, Fort William.

Presented at the 74th E.I.C. Annual General Meeting, Winnipeg, May 1960.

AT SILVER FALLS G.S. a 10,000 ft. horizontal tunnel was driven between Little Dog Lake and Big Dog Lake to by-pass a series of rapids and take advantage of the 350 ft. difference in the elevation of the two lakes in operating a 62,000 hp. turbine in a single unit powerhouse at Little Dog Lake. (Fig. 1).

Associated with the tunnel were two vertical shafts, (A) intake shaft approximately 300 ft. deep with a 90° elbow at the bottom and a 90° elbow and transition section at the top; and (B) surge shaft approximately 200 ft. deep and joined to the tunnel by a reinforced concrete "T" section.

The tunnel and shafts were concreted throughout. Variations from plain concrete were as follows: (Fig. 2.)

1) 336 lineal ft. of steel liner at the powerhouse or portal end, i.e., station 20+00 to 23+36.

2) 174 lineal ft. of reinforced concrete adjoining the steel liner, i.e., station 23+26 to 25+00.

3) 60 lineal ft. of reinforced concrete at the "T" junction with the surge shaft, i.e., station 26+70 to 27+30.

4) 530 lineal ft. of reinforced concrete at the "depression area" where there was rock cover of only 50 ft., i.e., station 100+70 to 106+00.

5) Reinforcing in intake shaft bottom elbow.

6) Reinforcing in intake shaft upper elbow.

7) Reinforcing in surge shaft.

8) 84 lineal ft. of steel liner in the

ɪp portion of the surge shaft.

The tunnel was driven to a nominal iameter of 17 ft. 6 in. and lined with 8 in. of concrete, providing a finhed diameter of 14 ft. 6 in.

The concreting operation was cared out in three distinct operations. ig. 3.)

1) Curbs—starting at the portal nd working in.

2) Invert—starting at the portal nd working in.

3) Arch—starting at the intake and orking out.

Because of the tight schedule in ne tunnel driving and concreting, was decided that the concrete opertion must start while the tunnel riving was in progress. The contruction schedule for the plain conrete allowed 12 weeks for pouring ne curbs, 6 weeks for the invert, and 0 weeks for the arch.

urbs

The work on the curbs started at ne portal when the tunnel driving ad reached the 8,200 ft. mark. The xcavation for the curbs was carried ut by a small gas driven rubber tire ackhoe, complete with scrubber, oading directly into muck cars, with he final cleaning being done by and. Re-usable plywood forms 18 n. in height and in 10 ft. lengths ith steel angle supports were set ccurately to line and grade along ither side of the tunnel. Irregularities between the bottom of the form nd the rock were filled in with in. x 6 in. lumber on end. Concrete was carried into the tunnel in two gasoline driven 8 cu. yd. mixers complete with catalytic scrubber, taken from transit mix trucks and mounted on specially constructed depressed rail cars. The concrete was chuted directly into place from the mixers. Screw anchors, later used to support the invert form, were set in the concrete at 5 ft. intervals and back 6 in. from the face of the curb. As this operation was carried out while the tunnel driving was in progress, concrete could only be poured during the drilling cycle. This meant that the operation extended over a longer period of time than would normally be required. The schedule called for the curb concrete to reach the intake shortly after the tunnel excavation was completed and before the intake shaft raising was complete. This would mean a minimum of lost time between the driving and the invert and arch concreting operations.

Passing tracks were left in position at this stage and gaps were left in the curbs at approximately every third car transfer slash left after the tunnel driving. These slashes were later used for switching cars during the invert clean-up operation.

When the curbs were poured, except in the previously reinforced sections and during the raising of the intake shaft, the "tights" left after the tunnel driving were marked. This was done by a frame moving along the curbs and fitted with radial spring steel feelers. Any tight spots were painted, drilled, and blasted, concurrent with the intake shaft excavation.

Fig. 1. Aerial view showing powerhouse with Big Dog Lake in background.

Invert Clean-up

During the tunnel driving there was approximately 18 in. of loose muck left in the bottom of the tunnel as a bed for the railway track. After the "tights" were removed and the intake shaft raised, the invert was cleaned, starting from the intake and working toward the portal. The rail track was lifted by mucking machine, ties were knocked off and the rails moved on to the curbs for use later in the concreting. A bulldozer was used to push up the muck and loose ties to the mucking machine which loaded this debris in the normal manner into the 6 cu. yd. mine cars. The direction of advance for this operation was opposed to the saw tooth effect caused by the flare of the bottom drills on the jumbo in drilling a 16 ft. round.

Due to ground water leakage and poor drainage created by the flat grade of the tunnel, the bulldozer was always working in a slurry of mud ahead of the final clean-up gang. Pneumatic air syphon pumps kept this to a minimum but at times it did hamper the operation of the bulldozer.

Final clean-up of the invert was done by men with a 2 in. diameter blow pipe working under a canopy. This canopy was on double flanged wheels and was moved by airtuggers along the rails set on the curbs. The canopy afforded protection for the bulldozer operator and those removing the rails. After the invert clean-up was completed and the tunnel meticulously washed, everything was ready to start the invert concrete.

Concreting Bridge

Both invert and arch concrete was placed by a pumpcrete machine. Consideration was given to using a pressweld machine but the engineers feared excess segregation if this method was used.

While the invert clean-up was in progress a mobile bridge was assembled outside the tunnel (Fig. 4) that would carry the two double 200 pumpcrete machines; (one as a spare) a conveyor belt to carry the concrete from the concrete cars to either pumpcrete machine and a passing track to handle full and empty cars. This bridge was 250 ft. long and was used for both invert and arch placing. It was supported on double flanged wheels running on the invert rails and plain wheels running on the concrete curbs. In addi-

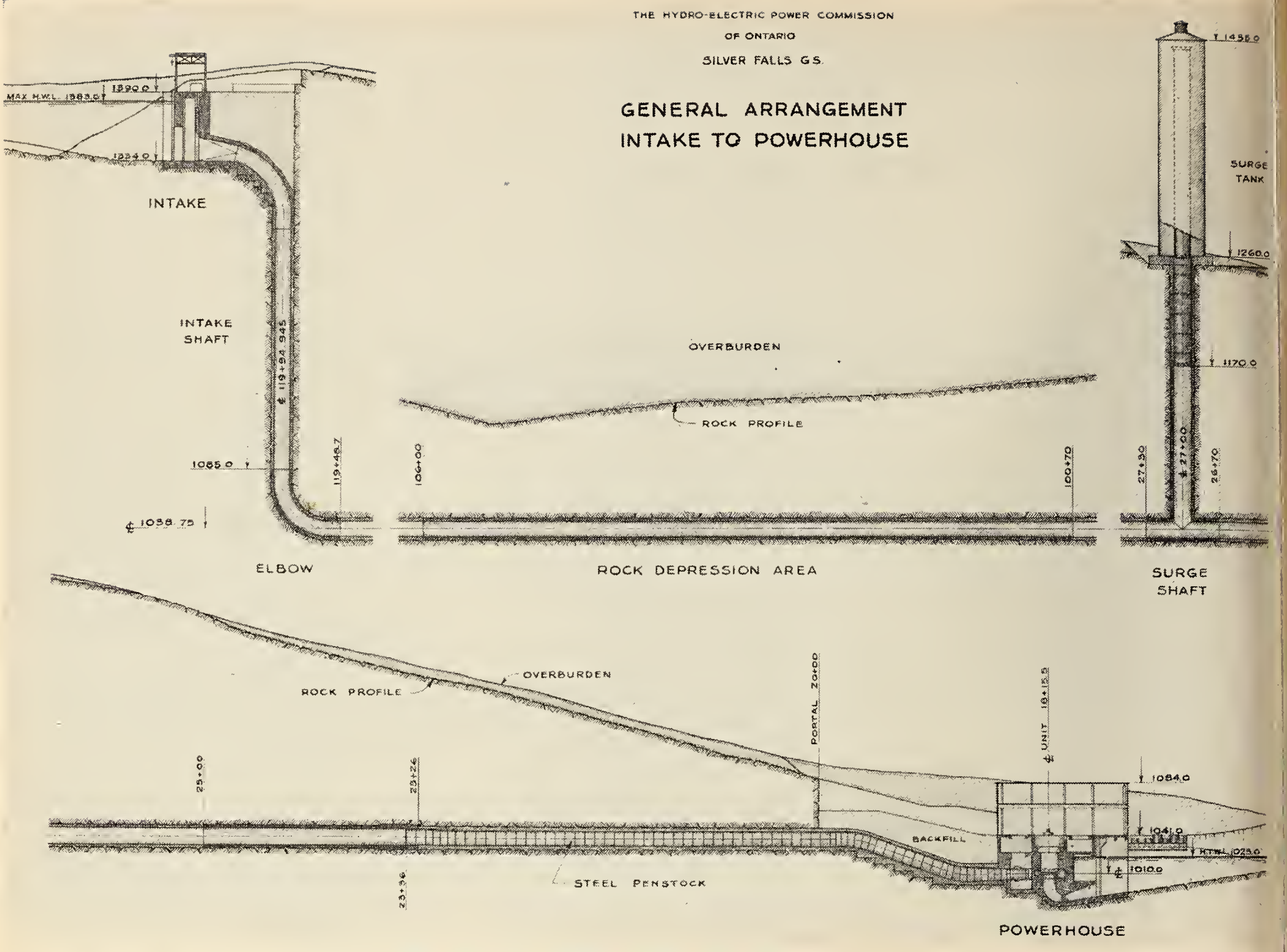


Fig. 2. Cross section of tunnel showing reinforced concrete sections.

tion to the pumpcrete machines the bridge was designed to carry a 15 ton locomotive hauling four 4 cu. yd. cars. The 12 in. diameter wheels were designed for a maximum loading of 24,000 lb. and were set 18 ft. apart. The wheels riding on the curbs were framed in two 12 in. channels, back to back, 20 ft. long. Eight inch wide flanged beams spaced at five ft. intervals along the channels formed a three span continuous support from curb to curb for the 85 lb. rail used on the bridge. An approach ramp, 50 ft. long, carried the trains up the 30 in. from the invert rails onto the bridge.

In placing the invert the concrete had to be pumped far enough ahead so that the concrete would be set up sufficiently hard to re-lay the rails on the poured invert and have them carry the weight of the pumpcrete bridge as it advanced. In order to obtain the scheduled advance of 600 ft. per day it was necessary to have a second bridge 600 ft. long ahead of the pumpcrete machines. (Fig. 5) The end nearest the machines ran on the invert rails while the leading end ran on the curb rails. This section of bridge carried the pumpcrete line and a light railway line and was high enough to clear both forms and screed as it moved along the tunnel. The steel invert forms, 200 lb. each, were removed from the curbs and with the aid of a small winch operated dolly, were loaded on the hand car. The car was then pushed to the forward end of the bridge and the forms man handled from there into their new location.

As the invert concrete hardened the rail was taken from the curb and placed on the invert on 4 in. x 6 in. ties with bevelled ends to fit the circular invert section. To make the transition of curb track loading to invert track loading, an inverted single Bailey bridge 40 ft. long was used. (Fig. 6.) The 30 ft. long rails were picked off the curb and moved into position on the invert under the Bailey bridge by means of small hand hoists attached to the Bailey.

Invert Concrete

The steel invert forms were bolted to the concrete curbs using preset screw anchors, giving a thickness of 15 in. on a radial joint between the edge of the curb and the finished 14 ft. 6 in. tunnel diameter. Twelve hundred lineal feet of forms were purchased (600 ft. each side) allowing them to remain in position 20 hours with four hours for re-positioning. The concrete was deposited in the invert by means of a swivel chute at the end of the pumpcrete line. Particular care had to be taken to ensure that the concrete was tight against the form. The invert was screeded by a 10 ft. long concrete screed riding on flanged wheels on the invert forms. It was found that the screed had to be loaded to a weight of about five tons to be sure it would not ride on top of the concrete free of the forms.

Following the steel screed were the two hand finishing platforms also running on rollers on the invert form. The invert was given a steel trowel finish. The hand finishers also placed screw anchors in the invert concrete 6 in. from the end of each 5 ft. panel, and 6 in. in from the edge. These anchors were used later to hold the arch form in place. Temporary sumps were located at 1,000 ft. intervals and where ground water seepage was occurring.

After the invert was hand finished fibre glass impregnated paper was placed on the centre section. This paper helped prevent droppings from the pumpcrete pipe and later concrete cars, from building up an objectionable roughness on the invert. Paper and droppings were removed during the final clean-up.

The complete bridge was moved ahead by an air operated hoist located at the front end of the bridge using a 1 in. two part line. A steel beam acting as a dead man was jammed between the curbs ahead of the invert forms. It was moved ahead as the work proceeded. The steel screed was either moved by a separate hoist or pulled ahead integral with the bridge. Pouring the plain concrete invert took 18 days with a maximum weekly advance of 3,660 ft.

The invert in the two reinforced sections had to be left out at this time because the reinforcing steel extended 3 ft. above the curb to provide the necessary bond length for the arch reinforcing. This reinforcing would not permit the bridge to advance. In these two sections of invert and the section at the portal where the steel liner was to be installed the rail track was cribbed up to the correct elevation.

Arch Concreting

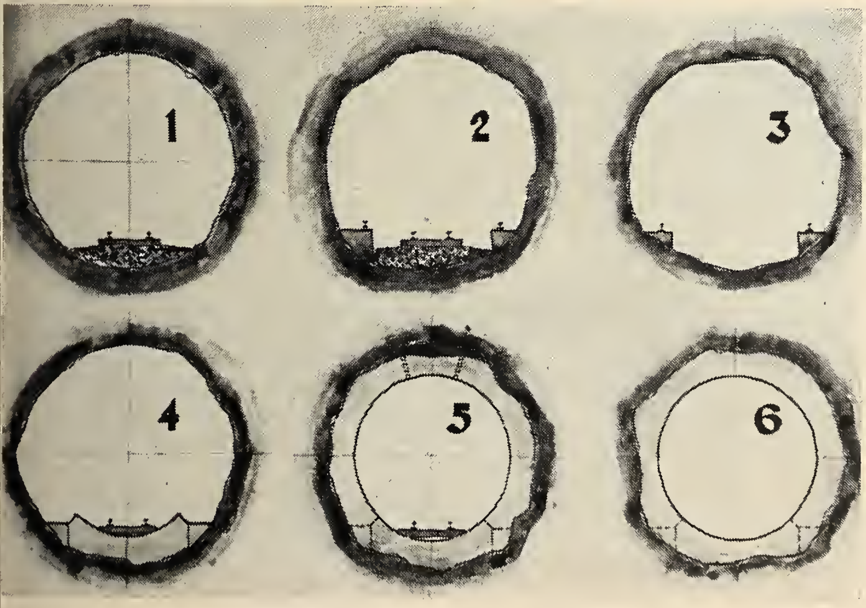
Knowing that we had to complete the arch pour in 10 weeks, a detailed engineering study was carried out to ascertain the method and type of form to be used to accomplish this in the most economical manner. The choice lay between the bulkhead method and the advancing face method. We were limited in our rate of pour to 50 cu. yd. per hour, this being the capacity of the pumpcrete machines.

In the bulkhead method pouring would be for 8 hours at 50 cu. yd. per hour producing an advance of 120 ft. down the tunnel. Steel pins in holes drilled around the rock circumference would brace the bulkhead. After the form was full the concrete would be allowed to set up for 12 hours, then the 120 ft. of form would be moved using a traveller running on the invert rails. The form would be in its new position ready for pouring before starting the next 24 hour period. This would give a daily advance of 120 ft., or 13 weeks to complete the plain concrete section. This method would mean the construction of 78 bulkheads and two shifts involved would only work 12 out of every 16 hours. This would mean paying the men's wages for four hours with very little return.

In the advancing face method, telescoping forms would be used and the pour would run continuously throughout the week with only a shutdown for Sundays. Based on the capacity of the pumps, we could attain a theoretical advance of 360 ft. per day and complete the arch in five weeks. Allowing the concrete to set up for 12 hours as in the bulkhead method, we would have to purchase 300 ft. of telescoping forms. Considering the economics and time allowed, the decision was made to use telescoping forms but only purchase 200 ft. and cut our rate of pour down to approximately 40 cu. yd. per hour.

On completion of the invert concrete, except the sections noted, the forward portion of the bridge ahead of the pumpcrete machine was taken out through the intake shaft and replaced with the arch forms and traveller.

Fig. 3. Tunnel sections showing concreting sequence.



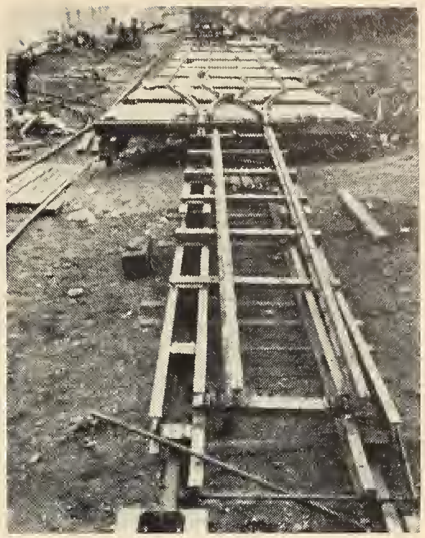


Fig. 4. Concreting bridge assembly showing approach ramp and passing tracks.

The steel arch forms were made up of panels 5 ft. wide with five panels bolted together to make a 25 ft. unit. The panels consisted of one-quarter inch skin plate on steel ribs hinged 6 ft. either side of the centre line so the units could be collapsed and telescoped through the others still in position. To allow for inspection of the sides, trap doors, 18 in. x 24 in. were located 4 ft. above the curb at 10 ft intervals on both sides of the form. To inspect the crown the trap doors were located on alternate sides of the centre line and at 5 ft. intervals. Provision was made in the panels for grout pipe connections.

The traveller used to move the 25 ft. units ran on the invert track and was fitted with vertical and side acting hydraulic rams for aligning the form to the 14 ft. 6 in. diameter circle. (Fig. 7). These rams were independently controlled from a consol incorporated in the front of the traveller. The hydraulic pump was electrically driven and the traveller pulled along the tunnel by an air operated winch. When the forms were correctly aligned they were bolted to the invert by means of the screw anchor bolts and also bolted to the preceding form. All bolting and unbolting was done with large pneumatic wrenches.

As only 200 ft. of form (eight units) had been purchased the concrete temperature and consistency were extremely critical in the placing of the arch. Too high a slump created segregation and made the concrete run too far so that all the forms were in use before the initial unit could be stripped and brought ahead to carry

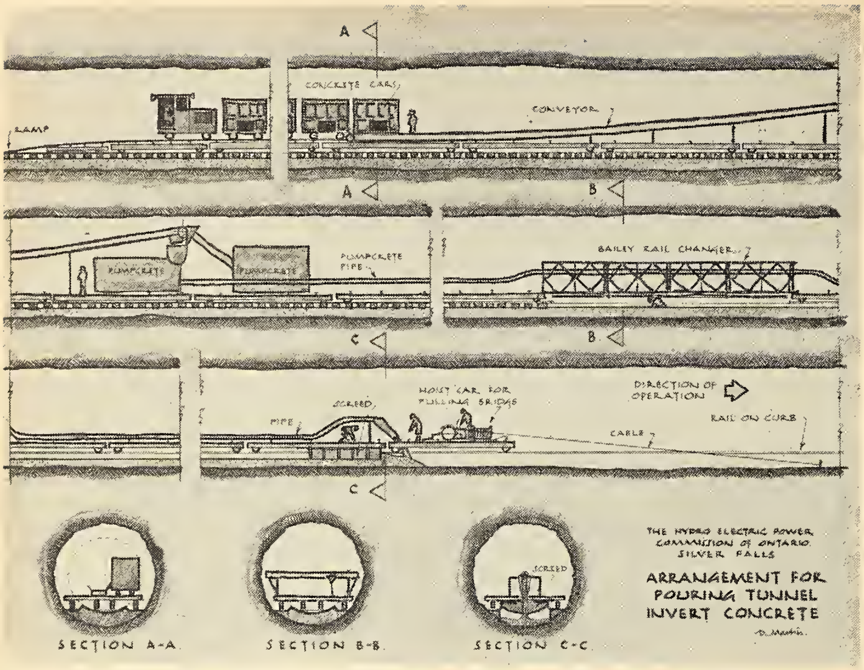


Fig. 5. Concrete bridge ahead of pumpcrete machines with hand car for moving invert forms.

on with the continuous pour. A very stiff mix, on the other hand, made it extremely difficult to force the concrete into all the irregularities of the shoulders and roof.

The pipe from the pumpcrete machine was carried on special cars high enough to support the pipe at a level between the arch form and the roof. (Fig. 8.) The last 250 ft. of line was made up of 8 in. pumpcrete pipe butt welded into a continuous length. This pipe, known as the "slick" line, is normally buried about 10 ft. in the concrete during placing. The arch concrete was started with a single slick line but was changed to a double slick line after the initial 1500 ft. had been poured. This meant there was a pumpcrete line coming off each side of the double 200 machine. Two slick lines afforded greater flexibility in filling voids and also keeping the face advancing uniformly on each side. When the pumpcrete began to labor the whole bridge was pulled ahead by the air operated hoist.

Specifications dictated that at the end of each week a bulkhead had to be set up on the end of the last form. As the arch pour progressed concrete test cylinders were made throughout the 24 hours. Results of these cylinders showed concrete strengths that would allow stripping earlier than the 12 hours specified. Setting up time was gradually decreased until eventually stripping was done after eight hours. Thus, although only 200 ft. of form was purchased, an advance of 300 ft. in 24 hours was ultimately achieved. Our average rate of production for all the plain concrete was 1,550 ft. per week. Once the organization and procedures were firmly established the most critical factor determining the rate of progress was the constant control of the concrete consistency.

The air and water lines used in driving the tunnel were supported on wall brackets and as the arch concrete progressed down the tunnel these services were re-laid on either side of the railway track on the invert. They were later required in the grouting operation.

At the start of the arch pouring we were using a seven bag mix. This produced an undesirable amount of hairline shrinkage cracks as the concrete set up. The mix was progressively dropped to a 6¼ bag, still keeping our stripping time at eight hours. The concrete for the arch left the mixing plant at an average of 64° F. Thermocouples buried 4 in. from the face showed a temperature rise after 24 hours to 90° F. for the 6¼ bag mix. In a further effort to minimize the cracking, fog nozzles were installed following the arch forms. This provided excellent curing for the freshly stripped forms at a lower cost than curing compounds. As the natural movement of air was along the tunnel and up the intake shaft the moisture laden air cured all the arch concrete previously poured.

Reinforced Concrete

After the arch was poured up to the start of the reinforced section in the depression area, 1500 ft. from the intake shaft, the bridge was pulled ahead over the cribbed section and the cribbing and rail track removed. Special slotted invert forms were set up in the same manner as previously described and the invert reinforcing steel placed. The ring steel varied from 1¼ in. diameter at 6 in. centres to ¾ in. diameter bars at 18 in. centres. The concrete bridge was positioned on the portal side of the depression area and the pumpcrete line extended as required to pour the invert. The steel screed was used as before and the invert hand finished.

When the invert concrete had set up, the reinforcing steel for the arch was installed. A complete circle of steel consisted of four bars with each joint having a lap of 30 diameters. As the steel was placed 11 in. back from the finished surface the slick line went between the form and the steel. The bridge remained stationary

Fig. 6. Bailey bridge rail changer.

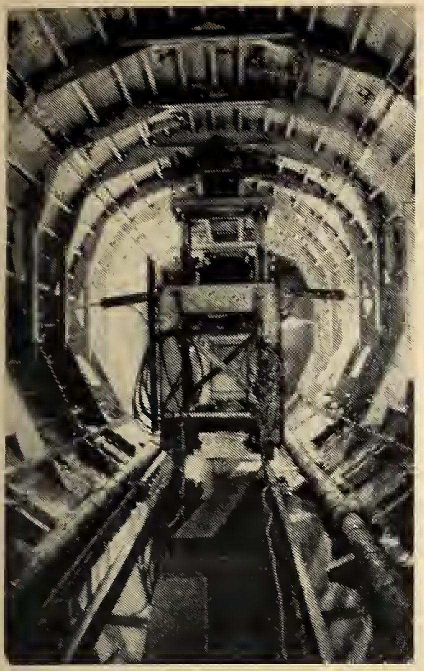


Fig. 7. Arch form and traveller.

for the arch pour in the depression area with the pumpcrete line being shortened as the arch advanced. To be sure that the concrete was forced behind the lapped sections of the reinforcing steel in the arch, a mix using ¾ in. stone was used and placed at a lower temperature. The lower temperature and elimination of the 1½ in. stone made it possible to force the concrete through the reinforcing steel and almost completely fill the arch before any setting up action occurred.

T Section

At the junction of the surge shaft there was a 60 ft. length of tunnel that was heavily reinforced in two layers. Bars, 1⅜ in. diameter, spaced from 6 in. to 15 in. centres and placed 45° to the vertical, formed the two circles; one 6 in. from the face of the form and the other 15 in. from the face. The tunnel in this "T" section was slashed out so that men could get in behind the reinforcing steel with vibrators.

After the reinforcing steel was in place in the invert and the invert poured using the same method as in the depression area, the reinforcing was set up for the arch. In addition to setting up the arch form, the steel forms for the bottom 10 ft. of the shaft had to be installed. These were attached at their top end to previously poured concrete in the shaft and the bottom end cut to intersect the arch forms. The two slick lines went through holes in these forms. As the concrete was poured in the arch the slick lines were withdrawn and the holes closed by sliding doors. Concrete was forced part way up the shaft forms by the slick lines and the remainder of the shaft topped off from doors in the shaft forms. With men in behind the reinforcing steel there was no problem in getting the crown and "T" section full.

Steel Penstock Liner

The steel tunnel liner was delivered to the site in rings 8 ft. long. These rings were assembled in a working area between the powerhouse and tunnel portal and welded together into sections having a maximum length of 70 ft. To move the liner into the tunnel, wheel brackets were welded to the sides of the sections. These were fitted so that the wheels ran on the rails set on the curbs. The sections, when rolled into the tunnel, were jacked into position, shimmed up and welded to the preceding section ready for concreting.

Each section was bulkheaded off 5 ft. from the free end and poured as a unit. The invert concrete was placed first, from one side of the liner, and the arch followed on before the concrete in the invert had a chance to set up and form a cold joint.

Shafts

The intake and surge shafts were concreted from the bottom upwards in 10 ft. lifts using two 5 ft. collapsible steel forms bolted together. The form was held in position by cables attached to rock anchors and aligned by anchors set in the previous pour, and raised to its new position by means of a mine hoist at the surface. In the surge shaft the concrete was placed by a 2 yd. bucket suspended from the hoist. The shaft was reinforced for its full length and in addition had a steel liner for the top 80 ft.

The intake shaft concrete was placed by an 8 in. pumpcrete pipe supported by a vertical cable and terminated in an enclosed hopper just above the forms. This method proved a quicker and safer method of placing. Both shafts were concreted at a rate of 10 ft. per day.

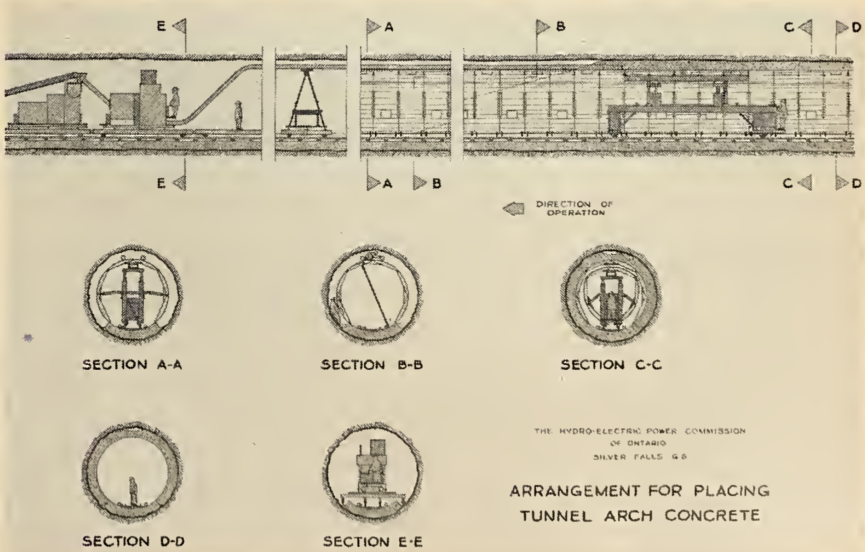
Grouting

The grouting pattern set up was to have one grout hole every 5 ft. throughout the length of the tunnel. The pattern for the holes was 36° to the left of the centre line, then 10° left of centre, next 10° right of centre line, then 36° right of centre, then back to 36° left of centre line and so on down the tunnel.

In the reinforced sections pipe sleeves were set in the concrete where grouting was required. These sleeves had tin cans over the ends next to the rock to prevent concrete from filling the sleeves. In the plain concrete sections, drilling for the grout holes followed as close as practical behind the arch placing. A muck car decked across the top was used as a drilling platform and the holes were drilled using stopper drills with air leg attachments. Grout holes were 1½ in. diameter throughout the tunnel and were drilled 6 in. into rock.

The grouting specifications called for the pressure grouting back of the tunnel lining to be done in two independent operations. The first was a low pressure operation up to 100 p.s.i. primarily to fill all voids around the concrete lining. The grouting could not be started until the concrete lining had been cured for 28 days. Grout mix for this operation was three bags cement, one bag fly ash, 5 cu. ft. sand and 22 gal. of water. The fly ash later was eliminated from this mix and replaced with cement. Connections were made to

Fig. 8. General arrangement drawing of arch placing.



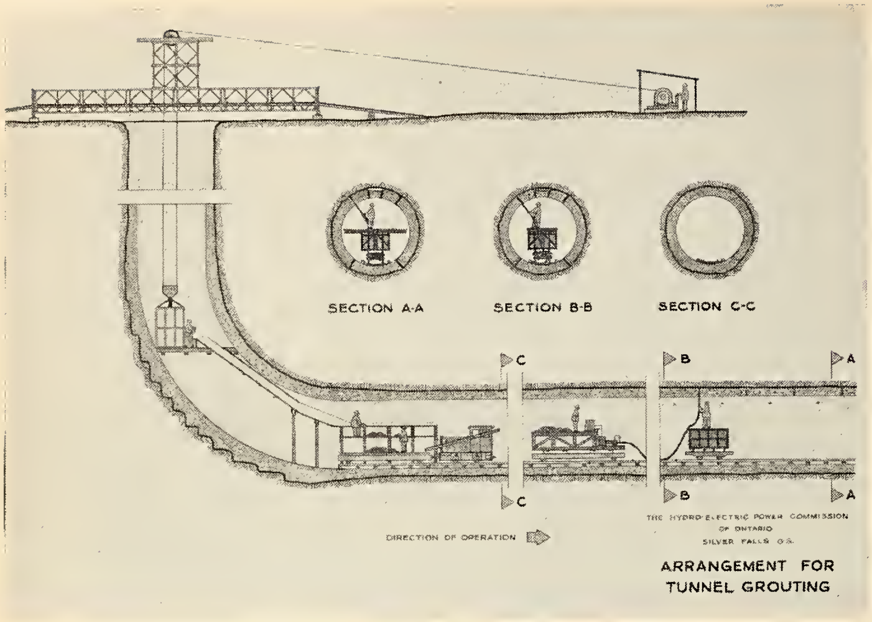


Fig. 9. General arrangement drawing of grouting operation.

all holes in the tunnel except those that vented grout freely within 20 ft. of the hole being pumped. The second operation was high pressure grouting at 150 p.s.i. This was required to fill all small voids remaining over the lining after the first operation. The holes used for low pressure grouting were drilled out and extended 3 ft. into rock. This ensured that any open seams or fractures in the rock were filled with grout. In all, over 14,000 lineal ft. of drilling was required for the grouting operation. No high pressure grouting could be started until the concrete had cured for 90 days. This requirement was later modified to 45 days. The mix used for the high pressure grouting was one bag of cement to 12 gal. of water.

To have the grouting sequence follow right behind the arch concrete it was necessary to lower all the grouting materials into the tunnel by way of the hoist at the intake shaft. (Fig. 9.) The fine sand taken from the blending sand stockpiled at the mixing plant was bagged and trucked to the intake. The sand, cement, and fly ash, all in bags, were man handled into a cage using roller conveyors and lowered onto a platform located at the bottom elbow of the shaft. A wooden chute dropped it down from this platform so that it could be piled on a flat car running on the invert rails. To cover the distance from the shaft to the grouting operation a locomotive was used to pull the loaded flat car. A small electrically operated conveyor was mounted on the side of the locomotive and conveyed the bagged ingredients from the flat car to the grouting platform's top deck.

The grouting equipment was located on a double platform car running on the 36 in. gauge invert track. The top platform had the mixers and material storage, while the lower platform carried the two grout pumps. The mixers fed by gravity into one or the other of the 6 in. pumps. One pump was a standby in case of a breakdown.

The grout was pumped ahead a maximum of 100 ft. through a 1 in. diameter hose and return line. This permitted continuous operation of the grout pump and a minimum of wasted grout while still maintaining a constant pressure. The specifications called for the pumps to have a minimum capacity of 50 gal. per minute at 100 p.s.i. pressure.

In the first 1500 ft. of the tunnel where only one slick line was used it was found that the quantity of low pressure grout required per lineal foot was over double that required per foot for the remainder of the tunnel where the two slick lines were used.

Total quantities used for low pressure grouting were 16,176 bags of sand, 11,411 bags of cement, and 1,574 bags of fly ash. In the high pressure grouting, 1,294 bags of cement were used. The low pressure grouting took 31 days triple shift, while the high pressure grouting took 14 days triple shift. A further pass of water testing was done in any area that accepted much high pressure grout. The same crew did all the operations consecutively. All holes drilled for grouting or testing had to be dry packed before the tunnel was flooded.

General

The concreting and grouting operations in the tunnel were under the supervision of a construction superintendent. He had a shift boss on each shift who was responsible for all operations. A concrete foreman was in charge of the placing and a grout foreman in charge of drilling, grouting and dry packing. Table 1 shows a list of shift personnel.

TABLE 1

Shift Personnel

Classification	*Arch*	*Invert*	*Grouting*
Shift Boss..........	1	1	1
Concrete Foreman...	1	1	—
Locomotive Operators	2	2	1
Brakeman..........	2	2	1
Pumpcrete Operator.	1	1	—
Conveyor Operator..	1	1	—
Oiler..............	1	1	1
Tugger Hoist Operator.........	1	1	—
Pumpman..........	1	1	—
Pipefitter..........	1	1	1
Electrician.........	1	1	1
Rigger............	1	1	—
Carpenter..........	3	4	—
Concrete Worker....	5	8	—
Building Laborer....	2	8	5
Finisher...........	1	3	—
Miner..............	1	3	—
Trackmen..........	2	2	—
Mine Hoist Operator	—	—	1
Cage Tender........	—	—	1
Grout Pump Operator	—	—	1
Grout Foreman.....	—	—	1

The safety record during the concreting and grouting of the tunnel, while not outstanding, did show that no serious injuries were sustained. A total of nine compensable accidents occurred, with the most serious being a dislocated shoulder sustained by a grouting foreman.

The co-operation received from the engineering staff on this work contributed greatly to the efficiency of the operations. The grouting inspectors particularly, gave us much valuable assistance.

TABLE 2

Concrete Materials for 2 cu. yd. Batch in Pounds—Class 3000 p.s.i.

Location	*Theoret. Quantity*	*Actual Quantity*	*Cement*	*W/C*	*Coarse Sand*	*Fine Sand*	*Med. Stone*	*Fine Stone*	*Slump*
Arch......................	30,668	31,582	1,095	.54	2,655	360	2,470	1,495	4 in.
Invert....................	7,750	9,114	1,230	.50	2,550	370	2,290	1,390	2 in.
Curbs.....................	2,606	3,117	1,050	.50	2,440	490	2,360	1,580	3-4 in.

TECHNOLOGICAL HORIZONS

J. W. Hodgins, M.E.I.C.,

Dean of Engineering, McMaster University, Hamilton.

From a talk presented at Hamilton, Ont., February 1960.

The horizons of technology stretch to the past and extend to the future. The vista is so great that it is difficult to set limits to such a discussion. Considered are three broad quests of man: for materials, for energy, and for a method of communication.

THE TITLE "Technological Horizons", may veer rather widely from the precision and terseness of definition which is supposed to be the hallmark of the scientist and engineer. Technological, of course, in the modern idiom, has the rather specific meaning of "applied science", and on definition of horizon is "limit of mental perception and experience". And since a horizon extends behind as well as ahead, for sheer presumptuousness at least, my title can hardly be surpassed.

Since it is probable that my audience represents a fairly broad spectrum of scientific sophistication, I must tread carefully between the Scylla of boring my technological colleagues with elementary science, and the Charybdis of losing students of the humanities in technical jargon, and this presents quite a problem. So I thought I would contemplate briefly the route along which we have come, and the elusive path which lies ahead as we proceed through our technological evolution. The difficulty with such a broad vista is to know where to start and in what direction to proceed. One is tempted to draw a poetic analogy about being lost at high noon in a forest. But here the analogy is false. For as one looks behind, the trees are increasingly sparse as the distance extends, while ahead their density increases almost exponentially. As engineers, we spend our entire careers as custodians and purveyors of materials, and energy, and information, and these three topics may very well serve as the basis for this discussion, for contemplation of them has suggested some rather strange inconsistencies. It is appropriate, too, to consider them in this order, for it was in this order that man's needs arose: first for materials to feed, clothe, and house him, then for energy to heat him, perform his work, and provide his transportation, and finally for a method of collating and communicating the vast store of knowledge which his active mind was discovering and inventing.

Man's quest for materials began far back in the mists of antiquity. Although our dental and digestive equipment are more appropriate to herbivorous diet, it is likely that our precursors on this planet took to eating flesh in times of drought. With his inadequate physical equipment, the first deliberate consideration of materials by the proto-man, was that of hand-weapons for killing of food. By the time the species had evolved into tool-makers, man was largely carnivorous—quantities of meat bones were associated with the remains of Pekin-man. His carnivorous habits were probably the cause of short-circuiting the extremely slow process of evolutionary bodily alteration in response to environmental change. By inventing extra-bodily equipment such as weapons, tools, shelter, and clothing which could be changed or discarded as circumstances dictated, man became the most adaptable of all creatures. The spread of tool-making skill, the ability to evolve, communicate, and perpetuate inventive ideas, and thus institute a tradition of manual skill and intellectual attainment has of course differentiated the development of our species from that of other animals whose power to evolve tradition is so limited. Whether or not this characteristic is the result of a series of random events of vanishingly small probability provides the basis for the current arguments raging on the possibility of intelligent animal life on the neighboring planets. Perhaps the argument will be settled within our generation.

The slow development of tools and weapons accounts for the passage of thousands of years in man's early history. Although a carnivore, he had not yet become a food producer, but remained a food hunter, and generation succeeded generation without any significant development in his methods. Everyone was a primitive tool artificer, a hunter, and a savage. There were, in other words, no specialists. In this sense, then, men have been savage for 95% of the lifespan of humanity. Only in the last 50 centuries has there been a division of activity by function—technology really dates from about 3000 B.C., when the idea of deliberate cultivation of food took hold. The first barbaric industry was born with the realization that a planned food surplus made life much easier and indeed, much more predictable. Since this surplus could support a full-time specialist who grew little food, but who would, for example, barter his primitive tools for it, the first differentiation of occupation had its beginning. Metal workers, specifically workers of copper were the first full-time industrial specialists.

Copper was the earliest useful metal, far more important than gold or silver. Its technology is an example of the enormous influence exerted by chemistry in moulding our lives, for although they did not know it, copper became useful in the late Neolithic Age because copper oxide has a rather low free energy of formation. Because of this, native copper could occasionally be found, and its malleability and ductility recommended it to the primitive metal workers. Moreover, the brilliantly-coloured oxides and sulfides of copper are easily roasted and reduced, and accidentally the annealing by heat was discovered.

And so the metal age started—some 20,000 tons of copper were produced between 1300 and 800 B.C., and alloys were fairly common (although usually an accident of the ore composition). Iron, whose oxide has a heat of formation nearly twice that of copper, was brought into use much later—about 1200 B.C. Its ores were widely distributed and the tools were cheaper and much more efficient than those of bronze. It made possible clearing of forests, drainage of marshes, and greatly improved cultivation. It was the democratic metal and greatly augmented man's arsenal of equipment for dealing with the forces of nature.

The materials used for man's dwellings have been profoundly influenced by both geography and geology, and it is thus impossible to treat the ancient world as a single unit. Large complex stone and brick structures were common in 3000 B.C. in Mesopotamia, some of them employing arch construction. Those of us who cope with that hallmark of suburbia, the septic tank, can contemplate the fact that 4000 years ago central sewers were fairly common in Persia. Some structural defects are surprising, particularly in Egypt, where without wheeled vehicles, they transported stone weighing over 2 million pounds regularly over large distances. They were most inconsistent in their foundation preparation, and frequently erected their gigantic structures on sand beds, or random rubble. And despite their great ingenuity at handling material the idea of squaring his stones before building, or even that geometrically prismatic blocks would be useful, seems to have eluded the early Egyptian stonemason.

The other material essential to any concentration of civilization is, of course, water, for irrigation, for human and animal consumption, and for sanitation, and great ingenuity was exhibited in earlier times to provide for the pumping, the storage, and transportation of water. The earliest engineered tunnels were engendered by the habit in Palestine and Arabia of creating an underground storage reservoir in the rock, connected to the citadel by stepped tunnels, often a half-mile long. But it was the conduction of water over long distances that brought civil engineering to a surprisingly advanced state 3000 years ago. The great aqueduct built by Sennacherib in 691 B.C. brought water from a tributary of the Greater Zab River to Ninevah, 50 miles distant. Wide as a highway, it was made of stone quarried near the beginning of the canal, and transported on wheels down the dry channel. The project, which involved the transportation of over 2 million blocks of limestone an average distance of at least 10 miles, was completed in 15 months. Obviously Sennacherib had better control of his labor force than any modern contractor. The bed of this canal showed considerable technical sophistication—concrete floated in bitumen, laid to a fall of 1/80 with astonishing accuracy which would put to shame some drain lines I have seen recently. In Rome at the time of Christ, Frontinus, the land surveyor, and water commissioner, recorded in splendid detail the engineering detail of the wonderful aqueduct system which daily conducted to Rome 300 million gallons—six times the average pumpage to this city.

By the time of Christ, then, the use of natural materials and the technology of building and elementary metallurgy were reasonably well developed. During the next 19 centuries, technology in the use of materials, in the production of alloys, and in the refinements of process metallurgy proceeded at an accelerated pace. But it is in this past half century – this minute 0.5% of our technological history, that materials have really come under our control. Since the turn of the century we have become increasingly the inventors, rather than the adapters, of materials. We are starting to have more than a glimmering of the chemistry and the physics of gases, liquids, and solids, and with the knowledge has come the ability to synthesize the properties we desire. This is what is different about this particular era in which we live—we are beginning to be able to produce a material to meet the requirements of a particular application, sometimes a material which never had a counterpart in nature.

Why are we so rapidly gaining confidence and sophistication with regard to the materials we need? Not merely because of the great wealth of information which increases almost exponentially. It is far less a random process than that. The main reason is that for the last two decades, science and technology have been combining their forces to answer the general question, "Why do materials behave as they do?" It is the realization that the properties of gases, solids and liquids are to be explained, in that microcosmic world of atomic structure, impurity content, crystal defects, and force fields. We are beginning to know why a material is viscous, or sticky, or hard, or shiny, why it does or does not conduct electricity or heat, how its properties will change with temperature, or electric field, or pressure.

The physical state which is simplest to explain and therefore elucidated earliest is the gas. A great deal was known about the behavior of gases 20 years ago. Since World War II (a time element amounting to 0.4% of our technological history) great attention has been focussed upon the next simplest physical state—the solid. Our solid state physicists, by applying the principles of quantum mechanics are providing a fundamental basis for our understanding of solids, and engineers have been quick to follow conception by technological application. Engineers unabashedly worry nowadays about what the atoms are doing. It is becoming commonplace for them to engage in what Professor von Hippel calls "molecular engineering". This gives the engineer a true spiritual connection to modern science—a partnership and a new freedom of action. He can conceive devices based upon ideal characteristics and then back in the laboratory inquire to what extent such properties can be made to order. It is symptomatic of these trends that new engineering curricula (such as that at McMaster University) have courses in "Properties of Materials", replacing the conventional metallurgy courses.

Probably the most spectacular solid state progress at present is in the field of semi conductors—a development of new and radical concepts. It truly has developed from nothing, for its genesis was the realization of the principles of the flow of holes in certain solids. The transistor is making possible striking reduction of power requirements and size, and spectacular improvements in the physical ruggedness of electronic equipment. The thermistor enables us to measure small temperature differences with startling sensitivity. New synthetic ferrites are revolutionizing the storage of information in computer cores or on tape. Crystals can now be grown artificially for optical, electrical, and cutting purposes. Polymer chemicals are developing plastics and elastomers as quickly as the requirement develops.

The scientist and the engineer are custodians of energy, and the next generation will become increasingly aware of this fact. As global society became more complex, so did the demand for energy increase—first to heat living space and to cook food, then to perform work for production and transportation. Since the first fire was kindled, our civilization has employed the legacy of energy emanating from our sun, and only a trivial fraction of our global energy supply has had any origin other than solar. For us, the most important chemical reaction in the world is the wonderful one:

$$CO_2 + H_2O \overset{h\nu}{\rightarrow} O_2 + C(H_2O)_n$$

This is the photosynthetic reaction, and represents the start of the synthesis of the food we eat, the fuel we burn, and the oxygen we breathe. After decades of research we are just starting to get a few glimmerings of the mechanism of this reaction. Its full elucidation may represent as important a technological renaissance as the utilization of the knowledge that matter and energy are related by a fairly simple mathematical equation. Why should such an innocent-looking chemical equation be so difficult to interpret? Why is its understanding so important? What applications might result from our ability to reproduce this reaction in the laboratory?

This short equation represents a monstrous simplification of the process involved when energy, in the form of sunlight, causes the combination of carbon dioxide in our atmosphere with water vapour, catalysed by the magnesium-organic constituent of green plants, chlorophyll. And what is wonderful about it is this:

Nature has found a way of storing pulses of energy until enough have accumulated to perform a chemical reaction. In order to cause carbon dioxide to combine to form one molecular weight of a simple sugar, 672 kilocalories of energy are required. Sunlight reaching the surface of the earth has an average energy equivalent only to about 312 kilocalories. And yet, wrapped up in the mystery of the chemistry of every blade of grass there is the ability to receive one burst of energy, then a second, and then even a third, and combine them to make available the little chemical reaction which makes it possible for us to continue living. This same reaction caused to grow the giant trees, which over geological time underwent chemical degradation, and stored the energy lavished millions of years ago as coal. Our petroleum came from a marine population whose life was sustained by sunlight's agency, which accumulated in the earth's wrinkles, in an endless rain through the silent ocean depths. It, too, is stored sunshine. Even our hydro-electric power, originates from water raised from one spot and deposited in another in probably our largest thermodynamic cycle—solar distillation.

Some of my engineering students will certainly have to cope with the problem of the source of energy as our irreplaceable fossil fuels become steadily more difficult to obtain economically.

One index of the development of a civilized society is the rate at which it consumes energy, and ours is gobbling up our reserves at a rate which is accelerating frighteningly. And the source of almost all of this energy is the fossil fuels—our irreplaceable legacy set aside over several million years of plant and sea animal growth, of anerobic oxidation, of conversion to complex hydrocarbon chemicals. It is hard to imagine at a period when gasoline is slightly cheaper than distilled water, that within the careers of my engineering students, world-wide study will have to be focussed on quite different patterns of energy distribution. The phrase which leaps to mind, of course, is "nuclear power" —which has developed from the first reasonable theory of the atom to those giant installations at Windscale and Calder Hall in a brief 40 years— 0.8% of our technological history. Surely from a development so spectacular, one can expect a practicable replacement for the energy we are so diligently dissipating as carbon dioxide into our urban atmospheres.

If the answer lies in power developed by the fission process—and this is at present the only practicable way to realize useful work from nuclear processes—there are two ancillary problems which loom very large indeed on our technological horizon, and to which great attention will have to be paid.

The first of these is the disposal of radioactive wastes from the power plant—already creating concern although nuclear power now supplies a negligible proportion of our requirement. If all of the electrical energy in the world were generated by nuclear fission it would be necessary to dispose of radioactivity equal to that resulting from the explosion of 200,000 medium sized atomic bombs per year! The second problem of major proportions is concerned with the distribution of the energy derived from nuclear reaction. It seems to be generally assumed that nuclear power will be distributed in the form of electricity—what other form of conduction is so convenient and rapid as that of the peripatetic electron? But it is all too infrequently pointed out that although we in Canada are fairly elaborately electrified, only about 15% of our total energy consumption is electrical! The other 85%, used for space heating, steam generation and surface transport is still derived from fossil fuels. If we do have to make a change, then, to complete electrification, an entirely new form of distribution grid would have to be devised —our present distribution network would be totally inadequate.

On our sun at a possible temperature of 50 million degrees Centigrade the fusion of hydrogen atoms proceeds, yielding helium and an attendant release of nuclear energy. One estimate is that 1000 billion pounds of hydrogen have been consumed this way every second since the beginning of time. It is inevitable that one of the most eagerly pursued researches of our era is the domesticating of the fusion reaction —the rendering docile of that awesome force which holds our populations in a state of trembling peace. The benign fusion reaction would have the great advantage that the problem of disposal of radioactive waste is negligible, and the supply of raw material is vast. Since the problem of distribution is difficult, but soluble, if the energy Utopia does arrive, it will probably be through the agency of atomic fusion. I still wistfully hope that the dark horse in the race will make a showing, that some quiet chemist will unravel the secret of the blade of grass, and learn how to store energy in a chemical system—upgrade it in potential, as it were. I hope he will learn to make an artificial chloroplast, so we may learn to collect and utilize the solar radiation which delivers more than 4000 horsepower to every sunny acre on our planet.

The third legacy of which we are all custodians and dispensers is information in its broadest sense, and in step with materials and energy, the accumulation, application, and processing of information have proceeded at a blinding pace. I am not going to quote statistics to prove how technical knowledge has proliferated; it has now become impossible for a single worker in certain fields to read all of the developments in his specialty, even if he ceased to be an active contributor and devoted all of his time to perusal of the literature. But this statement must not be construed to indicate that specialization must of necessity become more and more narrow. Far from it—great generalizations are beginning to appear in engineering which makes it draw closer to science—our engineer now must be more of a scientist than ever before. He must act as a translator, an inventor, and an expediter, ready to recognize the significance of modern scientific achievement, and apply it to the development of a process, a machine, or a structure.

It is entirely natural that the same ingenuity which provides this staggering wealth of scientific philosophy and technological data, has also developed elegant techniques for filing, and assembling, and processing these same data. In the trifling time of about a decade, it has become a commonplace in the laboratory to hear "I'll run it through the computer", or "See what the machine says". And we are becoming quite blase about hearing about aircraft, or distillation columns, or transformer, or control systems which have been designed by reference to some physical or electrical analogue device. Strangely enough, electronic computation demands not less, but more sophistication on the part of the engineer. The modern engineer must be a better mathematician than before, to realize both the striking advantages and the shortcomings of the electronic computer. He must be made aware that while a decade ago, his solutions of complex equations might grind to a halt because of the intractability of the mathematical expression, he now has a powerful tool for extracting answers from data which do not respond at all to traditional mathematical techniques. And he can solve problems, aided by the blinding speed which is a property of the electron, which hitherto were unattainable because of the limitations of time. This sudden burgeoning of electronic digital and analogue devices for solving of complex and tedious mathematical problems has, in one sense extended the imaginative horizons of our original thinkers, for they do not bog down in a morass of heartbreaking mathematical drudgery. They can see beyond, in the knowledge that the limitation is not physical or emotional stamina, but insight and ingenuity. But it has posed a problem for us academicians. In addition to bringing our engineers into the state of mind where mathematics is a friendly language and not a necessary evil, it has become our responsibility to make them at home in the field of applied mathematics. They must become aware at university of the total scope of the tools at their disposal, and numerical analysis is one of the most powerful. Our engineering schools in Canada are not, I think, sufficiently alert to this great opportunity, and indeed, it may be time to re-examine the entire mathematical program to assure ourselves that suitable balance is achieved between mathematical philosophy and our awareness of "mathematical hardware". I am aware that this can be misconstrued as a plea for less rigor and more empiricism, but can only repeat that the machine's excellence lies in its diligence, not its brilliance; it will always remain less intelligent than the man who directs its activities.

I have not presumed to demonstrate to those of you who are not scientists or engineers the fine philosophical development of our disciplines, for this has been done eloquently by far more qualified spokesmen. But the philosophy is there, and because of the technique of experiment which maintains balance between thought and action, is subject to checking at such frequency, that as Oppenheimer says, complacency can only be counted upon until the next issue of the journals. Nor do I want to pursue the discussion of the responsibility of the scientist for the sociological aftermaths of his discoveries. As Dr. Steacie once suggested, even the inventor of the milk bottle may be culpable, for a milk bottle does make a splendid weapon in hand-to-hand combat. But it may be worthwhile to ponder for a moment or two our horizons ahead, for the developments are going to continue to multiply as our understanding and control of our physical world becomes more and more sophisticated. Dr. Conant said, "Through many advances gained by science we may hope that as never before man may be free—free from want. But science alone, untempered by other knowledge can lead not to freedom but to slavery. At the root of the relation between science and society must lie a proper educational concept of the interconnection of our new scientific knowledge and our old humanistic studies."

It is in the adjustment of our society to our constantly changing background of technology that the inconsistencies I mentioned earlier seem so striking. Our human philosophies have lagged far, far behind our scientific ones, so that we stand confronted with one of the great ironies of history—the possibility, indeed the frantic hope that an agent of destruction will finally bring to us what thousands of years of philosophy have failed to do—global peace, ensured not by brotherhood, but by terror. Alfred Nobel's wish may finally be granted, that "A substance be produced of such frightful efficacy for wholesale destruction that it will make wars impossible." But whatever the reason, it allows room for the hope expressed by Oppenheimer for "a world to be united in law, in common understanding, in common humanity, before a common peril".

And so many other inconsistencies persist—much less basic than the threat to our survival, but strange in our modern scientific age, nonetheless. Our "way of life", replete with labour-saving gadgetry, has been achieved at a considerable cost in graciousness. It is indeed incongruous to contemplate our citizens in homes of consumate comfort, living in forests of overhead wiring, breathing atmospheres frequently polluted, unable to swim in the waters which lap the shores. Our insistence upon personal transportation has brought chaos to public transportation, and the leisure time created by extensive mechanization is causing a general relaxing of our sense of purpose and general propriety.

We are gathered on a campus where no amount of engineering ingenuity can now compensate for the losses incurred by a completely obsolete means of arriving at the price attached to the sale of labour services. The severe work stoppages on this continent have nullified millions of man-hours of engineering skill in the past year.

I wish to quote Mr. George F. Kennan, an historian and now at Princeton's Institute for Advanced Study, speaking about the United States, but his words ring fairly true for Canada as well:

"If you ask me—as an historian, let us say, whether a country in the state this country is in today; with no highly developed sense of national purpose, with the overwhelming accent of life on personal comfort and amusement, with a dearth of public services and a surfeit of privately sold gadgetry, with a chaotic transportation system, with its great urban area being gradually disintegrated by the switch to motor transportation, with an educational system where quality has been extensively sacrificed to quantity, and with insufficient social discipline even to keep its major industries functioning without grievous interruptions—if you ask me whether such a country has, over the long run, good chances of competing with a purposeful, serious, and disciplined society such as that of the Soviet Union, I must say the answer is 'no'."

I want to end by repeating one of my own effusions: "The scientist, the engineer, the historian, the sociologist, the psychologist and the economist must contribute as a team to the decisions of the future if we are to proceed rationally along this elusive path we tread. This presents a striking challenge to all of the disciplines, the challenge of re-establishing communication among the components of what was once a single philosophy." EIC

Winter Water Temperatures and Ice Prevention by Air Bubbling

G. P. Williams, M.E.I.C.
Research Officer, Division of Building Research,
National Research Council of Canada, Ottawa

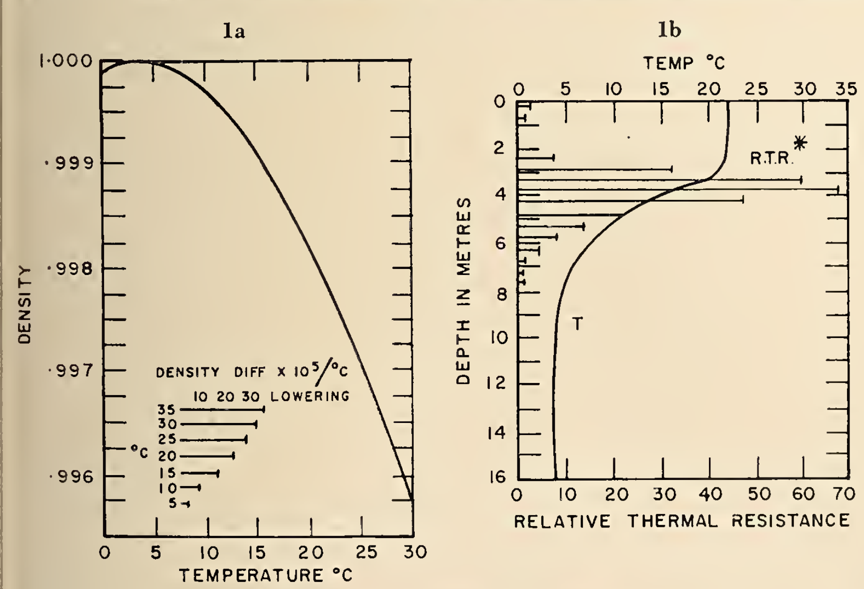
While much information is available concerning the prevention of ice formation by the use of an air bubbling system, apparently there has been no paper which summarizes this information. This report has been prepared primarily to be used by field engineers.

CONSIDERABLE interest has developed recently in Canada in the prevention of ice formation by the use of air bubbling systems. Although compressed air jets have been used to prevent ice formation for many years,[1] there has been apparently no paper which summarizes completely the information available. This report has therefore been prepared to present the essential technical information now available on air bubbling systems. It is designed primarily for field engineers, who are interested in the use of air bubbling systems but have not yet had an opportunity of investigating their application in detail.

Air bubbling systems depend on the fact that sub-surface warm water can be brought to the surface by rising air bubbles and thus used to prevent surface ice formation at specific locations. In order to plan an efficient air bubbling system, information is therefore required on the amount of heat available in a water mass. The amount of this thermal reserve can be estimated if water temperatures are known. Information on water temperatures and the factors which affect them are not generally available to Canadian engineers, so that it is a further purpose of this report to outline briefly the factors which govern water temperature, and to present some typical observations of water temperatures under winter conditions.

Fig. 1a. Density as a function of temperature and density difference per degree C lowering for distilled water.

Fig. 1b. A typical summer temperature profile and associated resistance to mixing.[2]



*1 R.T.R. = 8 x 10^{-6} i.e. the density difference between water at 5°C and 4°C for columns of water 0.5 metres long.

Water Temperatures in Lakes

The temperature of lake water is largely controlled by the process of convectional overturning of water from the surface to the bottom of the lake. The fact that fresh water has its maximum density at 39.2°F affects the circulation and the resulting temperature pattern markedly. Fig. 1a shows density as a function of temperature for distilled water as obtained from a recent paper by Vallentyne.[2] The density difference per degree centigrade change of temperature for water at different temperatures is shown in the lower part of Fig. 1a. Vallentyne stresses that in order to mix fluids physical work must be done and, other factors being constant, that the amount of work is proportional to the density gradient in the fluid. As an example he states that "Forty times as much work is required to mix layered water masses at 30° and 29° as the same masses at 5° and 4°, because the density difference is approximately forty times greater."

Vallentyne analyzed the typical lake temperature profile shown in Fig. 1b. He divided the temperature curve into ½ metre intervals and, from the dependence of the density on temperature, obtained the density at the top and bottom of each interval. He defined one unit of relative thermal resistance as the resistance to mixing offered by a ½ metre column of water with a temperature of 5°C at the top and 4°C at the bottom. By calculating the density differences between the top and the bottom of the ½

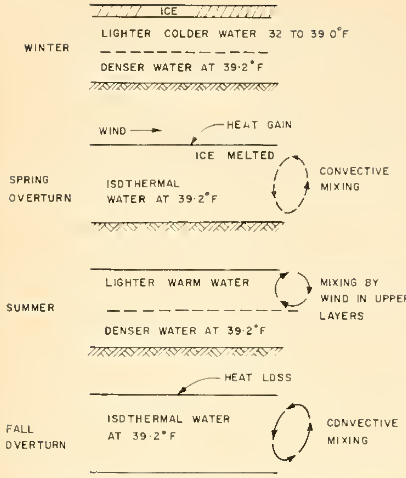


Fig. 2. Annual temperature cycle illustrated for a deep lake in the temperate zone.

metre intervals and comparing them with the standard, he then calculated for each interval the relative thermal resistance to mixing. The results of his calculations are shown in Fig. 1b. It may be seen that a slight increase in temperature difference in the warm water at the surface results in a large increase in the resistance to mixing.

Fig. 2 illustrates annual temperature changes in a typical deep lake. The water temperature of lakes is so markedly influenced by the process of convective heat transfer that it has been used as a basis of classification for fresh water lakes. Horton[3] divided lakes into three basic types:

(i) polar — surface temperature always below 39.2°F

(ii) temperate—surface temperature alternating above and below 39.2°F

(iii) tropical — never below 39.2°F.

He further divided the lakes into three classes according to depth: the first order 200 ft. and greater, second order 25 to 200 ft. and the third order 25 ft. and less.

In Canada most lakes of interest can be classed as temperate. In this type, with a first order lake, there are usually two turnover periods, in the spring and fall (Fig. 2). A second order lake, of depth 25 to 200 ft., also has two marked overturn periods in the fall and spring, but often in the summer there is complete mixing to the bottom, and in the winter the water on the bottom of the lake can cool below 39.2°F. A third order or shallow lake will have complete circulation at all seasons except when the surface is frozen. Brewer[4] indicates that water in a shallow lake at Barrow, Alaska, was essentially isothermal at any time during the ice free period. Fig. 3 illustrates the convective mixing of a shallow body of water during a period of cooling. These measurements made by the author illustrate that water remains essentially isothermal as long as the surface temperature is above 4.0°C (39.2°F).

Although water in third order lakes is generally isothermal during the ice free period, there are exceptions to this rule. Vallentyne[2] reports that, for a certain lake in Washington State, the density difference between the surface and bottom water is so great that the wind is unable to induce complete mixing, even though the lake is only three metres deep. The density difference is caused by large amounts of dissolved Epsom salts.

The importance of depth in studying the thermal regime of lakes cannot be overemphasized. Lebedev[5] states that "In the majority of cases the range of the lake heat budget is determined by the mean depth". In Sweden Melin[6] made some temperature measurements on Lake Kallsjön, which consists of three separate basins of different depths, connected by narrow shallow passages. He concluded that in thermal respects each basin could be classified as a separate lake. The shallow basin warmed more rapidly in the spring and cooled more rapidly in the fall, and the water temperature reached higher temperatures in the summer than in the other basins at corresponding depths.

In a lake considerable mixing can be caused by wind action. Brett[7] states that for Lakelse Lake, B.C., heavy winds tend to keep the greater part of the lake in circulation during the summer; and Kuenen[8] suggests that wind can keep an air hole open in a frozen lake by including a circulation in the water which brings warm water to the surface. He also suggests

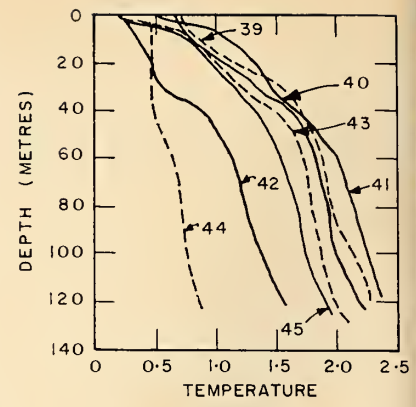


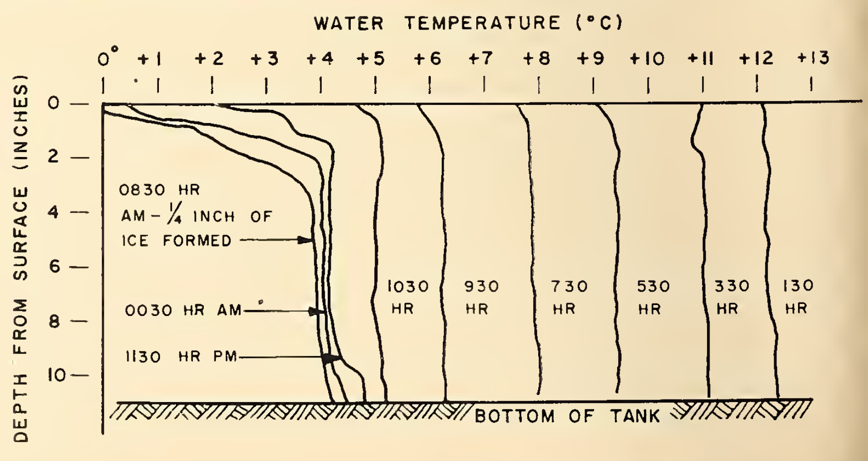
Fig. 4. Variations of water temperature with depth in the northernmost part of Lake Kallsjon, Sweden in March 1939 to 1945. Lowest water temperature observed during warm winter. Winter temperature of water in deep lakes is dependent on factors other than winter air temperature.[10]

that in freezing weather an air hole can be made larger by wind circulation, as the edge of the ice melts when warmer water is brought to the surface by wind action.

One major factor in determining water temperature is the heat flowing into or out of a specified area because of different water currents. Rauson[9] in a study of water temperatures in Great Slave Lake indicates the variation in water temperatures that can be caused by inflow from a large river.

It is not always appreciated that the winter water temperature of a lake shows considerable variation when observations are taken at the same time in different years. Fig. 4 shows the variation of water temperature with depth in lake Kallsjön, Sweden, for different years. Melin[10] noted that the mean winter temperature of lake water did not necessarily depend on the mean air temperature. According to his report the coldest

Fig. 3. Temperature variations in shallow pool of water subject to cooling conditions. Feb. 17, 1959, Ottawa.



water temperatures were observed during a comparatively warm winter.

Fig. 5 illustrates the gradual water temperature changes underneath the ice cover of a small pond in the Ottawa area measured by the author during 1957-58. At this particular site, the water at the bottom of the pond did not reach its maximum density until mid-February, although it should be noted that in late December a mild spell reduced the thickness of ice cover and appeared to increase the water temperature appreciably.

Fig. 6 shows some water temperature profiles under ice covers in small lakes obtained by the author in the Ottawa area. These are more typical of conditions in this region and may be compared with water temperature profiles taken in several lakes in north Sweden by Melin.[10] The lakes in the Ottawa area may be classed as third order or shallow lakes, whereas the lakes in Sweden may be classed as second order lakes.

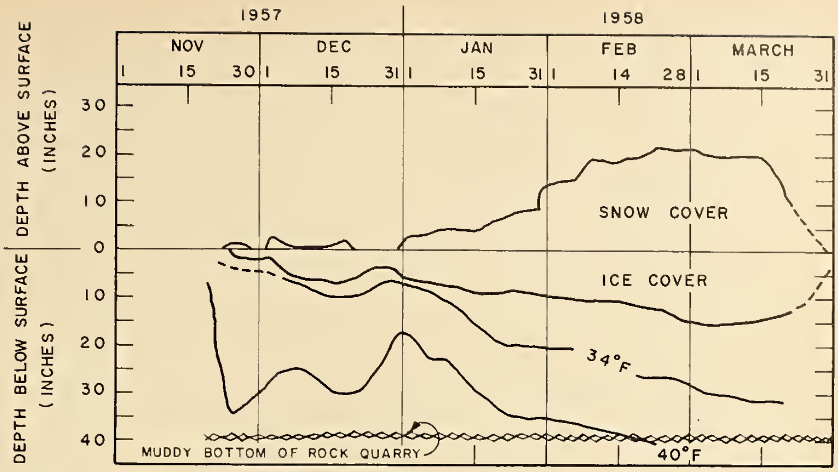


Fig. 5. Temperature variations under small ice covered pond — NRC grounds, Ottawa.

River Water Temperatures

In rivers the water mass is kept at nearly the same temperature by mixing. Thus an ice cover will not start to form until the temperature of the whole mass of river water is close to 32°F. Fig. 7 shows some typical water temperature profiles taken by the author in the Ottawa area in March, 1959. Even in Lake Temiskaming, a wide part of the Ottawa river where the flow velocities must be very low, there was sufficient mixing to prevent an appreciable temperature gradient from developing.

It is obvious that in rivers the heat inflow from upstream sources must have an important effect on the water temperatures at a particular site. For example, Cousineau[11] states that the water temperature at a particular section of Bersimis River never dropped to freezing point although this river is subject to fairly extreme winter cooling conditions.

TABLE 1

Summary of Air Bubbling Systems Reported in the Literature

Place	*Size of Hole*	*Spacing of Hole*	*Size of Line*	*Size of Compressor*	*Depth to Bottom*	*General*
Lake Mälaren Sweden	0.75 mm	10 metres	1½ in. I.D. anchored at 1-2 m from bottom	1.5m³/min. at 4 atmospheres	10-15 metres	Reference #14 approx. 900 metres length of area cleared of ice
Riddar Bay, Sweden	0.75 mm	5-7.5 metres	50 mm I.D. and 22 mm I.D.	8m³/min.	5–20 metres	Reference #14, variable success
Prescott, Ontario	1/32 in.	6-ft. intervals	3/4 in. anchored 1 ft. from bottom at 15-ft. centres	air pressure 40 p.s.i.	5-11 ft.	Reference #19
Celgar Ltd. B.C.	1/32 in.	40-ft. intervals	600′ 1-1.5 in. 2000′ of ¾ in.	125 c.f. per min.	15-20 ft.	Reference #20, 2-acre pond free of ice
Vernon Lake Narrows, Ont.	1/16 in.	10-ft. intervals	1.5 in. across 800-ft. channel			Reference #21, 200-ft. strip kept open
Kaministiquia River, Ft. William, Ont.			1¼-1½ in., 2000 ft. anchored 1 ft. from bottom			Reference #12, open water approx. 400 ft. x 15 ft. throughout winter
Slave Falls, Manitoba			1.5 in. iron pipe at 14 ft. along 1200-ft. dam			Reference #12
Mid-Finland District, Finland	0.8 mm	3-3.5 metres	1½-in. steel pipe also ¾ in. plastic hose	compressors at both banks of river		Reference #22, area 15 metres by 15 metres opened
Finland	0.75 in.	3.5 metres		Note: A 170-metre channel with an ice cover 60-70 cm thick required 43 compressor hours and 75 man hours to melt. Reference #23		
Safe Harbour, Maine			1-1½ steel pipe 1000 ft.	200 c.f. per min.	50 ft.	Reference #24

Sea-Water Temperatures

Although air bubbling systems have been used in sea water,[12] careful studies must be made of water temperature and salinity to ensure that ice can be removed or melted by this technique. The maximum density of sea water does not occur at 39.2°F and, therefore, convective mixing of the water may continue until ice forms at the surface. For air bubbling to be successful under these conditions, it is necessary that the water brought to the surface by the bubbles should have a salinity and temperature such that heat can be released for melting or preventing ice formation, that is the temperature of the salt water is higher than its freezing temperature. The freezing point of salt water decreases with increasing salt content. The action of wind and water currents is likely very important in determining water temperature profiles at a specific location. Fig. 8 shows the temperature gradients Tadashi[13] found under an ice cover in sea water.

No mention has been made of the subsurface flow resulting from variations in the amount of materials in suspension or horizontal variations in the amount of salt in sea water. The subsurface flows which result from these density differences are often referred to as "density currents" in engineering literature. For example, the upstream movement of salt water in open channels is attributed to the greater density of salt water compared with that of fresh water. The nature of such an intrusion is dependent upon the range of the tide and salinity of the sea water and the physical and hydraulic characteristics of the site. The effect of such intrusions are important in analyzing the thermal regime at those sites where salt water is mixing with fresh water or water of different salinity.

Design Considerations for Air Bubbling Systems

In any careful study of the feasibility of using an air bubbling technique to prevent ice formation, a thorough field investigation of the thermal regime of the particular site in question is an absolute necessity. An understanding of the heat losses to be expected from the surface and the lateral inflow of heat are also usually essential. In Sweden[14] a case was reported where an area 50 metres by 1.5 metres was kept free of ice when the mean water depth was only one to two metres. Conversely another instance was reported in the North Baltic where an installation in quite deep water was a failure because of supercooled water flowing into the area from a river source.

In the case of an open body of water under winter conditions, there can be very large heat losses from the surface. Fig. 9 compares various empirical formulae[15, 16 17] which give estimated heat losses for various air-water surface temperature differences. From these formulae it can be estimated that for a mean air-water surface temperature difference of 20°C (36°F), the total heat losses from an open water surface would be approximately 125 to 175 B.t.u. per sq. ft./hr.

Once an ice cover has formed, the rate of heat loss will be rapidly reduced because of the insulating value of the ice cover. For example, with an ice cover of 6 in. and a temperature gradient through it of 1.5°F/in., the heat loss is approximately 22 B.t.u./sq. ft./hr. If the ice cover is removed by air bubbling and the air-water surface temperature difference is approximately 20°C (36°F), then the heat loss would be 125 to 175 B.t.u. per sq. ft./hr.

If, for this example, the depth of the water was 20 ft. and the mean water temperature +33°F, then the thermal reserve would be 1250 B.t.u./sq.ft. of open water area. If the rate of heat loss was 125 B.t.u./sq.ft./hr. and no ice cover existed, the mass of the water would be cooled to 32°F within 10 hours. In the case where there is an ice cover and part of the ice is removed by air bubbling, the heat in the water

Fig. 6. Typical water temperature profiles under ice cover for small lakes in Ottawa area March 9-11, 1959.

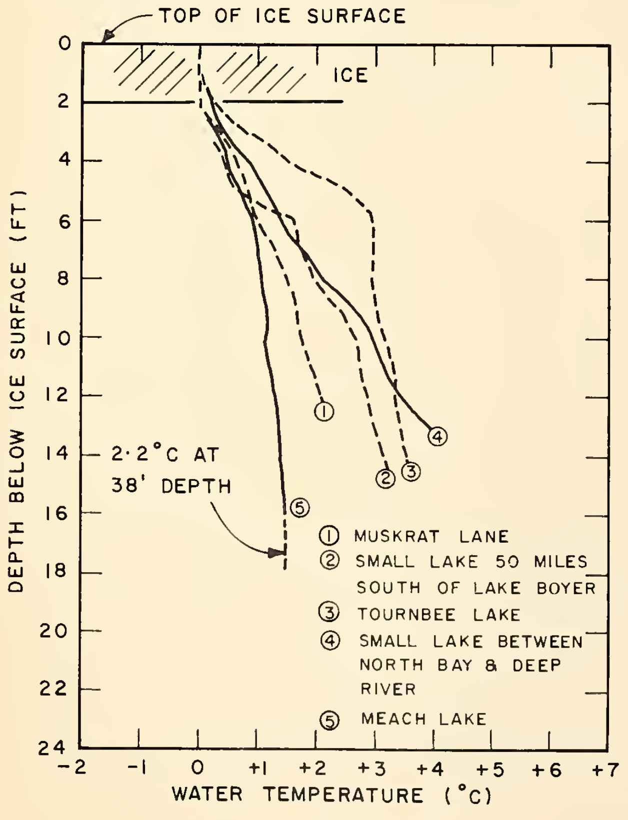
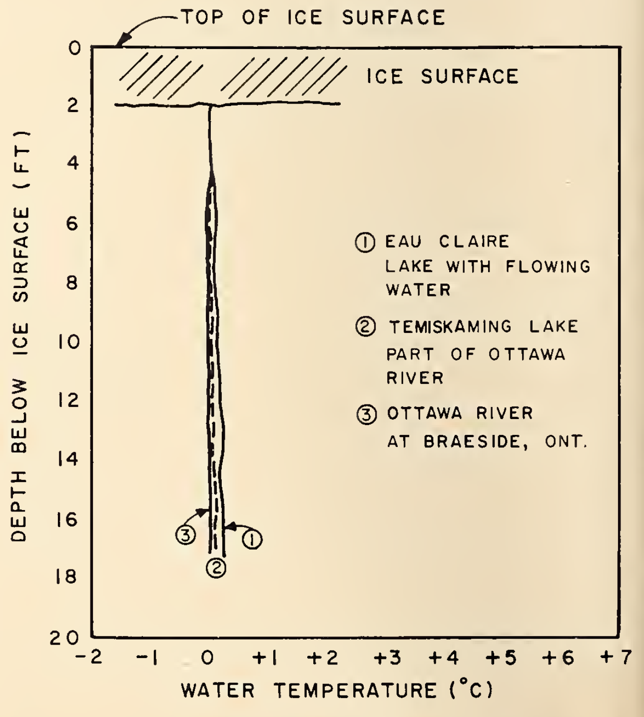


Fig. 7. Typical water temperature variation under ice sheet in flowing rivers, Ottawa area, March 1959. (Temp. gradient less than 0.1°C 10 feet.)



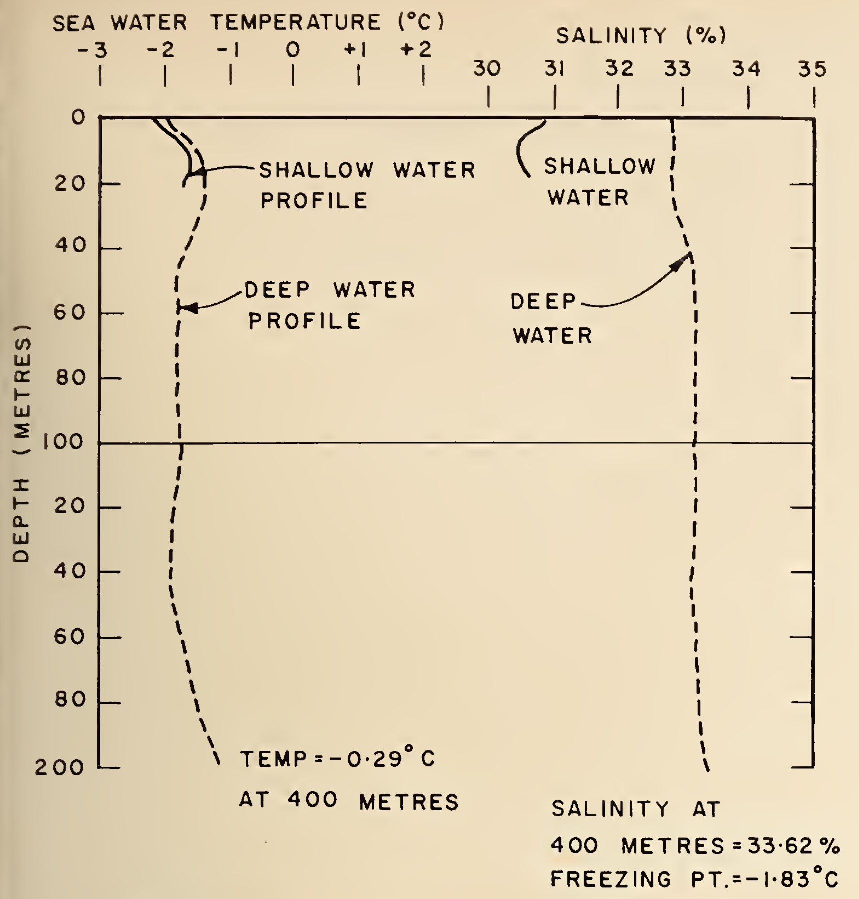


Fig. 8. Sea water temperature and salinity profiles at time of ice formation and under ice cover.[13]

for some distance surrounding the open area is available by advection for maintaining the water in the open area above 0°C.

Additional heat that can be supplied from the bottom of a lake or river is usually considered a minor factor. Nybrant[18] states that in latitude 50 to 60°N, the heat flow from the typical bottom material in October is approximately 1.8 B.t.u./sq. ft./hr; in December-January 1 to 1.8 B.t.u./sq. ft./hr, decreasing to almost negligible flow in April.

To plan the spacing and depth of air holes in a bubble system, information is required on the area of influence of a single air jet, on the size of air hole, and on the most efficient quantity of air to use. Since most studies on air bubbling systems appear to have been empirical, designed to give an answer for a specific location, there does not appear to be an engineering procedure for obtaining this design information. A summary of the various applications is outlined on Table I which gives the design values that have been reported in the literature. Although this table does not present a means of determining such things as air hole spacing, it does list the values which apparently have been satisfactory for the specific locations listed. In addition to the list of studies shown in Table I, there are a number of other cases reported where the technical information is so meagre as not to warrant inclusion in this table.

Experimental Investigations

Although most of the studies reported were empirical, there have been several experimental investigations on air bubbling techniques. Owen[25] in 1942 reported a detailed investigation of the flow pattern of various orifices studied in the development of an orifice to use for ice prevention at the Grand Coulee Dam. An orifice was developed which gave a balance between flow pattern, economy of operation, and non-freezing characteristics of the orifice.

One of the few other experiments in the laboratory on the flow of water induced by a rising column of air bubbles was recently completed by Baines and Hamilton.[26] They concluded that because the momentum of the vertical jet increases with distance from the source, other factors being equal, air bubbles increase in efficiency with depth. They indicated that the ratio of water discharge to air discharge increases with depth, but decreases with increasing air discharge. They also concluded that, with single orifices of 0.02 in. size or larger, flow is independent of size of orifice and depends only on the air discharge. They reported, finally, that further experiments might indicate that it is possible to apply scaling laws and thus have reliable model tests of air bubbling systems.

Clinch, Millman, Erickson[27] attempted to obtain some quantitative information on air bubbling systems under field conditions. Their calculated air-water flow ratios for a particular site varied over a wide range, but this they attributed to the inadequacy of field observations.

The area of influence of one air jet and the resulting water temperature distribution during air bubbling operation is a basic question which has not been answered satisfactorily. The only quantitative measurements on this problem of which the author is aware were made by Nybrant.[28] He noted that essentially the same water temperature was maintained throughout the whole body of water as far as 50 metres from the hose. He also noted that there did not seem to be a decrease in water temperature above the hose, as the mean temperature of the adjacent water was about the same. These observations suggest that, for this one application, the air bubbling system obtains very complete mixing of water within 50 metres of the hose. Although this one example is not sufficient to lead to a definite conclusion, it does suggest that the spacing of holes might be larger than is commonly used, as shown in Table I. In the Malar investigations[14] it was found that changing the spacing of the holes from 5 to 10 metres did not seem to change the area kept free from ice formation.

In what is perhaps the most detailed field investigation of air bubbles systems, Kaitera[29] made many observations of water temperature during air bubbling trials. He noticed that the temperature of the water did not fall as low as would be expected above the hose, though considerable heat was used to melt the ice and keep the area free of ice. He suggests that there must be considerable lateral movement of heat into the area near the air hose from the adjoining water mass.

Kaitera also investigated the dependence of ice melted on the volume of the compressed air used, the temperature of the water and the depth of the nozzle. Fig. 10 summarizes his findings. As might be expected, the higher the water temperature and the greater the depth of nozzle, the better the ice melting rate. His experiments provide some useful information on actual quantities of ice that can be melted under field conditions.

Conclusion

It is possible that much of the information available on air bubbling systems has not been made public. Judging from the reports that are available, however, considerable investigation is still needed before this technique can be so developed as to be the most efficient way of using the heat stored in water under ice cover to prevent ice formation.

Acknowledgements

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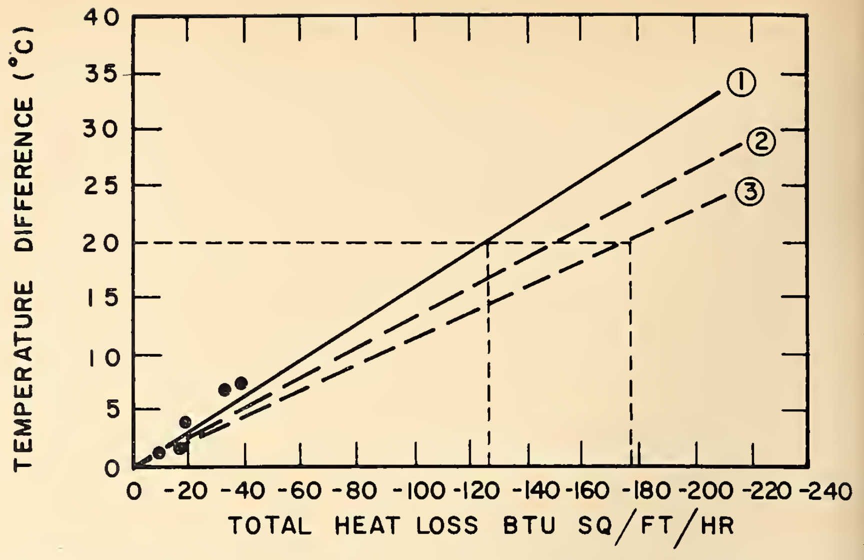

Fig. 9. Various empirical formulae for estimating total heat loss from open water surfaces[15,16,17].

● observations on heat losses from small lake in 1959 by G. P. Williams.

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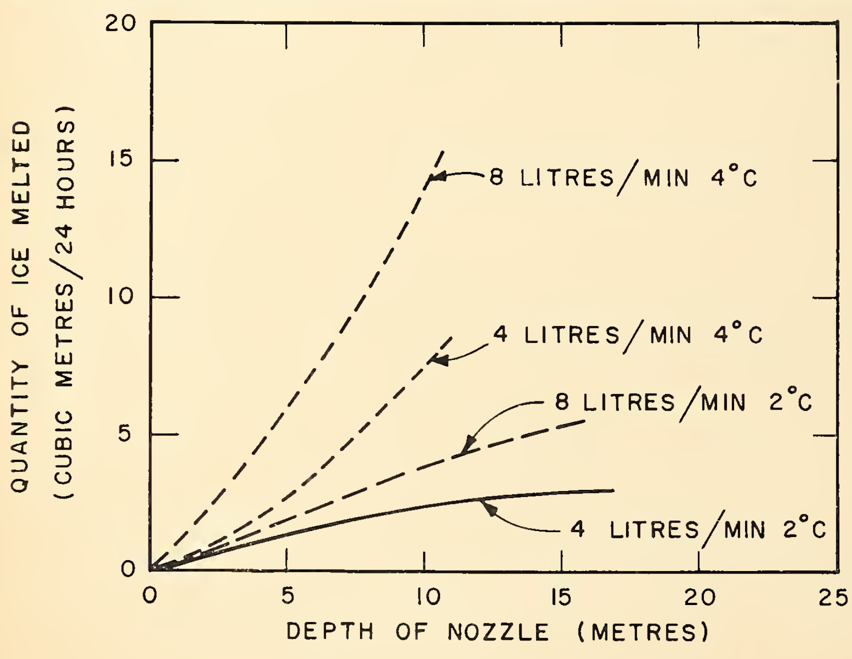
Fig. 10. Dependence of melted ice on depth of nozzle under various conditions[29].



Discussion

ELECTRONIC COMPUTATION IN THE CHEMICAL INDUSTRY

R. N. Boyd, M.E.I.C.
Supervising Engineer, Design Services, Dupont of Canada Limited, Montreal.

V. J. Bakanowski, M.E.I.C.
Principal Computation Engineer, Dupont of Canada Limited, Montreal.

The Engineering Journal, December 1960, page 47

Discussion by D. A. Lamont, MEIC

The authors are to be congratulated on presenting a most interesting paper.

In particular, I would like to express my complete agreement with the point they have raised in connection with the need for good analytical engineers in industry to take full advantage of computer techniques and facilities. To my mind, computers have emphasized the need for mathematical and analytical engineers, the emphasis being on this ability more than on the particular branch of engineering in which they have received their formal training. I also believe that this change in requirements has brought about a need for a change in education programs. I would strongly suggest that industry and educators work closely together.

It would appear from the paper that all the authors' experience is in "off-line" general purpose computers, whereby the computer is used to calculate the set-points in operating the process; these set points being then manually set by the operators. I would like to ask the authors if they have had any experience or given any consideration to using "on-line" special purpose computers whereby the computer becomes permanently an integral part of the process control.

Discussion by D. C. Baxter

The authors of this paper are to be complimented on their lucid exposition of the application of computers to their chemical engineering field. Their paper underlines the fact that such devices are now an accepted engineering tool and are used in many engineering organizations on a routine basis.

The authors have put forward as the dominant feature of engineering computation the implementation of mathematical models in various phases of their work. Some further noteworthy applications are discussed below.

(1) The assistance which can be given to engineering or scientific testing, both in the design of experiments so that maximum information can be obtained from a given number of tests, and in the statistical analysis of test results so that the required casual relationships can be uncovered or the results presented in a more meaningful way. An important product of such analysis, which engineers often ignore, is the measure of how accurate or how meaningful is the answer obtained.

(2) With regard to testing techniques, electronic computation has opened up the use of random techniques by which tests can be carried out on operating plants or systems without the need for artificial intervention. Random or chance disturbances themselves provide the needed information when inputs and outputs are analyzed by correlation function methods.

(3) Another computer field of application is of course that of data logging and/or control. Analog devices have been performing this task for a number of years, and the simulation of a plant controller is illustrated in the authors' example. The logical ability of digital computer control has led to the appearance of several commercial, general purpose control computers in recent years.

(4) The application of digital control to an analog plant simulation leads to the need for combined or hybrid computer installations—an interesting extension of the authors' description of the particular advantages of analog and digital devices. In such a unit each contributes to a more versatile computation and simulation tool.

(5) In the product scheduling field the assignment of production outputs or the specification of input quantities is often determined by a computer calculation and the techniques of linear programming. The quantities are chosen from among the possible ones in such a way that cost is minimized or profit made a maximum.

The present discussor will not examine in detail the two examples given by the authors. They certainly represent every-day problems of the types handled by the two computers. The involved computational, arithmetic and logical aspects of the stress analysis computation contrast with the easy manipulation of variables, convenient recording, low accuracy and high speed requirement of the analog plant simulation.

Finally the desirability of "open-shop" operation of computers by engineers can be supported by this discussor's own experience. There certainly arise problems of sufficient complexity and length that closed-shop operation is an economic necessity (for digital computers at least). On the other hand there are many problems in research, design and operation where the engineer can best set up and run his own problem. Changes in plan can be made easily as the problem progresses, results obtained have more meaning to the engineer, and further possibilities offered by computers are more easily recognized. As the authors point out, in such an engineering operation the amount of red-tape involved in using the computers must be kept to a minimum and expert consulting advice should be on hand as needed. It has been the discussor's as well as the authors' good fortune to have both analog and digital machines

(Continued on page 112)

Canadian Developments

P.F.R.A. New Soil Mechanics Laboratory

One of the most recent building additions to the campus of the University of Saskatchewan was opened Dec. 14. The Soil Mechanics Laboratory of the Prairie Farm Rehabilitation Administration, Federal Department of Agriculture, is a three-storey building, of brick construction with a reinforced concrete frame costing approximately $430,000 to build. The function of the laboratory is for the testing and analysis of soils, concrete and other materials used in the construction of engineering works built by the organization in connection with its water development program. The Soils Mechanics Division was established in 1941 to provide the basic soils information required in the planning and design of the many water conservation projects that have been built under the P.F.R.A. These works have included structures from small individual farm sized dams to such large scale water conservation and development schemes as the St. Mary and Bow River Irrigation projects in Alberta and the South Saskatchewan River Dam currently under construction.

Science Postgraduates

The schools of graduate studies in Canadian universities have been expanding so rapidly since 1945 that the National Research Council of Canada has increased its allocation for grants and scholarships by thirty times. Highly trained scientists constitute one of the country's most important resources yet little information concerning them has been brought together and made known to those interested. The higher education of scientists and engineers presents a complexity of problems, it is becoming increasingly necessary for educators, legislators, administrators and employers to know more about the students who are engaged in graduate study and research in our universities. It is important to have the facts concerning the number of graduate research students, their fields of study, universities attended, expenditures made, financial support received, where they go when they graduate, who employs them, starting salary and relevant personal information. The National Research Council is constantly concerned with these questions and an article written by E. H. Stock and P. J. Beaulieu published in Canadian Public Administration, Dec. 1960, reports on general information collected annually by the N.R.C. and on two recent surveys that have been made on graduate science students in Canada.

A questionnaire sent out in the summer of 1959 to 2,196 graduate students showed that more than one-third were non-Canadians. They were distributed as follows; 148 from the U.K., 95 from Continental Europe, 58 from India, 70 from other Asiatic countries, 47 from the U.S.A., 18 from the British West Indies, 17 from Africa and 11 from Australia and New Zealand. Most full-time graduate students received financial support of some type, only seven per cent reported no support. More than one-third were getting their assistance through university funds, a quarter of them through the National Research Council and the remainder from various other sources which included government, industry, foundations and associations.

A survey completed last summer was designed to find out more about what happens to the new Ph.D. This survey was made of 385 graduate students in science and engineering who, in the Fall of 1959, were registered to obtain their doctorate during 1960. Twenty-six per cent indicated that they would not be able to complete their doctorate during 1960. Two hundred and twenty seven students reported that they had completed or expected to complete the requirements for a doctorate degree in 1960. Of these, 157 were Canadians; 113 to be employed (96 in Canada, 16 in the U.S.A. and one in India), and 44 to accept fellowships (13 in Canada, 16 in the U.K., 6 in the U.S.A. and 9 in other countries). Almost 70 per cent were leaving the country for further study, only 10 per cent were taking up employment in the U.S.A. Of the 70 non-Canadians 36 were remaining in Canada, 25 of them to be employed.

Among the 121 Canadians and non-Canadians who indicated that they were accepting employment in Canada, the universities attracted the greatest number (44) at the lowest average of the basic annual salaries reported ($6,210). The Federal Government was employing the next largest group (37) at the next lowest average salary ($6,490). Canadian industry was employing 22 new graduates at the highest average salary ($7,-620). The remaining 18 were being hired by (or returning to) various employers mostly under provincial government jurisdiction, at an average salary of $6,-990 per annum. Twenty-six doctors in science were to be employed in the U.S.A., almost half of these were being attracted to industry at the highest average of all salaries reported ($9,780).

Of the 63 graduates who were continuing their work by means of a postdoctoral fellowship, most would be doing so at the universities: 16 in Canada with an average stipend of $3,740, 10 in the U.S.A. ($4,910), 18 in the U.K. and 6 in other countries. Government and research institute fellowships have been accepted by 13, seven of them to study in Canada with National Research Council postdoctorate fellowships at stipends of $3,-700 for single and $4,500 for married fellows.

The National Research Council has also compiled a list of students registered in the graduate schools in physical sciences, engineering and biological sciences 1960-1961.

Montreal Science Fair

The first Montreal Science Fair is to be held April 7-8 at the Université de Montreal and is open to all secondary school students from greater Montreal. Organized by the Montreal sections of the Chemical Institute of Canada and the Engineering Institute of Canada, the Science Fair will provide unique opportunities for students who show an interest in some aspect of science and engineering to earn a university scholarship and at the same time bring recognition to their schools. Contestants are required to submit self-designed and assembled projects and prizes include $400 and $200 university scholarships. Groups of outstanding scientists, industrialists, educators and laymen are to perform the judging.

Science Fairs have been held with considerable success in other Canadian centres over the past few years and the following are to be held in 1961:

March 17-18—Kingston Fair, at Kingston; March 18—Richelieu Valley Fair at Beloeil, Que.; March 23-25 — Hamilton Fair at Hamilton; April 5-6 — Ontario Fair at Toronto; April 6-7 — Manitoba Fair at Winnipeg; April 7-8 — Montreal Fair at Montreal; April 22 — Vancouver Fair at Vancouver.

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International News

International Current Meter Group

Among the methods for metering large rates of flow accepted by the various national and international test codes, few have been longer established than the current-meter technique of flow measurement. In consequence the experience available is substantial, particularly on the Continent where this form of gauging is used almost exclusively in hydro-electric power-station measurements.

Certain aspects of current-meter performance and calibration procedure need further clarification. Researches to that effect have been in progress for a number of years in different countries and it was with the aim of co-ordinating these that the International Current Meter Group, ICMG, was founded in 1959. Under the Chairmanship of Professor Gerber of the Swiss Federal Institute of Technology, Zurich, representatives of seven countries drew up a complete research and development program and reached agreement on the distribution of effort. Members meet annually to review progress and to discuss the results obtained and these are published on behalf of the ICMG by the National Engineering Laboratory at East Kilbride, Scotland.

The ICMG is essentially a working group composed of experts in the field of flow measurement by means of current-meters, who are directly concerned with the problems under investigation. It is hoped that the formation of this group will, by resulting in a deeper understanding of the possibilites and limitations of a standard technique of flow measurement, give rise to the development of advanced methods and instrumentation. Delegates are interested in receiving information on current-meter performance or measurements of unusual interest. Contributions should be addressed to Dr. F. A. L. Winternitz, Secretary, ICMG, National Engineering Laboratory, East Kilbride, Glasgow, Scotland.

Another Nuclear Power Station for U.K.

Britain's latest nuclear power station is to be built at Sizewell, Suffolk for the Central Electricity Generating Board by the English Electric Co. Ltd., Babcock and Wilcox and the Taylor Woodrow Atomic Power Group. The contract is worth about £55 million. Supplying 580,000 kw to the national supergrid, the station will have the highest output and be the most compact of the seven commercial atomic stations now on order in the U.K.

The major new features of the design from which this compactness is derived are a new type of reactor building with both reactors under one roof; thick-walled, small pressure vessels, few high capacity boilers and the use of two large turbines to give a small turbine hall. In the reactor building, the two reactors are placed at either end of a single building, the space between them being used for common control, service and plant rooms. The concrete shield floor above the reactors extends from one to the other and allows simplification of reactor fueling and servicing machinery. Work begins at Sizewell in April and the station is planned to be in full operation in 1966.

EDUCATION

Israel Trains Nuclear Engineers

For the past four years the Technion, Israel Institute of Technology in Haifa, has been training a select number of engineering students in their senior undergraduate year in a special program in nuclear engineering. About two and a half years ago a special Department of Nuclear Science and Engineering was established at the Technion for this purpose, and a graduate program was added for the training of nuclear engineers. This program includes advanced study and a research thesis.

In addition to its teaching activities, a large proportion of the time and resources of the new Department is devoted to research activity in the field of applied nuclear science and engineering, especially in theoretical and experimental reactor physics, reactor control, nuclear chemical and reactor chemical problems, applied radiation and heat transfer.

The expanding demands of Israel's national nuclear program for peaceful atom work and the increased number of nuclear scientists and engineers which will be required, has led to the recent decision to expand and consolidate the Department of Nuclear Science and Engineering. At present the department has a teaching staff of 12 senior and junior members and is equipped with special physics laboratories, a laboratory for work with radioactive substances and a reactor simulator. Over 50 undergraduate students in different branches of engineering have received special training and six post-graduate students have completed their research work and have been granted higher degrees.

French Government Scholarships for Canadians

The French Government has established a "Service de Corporation Technique", in Paris to organize and coordinate foreign student's work in France, both in formal courses and in training positions in industry. It offers a grant of 750 new francs a month, free return trip from France to Canada, free travel relating to work while in France and comprehensive medical coverage.

Candidates are required to hold an engineering degree from a university of high standing, to have had some field experience for at least one year, a sufficient knowledge of French, and must present good references and a proposed plan of study. Particularly suitable for such scholarships are professional engineers and university professors who wish to supplement their knowledge in their specific fields.

International Course in Hydraulic Engineering

The Netherlands Universities Foundation for International Co-operation has published its prospectus for 1961-1962 International Course in Hydraulic Engineering to be held at the Technological University of Delft. The Technological University has the scientific potential at its disposal and NUFIC takes charge of the administrative side, concerning itself with the recruitment of the participants and with the provision of social facilities on their behalf. The course is organized under the guidance of a Board of Trustees, composed of representatives of both bodies.

Subjects given on the course include civil engineering, geodetical engineering, mining engineering, chemical engineering, naval engineering, aircraft engineering, metallurgical engineering and mathematical engineering. Three programs have been compiled from these subjects. These are: a. Tidal and Coastal Engineering (including harbors), b. Reclamation (including ground-water recovery), c. Rivers and Navigation Works. If, with a view to his future, a participant should prefer a combination of subjects other than that provided by one of these branches of study, he may submit a special program for approval. The course begins Oct. 19, 1961 and terminates Sept. 14, 1962.

The course is open to those who have received a thorough preliminary training in engineering. Practical experience in civil engineering is desirable in order to derive the maximum benefit from the course. A degree in civil engineering (or a related branch of study) of some university or other institution of higher learning is the minimum requirement for admission. Thorough knowledge of the fundamental principles of construction, applied mechanics and hydraulics and a good knowledge of calculus is essential. The course is given in English. Closing date for application July 31.

Summer Conferences at University of Michigan

Twenty-seven courses are scheduled for the 1961 Engineering Summer Conferences. Lectures are presented by outstanding men from industrial and governmental laboratories, as well as from universities. In addition to lectures, course time is assigned to discussion and work sessions, laboratory work and demonstrations.

These one and two week courses held during June, July and August are: Technical Writing, Recent Industrial Engineering Developments, Quality Control by Statistical Methods, Foundations and Tools for Operations Research and the Management Sciences, Recent Mathematical Advances in Operations Research, Modelling and Simulation in Operations Research, Advanced Data Processing Techniques, Introduction to Digital Computer Engineering, Theory of Computing Machine Design, Programming Concepts, Automata, and Adaptive Systems, Advanced Automatic Programming, Advanced Numerical Analysis, Intermediate Numerical Analysis, Analog Computer Solutions of Partial Differential Equations, Systems Engineering, Human Engineering Concepts and Theory, Signal Detectability and Sensor System Design, Random Processes, Semiconductor Theory and Technology, Advanced Topics on Solid State Masers, Fundamentals of Infrared Technology, Machinability of Metals, Applications of Stress Analysis to Design and Metallurgy, Mathematical Modeling for Metal Casting Processes, Flight Mechanics of Space and Re-Entry Vehicles, Elements of Nuclear Power Reactor Engineering, Underground Storage of Natural Gas.

Month to Month

Why Bother?

IT SEEMS that every week the mails bring another questionnaire or form to be filled out and returned promptly to the sender. Recently another was sent to you; this one from the Institute. Why bother to complete and return it promptly?

The fact that the form is a simple one —it takes only a minute to complete— really isn't sufficient reason to bother. What should concern you is the fact that the information received from this questionnaire will help the Institute improve its many services to you.

Frankly, no one has more than an educated guess as to what specific work Canada's tens of thousands of engineers are doing. We can find that so many received their degrees as, say, Civil, Mechanical or Electrical engineers. But this doesn't tell us into what fields they may have drifted, or what specific positions they have attained.

And so much depends on knowing. Technical programs and activities can be planned with greater confidence and for greater benefit if the interests of Canadian engineers are known in detail. The selection of technical papers in the Engineering Journal might be improved. The Institute Library and other headquarters services could be performed for greater total benefit if the staff knows exactly whom they are serving. Both Montreal and local technical programs will be tailored to best suit your interests.

An accurate record of the positions, nature of the employers and technical interests of the readers of the Engineering Journal also is essential, so that we may conform to the requirements of the circulation auditors of EIC publications. And, when we produce the new EIC membership list later this year, you will be listed accurately.

This is why we feel it is worth the bother to complete the questionnaire. A minute of your time will help us to help you.

Garnet Page

COMMITTEE ON TECHNICAL OPERATIONS

The Committee on Technical Operations was formed six years ago to carry through the Institute's increasingly heavy technical programs and activities. Its formation put on a streamlined and continuing basis the flow of technical information to Institute members.

The Institute has been a technical society since its inception. The organization and presentation of technical meetings has always been one of its primary objectives, as stated clearly in the founding Charter of the Canadian Society of Civil Engineers.

Engineering science has become increasingly complex since the CSCE was formed in 1887. By 1918 the all-embracing term "Civil" was inadequate to describe the many new interests of Canadian engineers and the society was renamed "The Engineering Institute of Canada."

While the objects of the Institute have remained the same, the machinery for effecting these objects has recently been brought up to date by the establishment of CJO.

This outline describes the technical activities of the Institute at all levels, national, regional and branch; how the CTO ties in with these activities; and the part played by individual members in the work of CTO and the Institute's many technical activities.

Organization

The Committee on Technical Operations is the national organization within the Institute through which the interests of all the Technical Divisions, which correspond to the major branches of engineering, are co-ordinated into national programs. CTO advises Council on matters of policy regarding technical activities, and is the national technical voice of the membership.

Objects

The following, taken from Section I of the By-Laws of the Institute, are the objects of CTO:

(a) To develop and maintain high standards in the engineering profession.

(b) To facilitate the acquirement and interchange of knowledge among its members.

(c) To collaborate with universities and other educational institutions in the advancement of engineering education.

(d) To promote intercourse between engineers and members of allied professions.

(e) To co-operate with other technical societies for the advancement of mutual interests.

(f) To encourage original research, and the study, development and conservation of the resources of Canada.

Terms of Reference

The terms of reference of CTO, as stated in the By-Laws, are:

"The Committee on Technical Operations shall consist of representatives of the several technical divisions of the profession. It shall keep all technical activities of the Institute under constant review."

"It shall recommend to Council the establishment of such divisions of the Committee on Technical Operations as necessary to carry out reviews of specific fields of technical activity and also such special or standing committees of the Institute as may appear warranted by developing needs in technical areas. It shall recommend to the Publications Committee particular papers for publication."

"The divisions of the Committee on Technical Operations shall encourage the formation of technical sections dealing with its area of engineering in the branches, assist such technical sections in their work, and co-ordinate all activities of such technical sections in the various branches."

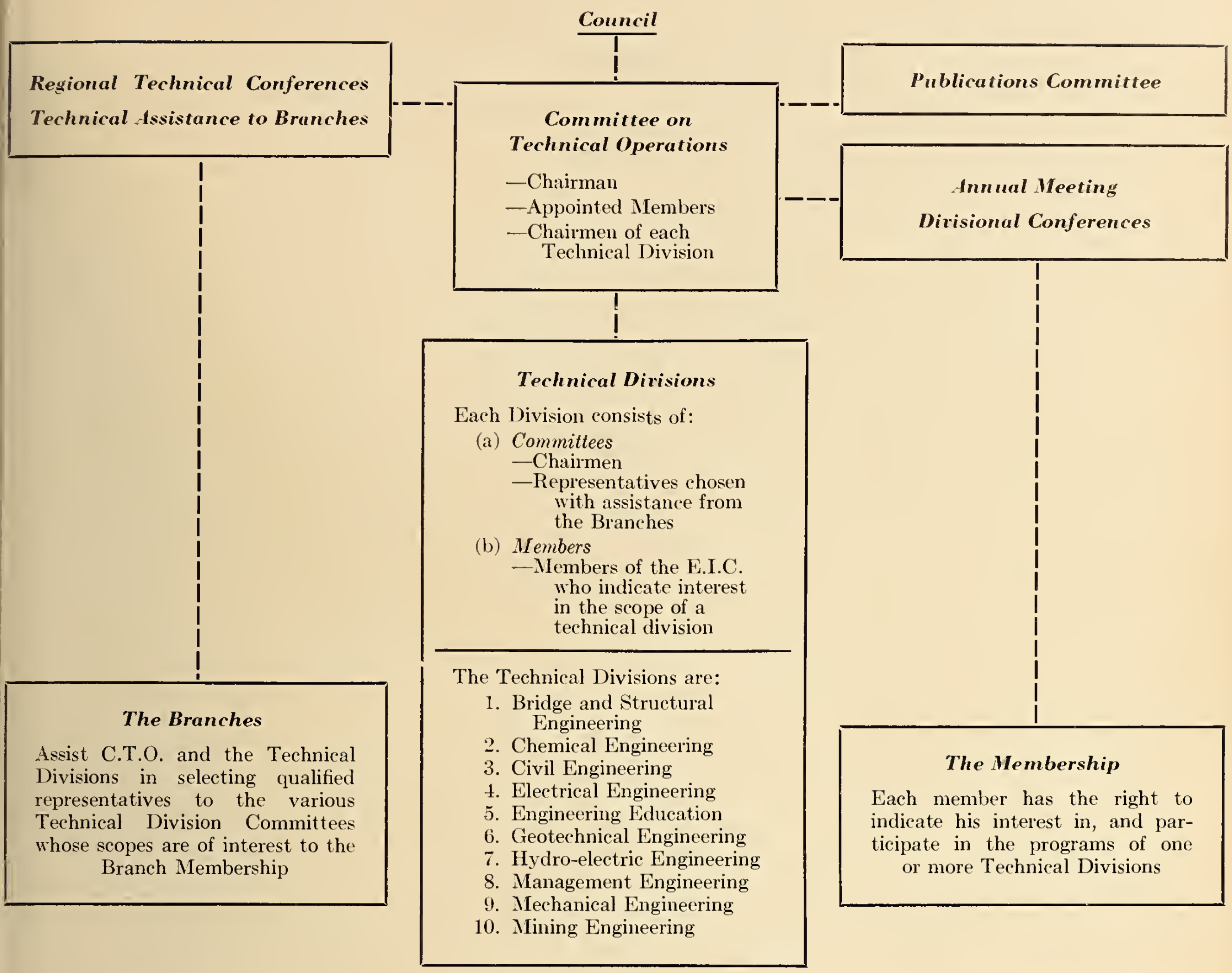
"It shall report quarterly to Council on technical activities of the Institute."

"That Council entrust responsibility for co-ordination of regional technical conferences and approval of requests for holding such meetings to the Committee on Technical Operations."

Composition

CTO is appointed by Council. It consists of a chairman, a number of appointed members, and the chairman of each of the Technical Divisions. At least two members of the Committee must be members of Council.

THE ENGINEERING INSTITUTE OF CANADA
TECHNICAL OPERATIONS



Organization

As is shown by the chart, CTO is a standing committee supported by the Institute's headquarters staff which provides secretarial and administrative assistance both to the national CTO and to the Technical Division Committees.

Each Technical Division Committee consists of representatives chosen with the assistance of the Institute's branches on the basis of technical eminence and geographic location. These representatives form the "grassroots" network through which reports of interesting activity are channelled to the national committee.

Operation

(a) General

Much of the responsibility for the successful operation of the technical divisions lies with the representatives who make up the Technical Division Committee.

The chairman of Technical Division Committees play key roles. It is incumbent upon them to evaluate correctly the material which they receive from many sources, and to develop ideas for technical papers and conferences and joint technical projects with other groups.

While the secretarial service of headquarters are available to division chairmen, it follows from the nature of their personal contact with their committee representatives that they are required to perform considerable administrative work.

The Technical Division Committees of CTO are in contact with practising engineers throughout Canada. Since the Committee represenatives are not obliged to attend meetings, there is no practical limit to the number of appointees.

(b) Annual Meetings

Each year CTO assigns to each Technical Division its quota of papers for the next Annual General and Technical Meeting. The technical division committee is responsible for the preparation of the best possible technical program for the division.

(c) Divisional Conferences

Divisional conferences are national in scope and deal exclusively with the specialized activities of one or more technical divisions. Such conferences call for the co-ordinated effort of all representatives on the committees of participating division or divisions, and for an extra effort on the part of those residing at the site of the meeting.

(d) Regional Technical Conferences

The part played by technical divisions in regional technical conferences is very much like that played at Annual General Meetings, except that a greater organizational responsibility usually rests on the divisional committee representatives resident at the site of the meeting. Strong, interesting and diversified technical programs are essential for regional technical conferences.

(e) Branches

Branch Executives are periodically asked for nominees as representatives to the Technical Division Committees and appointments are made by the Division chairman as required. As the technical division organization becomes more firmly established, it is anticipated that the representatives to division committees will become firmly involved with the organization of branch technical programs, so that branch activity will include the best possible technical programs and meetings in all parts of Canada.

(f) Co-operation with other groups

The technical divisions operate in specific branches of engineering, and are in a position to work closely with many specialized technical societies some of which operate branches or sections in Canada. Such co-operative efforts may be on either the national or local level.

CTO is so organized that new divisions may be formed by Council at will, the only requirement being evidence of a sufficient number of members who share a common interest in a generally recognized branch of the profession. Such members must be willing to devote time and effort to the development of new divisions, since the creation of a division merely provides a medium for the exchange of knowledge and ideas among members of the Institute.

As a general rule, specialized groups within the main branches of engineering should remain within the appropriate technical division as long as these members are able to obtain satisfactory service from it. This simplifies the administration of CTO, but does not preclude the creation of new divisions when a real need arises.

Descriptions and Scopes of the Technical Divisions

(a) Bridge and Structural Engineering Division

This division embraces the field of structural engineering, including new projects and techniques, new developments, research and application.

The entire field of structural engineering is covered, and the technical papers are concerned with bridge building, metal and steel construction of buildings, plastic design in steel, structural design in concrete, and new developments in the structural use of plastics and other synthetic materials.

The division represents the Institute as a member of the International Federation of Bridge and Structural Engineering, and as a participant in the activities of the Column Research Council.

It also co-operates closely with other divisions of CTO where there are overlapping interests, such as the civil engineering division and in the hydro-electric engineering division.

(b) Chemical Engineering Division

Through the Institute's international affiliations, the chemical engineering division has access to the programs and activities of the European Federation of Chemical Engineers. It co-operates closely with The Chemical Institute of Canada and with similar societies in other parts of the world.

(c) Civil Engineering Division

This division deals with all aspects of civil engineering not specifically covered by the Bridge and Structural Engineering Division and the Ceotechnical Engineering Division. It is concerned specifically with earth works, highways, hydrology, municipal engineering, transportation, marine works, and general construction.

There are few civil engineering projects of significance which are not now fully covered in the publications of the Institute, and the civil engineering division's attention is now largely concerned with the organization and sponsorship of technical meetings and conferences.

(e) Electrical Engineering Division

The electrical engineering division covers an extremely wide range of subject matter in the electrical field, with the only specific exception at the present time being in the field of Hydro-electric power which was made a separate division at the inception of the Committee on Technical Operations in recognition of the heavy emphasis on hydro-electric power in Canada.

The division now encompasses both power and electronics and is involved in all forms of electricity from direct current to the highest useable frequencies. Close co-operation is maintained with the Hydro-electric Engineering Division.

(f) Engineering Education Division

The reorganization of the Committee on Engineering Education to a division was made to facilitate general discussions at annual meetings, and to make it possible for interested members to present papers and to have them published in the literature.

Through the Institute's international contacts, this division is able to communicate and exchange ideas with other engineering educations organizations throughout the world.

(g) Geotechnical Engineering Division

This division, established in 1960, was organized to cover the technical requirements of the growing number of civil engineers who have become specialists in foundations and soils meehanics. The name was deliberately chosen to ensure complete coverage of this speeial field, which embraces the scientific applieation of man's knowledge of the earth's crust; since kindred subjects such as engineering seismology, and foundations in permafrost are dealt with by this group.

(h) Hydro-electric Engineering Division

Canadian engineers have an outstanding international reputation in hydro-electric work, and they are strongly represented at major world power conferences. The Hydro-electric Engineering Division plays a major part in fostering such partieipation, and in arranging for adequate representation and suitable papers to cover Canadian activity in this field.

Since hydro-eleetrical developments are usually joint civil-electrical-mechanical projects, this division works closely with these groups in the preparation of technical programs.

Specific subjects covered by the Hydro-Electric Engineering Division include rainfall studies, control of watersheds, design of penstocks, generators, turbines, control systems, surge tanks, floodways, load factors etc., and research into problems such as water hammer, cavitation, generator design, turbine design and control systems.

(i) Management Engineering Division

The management division was formed early in 1959 in recognition of the fact that large numbers of members are interested in the engineering aspects of modern business management. The main purpose is to foster and promote the exchange of ideas on scientific management at a level of the trained engineer-manager, but the division also embraces a number of related disciplines which apply to the operational level of management, such as industrial engineering, materials handling, quality control, and operations researeh.

The management division maintains close liasion with the Canada Management Council and is thus able to participate in the activities of the International Organization for Scientifie Management.

(j) Mechanical Engineering Division

The scope of this division's activity covers the major sub-divisions of mechanical engineering, including machine design, thermo-dynamics and fuels, prime novers and aeronautical engineering.

(k) Mining Engineering Division

Mining engineering was one of the first engineering subjects taught in Cana-

The Seventy-Fifth Annual General Meeting of the Engineering Institute of Canada will be held on Wednesday, May 31, 1961, at the Hotel Vancouver, Vancouver, British Columbia, between the hours of 9:00 a.m. and Noon. This meeting will receive the report of the official auditors, the Annual Report of Council, Committees, Representatives, and Branches, and such other business as may come before the meeting.

Garnet T. Page, M.E.I.C.

General Secretary

dian universities, and it is considered a very important branch of engineering in this country because of the importance of mineral resources in Canada's economic life.

This division is concerned with all aspects of mine operation and ore handling up to and including the concentrate stage. Its work involves both underground and open pit operations, so there is a close link with civil engineers. Activities in ore processing and concentrating call for close co-operation with the techniques of mechanical engineering and chemical engineering, and the mining engineering division works closely with both these divisions.

Branch Technical Activities

1. Objects

The Institute branches are the foundations from which grow the activity and the strength of its technical activities. The basis of these technical activities are the groups of members at the branch level who share common technical interests, and who engage in activities for their individual benefit and for the benefit of the profession as a whole. The reasons for the existence of the Institute are most simply and most dramatically illustrated at the branch level, because it is at the branch level that the Institute must provide the necessary organization to foster technical activities and services. This is the fundamental obligation of the Institute towards its members.

2. Organization

Branches are autonomous working within the overall scope of the Institute's Charter and By-Laws, and each is responsible to provide the organization best suited to the needs of the members in its area. Contacts are maintained through the technical divisions and the branch representatives on divisional committees, but a divisional committee may communicate directly with any branch, and is always ready to give advice and assistance to branches upon request.

3. Operation

One of the most effective media for the dissemination of knowledge at the branch level is the presentation of technical papers.

The planning, preparation and presentation of technical programs for branches is the major responsibility of the program committee of each branch. There are times, however, when they may require assistance and it is at these times that CTO and its divisions can provide useful services. Visiting speakers may be provided to deal with specific subjects of interest to the branch; advice and help in providing qualified panel members may be available; and the benefit of CTO's extensive experience in conducting symposia is always available.

In recent years CTO has advocated the organization of discussion groups for some of the smaller branches, to which it is difficult to attract good speakers of high repute.

It is stressed that the effective implementation of the Institute's agreement with the Institutions of the United Kingdom can come about only through branch action, and it is very much in the interests of all members to offer a satisfactory technical "home" to qualified members of these sister societies.

CTO and the Individual Member

This summary outlines the history, the purposes, and the organization of the Committee on Technical Operations of The Engineering Institute of Canada. It would be obtuse if it did not finally point out that the entire activity exists for the use and benefit of each individual member.

The world of engineering technology is vibrant and living; it requires the joint effort of all EIC members to keep it so, and it is to your personal advantage to give your professional talents in full measure, for you will receive much greater benefit than you give.

How can you participate? By serving the technical committees at the local level. By examining the technical programs made available at the local, regional, divisional, and national levels, and by making arrangements to attend meetings which interest you. Participate by questioning the speaker on points which may not be clarified adequately, and amplify his statements by your own experence if this is in order. Finally, participate by examining your own experience and trying objectively to decide whether or not you have some personal experience to offer to your profession in the form of a paper or address. Knowledge builds on knowledge, and one never knows the limit of a human idea, provided that idea is expressed to others who may be in a position to develop it. This is the very essence of the Institute's technical operations.

COUNCIL MEETING

The Council of the EIC met in Montreal, Saturday, Jan. 28, with President Dick as the Chairman. The following highlights are taken from the minutes of the meeting.

Budget

F. L. Lawton, Chairman of the Finance Committee, introduced the 1961 budget. Reviewing the Institute's activities of 1960 Mr. Lawton noted numerous areas in which marked progress was made. These included: more extensive coverage and higher quality technical papers at annual and regional meetings; 30 per cent more technical papers in the Journal; an active Membership Committee working on a national basis; the second largest increase in membership in the last 11 years; an active Committee on Branch Operations which already is achieving results; the completion of a long-term project which involved putting on a thoroughly sound basis the accounting practices of the Institute; the institution of the co-operative agreements with the United Kingdom Institutions and the initiation of discussions regarding co-operation with sister societies in France; the clarification of membership procedures; the streamlining of Council activities; the institution of procedures whereby the Vice-Presidents assume a share of the load carried previously by the President. A great deal of credit for these considerable achievements, Mr. Lawton said, rests with the President, Dr. Dick.

Mr. Lawton reported that a number of factors contributed to a 1960 deficit which was $38,572 higher than had been anticipated. These included a change in publications policy, which was discussed fully at every Council meeting from February to August, 1959, and which was announced too late in 1959 to achieve a maximum financial return in 1960. In addition, the cancellation of the members' subscription payment for the Journal decreased the revenue by some $58,000. Further, the regrettable death of the Publications Manager in 1960 caused the direct assumption of the responsibility for advertising sales by the Headquarters staff, with certain additional costs during the latter part of the year.

As a result there was a drop of about $17,000 in advertising revenue, a decrease of $58,000 in members' subscriptions and a large increase in printing and mailing costs due to a higher circulation than had been foreseen.

However, there are indications that the advertising sales revenue will increase in 1961 — the largest single sale of advertising space in the Journal's history just having been made. The Finance Committee has considered thoroughly the 1961 budget and is planning for a surplus of more than $22,000 in 1961.

Agreements with Provincial Associations

On the recommendation of the Finance Committee, the Council resolved that the President be authorized to name two members to represent the Institute on the Joint Finance Committee in Nova Scotia, thus reactivating the Joint Finance Committee in that province.

Notification was received from the Association of Professional Engineers of Alberta stating that "now that agreement has been reached to levy a charge of $1 against each Joint Member in Alberta to cover the administrative costs involved in the Joint Agreement, the A.P.E.A. Executive Committee has directed that the previous notice of termination of the Joint Agreement shall be withdrawn . . . "

On the recommendation of the Finance Committee, and recognizing that a number of problems are created by these agreements, it was resolved that the Institute should not now take action concerning these agreements, pending a decision with regard to Confederation.

Technical Operations

The Committee on Technical Operations has produced a draft E.I.C. Technical Operations Manual. A final version will be published soon. A summary of the manual appears in this month's Engineering Journal.

Also prepared is a draft Meeting and Conference Manual, and comments now are being received from previous Annual Meeting Committees.

A list of forthcoming technical meetings in 1961 was presented, as follows: EIC Annual Meeting, Vancouver, May 31 - June 2.

Joint Meetings

ASME-EIC Hydraulic Division Conference, Montreal, May 7-10

ASME (Co-sponsor EIC) Production Engineering Conference, Toronto, May 9-12

International Heat Transfer Conference, (Co-sponsor EIC) Boulder, Colorado, Aug. 28-Sept. 1

EIC-CIMM Regional Technical Conference, Newfoundland, November

Soil Mechanics Conference, Montreal, Nov. 9-11

Proposed Joint Meeting

CIC Chemical Engineering Division and EIC C.T.O. Chemical Engineering Division, November

EIC Regional Conferences

Southern Ontario Regional Conference, Niagara Falls, March 25

Montreal Regional Conference on Urban Transportation, Montreal, April 6-7

Northwestern Ontario Regional Conference, North Bay, May 6, tentatively

Quebec City Regional Conference, Quebec City, Nov. 2-4

75th Anniversary of EIC—1962

The 75th Anniversary Committee, with Dean H. Gaudefroy as chairman, presented its report which recommended projects, publications and special events to suitably mark this significant anniversary.

Branch Officers Conference

The Chairmen of the Committees on Branch Operations recommended that the nature of the Annual Branch Officers Conference at the 1961 Annual Meeting be altered. These changes would provide for demonstrations and illustrations of how branches may solve a number of problems, particularly regarding such things as membership promotion, attendance and support from senior executives in the area.

Policy Discussion

Council considered a letter sent by President Dick to members of Council in which he asked for opinions and suggestions concerning Institute membership and services. An ad hoc committee summarized the discussion, an abridgement of which follows.

EIC Image: There is a vital need to establish a clearer image of the Institute and this should be the major responsibility of the President as he visits Branches. A facet of this image should be a better realization of the many services available to E.I.C. members.

Communications: Apparently few members have sufficient knowledge of the Institute's activities beyond the Branch level. More liaison is needed between Branches and Council, and thus with the membership at large. There should be a militant effort made to promote better communications within the EIC and provide information to the membership. Every effort should be made to change the attitude of "What do I get out of the EIC?" to "What do I do for the EIC?" Increased effort should be made to inform non-members of the Institute. More attention should be given: improved communications between C.T.O. and Branch C.T.O. representatives; improved communications between the EIC and students; making good use of existing mailing facilities to assist in promoting the E.I.C. image and better communications; effective reporting of Branch and local engineering happenings to the Engineering Journal for publication.

Planning: There should be intelligent Branch planning of meetings and special care in the selection of officers. It may be dependent upon the Branch to obtain the maximum help from Headquarters in their planning. It should remain possible for as many members as feasible to take an active part in Branch affairs.

Sale of Advertising

Council noted that despite the pro forma nature of the Dec. 20, 1960, meeting of Council, it had been necessary to take immediate steps regarding the sale of advertising, due to the death of E. J. Blandford. Following careful discussion by the Finance Committee and other appropriate officers of the Institute it was agreed that the Institute assume sole responsibility for the sale of advertising in its publications. The advertising sales staff previously employed by the late Mr. Blandford have been employed by the Institute, and a Manager of Advertising Sales has been employed.

Activities of President and Vice-Presidents

Dr. Dick reported presidential visits had been made to the Ottawa and Quebec City Branches, that he attended the Annual Meeting of the Association of Professional Engineers of Ontario, and that he was to attend the Annual Meeting of the Montreal Branch. The President reiterated the necessity for the Institute to do for the Branches and the members what they particularly need, and these needs must be established and defined. Dr. Dick said the President will continue to visit Branches and that the General Secretary will make more separate visits to the Branches.

Vice-Presidents Cross, Antenbring, Higginson and Lawton reported on their activities and visits in their respective territories. The President said the Vice-Presidents have been extremely active, and suggested that their duties require more definition to assist in their expanding roles.

Tariff Item 180 (e)

The General Secretary said it had become obvious at the last minute that little good would be served if the Institute and the Canadian Council of Professional Engineers submitted to the Tariff Board a similar, but not precisely identical submission concerning Tariff Item 180 (e). Therefore, on the instruction of the President and subsequent ratification by the Chairman of the Institute's Special Committee on Tariff Item 180 (e), the EIC did not submit a separate detailed submission, but rather supported the proposals contained in the C.C.P.E. submission, Section 2, with reference to Number 128 — Engineers' and Architects' Plans, Drawings and Blueprints. The meeting accepted this report.

Report of Property Committee

T. N. Davidson, Chairman of the Property Committee summarized the Committee's report, which was ratified by Council. The report recommended no immediate action. The Chairman commented that the Headquarters buiding is inadequate as far as space requirements are concerned.

By-Law Amendments

J. S. Waddington, Chairman of the Committee on By-Laws, said the Committee, on receiving instructions, is prepared to submit proposed wording of By-Law amendments to Council prior to the 1961 Annual Meeting in time for circulation to membership as required by the By-Laws.

Action was deferred on revisions regarding the nomination and election of officers, Committee on Membership, Committee on Branch Operations and the Executive Committee. The Executive Committee will continue for a further year on a trial basis.

It was agreed that action should continue on proposed By-Laws changes concerning Honorary Members and Fellows and the title of General Secretary.

Canada's Centenary

On the suggestion of the Ottawa Branch, Council resolved that the Institute take the initiative at an early date in pressing for the establishment of a national museum of science and technology to mark Canada's Centenary, and in so doing, enlist the support of other technical societies in Canada, since a co-operative approach to the Government on this matter undoubtedly would be more effective.

Peterborough Branch

In discussion concerning a letter received from Peterborough Branch, Councillors agreed that engineers should be encouraged to participate in community life. It was the concensus that an engineer does not deserve to be supported in public service solely because he is an engineer, but that support should be on the basis of personal qualifications and qualities. In a resolution which incorporated this sympathy it was also stated that the name and crest of the Institute can not be used for any political pur-

(Continued on page 98)

ASME - EIC
Hydraulics Conference

Montreal
May 7-11

Queen Elizabeth Hotel

Technical Program

Monday, May 8

PRIME MOVERS I

1. "High Head Francis Turbines and Pressure Regulators — Mammoth Pool Project", *L. P. Brown.*
2. "High Head Penstock Design", *W. J. Smith.*
3. "The Quest for the Ultimate in the Interpretation of Experimental Data — An Engineering Challenge", *L. E. Jones.*

CAVITATION I

1. "Cavitation Tests of Hydrofoils Designed for Acceleration Flow Cascade — Report 1", *F. Numachi.*
2. "Problems of Predicting Cavitation Erosion from Accelerated Tests", *J. M. Hobbs.*
3. "On the Mechanism of Cavitation Damage", *C. F. Naude, A. T. Ellis.*
4. "Effect of High Velocity in Turbine Pitting", *F. L. Lawton, M. D. Lester.*

FLUID MECHANICS I

1. "A Flow Model for the Two-Phase Slug Flow in Horizontal Tubes", *E. S. Kordyban.*
2. "Adiabatic Flow of Flashing Liquids in Pipes", *M. Sajben.*
3. "Local Liquid Distribution and Pressure Drops in Annular Two-Phase Flow", *H. N. McManus.*

FLUID MECHANICS II

1. "A Preliminary Study of Turbulence Characteristics of Flow Along a Corner", *F. B. Gessner, J. B. Jones.*
2. "The Effect of Secondary Currents Upon the Capacity of a Straight Open Channel", *R. J. Kennedy, J. F. Fulton.*
3. "Theoretical and Experimental Investigation of Flow over Single and Double Backward Facing Steps", *D. E. Abbott, S. J. Kline.*

Tuesday, May 9

WATER HAMMER I

1. "Surges in Air Vents Adjacent to Emergency Gates", *I. W. McCaig, F. H. Jonker.*
2. "The Phase-Tank Topology of the Simple Surge Tank Equation", *A. V. Marris.*
3. "Complete Pump Characteristics and the Effect of Specific Speeds on Hydraulic Transients", *B. Donsky.*

COMPRESSORS I

1. "An Experimental Investigation of the Use of Supersonic Driving Jets for Ejector Pumps", *R. V. de Leo, R. Rose, R. S. Dart.*
2. "Characteristics of Helical Rotary, Positive Displacement Compressors", *K. E. Wichert.*
3. "A Correlation of Fan Performance for Solving Selection Problems", *N. J. Lipstein.*

JOINT PUMPS, PRIME MOVERS I

1. "Research Developments and Results Concerning Bulb Units Applications", S. X. *Casacci, J. P. Duport, R. F. Pariset.*
2. "Vibration of Vertical Pumps", A. *Kovatz.*
3. "Design Problems in Condenser Circulating Water Systems for Thermal Generating Stations", *J. T. Wieckowski.*

FLUID MECHANICS III

1. "Flow of Water Through a Force Field in a Soil Water System", *R. Yong, O. J. Frenkel.*
2. "Circulation in the Gulf of St. Lawrence and Subsequent Drift of the Ice", *G. E. Jarlan.*
3. "An Experimental Study of Vortex Chamber Flow", *J. P. Holman, G. D. Moore.*

Wednesday, May 10

JOINT COMPRESSORS—FLUID MECHANICS I

1. "Friction Drag on Bladed Discs in Housing as a Function of Reynolds Number, Axial and Radial Clearance and Blade Aspect Ratio and Solidity", *R. W. Mann, C. H. Marston.*
2. "Generalized Multi-Stage Compressor Characteristics", *G. L. Mellor.*

FLUID MECHANICS IV

1. "The Use of Wave Energy to Reduce Silt Deposition in a Harbour", *B. L. Mehaute, J. Cowley.*
2. "Moving Hydraulic Jumps in Fluidized Solids Systems", *R. W. Ansley, R. H. B. Hebbert.*
3. "The effect of Mass Transport of the onset of Turbulence at the Bed under Periodic Gravity Waves", *A. Brebner, J. I. Collins.*

FLUID MECHANICS V

1. "Parallelism of Open Channel and Gas Dynamics", *T. Blench.*
2. "Nonsteady Supercritical Discharge", *G. Rudinger.*
3. "Hydroelastic Vibrations of Flat Plates Related to Trailing Edge Geometry", *G. Toebes, P. Eagleson.*

HYDROLOGY AND ICE I

1. "On the Transfer of Heat from a River to an Ice Sheet", *W. D. Baines.*
2. "Measures of Value and Statistical Models in the Economic Analysis of Flood Control and Water Conservation Schemes", *D. J. Clough.*
3. "Formation and Destruction of Ice Covers on Rivers and Canals", *E. Pariset, R. Hausser.*

ADDED ATTRACTIONS

Sunday, May 7.	8 a.m. daily	"AUTHORS' BREAKFAST"
	5:00 p.m.	"EARLY BIRDS' SOCIAL"
Monday, May 8.	12:00 noon	HYDRO-ELECTRIC LUNCHEON
	5:00 p.m.	"DUTCH TREAT SOCIAL"
Tuesday, May 9.	12:00 noon	ASME-EIC LUNCHEON (Ladies Invited)
	5:30 p.m.	INSPECTION TOUR OF DOMINION ENGINEERING LIMITED PLANT
Wednesday, May 10.	8:30 p.m.	ST. LAWRENCE SEAWAY SYMPOSIUM—HIGHLIGHTS OF THE SEAWAY TOUR
Thursday, May 11.	10:00 a.m.	ST. LAWRENCE SEAWAY TOUR

LADIES' PROGRAM

Monday	9:00 a.m.	"COFFEE HOUR"
	12:00 noon	LUNCHEON AND TALK AT THE MUSEUM OF FINE ARTS
Wednesday	11:00 a.m.	LUNCHEON AT HELENE DE CHAMPLAIN RESTAURANT AND CITY TOUR

If you are interested in attending this Conference, Registration Forms and Advance Programs can be obtained from E I C Headquarters on request.

Mail to THE ENGINEERING INSTITUTE OF CANADA, 2050 MANSFIELD STREET, MONTREAL 2, QUE.

Please send me a registration form and an advance program concerning the ASME-EIC Hydraulics Conference to be held in Montreal May 7-11, 1961.

Name . . . .

Address . . . .

• MONTH TO MONTH

(Continued from page 95)

pose, and that EIC funds are not available for such purposes.

Sarnia Branch

Councillor J. E. Harris of the Sarnia Branch asked that Council recognize the newly-formed Lambton Institute of Professional Engineers as the official EIC Branch in the Sarnia area. After a full discussion it was the concensus that while Council is in sympathy with the desire of the Sarnia Branch to maintain the best possible local organization of engineers, it urged that at this time, when negotiations on the national level concerning Confederation are not yet complete, the EIC Sarnia Branch retain its identity. It was considered premature to change the title of the Branch now.

Engineers' Council for Professional Development

Council approved an amended Charter of the ECPD and the proposed amendments to the Rules of Procedure of ECPD as mailed to Council Jan. 11, 1961. Previously, the ECPD Executive Committee acted under authority granted by Council as follows: "Voted to approve the Charter as amended abd to refer it to the participating bodies for ratification." "Voted to approve the proposed amendments to the rules of procedure and to present them to Council for ratification, subject to the approval of the amendments to the Charter by the Participating Bodies."

President Elect

Bristow Guy Ballard was nominated for the presidency of the Engineering Institute of Canada for the year 1961. It was resolved unanimously, and by acclamation, that Dr. Ballard be named President for the year 1961-62, to take office at the 1961 Annual Meeting in Vancouver.

Membership

P. W. Gooch, Chairman of the Admissions Committee, tabled the procedures now being followed by the Admissions Committee. These procedures are to be considered at a future meeting of Council.

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on January 28, 1961.

Member: K. Brogaard, Vancouver; R. P. Byrnes, Montreal; W. S. Cramp, Montreal; J. H. DeBruyn, Toronto; K. Fiddy, Dartmouth; K. Giddings, Georgetown, Ont.; G. D. Howard, Montreal; G. A. Jeffs, Weston; T. J. Lynch, Montreal; L. R. Nash, Port Arthur; C. W. Ransome, Montreal; H. L. Schreiber, Hamilton; W. A. Thomann, Montreal.

Junior: R. D. Delaney, Chalk River; A. H. Lalonde, Three Rivers; A. J. Otter, Chalk River; J. A. M. van den Elshout, Montreal.

Junior to Member: H. T. Abbott, Port Credit; W. J. Adams, Winnipeg; J. C. Akerley, Boston; C. E. Alkerton, Hamilton; A. A. Albert, Rexton, N.B.; D. G. Allen, Toronto; G. E. Allen, St. Lambert; J. A. Allen, Sarnia; R. F. Allen, Whitehorse; W. L. Allen, Montreal; W. S. Amm, Hope, B.C.; G. J. Anderson, Papineauville; L. L. Anderson, Ottawa; S. S. Archer, Windsor; G. W. Argle, Revelstoke; B. T. W. Armishaw, Sydney; A. J. L. Aube, Buckingham; W. I. Aubin, Montreal; J. D. Baig, Halifax; M. E. Bailey, Kitchener; W. A. Ballantyne, Byron, Ont.; W. P. Banas, Montreal; G. L. Bancroft, Santa Ana, Cal.; G. Beauchemin, Montreal; R. F. Bell, Calgary; R. C. Bergey, Peterboro; H. Bily, Windsor; C. R. T. Bingley, Regina; D. R. Black, Montreal; C. C. Blackmore, Camlachie, Ont.; R. A. Booy, Temiskaming; J. Bourassa, Sherbrooke; J. P. Bourgon, Montreal; L. T. Brainerd, Montreal; F. M. Braybrooks, Vancouver; L. A. Broddy, Vancouver; D. A. Brooks, Montreal; D. S. Brown, Windsor; F. W. Brown, London, Eng.; J. A. Buchanan, Montreal; C. A. Buchholz, Sarnia; N. W. Bunn, Vancouver; F. G. Burchell, Copper Cliff; G. R. Burton, Coldbrook, N.B.; R. P. Cable, Edmonton; P. H. Cameron, Montreal; W. L. Canniff, Belleville; J. D. Cape, Kitchener; G. C. Cartwright, Winnipeg; J. L. Carveth, Calgary; J. R. Caza, St. Anicet, Que.; G. J. L. Chabot, Edmonton; W. S. Chick, Hamilton; R. Clarke, Montreal; T. H. Cooper, Scarboro; E. T. Cornell, Fort Frances; E. T. Cotton, N. Vancouver; M. A. Couse, Scarboro; J. S. Cummins, Brampton; J. W. S. Dalziel, Toronto; H. D. DeBeck, Kamloops; J. DeGuise, Montreal; W. G. Delahay, Scarboro; F. L. Delavigne, Scarboro; G. B. Delong, Agincourt; F. A. DeLory, Toronto; F. C. Desrochers, Montreal; L. Desrosiers, Montreal; G. Doin, Quebec; E. D.'Souza, Rimouski; H. H. Dofka, Toronto; T. E. Dolphin, Prince Albert; P. W. Douglas-Tourner, Kitimat; S. Dreluch, Montreal; P. A. Drouin, Riverbend, Que.; J. W. Drover, Isle Maligne; R. A. Ducker, Toronto; M. B. Duclos, Halifax; A. F. Dudek, Montreal; D. P. Duffey, North Bay; J. V. Y. Dupuis, Quebec; J. T. Dykes, Montreal; G. H. Eaton, Vancouver; D. H. Eckford, Kamloops; T. Elidoros, Montreal; V. G. Findlay, Montreal; G. W. Flewelling, Greenwood, N.S.; B. A. Foster, Montreal; D. R. Francis, Regina; E. C. Fraser, Montreal; J. B. Frederick, Kapuskasing; L. J. Frenette, Ottawa; D. Friesen, Hamilton; H. Furuya, Ottawa; F. E. H. Gardner, Toronto; C. A. Geddes, Burlington, Ont.; E. A. Gendron, Plattsburgh, N.Y.; D. H. Giauque, Vimy Ridge, Que.; K. R. Gillespie, Banff; E. H. Gilliatt, Roxboro; J. C. Gilmore, Port Arthur; W. F. Gilmore, Steep Rock; H. M. Gordon, Arvida; G. Gosselin, Montreal; J. W. Gouge, Vancouver; R. Gourdeau, Quebec; L. H. Groome, Montreal; G. K. Gunnarsson, Nanticoke, Md.; E. W. Halayko, Oakville; P. R. Hart, Brantford; F. C. Harvey, Edmonton; N. L. Harvey, Crofton, B.C.; D. W. Hawes, Montreal; N. J. Hawrysh, Toronto; H. R. Hayman, London; L. C. Hempsall, Port Mellon, B.C.; C. A. Hennigar, Kitchener; C. O. C. Henstridge, Montreal; S. E. Henwood, Toronto; R. Herdman, Corner Brook; H. S. Hicklin, Edmonton; J. C. Hickmore, Hamilton; J. L. A. Hogue, Gatineau; C. E. Holdway, Ottawa; W. G. Hollingsworth, Sault Ste. Marie; L. G. G. Holtby, Dartmouth; G. K. Hopper, Toronto; G. K. Hunter, Toronto; D. B. Imrie, Montreal; L. G. Jamieson, Montreal; A. P. Jesome, Ottawa; L. C. Johnson, Montreal; G. E. Johnston, Windsor; O. A. Juneau, Amos; K. E. Kansikas, Sault Ste. Marie; R. E. Kazan, Toronto; W. J. G. Kennedy, Vancouver; C. G. Kerr, Montreal; G. W. King, Santa Fe, N.M.; D. G. Kitson, Baie Comeau; E. N. Kolbeins, Vancouver; A. Koropatnick, Winnipeg; R. J. Kostick, Sarnia; M. Lajoie, Montreal; R. K. Lalor, Kingston; D. C. Lambert, Vancouver; J. M. Langevin, Quebec; M. L. Lapierre, Montreal; J. J. Lapointe, Montreal; A. R. Latham, Montreal; W. A. Laurin, Montreal; J. M. Lawrence, Clarkson, Ont.; G. L. Laycock, Trail; J. W. LeLacheur, Middle East; K. A. Le Mesurier, Ottawa; L. R. Letourneau, New Westminster; J. J. Leydon, Sarnia; E. E. Long, Vancouver; W. H. Lowry, Toronto; A. R. Luck, Nanaimo; C. F. Lund, Drummondville, C. N. Lund, Montreal; J. D. MacBride, Detroit; D. J. MacCandlish, Montreal; G. F. MacFarlane, Vancouver; I. C. MacFarlane, Ottawa; R. M. MacRae, Montreal; J. R. Mainprize, Montreal; J. E. Mainwaring, Windsor; L. Major, Chicoutimi; M. C. Malone, Toronto; D. G. Manzer, Baie Comeau; J. J. Marlow, Toronto; R. D. Marsh, Orillia; F. R. Marshall, North Bay; G. T. Marshall, Vancouver; A. P. Martinez, Los Angeles; M. H. Mayer, Detroit; D. A. McCammon, Toronto; R. D. McCargar, Hamilton; N. W. McDermid, Montreal; F. M. McGuire, Winnipeg; R. M. McIntosh, Winnipeg; D. J. McKinnon, Montreal; J. R. McMackin, North Bay; J. K. McMillan, Vancouver, W. L. McNamara, Fredericton; A. E. Meade, Fort William; A. O. Michaud, Sept Iles; S. L. Miller, St. John's, Nfld.; H. A. Mitchell, Plattsburgh; G. W. Morgan, Vancouver; L. Morgante, Orillia; B. E. Moore, Montreal; F. T. Moore, Montreal; L. A. Moore, Montreal; H. L. Morrison, Edmonton; J. F. Motyer, Winnipeg; W. Mowat, Sarnia; J. A. Mowry, Montreal; H. W. Nasmith, Victoria; J. Nathanson, Montreal; J. H. Noel, Kingston; R. C. Norgrove, Toronto; S. Nowak, Onaping, Ont.; J. B. Nuttall, Vancouver; W. E. O'Brien, Edmonton; N. F. Ogilvie, Garson Mine; D. I. Ourom, Kingston; P. N. Outerbridge, St. John's, Nfld.; R. E. G. Palmer, Scarboro; D. R. Parsons, Hantsport, N.S.; J. R. Phaneuf, Montreal; H. C. R. Pfeiffer, Hagersville, Ont.; S. H. Pope, Vancouver; G. L. Poulter, Hamilton; S. J. Pressman, Montreal; P. S. Price, Scarboro; T. P. Pumphrey, Corner Brook; J. B. Rea, Arvida; R. B. Reade, Guelph; T. W. Reade, Cardinal, Ont.; R. H. Rehder, Peterborough; E. E. Reid, Montreal; E. R. Reinelt, Edmonton; W. H. Renwick, Montreal; K. E. Rideout, Trenton; E. T. Rivington, Windsor; G. A. Robb, Gatineau; C. E. Robertson, Montreal; L. P. A. Robichaud, Quebec; A. K. Ross, S. Slocan, B.C.; A. W. Rowe, Temiskaming; A. Rozanski, Montreal; R. A. Ruddell, Kitimat; G. B. Ruiter, Windsor; D. H. Rutherford, Wenatchee, Wash.; D. M. Ryan, Montreal; J. Saintonge, Montreal; M. Saito, N. Burnaby; J. H. Saldat, Niagara Falls; L. R. Salkeld, Kingston; A. R. Sandall, Port Arthur; R. A. Sara, Los Angeles; M. H. Schmitt, Kitchener; J. E. Schneider, Arvida; A. P. Sentance, Ottawa; R. M. Senyshen, Kitchener; E. N. Shadeed, Montreal; L. Shakotko, Hamilton; S. Shapiro, Toronto; H. J. Shopland, Edmonton; A. G. Shugg, Vancouver; K. R. Simmons, Port Hope; M. P. Simon, Montreal; L. W. Skonieczny, Toronto; G. M. F. Smith, Windsor; N. Smith, Welland; W. A. Smyth, Farmington, Conn.; J. H. Spaulding, Sarnia; J. A. Spittle, Niagara Falls; W. N. Spratt, Montreal; A. G. Steele, New York; R. A. Stewart, Ottawa; W. A. Stewart, Toronto; T. Y. Strath, Montreal; J. H. Strong, Halifax; J. R. Stuebing, Erie, Pa.; A. J. Summach, Chalk River; F. G. Tanton, England; P. T. Taschereau, Montreal; C. L. Thompson, Toronto; D. G. Thompson, Vancouver; W. R. Tims, Montreal; E. H. Toms, Sarnia; G. H. Tosh, Oakville; J. H. Travers, St. Catharines; R. J. Trinder, Windsor; W. E. Turner, Calgary; G. C. Ufford, Montreal; R. H. Umbach, Calgary; L. W. Vaughan, Scarboro; W. J. A. Vey, St. John's, Nfld.; L. P. Villeneuve, Roberval; C. R. Vivian, Grand Falls; F. N. Walsh, Vancouver; J. M. Watson, Montreal; L. J. Watt, North Bay; W. E. Webb, Montreal; A. M. White, Vancouver; G. A. Wikhammer, Deep River; W. A. Willison, Winnipeg; P. J. Wooding, Pittsburgh; C. P. Woodward, Montreal; L. Yakimowich, Penticton; F. S. Yano, Toronto; H. Yanofsky, Montreal; R. M. Yeo, London; H. G. Young, Toronto; W. Zukowsky, Montreal.

STUDENTS ADMITTED

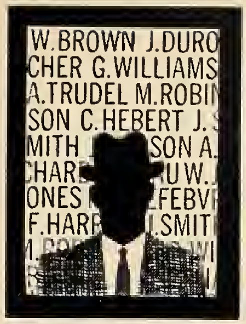
University of Western Ontario: E. L. Cambridge, D. J. Dickson, P. M. Dougherty, W. R. Dukelow, M. C. Foster, R. H. Harper, P. A. Holton, W. A. Huber, J. O. Hujer, A. Joosse, C. E. Kohn, J. Kortschinski, L. W. Martyn, R. L. Maxfield, J. A. McCorquodale, G. McKay, E. J. Medema, G. A. Mowbray, G. A. Pearce, G. A. Petraszko, M. Petrenko, R. L. Quibell, F. Ranacher, H. A. Roth, J. M. Thompson, A. V. Weirmeir, R. Yamada.

University of New Brunswick: A. L. Brown, J. R. Brown, J. W. M. Campbell, C. N. Crutchfield, P. C. Cushing, A. G. Gillies, P. L. Lister, R. H. Maxwell, R. C. Walker, J. E. White.

Queen's University: F. G. Amell, T. C. Anderson, D. R. Bock, R. S. Bryant, J. R. Grasse, J. D. F. Hendershot, D. E. Hilts, S. A. Kimmel, C. S. R. Overall, E. B. Peters, A. F. Reid, G. C. Tisdale, W. R. Wood.

University of Alberta: W. R. Bennett, K. A. French, R. W. Fuhr, D. K. Knudsen, R. H. MacDonald, D. L. Ozeroff, L. M. Plowman.

(Continued on page 163)



Personals

Thomas W. Toovey, M.E.I.C., has been elected president of Sherbrooke Machineries Limited, Sherbrooke, Que. Mr. Toovey has been associated with the company since 1950 when he was serving as sales manager.

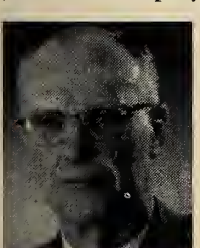
Penrose Melvin Sauder, HON. M.E.I.C. (Toronto '04), former general manager of the vast St. Mary-Milk Rivers Development in Southern Alberta, has retired. In accepting Mr. Sauder's retirement resignation, Hon. L. C. Halmrast, Alberta's minister of agriculture, paid tribute to him saying that his services as an engineer and advisor on all irrigation matters will be missed not only by Alberta, but by Canada as a whole. Mr. Sauder was awarded an honorary membership in the Agricultural Institute of Canada and the Julian C. Smith Medal for "achievement in the development of Canada" by the E.I.C. in 1947.

Leonard L. Youell, M.E.I.C. (Toronto '20), has retired as vice-president and general manager of Stone and Webster Canada Limited. Mr. Youell opened the company's first Canadian office in 1945.

Glenn H. Curtis, M.E.I.C. (Toronto '48), is succeeding Mr. Youell. Mr. Curtis joined the company in 1955 and was made vice-president in 1959.

A. Latreille, M.E.I.C. (Poly. '42), president of Alta Construction Co. Ltd., has been named director of the General Contractors' Section of the Montreal Builders' Exchange.

D. C. Crothers, M.E.I.C. (Queen's '37), has been appointed chief engineer, Compressor Sales, Canadian Ingersoll-Rand Co. Limited, Montreal. Mr. Crothers joined the company in 1937.



D. C. Crothers, M.E.I.C.

W. A. Devereaux, M.E.I.C.

William A. Devereaux, M.E.I.C. (Toronto '37), has been appointed general manager of the newly-organized Yarnall-Waring Company of Canada, Ltd., Guelph, Ont. This new Dominion-chartered company is a subsidiary of the Yarnall-Waring Company of Philadelphia.

Dr. G. G. Meyerhof, M.E.I.C. (London '38), has been elected Chairman of the Soils and Materials Committee of the Canadian Good Roads Association and member of the Advisory Council of the American Society for the History of Technology. He is Head of the Department of Civil Engineering of the Nova Scotia Technical College, Halifax.

Dr. G. G. Meyerhof, M.E.I.C.

J. L. Patterson, M.E.I.C.

James L. Patterson, M.E.I.C., has joined The Gas Machinery Company (Canada) Limited, Hamilton, as sales engineer. Mr. Patterson was formerly with Salem-Bresius Canada Ltd.

W. T. Hargreaves, M.E.I.C., has been named executive assistant to the minister and chief engineer, New Brunswick Dept. of Public Works. He has been associated with the department for the past 26 years.

R. E. Simpson, M.E.I.C. (Queen's '40), has been appointed general service manager The White Motor Co. of Canada, Ltd. Mr. Simpson joined the company at its Montreal factory in 1946 and in 1959 became assistant to the general service manager at head office, Toronto.

Marc Benoit, M.E.I.C. (Ecole Poly. '44) and **Fred J. Travers**, M.E.I.C. (Toronto '44), are managing partners of a recently formed consulting engineering firm — Benoit, Boucher, Simpson, Travers et Associes, Montreal. The firm plans to engage in general consulting engineering, providing comprehensive professional engineering services for hydro and thermal power developments, industrial plants and transportation.

William A. Wright, M.E.I.C. (Toronto '49), has been appointed manager, Electric Product Sales, Western District, Union Carbide Canada Limited, Linde Gases Division. Mr. Wright was formerly assistant to the sales manager, Electric Products.

W. A. Wright, M.E.I.C.

J. W. Hackney, M.E.I.C.

John W. Hackney, M.E.I.C., has been appointed vice-president Pan-American Management Ltd. Mr. Hackney will direct the technical staff services provided to corporations by Pan-American, from their offices in Montreal.

Louis Desrosiers, M.E.I.C. (Ecole Poly. '48), formerly with Gaspesia Sulphite Co., Chandler, Que., is now with Stadler Hurter and Company, Montreal. Mr. Desrosiers is spending a few months at their Paris office.

George N. Cater, JR.E.I.C. (U.N.B. '49), has been appointed assistant control superintendent at Anglo-Newfoundland Development Co. Ltd., Grand Falls, Nfld.

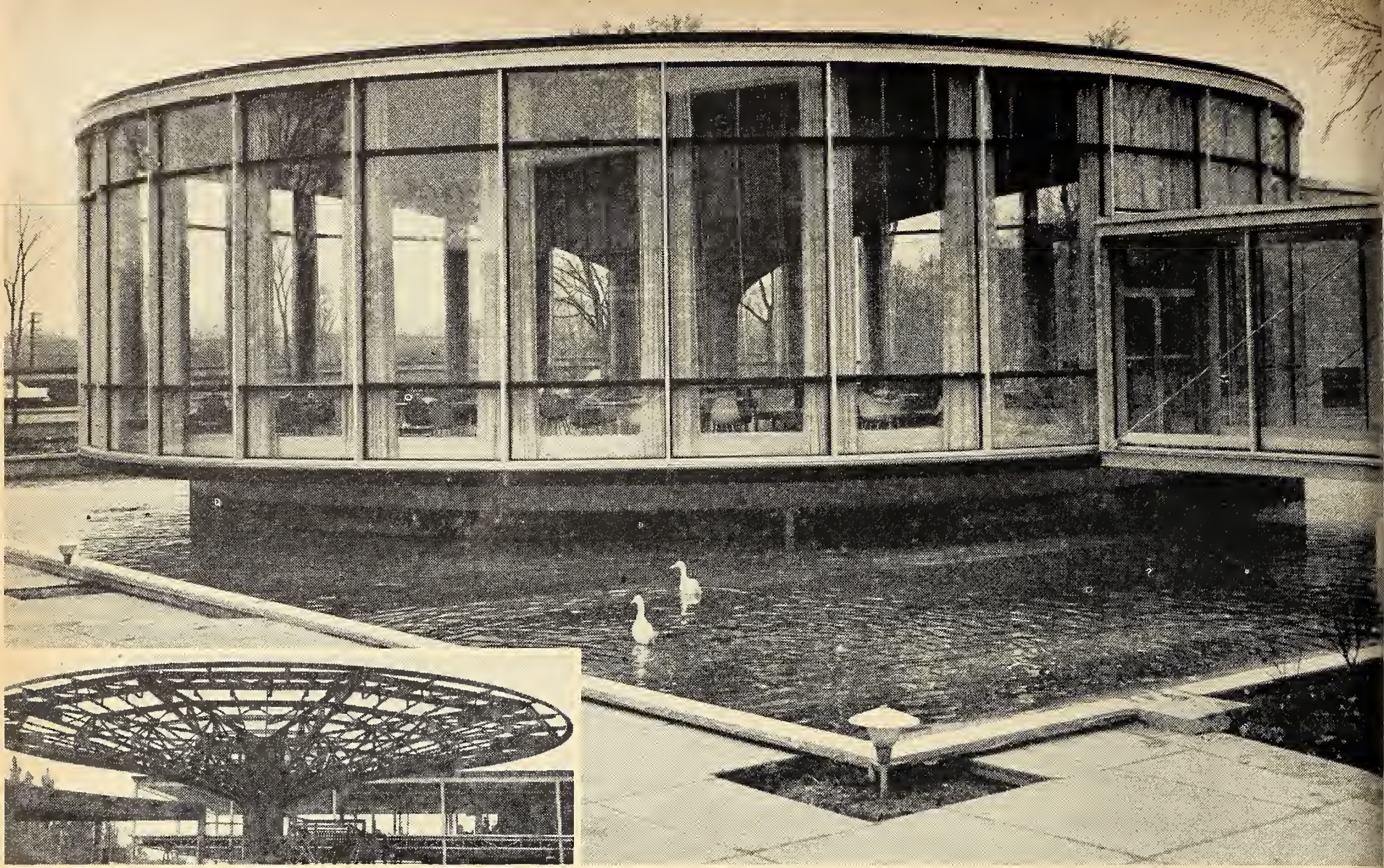
J. A. Smith, M.E.I.C.

M. A. Ward, S.E.I.C.

J. A. Smith, M.E.I.C. has been appointed vice-president of The Shawinigan Water and Power Company. Mr. Smith becomes vice-president, production and power operations.

Michael A. Ward, S.E.I.C. (Man. '59, a field representative in the Winnipeg Branch Office of The Master Builders Company, Ltd., has been awarded the Athlone fellowship from the U.K. government. Mr. Ward leaves for two years

(Continued on page 104)

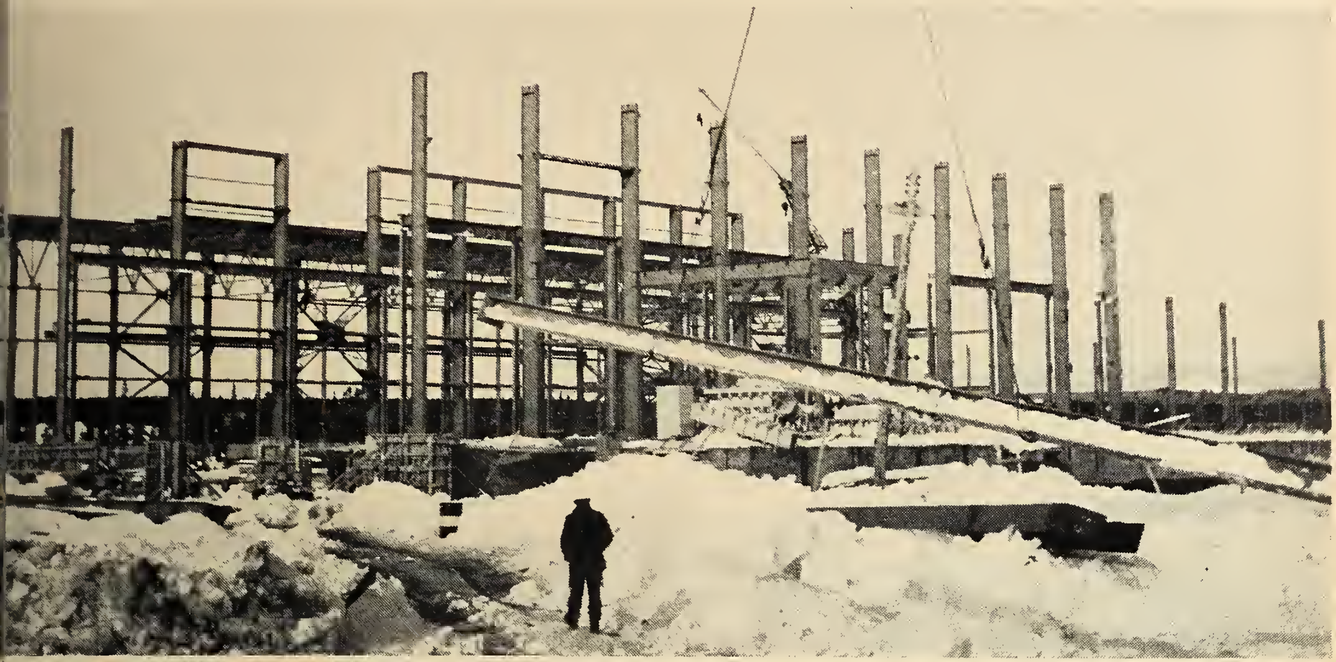


Beauty—This striking cafeteria on the CIBA building employs a steel umbrella-like cantilever roof structure. (See inset). The characteristics of steel offer great scope to the imaginative architect.

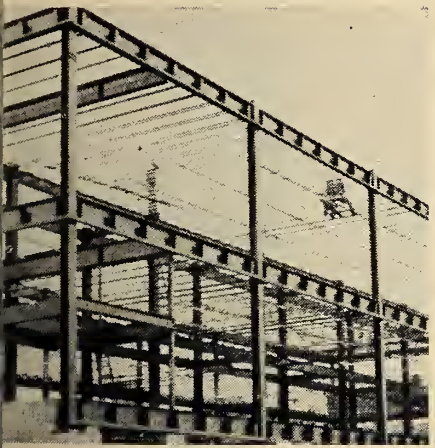
Why you shoul

Better Economy—This merry-go-round building is the kindergarten of a new school in Regina. Close co-operation between the architect and the steel fabricator made the best use of materials and helped cut costs.

Weather Construction—Steel goes up in any weather that men can work.
lding schedules are on time, no frosty weather delays.



esign and build in steel



e to the Future—A two-storey school
of steel that provides for the future
of a third storey. New columns and
an be weld-connected to this structure
e time comes.

FOR THE ARCHITECT it's design freedom. Structural steel is very versatile and can be made to take almost any architectural form. Its strength and lightness permit long spans to provide large column-free areas. The vertical supports that are necessary, take up minimum space and permit better use of basement areas.

FOR THE CONTRACTOR it's the ease and speed of erection. Steel arrives fabricated and goes up fast. High strength bolts speed the job and eliminate undue noise at the site. Steel is an all-weather building material and the job can go on no matter what the temperature. Schedules are easy to keep and sub-trades get in on time.

FOR THE OWNER it's early return on investment. Steel frame buildings go up fast, and start to pay off in the minimum time. Even a few weeks difference in completion dates can run into thousands of extra dollars. Steel is flexible too—changes and additions are easily made.

When you plan, consider carefully the merits of steel. Dominion Bridge maintain design, fabrication and erection facilities in most of the major cities. Their sales and engineering departments will assist you in any way they can. Have them show you what steel can do for your project.

STRUCTURAL DIVISION

67

DOMINION BRIDGE

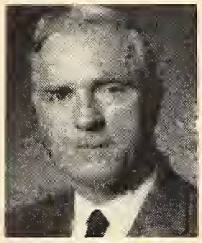
FIFTEEN PLANTS COAST-TO-COAST

• PERSONALS

(Continued on page 98)

study and training in University and engineering firms in Britain.

J. M. Sharpe, M.E.I.C., has been appointed executive assistant, production and power operations. **Ralph F. Brooks,** M.E.I.C., has been named manager of the newly formed system operating department.



J. M. Sharpe, M.E.I.C.

R. F. Brooks, M.E.I.C.

K. Colin MacKenzie, JR.E.I.C. (McGill '56), has been appointed Manager, Capital Branch, Canadian Ice Machine Company Limited. Before his present appointment Mr. MacKenzie was CIMCO refrigeration sales engineer.

Charles Aquelina, JR. E.I.C. (London '57) at present working in the Structural Design Dept. of the Dominion Bridge Co., is returning to England shortly to further his studies in steel research at the Imperial College of Science and Technology, London.

Dean H. G. Conn, M.E.I.C. (Queen's '31), has left for New Delhi to carry out a survey under the Colombo plan auspices to help with India's third five-year plan. Together with **Dean R. R. McLaughlin** of the University of Toronto faculty of engineering, Dean Conn will survey the requirements in connection with India's regional engineering institutes which form part of their development program.

Obituaries

Archibald Gordon, M.E.I.C., 80, a retired civil engineer, died Nov. 26. Mr. Gordon was a resident of Moncton, N.B. He had previously worked with the Department of Public Works. He became a member of the Institute in 1942.

J. A. Heaman, M.E.I.C. (McGill '02), retired office engineer of the C.N.R., Montreal, died Nov. 9. After his retirement Mr. Heaman became a resident of Victoria. He started his engineering career with the Grand Trunk Railway as resident engineer in 1902 and in 1932 became office engineer in Montreal. He joined the Institute as a student member in 1901, became an affiliate member in 1909 and a member in 1916. He was made a life member in 1943.

Thomas P. Hutchinson, M.E.I.C. (McGill '44), a prominent figure in the industrial consultant and construction fields, died Montreal, Oct. 31. Mr. Hutchinson has been associated with several large Canadian firms on major projects and in 1958 he was appointed representative of INFILCO. He became a member of the Institute in 1950.

T. P. Hutchinson, M.E.I.C.

Alexander Peden, M.E.I.C., a retired standards engineer, died Montreal Nov. 20. Mr. Peden was an employee of the Dominion Bridge Company from 1901 until his retirement in 1952. He joined the Institute as a student member in 1903 and beeame a member in 1925. In 1947 he was made a life member.

D. Roland Webb, M.E.I.C., (U.N.B. '35), widely known consulting electric engineer, died Nov. 26. He was 47. Mr. Webb had been engineer in charge of electrical installations in many public and private buildings throughout the Maritime Provinces. He joined the institute as a student member in 1933 and became a member in 1942. EIC

Other Societies

Athlone Fellowship

The E.I.C. entertained members of the Boards of Selectors for the Athlone Fellowship at a luncheon Jan. 19 at the University Club, Montreal. United Kingdom Representatives present were: Dr. A. C. Monkhouse; Mr. E. O. Laird; Mr. Arnold Heckle. Representatives from l'Ecole Polytechnique were: Dr. H. Gaudefroy; Prof. J. Laurence; Prof. J. C. Bernier; Prof. R. Brais; Prof. P. P. Vinet. Representatives from McGill University were: Dean D. L. Mordell; Prof. W. Bruce; Dr. G. L. d'Ombrain; Prof. R. G. K. Morrison; Prof. R. E. Jamieson; Dr. I. R. Tait. E.I.C. members present were: President Dick; F. L. Lawton; E. D. Gray-Donald; C. G. Southmayd; L. A. Duchastel; Garnet T. Page.

Canadian Nuclear Association

The first annual meeting and conference of this newly formed Association is to be held in Toronto, May 16-17. On the agenda are prominent speakers from the United States and Canada who are engaged in the research, development or utilization of the peaceful uses of nuclear energy and radio isotopes. It is anticipated that approximately 250 members will be attending the conference.

The Association's membership is drawn from all parts of Canada from industry, commerce, education, government and private individuals whose participation in the new and rapidly developing field is widely diversified. I. F. McRae, Chairman of the Board, Canadian General Electric Co. Limited, is President and The Hon. Robert W. Macaulay, Ontario Minister of Energy Resources, is Vice-President.

Canadian Reasearch Institute

The new production plant and research laboratory has been opened in Don Mills, Ont. This building more than triples the space previously occupied, and will include office, warehouse, laboratories and manufacturing facilities.

The Chemical Institute of Canada

A Russian scientist, V. V. Tchebotarevski, of the Institute fo Scientific Research, U.S.S.R., was one of the speakers at the Conference of the Protective Coatings Division in Toronto Feb. 23 and in Montreal Feb. 24. The same technical program was featured in both cities.

Other speakers and their papers were: C. A. Kumins, Interchemical Corp., New York,—"Diffusion of Gases and Vapors through Unpigmented and Pigmented Vinyl Polymers—Glass Transition Effects"; Andrew Bowman, British Titan Products (Canada) Limited,—"Some Recent Trends and Developments in the Protective Coatings Field in the U.K."; L. E. Gast, Northern Regional Research Laboratory,—"Fatty Vinyl Ether Copolymers: Potential Materials for the Coatings Industry"; R. Spolski, Polymer Corp. Limited,—"Stereoregulated Elastomers".

The Society for Nondestructive Testing, Inc.

The first three lectures of the Society's educational clinic were given in Montreal Feb. 1, Feb. 8 and Feb. 15.

O. L. Burlone, L. E. Baxter Ltd., spoke on "Ultrasonic in a Simple Way" Feb. 1. He described basic elements of wave generation and propagation; ultrasonic sources; types of crystals and characteristics; different equipment and methods; application to testing, its uses and limitations.

The second lecture was given by T. W. McFarlan, Sperry Products Company, on Feb. 8. The title of Mr. McFarlan's lecture was "Theory of Ultrasonic Contact Testing". Covered in his talk were descriptions of various types of instruments; transducers, properties, design, uses, and limitations; effect of couplants; effects of size, shape and location of discontinuities; theory of transmission and reflection methods; interpretation of results; special tests and applications; personnel.

The third lecture was "Immersion Testing" by B. W. Smith, Curtiss-Wright Corp. The Feb. 22 lecture was given by F. C. Parker, Union Carbide Chemicals Company. He spoke on "The Inspection of Welded Structures" and described the effect of velocity of sound. Also covered in his lecture were refraction, attenuation, sensitivity, size, shape, orientation and type of discontinuities; transducers design, couplants, preparation of parts for inspection; standards; test blocs; interpretation of results; field inspection techniques; training and qualification of personnel; acceptance and rejection criteria; comparison with radiography.

Coming Events

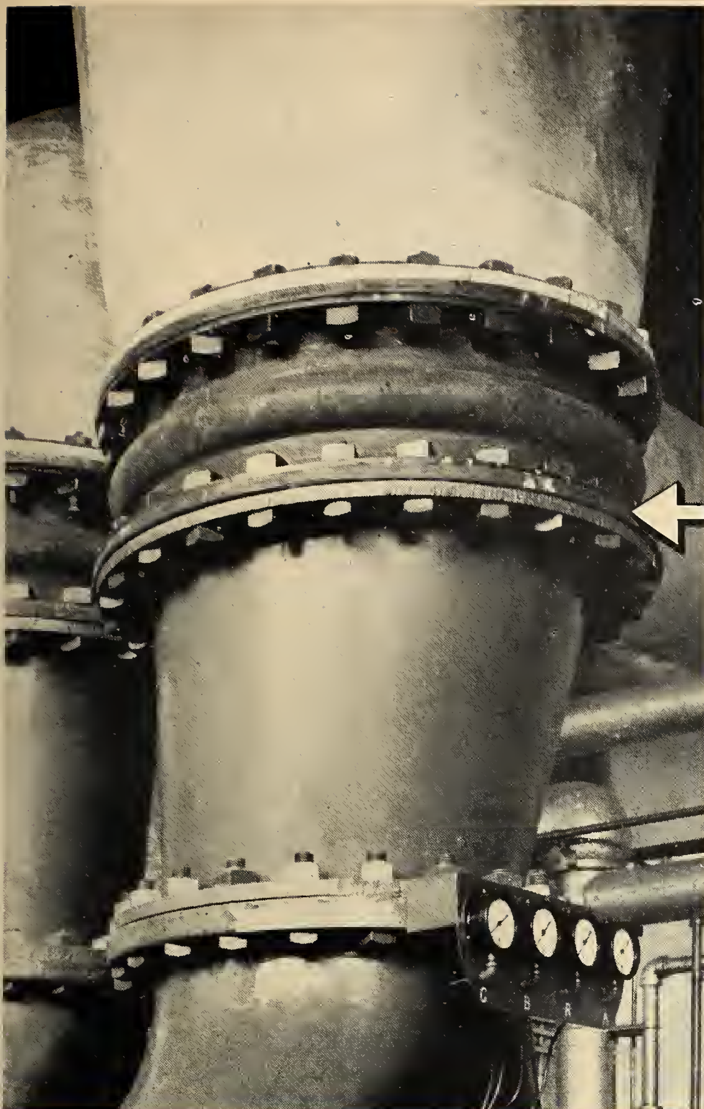
- Annual Conference of Canadian Building Officials, Ottawa, April 5-7.
- 42nd Annual Convention and Welding Exposition, American Welding Society, New York, April 10-21.
- 39th Milan International Trade Fair, Milan, Italy, April 12-27.
- 63rd Annual General Meeting, Canadian Institute of Mining and Metallurgy, Quebec City, April 17-19.
- Muskeg Research Conference, McMaster University, April 18-19.
- VI^0 Salon International de la Chimie and the Conference Internationale des Arts Chimiques will now be held in Paris, France, April 25-May 4.
- 3rd Annual Meeting, Specification Writers Association of Canada, Montreal, April 28-29.
- Engineering, Marine, Welding and Atomic Energy Exhibition, London, England, April 20-May 4.
- Railway Modernization Conference, Institution of Civil Engineers, London, England, May 3-4.
- Symposium on Titrimethic Methods of Analysis, Chemical Institute of Canada, Cornwall, Ont. May 8-9.
- European Convention of Chemical Engineering, European Federation of Chemical Engineering, Frankfurt am Main, June 9-17.

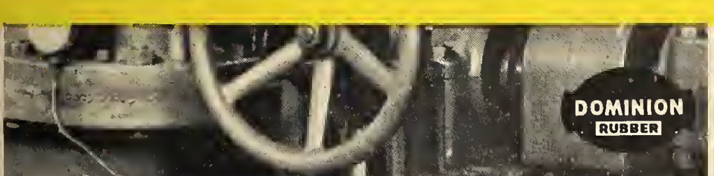
The Associations and Corporation

Ontario

A total of 15 brief committee reports were presented at the 39th annual meeting by their respective chairmen. Noting changing trends in the technological nature of industry, the professional status committee said a philosophy must be developed and encouraged within the profession towards building an attitude of self-improvement in each member. By this means, true technical competence will be recognized within the profession as well as by industry, the report states.

T. W. Eadie, president of the Bell Telephone Co. of Canada was the guest speaker. In addition to Mr. Eadie's address, a report on the Colombo Plan was given by F. J. Lyle, Director, Trade and Industry branch, Ontario Dept. of Planning and Development.





DOMINION
RUBBER

News of the Branches

Baie Comeau

G. W. Scott, M.E.I.C.,
Correspondent

Lloyd J. Severson, President of the Quebec Cartier Mining Company, gave a talk on "The Quebec Cartier Mining Project" at the Branch's Feb. 3 meeting. Mr. Severson was introduced by the Branch Chairman, S. J. Simons and his address covered a wide field in the geology and mining of iron ore. He described the nature of the various iron ore deposits throughout the world with particular reference to the Province of Quebec and Labrador. The geological surveys which led to the establishment of the Lac Jeannine project in Northern Quebec were explained in some detail as also were the features determining the nature of the sea and rail communications with the mining area. Mr. Severson explained the economic factors associated with the project which enabled the mining plant at Lac Jeannine, with an annual output of some 8 million tons of ore concentrate a year, to compete with the types of ore mined in the United States.

The actual description of the project, involving the construction of a deep sea harbour, a 192-mile railway, a mining plant and townsite was supplemented and vividly illustrated by an excellent film entitled "Accomplishment in Northern Quebec" recently produced by the Quebec Cartier Mining Company.

A vote of thanks was given by G. W. Scott of the Branch Executive at the conclusion of the discussion.

Border Cities

V. Corin, JR.E.I.C.,
Correspondent

The annual business meeting was held at the Prince Edward Hotel Dec. 14. Vice-President E. A. Cross gave an enlightening talk on the history of engineering organizations with particular emphasis on the Engineering Institute of Canada. Officers for the coming year were elected.

Forty-six members attended the annual "Smoker" on Jan. 25 at the Ridge Valley Golf and Country Club. A gambling night was featured in which prizes were awarded to winners.

Brockville

A. N. Campbell, M.E.I.C.,
Correspondent

John E. Brett, of Brett Oullette Blauer Associates, consulting structural engineers for Montreal's $80 million Place Ville Marie project, addressed the branch Jan. 17. Mr. Brett's topic was "Some Unusual Engineering Problems of Place Ville Marie Project". He described how special vibration pads were required for the steel columns of the 42-storey tower building, which were spaced between tracks. The pads are to absorb all vibrations eminating from the railroad. He also said how the presence of defective seams in the sedimentary rock which occupied the site area have no bearing capacity and make it difficult to find stable areas to place footings for steel columns, which required some footing levels to be at different depths.

Also discussed at the meeting was E.I.C. sponsorship of student "Science Fairs" and the possibility of their promotion in the area by the branch.

Cape Breton

Lloyd Boutilier, M.E.I.C.,
Correspondent

"Maintenance Metallurgy" was the title of a talk given by Frank Martin, Maintenance Metallurgist at Dosco's Sydney Works, at the Jan. 30 meeting. Mr. Martin discussed the causes of metal part failures, the factors influencing them, and methods of avoiding failures. He discussed non-destructive testing, splitting the subject up into five major divisions: penetration; radiation tests; ultrasonic tests; magnetic particle tests; electro-magnetic tests; liquid or dye penetrant tests. Slides were used to illustrate various points under discussion.

Mr. Martin was thanked by Bill Dodson.

Corner Brook

Robert G. Scott, JR.E.I.C.,
Correspondent

A meeting was held Jan. 10 and H. B. Carter, Assistant Resident Engineer, Bowater's Nfld. Pulp and Paper Mills Ltd., spoke on "Electric Motors in Industry". Robert Herdman, M.E.I.C., introduced the speaker.

Mr. Carter divided his lecture into two parts, a-c motors and d-c motors. Sub-dividing further into the various types he covered theory of operation, constructional features, typical uses, advantages and disadvantages of each. A large display of electrical motors in assembled and disassembled form were shown. These were provided by Bowater's Electrical Department. A lively question and answer period followed. The vote of thanks was given by Jack Fisher, M.E.I.C.

Loyola College

Richard Kind, S.E.I.C.,
Correspondent

A meeting was held Feb. 3 when John E. Brett of Brett, Ouellette Blauer Associates, discussed some of the problems met when designing the structure of the new Science Building erected at the College. An interesting question and answer period followed. The speaker was thanked by Ross Dugan, Chairman of the Student Section.

Montreal

J. Robert Sabourin, M.E.I.C.,
Correspondent

A une réunion du comité exécutif du Chapître tenue le 5 décembre dernier, le comité de nomination a annoncé le choix suivant des nouveaux officiers devant faire partie de l'exécutif du chapître pour l'année 1961:

Président: H. A. Mullins

Vice-président: C. G. Kingsmill

Membres du comité: G. H. Hoganson; M. S. Pappuis; M. E. P. Stephenson.

Durant les quelques années qui ont précédé son accession à la présidence, M. Mullins a rempli diverses fonctions et a été actif sur plusieurs des différents comités du chapître. Il a notamment été Président du comité des divertissements pour la période 1950-51-52, membre du comité exécutif durant 1953-54, représentant du Chapître au Conseil de l'Institut, et Président du comité des publications de l'Institut pour 1957-58, finalement, Vice-Président du comité exécutif et Président du comité de conduite et coordination pour l'année 1960.

M. Kingsmill a également apporté sa contribution aux activités de plusieurs des différents comités du Chapître et de l'Institut avant d'être nommé au poste de Vice-Président du Chapître. Messieurs Hoganson, Pappuis, et Stephenson ont également participé aux activités de plusieurs des différents comités du Chapître, avant leur nomination au comité exécutif pour l'année 1961.

At a regular meeting of the Branch Executive Committee held on December 5th, 1960, the Nominating Committee announced the following nominations as

Kodak
TRADEMARK

Kodak Industrial X-ray Film

Assures safe journey for airbound castings!

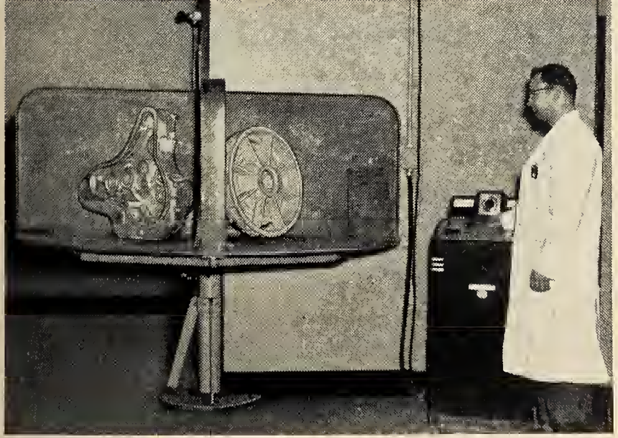
The air is no test ground for aeroplane castings. Radiography with Kodak Industrial X-ray Film finds any and every flaw first!

Light Alloys Ltd. of Haley, Ontario supplies castings to more than half a dozen manufacturers of aeroplanes and aeroplane engines. Everything from ski-clamps for commercial aircraft to gear boxes for helicopters is produced. And, almost every casting . . . whether it weighs 4 ounces or more than 120 pounds – is examined in the plant's radiography department. Only radiography gives proof that a casting is sound enough to withstand calculated design stresses!

"Radiography ensures that a casting meets the specifications", explains L. G. Day, plant manager. "Without industrial X-ray we would have no idea of metallurgical soundness. For example, a complex casting could have severe porosity and yet appear satisfactory to the eye. X-rays detect the flaws even in internal passages."

"All our machines are set for Kodak film", says Mr. Laporte, Chief Radiographer. "There is no tendency to fog or streak. Both the film and developing are so superior."

As at Light Alloys Ltd., Kodak Industrial X-ray Film can guarantee the right answers to your inspection problems. Contact your X-ray Dealer or Kodak Technical Representative for the full story. Or write: Canadian Kodak Co., Limited, Toronto 15, Ontario.



Light Alloys' Radiograph Dept. uses a revolving, 4-compartment "turntable" to speed its work. While castings are being radiographed in one compartment, other castings are set up in the other three ready to be radiographed. No time is lost between exposures of film!

CANADIAN KODAK CO., LIMITED
Toronto 15, Ontario

part of the new Executive for the coming year:

Chairman: H. A. Mullins
Vice Chairman: C. G. Kingsmill
Committeemen: G. H. Hoganson; S. Pappuis; E. P. Stephenson.

Prior to his accession to the chairmanship, Mr. Mullins served the Branch for a number of years in various capacities. He rose successively from Chairman of the Entertainment Committee during 1950-51-52, to member of the Executive Committee in 1953-54, and to Branch Representative on Council of the Institute and Chairman of the Institute Publications Committee in 1957-58. In 1960, Mr. Mullins was Vice-Chairman of the Executive Committee and also held the post of Chairman of the Policy and co-ordination Committee.

Mr. Kingsmill also served the Branch and the Institute in various positions prior to his nomination to the Vice Chairmanship. Messrs. Hoganson, Pappuis, and Stephenson, have likewise held a number of positions on several of the Branch Committees before becoming members of the Executive Committee for 1960.

L'assemblée générale annuelle du 30 janvier derner au cours de laquelle a eu lieu la mise en fonctions des nouveaux officiers de l'exécutif pour l'année 1961, a été rehaussé cette année de la présence du Président de l'Institut, le Dr. G. McK. Dick. Parmi les personalités éminentes présentes à cette cérémonie on notait: M. John Stirling ancien Président de l'Institut, M. Hugh Crombie ancien Président de Canadian Manufacturing Association, de même que messieurs Irving Tait, Ed. Smallhorn, Gury Martin et R. N. Coke, tous d'anciens Présidents du Chapître.

The Branch annual meeting which was held on January 30 last, and on the occasion of which took place the installation of the new Branch Officers was honored this year by the presence of Dr. G. McK. Dick, the President of the E.I.C. Among the several distinguished guests present were noted: Mr. John Stirling Past-President of the E.I.C., Mr. Hugh Crombie Past-Chairman of the Canadian Manufacturing Association and Messrs. Irving Tait, Ed. Smallhorn, Gerry Martin and R. N. Coke all Past-Chairmen of the Montreal Branch.

Professional Engineers' Wives Association, a voluntary organization formed about a year ago to promote friendship among the wives and widows of members of the Engineering profession has currently embarked on a drive to increase its membership. In this respect, approval was given for the group to make use of the Montreal Branch mailing list in its efforts to recruit new members.

Newfoundland

Anthony O. Nemec, JR.E.I.C.,
Correspondent

A dinner meeting was held Jan. 18 at the Newfoundland Hotel. John Henderson was Chairman. The speaker, David Straw, Assistant Chief Geologist, Canadian John's Manville Co., Ltd., was introduced by John Pike.

Mr. Straw spoke on "Asbestos Deposits in Baie Verte, Newfoundland" and outlined the geological features and extent of the deposits. The company has proven more than 35 million tons and believes that there is more to be located. A large processing plant and docking facilities for ocean vessels are now under construction. It was evident from Mr. Straws interesting talk that great progress is being made in the development of mining operations in that area of Newfoundland, which also has a large copper producing mine at Tilt Cove.

The meeting was attended by approximately 60 members and a vote of thanks was given by Mr. E. Ball from the Department of Highways. Mr. V. J. Southy, President of the local C.I.M.M. branch was a guest and was accompanied by a group from the C.I.M.M.

Nipissing and Upper Ottawa

J. W. Millar

A dinner meeting was held at the King Edward Hotel in Sturgeon Falls Jan. 11. R. S. McLennan presided and 20 members were present.

Following dinner, N. A. Burke of Temiskaming introduced the guest speaker, R. W. Bartholomew, resident engineer for Baily Meter Company Limited. The subject of his talk was "Modern Trends in Industrial Process Control."

Mr. Bartholomew said that measuring and controlling instruments were used most extensively in primary industries such as electrical utilities, water treatment plants, chemical and petroleum industry and pulp and paper mills. In the early days the steam-electrical and water treatment industry made the greatest use of industrial instrumentation. The major turning point in acceptance and subsequent development of modern metering and control equipment came with the industrial boom that accompanied World War II.

Since 1950 industrial instrumentation has experienced a fantastic expansion. In that year the gross sales in North

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

Address all information to: *The Engineering Journal,* Editorial, 2050 Mansfield Street, Montreal 2, Que.

Beaver Bill says:

There are over 6,000 books on all phases of engineering in the E.I.C. library, and new books are listed each month in the Library Notes section of the Engineering Journal. E.I.C. members can borrow any of them. The library will compile a list of books on any particular subject on request.

America were about two billion dollars and in 1960 is likely to have exceeded seven billion. The trend towards automation is the reason for this and already there are fully automatic power stations, both hydraulic and thermal. Automation produces better and cheaper products but the application of automation is limited by cost, the superiority of human skills in some processes, loss of production due to failure of automated mechanisms and the need for further development of the controlling devices. Mr. Bartholomew said he believed automation is desirable and advantageous from both an economical and sociological point of view.

J. S. Cooper thanked the speaker and the chairman reported that the next meeting would be Students' night in North Bay Feb. 8.

Nova Scotia Technical College

J. H. Bethune, S.E.I.C.,
Correspondent

The Annual Ball was held Jan. 27 in the Commonwealth Room of the Nova Scotian Hotel, Halifax. Special guests included the Lieutenant-Governor of Nova Scotia and Mrs. Plow; the Hon. R. L. and Mrs. Stanfield; His Worship the Mayor of Halifax and Mrs. Lloyd; Mr. and Mrs. A. E. Cameron; Mr. and Mrs. J. G. Belliveau; Mr. and Mrs. B. N. Cain. The theme of this year's ball was "Remember When . . ." Each faculty entered an exhibit to coincide with the theme. The E.I.C. trophy, won by the Chemical Faculty, was presented by Lt.-Gov. Plow.

University of Manitoba

Brian Grover, S.E.I.C.,
Chairman, Student Section

At the Jan. 19 meeting Angus Laughlin, Chief Design Engineer of the Bridge Department of the City of Winnipeg Engineering Office, presented a program on "The Disraeli Freeway". After outlining the project Mr. Laughlin showed slides on all phases of the construction of the latest bridge over the Red River in Winnipeg. An interesting discussion developed and the program was greatly enjoyed by the 150 students in attendance.

The student papers competition commenced Jan. 26 with Allan Lansdowne presenting his paper on "A Sketch History of Bridges". An interesting film about suspension bridges followed.

Winnipeg

Peter M. Abel, JR.E.I.C.,
Correspondent

"The Electrical Consultant's Role in Lighting a Modern Building" was the title of a talk given by V. S. Buckler, chief electrical engineer of Green, Blankstein, Russell and Associates.

The guest speaker introduced his talk by covering the general background and technical knowledge which an illumination engineer must have, and the boundaries within which he must work to meet the requirements of the architect, the client, efficiency and economy. The main part of his talk dealt with specific buildings and their illumination problems. Mr. Buckler described in detail the installations in the Lorne Building, Ottawa, now housing the National Gallery, and the Norquay Building, Winnipeg, the new home for Manitoba Provincial Government Departments. This part of the talk was accompanied by slides of the two installations. He also discussed the use of natural sunlight in conjunction with artificial, modular systems, bubbles and combined heating and lighting systems in suspended ceilings. The active question and answer period following indicated that the members had gained a new insight into the illumination engineer's field.

The speaker was introduced by Prof. H. A. MacDiarmid and was thanked by Prof. S. G. Wicks, both of the Electrical Section of the Faculty of Engineering, University of Manitoba.

John E. Brett gave his talk "Some Unusual Engineering Problems of Place Ville Marie Project" at a meeting of the **FREDERICTON BRANCH** Jan. 26. **CHALK RIVER** held a joint E.I.C.-C.I.C. meeting Jan. 17 and heard an interesting talk given by Dr. D. C. Rose entitled "Upper Altitude Research in Canada". Members of the **CALGARY BRANCH** heard Ross Smyth of Trans Canada Air Lines, give an informative talk on "Air Transportation To-day and Tomorrow". Jan. 10. Professor H. M. Edwards, who is a traffic consultant for the City of Kingston, presented an illustrated lecture to the **KINGSTON BRANCH** Jan. 25, on traffic control problems. President Dick addressed **OTTAWA BRANCH** Jan. 12.

● DISCUSSION

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available in the same location—another feature desirable to make these devices as useful as possible to engineers in their work.

Discussion by A. Porter, M.E.I.C.

During the past decade there have been increasing applications of high-speed computers in all branches of industry, but in few fields have these applications been more profitable than in the chemical and petrochemical industries. The authors are to be commended on presenting a well-balanced paper which indicates in specific ways how both analogue and digital computers can be used. Very rarely are both techniques considered in a single paper and for this reason alone the paper is a significant contribution to the literature. It is also encouraging to learn that "literally dozens of successful applications" have been recorded in spite of the fact that the computer techniques involved are still in their infancy—with the advent of highly reliable semi-conductor devices operating at ultra-high-speeds the future of computers in the chemical industry appears to be very bright.

A somewhat disquieting fact raised by the authors is that their company is obliged to organize classes in "advanced mathematics" for the benefit of their technical staff; because it should be expected that the universities would have handled this matter effectively. On the other hand, if "technical staff" implies non-professional personnel the establishment of the courses mentioned in the paper is a very encouraging sign. Professional engineers who have graduated during the past 20 years must surely have been given, at the universities, instruction in such topics as ordinary and partial differential equations, and the elements of probability and matrices. Indeed, instruction in the elements of the calculus, including elementary differential equations, is already common in many high schools of the Western World. And it is to be hoped that the universities will take very serious note of these deficiencies in their engineering graduates, if they still exist, and take urgent steps to correct them. The authors have contributed an important service to engineering education by bringing to light this most important matter.

Discussion by G. L. d'Ombrain

The further implications of this type of study are important. Management is being faced with the necessity of providing ever more expensive research tools for the appropriate extrapolation of its investigations and towards the further development of its research activities. For those who possess neither of these two valuable tools at the outset, there is the necessity to choose one or the other since economic considerations do not usually allow both to be purchased at the same time. The developments in analog computers while significant are nothing like so spectacular as those which are occurring every month in the field of digital computation. When engineering problems become complex, then really large-scale analog computers are required; the authors quote an example which uses the Pace computer and it is a computer with considerable ramifications which make it a costly instrument.

The interesting question, I think, would be whether the work which they did on the nitric acid plant could have been done on the digital machine. One of the complaints which many engineers have in regard to the use of digital machines is their feeling that they lose contact with the problem even if they themselves have been instrumental in programming the solution for their own problem. Having had some experience on working with analog computers, the idea that the analog computer gives a greater feel to the problem is in many cases an erroneous one if the problem is large and the analog computer has many operational amplifiers involved in the solution.

Another point that has to be remembered is that the authors use the analog computer to set up a differential equation which is subsequently solved by the computer; there is another approach which enables you to set part of the process as a direct analog, though on a different time scale which does certainly give one a greater feel of the problem, but this type of attack is usually only possible on special purpose computers. To illustrate what I mean by this, take the simple case of three cascaded, non-interacting (simple exponential lags) time lags having time constants T_1, T_2 and T_3, respectively. The output-input relationship for this is given by the following expression:—

$$\frac{\theta_0}{\theta_1}(S) = T_1T_2T_3S^3 + (T_1T_2 + T_2T_3 + T_1T_3)S^2 + (T_1 + T_2 + T_3)S + 1$$

From this it will be seen that if you wish to make an alteration in one of the time constants, for example the flow rate across a particular heat exchanger surface, you have to make three adjustments to the settings of the coefficient potentiometers of the analog computer. If the problem is more complicated as is normally the case, then a similar change would necessitate anything upward of 12 to 14 coefficient changes. In a special purpose computer, or in a general purpose computer arranged for this method of presentation, you represent each cascaded lag by its physical entity and therefore it is possible to go to one section of the computer and to mentally visualize this as the actual physical entity.

Now consider for a moment the problem placed on a digital machine. A program can be written in which the successive values of a particular time constant can be stored in appropriate locations, and the calculation carried out by the machine can successively call on the different values of this time constant to give appropriately different solutions. With the curve tracing attachments which can now be fitted to digital computers, the engineer can then be presented with a series of graphs showing the effect of the change of this, or any other, physical parameter of his problem. A disadvantage to this approach is that the individual separate solutions are obtained at the expense of a longer computation time than is the case with the analog computer. On the other hand, the engineer who is conducting the work is not necessarily tied to the computation machine in quite the way that he is tied when using the analog computer. The method of parameter variation on the digital machine also utilizes a considerable amount of computer memory and this was certainly a disadvantage with earlier types of computers, but with the ever increasing size of computers this disadvantage is disappearing. I would therefore ask both the authors whether they do not think that with the advent of high speed computers that the time may well be near when problems such as they put forward in their paper on the analog computer might not equally well be done on the digital machine; and I would further ask them that in view of the considerable advantage of digital machines for commercial transactions carried on within large companies whether it is also not likely that there will be an increasing tendency to buy large general purpose digital computers for engineering calculations which in the past have been done on analog computers.

In conclusion, I feel that there is a very definite field for the analog computer, but it is for the comparatively small scale analog computers which may be used as a handy laboratory tool rather than the very massive analog devices which are currently in use in certain organizations.

Authors' reply

D. A. Lamont: The authors have not had experience with "on line" computers, otherwise known as computer directed process control. The pioneering work being done in this field by others gives promise of effective optimizing control for chemical processes. The authors feel that training in mathematical analysis and in general purpose computer programming is mandatory for persons who are to design and operate the computer directed processes of the future.

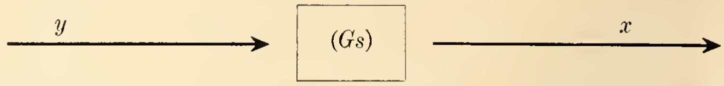
D. C. Baxter: The authors agree completely with the effectiveness of the other applications described. The use of random noise generators to provide input signals to general purpose analog computers opens up an important means of optimizing the design of systems or of individual components.

A. Porter: The training in "advanced mathematics" mentioned in the paper was given only to university graduates, over 80% of whom were professional engineers. While it must be remembered that many graduate engineers are employed in work not requiring mathematical skills, it is certain that the solution of engineering problems will increasingly depend on sound mathematical analysis. It is encouraging to note the growth in emphasis on analytical subjects in the curricula of Canadian engineering faculties.

G. L. D'Ombrain: If a large engineering or research organization were confronted with the need of buying either an analog or a digital computer, it is true that the latter might be selected largely on the basis of its data processing capabilities. These capabilities would be of great value for accounting work, and would undoubtedly contribute greatly to the justification of the computer. The point that must not be overlooked, however, is that digital and analog computers can be rented, at reasonable hourly rates, in the larger centres in Canada. Even a small organization can justify the rental charges, which are modest in relation to the results obtained, although the hourly rates may seem formidable.

The authors cannot agree with Dr. D'Ombrain's preference for digital computers for the simulation of processes and for dynamic analysis in general. While it may be an oversimplification, it has been their experience and that of others who have had experience with both types of machines that digital computers reign supreme for data processing and static design, and analog computers for simulation and dynamic design. The authors have frequently observed the reactions of design engineers and operating personnel to the simulation on an analog computer of one of their processes. Even with no previous exposure to analog methods, these people quickly develop a "feel" of the problem, and invariably increase their insight into the process being modelled.

The authors do not use the analog computer to set up differential equations. The equations are written in the form which best describes the physical system to be simulated and then the computer is used to solve the equations. Dr. D'Ombrain's example describing the simple case of three cascaded, non-interacting time lags is not normally programmed and solved in the way suggested. Therefore his comment regarding 12 to 14 coefficient changes is not necessarily applicable. One simple way to programme transfer functions is as follows:



(the input variable) (the transfer function) (the output variable)

$$\frac{x}{y} = \frac{a_1 s^n + a_2 s^{n-1} + \ldots + a_n s + a_0}{b_1 s^m + b_2 s^{m-1} + \ldots + b_m s + b_0} = G(s)$$

Procedure:

1. Cross multiply and divide by the highest power of s (the Laplace operator). (Assume $m > n$).
2. Re-arrange so as to define the output x in terms of the remaining factors, grouped in powers of $1/s$.
3. Synthesize the computer diagram by substituting

$$\frac{1}{s} = \int dt, \frac{1}{s^2} = \int\int dt\,dt, \text{ etc.}$$

With this approach the number of coefficient setting potentiometers which must be adjusted to change one time constant in the three capacity system described by Dr. D'Ombrain is 5 or 6, rather than 12 or 14 as his formula would suggest.

It should be stressed that a general purpose analog computer is adequate for the solution of even highly sophisticated programmes and special computers are not necessary.

RECENT ADVANCES IN EXPERIMENTAL STRESS ANALYSIS

J. B. Mantle, M.E.I.C.
Professor & Head, Mechanical Engineering Department,
University of Saskatchewan, Saskatoon
The Engineering Journal, January 1961, page 42

Discussion by C. M. Hovey

It is gratifying to note the active interest at the University of Saskatchewan in photoelasticity which, in my opinion, is one of the most powerful tools of experimental stress analysis.

Professor Mantle has given a good description of the characteristics of materials used for 3-dimensional hotoelasticity. However, the method of machining and slicing 3-dimen- ional models as well as the optical echniques used are just as important o accuracy as the selection of a roper material. It is felt that many vorkers in this field would have enefited from a description of the nethods used at Saskatchewan if hese had been included in the paper.

One also wonders whether or not he laborious iterative procedure for eparation of the principle stresses ias now been delegated to the com- outer.

The large number and variety of roblems being solved photoelasti- ally under Professor Mantle's direc- ive is impressive. In this connection, ie may be interested to learn of a olution for the design of a rein- orcement for a circular hole in a late under any condition of plain tress, which was derived by Pro- essor W. Bowes at Dalhousie Uni- ersity in 1951. This solution was hecked photoelastically at the Uni- ersity of Manitoba, but the check vas rather inadequate due to the dif- iculty of using 61-893. It would be nteresting to recheck the solution ising Hysol 6000.

In connection with Photostress, one s somewhat amazed at the advertised ensitivity of this method. It would e of value if a few figures were given, for example, as to the stress ensitivity and accuracy of this nethod for determining stresses in ull scale steel rigid frame structures.

The use of resistance strain gauges t high temperatures has always been f interest to manufacturers of gas nd steam turbines. I wonder if Pro- essor Mantle would care to comment n the reduction of data from such gauges. I have in mind the problem f determining the stress in a hot part which has experienced thermal ex- ansion by means of a gauge whose gauge factor has changed due to emperature, which is attached to a naterial whose value of E has changed with increase in temperature.

Discussion by John E. K. Foreman, M.E.I.C.

The Department of Engineering Science at the University of Western Ontario has been considering the purchase of this type of equipment, and the technique is thus still suf- ficiently new to us that I may be open to question in the following comment. However, it is my im- pression that the thickness of photo- elastic material attached to an actual structure has a considerable bear- ing on the accuracy of the results which are obtained when there is any bending present, in that the strains which are interpreted are average strains in the plastic, and not necessarily those at the surface of the structure. I understand that there are certain correction factors which can be applied to compensate for this (although probably only in circumstances where the curvature is known), but I have not as yet been able to elicit a satisfactory explanation from the manufacturers. I was therefore wondering if Prof. Mantle, in his experiments with this particular experimental stress analysis method, had been able to satisfactorily account for this discrepancy.

Author's reply

I am very appreciative of Mr. Hovey's remarks and questions.

Techniques for machining and slicing of three dimensional models at the University of Saskatchewan have been developed from recommendations in standard reference works, such as Frocht and Hendry. It is anticipated that our experiences in this regard will be detailed in subsequent papers dealing with specific projects.

The reader is referred to a recent paper by Thomson in the Proceedings of the Society for Experimental Stress Analysis (Vol. XVI, No. 1, 1959) in which an application of computers in photoelasticity is described. The digital computer was used to assist in separating principal stresses by the shear-difference method. So far as I have been able to determine computers do not lend themselves conveniently to speeding up the iterative process since the boundary conditions are usually quite irregular in stress analysis problems. Of course, the electrolytic tank method described in the Handbook of Experimental Stress Analysis is a form of analog computer that can be used to advantage in place of the iterative process.

As yet, my experience with "photostress" is rather limited but quite amazing accuracy is possible with the "photostress gauge" on steel. The tests that were made at the University of Saskatchewan indicated an accuracy of ±5 micro-inches per inch at strain levels up to 6000 micro-inches per inch using the unaided eye and numerical average of about five double readings.

The metal foil gauges are now being constructed so that they are self temperature compensating up to 1000°F and attempts are being made by the manufacturer to push this up towards 3000°F. These developments will simplify the reduction of data for the problem cited. In all probability one would have to choose an intermediate value of E to compensate for the change. Some research in this area might very well be undertaken.

In replying to Professor Foreman's question I cannot refer to our experiences because our work to date with "photostress" has been confined to cases where bending is not present. However, I concur with his belief that the equipment could be seriously in error if corrections are not applied. The manufacturer of course realizes this and has done considerable work on this. They have a report available entitled "Photostress Technical Report, April, 1958", by E. I. Riegner which deals with correction factors. Also the paper, "Reinforcing Effect of Birefringent Coatings" by Zandman, Redner and Riegner presented at the October 21, 1959, meeting of the Society for Experimental Stress Analysis treats the subject.

BRAKING OF HYDRO-ELECTRIC GENERATORS

H. O. Wilson, M.E.I.C.
Chief Engineer, Electrical Division, The Shawinigan Engineering Co. Ltd., Montreal
The Engineering Journal, January 1961, page 50

Discussion by Canadian Westinghouse Company Limited

The author of this paper is to be congratulated for focusing attention on the factors which need to be considered, relative to the satisfaetory braking of vertical water-wheel generators.

For the particular unit dealt with in the paper, it is quite reasonable that the initial brake application should commence at approx. 50 r.p.m. or 40% of rated speed. This takes full advantage of the natural braking from the turbine runner and the generator rotor, but yet allows for some possible gate leakage.

However, from tests made on a large, low speed Francis turbine driven generator, satisfactory braking has been achieved with the initial brake application at 27 r.p.m. or 28% of rated speed. In this case the deceleration curve was steeper than for the unit dealt with in the paper.

Again, for a large, high speed, impulse turbine-driven generator, it has been found that satisfactory brake life could not be obtained with initial brake application at speeds above 80 r.p.m., i.e. 25% of rated speed. In the case of this impulse turbine, no braking from the turbine runner was available, but only the friction and windage in the generator. Braking from an initial speed of 100 r.p.m. simply involved too much kinetic energy and severe warping and wear of the brake track resulted.

The above examples point out the variations that may be encountered between types of turbines, and of kinetic energy in the rotating parts, and of peripheral speeds at the brake track.

With the usual type of asbestos brake pad operating against steel brake segments, a co-efficient of friction of 0.40 at 350° is achieved at 50 p.s.i.

The maximum permissible pressure is taken at 150 p.s.i. but the operating pressure in general use is 100 p.s.i.

A rubbing speed of 80 f.p.s. is considered safe practice with a maximum temp. rise in the track of 200°F and the initial rate of heat input in the order of 40 BTU/ff^2 sec.

It is the practice of our Company to divide the brake track into segments which allows for replacement without dismantling the machine. But more important, gaps between the segments allow for expansion with heat.

The segments are designed and mounted to be as flexible as possible to reduce stresses from heating. Thick segments are avoided and the length and width are kept nearly equal.

Initial application of the brakes at reduced pressure will reduee the rate of heat input into the brakes. However, this extends the total braking time, and the total heat input will increase in the event of broken or leaky wieket gates.

The Paper considers only a normal automatic shut-down of the generator and under this eondition, the braking system must give long life of the brake track segments. Under emergeney shut-down conditions, the speed switch is sometimes bypassed and the brakes applied at high peripheral speeds. This may result in such permanent damage as to require replacement of brake tracks, as well as brake shoes, before starting up. If this is not acceptable under emergency conditions then the design would need to go to a very much oversized braking system, which would not only increase the cost but likely the overall dimensions of the generator.

Some more work remains to be done to establish closer parameters of good brake design and operating practice. It is to be hoped that the author in presenting this Paper will have encouraged the collection and study of operating data on this important subject of braking, from all designers and operators of hydroelectric generator stations.

Discussion by G. E. Ransom

I have read this paper with interest and agree with it whole-heartedly. Continuous braking has eliminated many of our troubles with brake tracks especially on the larger machines. Here also the selection of materials is critical to avoid surface cracking of the tracks.

The further refinement mentioned of building up pressure slowly as the units decelerate so that the rate of heat generation can be controlled has proven to be necessary. This is not as difficult as it sounds when one realizes that deceleration is proportional to time and to air pressure in a given volume building up through a given orifice is also proportional to time. Three devices connected in parallel have been used to accomplish the desired result: a needle valve and manifold adjusted to build up the pressure to maximum in the time required; a check valve in the direction to drain the system when releasing

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• DISCUSSION

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the brakes and a pressure reducing valve set at the minimum pressure required to lift the brake shoes onto the track. When the brake pressure air is applied the pressure immediately builds up to the minimum set by the reducing valve and then builds up to the maximum at a rate set by the proportions of the manifold and the size of the needle valve opening. By releasing the pressure, the brakes can be released through the check valve.

Discussion by J. B. Young, Jr.E.I.C.

In case of a serious emergency as for example in the event of a bearing failure or an earth fault in the alternator with the attendant risk of fire the brakes must be suitable for immediate application from full speed. It is therefore normal practice to design the brakes to bring the set to rest from full speed but in the interests of economy in brake shoe wear it is customary on a normal shut down to delay application of brakes till the speed has fallen to approximately half and the stored energy to quarter of its full speed value.

While it is true that for uniform rate of brake heating the pressure would require to be small at top speed and be gradually increased to maintain approximately constant the product of speed times pressure, this is an unnecessary complication.

It is more usual to design the brakes for constant pressure and of such dimensions that the average heat rate does not exceed ½ hp. p.s.i. of brake shoe surface. The diameter of piston in the brake cylinders and the number of cylinders is usually fixed to give a reasonable oil pressure (say 2,000 p.s.i.) when the pistons are required to jack up the rotating parts. Brake shoe linings (Ferodo in our case) can generally withstand a pressure of approximately 15 p.s.i. when jacking. The coefficient of friction of this material is of the order of 0.3.

Under earth fault conditions it is essential that the field be suppressed as quickly as possible in order to minimize damage to the stator core, under a normal shut down there is nothing to be gained by trying to maintain the field to obtain a slightly greater initial retarding effect as the field will have died away before the speed has dropped to 50% value.

While it is agreed that manual as well as automatic braking should be provided care must be taken to ensure that subsequent opening of the turbine gates automatically releases the brakes. Cases have been known where the turbine has run the alternator up to speed with brakes on with resultant damage to brake shoes and track. This can of course be avoided by suitable interlocking.

Most hydro sets are now equipped with permanent magnet governor generators whose voltage can be used as an indication of speed at which brakes are applied. A time delay relay is arranged with a 0 to 20 minute adjustment to release the brakes about 15 minutes after initiation of shut down.

In the event of failure of brake application the lubricating oil pumps continue to run for a short time to cover shut down time without brake application.

We (English Electric Company) have no actual test data of brake shoe temperatures but should expect these to be of the order of 300°C maximum.

Discussion by H. A. Janson

Mr. Wilson's suggestion that the turbine and generator manufacturers should collaborate closely for the best design of the braking system should be given every consideration. In practice, however, the customer himself or his consulting engineer might be in the best position to obtain the data

and provide the design specification required by the generator designer. Such a design specification should contain information concerning the retarding and driving torque on the set from a specified braking speed down to standstill. Information concerning the minimum braking torque desired would also be of value to the generator designer.

To the design considerations mentioned by Mr. Wilson, I would like to add one point which the designer, unfortunately, must not disregard. This is the possibility that, some time during the life of the machine, in spite of all safety measures, the brakes may be applied at full speed. The design should be such that any cracks and/or deformations which may appear due to such maloperation do not affect the strength and shape of the brake track to such an extent as to require immediate repairs.

In connection with the design considerations and design requirements raised by Mr. Wilson, a short description of ASEA's design of generator braking system may be of interest.

A fairly narrow braking track is machined on a main, wide brake plate having a radial depth equal to or greater than the depth of the rim. The brake plate is secured to the rim by all of its through bolts. Should the brake plate be in the form of segments, spigots are used in addition to the above bolts to ensure the greatest possible rigidity. The thickness of the brake plate is such that the temperature rise on the track surface will not exceed 200°C. Low carbon steel with good plastic qualities under heating and cooling cycles is used.

To counteract any waviness or unevenness of the brake track resulting from the rim stacking the final machining and polishing of the brake track is carried out on the assembled unit at a speed of 5-10% of the normal. While about one day is required for this operation, the design of the thrust bearings permits it.

The pad lining material used is of asbestos type without metallic particles or threads. The specific pressure is 20 to 30 p.s.i. and the co-efficient of friction not less than 0.3 at all speeds. The pad linings are designed for roughly three hundred complete brakings. The pads can be easily replaced by spare pads and the worn down ones provided with new linings by the station personnel.

Discussion by Douglas G. Berry

Intermittent operation of the brakes while the turbine is still absorbing power reduces the total heat production in the brake segments since a larger amount of the kinetic energy is dissipated by churning up the water in the draft tube.

Distortion of the brake segments is less with intermittent braking than with continuous braking. This is because, during the periods when the brakes are not operating, heat flows into the cooler parts of the segments and temperatures tend to equalise. It is obvious that with the intermittent braking the number of thermal cycles is increased but the severity of the additional cycles is not as great as during the initial operation.

The following observations apply to figure 1 in the paper:

1. The speed on curve 2, some 37½ seconds after synchronous speed, is 7% higher than on curve 1 and hence the rotating parts contain 14% more kinetic energy. This may be a result of changed tailwater level which could have a considerable influence on the retardation effect of churning up water in the draft tube. It would appear that the two retardation curves are not directly comparable.

2. On curve No. 2 it will be noted that the generator brakes are ap-

plied at 50% synchronous speed. At this speed the retardation effect caused by churning of water in the draft tube is very much greater than the retardation produced by application of the brakes. The effect of intermittent brake operation would be seen more clearly if the brakes were intermittently applied when the retardation effect of churning water in the draft tube was less.

3. In figure 1 the brakes are initially applied at 50% and 20% synchronous speed respectively and so a direct comparison cannot be made between the differences in performance. Direct comparison would have been facilitated by applying the brakes initially at the same speed.

Discussion by H. R. Sills, M.E.I.C.

Friction brakes are an excellent means of stopping and holding a generator at low speeds but, at high speeds, they have limitations:

(1) *The total energy to be absorbed*: Due to inertia alone, the energy in the form of heat that the brake surface must absorb varies as the square of the speed at which the brakes are applied. In addition, they must absorb energy due to gate leakage, which normally amounts to ½ to 2% of rated torque at standstill, to zero between 20 to 35% speed, and negative at higher speeds. At normal speed the braking effort of the turbine can vary from zero for an impulse turbine, to 6% for a high speed Francis turbine, to 20% for a low speed Francis turbine and to 80% for a propellor turbine. Thus, to limit the duty on the brakes, it is desirable to let the turbine absorb most of the energy of inertia at the top part of the speed range.

(2) *The rate at which heat can be absorbed*: Heat is absorbed into the brake plate at a rate determined by its thermal conductivity. The difference in temperature between the surface and the interior causes expansion on the outer surface. This is mitigated, by using a segmental brake surface, flexibly mounted, to provide for expansion; but if heat entry is too rapid the plates or their fastenings may be strained beyond their fatigue or elastic limits, resulting in cracking or possible failure. As the brake surface rotates from shoe to shoe, it is alternately heated and cooled, and rapidly expands and contracts. Should this cause the surface to exceed its limit of fatigue, it will develop hair line cracks, which may propagate. Heat also raises local spots which are subject to slightly higher pressure than adjacent areas and become progressively hotter and higher; they show up as spots of blue oxide, which fortunately is usually smooth and adherent; but, if too hot, the oxide flakes off and the surface roughens. Thus there is a limit to the rate at which heat may be safely absorbed, and this appears to be between 400 and 600 watts/sq. in. of brake shoe; by comparison, a stove elements operate at 40 watts/sq. in.

(3) *The number of brakes*: It is customary to design brakes to operate at 100 p.s.i. pressure, and corresponding shoe pressure of 40 p.s.i., to exert a friction force of 4 to 5% of rated torque, which is usually adequate to stop and hold a generator against gate leakage. More brakes would be worse for the brake surface; fewer would be inadequate.

(4) *The condition to be met*: The brakes are intended to be used to capacity mainly during the transition from idling speed to full stop. For a normal stop, the required rate of deceleration over this range is not usually a limiting factor. To get best utilization of the brake surface, the continuous capability should be assessed and not exceeded except, perhaps, in an emergency. If the heat transfer rate is limited to 400 w./sq.-in. most of the other factors are safe.

At 40 p.s.i. shoe pressure (100 p.s.i. air), a velocity of 1800 r.p.m. will produce 400 Watts/sq. in. and any appreciable operation above this speed may initiate hair line cracking. If the normal idling speed is less than this, brakes may be applied at full pressure. This speed is, usually less than half speed for most units. In Mr. Wilson's illustration, the brake surface speed at generator rated speed is 7900 f.p.m., and only reaches 1800 ft. at 23% speed, somewhat below the normal idling speed shown in his curves. But, in this case, the initial overload would not be serious, as the brakes would be cold and the rate of deceleration fast enough to reduce the overload before strains can develop; but the duty on the brakes can be made easier by always letting the generator idle for a minute or so after reaching 40% speed to assure it will be at minimum idling speed when brakes are applied.

Large machines have been built with brake surface speeds of 11500 ft./min. at rated speeds, and even larger ones with higher speeds are contemplated. On these it is desirable to initiate the braking sequence at 50% speed at low pressure, and to gradually increase the pressure as the machine decelerates. By this means the rate of heat input can be kept below 200 watts/sq. in. which is desirable to prevent charring and rapid wear.

One of the potentially dangerous hazards of generator brakes is the possibility of their being applied when the generator is on load. This has happened to my knowledge, twice on machines with automatic brake sequences, and several times by accidental hand operation. Fortunately, in none of these cases, did the brake surface break loose from the rotor, but they were badly cracked and had to be replaced. Thus I concurr with Mr. Wilson in recommending brake limit switches, a practice now gaining favour, to insure that the brakes are down when the generator is started and running. I agree heartily that intermittent braking should be discontinued. The origin of this practice is lost but I suspect it was initiated by operators to blow out the flames on the original maple brake shoes now not necessary.

Another survival which I suggest should be liquidated is the invariable specification requirement that "The brakes shall be capable of bringing the generator to a stop in five minutes against a gate leakage of two percent". Mr. Wilson, in his paper, has pointed out that the condition of 2% gate leakage torque is a fact only at standstill. I have shown why the five minute period should be modified so that the brake system of large units may endure as well as meet the stopping requirements. As the most desirable stopping sequence and time varies with the size and type of turbine, it is not easy to get a pat successor to this clause, but if the essential function is clearly specified, the brake designer can then be invited to describe his method of attaining it within the known limitations.

Author's reply

This paper was presented with the expectation that the discussion would be of value both to the manfacturers and the utilities, and I think that this has been accomplished.

With reference to Canadian Westinghouse remarks, it is never safe to generalize on a topic such as this and application of brakes at 40% rated speed should be taken as representative but each case must be considered individually.

From Mr. Berry's remarks it can be seen that this is a controversial subject. We agree that the two curves in Figure 1 strictly speaking are not directly comparable but we think that they serve to indicate in a general way that there is no advantage in our past practice of applying brakes intermittently at 50% speed and then continuously after a few intermittent applications as compared to applying the brakes continuously at approximately 40% rated speed. EIC

You and the Institute

THE ENGINEERING INSTITUTE OF CANADA means different things to different people. It may even mean different things to the same person at different times. Each member is constantly writing and rewriting his own definition; and it is the sum of these definitions that charts the course and progress of the Institute from year to year.

One concept of the E.I.C. is becoming more and more fixed. It is something like this:

"E.I.C. is a family of professional men engaged in related endeavours. Through participation in E.I.C., they create and grow and advance together".

As participating members of the Institute, they find ways to express and develop almost every individual talent they may have — through that expression, they gain much satisfaction for their creative desires.

By the nature of these opportunities, E.I.C. is most rewarding to those who use it as a facility for giving of themselves for the benefit of others.

It is also in the nature of these opportunities to be timeless. They have been the sturdy foundation of E.I.C. progress through almost 75 years. And as they are increasingly grasped, they will become the motive power of E.I.C.'s rise to new heights in the 75 years immediately ahead.

Why join the Institute?

No one can live in a vacuum — least of all an engineer. His professional world is growing and changing constantly. Unless he is content to be merely a time-server, he must always continue his own education and growth. In the strictly technical sense, he must keep up with new developments in his profession, through meetings and discussions, publications and personal contacts. The easy — and only — access to all of these in all fields of engineering in Canada is the E.I.C.

Further, through the strength of its history, record of service and numbers, the E.I.C. has a respected voice with which to speak for its members when needed. Joining the E.I.C. will add to this strength which is used for the benefit of the profession and the nation.

Becoming a member of the E.I.C. will not guarantee a promotion or a salary increase (although salary surveys show that members of technical societies generally earn more than non-members, and that management regards participation in technical society activities as important). What an engineer will get out of E.I.C. is really what he puts in. The Institute is not an abstraction, it is a collection of engineers. What it accomplishes is the sum of what its individual members do for themselves.

Most members of the E.I.C. can talk generally about why they belong and the benefits of membership, but this is rarely sufficiently detailed to convince a non-member engineer why he too should belong.

A Member's Check List

There are probably as many good reasons for being a member of the Institute as there are members. This following brief check list includes some of the more obvious advantages enjoyed by every member.

1. He can participate in Branch and Section activities at any one or more communities.
2. He can participate in preparation and presentation of engineering papers in his field.
3. He can participate in discussion of engineering papers.
4. He can participate in Annual and Regional meetings and Special Conferences on the same basis as leading Canadian engineers and industrialists.
5. He can participate in technical activities sponsored by any one or more of the Engineering Divisions:
   - Bridge and Structural Engineering
   - Chemical Engineering
   - Civil Engineering
   - Electrical Engineering
   - Engineering Education
   - Geotechnical Engineering
   - Hydro-electric Engineering
   - Management
   - Mechanical Engineering
   - Mining Engineering
6. He can receive The Engineering Journal and Transactions, the outstanding media for Canadian engineering papers.
7. He can have the benefits of the finest engineering library service in Canada.

8. He can have the benefits of an experienced employment service.
9. He can associate with his fellow engineers in life-long participation in Canada's outstanding engineering "University" — the E.I.C. — and enhance his stature as an engineer.
10. He can serve on Branch and National Committee activities, thereby improving his capability as an engineer and administrator.
11. He can become eligible for outstanding Institute awards and prizes.
12. He is welcomed, as an E.I.C. member, at general meetings of many leading cognate Commonwealth and U.S.A. founder societies in which he wishes to participate, on the same basis as their members.
13. He will benefit from the prestige of membership in the Institute.
14. He benefits from the collective technical activities of his professional co-workers.
15. He may use after his name the legally authorized letters indicating his membership: Member, M.E.I.C.; Junior, Jr.E.I.C.; Student, S.E.I.C.

LIBRARY

Access to the Institute's library is one of the many advantages of membership. The library belongs to the members of the Institute, and although it is located at headquarters in Montreal, its services are available to all members, wherever they may live.

The Institute's predecessor, The Canadian Society of Civil Engineers, was founded in 1887 and the first library catalogue was printed 1892. This continuous existence of nearly 70 years means that not only is the latest information available in the library, but that the collection contains much unique historical material, especially valuable for research purposes.

The library contains more than 7,000 books covering all branches of engineering and allied subjects. The prestige of the Institute is such that many publishers send us their new books for review in The Engineering Journal, and these volumes are added to the library's loan collection. More than 500 periodicals from over 30 countries are currently received. Complete files of many of these are kept, from Volume I, Number I.

Reading Room

Anyone may use the Reading Room, but only members may borrow books. A trained staff is available to answer queries and to direct the reader to the best sources of information. The Reading Room is open from 9 to 5 on week days, and 9 to 12 on Saturdays in the winter.

Telephone Service

Queries will be answered over the telephone whenever possible, but members requiring detailed information will probably find it more satisfactory to send their requests in writing if they cannot visit the library in person. It is not usually practical to give such information as formulae and specifications over the telephone.

Borrowing

Any item in the library may be borrowed by members, with the exception of some reference books. It has also been found impractical to send bound volumes of certain periodicals through the mail, and photo-copies of articles from these will be sent to members living outside Montreal.

Two books, periodicals or pamphlets (or more at the discretion of the librarian) may be borrowed at one time. The normal loan period is two weeks, which may be extended on application for another two weeks. Additional time is added to the loan period when books are sent by mail.

There is no rental charge for items borrowed from the library. Books sent out of Montreal are usually mailed at a special rate, and members are not required to pay postal charges.

Searches

The library staff is always glad to recommend books on a particular topic.

Bibliographies of books and periodical articles will be compiled on request. These are compiled from many sources and indices, and although the items may not all be available in the Institute library, they can be borrowed elsewhere, or photo-copies obtained. It is regretted that bibliographies cannot be compiled for students writing theses, as this is considered an integral part of the work. However, sources of possible information will gladly be recommended.

Other

The library provides a photo-copying service and makes a nominal charge of 25 cents a page. The library does not maintain its own translation service, but has access to translations prepared by other organizations. The charge for these varies.

A very active co-operation exists among technical libraries in the Montreal area and across Canada, and it is usually possible to borrow any item not in the Institute collection, or to obtain a photo-copy.

Members may subscribe to the periodical publications of other engineering societies at greatly reduced rates. A complete list of these will be sent on request.

THE PRESIDENT'S LETTER

On January 6, 1961, the President wrote members of Council asking certain specific questions which were designed to result in answers which would help Council assess how it could best enhance member satisfaction with the operation of the Institute.

Obviously, the returns to a questionnaire of the nature involved cover a range of situations. They cannot be reduced to specific percentages without qualification. Nevertheless, most useful guides to the thinking of membership can be derived. From this, recommendations for action can be framed.

The following includes some of the highlights of the tabulation of replies.

Councillors and the Branches

At Branch level what should Council do to make members satisfied? Answers to this varied widely, but from them three recommendations were made.

1. Pursue with all possible speed the plans of the Committee on Branch Operations.
2. Use the Engineering Journal to convey vital messages on optimum Branch activity.
3. Use Councillors more effectively than in the past in Branch Executive deliberations.

Members and Council Activity

What should Council do to make members satisfied with Council activity? Again there was a wide range of opinion, from which the four following recommendations could be made.

1. Take steps to achieve optimum performance by Councillors as the channel of communication between Council and Branches.
2. Make the Executive Committee a permanent feature as soon after the expiration of the additional trial period, in January, 1962, as possible, so that Council can deal with development of policy.
3. Provide, as soon as possible (1962 fiscal year), for payment of travelling expenses by Councillors to four meetings of Council per year devoted to policy deliberation.
4. Run a well-written story on the role of Council and the function of Councillors.

Members and Headquarters

Following are three recommendations made on the basis of replies to the question, "What should Council do to make members satisfied with Headquarters' Operations?"

1. The Committee on Branch Operations should examine what can be done about visiting speakers and engineers, to establish a policy and outlines of practice, for execution by Headquarters and publicity in the Engineering Journal.
2. The Committee on Branch Operations should investigate what can be done to provide more effective results from the Branch News correspondents.
3. The annual financial report can be developed to emphasize the reasons for the cost of Headquarters Operations.

Members and Vice-Presidents

Aside from four "no comment" replies, the Branches consider Vice-Presidents should play a much more active role than hitherto, and that an encouraging start has been made. Two recommendations arose from replies to the question, "What should Council do to make Members satisfied with Vice-Presidential assignments?"

1. Select the right men, willing to work and capable of travelling.
2. Pursue a policy of Vice-Presidents attending at least one Branch Executive Committee meeting for each Branch in his Zone. This should be done without waiting for an invitation. Advise Branches of proposed itinerary and ascertain if agreeable.

Members and the President

Councillors were asked: "What should Council do to make members satisfied with their relationship with their President?" In this connection, replies stressed the importance of the Presidential visit and early scheduling. It should be annual. Branches should be informed of Presidential visits to nearby Branches. Finally, the President should speak on an inspirational tone, free from the connotations of operational aspects of Institute activities.

The only recommendation which appears to be inherent in the replies on this question is the separation of visits by the President and by the General Secretary.

Members and the Journal

The question, "What should Council do to make members satisfied with The Engineering Journal?", again evoked a wide range of replies. From these, four recommendations could be made.

1. Draw to attention of Publications Committee.
2. Have General Secretary look into situation as regards delivery of Journal to Students.
3. Provide explanation of Journal financial aspects in Annual Report of Finance Committee.
4. Draw attention of CTO to coverage of chemical, metallurgical and mining fields.

Members and Transactions

A question similar to the one asked regarding the Journal also was asked concerning Transactions. From the replies, no recommendation appears in order beyond:

1. Continuance of Transactions.
2. Look into the possibility of shifting some papers from the Journal to Transactions.

CODE OF ETHICS

Adopted at the Annual Meeting, January 27th, 1925

(1) The engineer shall carry on his professional work in a spirit of fairness to employees and contractors, fidelity to clients and employers, and devotion to ideals of courtesy and personal honour.

(2) He shall refrain from associating himself with or allowing the use of his name by an enterprise of questionable character.

(3) He shall advertise only in a dignified manner, being careful to avoid misleading statements.

(4) He shall regard as confidential any information imparted to him as such as to the business affairs and technical methods or processes of a client or employer.

(5) He shall inform his client or employer of any business connections, interests, or circumstances which may be deemed as influencing his judgment or the quality of his services to his client or employer.

(6) He shall avoid attempting to obtain employment or professional engagement or advancement by competitive underbidding, by unjustly criticizing other engineers, or by other improper or questionable methods.

(7) He shall accept compensation, financial or otherwise, for a particular service from one source only, except with the full knowledge and consent of all interested parties.

(8) He shall discourage the practice of free engineering designing and advice by manufacturers and contractors.

(9) He shall not review the work of another engineer for the same client or employer, except with the knowledge of such engineer, or unless the connection of such engineer with the work has been terminated.

(10) He shall co-operate in upbuilding the engineering profession by exchanging general information and experience with his fellow engineers and students of engineering, and also by contributing to the work of engineering societies, schools of applied science and the technical press.

Beaver Bill says:

Did you realize Canada, with several sister nations of the Commonwealth of Nations, is singularly fortunate in its facilities for the education and professional development of engineers?

It is indeed unique, because Canada has a great Engineering University with 59 branches and sections serving our country on a regional basis, from St. John's to Victoria, from Hamilton to the Yukon. Of course, some of the branches are very large, some quite small, depending on the population served.

But each one of them has at its disposal the services of 10 faculties, covering every field of engineering. These faculties, or Engineering Divisions of the Committee on Technical Operations, are staffed with keen engineers anxious to provide you with the basis for a lifetime of improvement of your professional stature as an engineer, and your professional ability to serve Canada better.

This great Engineering University is the Engineering Institute of Canada, whose membership rolls proudly proclaim most of the great engineers who have played such a vital role in the development of Canada. Who are these men? Just a few —

Thomas Coltrin Keefer	***John Galbraith***
Sir Casimir Gzowski	***Col. R. W. Leonard***
Sir John Kennedy	***Julian C. Smith***
Henry J. Bovey	***George J. Desbarats***

This great Engineering University celebrates its Seventy-Fifth Anniversary in 1962.

Want to join? How much does it cost? Just 40 cents a week! The price of a package of cigarettes! But what a difference!

Sincerely,

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.

*FREQUENCY-POWER FORMULAS.

This monograph is a report on an attempt to find necessary and sufficient conditions for a physical system to obey the frequency-power formulas. In part one are described various energy function methods, and four types of frequency-power formulas, including the Manley-Rowe formulas. These four are also tabulated, along with other important information, in the appendices. In part two specific systems are considered—lumped dissipative, lumped reactive, and distributed systems. The final part discusses rotating machine applications and communications applications. (P. Penfield, Jr. New York, Wiley, 1960. 168p., $4.00.)

*ATOMIC THEORY FOR STUDENTS OF METALLURGY.

The third edition of a monograph first published in 1946 for advanced metallurgy students, to describe the general ideas on which the electron theories of metals and alloys are based. No attempt is made to deal with mathematical technique. The six parts of the book deal with general background theories; the structure of the free atom; the nature of the interatomic forces involved in the formation of solids, liquids and compound molecules; the free-electron theory of metals; the Brillouin-zone theory of metals; and finally specific metals are discussed from this standpoint. The crystal structure of the metallic elements is given in an appendix. (W. Hume-Rothery. London, England, The Institute of Metals. 427p., $7.50.)

*IP STANDARDS FOR PETROLEUM AND ITS PRODUCTS, PART IV: METHODS FOR SAMPLING, 19th. ed.

Beginning with 1960, the Institute's "Standard methods for testing petroleum and its products" will be issued in four separate sections—methods for analysis and testing; methods for rating fuels—engine tests; methods for assessing performance of crankcase lubricating oils—engine tests; and methods for sampling. Part 4 is the first to be received, and is a revised version of IP no. 51. The sampling techniques and apparatus described are technically equivalent to those in the ASTM 1957 manual. Minor differences in terminology persist through reluctance to change established nomenclature. (London, England, Institute of Petroleum, 1960. 44p., 10/-.)

*AN INTRODUCTION TO ASTRODYNAMICS.

An undergraduate-level text which relates the theory and techniques of celestial mechanics directly to contemporary space vehicle problems. There are two broad divisions in the text: "Fundamentals" includes discussions of general laws, minor planets, comets, geometry, and the astrodynamic constants; "More Detailed Analysis" covers such topics as orbit-determination, orbit computation, n-body problem, nongravitational forces, observation theory, and applications to interplanetary orbits. (R. M. L. Baker, and M. W. Makemson. New York, Academic Press, 1960. 358p., $7.50.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*THE PHYSICS OF FLOW THROUGH POROUS MEDIA, 2nd. ed.

This monograph continues the purpose of its first edition—to collect and coordinate information on the physical principles of hydrodynamics in porous media. The volume of material available made selection imperative, and this has been made on the basis of emphasizing general physical aspects and theory rather than particular cases and experimental aspects, and by presenting only one solution for basic differential equations where there may be many available. This present edition retains the material of the first, adding accounts of developments up to the summer of 1959. The major revision has been expansion of the treatment of multiple phase flow to three chapters—elementary displacement theory, immiscible displacement, and miscible displacement. The author is with Imperial Oil Ltd. in Calgary. (A. E. Scheidegger. Toronto, University Press, 313p., $16.50.)

*THE MECHANICS OF VIBRATION.

As the aim of this book is to present ideas rather than to describe applications, most of the discussion is in terms of "academic" systems—spring-connected rigid masses, taut strings, and uniform elastic bodies—although chapter 5 does discuss the extent to which real systems may be analyzed in terms of these ideal systems. The first three chapters discuss analysis of simple, complex and multi-freedom systems, and contain a progressive exposition of the receptance concept. The remaining chapters discuss vibration systems in shafts, bars and beams, systems with damping, and the excitation of a system by transient forces. (R. E. D. Bishop. Toronto, Macmillan, 1960. 592p., $20.50.)

*PHYSICS OF THE UPPER ATMOSPHERE.

Eleven chapters of this book are detailed monographs on particular topics by specialists, all concerned with that part of the atmosphere above the height of 60 km. These deal with the thermosphere, the ionosphere, the properties and constitution of the upper atmosphere and its study by rockets and satellites, the airglow, general characteristics of auroras and their study by means of radar, interpretation of the auroral spectrum, and consideration of geomagnetism and meteors in the upper atmosphere. The final chapter contains brief comment on advances during the IGY 1957/58 in each field, written by the author of the relevant chapter of this book. (Ed. by J. A. Ratcliffe. New York, Academic Press, 1960. 586p., $14.50.)

systems, and Fourier analysis. Some of the topics covered include circuits, impedance, dipoles, network theory, resonance, oscillating circuits, resistance, condensers, and inductance. There are useful bibliographies which include many references in English, at the end of each chapter.

It is planned that each volume will be complete in itself, and will give the reader enough basic information to enable him to read advanced texts and periodicals. (P. Grivet and R. Legros. Paris, Masson, 1960. 553p., 90 NF.)

TRAITE THEORETIQUE ET PRATIQUE DES ENGRENAGES, 3. ed.

Various changes and corrections have been made in this third edition to bring it up to date, and new tables and diagrams included. This first volume deals with theory and technology, and covers basic theory, surfaces of different types of gears, helicoidal and worm gears, teeth, pitch calculation, shafts, materials used, wear, train of gears, etc.

The author, a well-known university professor, is at present preparing a third edition of the second volume of this work, which is a study of material and equipment. (G. Henriot. Paris, Dunod, 1960. 443p., 64 NF.)

STANDARDS RECEIVED

ASTM standards. American Society for Testing Materials, 1916 Race Street; Philadelphia 3, Pa.

Bituminous materials for highway construction, waterproofing, and roofing (with related information). 8th ed., 1960. $5.50.

Mineral aggregates and concrete (with selected highway materials). 9th ed., 1960. $5.75.

Petroleum products and lubricants (with related information). vol. 1, 37th ed., 1960. $9.50.

Steel piping materials. 17th ed., 1960. $7.00.

CSA standards. Canadian Standards Association, 235 Montreal Road, Ottawa 2.

A23 — 1960 — Standards for concrete and reinforced concrete. $2.50.

A119.1 — 1960 — Code for split-barrel sampling of soils. $1.00.

A119.2 — 1960 — Code for thin-walled tube sampling of soils. $1.00.

C22.2 No. 5 — 1960 — Construction and test of service-entrance and branch-circuit breakers. 3rd ed. $1.25.

C105 — 1960 — Specification for indoor high-potential full-load air interrupter switches. $1.75.

G40.8 — 1960 — Specification for structural steels with improved resistance to brittle fracture. 35c.

0132.3 — 1960 — Specification for wood doublehung prefit window units. $1.00.

Z69 — 1960 — Specification for a radiation symbol. $1.00.

TECHNICAL BULLETINS AND PAMPHLETS RECEIVED

Beams and girders.

Buckling tests on plate girders, by Konrad Basler and Bruno Thurlimann. Stockholm, International Association for Bridge and Structural Engineering, 1960. 14p.

Effect of tensile properties of reinforcement on the flexural characteristics of beams, by R. G. Mathey and David Watstein. New York, American Iron and Steel Institute, 1960. 21p.

Breakwaters. Pneumatic.

A laboratory study of pneumatic breakwaters, by T. M. Dick and A. Brebner. Kingston, Ont., Queen's University Civil Engineering Dept., 1960. 31p. (C.E. Research Report no. 12).

Canada. National Research Council. Division of Building Research.

Canadian building digests.

Condensation between panes of double windows, by A. G. Wilson. Ottawa, 1960. 4p.

Rain penetration of walls of unit masonry, by T. Ritchie. Ottawa, 1960. 4p.

Technical papers.

Permafrost aspects of Hudson Bay Railroad, by J. L. Charles. Ottawa, 1960. 11p. (Technical paper no. 94). 25c.

Canadian Good Roads Association, 41st Convention, Toronto, 1960.

The behaviour of subgrades under repetitive loadings, by V. E. Vaughan.

Bridge location in relation to highway planning, by L. C. Johnson.

Can we save the cities from the stranglehold of traffic? by C. T. Brunner.

Evaluating highway-railway grade crossing treatments, by W. A. McLaughlin.

Landscaping for highway improvement, by A. K. Hay.

Problems in grouting prestressing cables, by T. Lamb.

The role of the resident engineer in construction control, by W. J. Malone.

Rural municipal road markings, by D. L. Lawrysyn.

Some aspects of traffic theories, by J. L. Vardon.

The study of the economic impact of urban expressways upon adjacent areas, by F. J. McGilly.

The use of chemicals in winter maintenance, by D. R. Brohm and H. M. Edwards.

Cement.

Long-time study of cement performance in concrete: Chapter 12, concrete exposed to sea water and fresh water, by I. L. Tyler. 1960. 12p.

Coal.

Possibilities of using nuclear energy for gasifying coal, by J. P. McGee and Sidney Katell. 1960. 11p. (U.S. Bureau of Mines information circular 7965).

Concrete. Prestressing.

Notes on fire tests of prestressed concrete. Chicago, Portland Cement Association, 1960. 13p.

Electrical engineering.
Electrical Research Association.

Technical reports.

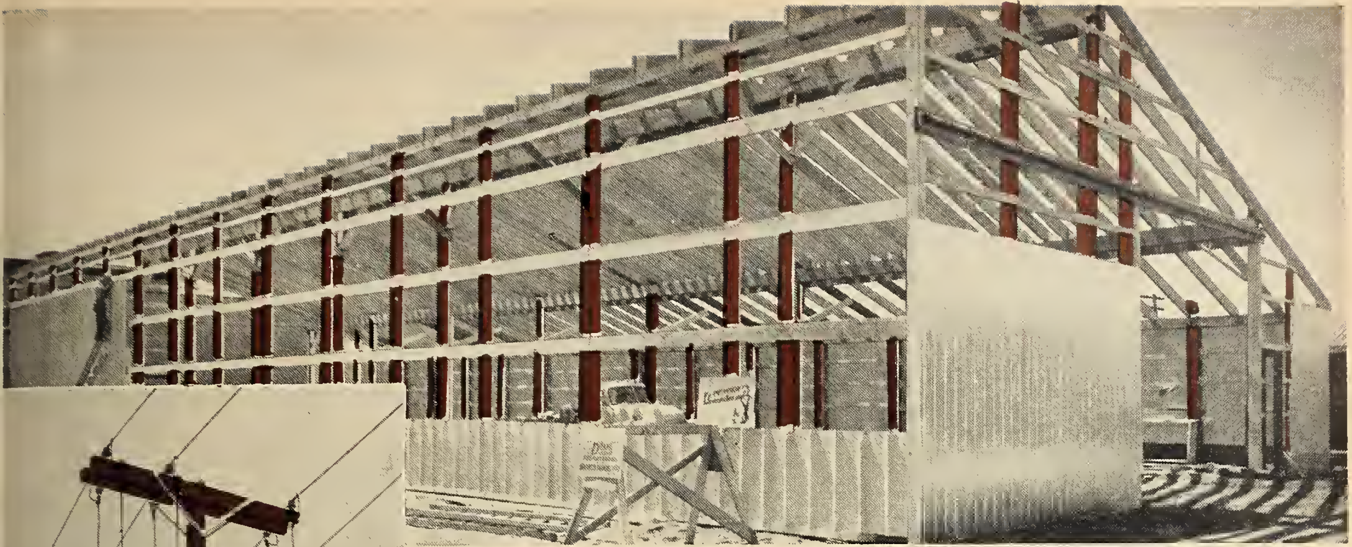
A/T153 — Effect of heat ageing on the electrical and mechanical properties of varnished terylene fabric. 1958. 12/6.

A/T155 — Grips for tensile tests on very extensible tapes, by A. G. Day. 1959. 4/6.

D/T109 — Pressure piling in compartmented enclosures. I. Effects of bore and length of connecting tube in explosions of pentane/air mixtures, by T. J. A. Brown. 1959. 12/6.

J/T172 — The creep and rupture properties of 2¼% chromium, 1% molybdenum quality steel. A summary of British data (1% strain and rupture).

(Continued on page 162)



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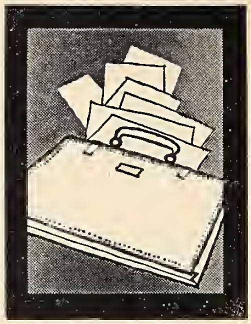


Appointments and Transfers

Atlas Copco AB has appointed Harry Grevby as managing director of Atlas Copco Canada, Ltd. Mr. Grevby succeeds **H. Sommerfeldt Jacobsen** who has been appointed managing director of the international Swedish Diamond Drilling Company, parent company of the Craelius organization, acquired by Atlas Copco in 1960.

Nik Cavell, recently High Commissioner to Ceylon, and from 1950-1958 administrator of Canada's Colombo Plan Aid, has been appointed a director of Balfour, Beatty and Co. (Canada) Limited.

Edwards of Canada Limited has announced the appointment of **Earland M. Dawson** as chief engineer.

The appointment of three managers within the North American Division of Atlas Steels Limited, has been announced. **George C. Olson** as works manager will be responsible for all manufacturing operations. **Bruce M. Hamilton** as manager of metallurgy will direct all divisional metallurgical functions. A. V. Orr as manager of marketing will be in charge of sales.

Atlas Copco Canada Ltd. has appointed **A. R. Belanger** district manager of the company's Vancouver branch.

Claude Clermont has been appointed district manager, British Oxygen Canada Limited at Montreal.

The Civil Service Commission has appointed **Arnold M. Tedford** director of the Commodities Branch, Department of Trade and Commerce. He succeeds **Denis Harvey**, who was appointed assistant deputy minister in July.

For the third consecutive year **M. S. Greene** of Montreal has been elected chairman of the Associated Equipment Distributors advertising committee. Mr. Greene acted as moderator for the business session on advertising at the A.E.D. annual meeting in February in California. He is sales promotion manager of Construction Equipment Co. Limited.

The appointment of **John Getgood** as president of Pacific Petroleums Ltd., Calgary, has been announced. Mr. Getgood succeeds **George L. McMahon** who has been appointed vice chairman of the board.

F. I. Morrissey has been appointed to the newly created post of superintendent of the engineering division, Canadian Club distillery, Hiram Walker and Sons Limited.

Recently elected to the Board of Directors of Union Carbide Canada Limited is **Allen T. Lambert.** Mr. Lambert is president of the Toronto-Dominion Bank and a director of a number of other companies.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

THE ANNUAL REPORT for 1959 of the European Federation of Corrosion now is available. The report is in three parts: the report of the General Secretariat with an account of activities within the Federation; reports from member societies on their technical work in the corrosion field; and a survey of institutes and research centres in individual countries which are concerned with problems of corrosion and the protection of construction materials.

COMPLETE PAINT finishing systems and component units for such systems is the subject of a new, 12-page technical bulletin released by Ross Engineering of Canada, Ltd. Data includes typical schematic layouts of finishing systems, illustrations and materials on such items as metal preparation units, spray booths, flow coat units, dry-offs, ovens, air heaters, conveyors and air make-up units.

A DEFICIT of $218,930 for the year ended March 31, 1960, was noted in the annual report of the British Columbia Power Commission. Gross revenues increased 11.4% to $19,077,564. The deficit, which was charged to reserves, was caused largely by increased fixed expenses, interests and depreciation, on capital works which had been put into service during the year and which had not yet been fully utilized in normal production.

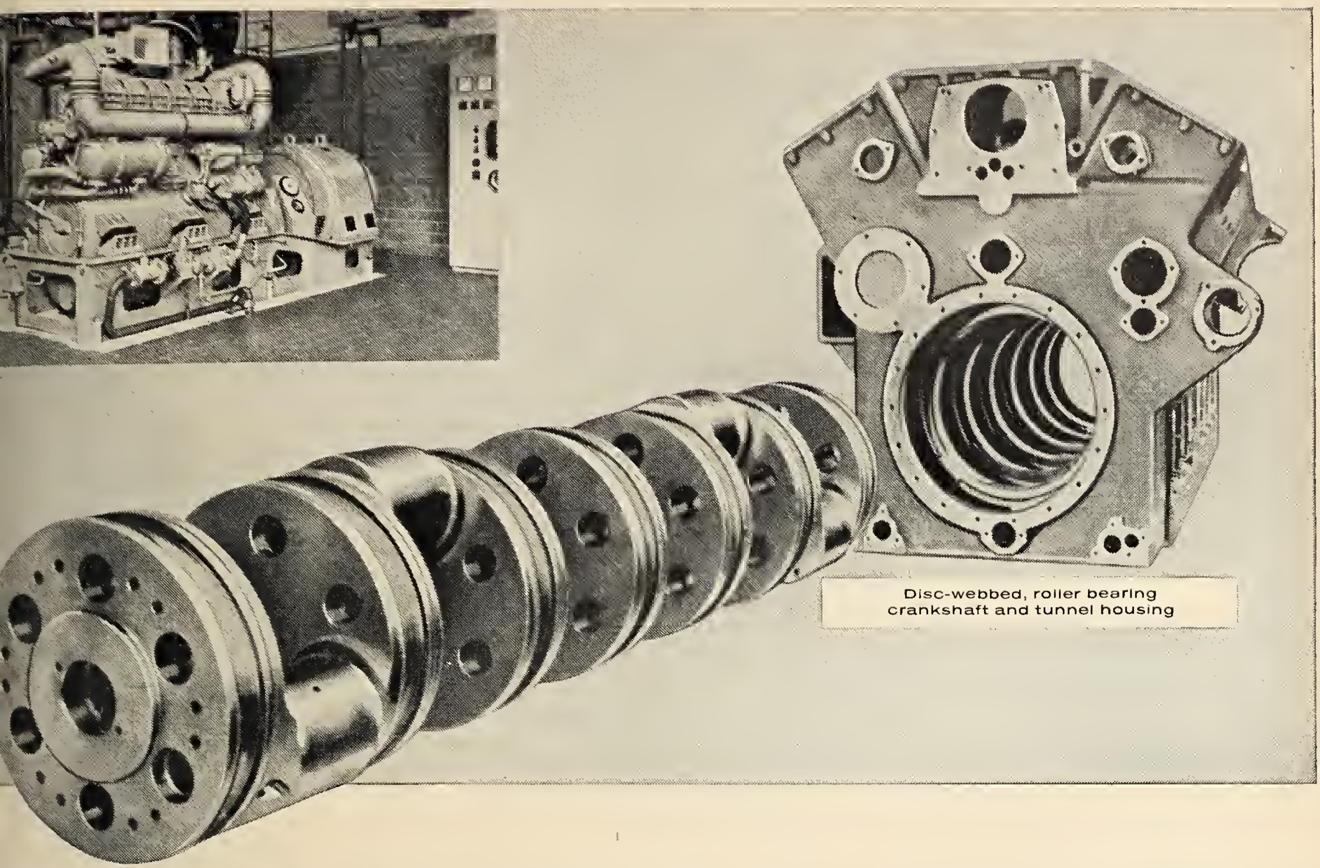
MONTREAL LOCOMOTIVE WORKS, LIMITED, has been awarded a major contract for subway cars by the Toronto Transit Commission. Thirty-six cars are to be purchased by the TTC. The current move marks an important step in the Company's diversification program.

A NON-CONTACT CONTROL which is claimed to anticipate material breakage and to automatically stop a strip being rolled to prevent excessive material damage is announced by Canadian Allis-Chalmers. Anticipation of strip breakage is achieved by using magnetic amplifier static switching circuits in conjunction with an indicating tensiometer.

A "DO-IT-YOURSELF" self-curing kit has been introduced by Dominion Rubber Company which enables industrial users to make permanent repairs to conveyor belting and other products without special equipment, highly skilled personnel or the heat sources generally required for such operations. The kit, marketed under the name Holdtite Self-Vulcanizing Products, consists of various styles and sizes of repair components (rubber and fabric reinforced patches, sheet material, putties and cements,) the simple tools required to do most repair jobs and an instruction manual. The sealing and patching materials are self-vulcanizing compounds that cure quickly to a touch, resilient rubber at room temperatures.

AN OUTLAY OF $7½ MILLION is involved in an extensive electric generating plant expansion program scheduled by Canadian Utilities, Limited. Major item is a $4.4 million extension to the Company's Battle River plant south of Forestburg. Another $2.8 million is earmarked for extensions to the 17,500 kw. plant at Vermilion and almost $300,000 is set aside for the removal of the 8,500 kw. turbine from Vermilion to the Company's Sturgeon plant in northwestern Alberta.

(more Briefs on page 163)



Disc-webbed, roller bearing crankshaft and tunnel housing

Maybach industrial diesel engines — from 300 to 1,800 hp — can achieve 16,000 hours between major overhauls

Bristol Siddeley Engines Limited produce Maybach* diesel engines. Covering a power range from 300 to 1,800 hp, Maybach diesels are amazingly reliable and have shown that they can achieve major overhaul lives of between 12,000 and 16,000 hours.

The *proven* basic design features of the whole range (straight 4 to 16-cylinder V) are the same, and each unit can be turbo-charged, or turbo-charged and intercooled. The range operates up to 1,600 rpm and *combines the best performance and design qualities of high, medium and low-speed diesel engines:* light weight and compactness; excellent thermal efficiency; and extremely long life.

Advanced design features

The pistons are pressure-oil cooled. This gives very efficient heat dissipation and reduces liner and gas ring wear to a minimum. The roller bearing, disc-webbed crankshaft is exceptionally rigid within its tunnel housing, and in practice withdrawal is not normally necessary before 12,000 hours running. So low is big end bearing wear that in some cases the protective lead flash has been found intact when examined after 15,000 hours running!

Since the cylinder bore and stroke, and the majority of components, are identical in all models, spares stocks are considerably reduced. And during servicing semi-skilled labour can be used because great thought has been given to easy accessibility and removal of components.

World-wide application

Bristol Siddeley Maybach diesel engines are designed for a wide variety of industrial applications, from stationary and mobile light and power generator sets to oil-drilling rigs and pumping stations. Maybach diesel engines are in service all over the world and have built up an unrivalled record for reliable and economic operation.

For further information please write to: Bristol Aero-Industries Limited, 10210 Pie IX Blvd., Montreal North, P.Q.

* *Manufactured in the UK under licence from Maybach-Motorenbau GmbH.*

BRISTOL SIDDELEY ENGINES LIMITED

HIGH-LEVEL MANPOWER IN OVERSEAS SUBSIDIARIES.

Foreign investment and management have always played an important role in industrial development throughout the world. This study considers the problems United States corporations operating abroad face in selecting and developing high-level manpower. The study is based on the experiences of American companies in Mexico and Brazil, but the conclusions are equally applicable to other parts of the world.

The topics covered in the study include: operation in a foreign country; relationship between the parent organization and overseas subsidiaries; the cost of imported manpower; dependence on Americans abroad; the selection and utilization of both imported and domestic manpower. A useful bibliography is included. (J. C. Shearer. Princeton, University, Industrial Relations Section, 1960. 159p., $3.00.)

CENTENARY OF THE BIRTH OF NIKOLA TESLA, 1856-1956.

Nikola Tesla was a Yugoslav physicist and electrical inventor who went to the United States in 1884, dying there in 1943. He was one of the first to convert electricity into mechanical energy, and in 1888 patented the induction motor, and designed new forms of dynamos, transformers, condensers, arc and incandescent lamps, etc. He also invented a means of controlling a torpedo boat from land.

This volume contains the papers presented at a Congress held in 1956 in Belgrade in his honour. The papers cover various aspects of his work and contribution to the advancement of electrical engineering, including one on his power system and the role it played in the success of the first power plant at Niagara. (Belgrade, Nikola Tesla Museum, New York, Heinman, 1959. 240p., $5.00.)

*ELEMENTS OF FLIGHT PROPULSION.

Written for students and practicing engineers, this book is used in undergraduate and first-year graduate courses, and requires a working knowledge of elementary calculus. It gives equal attention to both steady and non-steady propulsive flows, and is concerned more with broad views than rigorous analytical treatment. Specific classes of thrust generators are discussed merely as illustrations of general methods and ideas, in the final two chapters. The earlier chapters discuss basic laws and concepts, one-dimensional approximations, one dimensional steady and non-steady flow, non-uniform flows, diffusers, nozzles, dynamic flow machines, pressure exchange, combustion chambers, thrust, and drag. (J. V. Foa. New York, Wiley, 1960. 445p., $12.50.)

*DIGITAL APPLICATIONS OF MAGNETIC DEVICES.

Both a text and a reference handbook, this book describes the theory, electrical design, and logical design necessary for the development of digital systems using the magnetic core as the basic circuit element. Attention is concentrated on core-diode circuits, but transistor-magnetic core combinations and other specialized data-handling circuits also are discussed. Specifically excluded are memories employing magnetic tapes and drums, other electro-mechanical devices involving magnetic phenomena, and standard magnetic amplifiers. (Ed. by A. J. Meyerhoff. New York, Wiley, 1960. 604p., $14.00.)

*THE CONTROL OF MULTIVARIABLE SYSTEMS.

This monograph presents the results of the author's work while visiting professor at MIT, in the development of a theory of control for multivariable systems. The first part of the book is devoted to the most important property specific to such systems: interaction. It discusses the black box problem, the significance of indeterminancy in interrelations, representation of interrelated systems by P-canonical and V-canonical structures and the problem of decoupling, the strength of interrelations defined in terms of output, and a measure for strength for purposes of systems comparison. In part two the synthesis of control systems is dealt with through the development, study, and expansion of the representation of systems by binary operations. (M. D. Mesarovic. New York, Wiley, 1960. 112p., $3.50.)

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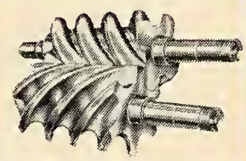

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● LIBRARY NOTES

***PROGRESS IN METALLURGICAL TECHNOLOGY.**

Four lectures delivered at the 13th Annual Refresher Course of the Institution of Metallurgists, held in Scarborough, 1959. The papers cover modern developments in iron and steel production, extrusion and refining of non-ferrous metals, and melting and casting of both ferrous and non-ferrous metals. (Published for the Institution of Metallurgists by Iliffe, London, Toronto, British Book Service, 1960. 147p., $7.50.)

***OFF-THE-ROAD LOCOMOTION.**

General in treatment, this book serves as an addendum to the author's "Theory of land locomotion," (1956), in discussing subsequent developments and outlining the present state of the art of "terramechanics." Here, the author describes important developments since 1956 in industry and education, discusses soil and snow mechanics, tracks, wheels, tires and the making of predictions of vehicle performance and design parameters, all relevant to the vehicle treated as a unit in physical relationship to the soil over which it moves—other than the conventional roads and highways. (M. G. Bekker. Ann Arbor, University of Michigan Press, 1960. 220p., $10.00.)

***AMERICAN POWER CONFERENCE, PROCEEDINGS, 1960.**

The annual American Power Conference is concerned with practice rather than theory, and a broad overall view of problems of interest to the power industry and associated groups. Six topical sessions were held at the 1960 meeting. Papers presented at the General Sessions deal with national considerations such as American economic power, national strategy, nuclear propulsion in the Navy, and the challenge of new power sources such as magnetohydrodynamic generation, isotopic heat and power, and space vehicle propulsion. Nuclear power plants are discussed in the nuclear power sessions papers; steam generators and turbines, peaking and central station power plants and auxiliaries, condensers, fuels, industrial plants, traction vehicle power and space heating in the mechanical sessions papers; turbine-generators, high-voltage systems, switching, distribution, communications and protection control, computers and network analysers, and system planning and operation in the electrical sessions papers. The final two sessions dealt with hydroelectric power-rates, revenues, and new project financial and water technology-analysis and pollution control in industrial waters, and sea water conversion. (Chicago, Illinois Institute of Technology, 1960. 869p., $10.00.)

***STRESSES IN SHELLS.**

Written for practising engineers and research workers, this book contains a unified presentation of the basic facts of shell theory, and solutions in sufficient detail to make them readily applicable to design work. The level of the mathematical tools employed has been kept as low as compatible with the needs of the subject matter. Familiarity with linear differential equations is necessary, and with partial differential equations would be useful. Chapter one contains introductory matter, chapters 2-4 cover membrane theory, chapters 5-6 are devoted to the bending theory of the circular cylinder and the general shell of revolution, and the final chapter is concerned with the stability of shells. The appendix contains a compilation of formulas concerning forces and deformations in circular rings. (Wilhelm Flugge. Berlin, Springer-Verlag, 1960. 499p., DM 58.80.)

***STATISTICAL THEORY OF COMMUNICATION.**

This college-level introduction covers essentially all the basic elements of linear systems in the statistical theory of communications. Discussion in the final two chapters of orthonormal functions and the orthonormal representation of linear systems, important in the statistical theory of optimum nonlinear systems, is the only inclusion of nonlinear aspects. The text covers harmonic analysis, probability, random variables, ensembles, distributions, averages, densities, correlation functions, sampling theory, the fundamental relations of a linear system, and optimum linear systems, filtering, and prediction. (Y. W. Lee. New York, Wiley, 1960. 509p., $16.75.)

TECHNIQUES OF PLANT MAINTENANCE AND ENGINEERING, 1960.

This report of the eleventh Plant Maintenance and Engineering Conference is, as usual, divided into two sections. The first section contains the thirty-three papers presented at the Conference together with the discussions and questions on them. The topics covered include: the control of maintenance; training; air and water pollution; maintenance problems in small plants; sanitation control; maintenance costs, and work scheduling; planning to combat disaster by floods and tornadoes; preventive maintenance, etc.

The second section contains the proceedings of the round table discussions on maintenance in various types of plant: chemical; food processing; foundries; metalworking; petroleum processing; pilot; rubber; pulp and paper; steel and textile mills. (New York, Clapp and Poliak, 1960. 341p., $10.00.)

VIDEO TAPE RECORDING.

A basic treatment of the techniques, mechanics and circuitry used in video tape recording, based on lectures given by the author. Introductory chapters deal with the waveforms and signals used, and with electronic photography, followed by chapters on the mechanics of recording, the electronics of tape recording, and video recording. The rest of the volume is more advanced, and covers servo systems, the video system, colour correction circuits and servo and video circuits. A final chapter deals with machine and tape operations, and the Ampex and RCA control panels. There are many diagrams and illustrations. (J. L. Bernstein. New York, Rider, 1960. 268p., $8.95.)

PHYSIQUE DES CIRCUITS.

The first of a projected series of volumes giving a complete course in electronics, this text covers basic theories, and is limited to sinusoidal

E.I.C. CERTIFICATE OF ADVERTISING MERIT

Phillips Electrical Company has been awarded the E.I.C. Certificate of Advertising Merit for their full colour, full page "bleed" advertisement which appeared on page 101 of The Journal in December, 1960. Short, factual copy and the use of almost two-thirds of the page for a striking, natural colour action photo of two men handling the product —a bright yellow butyl rubber covered cable—undoubtedly contributed to the selection of this advertisement as the winner.

Each month a different panel of fifty readers of The Journal—five from each province—is asked to select the award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

The advertising Manager of Phillips Electrical Company Limited, Brockville, Ontario, is Mr. A. M. Antliff. The advertising agency which prepared and placed the advertisement is Heggie Advertising Company, Toronto. Jack Heggie is the Account Executive.

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Consulting Services

LIBRARY NOTES

(Continued from page 138)

1959. 7/6.

L/T373 — Oil-impregnated paper capacitors; some factors affecting the discharge inception stress, by J. H. Mason. 1958. 10/6.

S/T106 — Display-storage oscillography in impulse testing, by E. L. White. 1960. 6/-.

Z/T122 — High-speed cinematography of sustained power arcs, by J. C. Needham. 1959. 10/6.

Engineers. Remuneration.

Report on salaries of professional engineers by levels of responsibility, as of July 1, 1960. (Copies of this report may be obtained from the Canadian Council of Professional Engineers, 77 Metcalfe Street, Ottawa).

Hydraulic structures.

Concrete for hydraulic structures. Chicago, Portland Cement Association, 1960. 7p.

Hydrology. Bibliography.

Selected bibliography of hydrology to the end of 1958. Canada. Ottawa, National Research Council, 1959. 94p.

Nuclear reactors. Fuel elements.

Nuclear fuel element development, by R. C. Dalzell. Philadelphia, American Society for Testing Materials, 1960. 14p.

Pipe. Concrete.

Concrete pipe irrigation systems. Chicago, Portland Cement Association, 1960. 24p.

Polymers.

New polymers — new problems, by H. F. Mark. Philadelphia, American Society for Testing Materials, 1959. 8p.

Portland Cement Association.

Facilities and test methods of PCA structural laboratory, by Eivind Hognestad and others. Skokie, Ill., Portland Cement Association Research and Development Laboratories, 1959. 32p. (Bulletin D33).

Roads and streets. Concrete.

A charted summary of concrete road pavement standards used by state highway departments, 1960. Chicago, Portland Cement Association, 1960. 15p.

Subgrades, subbases and shoulders for concrete pavement. Chicago, Portland Cement Association, 1960. 15p.

Science. British Commonwealth.

The promotion of the sciences in the Commonwealth. London, Central Office of Information, 1960. 73p.

Science. Great Britain.

The promotion of the sciences in the United Kingdom. London, Central Office of Information, 1960. 27p.

Sewers. Maintenance and repair.

Sewer maintenance. Washington, Water Pollution Control Federation, 1960. 64p. (WPCF manual of practice no. 7).

Shipyards. Great Britain.

Fairfield, 1860—1960. Glasgow, Barbour MacLaren Advertising Ltd., 1960.

Soil-cement.

Suggested specifications for soil-cement base course. Chicago, Portland Cement Association, 1960. 3p.

Solar radiation.

Utilization of solar energy, by Farrington Daniels. Philadelphia, American Society for Testing Materials, 1960. 14p.

Stockholm. Swedish Cement and Concrete Research Institute.

Reprints.

Arbet inom Europeiska betongkommitten: work of the European Concrete Committee, by G. Wastlund. 1960. 20p. (Reprint no. 4).

Background of the Swedish tentative standard specifications for limitation of crack widths in reinforced concrete structures, by P. O. Jonsson and others. 1960. 21p. (Reprint no. 1).

Bearbetning av resultat fran tellverkningskontrollen, by B. Warris. 1960. 4p. (Reprint no. 7).

Inverkan av flygbranslen, olja och tvattmedel pa betong, by S. G. Bergstrom and P. E. Lundstrom. 1960. 5p. (Reprint no. 6).

Slip between reinforcement and concrete, by S. T. A. Odman. 1960. 13p. (Reprint no. 2).

Use of high-strength steel in reinforced concrete (with discussion), by G. Wastlund. 1960. 25p. (Reprint no. 3).

Waves.

An introduction to the mathematical theories of two-dimensional periodic progressive gravity waves, by B. Le Mehaute and A. Brebner. Kingston, Queen's University Civil Engineering Dept., 1960. 49p. (C.E. Research report no. 11).

A theoretical study of waves breaking at an angle with a shore, by B. Le Mehaute. Kingston, Queen's University Civil Engineering Dept., 1960. (C.E. Research report no. 10). EIC

Reading is the Key

CANADIAN LIBRARY WEEK

April 16-22, 1961

• MORE BRIEFS

EXCLUSIVE SALES AGENT for Pentachlorophenol manufactured by Naugatuck Chemicals, Division of Dominion Rubber Company Limited, is the Dominion Tar and Chemical Company Limited, the two firms announced.

THE CHEMICALS DIVISION of Canadian Industries Limited has announced the establishment of a polyurethane rigid foam technical service laboratory at Toronto. Facilities are available for the demonstration and application of techniques for foaming-in-place by both spraying and dispensing (pouring). Development of new techniques and uses of rigid foams is also planned.

WORLD WIDE SERVICE now is provided by the Steel Company of Canada, Limited, for high tensile steel bolts and nuts produced to the latest standards of the International Metric System. An increasing demand has been noted for metric threaded fasteners, not only from countries where the metric system is standard, but through the growing markets created in North America for servicing European-made automobiles and machinery.

THE PRODUCTS DATA GUIDE issued by the Master Builders Company, Ltd., provides information covering the use of all Master Builders products for improving concrete and other masonry products. The company calls it an indispensable guide to regular users of concrete admixtures, iron-armoured floor products, grouting and waterproofing material and other related products.

A LOW-COST system of photo-recording highway surfaces has been announced by Canadian Aero Service Limited, Ottawa. Called Sur/Fax, the system includes a precise strip camera, a specially-equipped truck, a film projector and a reader-printer. Sur-Fax film records are an objective, detailed record, obtained at a fraction of the cost and time of inventories made by walking or driving the area and noting or sketching defects.

A TRAMP METAL DETECTOR that is claimed to indicate tramp metal in practically any kind of material is available from Canadian ASEA Electric Limited, Montreal. This detector is sensitive to magnetic and non-magnetic metals alike. It consists of a search coil and a detector box that can be mounted separately. This equipment is designed for connection to a single phase, 115 or 230 v., 60 cycles supply and comes in a water-tight enclosure. A wide range of search coils is available for different kinds of materials and conveyances. The "Adset" is being operated in mines, ore handling plants, quarries, chemical plants, sawmills and the food and tobacco industries.

AN EIGHT-PAGE catalogue describing the features of the "Super 30" Fabricator has been prepared by Strippit Tool and Machine Company, Brampton, Ont. The publication explains in details how precision micrometric gauging enables the operator to position work quickly and accurately on this single-station metal-working machine. The catalogue also describes some of the special production-tested accessories.

METHODS FOR GROUTING the different types of heavy industrial equipment are described in a seven-page Master Builders Company publication, EPMG-2A. Non-shrink Embeco premixed grout is used to explain preferred grouting methods and techniques. The preparatory steps, forming selecting materials, mixing and placing the grout are seen in diagrams, charts and photographs.

OPERATION OVERTHRUST is the name of a geological study of the 372,-000 sq. miles of the Precambrian Shield that has been carried out by Hunting Survey Corporation Limited. This geological compilation consists of 500 individual photo mosaic sheets, each covering an area of approximately 720 sq. miles and with a separate transparent overlay showing all geological data and pertinent geophysical interpretation. All sheets are individual and have a scale of 1 in. to 1 mile, each covering ½ degree of latitude and ½ degree of longitude.

A SYSTEM to generate impulses for the operation of demand meters, totalizing relays, and data counting and printing has been developed by General Electric's Meter Department, Somersworth, New Hampshire. This impulse generator, designated type D-41, is applicable to large consumer billing, tie-line metering between utilities, electric generation, load survey and kilowatt demand load control systems. It is claimed that the device can be used where conditions of oscillation or float of in-out power occur with no impairment of accuracy. The machine is rated to operate from a power supply of 120 v. a-c and at temperature ranges from −25°F. to 150°F.

AN EMERGENCY lighting unit, which is claimed to operate automatically and instantaneously upon failure of normal power and also to automatically prepare itself for the next blackout, is marketed by Exide Industrial Division of The Electric Storage Battery Company (Canada) Limited, Toronto. The Lightguard Model "A" is designed for installation on posts or walls and is available as auxiliary lighting equipment for plug-in connection to 115 v., 60 cycle alternating current power sources. The equipment is powered by 3-COE-7 Exide-Tytex batteries and only requires additional water two or three times a year.

ASSOCIATED TUBE INDUSTRIES (Coldwater) Limited, has entered the welded stainless steel tubing and pipe field. This company has purchased the assets of Tri-Bay Industries which has been engaged in the manufacture of welded stainless steel tubing at Coldwater, Ont. It is directly associated with Oakton Products Limited whose name has been changed to Associated Tube Industries (Toronto) Limited. The A.T.I. (Toronto) has been manufacturing welded nickel alloy tubing up to ½ in. O.D. Both companies will be referred to as Associated Tube Industries (A.T.I.) for commercial purposes. The Coldwater plant will manufacture welded stainless steel pressure tubing in diameters ½ in. O.D. up to and including 2½ in. O.D.

THE FAIRFIELD Shipbuilding and Engineering Company Limited, Glasgow, Scotland, has produced a handsomely bound volume to mark its shipbuilding centenary. Colorfully illustrated the book tells of how the company which, in recent years has built some of the biggest naval and passenger ships in the world, began in 1834 as a little engine shop sixty feet by forty. Its first order was worth sixpence. By 1852 the company entered the marine engine industry and by 1860 built its first ship, the MacGregor Laird. Since then the company has been building battleships, battle cruisers, aircraft carriers, destroyers, submarines, passenger ships and tankers. Its subsidiary at Chepstow, Monmouthshire, specializes in welded constructional steelwork and recent contracts have included many bridges, steel framed buildings, crane girders and dock gates. EIC

ELECTIONS AND TRANSFERS

(Continued from page 98)

Dalhousie University: A. C. Bell, W. G. Campbell, R. D. MacDonnell, D. A. MacNeill, T. P. A. Power.

Memorial University: P. R. Clark, J. G. Evans, B. A. Frey, E. K. Jerrett, J. E. Woolfrey.

Ontario Agricultural College: B. M. Auguste, W. B. German, J. W. Kneeling, J. P. King.

McGill University: J. P. Roberge, M. M. Saeed, J. B. Smith.

Loyola College: M. J. Nituch, R. M. Glacins.

University of Toronto: K. L. Coddling, D. J. Ross.

Laval University: C. Robitaille.

Mount Allison University: R. N. Phillips.

University of Idaho: G. A. McKnight.

Corp. of Prof. Engrs. Que.: E. C. Schneider.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective January 28, 1961.

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SASKATCHEWAN

Junior to Member: T. H. Lackie.

MANITOBA

Junior to Member: R. J. Crawley, W. H. Finnbogason, H. R. Hopper, A. G. Loadman O. C. Norris-Elye, A. T. Sloane, J. Tarnava, W. E. Trann.

NOVA SCOTIA

Member: A. C. Harris.

NEW BRUNSWICK

Member: J. B. J. Vautour.

INDEX TO ADVERTISERS

March 1961

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The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

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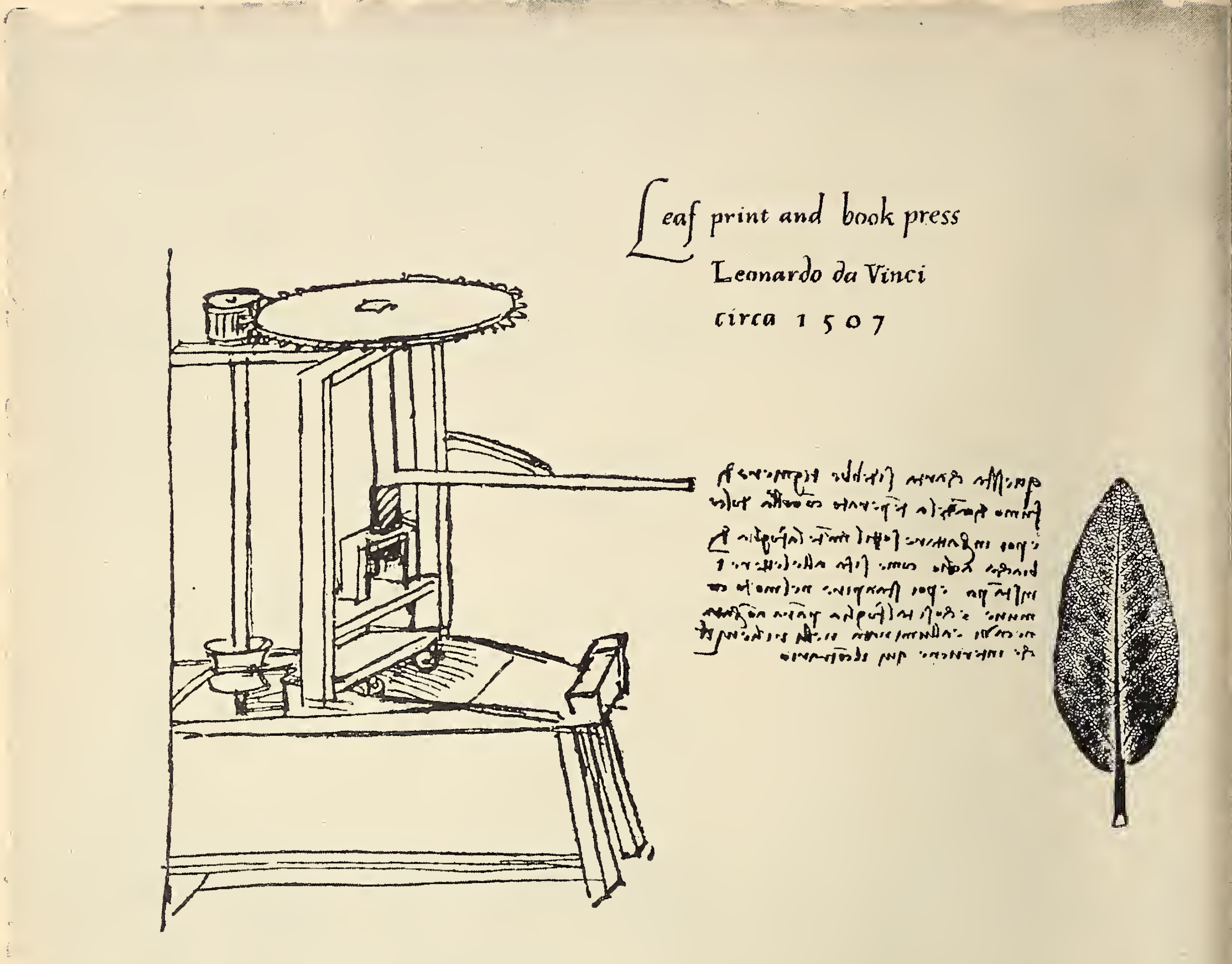
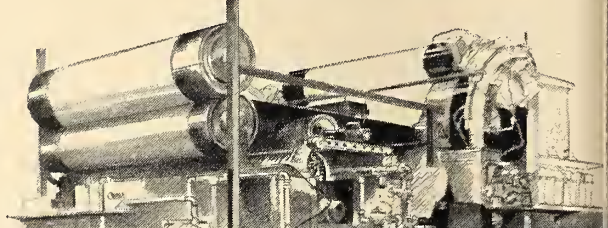
CONTENTS



LEONARDO DA VINCI, *artist, engineer, inventor, was one of the truly creative men of all time. Reproduced here are original sketches of a leaf, printed by a process of his own, and a press used in this printing operation.*



IN THIS ISSUE

A *High-Speed Gearbox* discusses the problems of high speed gear design for Canada which centre upon the correct compromise between large diameter gears with conservative tooth loading, and heavily loaded smaller gears permitting better lubrication conditions in consequence of their lower peripheral speed. The author, C. E. Gay, is in the Gear Engineering Department, Associated Electrical Industries Limited, Toronto. During a period of many years, the experience of AEI in this field has been wide, and in this paper the author describes the approaches to the problems encountered in the design of a recent gear drive with a tooth speed of 315 m.p.h.

Karl H. **Zement** brings 15 years of experience to bear on his paper, *Planning of Radio Relay Systems.* Since coming to Canada in 1951 he has worked mainly in electronic fields such as feed-back-control systems (servomechanisms) and communications. He has been associated with the Quebec Telephone Company at Rimouski, Que., since 1955. Mr. Zement explains that the ever-increasing requirements for long distance telephone and television circuits in the last few years, and the development of high grade FM radio systems designed to meet these needs, have contributed to a large amount of research done on radio propogation and radio system performance in recent years. His paper, which should be useful as a handy reference for evaluating a radio network, is a synthesis of information taken from a number of sources discussing different aspects of system engineering.

The high cost of modern construction has resulted in smaller operating rooms which require pulsed air for their ventilation, **Dr. Victorien Fredette** says in his paper, *Problemes de Bacteriologie dans la Ventilation des Salles d'Operation.* If no adequate filter is used in such ventilating plants, bacteria from the outside air may accumulate inside the operating rooms and may represent a source of potential danger. Dr. Fredette, eminently qualified to discuss such problems, earned a Bachelor of Pharmacy degree from University of Montreal. He later received degree in Chemistry and in Biology from the same university, and eventually earned a Doctor of Science degree from the Sorbonne in Paris. His present responsibilities include teaching at University of Montreal, and serving as assistant director of the University's l'Institute de Microbiologie et d'Hygiene.

The South Saskatchewan River project will provide extensive benefits in several broad areas. The project is discussed in *Hydrologic Investigations for the South Saskatchewan River Project* by **W. M. Berry**, M.E.I.C., **E. F. Durrant**, M.E.I.C., and **Casper Booy**. Mr. Berry received a B.Sc. degree from University of Manitoba in 1944, and an S.M. degree from the Massachusetts Institute of Technology in 1947 following studies in water resources development. In May, 1959, he became Chief Design Engineer for the Prairie Farm Rehabilitation Administration. Mr. Durant was born in Ladner, B.C., and was raised in Moose Jaw, Sask. He graduated from University of Saskatchewan in 1947 after following a course in Engineering Physics and two years later returned for supplementary courses in Civil Engineering. After four years as District Engineer with the Water Development Branch, P.F.R.A., he joined the staff of the Hydrology Division where he is now Chief. Mr. Booy, Design Engineer for the South Saskatchewan River Project was educated and trained in his native Holland. He joined the P.F.R.A. in Winnipeg in 1951.

Built-in extinguishing systems to protect rotating electrical equipment utilize either water or carbon dioxide. **J. H. Ingham**, M.E.I.C., discusses the relative merits of both types in *Fire Protection for Rotating Electrical Equipment.* Attention is paid to the speed of extinguishing, extinguishing power, economics, and intangibles. Mr. Ingham clearly indicates the preferences of both manufacturers and operators. The author joined the Dominion Bridge Company at Lachine, Que., after graduating from McGill in 1935. Mr. Ingham has been associated with Walter Kidde & Company of Canada Ltd., Toronto since 1941. He was Factory Manager until 1946 and Contract Engineer and Assistant to the Managing Director until 1953 when he was appointed Manager, Toronto District Office.

The Crisis in Measurement has long been an absorbing topic for **Dr. Leslie E. Howlett**. In his paper, Dr. Howlett explains that much of man's developments has depended upon his ability to measure the multitudes of phenomena. Measurement qualifies as a keystone to civilization. Lack of conformity of measurement systems constitutes a very real crisis. Dr. Howlett, a native of London, England, graduated from the University of British Columbia in 1927 with a B.A. in Mathematics and Physics. In 1928 he received an M.A. in Physics from University of Toronto and three years later a Ph.D. from McGill. Dr. Howlett joined the National Research Council in 1931 and culminated a series of promotions in 1955 by being appointed Director of the newly-established Division of Applied Physics. He was named President of the Advisory Committee for the Definition of the Metre in 1956, and Vice-President of the International Committee on Weights and Measures in 1960. In 1943 he was awarded the M.B.E. for his service in developing the optical instrument industry in Canada during the Second World War.

The main features of design and construction of the graceful Hugh John Flemming Bridge are described in the paper, *Concrete Arch Bridge at Hartland, New Brunswick,* by **E. van Walsum**, JR.E.I.C., and **T. J. Sluymer**, JR.E.I.C. The bridge consists of seven reinforced concrete arches with spans ranging from 250 feet to 280 feet. The structure was completed in 1960. Both authors are graduates of the University of Delft, Holland. Mr. Sluymer graduated in 1951 and joined the Heavy Engineering Section of the Foundation of Canada Engineering Corporation Limited in 1957 as Design Engineer. Mr. van Walsum graduated in 1952 and joined FENCO in 1955. He now is Project Engineer.

Two-Way Slabs and their Supporting Beams gives a brief, non-mathematical discussion of stress distribution. The more scientific approach used in advance literature is not sufficiently useful for those who have not made a special study of two-slab theory and have too little time available to do so when a problem is encountered. The author, **E. M. Rensaa**, M.E.I.C., was a member of the revision committee which decided to adopt the Marcus theory for the new edition of the National Building Code. He points out, however, that the opinions expressed are his own and may not in every detail be shared by other committee members. Mr. Rensaa received his B.Sc. Civil from University of Manitoba in 1933. After obtaining his M.Sc., Mr. Rensaa worked with the C.N.R. and the Federal Department of Public Works in Winnipeg. He then returned to his native Norway for nine years and started his own designing and consulting practice. Since 1947 he has been a partner in the Edmonton firm of Rensaa and Minsos, Architects and Consulting Engineers.

COVER ILLUSTRATION

Aerial view of the City of Vancouver, where the 75th Annual General Meeting of the Engineering Institute of Canada will be held May 31-June 2. (photo courtesy CPR)

HIGH SPEED GEARBOX

C. E. Gay, Gear Engineering Department, Heavy Plant Division of Associated Electrical Industries

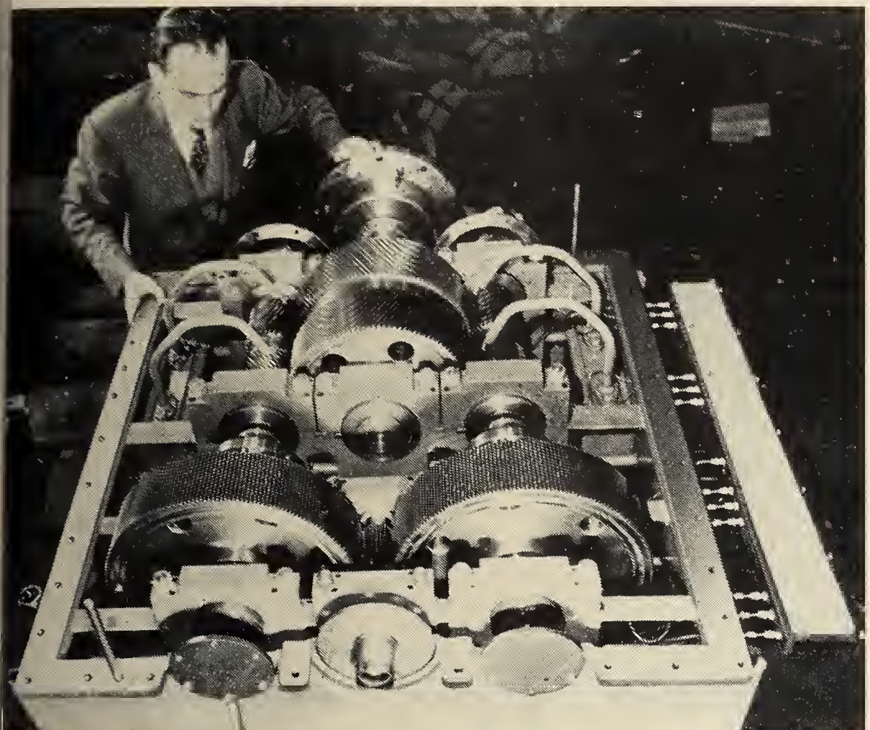


Fig. 1—The gearbox viewed from high-speed end with top cover removed.

THE PROBLEMS of high speed gear design centre upon the correct compromise between large diameter gears with conservative tooth loading, and heavily loaded smaller gears permitting better lubrication conditions in consequence of their lower peripheral speed. Over a period of many years, the experience of AEI in this field has been wide, and in this article the author describes the approaches to the problems encountered in the design of a recent gear drive with a tooth speed of 315 m.p.h.

A high-speed gearbox was recently supplied by the Heavy Plant Division of our company to an aircraft firm, for use in driving a gas-turbine test rig. The gearbox was delivered within five months from the receipt of the order.

The schematic arrangement of the rig is shown in Fig. 2. The gearbox has a variable speed input from 2000 hp. driving motor through a eddy-current coupling. It is designed to transmit 220 lb. ft. torque at speeds up to a maximum of 45,000 r.p.m. corresponding to a speed of 1700 r.p.m. input and, by simple changes of gear ratio, speeds between 20,000 and 55,000 r.p.m. may be obtained for values of torque of 525 lb. ft. and 175 lb. ft. respectively.

The operational characteristics are shown in Fig. 3, from which it will be evident that the major problems confronting the designer were resultant from the combination of high power and high speed. A design had to be adopted which would incorporate gears sufficiently large to meet the limitations of Hertzian and root bending stresses in the gear teeth, yet not be of such size that rotational hoop stresses would exceed limits of safety, nor that the special problems associated with lubrication and peripheral speed could not be solved. For these reasons the double increasing locked train design shown in the sectional view Fig. 4 was chosen, thereby dividing the torque equally between two layshafts and providing two mesh points each at half-load on the input and output gears. By this means the maximum pitch line speed was limited to 460 ft./sec.

As previously mentioned the design provides for speed and torque changes beyond the scope of the set of gears supplied, by the substitution of alternative gears. These changes involve only the output train. The factors which influenced this choice in preference to the low-speed train were:

(1) considerations of surface stress on gear teeth;

(2) cost — the low-speed gears would be considerably wider than the high-speed, the pinions would be hollow, and either an extra input coupling would have been required with each set of gears supplied or alternatively its removal and transference would have been necessary for each gear ratio;

(3) the simplicity of manufacture and accuracy of measurement of the spur output gears referred to later.

Tooth Loading

The curves of 'K-factor', root stress and pitch line speed given in Fig. 3 assume that an infinite number of output train gear ratios would be used to cover the output torque/speed envelope, that all points on the output torque curve therefore correspond to a maximum output speed, and that for any particular maximum speed the corresponding output torque value would not be exceeded. Since each of the machines to be tested with the rig have a torque characteristic which varies as the square of the speed, and that the number of machines to be tested is restricted, it will be seen that the above limitations are no embarrassment to the operator. The K-factor curves are related to Hertzian compressive stress in the gear teeth. This is the surface stress resultant from load per unit length of tooth and the relative radii of curvature of the teeth in mesh, and is one of the contributory factors giving rise to the phenomenon of pitting. K-factor varies directly with load and as the square of the Hertzian stress for any particular set of gears. In full consideration of the duties of the gearbox, the required life, and the economics of the design, the limits of K were fixed at a maximum of 150 for the low-speed train and 130 for the high-speed output gears. The economy of the design is illustrated in Fig. 3 by the proximity of the torque curves for these values of K, to the curve of output torque requirements. In line with the fact that Hertzian stress is proportional to load and that the ratio of the input train is never varied, it will be seen that the curves of horsepower and input train K-factor are proportional to each other. The gearbox is protected from overload by a torque meter on the output shaft controlling the excitation of the eddy current coupling. The input coupling is of the shear pin

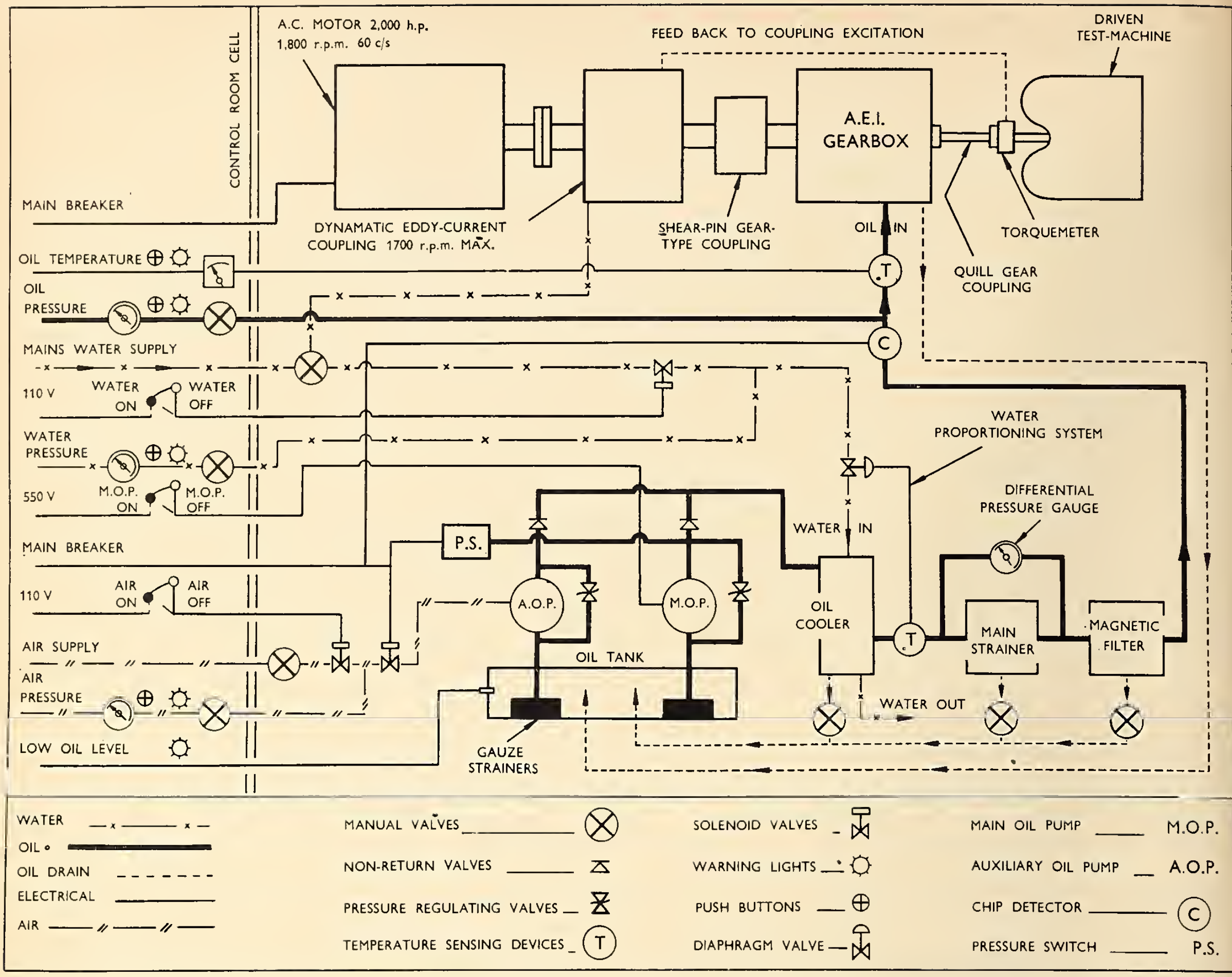


Fig. 2—The high-speed test rig, showing automatic circuits for control of oil temperature and pressure, and filtration system.

gear type and serves as further protection.

Gear Materials

Further economies in the size of the gears could have been made by the use of hardened gears with higher surface stress factors and certain advantages obtained in reduced pitch line speed and centrifugal hoop stress. However, all known methods of hardening gears produce some tooth distortion which, for high-speed gears, must be ground away after the hardening process to avoid destructive vibration. Had hardened and ground gears been used, the saving in size would have been little, due to the dictates of shaft diameters and the proximity of bearings, and the cost may have been a little more than that of the design chosen. After consultation with the Research Department on questions of metallurgy and machinability, high-tensile chrome molybdenum steel was used for each pinion, and carbon steel approximating to EN 9 was used for the three gearwheels. All gears were hobbed in a temperature-controlled cubicle to limits of accuracy approximately conforming to BS. 1807, Class A 1.

Axial Location of Gears

It is common knowledge that helical gears provide for quieter running than straight spur gears, so that a double helical train was designed for the low speed. However, since double helical gears are subject to axial oscillation at tooth contact frequency due to inherent minute axial pitch errors, and since for the high-speed output train this frequency would be of the order of 20,000 cycles per second, it was recognized as damaging to attempt to allow the inertias of the high-speed rotating parts to be accelerated in accordance with the dictates of these errors. In consideration of the use of single helical gears in the output train, the magnitude of thrust would have necessitated a thrust bearing collar diameter larger than centrifugal hoop stress would permit, and the use of such a bearing at 55,000 r.p.m. is beyond the experience of design. A straight spur high-speed train was therefore chosen recognizing that, for most of its service, tooth contact noise would be beyond the audible range. In consequence, the design had to provide for the axial location of all gears with the exception of the low-speed pinions. These had to be allowed complete axial freedom to follow the input gearwheel, so that a gear-type coupling was introduced into each layshaft.

Load distribution

The locked train system requires a means for adjustment whereby even distribution of the load between the layshafts can be achieved, since small differences in backlash between gear teeth at corresponding mesh points at each side of the train can be of considerable consequence. This adjustment is provided at the ends of the two low-speed pinions by taper bore couplings fitted by an oil injection method, and should some small error still be present after adjustment, the torsional flexibility of the layshafts through the hollow low speed pinions is designed to cater for it.

Bearings

Plain bearings are fitted throughout the gearbox to meet the high speed and high load conditions, and special consideration had to be given the oil supply pressure and journal clearance of the output pinion, which has a journal speed of 300 f.p.s. Consistent with maximum reliability, bearing pressures were designed to be a little higher than for most applications, to offset the power losses applicable to large bearings at high speeds. The temperatures of all bearing shells adjacent to the bearing metal are measured with thermocouples taken to a special instrument which simultaneously records the temperature of any bearing selected by a multi-position switch, and constantly scans all bearings to sound an alarm should any one of them exceed a preset temperature figure.

Tooth pitch and accuracy

Careful attention had to be given to the choice of tooth pitches, since while a coarse pitch minimizes tooth root bending stress, greater accuracy and a lesser liability for gears to scuff are obtained from the use of a fine pitch. It should be appreciated that, for a locked train system with all gears on the same horizontal centre line, the loads on the bearings of the central gears, i.e. the input and output gears, are purely gravitational since tooth load from one side of the train is counteracted by that from the other side. The weight of the output pinion is of the order of only 20 lb. so that, had not extreme accuracy been obtained, dynamic forces due to tooth pitch error would have been of considerably greater magnitude than the weight, causing instability of the pinion and destruction of the bearing metal. While it is true that, had the pinion centre line been raised or lowered with respect to the high-speed wheels, a positive pinion bearing load could have been obtained, the pinion would not have remained equidistant between the two gearwheels within the limits of bearing clearance. Consistent with safe root tooth stresses therefore, fine pitches were used. Addendum correction was introduced to improve further the conditions of tooth sliding velocity, for it is this factor, unaccompanied by a similar or larger value of tooth rolling, which is largely responsible for scuffing disorders.

High-speed coupling

For physical reasons associated with the driven machine, the high-speed coupling is required to project at least 12 in. from the gearbox, and calculation of whirling speeds indicated that this coupling should be of a minimum weight and diameter. To meet these conditions a hollow quill gear-type coupling is used having less weight and greater torque carrying capacity per unit diameter than other types of flexible coupling. The quill member has external teeth and is free to float axially; the two internal toothed members are mounted to the adjacent shafts. For the further avoidance of whirling speeds and also journal instability, out of balance was removed from the high-speed pinion to an accuracy of 0.003 lb. in. A similar high degree of balance related to speed was ensured for each of the other rotating members.

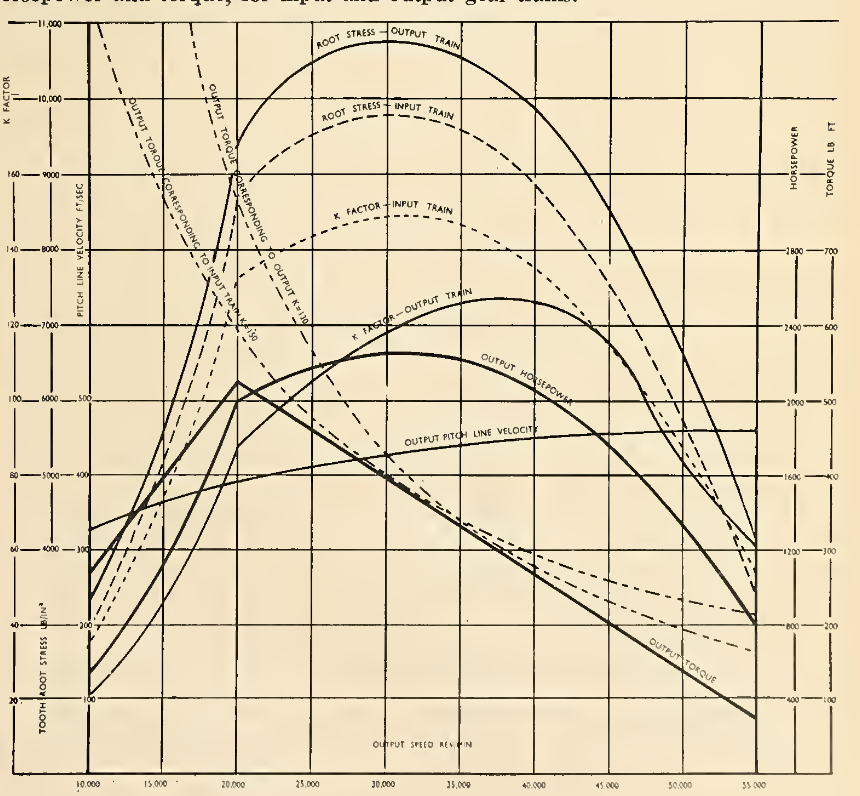
Lubrication

One of the major problems concerning the operation of gears at high pitch line speed is that of the lubrication of the teeth and the removal of the heat energy from the mesh. Even at relatively low speeds it will be found by simple calculation that the teeth move away from particles of oil supplied at pressure at a rate which does not permit them to penetrate to the full tooth depth, and that the position is further aggravated by windage. However, experiments show that, having established an oil film on gear teeth, it is very difficult to destroy it so long as the teeth are kept adequately cool. Provided that oil can penetrate the windage film, heat will be conducted away from the teeth satisfactorily whilst maintaining sufficient oil between them for lubricating purposes. At very high speeds the windage barrier is of considerable consequence. Oil must be delivered at pressure in a continuous jet and at right-angles to the air stream to prevent atomisation. That oil which does not reach the gears forms a medium of high density with the air, and becomes not only a more effective barrier to the supply, but a source of considerable power loss. A means for breaking the windage barrier in the vicinity of the supply jets is provided together with adequate capacity within the gearcase for hot oil to move away from the gears. Special attention had to be given to the choice of lubricating oil. Gears normally require heavy oil, particularly at high loads, to ensure that lubrication is hydrodynamic, but the viscous friction of heavy oil is contributory to power loss. A compromise solution was found.

Automatic controls

Referring again to Fig. 2, it will be noted that the entire rig together with all auxiliary equipment is housed within an enclosed cubicle. This is for safety reasons and necessitates remote control of all aspects of operation and testing. In order that the tester need

Fig. 3—Performance curves, showing K-factor, tooth root stress, pitch line speed, horsepower and torque, for input and output gear trains.



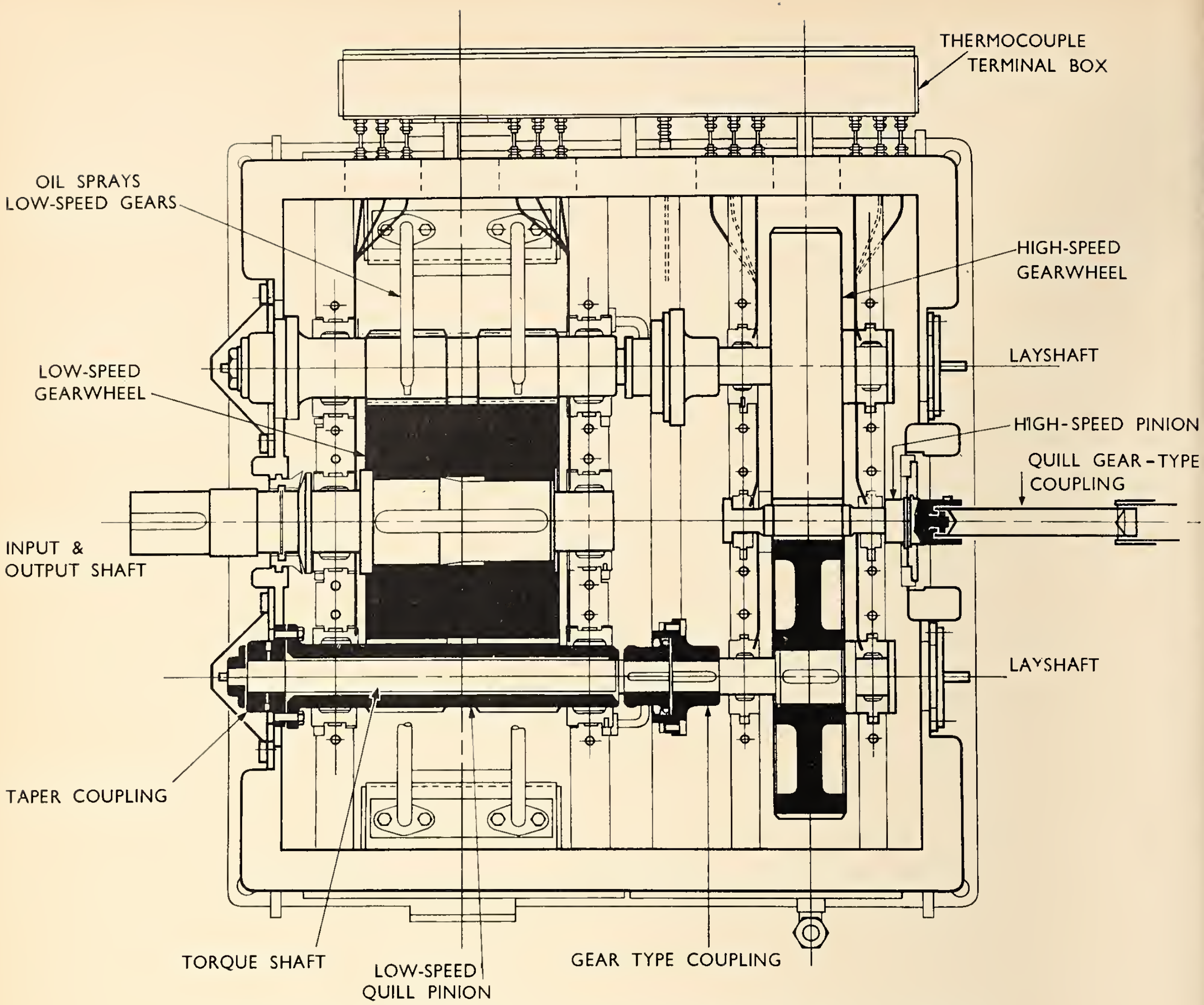
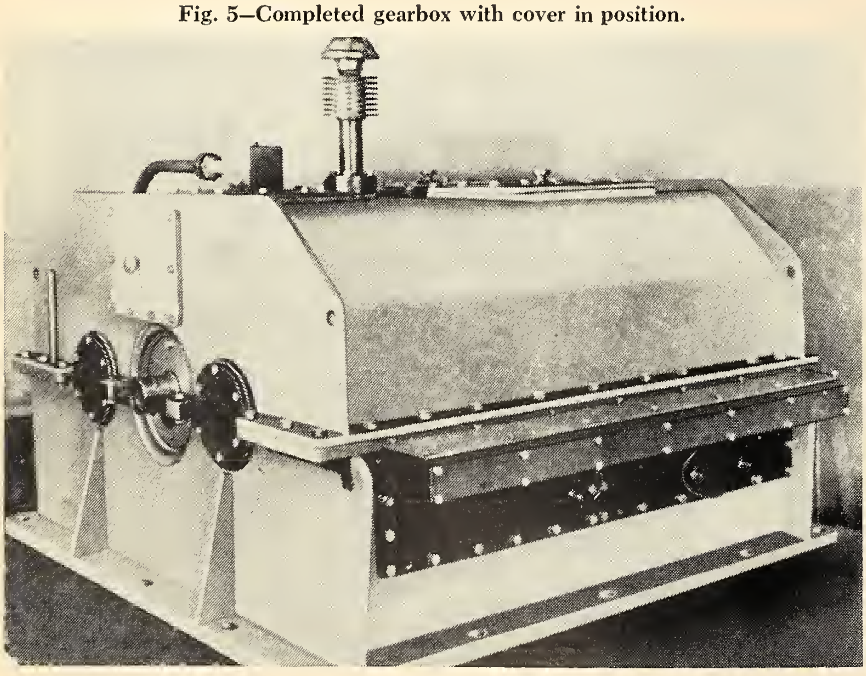


Fig. 4—Sectional view of gearbox, showing arrangement of layshafts and couplings.

give little attention to the operation of the rig, many controls have been made fully automatic. It will be observed that the oil inlet temperature is kept within a preset range by automatic control of cooling water, and similarly if there is a fall in oil pressure, then the air driven auxiliary pump will start automatically, Careful attention is paid to filtration by the provision of suction and delivery strainers, a magnetic filter and a chip detector, as the blockage of an oil spray or the failure of a high speed bearing could have serious consequences.

Fig. 5—Completed gearbox with cover in position.



Successful tests

Extensive testing of the gearbox, occupying a total running time of approximately 24 hours, was carried out before despatch. Much valuable information was obtained concerning the behaviour of both gears and journal bearings at high speeds. This data correlates effects of oil pressure and flow, bearing temperature, and power losses. The quietness of running during test was quite remarkable and the maximum value of acceleration obtained from vibration readings was 244 in./sec.^{2} at full speed. The gearbox has been in successful operation at Montreal since February, 1960. EIC

PLANNING OF RADIO RELAY SYSTEMS

Karl Zement,

Quebec Telephone Engineering Department, Rimouski, P.Q.

THE ever-increasing requirements for long distance telephone and television circuits in the last few years, and the development of high grade FM radio systems designed to meet these needs, have contributed towards a large amount of the research done on radio propagation and radio system performance in recent years. Much information is presently available in the technical literature for engineering FM radio systems operating in the UHF and SHF bands and assessing the performance and reliability of such systems.

This paper is a synthesis of information taken from a number of sources discussing different aspects of system engineering. It should be useful as a handy reference for evaluating a radio network. The text will give the basic formulæ. Derivation of these formulæ with graphs and monograms will be given in the Appendix. A single hop system will be analysed as an example of the application of the above formulæ. Finally measured values of performance will be given and compared with calculated value for a 74A–I Lenkurt radio equipment operating at a frequency of 6000 mc. This model of equipment was the first to be installed in Canada.

General

Radio waves in the UHF, SHF range behave similarly to light waves in that they travel approximately in a straight line and are consequently subject to normal reflection and refraction phenomena.[12]

Refraction is a bending of the radio wave caused by changes in the dielectric constant of the atmosphere. The dielectric constant depends of course upon the temperature, pressure and humidity. Due to the fact that in a standard atmosphere the refraction decrease linearly with increasing height, the upper portion of the wavefront travels at a higher velocity than that portion near the earth and as a result, the radio wave follows the curvature of the earth. The amount of curving of the radio beam depends on the gradient of the refraction index of the atmosphere.

Since both the earth's surface and the beam are curved, trigonometric calculations of such a path become extremely difficult. These calculations may be simplified by assuming that the radio beam is travelling in a straight line, and that the earth's radius is changing in accordance with changes in the atmospheric density. The earth's radius can therefore be multiplied by a constant "k" the value of which will depend on the rate of change of the refraction index of the air with altitude. The value of "k" may vary between 0.5 and 3.0 with a value of 4/3 generally in agreement with the conditions normally found to exist in the atmosphere. However, where a radio system is designed with a high degree of reliability, "k" = 2/3 must also be considered.

To find the relationship to be expected between the geographical characteristics and the radio beam it is necessary to draw the profile between the proposed sites. This can be readily accomplished by the use of contour maps.

As an example, assume that site "X" and "Y" have been chosen. Ground elevations, i.e., clearance above hills, trees, buildings or other obstacles should be determined by plotting the profile of the land along the transmitting path on 2/3 and 4/3 earth's radius profile paper. If suitable profile paper is not available, a 4/3, 3/3 or 2/3 curve can quickly be drawn on rectangular coordinate graph paper using the following formulæ:

$h = 0.5\ DD_1$ for 4/3 earth's radius

$h = 0.67 DD_1$ for 3/3 earth's radius

$h = DD_1$ for 2/3 earth's radius

Where "h" = height in feet to be added to elevation obtained from contour maps at distance of "D" miles from site X, and "D_1" miles from site Y.

Having completed the profiles for values of "k" = 4/3 and 2/3 we must now determine whether the sites are satisfactory, and if so, the required tower heights.

The signal strength at the receiving antenna depends on the refractive condition of the path. If the waves arrive in phase, a maximum signal will be received. However, if the waves arrive in antiphase a minimum signal will be obtained. Since the distance traveled by each of the rays in a function of the relative altitudes of the transmitting and receiving antennas and the point at which refraction occurs, the signal will pass through a series of maxima and minima as the clearance above this point is increased. This phenomenon is discussed in the Appendix under "Fresnel Zones".

Reference is made to Fig. 1 and 2, showing a typical ground profile between two sites at values of "k" equal to 4/3 and 2/3 respectively. It can be seen that with the antennas at ground elevation at point D and E, a clear line of sight is obtained with $k = 4/3$ (Fig. 1) whereas, on the very same path peak C constitutes an obstruction with $k = 2/3$ (Fig. 2). Since it is usual to design microwave paths in such a manner as to obtain a clearance of at least 0.6 of the first Fresnel zone at $k = 4/3$ condition, and 0.33 first Fresnel zone at $k = 2/3$ condition, it is necessary in the case of peak C to elevate the antennas at each end of the path. Thus the antenna heights AD and BE are obtained.

As stated before, it is of primary importance that a prospective microwave station be capable of providing an unobstructed view of the adjacent station with which it must work, and that adequate clearance exist between the line-of-sight and the intermediate terrain. However, if transmission considerations alone were allowed to govern the choice of sites, some of the locations selected would undoubtedly turn out to be in elevated areas difficult to reach. Consequently in selecting possible sites for a radio system, it is well to keep in mind from the beginning that power must be made available at the site, and that access to the site will be highly desirable.

When a satisfactory path, with alternate station sites, has been selected on the topographic maps, a field inspection should be made to determine the probable accessibility of the various ocations.

Furthermore, it may be desirable to check the actual profile along the paths to make certain that the clearance indicated by the map elevations actually exist in the field. There are several ways of making these field checks to prove actual sighting between locations such as a signal lamp viewed through a transit or theodolite by night, or by using a heliograph signal by day, altimeter survey of the path, etc. However, these methods will not provide any information concerning the radio transmission conditions along the path. More complete data concerning the path may be obtained by making path testing with radio equipment. This method would be of great value on questionable paths, especially on those involving high towers and greater transmission distance. The result of these measurements will provide, together with all the physical data of the path the actual required tower heights.

Once the mechanics of drawing the path profiles between radio sites and of determining antenna heights are understood, it is essential that the transmission objectives of the projected radio system be set, so that in turn the various factors affecting the quality of the intelligence received be controlled during the system design period. The choice of the path lengths between sites, antenna type and size, type and quality of transmitters and receivers will depend on the amount of noise and signal-to-noise ratios acceptable at the receiving end.

Transmission and Noise Objectives on a Radio System

Toll telephone transmission objectives have been covered in detail in several papers.[1,2] They are usually presented under the headings "Long Haul" or "Medium and Short Haul" toll telephone objectives.

Long Haul System Noise Objectives

Multihop radio system carrying circuits over a distance of more than 1000 miles are placed under "Long Haul Systems". The noise level measured at the receiving terminal at a Zero Transmission Level Point (OTPL) with FIA weighting should not exceed 38 dba under normal conditions on a 4000 miles system. For systems less than 4000 miles in length the noise objective should be improved by a ratio of 10 log (4000/system mileage). The minimum for a system irrespective of length is 31 dba at OTLP. Details and definitions of Noise Quantities on Telephone Circuits are given as part of the Appendix.

Medium and Short Haul Noise Objectives

The noise objectives established for this type of system, i.e. up to 1000 miles in length, is 31 dba under normal conditions. For systems which have only one or two repeaters, an additional 3 db of margin should be provided in the noise objective (net 28 dba) to reduce the effects of nominal fading associated with the day to day operational characteristics of radio paths.

Contributing Noise Components

The main sources of noise are[3]:

(a) Thermal noise consisting mainly of noise introduced by first stages of receivers at repeater and terminal stations. This noise varies with the r.f. input frequency of the receiver, i.e. with the propagation conditions, but is independent of the speech content of the transmitted multichannel signal.

(b) Intermodulation noise is caused by non-linearity in the system, and may be divided into two parts of noise sources :

(i) Equipment noise sources which are intermodulation noise caused when multiplex signals give rise to harmonics or other distortion products. Such noise is dependent on the frequency distribution and the level of the transmitted multichannel signal. It is amplitude distortion in the terminal modulator, demodulator and amplifiers bandling the base band signals. Another source of equipment noise is phase distortion, i.e. group delay distortion in circuits handling r.f. and i.f. frequency modulated signals as well as nonuniform amplitude-frequency characteristics in such circuits. The latter may affect the relative sideband amplitude by causing distortion of the modulating signal. Some noise may also add by imperfect limiting at the demodulator. Normally, however, amplitude modulation introduced by the modulator and transmission system should be adequately suppressed by well designed limiters.

(ii) Feeder noise sources will be caused by mismatches in antenna feeder systems or other long i.f. or r.f. connections. A long i.f. cable, connecting a receiver to a transmitter at a repeater station for example, will produce a form of phase distortion, which may result in some noise contribution. Another undesirable effect which may be placed under Feeder Noise Sources are radio frequency echo signals, i.e. signals arriving at the receiver via an indirect path. These are normally high-level echoes as distinct from feeder reflections which are low level echoes having a relatively long delay.

(c) Multiplex noise contribution to the total noise on a radio system consists especially of "Residual Equipment Noise", "Interchannel Crosstalk" and or "Non Linear Noise".

Total Noise in the Radio System

The distribution of noise contributed by the thermal, intermodulation and multiplex sources are shown in Fig. 3 and 4, where a total objective of 28 dba is assumed in example No. 1 and 31 dba in example No. 2.[1,2,10]

If more than one hop is used in a

Fig. 1. Ground profile between two imaginary radio sites based on 4/3 earth's radius.

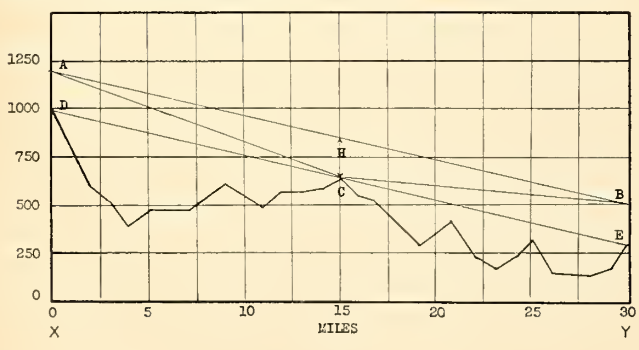
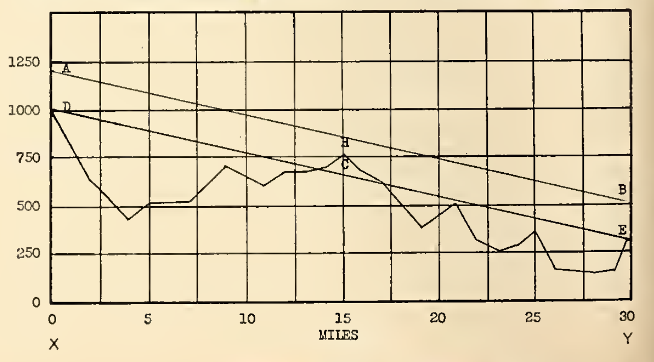


Fig. 2. Ground profile between two imaginary radio sites based on 2/3 earth's radius.



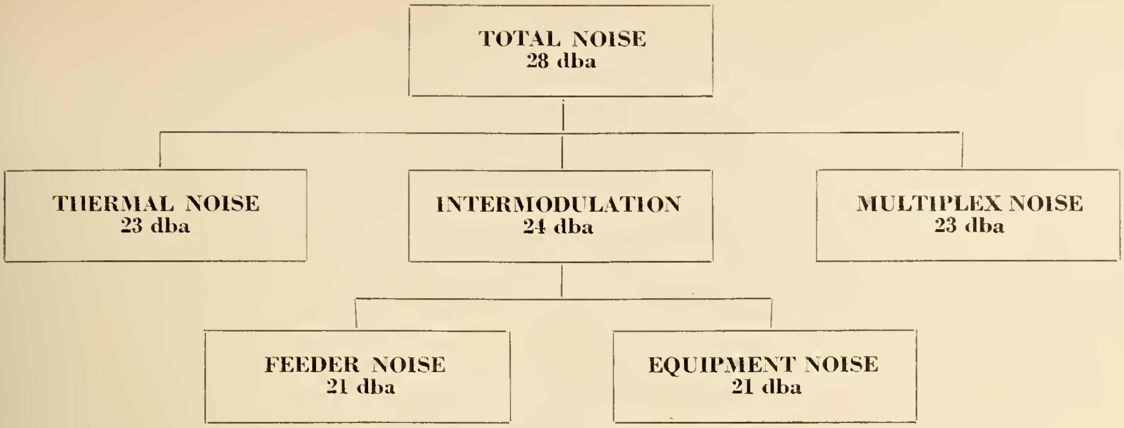


Fig. 3. Contribution of noise components with a total noise objective of 28 dba.

system, the signal, to noise ratio of the complete system may be found by using formula :

$$\text{Total Signal to Noise Ratio of the System} = 10 \log [1/\text{antilog}\,(db_1/10) + 1/\text{antilog}\,(db_2/10) + \ldots]$$

Where db_1 is the signal to noise ratio in db of repeater No. 1 and db_2 the signal to noise ratio of the repeater No. 2 . . . and so on. If it is desired to convert noise power given or calculated in dbm into picowatts (10-12 watt) or visa versa, Fig. 5 of the appendix can be used.

Some times it is convenient to convert the noise objective given in dba (FIA) or *dbRN* (144 wtg.) into a signal-to-noise ratio. With reference to the example given in this paper which is considering a single hop radio system, assume that the proposed total objective of noise falling in a 3 Kc bandwidth of a voice channel is 28 dba. Then from Fig. 3 we note, that for a total noise objective of 28 dba the maximum thermal noise should not exceed 23 dba under normal transmission condition.

From Table 2, column 3 (Part of the Appendix) we note, that the corresponding signal to noise ratio for 23 dba is 59 db flat weighting at OTLP. This ratio represents the signal to noise ratio comparing a 1000 cycles test tone with the flat noise power in the bandwidth of the voice channel.

Calculation of Thermal Noise

Basic Formula: It will be shown that fluctuation noise falling in a single 3 kc voice channel bandwidth is approximately determined by the following expression :

$$\frac{\text{Channel Signal Power}}{\text{Channel Noise Power}}\ (S/N)$$

$$S/N = 10 \log B/b + 20 \log \Delta f/mf + 10 \log (C/N) \qquad \text{(A)}$$

where

B = i.f. bandwidth in cycles
b = voice channel bandwidth in cycles
Δf = R.M.S. deviation in cycles
mf = mean frequency of worst channel in cycles
C/N = carrier to noise ratio at the receiver input (C/ENI)

Carrier - to - Noise Ratio (C/N)*:* It should be mentioned that the (C/N) carrier-to-noise ratio for a radio system can be calculated, providing the following basic system parameters are known :

P_t = transmitter power output (in db)
G_t = gain of transmitting antenna (in db)
G_r = gain of receiving antenna (in db)
L_p = path loss in db, relative to isotropic radiators
ENI = equivalent noise input power of receiver
L_m = misc. losses

G_t and G_r for simple parabolic antennas may be found by using formula (1)

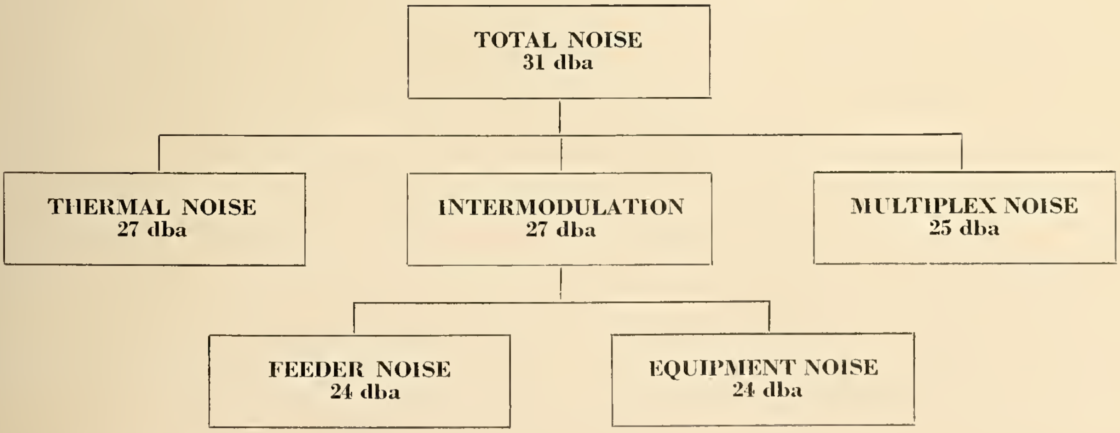
$$G_t \text{ or } G_r = 10 \log 4K(\pi R/\lambda)^2 \qquad (1)$$

where K is the illumination factor (usually taken for 55%)
R is the radius of the antenna mouth
λ is wavelength.

The same unit length must be used for R and λ. (For simplicity Fig. 6 may be used).

When the path length is known, the path loss between isotropic radiators may be found by using formula :

Fig. 4. Contribution of noise components with a total noise objective of 31 dba.



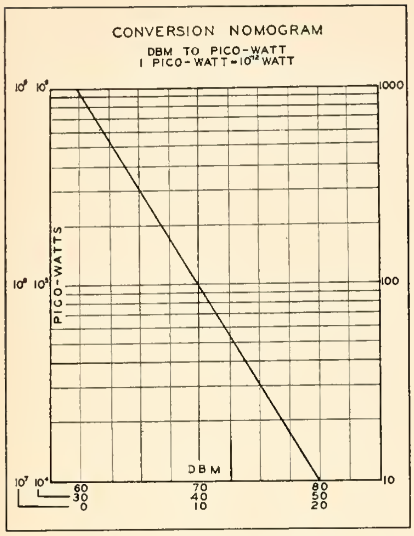


Fig. 5. Conversation Nomogram dbm vs. picowatts.

$$L_p = 10 \log 4543 f^2 D^2 \qquad (2)$$

where f is the frequency in megacycles,

D is the distance between the antennas in miles,

L_p is the path loss between isotropic radiators.'

The path loss can also be evaluated graphically by the use of Fig. 7.

The received r.f. carrier level or power defined as "P" may now be found.

$$P_c = P_t + G_t + G_r - L_r - L_m \quad \text{(or gains } - \text{ losses)} \qquad (3)$$

It should be noted that the value of "P_t" is normally determined from the specification of the equipment to be used.

The ENI or equivalent noise input of a receiver is the thermal noise of the receiver KTB times a noise factor, the value of which depends on the operating frequency and the type of mixer used in the receiver. For ease of calculation RETMA has proposed an empirical relation "$10f^{2/3}$", as a safe noise factor, where f is the frequency in Kmc/s.

From this we can find an approximate noise figure

$$N_f = 10 \log 10 f^{1/2} \text{ or } 10(1 + 2/3 \log f)$$

where N_f is expressed in db.

The thermal noise is "KTB", where "K" is the Boltzmann's constant, "T" is the temperature in degree Kelvin and "B" is the receiver bandwidth.[10,12] This may be shown as follows:

Suppose a noise source impedance of R ohms equal to the input impedance of the receiver. In considering the noise power, the internal impedance of the receiver is neglected as a noise source since it is accounted for the receiver noise figure. The maximum noise power that can be delivered by a generator of resistance R is, using equation (5)

Thermal Noise Power (p)

$$P = E^2/4R = KTB \text{ (watt)}$$

or in terms of db

$$P = 10 \log KTB \times 10^3 \text{ (db)} \qquad (5)$$

Combining equation (4) with equation (5), the ENI or equivalent noise input of the receiver is:

$$ENI = 10 \log (KTB \times 10)^3 + 10(1 + 2/3 \log f) \qquad (6)$$

The ENI can also be evaluated from Fig. 8.

It should be noted that:

(a) The ENI may also be obtained with greater accuracy by finding KTB and adding the known receiver noise figure usually given in the equipment specifications.

(b) The noise figure of a receiver is defined as the ratio (expressed in db) between the noise power output of the receiver and the noise power output of a hypothetical perfect receiver of the same bandwidth and measured at equal level points.

The receiver noise figure "N_f", equivalent noise power generated within the receiver "p" and noise power in a perfect receiver "P_h" are related as follows:

$$N_f = P - Ph,$$

where P_h is the noise power of a perfect receiver taken as KTB.

(c) In some equipment specifications the threshold level may be given. The receiver threshold level is usually defined as that level at which an incoming signal is 10 db greater than the receiver i.f. noise power referred to the input.[11] The knowledge of the detection threshold is important since this characteristic defines the signal level below which the system becomes inoperative.

The value for the received carrier power (equation No. 3) may now be compared with the equivalent noise input of the receiver ENI (equation No. 6) in order to obtain the carrier to noise ratio (C/N) at the input of the receiver.

$$C/N = P_c - ENI, \qquad (7)$$

where P_c and ENI are expressed in dbm.

Improvement factor for FM or Ph.M as compared to AM (expression $20 \log \Delta f/mf$): The thermal noise is uniformly distributed with frequency and in the case of AM the noise is uniformly distributed throughout the demodulated baseband. In FM, the uniformly distributed noise at the input of the frequency discriminator is changed to a triangular distribution at the discriminator output. This is fully explained in the Appendix under the paragraph "Demonstration of FM improvement factor".

$$\text{Improvement factor} = 20 \log \Delta f/mf$$

where Δf = R.M.S. deviation in cycles

mf = mean frequency of worst channels in cycles

Fig. 9 may be used for evaluating this improvement.

Bandwidth Improvement Factor (expression $10 \log B/b$ *of equation A):* The receiver noise in equation No. 6 was evaluated for a bandwidth "B" consisting of the total bandwidth of the i.f., usually taken between 3 db points. However, only the noise falling in a voice channel, taken as 3000 cycles wide for normal telephone operation, should be considered. The channel signal power/channel noise ratio for a voice channel is therefore improved by $10 \log B/b$ where "B" is the i.f. bandwidth between 3 db points and "b" is the voice channel bandwidth. Fig. 10 may be used to evaluate this factor.

Pre-emphasis Improvement: In a multi-

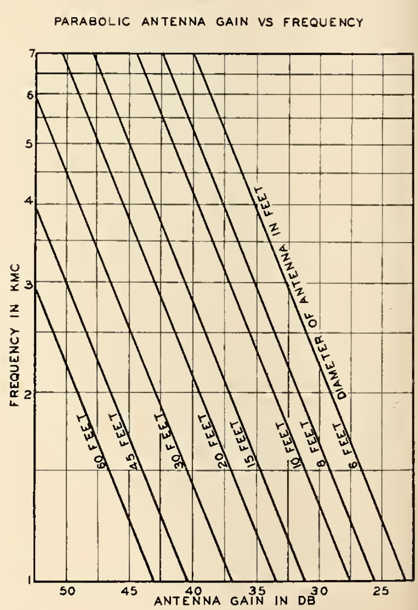
TABLE I

1000 cycles Test Power into 2B Test Set

dbm 1000 c	2B Test Set dba (F1A wtg.)	dbRN (144 wtg.)
0	85	90
−10	75	80
−20	65	70
−30	55	60
−40	45	50
−50	35	40
−60	25	30
−70	15	20
−80	5	10
−90	−5	0

Note: With 1000 c test power applied to the input of the test set, this table shows the relation between corrected values in dba or dbRN measured with a 2B Noise Measuring Set.

Fig. 6.



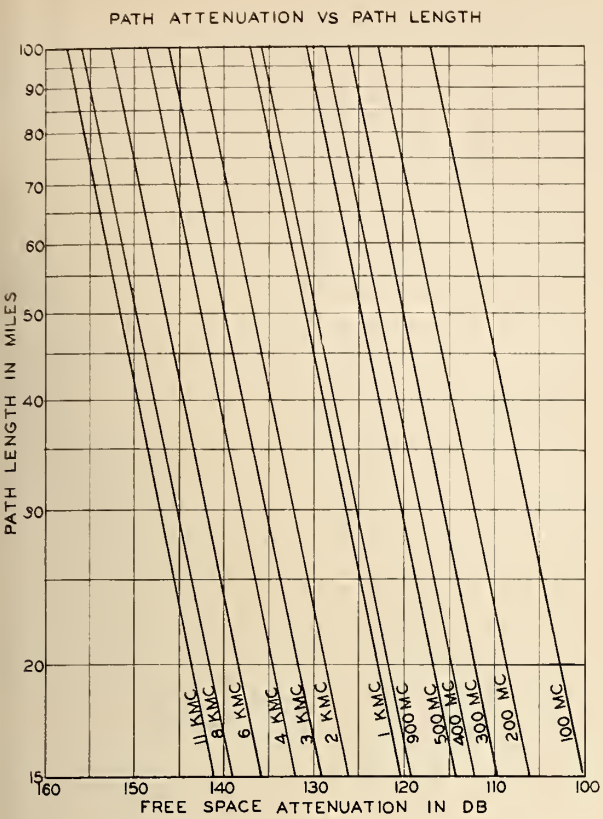


FIG. 7

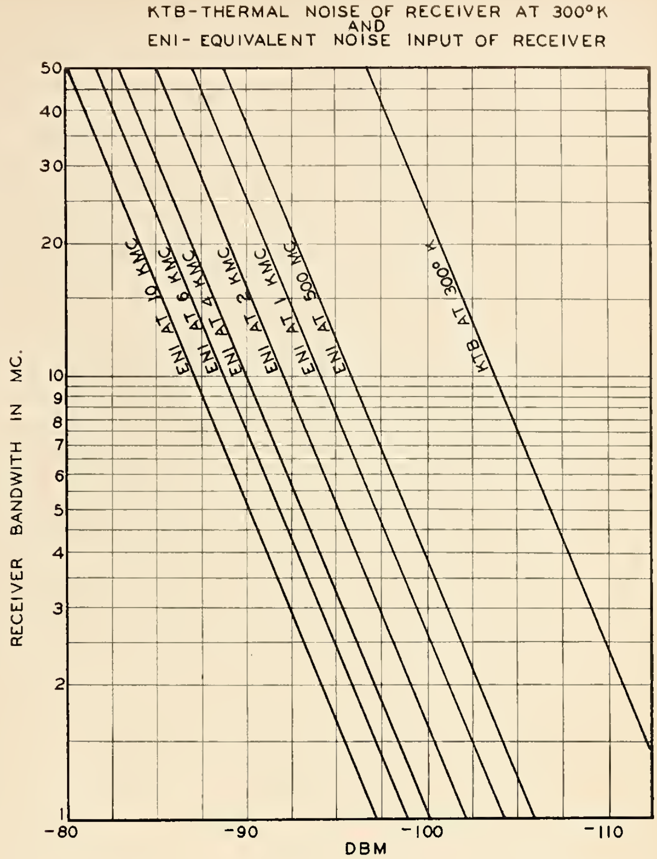


FIG. 8

channel FM radio receiver the output noise has a triangular distribution with frequency and therefore the top channel will have the poorest signal-to-noise ratio. By inserting a pre-emphasis network with an output increasing proportionally with frequency at the transmitter input, the output signal voltage will also be triangular. By passing the discriminator output voltage through a reciprocal network, the signal-to-noise ratio at the receiver can be reduced to a constant value, independent of frequency.

The degree of improvement expected from pre-emphasis, de-emphasis and correcting networks will depend on the circuit capacity and the pre-emphasis characteristics of the system. It is essentially a receiver design problem, and information with regard to this improvement are usually given in manufacturers' equipment specifications.

Multiplex Loading Factor: The signal-to-noise ratio derived above considers a radio system modulated by only one voice channel. Since more than one channel is used simultaneously on the radio system, the level of each voice channel must be reduced accordingly, to prevent overloading of the system. This reduction in level depends on the complex addition of individual amplitudes and phases of each voice channel. Also the number of simultaneously active channels must be considered in determining the level reduction. The multiplex loading factor has been subject of a thorough investigation by Holbrook and Dixon of the Bell Labs.[4]

Calculated and Measured Values for a Single Hop 74A1 Lenkurt Radio System

Suppose that the radio path characteristics are known. Furthermore, the total noise objective is set at 28 dba, as discussed previously. Then with reference to Fig. 3, the allowed thermal noise should not exceed 23 dba. This corresponds to 59 db signal-to-noise ratio in the worst channel.

The Lenkurt 74A1 radio equipment is now analysed in order to check if it meets the noise objectives. In the following system study, figures measured on a working 74A1 system operating between Grosses Roches and Matane in the Quebec-Telephone territory are given in order that the amount of error between calculated and measured values may be compared.

Known Parameters

$*P_t$ =	Transmitter output power	+27 dbm
$**G_t$ =	Gain of transmitting antenna	38.5 db
$**G_r$ =	Gain of receiving antenna	38.5 db
$*B$ =	i.f. bandwidth	8 mc between 3 db points
$*mf$ =	top frequency occupied by the multiplex on the baseband (12 kc to 1.2 mc)	1,080 kc = 1.08 mc
$*\Delta f$ =	Peak deviation	plus or minus 2 mc
$*N_f$ =	Noise figure of receiver	14 db
***	Path length in miles	18.4 miles
	Operating frequency	

* Parameters taken from 74A Lenkurt Equipment Specifications.
** The gain of antennas may be found from Fig. 6 of the Appendix. 38.5 db gain represents the gain of a 6 feet parabolic type antenna at 6,000 mc with 55% assumed illumination.
*** The profile below the transmitting path is shown in Fig. 11 and Fig. 12.

Gains

P_t =	Transmitter output power	+27 dbm
G_t =	Transmitter antenna gain	38.5 db
G_r =	Rec. antenna gain	38.5 db
Total gain		104.0 db
Losses		
L_p =	Path loss for 18.4 miles at 6000 mc	−137.5 db
L_m =	Misc. losses (waveguide, filters, etc.)	− 6.5 db
Total losses		−144.0 db

Received r.f. Carrier Level		
$P_c = P_t + G_t + G_r - L_p - L_m$		
or Gains − Losses		−40 dbm (−40 dbm meas.)
Noise Calculations		
KTB or thermal noise	−105.0 dbm	
N_f or noise figure	14.0 db	
$ENI = KTB + N_f$	91.0 db	
Threshold =	− 81.0 db	(−77 db meas.)

KTB is taken from Fig. 8 for 8 mc. i.f. bandwidth at 300° Kelvin. If the noise figure of the receiver is known, ENI may be found with more accuracy by using the relation $ENI = KTB + N_f$. If however, the noise figure is not known, ENI (approx.) may be found from Fig. 8.

Carrier-to-Noise Ratio (C/N)

$$C/N = P_0 - ENI$$
$$C/N = -40 - (-91) = 51 \text{ db}$$

where P_c is received r.f. carrier level. ENI is equivalent noise input power of receiver.

The threshold level equalt $ENI + 10$. This is based on the assumption that the noise peaks are 10 db above R.M.S. level. Therefore, if it is desired to find the signal-to-noise ratio at threshold the following equation may be used :

$$C/N_t = C/N - 10$$
$$C/N_t = 51 - 10 = 41 \text{ db}$$

Improvement Factor for FM as compared to AM (20 log $\Delta F/mf$)

When frequency of phase modulation is employed, large improvements in signal-to-noise ratios are possible due to the triangular noise distribution.

According to the equipment specification, Δf is 2×10^6 cycles per second and mf is 1.08×10^6 cycles per second for 240 voice channels.

$$\Delta f/mf = 2 \times 10^6/1.08 \times 10^6 = 1.85$$

From Fig. 9, we find for a $\Delta f/mf$ ratio of 1.85 an improvement of 5.5 db. The improved C/N ratio is therefore

$$C/N = C/N + 5.5$$
$$C/N = 51 + 5.5 = 56.5 \text{ db}$$

Bandwidth Factor (10 log B/b)

In KTB the noise has been considere for an 8 mc bandwidth. To convert tl noise level in a 8 mc bandwidth to tha in a 3 kc voice channel bandwidth, th noise level should be decreased by factor 10 log B/b where "B" is the i. bandwidth between 3 db points an "b" the voice channel bandwidth. Fror Fig. 10, we note that, the noise fallin in a 3 kc voice channel bandwidth i nearly 35 db less than that noise foun in the i.f. bandwidth of 8 mc. Thus th voice channel signal to noise ratio, S/N is therefore

$$S/N = C/N + 10 \log B/b$$
$$S/B = 56.5 + 35 = 91.5 \text{ db}$$

Pre-emphasis Improvement

The degree of improvement expectec from pre-emphasis, de-emphasis and cor recting networks depends on the circui capacity and the characteristic of the equipment in question. Since the exac value for this improvement is not available for the equipment involved, ar improvement of 2.5 db is assumed Therefore, the improved signal-to-noise ratio S/N in a voice channel bandwidth becomes.

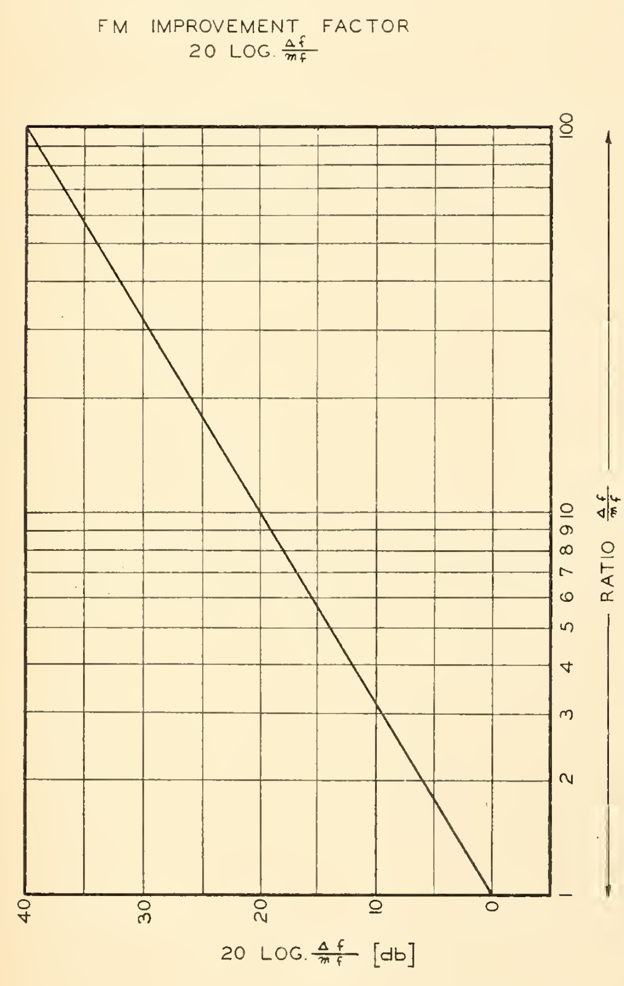


FIG. 9

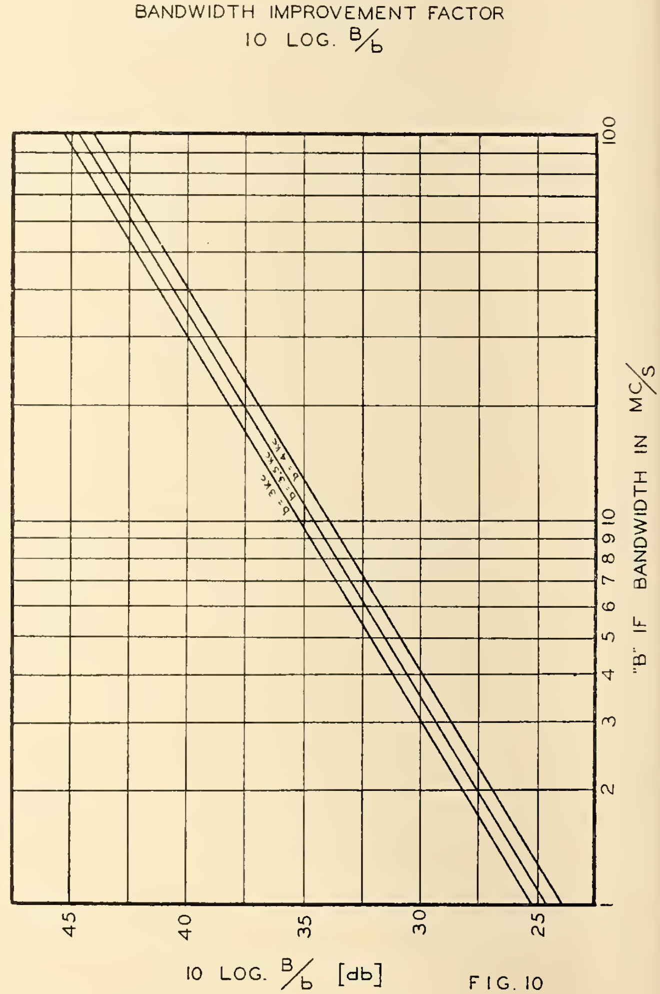


FIG. 10

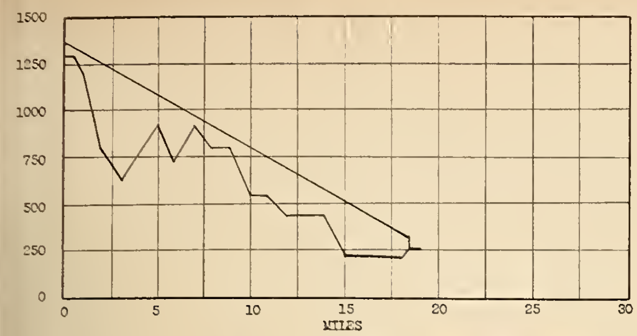


Fig. 11. Ground profile between Grosses Roches and Matane, Que. based on 4/3 earth's radius.

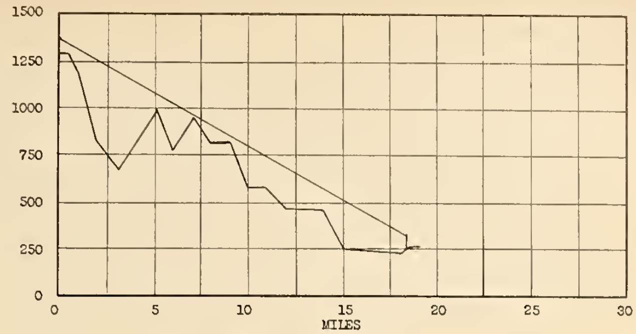


Fig. 12. Ground profile between Grosses Roches and Matane, Que. based on 2/3 earth's radius.

$S/N = S/N$ + Pre-emphasis improvement

$S/N = 91.5 + 2.5 = 94$ db

Multiplex Loading Factor

In a multiplex carrier system each channel must be reduced to prevent overloading or over-deviation of the modulator. The single multiplex channel input level to the transmitter, recommended by the manufacturer for 240 channels, is 18 db below the level producing 100% deviation. With reference to this, the voice channel signal-to-noise ratio must be reduced accordingly.

$S/N_{240\text{ channels}} = S/N - 18$

$S/N_{240\text{ channels}} = 94 - 18 = 76$ db

Noise in Terms of dba, F1A wtg.

As it has been stated above, the absolute value of signal-to-noise falling in a 3 kc voice channel bandwidth is 76 db.

Noise power may be measured on a Noise Measuring Test Set such as the W.E. 2B in terms of dba F1A wtg. With thermal noise uniformly distributed in a 3 kc band, −82 dbm flat wtg. corresponds to 0 dba F1A wtg. Therefore, the noise falling in the voice channel bandwidth is 82 − 76 = 6 dba F1A wtg.

Actual performance figures obtained for the radio system, as shown beween brackets (. . . meas.) in the system calculation are values as measured or based on measured values found in the field.

Measurements of Idle Noise

In practice, the noise contribution of the r.f. and i.f. stages of the receiver, as calculated above, are small compared to the noise produced by the modulator, demodulator, and other equipment with normal or high r.f. input levels. It is practically impossible to calculate the total noise without modulation, usually called idle noise, contributed by these other sources. Measurements of idle noise are therefore required if a complete picture of the equipment characteristics is desired.

Such measurements were taken on the 74A-1 radio system with an HP623B Signal Generator used as r.f. signal source. The results obtained are plotted in Fig. 13. The curves shown are average values of idle noise in dba F1A wtg. versus receiver input level in dbm.

The distant transmitter was then used as a signal source. The average idle noise level measured in the 26 kc slot with a median received signal of −40 dbm was found to be 23 dba. Average idle noise in a 550 kc slot was in the order of 17.5 dba, and finally in a 1200 kc slot, 16.3 dba.

Measurement of Intermodulation Noise

A typical arrangement of the test equipment for measuring the intermodulation noise of a radio system is shown in Fig. 14. The test consist of illuminating the baseband at the transmitting end with white noise between 50 kc and 1100 kc at a level 10 db above test tone input level for 240 channel loading. At the receiving end, the noise falling in a 26 kc and a 1200 kc slot of 3 kc bandwidth are measured.

Average values obtained for the 74A-1 equipment are shown in Fig. 13. The worst intermodulation noise figures obtained in a 24 kc and 1200 kc slots were 27.5 dba and 24 dba respectively.

The methods used for the above measurements are very similar to those described by E. V. Hird and R. A. March of the Lenkurt Co. of Canada Ltd.,[5] in a paper which also gives detailed information on the characteristic and performance of the 74A-1 radio equipment.

The measurements were made directly following a recent equipment modification and complete re-alignment by Lenkurt personnel.

APPENDIX

Diffraction of Radio Waves

The propagation of a radio wave in free space has been explained and it is possible to evaluate the strength of the energy at the receiving point if the distance to the transmitter is known. However, along an actual path the energy can seldom be considered to travel in a free space condition, since there is usually a finite distance between the direct ray and the earth contour between transmitter and receiver. The received energy can be greater or smaller than the free space value depending on the relative height of the diffraction point or obstruction.

The amount of attenuation due to diffraction can be calculated if we apply the diffraction theory of electromagnetic energy propagation as proposed by Christian Huygens, and Fresnel[1,6,12]

Fresnel Zones

Fresnel zones are circular areas surrounding the direct line of sight path between transmitting and receiving antennas at a radius that will make the distance from the perimeter a multiple of one-half wavelength longer than the direct line-of-sight path.

Let us consider then a transmitting path *"TOR"* of Fig. 16. At a distance *"d_1"* from the transmitter, and *"d_2"* from the receiver, an elevation along the path at point *"C"* can be taken as the diffraction point. The antenna heights at both ends can be chosen such that the diffraction point be one Fresnel zone below the direct ray. This means that, according to the above description of the Fresnel zone, the distance *"TCR"* will be one-half wavelength longer than the distance *"TOR"*. The radius of the first Fresnel zone can now be computed by simple geometry as follows.

Let *"H"* be the radius of the first Fresnel zone.

Let *"TC"* be longer by x_1 than d_1, and *"RC"* be longer by x_2 than d_2. Then by definition,

$$x_1 + x_2 = \lambda/2 \qquad (1)$$

By simple geometry

$$H^2 = (d_1 + x_1)^2 - d_1^2,$$

$$= 2d_1x_1 + x_1^2,$$

$$= x_1(2d_1 + x_1),$$

in all practical cases,

$$d_1 \gg x_1, \quad \text{and} \quad H_1^2 = 2d_1x_1 \qquad (2)$$

Similarly $\quad H^2 = 2d_2x_2 \qquad (3)$

Replacing x_1 of equation (2) by its value in equation (1) we obtain

$$H^2 = 2d_1\lambda/2 - 2d_1x_2 \qquad (4)$$

Subtracting equation (3) from equation (4)

$$2d_1\lambda/2 - 2d_1x_2 - 2d_2x_2 = 0$$

$$2x_2(d_1 + d_2) = d_1\lambda$$

$$x_2 = \frac{d_1\lambda}{2(d_1 - d_2)}$$

Substituting x_2 in equation (3)

$$H^2 = \frac{2\lambda d_2 d_1}{2(d_1 + d_2)} \text{ and } H = \sqrt{\frac{\lambda d_1 d_2}{d_1 + d_2}}$$

where H, λ, d_1, and d_2 are in the same units.

Practical forms of this same equation are given as:

$$H = 13.15\sqrt{\frac{\lambda d_1 d_2}{d_1 + d_2}}$$

or

$$H = 2280\sqrt{\frac{d_1 d_2}{f(d_1 + d_2)}}$$

Where H is given in feet,
λ is given in cm.,
f is given in mc,
d_1 and d_2 are given in miles.

Similarly it can be shown that the radius of the second, third, . . . Fresnel zones may be obtained by multiplying the above formulæ by $\sqrt{2}$, $\sqrt{3}$, ...

Effect of Fresnel Zone Diffraction

According to Huygens, every small element of the train of electromagnetic waves originating from the transmitter can be considered as a secondary energy source, sending out wavelets always away from the transmitter. This means that every point along the plane "*COD*" is an energy source radiating towards *R*.

Consider an instant at which the phase "*R*" of the wave "*T*" is zero. The energy from a point "*a*", slightly below "0", we arrive at "*R*" at a very short instant after the direct ray and add vectorially with it. The energy from all the points between "0" and "*C*" will act similarly, until at "*C*", the ray will be π radian, or half a wavelength behind the direct ray. The vectorial sum of all these points from the first Fresnel zone will produce an energy vector lagging the direct ray by $\pi/2$, and the total diffracted energy will be better than the free space value.

If point "*C*" were located such that it be two Fresnel zones below the direct ray, then the points along "*OC*" would radiate towards "*R*" with ever increasing phase difference, until at "*C*", the ray would be 2π radians or one wavelength behind the direct ray. The vectorial sum of all the energy sources along "*OC*" would then produce at "*R*" a total diffraction energy less than the free space value.

This diffraction theory also explains why energy can still be received when the direct line of sight path between "*T*" and "*R*" is completely obstructed.

Reference may be made to Fig. 15 which shows the effect of clearance on radio transmission.

Reflection

When dealing with wave propagation over surfaces such as water, desert or salt flats which can act as mirrors for some of the energy travelling between the transmitter and the receiver, it is usually preferable to consider the possibility that the total energy at the receiver may consist of energy arriving directly from the transmitter and also energy arriving after reflection on the intervening ground surfaces.

It is convenient to express the energy relations of the incident and reflected waves by a ratio called the coefficient of reflection. The coefficient of reflection (R) is defined as the square root of a power ratio, and is found by dividing the reflected energy per second leaving a reflecting surface by the energy per second incident to the same surface. If the two energies are of equal magnitude ($R = 1$), we have perfect reflection. If the reflected energy is smaller than the incident energy, the difference is either dissipated at the reflecting surface, or partially dissipated at the surface and partially passed through the surface as a refracted ray. In fact, when a radio wave encounters any medium whose electromagnetic properties differ from those of the previous medium, reflection and refraction take place simultaneously.

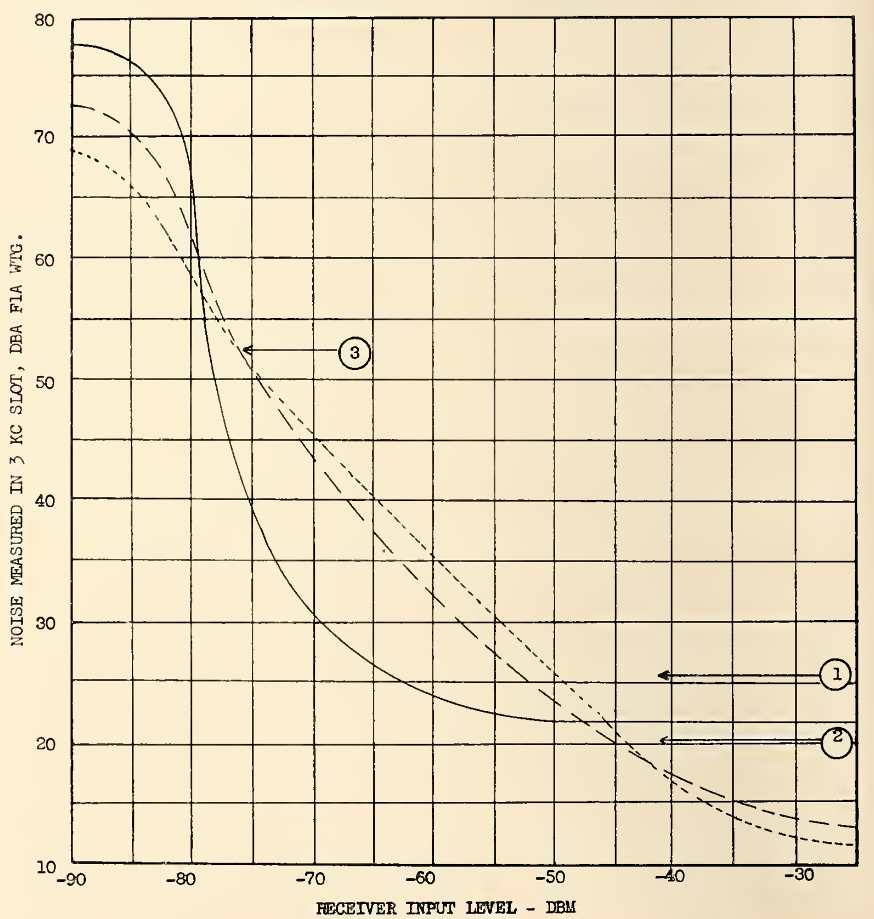
When a radio wave is incident upon the earth's surface it is not actually reflected from a point on the surface, but from a sizeable area. This reflection area may be large enough to include several Fresnel zones, or it may be in the form of a ridge or peak including only a part of the first Fresnel zone. For the case where the wave is incident upon a plane surface, the resulting Fresnel zones formed on the reflecting surface are elliptical zones and are similar to those which would be formed on an oblique

Fig. 13. Noise performance of 74A-1 radio equipment.
(Average Values of 4 Working Systems)

Idle Noise **——— in 26 Kc Slot, — — — in 550 Kc Slot, - - - - - - in 1200 Kc Slot.**

Intermodulation Noise **(1) in 26 Kc Slot (2) in 1200 Kc Slot.**

(3) Threshold Level taken for 52 dba



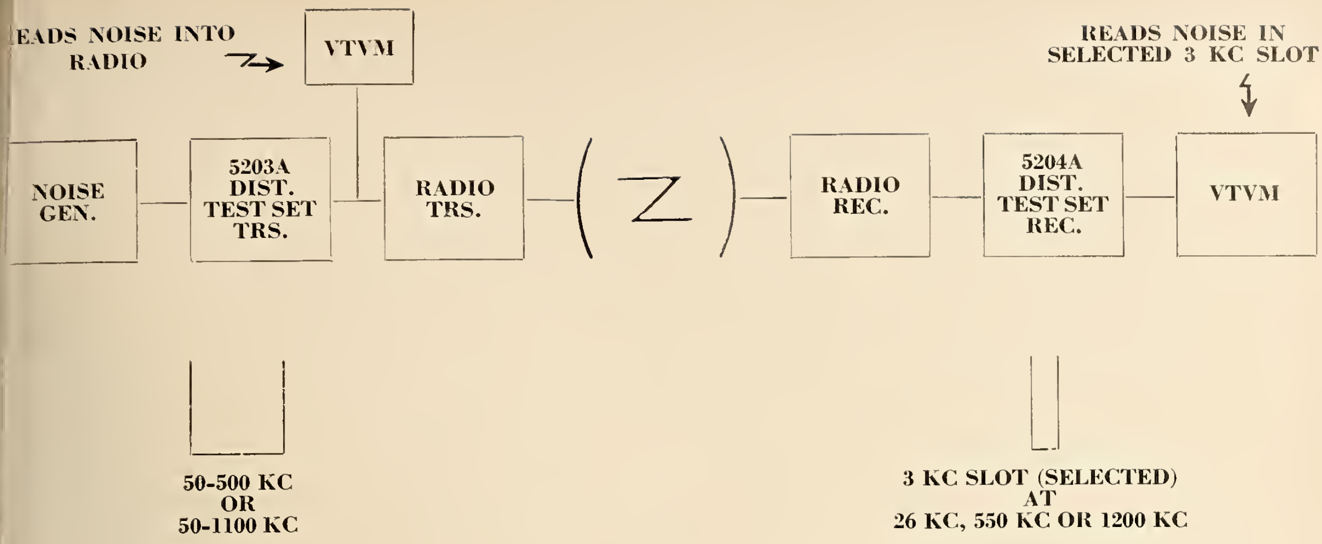


Fig. 14. Arrangement of Test Equipment for Measuring Intermodulation Noise of a Radio System. Idle Noise Measurement made with Terminated Input to Radio Transmitter.

plane placed between a transmitting source and a receiver in free-space. Therefore, the earth-reflected Fresnel zones are simply a projected image of the free-space Fresnel zones at the plane of reflection and may be determined by the same geometry as that used for the free space Fresnel zones.

The significance of the ground reflected Fresnel zones is similar to that mentioned for the free-space zones. However, as radio waves are reflected from the earth's surface, they are generally changed in phase depending upon the wave polarisation and the angle of incidence. For horizontally polarized waves at the frequencies in the UHF, SHF range, such waves reflected from the earth's surface are shifted by about 180°, effectively changing the electrical path length by half a wavelength. On the other hand, for vertically polarized waves, a considerable variation in the phase angle will be found to exist for different angles of the incidence and reflection coefficients, and will vary between 0° and 180° lag depending upon ground conditions.[12] For horizontally polarized waves, therefore (and in some cases for vertically polarized waves) if the area of the reflecting surface is large enough to include the total area of any odd-numbered Fresnel zones, the resulting wave reflection will arrive out of phase at the receiving antenna with the direct wave and cause destructive interference.

In general, reflections occur at a number of points along the radio path and it is necessary to select the antenna height at which the reflected waves will not cause severe interference under varying propagation conditions. Where strong ground reflections are prevalent such as occur over salt flats, over-water or desert paths, one method of minimizing the effect of reflection is to provide clearances such that under normal propagation conditions the received signal level lies in the middle of a broad hump. (See Fig. 15). Another method consists in choosing the transmitter or receiver location such that the unwanted or destructive reflected rays are blocked by intervening hills or other obstacles.[7]

Noise Quantities on Telephone Circuits

The performance of a particular channel of a multiplex system for speech transmission involves many parameters which are in direct relation to the transmission quality.[8]

One of these parameters is the transmission impairment caused by the amplitude frequency characteristic of noise existing on the telephone circuit.

Because the different methods are difficult to interpret, this part of the paper proposes to compare noise quantities and to explain terms currently used.

In general two different types of instruments are used for noise measurements.

(a) The Western Electric 2B Noise Measuring Set,
(b) The 12A Transmission Measuring Set, manufactured by the Daven Company.

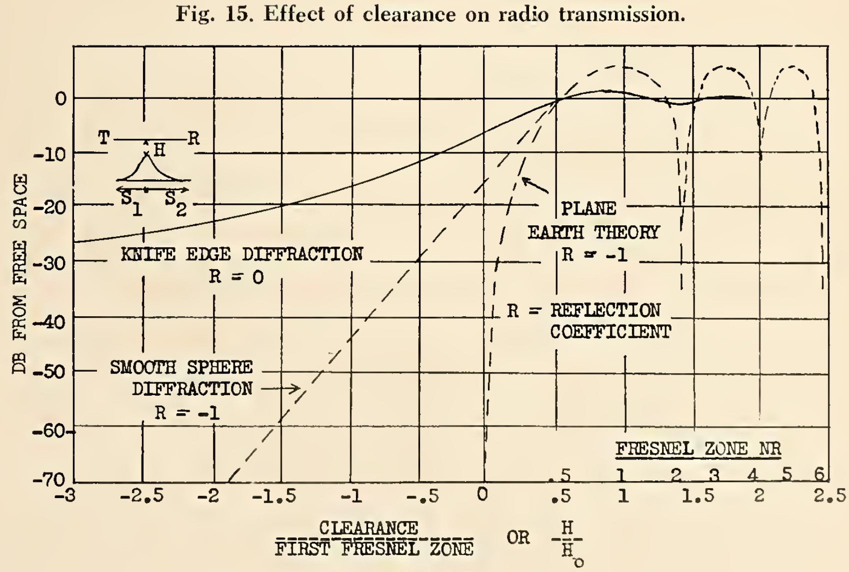
Both are used for noise measurements on voice frequency circuits and have comparable characteristics. However, they are calibrated to entirely different references.

The reference for reading dba (db adjusted) is obtained by making an adjustment to 10^{-12} watt reference, for equal transmission impairment due to the noise for the two different types of telephone sets.

The reference for reading dbRN (db above reference noise) is a 1000 cycle calibrating point at 10^{-12} watt or 90 db below 1 mw.

The terms 144 weighting and F1A

Fig. 15. Effect of clearance on radio transmission.



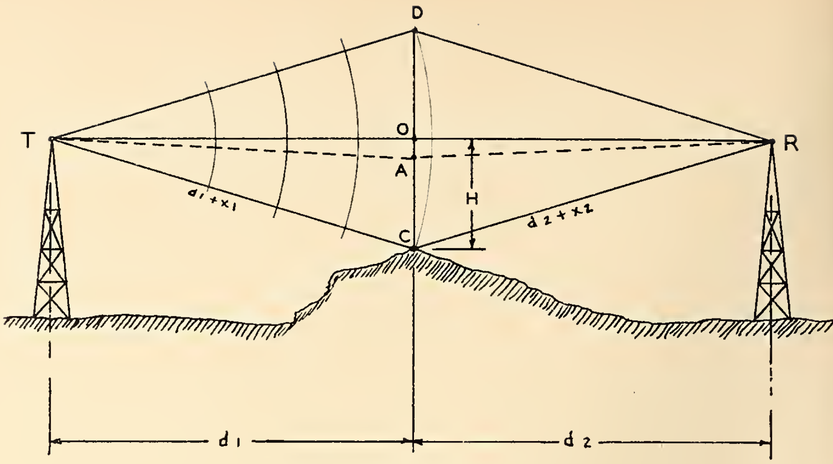
weighting take into account the relative interferring effects of different noise frequencies on a telephone line equipped with a telephone set using either a 144 type or a HA-1 type telephone receiver.

The comparison of the quantities measured with the two types of instruments, where a test power of 1000 cycles per second is applied to the input of each test set, is shown in Table I. The magnitude of the test signal is expressed in dbm, i.e. db with reference to 1 mw.

Table II compares the readings obtained from the two types of measuring sets when thermal type noise, flat over a 3 kc band, is applied to the test sets with different weighting conditions.

With reference to Fig. 17, it is also clear that with noise of types other than a 1000 cycles sine wave or a 3 kc band of thermal noise, the relations between the readings with different weightings would necessarily be different from those shown in Table I or II. In other words, a 500 cycle noise would read about 14 db greater on flat weighting than it would with 144 weighting or about 9 db greater with flat weighting than it would with F1A weighting. This is true whether the measuring set is a 2B set or a 12A.

The signal-to-noise ratio is obtained from two measurements, one of the signal and the other of noise. As a general rule, if the readings of signal and noise differ by more than 10 db, the magnitude of the signal can be considered the true value for practical purposes. However, in cases where these readings differ by less than 10 db, the magnitude of the signal will be considerably masked by noise and will require correction in order to ascertain the magnitude of the signal alone. This correction given in db can be found in Table III.



FIRST FRESNEL ZONE.

Fig. 16.

Demonstration of FM Improvement Factor

Consider a thermal noise component of frequency r.f.$_0$ This may be demodulated in a mixer to produce a frequency i.f. Such a noise component produces no output at the frequency discriminator assuming the discriminator is tuned to i.f. since the output depends upon the deviation from i.f.$_0$ Similarly a thermal noise component of r.f.$_0 + X$ cycles produces an output proportional to i.f.$_0 + X$ cycles and one at r.f.$_0 + Y$ proportional to i.f.$_0 + Y$ cycles. Assuming the discriminator curve is linear, a plot of noise output amplitude versus frequency will show a triangular distribution.

The improvement signal-to-noise ratio of a frequency modulated carrier compared with that of an equal amplitude modulated carrier when modulated by a single frequency is approximately 20 log D. However, where a single channel is transmitted with frequency modulation and the greater portion of the band is occupied, as for example, the transmission of TV signals, the improvement for the band as a whole becomes 5+20 log D. The derivation of the FM noise improvement over AM, i.e. the output signal-to-noise ratio of a FM carrier as compared to that of an AM carrier, assuming that the modulation by a single frequency is of equal amplitude, may be approached as follows. Equal signal outputs at full modulation and perfect limiting are assumed.

f_n = frequency of noise component
OH = modulated baseband
OB = Δf, r.m.s. swing of carrier (only 1/2 of the detector output is shown)
JH = top channel bandwidth
$OHED$ = represents the noise in an AM system
$OHGO$ = represents the noise in the FM system
f_h = (mf) = mean frequency of worst channel on the baseband occupied by multiplex
D = OB/f_h = Δf/mf = deviation ratio.

Consider the whole baseband as one channel as for TV signals for example.

N_{pa} = Noise power in amplitude modulated system
N_{pf} = Noise power in frequency modulated system

$$\frac{N_{pa}}{N_{pf}} = \frac{\text{Area } OHED \text{ (ordinates)}^2}{\text{Area } OGH \text{ (ordinates)}^2}$$

$$= \frac{(OD)^2 OH}{\int_0^H a^2 dfn}$$

$$\frac{a}{f_n} = \frac{AB}{OB} = \frac{KJ}{OB}$$

Solving a in terms of "fn"

$$a^2 = \frac{fn^2 (KJ)^2}{(OB)^2}$$

TABLE II

Thermal Noise in a 3 kc Band

Noise dbm	*2B Test Set* *dba*	*dbRN*	*Signal-to-Noise Ratio db 2B Test Set or TMS* *F1A wtg.*	*144 wtg.*	*Flat wtg.*
0	82	82	3	8	0
−10	72	72	13	18	10
−20	62	62	23	28	20
−30	52	52	33	38	30
−40	42	42	43	48	40
−50	32	32	53	58	50
−60	22	22	63	68	60
−70	12	12	73	78	70
−80	2	2	83	88	80
−90	−8	−8	93	98	90

Note: With thermal type noise uniformly distributed in a 3 kc band applied to the input of the test set, this table shows the relation between corrected values in dba or dbRN measured with a 2B Noise Measuring Set.

$$\frac{N_{pa}}{N_{pf}} = \frac{(OD)^2 OH}{\frac{(KJ)^2}{(OB)^2}\int_0^H fn^2 dfn} = \frac{(OD)^2 OH}{\frac{(KJ)^2}{(OB)^2}\frac{f_h^3}{3}}$$

since

$$f_0 = 0 \qquad (OD) = (KJ) \qquad (OH) = (f_h)$$

$$\frac{N_{pa}}{N_{pf}} = \frac{3(KJ)^2(OB)^2 OH}{(KJ)^2(OH)^2} = \frac{3(OB)^2}{(OH)^2}$$

but OB = maximum swing of carrier
f_h = maximum frequency of channel $f_h = (OH)$

and

$$\frac{(OB)^2}{(f_h)^2} = (\text{deviation ratio})^2$$

or

$$D^2 = \frac{(\Delta f)^2}{(\mathrm{mf})^2}$$

$$\frac{N_{pa}}{N_{pf}} = \frac{3(OB)^2}{(f_h)^2} = 3D^2$$

If N_a = amplitude modulated noise voltage

N_f = frequency modulation noise voltage

$$\frac{N_a}{N_f}\sqrt{\frac{N_{pa}}{N_{pf}}} = \sqrt{3}\frac{(OB)}{(f_h)} = \sqrt{3}D$$

Assuming that the signal level input for AM "S_a" equals the signal input for FM "S_f", i.e. $S_a = S_f$, then

$$\frac{S_a/N_a}{S_f/N_f} = \frac{1/\sqrt{3}D}{1/1} = 1/\sqrt{3}D$$

and in terms of logs $= 20 \log 1/\sqrt{3D}$

$20 \log 1/\sqrt{3}D = -4.7 - 20 \log D$ (db),

i.e. very nearly $-5 - 20 \log D$ (db)

$$\frac{S_f/N_f}{S_a/N_a} = 5 + 20 \log D$$

TABLE III

Signal in the Presents of Noise

Difference in db between combined signal and noise, and noise measured alone	*Correction in db to be applied to the combined signal and noise reading to obtain signal alone*
0	
1	−6.9
2	−4.3
3	−3.0
4	−2.2
5	−1.7
6	−1.3
7	−1.0
8	−0.8
9	−0.6

Note: Correction for signal level measurements in the presents of noise.

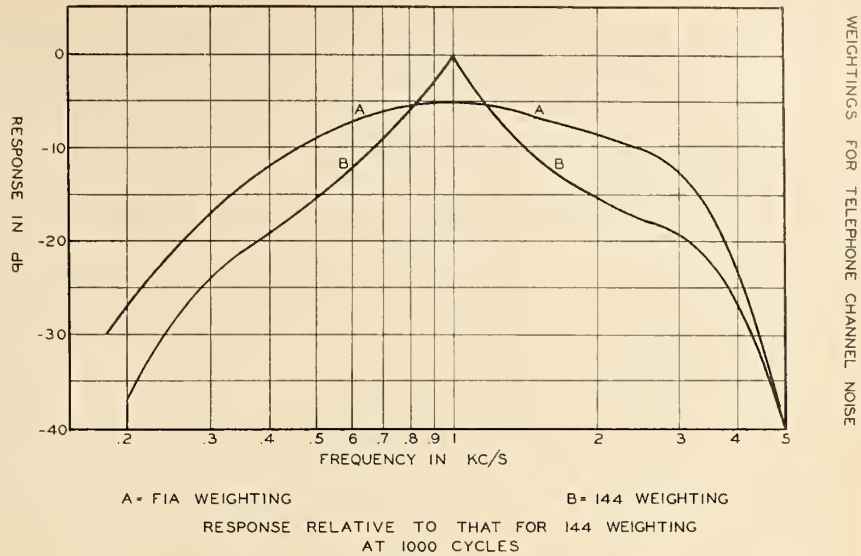


Fig. 17. Weightings for telephone channel noise.

FM noise improvement over

$$\text{AM} = 5 + 20 \log D$$

If multichannel transmission is used, we would be interested in the FM noise improvement over AM in the worst channel (top channel) of the base band. Assume that the baseband of both the AM and FM systems is represented by "OH". Then the AM noise power "N_{pa}" is again $(OD)^2 f_h$ while the FM noise power "N_{pf}" is again $\int_0^H a^2 dfn$.

Consider the noise in the top channel which is shown as "JH", i.e. $f_h - f_j$

$$\frac{N_{pa}}{N_{pf}} = \frac{\text{Noise in the top channel of AM}}{\text{Noise in the top channel of FM}}$$

$$= \frac{\text{Area } KJHE \text{ (ordinates)}^2}{\text{Area } LGHJ \text{ (ordinates)}^2}$$

$$= \frac{(KJ)^2(f_h - f_j)}{\int_0^H a^2 dfn}$$

$$\frac{N_{pa}}{N_{pf}} = \frac{(KJ)^2(f_h - f_j)}{\frac{(KJ)^2}{(OB)^2}\int_j^H f_n^2 dfn}$$

$$= \frac{(KJ)^2(f_h - f_j)}{\frac{(KJ)^2}{(OB)^2}\left(\frac{f_h^3 - f_j^3}{3}\right)}$$

$$= \frac{(KJ)^2(f_h - f_j)}{\frac{(KJ)^2(f_h^3 - f_j^3)}{3(OB)}}$$

$$= \frac{3(OB)^2(KJ)^2(f_h - f_j)}{(KJ)^2(f_h - f_j)(f_h^2 + f_h f_j + f_j)}$$

Performing the cancellation and noting that f_h is very nearly f_j, we have

$$\frac{3(OB)^2}{(f_h^2 f_h f_j f_j^2)} = \frac{3(OB)^2}{3(f_h)^2} = D^2$$

or in decibels $= 20 \log D$. FM noise power improvement over AM on top channel $20 \log D$ or $20 \log \Delta f/\mathrm{mf}$.

Acknowledgement

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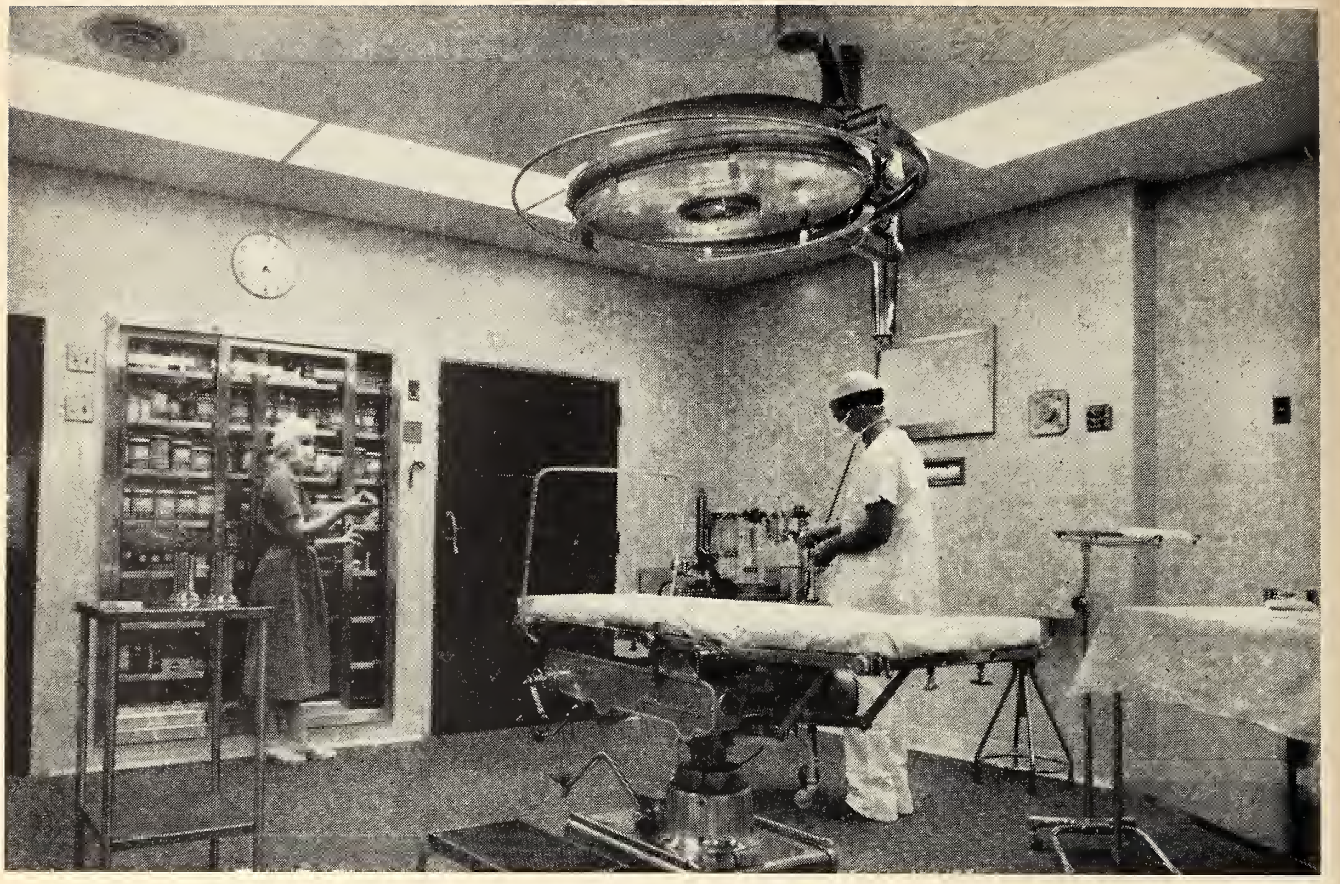


Problèmes de Bactériologie dans la Ventilation des Salles d'Opération

V. Fredette, B.PH., D.SC., FCIC, FAAAS, *Directeur-adjoint de l'Institut de Microbiologie et d'Hygiène de l'Université de Montréal, Professeur agrégé de Bactériologie à la Faculté de Médecine.*

Conférence prononcée devant "The Engineering Institute of Canada", chapitre de Montréal, le 10 février 1960

The high cost of modern construction has resulted in smaller operating-rooms which require pulsed air for their ventilation. If no adequate filter is used in the ventilating plant, bacteria from the outside air may accumulate inside the operating-room and may constitute a source of potential danger. Reports from abroad have repeatedly described fatal accidents of this nature.

A simple technique is described for the bacteriological examination of sterile rooms and ventilating plants. It consists in looking for the perfringens bacillus. Such a technique may be used to control the installation and operation of similar devices.

From the knowledge obtained from the literature as well as through the personal examination of some twenty rooms (filling, operating, etc.) in six local institutions, requirements for the design and operation of ventilating plants in hospitals and drug manufacturers are fully described. Standards are still lacking, however, and only additional research can supply the necessary information.

LE COUT ELEVE de la construction moderne et l'impérieuse nécessité d'enfouir les salles d'opération dans le sol afin de parer aux accidents de la guerre atomique, biologique et chimique, contraignent les hôpitaux à restreindre les dimensions de ces pièces, d'ailleurs de plus en plus nombreuses, avec le résultat que la ventilation de celles-ci à l'aile d'air pulsé crée des problèmes nouveaux auxquels les chirurgiens et les ingénieurs font face depuis quelques années déjà.

En effet, lorsque les systèmes de ventilation ne comportent pas de filtres susceptibles d'arrêter de manière efficace et continue les bactéries de l'air extérieur, on risque des accidents spectaculaires comme les épidémies de tétanos post-opératoire rapportées en Angleterre depuis 1946, ou encore les cas de gangrène gazeuse comme celui rapporté en 1955 par un hôpital montréalais.

Ces redoutables agents microbiens, bacille tétanique et bacille perfringens, sont des hôtes normaux de l'intestin de l'homme et des animaux; on les retrouve nécessairement dans les matières fécales et le fumier, et partant, dans le sol enrichi avec ces excréments. De ce dernier habitat, ils passent facilement dans l'air avec l'aide du vent, surtout quand le sol est découvert.

Tant que ces hôtes microscopiques demeurent dans leur habitat naturel, ils se comportent comme de véritables bactéries saprophytes, i.e. qu'ils sont inoffensifs. Parviennent-ils à se retrouver *en nombre suffisant* dans une trouver plaie traumatique, surtout au niveau des grandes masses musculaires pour ce qui est de l'agent de la gangrène gazeuse, aussitôt ils deviennent les grands seigneurs de la pathologie infectieuse en déclenchant des processus graves dont la mortalité excède 50% dan la plupart des cas, même en présence de l'arsenal thérapeutique le plus approprié. Il devient évident qu'il importe avant tout *d'éviter* ces accidents.

Examinons donc à la lueur des acquisitions les plus récentes la situation actuelle et les moyens d'y remédier s'il y a lieu.

Technique d'analyse bacteriologique

Plusieurs techniques bactériologiques peuvent être utilisées pour rechercher la présence de germes dangereux dans les salles l'opération. Celle qui a été utilisée pour le présent travail est à fois simple et rapide: elle consiste en la recherche et caractérisation du seul bacille perfringens, l'agent le plus fréquent et le plus meurtrier dans la gangrène gaseuse chez l'homme.

Pour ce faire, des échantillons de poussière sont prélevés à l'aide d'écouvillons que l'on introduit aussitôt dans des tubes de bouillon à la viande cuite, fraîchement régénéré; ces tubes sont portés le plus rapidement possible à l'étuve réglée à 37°C. Si les bacilles perfringens sont présents, ils se multiplient si rapidement que déjà, au bout de 12 heures, ils forment un trouble homogène abondant agité par des bulles de gaz à odeur acide. Examinées au microscope, ces cultures montrent de gros bâtonnets trapus et immobiles, mesurant environ 1 micron de largeur par 2-3 microns de longeur (photos 1 et 2); transférées dans des tubes de lait scellés ensuite sous vide, ces cultures provoquent une coagulation alvéolaire en 8 heures. Mais c'est l'injection de ces mêmes cultures au cobaye qui demeure le test crucial pour l'identification certaine de ce germe: déjà en 4-6 heures après l'injection dans le muscle de la cuisse, un oedème volumineux occupe celle-ci et progresse rapidement pour envahir l'abdomen en 12 heures; l'animal meurt, enfin, en moins de 24 heures avec une grande destruction des tissus musculaires (photos 3 et 4).

Resultats

Ce jeu de détective bactériologique, pratiqué comme il vient d'être indiqué, fut répété dans une vingtaine de salles d'opération ou de remplissage dans 6 institutions locales differentes, avec le résultat net que le système de ventilation fut mis directement en cause dans tous les cas où le bacille perfringens fut retrouvé. Il faut signaler ici que plusieurs institutions, hôpitaux et autres, ont effectué des changements radicaux depuis cette époque.

Les résultats obtenus sont consignés dans la série de tableaux ci-joints.

A l'hôpital No 1, on peut voir qu'à la surprise générale, le bacille perfringens a été retrouvé pratiquement partout, même sur la lampe que l'on bascule au-dessus des plaies pendant les opérations. Bien qu'il ait été présent dans la bouche d'arrivée d'air et sur la grille de la bouche d'évacuation, le bacille perfringens n'a pas été retrouvé dans les interstices des fenêtres ni sur les murs. Dès lors, le système de ventilation devint l'objet de tous les soupçons.

Dans l'hôpital No 2, on note la présence du bacille perfringens régulièrement dans la bouche d'évacuation, plus rarement dans la bouche d'arrivée et sur le scialytique; ici, rien sur le plancher. Le système de ventilation semble donc encore en cause.

Au troisième hôpital, 6 salles ont été examinées dont 4 après nettoyage habituel, une sans nettoyage, et la dernière pendant une opération pour appendicite. On y voit que le bacille perfringens a été retrouvé dans 4 bouches d'évacuation puisqu'il a tué le cobaye en 22 heures; on le trouve aussi quelquefois dans la bouche d'arrivée, et une fois seulement sur le plancher. Ici encore, tout semble indiquer le système de ventilation.

L'hôpital No 4, enfin, a fourni deux fois sur trois du bacille perfringens dans la bouche d'évacuation; le plancher et le scialytique sont indemnes dans cet hôpital.

En conclusion de cette étude rapide, il semblait bien que le système de ventilation fût toujours en cause. Aussi, était-il urgent de vérifier si les installations étaient adéquates.

A l'aide de la même technique, toujours, des prélèvements aux endroits indiqués sur le schéma ci-joint permirent de poursuivre le bacille perfringens depuis la prise d'air à l'extérieur jusqu'à la salle d'opération, en passant à travers les divers grillages et filtres, y compris les jets d'eau. Le tableau suivant résume l'ensemble des trouvailles pour les 4 hôpitaux déjà mentionnés.

Fig. 1. Spores de B. *perfringens*. Souche Lech.; culture de 3 jours sur sérum de cheval coagulé.—D'après Weinberg et Séguin.

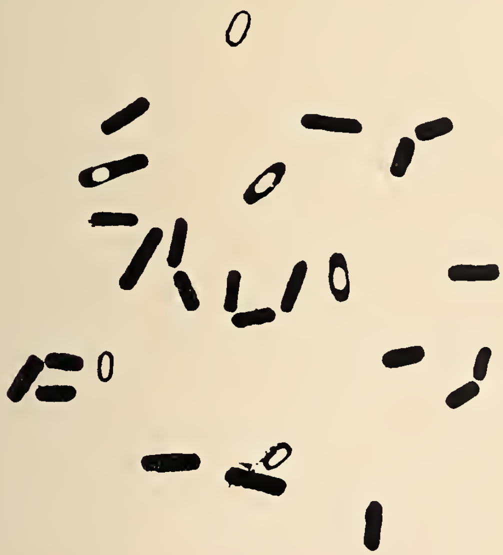


Fig. 2. Un echantillon de B. *perfringens* où dominent les formes incurvées. Souche *Lech.*; bouillon glucosé à 2 p. 1000; culture de 24 heures (grossissement: Obj. Zeiss 1/12. Oc. 4).—D'après Weinberg et Séguin.

HOSPITAL No. 1

Operating-Room	
AIR INLET	B. perfringens
TOP OUTLET	B. perfringens
BOTTOM OUTLET	B. perfringens
LAMP	B. perfringens, Streptococcus spp.
WALL	Gram + cocci
Recovery-Room	
WINDOW	No growth
FLOOR	B. perfringens, Gram-rods, large Gram + cocci
Pleural Puncture Needles	
NEEDLE No. 1	No growth
NEEDLE No. 2	No growth

HOSPITAL No. 2

Operating-Room No. 1	
AIR INLET	B. subtilis
AIR OUTLET	B. subtilis, B. perfringens, Staph. albus, Staph. aureus, Ps. aeruginosa
LAMP	No growth
FLOOR	No growth
Operating-Room No. 5	
AIR INLET	B. perfringens
AIR OUTLET	B. perfringens
LAMP	B. perfringens, B. subtilis
FLOOR	No growth
HUMIDIFIER	B. perfringens, B. subtilis
WINDOW	B. subtilis
Delivery-Room	
AIR INLET	B. subtilis, Ps. aeruginosa Staph. albus, Staph. aureus
AIR OUTLET	B. perfringens
LAMP	B. subtilis, Staph. albus
FLOOR	No growth
WINDOW	B. perfringes

On note d'abord qu'à l'hôpital No 1 le bacille perfringens a été retrouvé des deux côtés des deux filtres constitués, en l'occurrence, de laine d'acier imbibée d'huile.

A l'hôpital No 2, qui ne possédait pas de filtre central à l'époque, uniquement des filtres individuels à l'entrée de chaque salle, le bacille perfringens a également été retrouvé tout le long des canalisations.

Quant à l'hôpital No 3, il possède un filtre rotatif, à l'huile également; les résultats exposés ici montrent que ce type de filtre n'est guère plus satisfaisant que les autres.

L'hôpital No 4, enfin, voit ses filtres changés tous les 15 jours par le fabricant, ce qui devrait assurer, semble-t-il, le meilleur rendement; or, ici encore, le bacille perfringens a été retrouvé partout dans la canalisation.

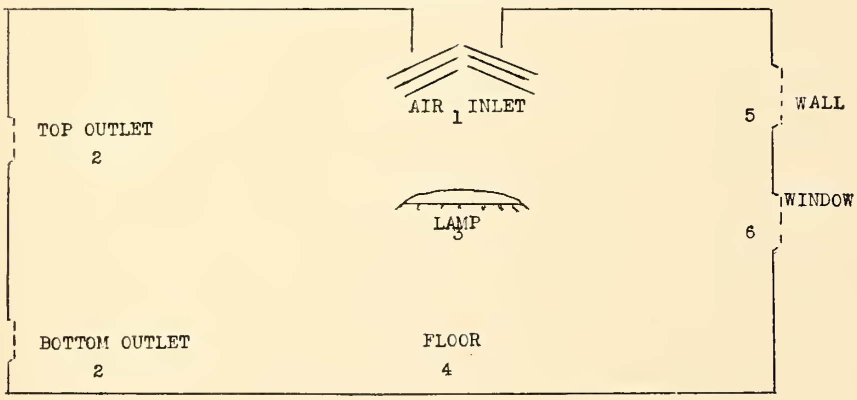
En somme, aucun de ces 4 hôpitaux ne possédait alors un filtre convenable pour ces germes.

D'un autre côté comme ce problème de la stérilisation de l'air est primordial également chez les fabricants de médicaments injectables, il a semblé intéressant de comparer leurs installations à celles des hôpitaux déjà examinés. A cette époque, une seule fabrique possédait un type de filtre différent de ceux rencontrés dans les hôpitaux. Il s'agit d'un filtre électrostatique, doublé d'un filtre en laine de verre; il semble qu'il donne la plus entière satisfaction puisque, des 8 pièces alimentées par cette installation, une seule a fourni le bacille perfringens dans de la poussière accumulée derrière un meuble avant l'installation du filtre; partout ailleurs dans ces pièces, planchers, crevasses dans les fenêtres et cloisons, dessus de tables, on n'a pas pu trouver de germes, pas même le bacille subtil, alors qu'à la surface extérieure de la prise d'air, située d'ailleurs face à une écurie, 4 espèces différentes d'anaérobies sporulées ont été isolées. Or, ce filtre n'avait pas été nettoyé depuis un mois.

En résumé, on voit donc qu'une technique relativement simple peut fournir rapidement des renseignements précieux concernant le fonctionnement des systèmes de ventilation dans les salles d'opération et les salles stériles ou de remplissage. Cette technique a le seul inconvénient de coûter cher en animaux de laboratoire.

Bien entendu, plusieurs autres techniques ont été proposées pour faire cette étude bactériologique de de l'air; le seul ennui à l'heure actuelle réside dans le fait que les bactériologistes eux-mêmes ne sont pas d'accord sur la valeur de celles-ci Ce qui revient à dire que des standards bactériologiques restent encore à être formulés pour la direction des ingénieurs et des chirurgiens. Il semble justement que la situation, parce, qu'elle est récente, ressemble énormément à celle de l'analyse bactériologique de l'eau au début du siècle; des études nombreuses dans divers pays du monde ont permis eventuellement d'établir une technique officielle et des standards qui règlent efficacement la question de l'eau d'alimentation. Il devrait en être de même pour la bactériologie de l'air. Aussi, est-il opportun d'examiner, à la lueur du bacille perfringens, toujours, ce qui peut être réalisé à l'heure actuelle en fait d'installation susceptible de donner une certaine tranquillité d'esprit à tous ceux que la question concerne.

Fig. 3. Sampling areas of Operating Rooms.



HOSPITAL No. 3

Operating-Room No. 12 ("clean")

AIR INLET	No growth
AIR OUTLET	Slight growth, no gas; few plump Gram + rods; *stormy fermentation of milk;* guinea-pig survived.
LAMP	No growth
FLOOR	No growth

Operating-Room No. 15 ("clean")

AIR INLET	Cloudiness, gas; numerous Gram + rods; *stormy fermentation of milk;* guinea-pig survived.
AIR OUTLET	Cloudiness, gas; numerous Gram + rods; *guinea-pig died in 20 h.* from generalized gas gangrene.
LAMP	Slight growth, no gas; few Gram + rods; acid coagulation of milk, no gas; guinea-pig survived.
FLOOR	No growth
WALL	Cloudiness, no gas
FIXTURE	No growth

Operating-Room No. 2 ("clean")

AIR INLET	Cloudiness, no gas; large Gram + rods; acid coagulation of milk; guinea-pig survived.
AIR OUTLET	Cloudiness, no gas; large Gram + rods; stormy fermentation of milk; *guinea-pig died in 20 h.* from generalized gas gangrene.
LAMP	Slight growth; numerous Gram + Cocci and few Gram + rods; peptonization of milk; guinea-pig survived.
FLOOR	No growth

Operating-Room No. 4 ("clean")

AIR INLET	Slight cloudiness, no gas; no visible bacteria.
AIR OUTLET	Cloudiness, gas; few Gram + rods; stormy fermentation of milk; *guinea-pig died in 20 h.* from generalized gas gangrene.
LAMP	No growth
FLOOR	Cloudiness, no gas; large Gram + rods; stormy fermentation of milk; *guinea-pig died in 20 h.* from generalized gas gangrene.

Operating-Room No. 9 ("dirty")

AIR INLET	Cloudiness, no gas; no visible bacteria.
AIR OUTLET	Cloudiness, gas; large Gram + rods; no milk done; *guinea-pig died in 20 h.* from generalized gas gangrene.
LAMP	No growth
FLOOR	No growth

Operating-Room No. 11 ("working")

AIR INLET	No growth
AIR OUTLET	Slight cloudiness, gas; few Gram + rods;
LAMP	Not done for obvious reasons.
FLOOR	No growth

HOSPITAL No. 4

Operating-Room No. 1

AIR INLET	No growth
AIR OUTLET	Cloudiness, no gas; large Gram + cocci and rods, some chains; acid coagulation of milk; guinea-pig survived.
LAMP	No growth
FLOOR	No growth

Operating-Room No. 4

AIR INLET	Cloudiness, gas; large Gram + rods; Peptonization of milk; guinea-pig survived.
AIR OUTLET	Cloudiness, gas; large Gram + rods; stormy fermentation of milk; guinea-pig died from generalized gas gangrene.
LAMP	Slight cloudiness
FLOOR	Slight cloudiness

Operating-Room No. 11

AIR INLET	No growth
AIR OUTLET	Cloudiness, gas; numerous Gram + cocci, few Gram + rods; stormy fermentation of milk; guinea-pig died from generalized gas gangrenc.
LAMP	Slight cloudiness
FLOOR	Slight cloudiness

Recommendations

Prise d'air au-dessus du sol: Bien que l'on sache depuis le début du siècle que le bacille perfringens habite normalement le sol, des installations que se prétendent modernes placent encore leur prise d'air au niveau de celui-ci; c'est risquer énormément et inutilement. En effet, pour la simple raison que l'on trouve de 3 à 10 fois moins de bacille perfringens dans l'air que dans le sol, tous les bactériologistes sont d'accord pour recommander que la prise d'air soit placée au-dessus du troit de l'hôpital ou de l'édifice concerné. Encore faut-il tenir compte le facteurs locaux comme la densité du traffic automobile dans la région, la prédominance des vents, etc.

Filtration bactériologique: Malgré les précautions recommandées ci-dessus, on trouve encore le bacille perfringens comme principal pathogène humain dans l'air extérieur, même au niveau du 11ième étage. Il est alors évident qu'un filtre bactériologique efficace doit être placé dans la canalisation pour empêcher ce bacille d'aller se concentrer soit sur le scialytique, soit sur les grilles des bouches de sortie. D'autre part, comme le bacille perfringens est une grosse bactérie, bien d'autres germes dangereux passeront également si on le laisse filtrer.

Plusieurs types de filtres satisfaisants se trouvent aujourd'hui dans le commerce: filtres électrostatiques, filtres en fibres de verre ou de cellulose, etc. Toutefois, seule une analyse bactériologique permet d'en déterminer l'efficacité sur place.

Souvent on soulève ici la question le l'emploi des rayons ultra-violets pour la stérilisation de l'air. Or, un comité spécial de l'American Medical Association a conclu, il y a plus de dix ans que: "they are not satisfactory for moving air". Par exemple, dans une école de l'état de New York, on a rapporté avoir obtenu une diminution de seulement 42% des bactéries en suspension lans l'air. Disons donc tout de suite qu'ils ne sont pas pratiques. En effet, pour stériliser 5,000 mètres cubes d'air à l'heure, il faut 22 lampes germicides de 25 watts chacune que l'on doit nettoyer régulièrement à l'alcool, et, enfin, remplacer dès que leur énergie atteint 60% de la puissance initiale.

Arrivée d'air filtre au niveau du plafond: Afin d'éviter de soulever les bactéries apportées par les pieds et les vêtements du personnel, on conseille de faire arriver l'air filtré à hauteur du plafond et de diriger le courant vers le bas. Cette disposition a pour but d'empêcher la formation de tourbillons et la création d'un point mort au-dessus de la table d'opération.

Pression positive dans la salle d'opération: Depuis le début du siècle, les ingénieurs anglais ont prôné le "plenum" system, i.e., l'air pulsé, pour la ventilation des salles d'opération. Or on voit encore de véritables égoûts aériens créés par les systèmes qui consistent à aspirer l'air des corridors environnants vers la salle l'opération; inutile de dire qu'il n'y a rien d'autre à faire qu'à supprimer radicalement de telles installations.

L'emploi d'air pulsé devient obligatoire avec les dimensions réduites des salles modernes. Or, la création d'une pression positive à l'intérieur de ces pièces entraîne automatiquement l'obligation de prévoir des écluses pneumatiques pour l'introduction du patient et du personnel ainsi que du matériel sans risquer la perte de cette pression positive qui constitue en quelque sorte un rempart contre les bactéries qui guettent aux interstices des portes et des ouvertures.

Sorties munies de soupapes pneumatiques: Comme nous l'avons vu, les bactéries introduites par le système de ventilation ont tendance à s'accumuler sur les grilles des bouches l'évacuation. Non seulement celles-ci doivent-elles disparaître, on doit les remplacer par des soupapes pneumatiques qui empêcheront les retours offensifs d'air extérieur quand le système est en arrêt soit pour nettoyage, soit en panne. De même l'ouverture d'une porte ne peut provoquer la chute de la pression positive si les bouches d'évacuation sont ainsi décorées.

Vingt changements d'air par heure: Ce minimum est nécessaire non seulement pour l'élimination des vapeurs explosives, et au contrôle de l'humidité et de la température, mais aussi à la dilution des bactéries apportées par les humains dans la salle d'opération. Des études classiques en Angleterre ont démontré que ces nombres microbiens augmentent avec l'activité déployée dans la salle, en particulier au début et à la fin de l'opération.

Evacuation à l'extérieur de l'air usé: Bien que la question de chauffage soit onéreuse, il n'est pas recommandé à l'heure actuelle de re-circuler une partie le l'air usé. En outre, à cause de sa teneur élevée en germes, cet air usé doit être éliminé aussi loin que possible de la prise d'air, et non côte à côte dans une même canalisation séparée par une cloison médiane, comme je l'ai vu dans une installation locale.

BACTERIOLOGICAL EFFICIENCY OF VENTILATING SYSTEMS

Hospital No. 1	
OUTSIDE SURFACE OF 1st FILTER	B. perfringens
INSIDE SURFACE OF 1st FILTER	B. perfringens
INSIDE OF DUCT	B. perfringens
OUTSIDE SURFACE OF 2nd FILTER	B. perfringens
WATER SPRAY	No growth
Hospital No. 2	
AIR INTAKE ON ROOF	B. perfringens, B. subtilis, Ps. aeruginosa, large Gram + cocci
SCREEN IN DUCT	B. perfringens, B. subtilis, Ps. aeruginosa, large Gram + cocci
Hospital No. 3	
AIR INTAKE	B. subtilis, B. perfingens
OIL FILTER	B. perfringens
WATER SPRAY	B. subtilis, B. perfingens
Hospital No. 4	
AIR INTAKE	B. perfringens
OUTSIDE SURFACE OF OIL FILTER	B. perfringens
INSIDE SURFACE OF OIL FILTER	Bacillus spp.
WATER SPRAY	B. perfringens

Nonobstant toutes ces recommandations, la seule façon d'être absolument certain qu'une installation est adéquate, c'est d'en faire l'épreuve sur place à l'aide de l'une ou le l'autre des nombreuses méthodes actuellement proposées dans la littérature mondiale. Tout comme le pharmacien grossiste ne livre pas une bouteille de médicament injectable sans y pratiquer une épreuve dite de stérilité, ainsi que l'exige la Loi des Aliments et des Drogues du Canada, l'ingénieur ne doit pas livrer et le chirurgien ne doit pas accepter un système de ventilation sans quelques épreuves bactériologiques qui donnent entière satisfaction quant à l'installation et au fonctionnement. D'autre part, seul le bactériologiste peut, à l'aide d'épreuves pratiquées à des intervalles réguliers, dicter le moment de nettoyer ou de remplacer les filtres proprement dits.

Un autre problème bactériologique qui semble loin d'être résolu bientôt, c'est la stérilisation des canalisations de faible diamètre maintenant possible de nos jours à cause des grandes vélocités utilisées. En effet, pendant les travaux de construction, les poussières et les germes s'accumulent dant ces tuyauteries, et, seule, une désinfection bien conduite peut mettre un système en état de fonctionner convenablement. Il n'est plus possible de faire nettoyer manuellement par des nains ou autrement ces tuyaux de faible diamètre; ou ne peut plus se contenter, non plus, de faire fonctionner le système pendant un temps plus ou moins bien défini dans l'espoir qu'il se nettoiera spontanément: les cannelures des tuyauteries modernes s'y opposent. Il faut donc désinfecter, et, ici encore, seule une analyse bactériologique peut déterminer si celle-ci a été efficace.

Standards

La question des standards bactériologiques pour les salles d'opération commence à s'agiter, comme je le signalais au début de cet entretien. Elle est à l'étude à l'heure actuelle et nous pouvons espérer que bientôt les ingénieurs et les chirurgiens auront des spécifications précises comme guide.

Les rares tentatives publiées jusqu'ici sont basées sur l'évaluation totale de la population bactérienne au sein d'une enceinte; aussi n'est-on pas surpris de voir des recommandations qui varient du simple au décuple (transparent). Il faudra probablement en arriver au choix d'un indicateur de pollution tout comme il en existe actuellement pour l'eau et le lait. La recherche du bacille perfringens peut servir ces fins, ainsi que l'expérience rapportée ici en fait foi.

De toute façon, on peut quand même énoncer déjà le principe suivant en guise de standard: "Il faut que la teneur en germes de l'air intérieur soit inférieure à celle de l'air extérieur". Autrement, mieux vaudrait en revenir à l'ancienne pratique de construire de grandes salles au dernier étage et d'y ouvrir de larges fenêtres pour diluer l'air intérieur avec l'air extrérieur.

Conclusion

En guise de conclusion, laissons la parole au Dr. Lowbury du Birmingham Accident Hospital en Angleterre qui écrivait: "More collaboration of surgeons, bacteriologists, architects, engineers and administrators would help to overcome these troubles, and there is also plenty of research to be done." EIC

W. M. Berry, M.E.I.C.,
Chief, Design Division

E. F. Durrant,
Chief, Hydrology Division

C. Booy,
S. S. R. P. Design Engineer
Prairie Farm Rehabilitation Administration

HYDROLOGIC INVESTIGATIONS for the South Saskatchewan River Project

Presented at the 74th EIC Annual General Meeting, Winnipeg, May 1960.

THE SOUTH Saskatchewan River Projeet is a large multi-purpose water conservation project, providing for the use of the available water resources through river control, power supply, urban water supply, recreation and irrigation developments.

The projeet requires the creation of a reservoir 140 miles long having a flooded area of about 180 square miles. The reservoir will impound 8 million aere-feet of water. The main dam, situated 20 miles south of the town of Outlook, Sask., will be a rolled earth fill about 205 ft. high with a length of about 17,000 ft. involving the movement of about 50 million cu. yd. of material. A secondary dam is required in the Qu'Appelle River Valley which will be about 100 ft. high.

The project,[1] when completed, will irrigate approximately 500,000 acres in an area which has experieneed severe losses from drought conditions and it will stabilize agriculture in an area several times as large. It will make possible the construction of a large hydro eleetric power development in an area where hydro electric power possibilities are otherwise limited. It will provide unlimited water supply for urban centers in southern Saskatchewan which have no other visible source of supply. It will provide flood control along a 400-mile reaeh of the South Saskatchewan River and it will create valuable reereational facilities within reasonable access for a large portion of the population of Saskatchewan.

Description of the Drainage Basin

The South Saskatchewan River rises in Alberta and Montana, flows into the Province of Saskatchewan, merges with the North Saskatchewan River and proceeds as the Saskatchewan River into Lake Winnipeg in Manitoba. From there its waters reach the Hudson Bay through the Nelson River system. The drainage area above the dam site can be divided into three distinct parts which contribute to the flow characteristics of the river. The first part consists of the eastern slopes of the Rocky Mountains. Although this portion comprises only a small percentage of the total drainage basin of 48,800 sq. miles, it contributes a relatively large volume of runoff during the summer when the snow melts. The second part consists of the foothills east of the mountains. This part is a major contributor to the runoff: from snow melt in the spring and also from rainfall in the spring and summer. Together, the eastern slopes and the foothills produce approximately 92% of the average annual flow at the damsite. The third and the largest part consists of the relatively arid prairies, roughly east of a line through Calgary and Lethbridge. East from this line the average precipitation decreases considerably and in addition, there is generally a large moisture deficiency. As drainage in this large area is poorly developed the average runoff is usually low.

As a result of these conditions, the annual runoff usually follows a distinct pattern. From a relatively low winter flow, the river rises in the early spring due to snow melt in the Prairies and the foothills and reaches a spring peak usually sometime in April. After this peak has passed the river drops, and starts to rise again in May and June when the snow runoff from the mountains comes down. After the summer flood has subsided the river normally drops to relatively low flows in August and September until it reaches a fairly constant base flow which is maintained during the winter. Superimposed on this basic pattern are flood peaks eaused by heavy rainfalls in the foothills and mountains.

The variation in volume and peak flow from year to year is considerable. The primary factor that determines the total amount of runoff is usually the amount of snow available in the mountains. The rate of summer runoff, however, is affected by the rate at which the temperature rises in the mountains, and the timing and intensity of June-July rainstorms. The spring runoff from the foothills and the Prairies also shows large fluctuations due to the variations in extent of snow cover, rise in temperature, moisture conditions of soil, and coinciding rainfall. The summer peak is usually the larger of the two. Extreme floods on the river occur when a rapid melt in the mountains coincides with the occurrence of major rainstorms in the foothills.

Floods

After reviewing the factors related to the safety of the dam, it was decided that the spillway and related features should be designed to pass the following two floods:

Spillway Design Flood which is defined for purposes of this project as a large flood which has a probability of occurrence not greater than 0.1% (that is the chance of occurrence in any one year should be less than one in one thousand).

Probable Maximum Flood which is defined for purposes of this project as the largest flood that ever could reasonably be expected to occur at this site. This was to be obtained by a rational consideration of the chances of simultaneous occurrence of the maximum of the several conditions which contribute to a flood.

Further, it was decided that the spillway and related features should be designed (1) to pass the Spillway Design Flood with ample allowances provided for freeboard on the main dam and for hydraulic performance of the spillway structures, and (2) to pass Probable Maximum Flood with nominal allowances for freeboard and hydraulic performance.

Historical Floods

Flood peaks on the South Saskatchewan River at Saskatoon, a few miles downstream from the damsite, are the integrated result of several merging flood peaks contributed by the major tributaries. Rivers such as the Belly, Waterton, St. Mary, Oldman, Bow and Red Deer produce frequent floods individually due to two things—heavy accumulation of snow in their mountain headwaters, and early summer rainstorms on the foothill and mountain slopes. When the snow pack is heavy in this region, a heavy rainfall causes large flood peaks on these tributary streams. These peaks can coincide. The resultant flood crest then flows down the South Saskatchewan River with its peak being gradually decreased in magnitude due to valley storage.

The highest discharge recorded at Saskatoon during the period 1911-1959 was 147,500 c.f.s. on June 15, 1953. The second highest occurred on June 6, 1923 when a flow of 131,000 c.f.s. was recorded. Large floods are known to have occurred in 1908, 1902 and 1897. It is estimated that the flood in 1897 reached a peak of about 178,000 c.f.s. at Saskatoon. The flood of 1948 is worthy of mention since it is the only major spring flood which has occurred during the period of record. In that year a heavy snow cover on the Prairies and foothills, combined with a rapid warm-up produced a flood peak of almost 100,000 c.f.s.

General: The procedure followed in obtaining the probable maximum flood may be summed briefly: a very large rainstorm was assumed, the surface runoff from this storm was deduced for the various tributaries, and the tributary floods were then combined and routed down to the reservoir. A fuller description of each major step in the procedure follows:

Rainstorm: The first step in computing the probable maximum flood was to determine a storm that would be close to the maximum possible rainstorm. No attempt was made to derive this storm from air-mass analysis. This would have required a considerable amount of detailed information on recorded storms that was not available at that time. The following procedure was therefore used to obtain the design rainstorm. Isohyetals were drawn for all recorded 48-hour storms that had occurred on or near the basin. The most severe storm, (June, 1944) was then transposed to the center of the basin. In order to ensure better coverage and thus compensate for possible lack of optimum moisture content and storm efficiency, the shape of the isohyetals was modified somewhat without radically changing the total volume of rain. Care was taken, however, not to change the shape beyond that which was considered possible on account of the shape of other recorded major storms. The resultant isohyetal pattern of the design storm is shown on Fig. 1. A rainstorm with a greater total volume would probably be possible but the severity of the additional assumptions on the location, the shape and the distribution was assumed to compensate for that possibility.

Runoff from Rainstorm: The second step was to determine the runoff that would result from this rainstorm. For the foothill and mountain streams it was assumed that the soil would be soaked by heavy rain during the preceding months. The losses due to such factors as retention and infiltration were therefore assumed to be equal to the smallest values that occurred in the past during runoff due to the major recorded rainstorms. To determine these losses the hydrographs of the tributaries resulting from these rainstorms was studied. The runoff due to snow melt and base flow was separated by inspection taking into consideration the shape of the hydrographs and the variations in temperature at the mountains. The losses on the remaining part of the drainage basin were arbitrarily assumed to be a certain percentage of the rainfall. Those parts of the prairie that have a low average rainfall were assumed to have a relatively low runoff.

Total Runoff: The third step in determining the maximum probable flood was to estimate a major snow runoff. The severity of the snow runoff depends mainly on the extent of the snow cover in the mountains

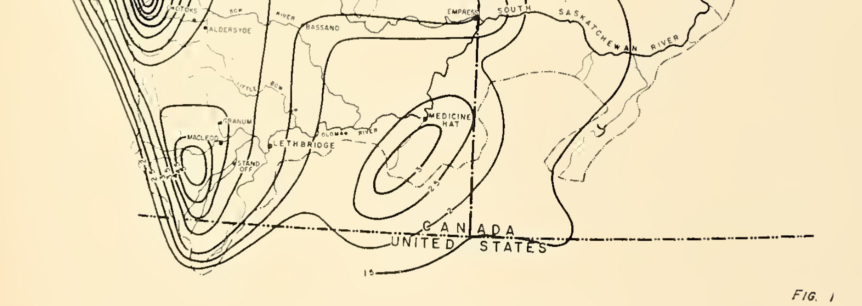


FIG. 1

TABLE I

Summary of Flood Studies

Stream	Gauge station or reach	Estimated drainage area	Recorded peak flow	Spillway Design Flood: Rainfall	Spillway Design Flood: Surface runoff & snow-melt	Spillway Design Flood: Base flow from local area	Spillway Design Flood: Peak at down-stream end of reach	Probable Maximum Flood: Rainfall	Probable Maximum Flood: Surface runoff	Probable Maximum Flood: Base flow & snow-melt from tributaries	Probable Maximum Flood: Peak at down-stream end of reach
		sq. miles	C.F.S.	inches	inches	C.F.S.	C.F.S.	inches	inches	C.F.S.	C.F.S.
1 Red Deer	Ardley	5,700	65,000(?)	4.6	4.0	10,000	200,000	4.6	4.1	16,000	208,000
2 Bow	Calgary	3,140	99,000	3.3	2.6	6,500	99,000	4.7	4.1	24,000	169,000
3 Elbow	Calgary	470	15,300	3.6	3.9	1,200	19,400	6.0	5.8	4,000	31,000
4 Sheep	Okotoks	630	21,400	3.3	3.2	2,000	29,800	5.6	5.4	4,000	50,000
5 Highwood	Aldersyde	880	22,700	3.3	2.8	2,600	27,000	5.1	4.5	8,000	47,000
6 Willow	Granum	810	10,700	3.0	1.7	1,500	14,500	3.6	3.4	2,000	28,000
7 Oldman	MacLeod	2,230	78,500	3.5	3.1	7,000	99,500	4.1	3.5	20,000	123,000
8 Waterton	Standoff	700	14,240	2.9	2.2	2,000	12,800	4.9	4.7	8,000	31,000
9 Belly	Standoff	480	16,000(?)	2.9	2.2	1,000	9,400	4.2	4.0	3,000	18,000
10 St. Mary	Lethbridge	1,330	18,000(?)	2.8	2.1	2,500	28,900	3.4	2.9	6,000	42,000
11 Red Deer	Ardley to Empress	—	—	2.3	0.5	20,000	207,000	3.4	1.4	—	250,000
12 Bow	Calgary to Bassano	—	—	2.7	0.6	7,000	169,000	3.3	1.6	—	317,000
13 Oldman	MacLeod to Lethbridge	—	—	2.6	1.0	5,000	163,000	3.7	1.8	—	250,000
14 South Sask.	Lethbridge and Bassano to Medicine Hat	—	—	2.0	0.3	5,000	258,000	2.9	0.6	—	497,000
15 South Sask.	Medicine Hat and Empress to Dam	48,800*	—	1.7	0.1	13,000	400,000	2.0	0.4	—	648,000
16 South Sask.	At Saskatoon	51,000	170,000(?)	—	—	—	350,000	—	—	—	560,000

* Total Tributary Area above Damsite

and on the temperature. To investigate these factors the accumulated runoff at a given gauging station may be plotted against the accumulated degree-days above 32°F. It was found that the curves thus obtained would first show a gradually increasing runoff per degree-day. After some time the curve would remain fairly straight and then it would show a gradual decreasing runoff per degree-day. Rainfall during the melting period would disturb the regularity but its effect could be estimated. Evidently the maximum runoff would occur when a warm period coincides with the time indicated by the flat portion of the curve. The maximum rate of discharge per degree-day varies for different years. It was therefore assumed that a major snow runoff could be obtained by combining the maximum recorded rate of runoff per degree-day with the assumption of a very warm period of several days. This procedure was followed for the Bow River at Seebe and for the Highwood River at Aldersyde. It was then found that even under those conditions the contribution of snow melt, including base flow, was of secondary importance compared to rainfall. Because of the large amount of work involved in this type of analysis and especially because of the scarcity of reliable data, the major snow runoff was estimated rather arbitrarily for the other tributaries.

Tributary Floods: To obtain the distribution of the runoff from rainfall for each tributary, 24-hour distribution graphs were obtained for each of these streams. The method followed in each case was essentially the method outlined on page 148 of "Engineering for Dams" by Creager, Justin and Hinds. Since, however, it has been observed that distribution graphs derived from ordinary floods generally have peak ordinates that are too small when used to calculate floods of extraordinary size, it was decided to arbitrarily increase these peak ordinates. The rule followed in getting the final distribution graph for each tributary was to use the larger value for the peak ordinate obtained from either (a) increasing the peak of the average distribution graph 15%, or (b) increasing the peak of the largest distribution graph by 7.5%.

The tributary floods then were obtained by applying the distribution graphs to the volume of rainfall runoff and adding the contribution from snow melt and base flow.

Routing: Routing of the tributary floods was done in steps governed by the location of the available gauging stations. Thus the Bow, Elbow, Highwood and Sheep tributaries were routed and combined at Bassano on the Bow River, while the Oldman, Willow, Waterton, St. Mary and Belly tributaries were combined at Lethbridge on the Oldman River. The Lethbridge and Bassano floods were then routed to Medicine Hat.

In each case the general method of discharge relationships was used. Stream flow records were analysed to discover the manner in which previous great floods had combined, including a determination of whether a flattening of the tributary peaks was required and to what extent the effect of the peak's time-lag must be considered. Having determined the manner in which the flood hydrographs combined, assumptions as to the amount and form of the inflow from the ungauged areas above the downstream gauging station were made, based on studies of similar inflows during past floods. Such inflow was added directly to the previously found flood hydrograph.

The question of time-lag, or time-of-travel, of peaks deserves special consideration. The worst condition for the final flood would be obtained if the peaks of all the tributaries coincided. It was found that in certain cases where a uniform storm occurred over neighboring tributaries, the resulting peaks did not coincide by a day or more. It was thought that in some cases these peaks could be made to coincide if it was proved feasible to assume the storm moving in such a way as to cause this coincidence. With this in mind a study was made of the direction and time-of-travel of past storms to determine limitations to storm movements over this area. The only case where it proved desirable to utilize this study of storm movements was in providing for the coincidence of the Red Deer and South Saskatchewan River peaks at Empress.

The review of past floods indicated that considerable flattening of flood peaks occurred in the reach of the South Saskatchewan River between

Medicine Hat and Saskatoon. For this reason it became particularly important and to correctly choose the point on the river at which to determine the spillway inflow hydrograph. This point is near the upstream end of the resorvoir at South Saskatchewan Landing because the effect of a large flood at the upper end of a reservoir is felt almost immediately at the lower end.

Results: As a result of the foregoing procedures, it was found that the probable maximum flood would have a peak flow of about 650,000 c.f.s. and a total flood volume of about 7 million acre-feet. (Fig. 2)

Flood	Peak @ Dam (cfs)	Peak @ Saskatoon	Apparent Probability of Occurrence
Spillway Design Flood	400,000	350,000	0.07%
Probable Maximum Flood	650,000	560,000	< 0.01%

Spillway Design Flood: The spillway design flood was obtained by following essentially the same method used to obtain the maximum probabe flood. The method differed only in the assumptions regarding the size and distribution of the rainstorm and the losses applied to it. Table I summarizes these assumptions. This study indicated that the spillway design flood should have a peak flow of about 400,000 c.f.s. and a total flood volume of about 4,000,000 acre-feet. (Fig. 2)

Check with Enveloping Curve: A plot was made of the maximum peak discharge per square mile of drainage area against the drainage area for streams of varying sizes rising on the eastern slopes of the Rocky Mountains north of latitude 44°. Since all the plotted points represent the greatest flood on record for each stream represented, an enveloping curve should indicate roughly the worth of the results. As may be seen from the graph (Fig. 3), the results appear reasonable.

Check with Frequency Curve: A frequency curve of peak discharge at Saskatoon was determined for the period 1908-1953. Plotting positions were obtained by Gumbel's equation. The frequency curve was drawn by eye, and a supplmentary curve for momentary peak flows was obtained by Fuller's formula. (Fig. 4) This frequency curve indicates that the results obtained are not unreasonable.

Discussion

Peak-Volume Alternatives: For any given reservoir and spillway, a flood having a smaller peak and larger volume may cause a larger spillway discharge than another flood having a larger peak and smaller volume. In this particular case, the actual shape of the flood hydrograph on the main stem will depend on the magnitude of the flood peaks on the tributaries and on the degree of coincidence of these peaks. In other words, every storm will cause a differently shaped hydrograph. To assess this complication it was decided to assume an arbitrary shape for the inflow hydrographs that would be both realistic and convenient for reservoir routing purposes: the well known Gaussian probability function was found suitable in this respect. This assumption made it possible to determine analytically a series of curves defining the maximum spillway discharge as a function of the magnitude of the peak and the total flood volume of the inflow hydrograph. The curves are shown on Fig. 5 and are based on the assumption that the reservoir is full at the start and that the outflow is kept equal to the inflow until the spillway gates are entirely opened.

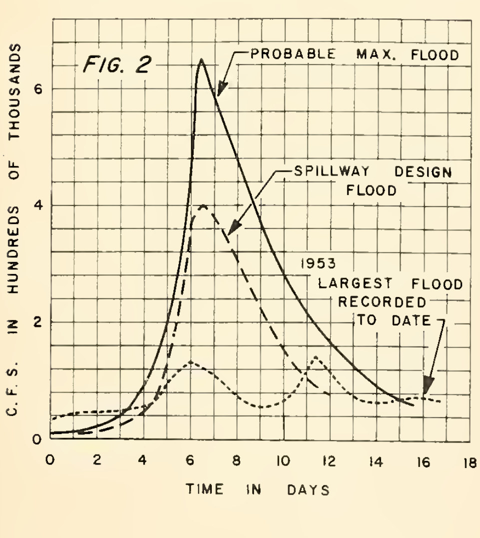
By plotting on the graph the appropriate points representing the two great floods derived herein, one may make one's own assessment of this aspect of the safety of the dam.

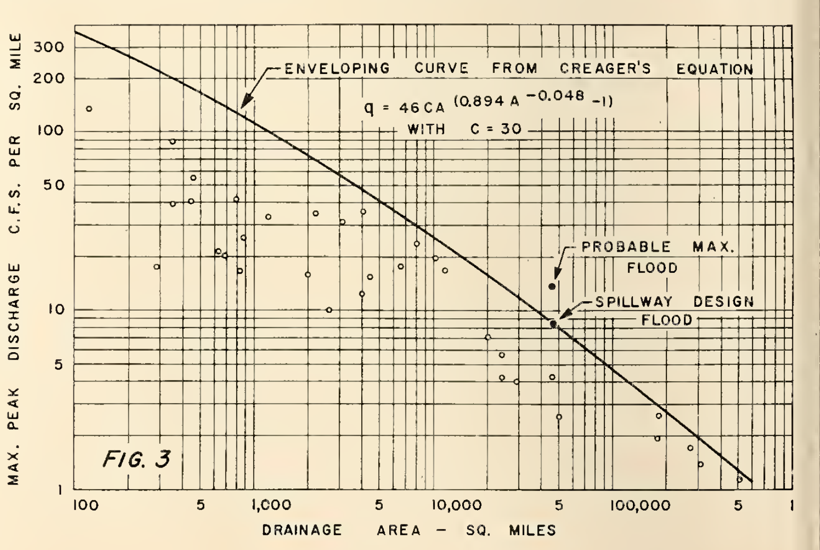
Spillway: Since a description of the spillway design and its hydraulic features is not properly a function of this paper, it will suffice to summarize the results of routing the floods through the reservoir and spillway.

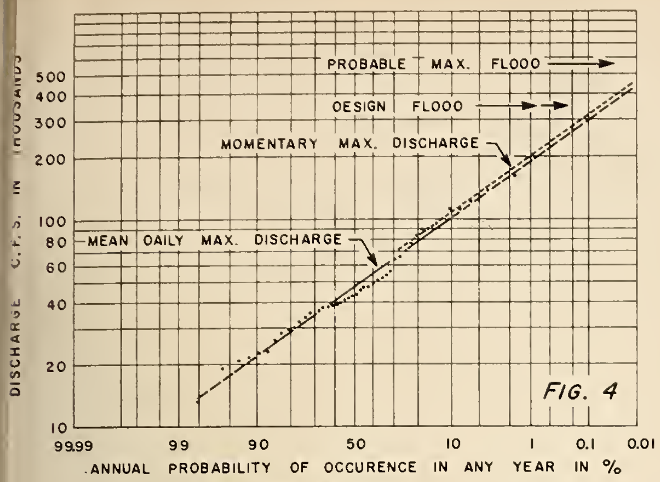
Spillway Design Flood	
—inflow	400,000 c.f.s.
—outflow	265,000 c.f.s.
Probable Maximum Flood	
—inflow	650,000 c.f.s.
—outflow	400,000 c.f.s.
Full Supply Level	1827.0 elevation
Maximum Water Level During	
—spillway design flood	1832.0 elevation
—probable maximum flood	1841.0 elevation
Top of Dam	1845.0 elevation
Minimum Freeboard During	
—spillway design flood	13.0 ft.
—probable maximum flood	4.0 ft.

Water Supply and Water Use

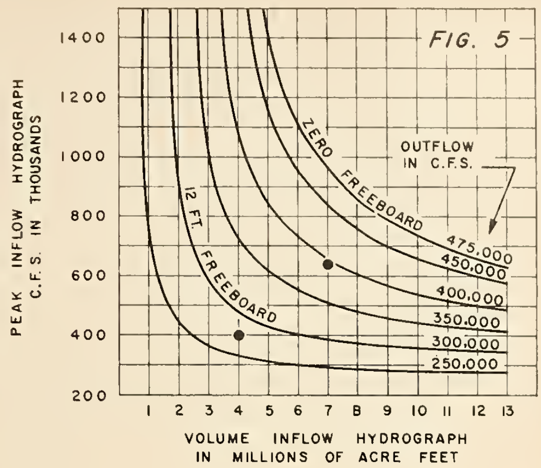
During the planning of any project, the ability of the river flow to satisfy the project demands must be studied. For this project an investigation was carried out in six phases. First, the recorded flows at several points in the basin were assembled and missing data were estimated; second, historical uses were estimated; third, the recorded flows were adjusted to nullify the effects of historical uses thereby obtaining natural flows; fourth, the water requirements under "full development" conditions in Alberta were estimated, (see Table 3); fifth, the residual flows, after deducting full development demands, were routed through the South Saskatchewan reservoir assuming all phases of this project were fully de-







FLOOD PEAK PROBABILITIES AT SASKATOON



veloped; and sixth, the effect of full development on flows downstream from the dam was studied.

Water Supply: Table 2 summarizes the natural flows at various points in the watershed for the period of record 1911 to 1956.

Uses of Water: Irrigation in Western Canada began in 1878 when John Glen constructed a ditch to water his haylands from Fish Creek south of Calgary. In the early years of this century, irrigation grew rapidly under the auspices of several irrigation companies. Since then, irrigation growth has been fairly constant and continuous (Fig. 7). At the present time, 856,400 acres have been developed for irrigation in the South Saskatchewan River basin, and completion of the projects listed in Table 3 will raise this total to 1,717,035 acres. In most areas where irrigation has developed, the land without water will support cattle grazing if there are 20 to 40 acres per head. Under irrigation and with mechanical grazing techniques, the same land will support cattle grazing with 0.5 acres per head. Also, the agricultural economy becomes more versatile under irrigation, with forage crops, sugar beets, truck garden crops and oil seed crops.

Municipal uses in the river system are also important. Edmonton, Calgary, Lethbridge, Red Deer, Drumheller, Medicine Hat, Regina, Moose Jaw, Saskatoon, North Battleford and Prince Albert—all the major centres on the Prairies except for Winnipeg—rely on the Saskatchewan River and its tributaries for their water supply. The growth of these centres and small communities along the river will place growing demands on the available water supply. At the present time, an urban population of about 1,000,000 is served from the river at an average rate of 120 gallons per person per day.

Industrial use of water has been increasing rapidly in the last few years. Large deposits of coal are available on the Prairies and for some time to come the generation of steam electric power will be economically feasible. Other industrial users, such as fertilizer, petro-chemical, mineral recovery, pulp and paper plants and others will be placing increasing demands on the flow of the river. Most industrial uses are recirculating. Although the actual consumption of water is low, a large flow of water must be on hand to satisfy the diversion requirements. Increasing industrial use may lead to stream pollution at some points but this is not now a problem.

TABLE 2

All figures in acre-feet

	For the Period 1911 to 1956		
	Minimum Annual Flow	Maximum Annual Flow	Mean Annual Flow
North Sask. R. @ Edmonton	3,922,000	9,287,000	5,673,000
North Sask. R. @ Prince Albert	3,494,000	10,501,000	6,345,000
South Sask. R. @ Alta-Sask. Bdry.	4,144,000	13,386,000	7,760,000
South Sask. R. @ Saskatoon	4,129,000	14,594,000	7,950,000
Sask. R. @ The Pas	10,776,000	30,176,000	18,200,000

Historical Background

Any attempt to discuss the relationship of water use to the water supply available would not be complete without a discussion of the various treaties and agreements which place restrictions on the present and future use of water. In 1909, Great Britain and the United States signed the Boundary Waters Treaty. Under Article VI of that treaty, Montana was given the right to use approximately 50% of the St. Mary and Milk River waters. Ultimately, this will mean an average annual depletion of 258,000 acre-feet before the St. Mary River enters Canada.

The transactions of the Prairie Provinces Water Board are also of interest. This Board has its origin in the British North American Act which gave the provinces the ownership of natural resources. In 1894, the Irrigation Act replaced the Riparian Doctrine on the prairies with an appropriate doctrine for water law. This act was administered by the Federal Government until 1930. Then the provinces assumed the administration of their water resources and each passed a Water Rights Act based on the Irrigation Act. Now it would appear that the Crown in the right of each province has ownership of the waters of the South Saskatchewan system within its boundaries. Some aspects of this situation are unworkable and the Prairie Provinces Water Board (P.P.W.B.) was established in 1948, "to recommend the best use to be made of interprovincial waters in relation to associated resources in Manitoba, Saskatchewan and Alberta and to recommend the allocation of water as between each such province of streams flowing from one province

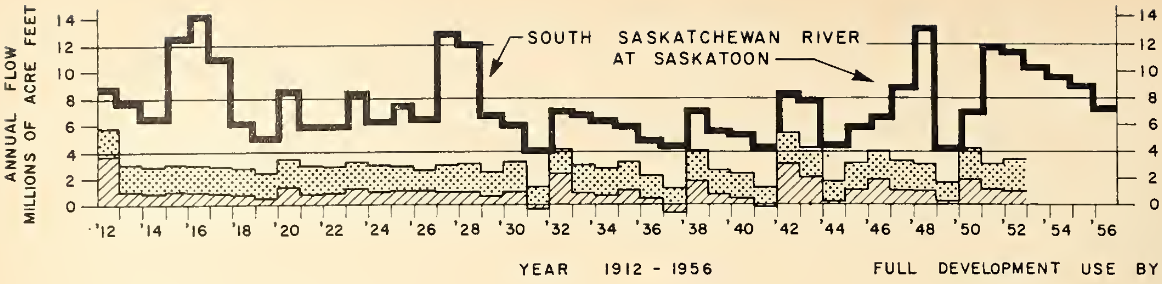


FIG. 6

into another province".

In carrying out its duties, the P.P.W.B. recommended the allocation of water for several projects, one of which is the South Saskatchewan Project. Before recommending that allocation, the Board carried out, in co-operation with P.F.R.A., a detailed water supply study. The object of this study was to ascertain whether there would be sufficient water for the project after allowing for the full development of allocations in Alberta (some 2.3 million acre-feet annually). The effects of future Alberta and Saskatchewan depletions of the flow into Manitoba was also studied.

As a result of these studies, the P.P.W.B., in October, 1953, adopted a resolution, subsequently ratified by the governments of Alberta, Saskatchewan, Manitoba and Canada, which follows:

1. The allocations already made by the Board and confirmed by the parties to the Agreement have assured an adequate water supply for the full development of each project.
2. There is sufficient water in the South Saskatchewan River and its tributaries to permit the full development, not only of existing projects but also of certain proposed projects, including the South Saskatchewan River Project and the proposed Red Deer Project.
3. The natural flow remaining in the river after water consumptive uses has been diverted will provide for the full water storage requirements for the purpose of all proposed projects, including the South Saskatchewan River Project.
4. The estimated amounts of hydro electric power to be produced by the South Saskatchewan River Project have been based on the estimated flows available after all consumptive uses of existing and projected upstream developments have been provided for.

Water Studies made by the P.P.W.B. Prior to the 1953 Resolution

Computation of Natural Flow: At several points along the main stem of the South Saskatchewan and North Saskatchewan Rivers and for most of the major tributaries, stream flow records are available for the period 1911 to the present. However, throughout this period water has been diverted from the river system for irrigation in Montana, for irrigation in Alberta and for the generation of hydro power by the Calgary Power Company.

The first step of the water supply study was to reconstruct these historical diversions and add them to recorded flows to obtain natural flows. From this study, a growth curve of irrigation in Alberta was prepared which may be of general interest to the readers. (Fig. 7)

Throughout the study, average monthly flows were used. Since it takes about two weeks under normal flow conditions for water to move from Calgary to Saskatoon and another 10 days to reach The Pas, it was necessary to adjust all flows for time-lag.

Future Water Requirements: Present irrigation diversions in Alberta are only about one-third of the estimated diversion when full development of existing allocations is reached. To assess the ability of the stream to supply future water requirements in Alberta and Saskatchewan, it was necessary to estimate the month-by-month requirement under full development conditions. Full development in this context refers to the irrigable areas shown in Table 3.

It was obvious from the flow records that the most critical water supply period would be during the 1930s and so the period 1923 to 1948 was chosen for study. Monthly diversions for that period were then estimated for the irrigation projects listed in Table 3.

The operations of the Calgary Power Company on the Bow River tend to convert summer flows into winter flows. It was, therefore, necessary to make an allowance for their future operations because of the importance of summer flows in meeting irrigation requirements.

These estimated diversions were deducted from the computed natural flow to obtain the surplus or balance of water which would be discharged from Alberta to Saskatchewan when full development is reached.

TABLE 3

Irrigation Development Upstream from the Dam

	Acres now under irrigation	Assumed for "Full Development Studies"
Western Irrigation District	50,000	50,000
Eastern Irrigation District	200,000	281,000
Bow River Project	131,000	240,000
Lethbridge Northern Irrigation District	96,100	96,135
United Irrigation District	34,000	34,000
Mountain View Irrigation District	3,600	3,600
Aetna Irrigation District	8,000	7,300
St. Mary, Milk River Project	318,200	495,000
Red Deer Project		350,000
MacLeod Irrigation District	3,500	5,000
Carmangay, MacLeod Extension, etc.		64,000
Swift Current Irrigation Project	7,000	21,000
Private Projects	5,000	70,000
	856,400	1,717,035

Water Requirements

Before the adequacy of the water supply can be studied, it is necessary, of course, to determine the requirements of the South Saskatchewan River Project. This was done by making due allowance for reservoir losses (seepage and evaporation) diversion to the Qu'Appelle basin, irrigation diversion, and water to generate power for irrigation pumping. The balance was assumed to be available for generating commercial power.

Irrigation Diversion: On the basis of plane table topography, gathered over a six-year period and a preliminary soil survey, it was assumed that 455,000 acres could be irrigated from the reservoir. After a study of Alberta projects, with similar climate and soils, a duty of water of 18 in. was assumed with an irrigation factor of 80% and gross conveyance losses of 30%. This annual demand was broken into monthly demands using percentages derived from measured diversions to projects in Southern Alberta. The gross demand was reduced for years of above normal rainfall.

Irrigation Pumping Water: Since 35% of the irrigable area would be served by gravity irrigation, the balance would have to be lifted from 15 to 120 ft. The energy for pumping this water was assumed to be derived from the power house at the project.

Qu'Appelle Diversion: For irrigation, municipal water supplies, truck farming and recreation, the Qu'Appelle Valley will require a firm water supply. Adequate water supply for the above purposes could be provided by a release from the reservoir of 200 c.f.s. during the seven summer months (April to October) although this would not be needed every year. The 24,000 acres of irrigation potential in the Qu'Appelle Valley were included in the figure given for total project acreage.

Reservoir Seepage: A constant seepage loss of 100 c.f.s. was assumed: 25 c.f.s. through the main dam and the balance through the Qu'Appelle dam and elsewhere.

Reservoir Evaporation: An annual allowance of 24 in. of net evaporation (evaporation minus precipitation) from the ever-changing reservoir surface area, was assumed.

Reservoir Operation: The purpose of the study was to assess the ability of the reservoir and the water supply to serve the project, rather than to develop operation rules for the reservoir. Basically, the method of computation was to supply the consumptive requirements listed in the foregoing section, and use the balance of the water to operate a hydro plant with an assumed efficiency of 80%.

It was assumed that the plant would be operated to produce the same amount of firm energy each year. The monthly output was assumed to vary from a low of 4.5% of the annual energy production in July to 14.0% in December.

By trial and error it was found that 325,000,000 kwh. could be produced each year. It was realized that if interconnection with other plants having reserve capacity were assumed, a different picture of the potential would be produced, but for the particular purpose of this study it was unnecessary. A capacity of 150,000 kw. was sufficient to produce this firm commercial energy, to produce an additional 125,000,000 kwh. per year of secondary energy and to provide all the energy required for pumping the irrigation water. Any installation greater than 150,000 kw. would generate still greater amounts of energy. Present indications are that ultimately the site may be developed to a capacity of 300,000 kw.

The over-all effect of "full development" on the average flows in the system are shown on Fig. 6.

Effects on Downstream Power Potential

There are several power sites in the Saskatchewan-Nelson River system downstream from the South Saskatchewan River Dam, three of which are under construction. On the South Saskatchewan there are the proposed plants at Batoche and Coxby. Below the junction with the North Saskatchewan River, plants have been proposed at Fort a la Corne and Nipawin. The hydro developments at Squaw Rapids and Grand Rapids are under construction. On the Nelson River there is a gross power potential of about 3,000,000 hp., with one plant (Kelsey) already in operation.

Although stream flow depletions in Alberta and Saskatchewan will average 3,050,000 acre-feet annually, the operation of the South Saskatchewan River Dam will increase downstream power potential (except on the Nelson River) over natural conditions because of the firm winter flows to be derived from storage.

The proposed Nelson River plants will derive their flows from the Lake Winnipeg watershed. About 20% of the inflow to this lake is contributed by the Saskatchewan River. It was found from an approximate analysis that "full development" depletions in Alberta and Saskatchewan would reduce this Nelson River power potential by about 3% to 4%.

Recent Developments

The changing concepts and needs of a water-hungry economy are variables which cannot be evaluated permanently but which need a continuing review. Since these water supply studies were completed in 1953, several major changes in the basic assumptions have occurred. Three important ones have been described to illustrate this problem.

Red Deer Project: (William Pearce Scheme) For the Water Board studies, 350,000 acres were assumed irrigable. On the basis of recent soils surveys, only 250,000 acres are considered suitable for irrigation (excluding the extension of this project into Saskatchewan). Recent proposals suggest that one of the main functions of this project would be to supply stockwater and municipal water by gravity to most of east central Alberta and west central Saskatchewan.

However, should economic concepts change and favor the development of sprinkler irrigation, the original acreage and more could be considered irrigable.

Municipal Water in Saskatchewan: Recently (December 1959) Saskatchewan recorded with the Prairie Province Water Board a proposal to supply by pipelines, 30,000 acre-feet of water annually from the North and South Saskatchewan Rivers for municipal purposes. At the moment, development appears costly, approximately double the cost of existing systems, but eventually, it will provide the only solution to expanding municipal requirements. Looking far into the future one can see pipeline systems of this sort leading to expanded industrial use, specialty irrigation, and even more municipal water to serve a stimulated population growth.

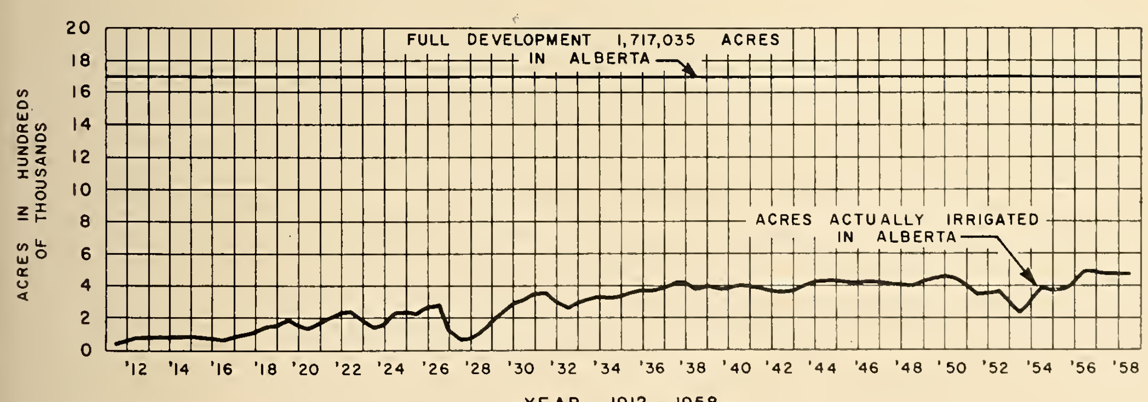
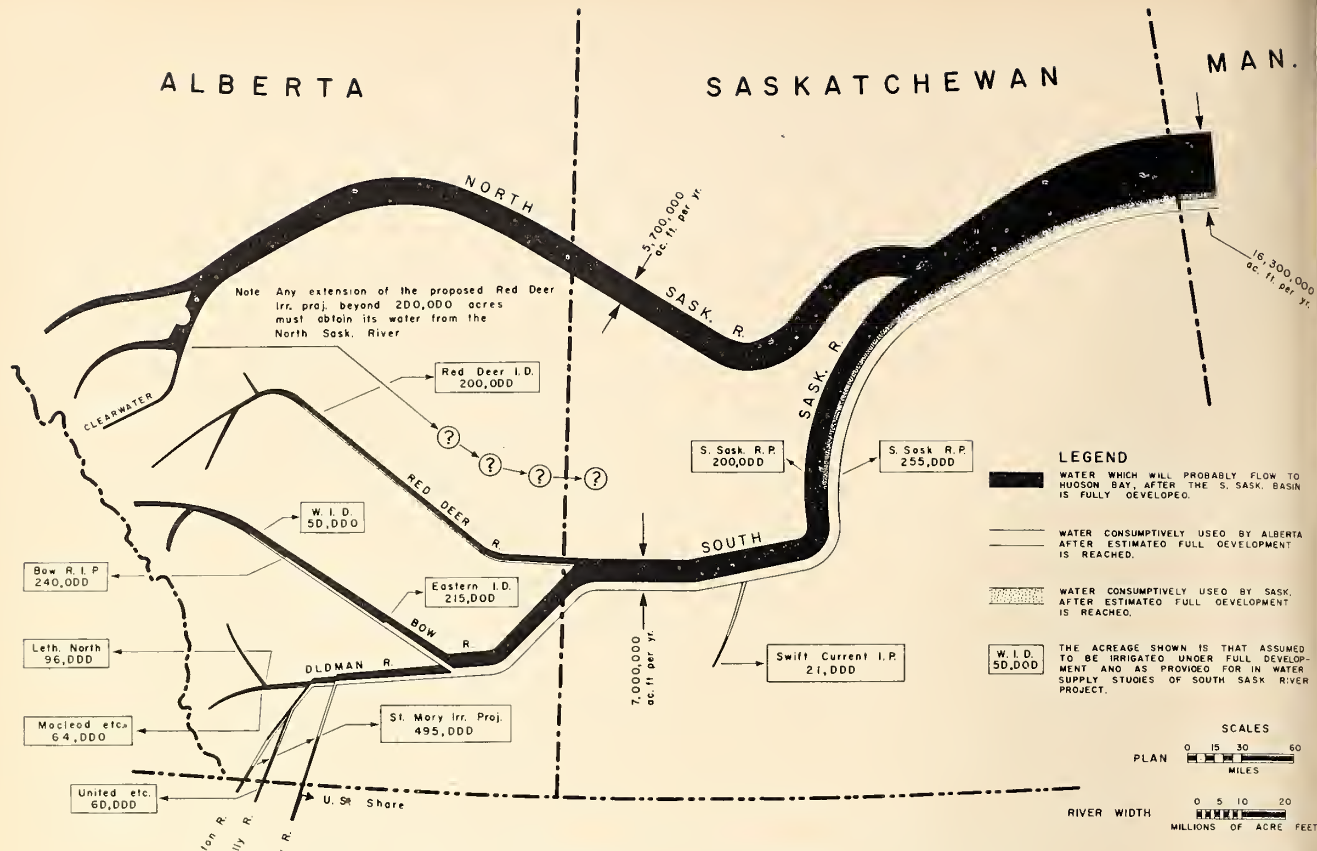


FIG. 7



EFFECT OF "FULL DEVELOPMENT" ON SASKATCHEWAN RIVER SYSTEM

FIG. 8

Recent Power Developments: Until three years ago, hydro power in the Saskatchewan basin was limited to 320,000 kw. on the Bow River system operated by Calgary Power Company. In the balance of the watershed, electrical loads were served by coal, oil, and gas-fired steam plants, which can be expanded in small increments. However, as loads increase, the possibility of absorbing the capacity of a large hydro plant increases, and the construction of each plant, with associated storage and regulation enhances the power potential at all downstream sites.

The inter-related effects of power regulation and other storages which will probably be built over the next 20 years have not yet been studied. However, three general observations may be made; (i) as river regulation increases, better use can be made of the water resources, (ii) as river regulation increases, power potential increases and the water supply picture, particularly in the winter, will improve, (iii) moderate floods on the river will be fully controlled, although major floods will be less affected.

Review

Flood Inflow Hydrographs: The flood potential of the South Saskatchewan River is such that the spillway proposed for the South Saskatchewan River Dam will have to be capable of handling floods having inflow peaks of up to 650,000 c.f.s.

Water Supply: The South Saskatchewan River system after meeting existing municipal and industrial water requirements, and after watering 1.7 million acres of irrigation in Alberta, is capable of irrigating 450,000 acres from the South Saskatchewan River reservoir and generating a minimum of 325 million kwh. annually of firm commercial energy.

In Times to Come

In 1878 the irrigation phase of development in this huge watershed was begun. This development is continuing. Until now, the river flows have been adequate to supply this phase of water development. We now are on the brink of a rapidly expanding hydro power development. This phase will probably dominate the development scene for the next 20 years. However, thoughts of even the following phase have been expressed by some who like to peer into the future: municipal and domestic water distributed in pipeline transmission networks to areas far removed from the river; industrial growth placing large demands on the river for process water with attendant pollution problems; changes in agricultural science which lead to intensified irrigation and which justify high water rates. Although this tertiary phase cannot be clearly defined at the moment, it is safe to say that within the lifespan of some of us, the Saskatchewan River will be completely harnessed to supply the ever-expanding needs of a burgeoning population. When that day arrives, the South Saskatchewan River Project, with its 8 million acre-feet of storage will play a vital part in serving those needs.

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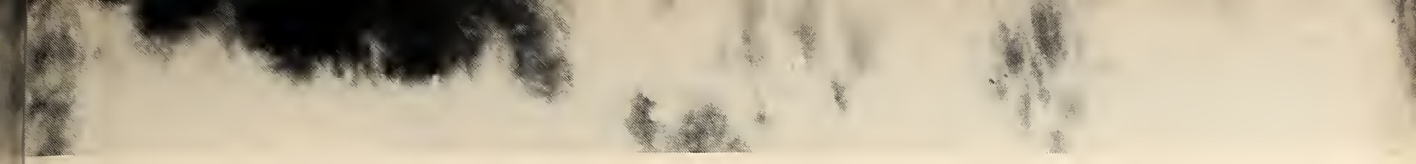


FIRE PROTECTION for Rotating Electrical Equipment

Jason H. Ingham, M.E.I.C.
Walter Kidde & Company of Canada Ltd., Toronto

FIRE losses in Canada during 1959 amounted to $30 million. This covers only property damage. The loss of life and the loss attributed to reduced hours of production and other disruptions cannot be properly assessed. These indeterminates must be shared by the employer, the employee, and the general public.

Startling as is this figure, it doesn't tell us how much greater the cost would have been without the benefit afforded by built-in protection systems which went into action to prevent or control many other fires. It is true that when water sprinkler systems operate there is damage other than that attributed to fire. However, the cost of such damage is infinitely small compared with that caused by fire uncontrolled for any extended period of time. It is equally true that in certain applications, the loss due to water damage can be eliminated by the use of carbon dioxide as the extinguishant. It is of interest, therefore, to compare water and carbon dioxide as extinguishants for one important application of fire protection, the protection of rotating electrical equipment. This paper outlines the characteristics of the two media, and indicates some of the preferences expressed in favour of one or the other. It is an attempt to summarize in an objective manner the results of many conferences, interviews, and discussions, covering the overall problem.

Fires in rotating electrical machines vary in character. At one extreme there is the mere threat of fire which reveals itself in the operation of differential relays, thermostats, or other indicators of operational irregularities. At the other extreme is the fire so complete, so intense, that the copper components of the machine are fused. In such extreme cases, steel components of the machine warp, crack, and twist, particularly if water is applied to extinguish the fire or to control its spread to other parts.

In the field of hydro generators, it has been estimated that fire and the threat of fire cause shutdowns equal to 2% of the working hours of a machine. The shutdown period covers inspections, tests, repairs, and replacement of components. As with all other forms of combustibles, fire will occur in rotating electrical machines if there is:

(1) a source of ignition;

(2) oxygen (or air) to support combustion;

(3) a flammable material present.

The usual sources of ignition are sparks from short-circuits, overheated bearings, and friction heat from metal components that have suffered misalignment. The flammable materials may be deposits of dust or an oil film on the windings, lacquer or varnish used in the splicing of wiring, or the bonding material used in laminated components of the machine. The insulating material used in the windings may not burn readily but it decomposes under intense heat causing further short circuits, thereby intensifying the heat generation as well as creating a source of ignition.

Good fire protection requires prompt detection of the fire through the use of automatic detection equipment. Once the fire is detected, a built-in fire extinguishing system should discharge automatically to control the fire and hold the damage to a minimum. Simultaneously the machine should be de-energized and brought to rest as quickly as possible to reduce the spread of fire through wind currents caused by the moving rotor, and to permit access to the internal parts of the equipment.

The requirements for an effective extinguishing system may be summarized as follows:

(1) The system should extinguish the fire as quickly as possible to minimize fire damage;

(2) The system should prevent reignition until the rotor can be brought to rest and access gained to the internal parts;

(3 The agent used should not contribute to the damage incurred;

(4) The agent should contribute to the cooling of heated parts that would induce reignition.

The total damage may be broken down into two categories: first, the actual repair cost; and secondly, the revenue loss because of decreased system capacity or higher cost of power to replace that supplied by the damaged equipment.

The discussion to this point has concentrated on circumstances surrounding actual fires. It is important to consider also the situation where abnormal heat conditions in the equipment either necessitate a decision with regard to operation, or cause premature discharge of an automatic system.

Abnormal heating which develops in rotating electrical machines may be caused by internal shorts or by external faults caused by electrical storms or malfunctioning of control equipment. This abnormal condition may be detected through operation of differential relays, use of fixed temperature thermostats, or employment of smoke detection equipment.

Under automatic operation, there is immediate initiation of the fire-prevention system. If the condition is one which would ultimately lead to fire, damage is minimized by actuation of the system. If, however, the condition is due to equipment malfunction or is merely transient, the automatic feature of the system should be such that resulting costs caused by the employment of the agent, the inspection of equipment, and the interruption of service, should be kept to a minimum.

Under manual operation, these unnecessary costs are avoidable but another formidable problem is presented. Now the responsibility for an error initiating the operation of the system, is placed squarely on the shoulders of operating personnel, with the possibility of further damage while the operation of the system is delayed in order to ascertain that there is actually a fire condition.

Before analyzing protective systems in the light of the foregoing considerations, it is appropriate to review the basic extinguishing system. It has five components:

(1) a supply of extinguishing agent;

(2) piping to conduct the agent to desired point of application;

(3) a source of energy to move the agent from storage to the scene of use;

(4) suitable nozzles and other components to apply the agent in the manner desired;

(5) a method of initiating and shut-off, either manual or automatic.

In the carbon dioxide system, illustrated in Fig. 1, the agent, in a partially liquid state, is stored in cylinders at 850 p.s.i. This pressure, on release, causes the extinguishant to flow through the piping system to the discharge nozzles, and further, it can be used to initiate controls and protective equipment.

With water systems, pressure is provided by pumps, storage tanks pressure systems, or, in the case of hydro electric generators, by the penstock operating head itself. Here again a piping system is required but the discharge means is usually limited to the provision of a perforated pipe located within the machine to direct water on as great an area as possible of both rotor and stator windings.

Although total enclosure of a machine is desirable, it is not mandatory when a built-in water extinguishing system is installed, while it is a necessary requirement with a built-in CO_2 extinguishing system. However, where there is dirt or a flammable moisture-laden atmosphere, total enclosure of rotating electrical equipment is good insurance against fire risk. In addition, maintenance costs are reduced substantially because the internal working parts are kept cleaner.

It is readily apparent from the above brief outline of a system's components that the physical characteristics of the two available alternatives are not radically different. Any indication of superiority must be found in the characteristics of the extinguishing agents and the actual methods in which they are used.

Carbon Dioxide Systems

With respect to the speed of extinguishment, experience with carbon dioxide has been favourable. Although carbon dioxide has a lesser cooling effect than water, it has the advantage that as a gas it penetrates to portions of the wiring that water cannot reach.

To ensure immediate control of the fire and to maintain control during the period of rotor deceleration, carbon dioxide systems are so designed that gas is injected into enclosed rotating machinery through two independent discharge systems. The initial injection of carbon dioxide from the first piping system lasts for about two minutes and creates an oxygen-deficient atmosphere which extinguishes any fire that may have flashed. Also, with a fire condition imminent, the carbon dioxide, when released by differential relay actuation, establishes an oxygen-starved atmosphere that will not support combustion, thus preventing an outbreak of fire.

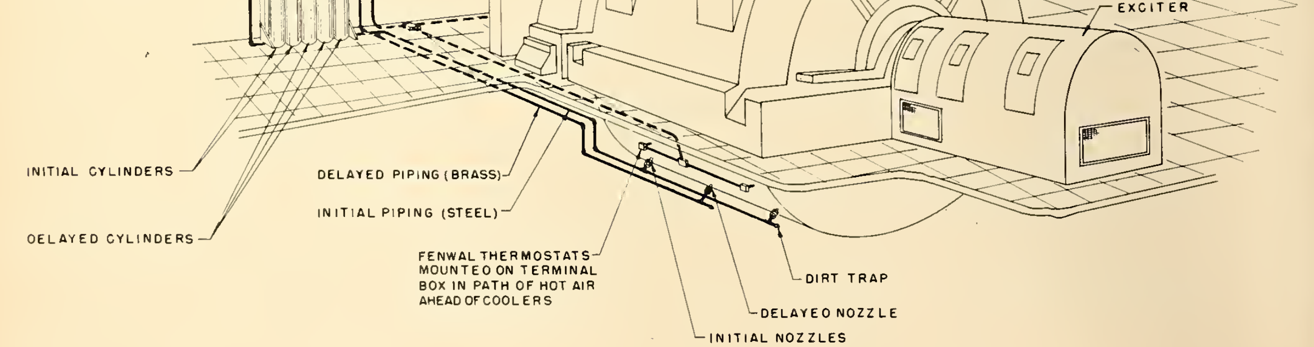
The second piping system is designed with an extended time of discharge so that the oxygen-deficient atmosphere is maintained throughout the period of deceleration. It is, of course, necessary to know the time of deceleration of the machine protected. Adequate data exist and accepted standards, such as are outlined in pamphlet 12 of the National Fire Protection Association, make this procedure reliable. Further, actual extinguishment of many fires in rotating electrical machines has proven conclusively the effectiveness of carbon dioxide in fires of this type, with complete extinguishment taking place either immediately following the discharge of the carbon dioxide system or within a few minutes after the machine has been brought to rest.

That carbon dioxide is non-damaging follows a consideration of the characteristics of the material. Although stored as a liquid, the rapid expansion which occurs at the discharge nozzles causes it to be discharged as a mixture of carbon

Fig. 1. Typical installation diagram of built-in carbon dioxide fire extinguishing system protecting a turbine generator.

NOTE
WHEN MORE THAN ONE GENERATOR IS PROTECTED BY THE SAME BATTERY OF CYLINDERS, DIRECTIONAL VALVES ARE INSTALLED TO ROUTE THE CARBON DIOXIDE TO THE GENERATOR AFIRE. THESE VALVES ARE AUTOMATICALLY OPENED BY THEMOSTATS IN THE GENERATOR THEY PROTECT.

INITIAL AND DELAYED CYLINDERS ARE RELEASED SIMULTANEOUSLY. INITIAL CYLINDERS PROVIDE FOR RAPID INJECTION OF CARBON DIOXIDE TO IMMEDIATELY BUILD UP AN INERT ATMOSPHERE. DELAYED CYLINDERS ARE SLOWLY DISCHARGED INTO GENERATOR TO MAINTAIN INERT ATMOSPHERE.



ioxide snow and gas. The snow asifies without passing through the iquid state so that neither wetting ction nor the depositing of moisture ccurs. Since carbon dioxide is dry, t neither damages the equipment nor nakes necessary a clean-up or dry-out after discharge. Because of its non-conductivity, carbon dioxide does ot provide a path for short circuits hrough partially decomposed insulation. It can be stored indefinitely vithout deterioration and when discharged neither corrodes nor damages nachines or parts, no matter how lelicate.

Under conditions of abnormal heating or equipment malfunction, carbon lioxide once again exhibits desirable characteristics, in that it has no ill effects on the equipment protected. If there is no fire in the machine at time of discharge, the carbon dioxide serves to prevent an outbreak should conditions develop which would favour combustion.

Again, in the event of an equipment malfunction or a temporary heat condition, which, on detection, is readily controlled, the equipment quickly can be brought back into operation. This is highly advantageous since short shut-downs can usually be handled without extensive re-routing or delays, whereas in the case of extended shut-down the load must be dropped for the duration of the time the machine is down and during that time replacement power or equipment must be paid for at emergency rates.

This characteristic of short shut-down permits carefree operation of a carbon dioxide system in time of doubt, since the only cost to the operator is the gas expended, while the potential saving is very great.

Water Systems

With one qualification, it is apparent that water systems are capable of quickly extinguishing a fire. However, since water extinguishes by cooling, fire in internal unexposed wirings can be controlled only by the relatively slow process of conducting water-chilled currents to the internal burning area. Water, being a liquid, can go only where driven by pressure.

It is also readily apparent that a water system will ordinarily prevent re-ignition during the deceleration period. The disadvantage of the water system lies in the damage chargeable to its use. It is in the evaluation of this damage that the greatest source of disagreement lies. Since the damage caused by the water used to extinguish the fire is absorbed in the cost of putting the machine back into service, it follows that there are no dependable cost figures for water damage alone. To recondition water soaked equipment, it is reasonable to assume the following operations:

Dry the rotor and stator either by removing the stator or by running under reduced load for the required period;

If damage is extensive, repairs and replacements must be made, followed by operation tests, under reduced load, for assurance of complete dry-out of insulation.

In addition to the actual cost of doing that portion of the above work which can be directly attributed to water damage, it is necessary to assess the added shut-down time caused and the resulting cost of this lost production time.

While the added costs resulting from the use of water rather than carbon dioxide may be hard to assess under conditions of actual fire, the delineation is more obvious under conditions of abnormal heating and equipment malfunction.

It is significant that most built-in water systems are manually controlled in an attempt to prevent premature operation. Furthermore, manual operation is restricted. Some operators have a firm rule that water systems will be operated only as a last resort after a fire has reached such proportions that the machine will be a total loss. Others instruct operating personnel that the water extinguishing valve must not be opened unless there is positive evidence of fire by the presence of smoke, excessive heat, or both. This fear of the adverse effect of water on rotating electrical equipment was responsible in at least one instance for unusually extensive damage because at the inception of fire in a machine the operators did not discharge the water for fear of creating unnecessary damage.

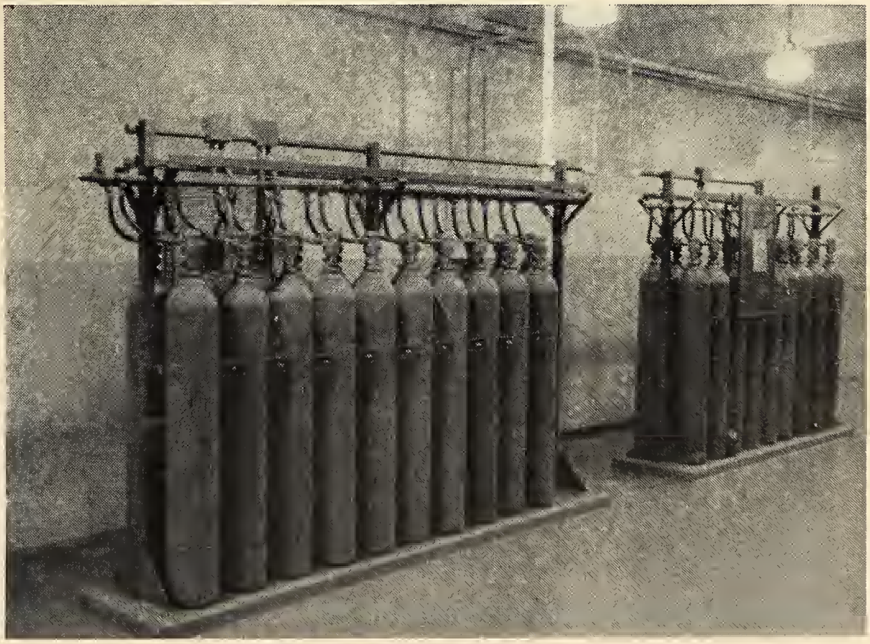
There is considerable difference of opinion with regard to the exposure of rotating electrical equipment to water. Many hydro-generator operators dislike any wetting and drying of their machines. They say there is substantial evidence to support the view that repeated wetting and drying of coils causes a break-down of the insulation, thereby shortening the life of the machine and increasing the risk of fire.

It has been argued that drying is relatively simple because facilities are always present to achieve it. At the time of installation, formal delivery requires that after erection and just before the acceptance test, the machine must be dried. Heat for drying is applied by shorting the windings. In some locations the use of permanently installed auxiliary heating equipment is a requirement, since there may be present in the machine, in addition to moisture, flammable solvents used in the field splicing of coils.

Generally, operators and manufacturers disagree on the need for care in any further drying operations following the acceptance tests. Operators, however, generally exercise the same care whenever the machine is exposed to moisture as is used at the time of the original drying operation.

Further, operators emphasize that water damage is not limited to the effect on the wiring. The machine must be carefully examined to ensure

Fig. 2. Carbon dioxide cylinders. The initial bank is in the foreground, the reserve bank in the background.



that bearing and machined metal surfaces are free of rust and other foreign matter. These operations all take time, with a resulting extension of the shut-down period and an increase in the indirect costs due to lost capacity.

Operators' Opinions

Many operators favour carbon dioxide to water, because they feel that automatic operation of the extinguishing system is mandatory to control the spread of fire within the windings. They consider the introduction of water undesirable, particularly if automatic actuation is provided.

For machines of 20,000 kva. or more, automatic systems are preferred. For small machines, the carbon dioxide can be applied using portable or wheeled extinguishers, or by manually-operated carbon dioxide hose-reel systems. The preference for automatic systems has extended to the point of reworking open-type or semi-enclosed equipment with forced ventilation, into closed systems, so that automatic-flooding carbon dioxide systems may be installed.

One usually forgotten advantage, operators point out, is the reduced insurance cost, which in the long run compensates for increased initial outlay. Insurance Underwriter make the following provision in their schedules for generating stations:

(A) Reduced premium rates when fixed steam systems are installed, or where the interior of the machine is accessible, when approved portable extinguishers are provided in quantity as required by the rating authority.

(B) Additional reductions when internal water spray or manually-operated carbon dioxide fire extinguishing systems are installed.

(C) Further reductions when automatically-actuated carbon dioxide systems are installed.

Thus the owner who installs approved built-in fire extinguishing systems enjoys an advantage as he negotiates his insurance rates from year to year as well as continuous peace of mind.

Water vs. Carbon Dioxide

Disadvantages of Water:

1. Only manual operation is normally furnished;

2. Generally, operators will discharge a water extinguishing system only when they are positive that there is fire which cannot be otherwise extinguished and only after the machine has been de-energized and there is no risk of the electrically conductive water causing a further short. Such delay increases the spread of fire;

3. Extensive cost (a) incurred in putting the machine back in operation after discharge of the system and (b) through interruption production during the shut-down;

4. No basic system design data. Water is discharged until operating or fire-control personnel judge that the outbreak is under control;

5. Water cannot penetrate windings to reach fire in interior coils, hence complete extinguishment depends on the cooling effect of externally applied water;

6. For modern, remotely controlled generating stations, any automatically operated water system would require automatic shut-off, since otherwise the deluge system would have to be shut off by someone lacking positive knowledge as to whether the fire is under control;

7. Repeated wetting and drying of machine windings is objectionable. Therefore it is not desirable to run proof tests, either after completion of installation or at periodical intervals thereafter. Consequently the effectiveness of any system is established only after it has been used to extinguish a fire.

Advantages of Water System:

1. There is usually a continuous, inexhaustable supply of extinguishant except where the supply is restricted to a water storage tank which must supply water for other service in the plant, or where the water supply is dependent on motor driven pumps that draw their power from a generator involved in the fire;

2. Total enclosure of the machine is not required;

3. Water will ordinarily extinguish and prevent re-ignition during the deceleration of the machine, provided that the fire is confined to exposed windings;

4 Almost unlimited cooling effect.

Disadvantages of Carbon Dioxide:

1. Requires total enclosure of the machine, for automatic built-in protection;

2. The quantity of carbon dioxide is limited to the available stored supply based on established design requirements;

A connected reserve bank can be furnished and is usually specified for multiple hazard protection;

3. Cooling effect is less than water.

Advantages of Carbon Dioxide:

1. Adequate design data is available based on proof tests and on results of positive extinguishment of fires in rotating electrical machines;

2. System can be discharged automatically;

3. If system is discharged automatically by differential relay actuation due to momentary power surge but no fire, no harm is done;

4. Non-damaging, i.e. no wetting action, no corrosive action, and no moisture deposits on delicate parts of machine.

5. Wind currents created by rotor in motion, help to distribute the carbon dioxide gas to insure complete penetration of all windings;

6. Decreased shut-down time after a fire or threat of a fire;

7. Complete discharge tests to verify that the fire extinguishing system is in perfect operating condition, can be run periodically without extended shut-down, since cleaning and drying are unnecessary after use;

8. Concentration tests can be run after installation to check distribution of carbon dioxide and verify that the desired dilution of air is achieved throughout the machine;

9. Carbon dioxide is stored under pressure ready for use. Pumps or other mechanical equipment are not required to pressurize the discharge system;

10. Carbon dioxide is a non-conductor of electricity, hence it is not necessary to de-energize the machine before carbon dioxide is discharged within it;

11. Carbon dioxide can be stored indefinitely without deterioration.

Costs

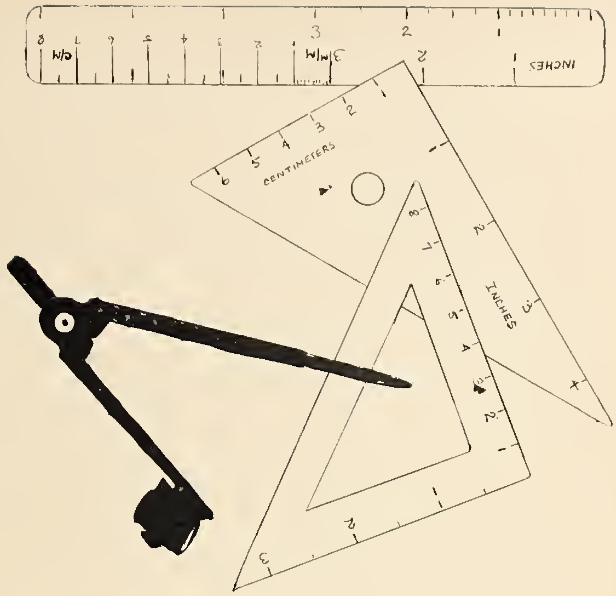
No paper of this type would be complete without data on comparative costs. A study of a recent project revealed that, based on protecting a bank of five generators each of 40,000 kva. and valued at $450,000 per machine, the cost of equipment for a water installation with automatic actuation (but no automatic shut-off after extinguishment) would be in the neighbourhood of $2,200 per machine. The cost of equipment for a built-in automatic carbon dioxide system having a main and reserve bank would be $2,600 per machine.

Conclusion

This paper has attempted to establish that, in the possibility of a serious fire when discharge of a *manually* operated system is delayed, the carbon dioxide system has the advantage in that it prevents or greatly reduces damage from possible ignition and permits immediate operation after inspection.

Finally, because of the costs inherent in drying after discharge, water system are usualy manually controlled. This introduces an intangible factor in the form of human error. As with all intangibles, the assessment and control of this factor are almost impossible.

THE *CRISIS* IN MEASUREMENT



L. E. Howlett
Director, Division of Applied Physics,
National Research Council, Ottawa.

Many of man's developments depend upon his ability to measure — and to corelate these measurements. Measurement qualifies as a keystone of man's civilization. Lack of conformity is a crisis.

EVEN superficial consideration of man's history suggests that his degree of civilization is directly proportional to his understanding and command of the world around him and that these accomplishments depend on his ability to measure the phenomena that he observes, and subsequently to relate them. Thus, measurement qualifies as one of the keystones of civilization. This conclusion makes it of considerable interest to take a survey of the history of measurement, analyze the philosophical principles involved and make an appraisal of where we stand today in such a fundamental field.

The urgent importance to make measurements in every field of human endeavor is probably the principal reason why the human race has developed through the ages such a startling hodge podge of units, standards and methods of measurement. Contradictory and unrelated units have grown everywhere to meet special and local needs in various activities because the devising of some sort of reference frame for measurement is essential before development can take place. Thus we had goldsmiths developing a number of systems of weights and measures; farmers developed others for their produce; surveyors were not to be outdone. The list is endless. Local borders, as well as national ones, have compounded the confusion. Even science itself has not been blameless. With the passage of time a large number of these variegated systems have become firmly entrenched in sentiment, tradition and familiarity. Some of these arbitrary units were at a later stage sometimes related to each other by direct measurement but this could not overcome the complexity and inconvenience of their use and manipulation which resulted from the way they were established in the first place. Once a system is well established in a particular area of human activity those who use it always howl rage and shock at the thought of change, quoting the cost and inconvenience involved without a thought for the future and the further compounding of confusion and waste.

It seems completely reasonable to us now that length, volume and area should be related in a simple way and very little extra thought shows the advantages of relating mass with length through volume. Nevertheless it is surprising to find that before the French Revolution it was only in ancient Egypt that these simple thoughts were grasped and practised. The Egyptians defined a cubic cubit of water as a talent of mass because they had observed by experiment that the cubic cubit of water always had the same mass. They ignored, it is true, the temperature effect because their methods of measurement were still too crude, but for this reason the effect to them was unimportant. Many of our own measurements — perhaps all — suffer from parallel limitations. Thus it could be said that within their limits of knowledge the ancient Egyptians had a consistent logical and simple system of measurement for mass, length, area and volume.

Having lost the simple Egyptian answer the world had to wait for the fresh, eager approach to reason and rationality, born in the French Revolution and in the logic of the French mind, to produce the metric system, consisting of the metre, the kilogramme, simple multiples and submultiples of these units and a relationship between the metre and the kilogramme through water. There was also an attempt to relate the unit of length to an unchanging natural constant. This failed because of experimental difficulties but was attained last October at the XI Conference on Weights and Measures held at Paris. The standard for the metre was not, however, related, as its founders hoped, to the circumference of the earth but to a particular wavelength of light emitted by an unperturbed atom of Krypton 86.

The metric system as proposed initially was, by today's standards, not a satisfactorily comprehensive system of measurement. It coped quite conveniently with length, area, volume, mass and any quantity which was a combination of these quantities, but not so conveniently with quantities such as force, electricity, temperature, brightness, and velocity. It was English scientists in the early 18th century who made the first desirable extension of the metric system by including another unit, the second, and so created the widely used centimeter, gram, second, system. They preferred to use centimeters and grams instead of meters and kilogrammes for reasons that seemed good and sufficient to them but this deviation is insignificant compared with the concept of introducing an extra unit of time to permit convenient measurement of a greater variety of phenomena including force, velocity, and momentum. At that time England could have gone over wholly to this extended metric system, at minimum economic cost and with great benefit to the budding industrial revolution and the development of engineering. However, England was proudly developing as a world power and this naturally did nothing to reduce her pride in and her attachment for her traditional national units. Further, the memory of the recent long and costly war with Napoleonic France did little to make generally popular anything of French origin. Therefore in spite of considerations of logic, simplicity and convenience the ancient systems of English measure continued not only to maintain their position in the everyday world but to improve and consolidate it.

In 1875, France called a very important international meeting in Paris that had as its aim the unification of international measurements and the promotion of the use of the metric system. The culmination was the signing of the Convention du Mètre. Among other things this treaty provided for a meeting of an international conference on weights and measures in Paris every six years, an international laboratory — the International Bureau of Weights and Measures, at Sèvres — and an executive — the International Committee on Weights and Measures — to direct international metrological activities between general conferences. This Convention is in force to this day and has been the greatest single influence in unifying measurement both in science and at the practical level. Initially the Convention covered only length and mass but was revised in 1921 to include electricity, photometry, thermometry and the establishment of physical constants needed for improving the accuracy and precision of the measurement standards. The Convention will probably be revised again in the near future to include fundamental units and standards for x-rays and nuclear radiations.

It is interesting to note that in the United States, from the American Revolution onwards, there was always a significant interest in the use of the metric system. The principal obstacle to its adoption in early days may well have been some question as to whether it might not ultimately disappear with other inovations of the French Revolution. In the last days of the 19th century this interest had developed to the point where the demand for a change-over to the metric system had become very great. By 1902 it was admitted by even the opponents of this step that a Bill then before the Congress, sponsored by Congressman Southard of Ohio to replace the English system by the metric system, would pass with a large majority. At the last moment, to the surprise of all, he withdrew the Bill. His later explanation was that he wished to persuade opponents rather than force a minority to an undesired action. However, the opportunity once lost was lost for many years because America was at that time industralizing rapidly and with each step the change became more costly and opposition to change became correspondingly greater.

This very brief historical account suggests how confused and arbitrary has been the approach to measurement throughout most of human history. We have already suggested that the very importance of measurement almost ensured such a condition in the absence of rapid means of communication. Be that as it may it is certainly only during the last 75 years that there has developed a degree of international agreement not only on common units but also as to what comprises a logical philosophical approach to the design of a system of measurement in order that we may have the simplest and most convenient framework on which to hang all our measurements. Clearly the closer we come to such an ideal the easier and more convenient it will be to make progress in scientific research or, for that matter, in any human endeavor.

We will now leave the history of the measurement muddle and take a look at the problem from what we may call a modern viewpoint. We shall try to build what we want from first principles without prejudice, if that is possible, from what has gone before. The Italian physicist Georgi did this at the beginning of the century.

We are confronted in the world about us by a great variety of quantities which must be measured if we are to develop a framework of physical laws. These are quantities such as length, time, mass, force, velocity, momentum, electric current, brightness, temperature, and radiation. We can call these quantities dimensions. We could obviously define an independent unit of measurement for all these dimensions but we would be reluctant to do so. The system would be too cumbersome. On the other hand we could base a system of measurement on only one dimension but we would reject this also as being rather inconvenient and artificial. In the light of the very distinguishable physical phenomena involved we would rather have for convenience, or perhaps for reasons largely of common sense, an adequate but minimum number of dimensions for which to establish measurement units with which we could, in combination with the laws of physics, measure any desired dimension. These chosen basic dimensions should be ones for which we have developed measuring techniques of the highest percentage precision and accuracy in order to keep our whole fabric of measurement as precise and accurate as we can.

Thus, it is apparent in the modern view that the reasons for selecting a group of dimensions to form the basis of a general measuring system are entirely pragmatic. This concept has not by any means always been clearly recognized. There have been interminable arguments that some dimensions are more fundamental in some sort of absolute sense than others. Arguments have at times bordered on the realm of mysticism rather than physical science. Preoccupation with the conservation of energy and the very successful development of generalized mechanics during the 19th century created a desire on the part of some physicists to attribute a special fundamental significance to the dimensions, length, mass and time. This outlook was probably largely responsible for the fact that when the theory of electricity was worked out there seemed to be no inclination to add an electrical dimension to the basic dimensions of length, mass and time for the same reason that English scientists had earlier added the dimension of time to the two original metric dimensions. Instead, electrical units were awkwardly expressed in terms of the three so-called fundamental dimensions length, mass and time. It also seemed to escape the notice of some hat the awkward fractional indices which appeared in electrical dimensional equations were no more than a natural result of using an awkward number of basic dimensions for the measuring system. Similar natural but somewhat startling results come from other choices. The astronomers, for good and sufficient reasons of their own, have used a measuring system in which the basic units are L and T with G the gravitational constant made equal to 1. This leads to mass being expressed as L^3T^{-2} which suggests the interesting possibility of measuring mass as cubic miles per hour per hour.

Such results are hardly justification for the philosophical discussions that at times have surrounded the choice and significance of the primary dimensions of a system. When the Italian physicist Giorgi introduced this modern approach to the problem he ended the 19th century's exclusive preoccupation with L.M.&T. He suggested that, because electricity presented a new group of physical phenomena quite distinguishable in intrinsic character from those of mechanics, it was sensible and convenient to add an electrical dimension to the length, mass and time group. He further indicated that the particular choice of electrical dimension was not important except for the usual reasons that should govern the choice of a basic dimension. The significance and value of his proposal was quickly recognized but physicists discussed it for nearly 50 years during which time it was further suggested that for the same reasons that the electrical dimension and the time dimension were added to length and mass two more basic dimensions were required to cover the distinguishable phenomena of temperature and photometry. Finally in 1954, the 10th International Conference of Weights and Measures meeting at Paris chose the dimensions, length, mass, time, current, temperature and luminous intensity to be the basis of an international measurement system called the International System of Units.

At the same time that the 10th International Conference chose these basic dimensions it also established units of measurement for each. These were and, of course, still are metre, kilogramme, second, ampere, degree Kelvin and candela. To establish the value of these units and to ensure their preservation standards for each were also defined. The metre is defined in terms of a special wavelength of Krypton 86. The kilogram is preserved by a platinum iridium mass held in the vaults of the International Bureau of Weights and Measures at Sèvres, France. The ampere was defined theoretically in terms of the force between two parallel infinitely long wires carrying an ampere. The degree Kelvin was defined by assigning a thermodynamic temperature of 273.16°K to the triple point of water. The unit of luminous intensity, the candela, was established by defining the brightness of a black body at the temperature of melting platinum as 60 candela per sq. cm. This system is a natural development from and a very material improvement over the metric system of the French Revolution.

At this stage of our discussion it might be pointed out that the Procès-Verbaux of the International Conferences on Weights and Measures, the meetings of the International Committee on Weights and Measures and those of the Consultative Committees of the latter provide a very rich source of information on measurement units, standards and the wealth of research that has gone into this field. Unfortunately these references are not too familiar to a great many physicists and engineers.

One more point about the international system of units should be mentioned. When Giorgi first proposed the addition of an electrical dimension he pointed out that if for example electric current were the chosen dimension, its unit — the absolute ampere — defined in terms of a force expressed in metres, kilogrammes and seconds, was very closely equal to the practical unit, the International ampere, which had been well established for some time on an arbitrary basis. Thus the unit of current could be placed on a fundamental basis instead of an arbitrary one without significant loss of continuity in the ampere. The absolute ampere as well as the candela were adopted officially by the Ninth International Conference on Weights and Measures in 1948.

The measurement system of Giorgi is often called the M.K.S.A. system or, more briefly, the M.K.S. system. Since there is literature on the subject which is misleading it is well to point out here that the two distinguishing marks of the M.K.S. system are

(1) the use of length, mass, time and an electric dimension as basic dimensions and

(2) the use of metre, kilogramme, second and ampere as units.

There is no necessary connection between the M.K.S. system and rationalization — an arithmetic artifice which changes the positions of 4π in the electromagnetic equations. The M.K.S. system like any other system can be rationalized or not depending on whether the user considers rationalization a simplification, as do most, or unnecessary as some still do.

Although the International System of Units is accepted without regard to national barriers by the scientific world the same is not true in the every-day world. Since the beginning of industrialization the ordinary industrial and commercial world has hardened into two camps, the English-speaking countries and their dependencies with the English system of measurement on one hand, and the majority of the other countries with the metric system on the other. Because of the industrial power and foreign trade of the English speaking countries the English system has to date much more than held its own in spite of the fact that it is awkward, inconvenient and illogical. On occasion groups in the English speaking world have pushed for the adoption of the metric system but they have generally been laughed out of court as longhairs who did not understand the economic facts of life and the tremendous cost that they were proposing for industry on the basis of what seemed to the industrialist a collection of scientific and academic niceties. In other words industrial strength overwhelmed logic, simplicity and convenience and none of the movements for change either in the United Kingdom or the United States have to date been able to get off the ground. The world of 1961, however, is a very different one and is likely to become more so very quickly. A real crisis confronts the users of the English system.

Today, the English speaking world using the English system of measurement is becoming proportionately a smaller and smaller island in a growing sea of metric system. The industrial development of metric Russia has changed immeasurable the influence of metric Europe in the last 40 years. India has just adopted the metric system and it became obligatory in Japan in 1959. Red China is using the metric system and will no doubt in the near future join the Convention du Mètre. These changes in the balance between the users of the English and metric systems are very formidable and cannot but affect world trade. To these accomplished facts can be added that it is only reasonable to suppose that the new countries of Africa and Asia, as they rise from colonial status, will adopt the elegant metric system in the absence of prejudice coming from economic or sentimental reasons. In the case of those developing from the colonies of European metric countries the metric system already has roots. Therefore it requires no crystal ball to see that what might be called the unfair dominance of the English system through trading and industrial capacity is rapidly becoming a thing of the past. It seems unbelievable that the new countries starting out on a basis of the metric system will wish indefinitely to introduce confusion into their developing economies by the acquisition of capital and other goods based on a system of measurement in conflict with their own when there will be substantial sources of similar goods in the metric area of the world either on this side or the other of the political boundaries between the East and West.

The undercurrent of strength which the trend to the metric system possesses at the present time, despite all the deep-rooted prejudices that still exist, can be detected in a recent development within the area using the English measure. The American yard and pound have been related to the metre and kilogramme since 1893 by equivalence ratios. There have been no particular physical standards which could be pointed out as the legal American yard and pound. In England it was otherwise — the physical entities, the Imperial yard and Imperial pound, were the standards. In 1893 these physical standards were identical to the American yard and pound defined by ratios. Since then, however, the Imperial pound and the Imperial yard, following the way of most flesh, changed in size so that small but industrially significant discrepancies developed between the United Kingdom units and American units. In Canada in 1951, the Canadian yard and Canadian pound were legally related by ratios to the metre and the kilogramme thus displacing the previous physical standards, the so-called Parliamentary copies of the Imperial standards of the United Kingdom. In 1959 the Commonwealth countries and the United States decided to remove discrepancies between their units to do away with troublesome industrial problems. They agreed on a definition for an International yard and an International pound which tied these units by ratios to the metre and the kilogramme. These units will be used for all commercial and industrial purposes in the Commonwealth (except metric India) and the United States. Thus the whole world now derives its units of measurement of length and mass from the metre and kilogramme prototypes held at Sèvres. The peculiarity of the Commonwealth and the United States is their current insistence on working with units established from these by ratios that are not simple; they then compound the folly by using multiples and submultiples that are also inconvenient. One thing, however, is now simple— one inch is exactly 2.54 cm! The displacement of the physical Imperial yard and Imperial pound as the basis of the English system in the United Kingdom would have been unthinkable in the heyday of the English system because of the loss of prestige by the tacit acknowledgment of the superior permanence of the metric standards, but the need for uniformity in precise measurements for international trade can be no longer ignored.

Trading nations using the English system of measurement already have grounds for very serious thought. The United Kingdom and the United States are already giving such thought to the problem. On this occasion it is not the longhairs who are concerned but the legislators, the industrialists and the traders. The study has been going on intensively in the United Kingdom for some 10 years. A Committee of the British Parliament reported favorably in the early fifties on a changeover to metric units to take place over several decades. Currently the British Association for the Advancement of Science, in co-operation with British industry, is endeavouring to count the cost of a change-over. In the United States the American Association for the Advancement of Science is undertaking similar enquiries and more recently steps have been taken to set up an investigating committee under the authority of the Congress to the same end. This committee is to report within four years. These various activities may not as yet foreshadow early action on a change-over but they do emphasize an entirely different attitude to the whole problem than that which has existed at any previous time. Fear is in the air about ability to maintain indefinitely foreign markets when using an archaic measurement system when the rest of the world has gone metric. Such fear of financial loss can be very effective in clearing prejudices. Sentimental attachment to a historical and traditional system can quickly take second place to expediency when financial loss is involved.

If a change-over to the metric system is to be dictated by the need to survive in international trade there are clearly many complex problems involved. They need ample study to minimize cost and confusion. It is a matter of grave concern that such studies are not being conducted in Canada as they are in the United Kingdom and the United States. It is a study that must be made by very diversified groups that constitute a cross section of our economy and its interests. If I may venture to say so the Engineering Institute of Canada, representing as it does both management and engineering, would seem one very appropriate body to set up a committee to make a twofold study to (1) keep closely abreast of the results and the thinking in the similar investigations going on in the United Kingdom and the United States and (2) uncover and study any problems that may be peculiar to Canada in any eventual change-over. With the unfavorable export balance that Canada possesses at the present time it would seem that any factor bearing on foreign trade is of great importance and deserves the closest study. The measurement problem is soon likely to be of greater significance rather than less.

There is another factor which justifies early consideration. A final legal change-over would probably have to be done concurrently with the Commonwealth and the United States. This leaves the ultimate initiative to the more powerful members of the measurement block. However, the problems of the coming years may not necessarily involve an all-or-nothing solution. If there were revealed by investigation any evidence that Canadian export trade in a particular area could profit by the use of the metric system it would be only sensible to start employment of it immediately. The metric system has been legal in Canada since 1871, so in this respect there are no impediments. Even in an ultimate complete change-over it is inevitable that both systems would have to exist side by side for a number of years. There may very well be a great many areas where we could do something parallel to that done by the manufacturers of scales in the metric countries of Japan and Germany. They sell us scales calibrated in the English system on one side and the metric on the other.

I hope very much that this brief and very incomplete presentation of a few of the aspects of this crisis in measurement will do a little to stimulate serious studies of where we are going as a nation in this fundamentally important area, what problems we will meet, what we can do about them, and when. EIC

CONCRETE ARCH BRIDGE AT HARTLAND, NEW BRUNSWICK

E. van Walsum, Jr., M.E.I.C.
Project Engineer, Foundation of Canada Engineering Corporation Limited, Montreal

T. J. Sluymer, Jr., M.E.I.C.
Design Engineer, Foundation of Canada Engineering Corporation Limited

A RATHER striking looking series of reinforced concrete arches near Hartland, N.B., was completed in the early summer of 1960 as part of the Trans-Canada Highway program.

The Department of Public Works of New Brunswick retained our company in June 1956 to make engineering studies for a proposed bridge carrying the Trans-Canada Highway over the Saint John River at Hartland.

Design Criteria

The design was governed by the Department's specifications which required a roadway of 26 ft. width, with safety curbs 9 in. high and 2 ft. wide on each side of the road. The structure was to be designed for H20-S16 truck loading or the CSA U-100 uniform live loading, whichever was governing.

Site

The location of the proposed bridge was chosen by the Department of Public Works of New Brunswick, some 3,500 ft. upstream from the longest covered bridge in the world, crossing the Saint John River at Hartland. The proximity of this famous old bridge was a challenge to create an attractive modern structure.

The Saint John River at Hartland is closed in by steep banks on both sides. The old road followed the curves of the river close to the river banks. The new alignment of the Trans-Canada Highway, however, was chosen to run through the hills. The centreline of the bridge, as established by the New Brunswick Highways Department, was virtually perpendicular to the main channel of the river and passed between two wooded islands, one just upstream and the other just downstream of the site.

Since the Trans-Canada Highway was projected to run through the hills on both east and west banks, the road level of the bridge was to be approximately 100 ft. above the average river bed. The deck was to have a grade of 1%, sloping up to the east. On the east side of the river, the structure was to pass over a single CPR track and N.B. Highway No. 2.

Hydrography

River flows in the Saint John River near Hartland vary between 5,000 and 245,000 c.f.s. Normally, the depth of water in the river averages about 3 ft. during two 3-month periods of the year, i.e., during Janauary, February and March, and during July, August and September.

During October, November and December, work in the river is possible although difficult due to increased flow. During April, May and June, work in the river is virtually impossible. The water levels fluctuate between an extreme low of 126 ft. and an extreme high of 157 ft.

Soil Investigation

A soil investigation, carried out during October and November 1956, showed foundation conditions to be excellent. Either bedrock or a dense grey till bearing stratum was present at depths of 5 to 45 ft. under the river bed. The overburden on these bearing strata consisted of a 5 to 10 ft. layer of loose to compact silty sand and gravel and for the remaining depth of compact silty sand.

Preliminary Design

Under the given conditions, a great number of alternative solutions would have been possible. The two alternatives which were most closely examined were a scheme of concrete arches (Fig. 1), and a scheme of steel deck truss spans (Fig. 2). According to preliminary estimates, the initial cost of the steel scheme would have been slightly less than that of the concrete arch scheme. Notwithstanding this difference in cost, the more expensive concrete scheme was recommended primarily on the basis of availability in the area of an abundant supply of labour, lumber, sand, gravel, reinforcing steel and cement. Good sand and gravel was present right at the bridge site. Other factors in favour of the concrete scheme were appearance and maintenance.

The recommendation to build the bridge as a series of concrete arches was accepted, so we proceeded with this scheme.

Due to the favourable soil conditions, the design of the substructure was relatively simple. The layers of sand and gravel and of compact silty sand which covered the bearing strata had N values varying between 10 and 160. In order to penetrate the very dense layers in this overburden, it was decided to use steel H bearing piles. The main features of a typical pier are illustrated in Fig. 3. The wide base of the piers was kept underground for aesthetic reasons. This base was made of Prepakt concrete placed within a steel sheet pile cofferdam. Piers 2 and 4 were made extra strong to withstand large horizontal thrusts during construction as will be discussed in more detail later. The main features of piers 2 and 4 are shown in Fig. 4.

When designing a series of concrete arches, it would seem logical to make all arches identical. In the case at hand, however, the roadway was to have a 1% grade. For aesthetic reasons it was decided to let the crown of all arches follow the 1% grade of the roadway, and to keep the spring lines of all arches in the same horizontal level. Thus all arches had different heights, spans and height-to-span ratios, but all arches were cut from the same parabola (Fig. 5). By cutting the various arches from the same parabolic shape, a great deal of re-use of forms and scaffolds was made possible and the computations were simplified.

Another basically important factor which had to be considered was whether the arches should be rigid or hinged, and, if hinged, to what degree.

A point in favour of hinges is that they make computations simple. To a certain extent hinges even make the computations more reliable in that they give the designer the advantage of knowing that the moments at hinges are zero or at least negligible.

From a construction point of view, hinges can be highly advantageous in certain cases if such hinges allow the use of precasting techniques. At this site, and with the size of arches under consideration, precasting of the arches was not practical. The use of hinges would therefore have no advantages from a construction point of view, while it would have the disadvantage of requiring some complicated details. It was therefore concluded that construction would be simplified by the elimination of hinges.

From a design point of view, it should be noted that a statically indeterminate structure has a great deal of reserve strength. Each hinge which might have been put in the arches would have reduced this reserve strength. This, therefore, is another reason for eliminating as many hinges as possible.

In certain cases, hinges may be used to advantage to relieve stresses, caused by such conditions as settlement of foundations, and temperature changes. Due to the excellent foundation conditions in this instance, however, settlements of appreciable magnitude will not occur. The magnitude of temperature-, shrinkage- and creep-stresses was limited by giving the arches a slender shape; rather than using two arch ribs per span, one slender arch barrel was used for each arch.

It was therefore concluded that the arches were to be fully fixed.

Serious consideration was still given to the possibility of using a *temporary hinge* at the crown of the arches. By placing some hydraulic jacks in the crown of the arches, it would have been possible to adjust the thrusts and moments throughout the arches. It was found, however, that the use of such jacks would have altered the stress condition at one point to advantage, but to equal disadvantage elsewhere in the arch. This was ample reason to eliminate this refinement.

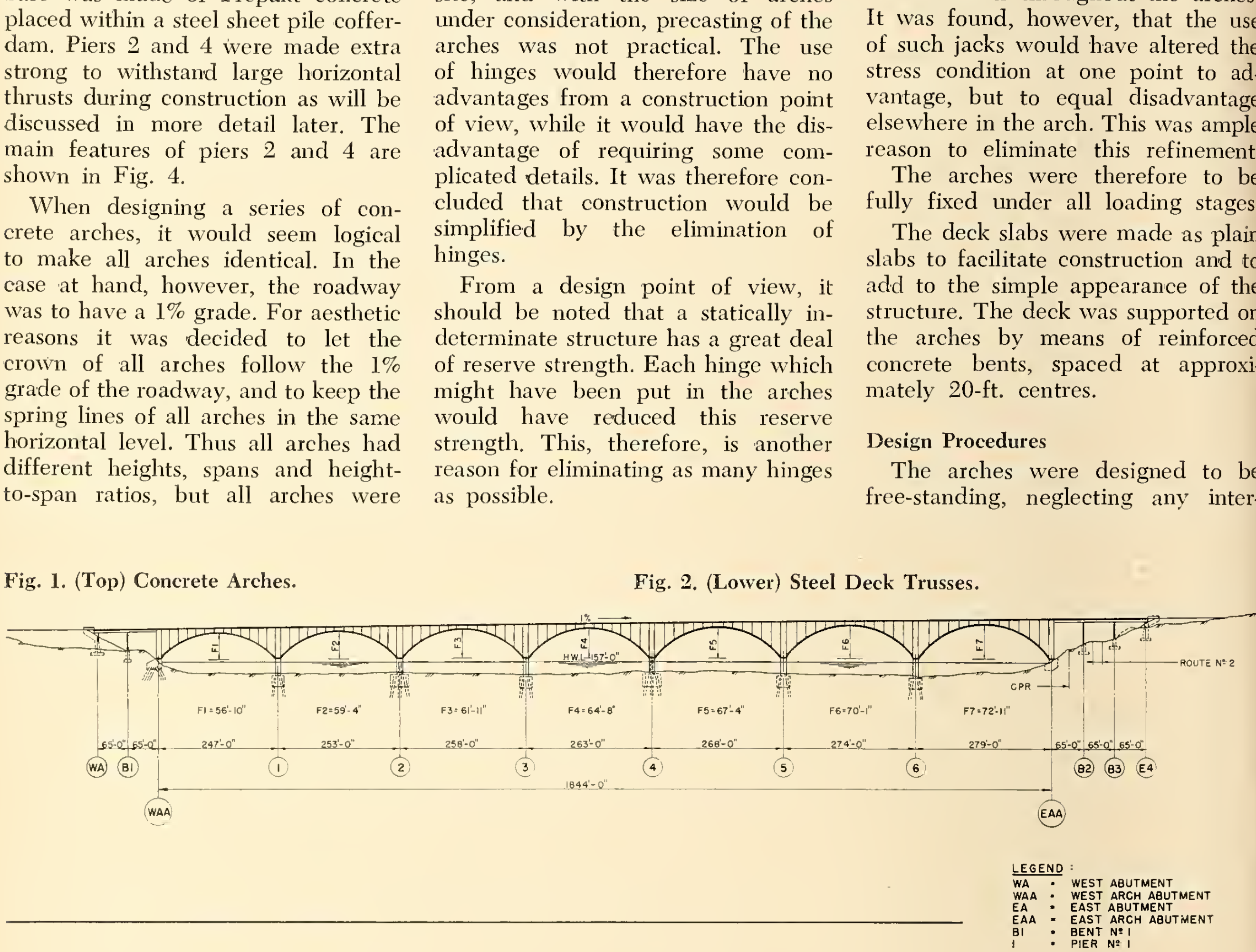
The arches were therefore to be fully fixed under all loading stages.

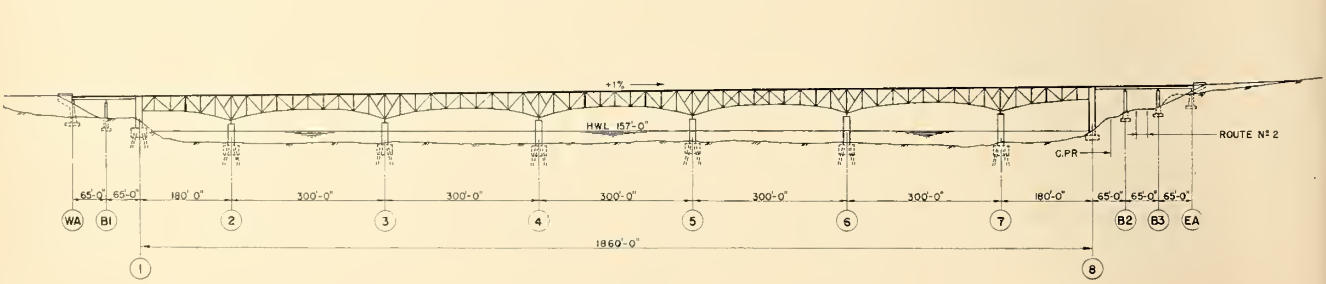
The deck slabs were made as plain slabs to facilitate construction and to add to the simple appearance of the structure. The deck was supported on the arches by means of reinforced concrete bents, spaced at approximately 20-ft. centres.

Design Procedures

The arches were designed to be free-standing, neglecting any inter-

Fig. 1. (Top) Concrete Arches. **Fig. 2. (Lower) Steel Deck Trusses.**





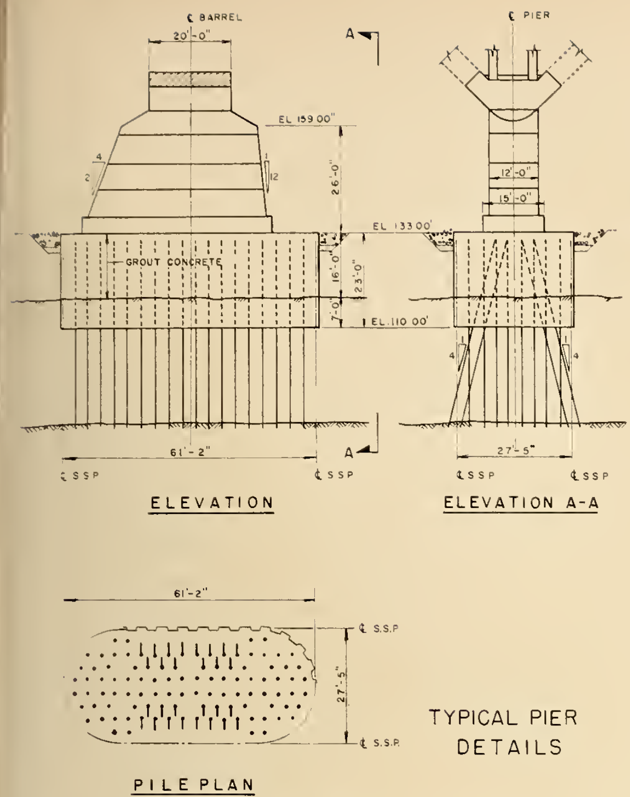


Fig. 3. Typical Pier (Piers 1, 3, 5 and 6).

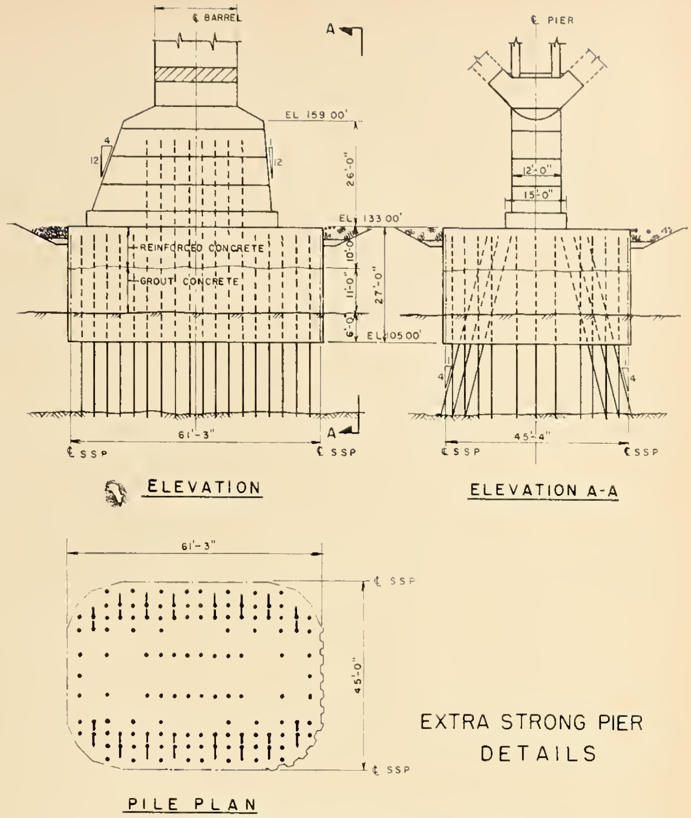


Fig. 4. Extra Strong Pier (Piers 2 and 4).

action between arch and deck. Neglecting this interaction was justified since the stiffness of the deck is about 1/30th that of the arches at the crown. Moreover, the most unfavourable loading of the arches occurred during construction, when the concrete bents were in place and the decks were being poured. During this governing stage it was impossible to count on the deck for stiffness.

The cross section of the arches varies so that the vertical projection of the arch thickness is constant at 3 ft.-6 in. (Fig. 6). The weight of the arches was reduced by approximately 20% by the use of cylindrical voids (Fig. 7).

The expansion of the deck was provided for by expansion joints in the deck above each pier.

Basic Formulae

The free-standing arch as adopted for this design is three times statically indeterminate. The three indeterminates were chosen at the elastic centre as shown in Fig. 8. From these basic formulae the stress distributions under different loading conditions were derived. The above formulae are based on deflections of the arches, due to bending only.

The normal forces in the arches cause a shortening of the arches. The M, N and V resulting from the arch shortening were computed separately. The influence on the stress distribution of deformations due to shear was neglected. This simplification is justified in this type of arch design since the line of compression of the arches follows more or less the parabolic centre line of the arches. The shear forces are therefore small under all conditions of loading and no appreciable forces are induced due to shear deformations.

Dead Load

Any deviation from the design dimensions of a structure will affect the dead load distribution. Since a contractor cannot build without certain tolerances, the actual weight distribution of a concrete structure is never the same as that assumed in the design. Usually there is no allowance made in a reinforced concrete design for variations in the dead load caused by inaccuracies during construction. This is due to the fact that in most instances a slight deviation from the design dimensions causes only very small additional stresses.

This situation is different, however, with arches. A uniform load on the arches causes no moments at all. Any change in a uniform load distribution, whether it is an increase or a decrease, will cause moments to develop in the arch.

A slight inaccuracy during construction will increase the moments in the arch appreciably. It was therefore assumed in the design that any part of the arch might in reality be 5% heavier than called for on the plans. This additional dead load was referred to as "moving dead load". This "moving dead load" was placed in different positions so as to create the worst stress condition in any one section.

In building the structure, the contractor was restricted to a certain construction procedure which was analyzed in the design. The restrictions which were imposed on the contractor will be discussed later.

Live Load

The CSA U-100 uniform live loading or H20-S16 truck loading was used, whichever was governing. This means that in the design of the arches the CSA U-100 live loading was used, and in the design of the deck the H20-S16 truck loading.

The arches were designed for eight construction stages and the final stage with live load. For each stage the influences of temperature,

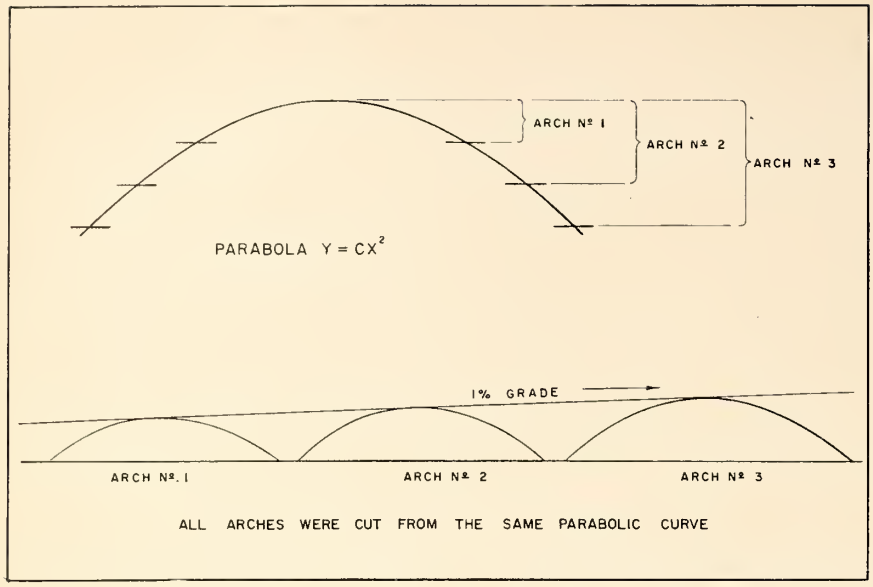


Fig. 5. All arches were cut from the same parabolic shape.

shrinkage, elastic deformation, plastic deformation, wind and assumed foundation settlement were analyzed. Also the stability of the arches was analyzed for each of the above stages of construction. The following assumptions formed the basis of these analyses.

Temperature and Shrinkage

Seasonal temperature rise of 35°F.

Seasonal temperature drop of 55°F.

Daily temperature variation of 20°F difference in temperature between top and bottom of barrel.

For the reinforced concrete of the arches a shrinkage strain of .0003 was assumed.

Elastic and Plastic Deformations

The instantaneous modulus of elasticity of the concrete was assumed to be 4×10^6 p.s.i., referred to as E_1. The creep was assumed to be 2.5 times as large as the instantaneous, elastic deformation. In other words, the modulus of "elasticity" for long time loadings was assumed to be

$$\frac{4 \times 10^6}{3.5} = 1.14 \times 10^6 \text{ p.s.i., referred}$$

to as E_2.

The arch deformation due to the dead load of the structure was computed using E_2, the modulus of elasticity for long time loading. The arch deformation due to live loading was computed using the instantaneous modulus of elasticity E_1. In computing the moments, shears and normal forces which result from these arch deformations, the same variations in the modulus of elasticity were adopted.

The moments, shears and normal forces resulting from arch shortening due to shrinkage were computed using the modulus of elasticity for long time loading E_2. Arch deformations due to daily temperature changes were analyzed using the instantaneous modulus of elasticity E_1.

In computing the moments, shears and normal forces which result from seasonal temperature changes, a third modulus of elasticity E_3 was used. The value assumed for E_3 was 2.7×10^6 p.s.i.

Wind

The wind forces which were assumed in this design were 50 p.s.f. This wind force was assumed to act parallel to the centre line of the structure on twice the area as seen in this direction and perpendicular to the centre line of the structure on 1½ times the area seen in that direction.

Settlement of Foundations

Horizontal, vertical and rotational movements of the foundations were considered. The foundation settlements which were taken into account were computed from the elastic deformations of the foundation piles, assuming that these piles were driven to unyielding rock and neglecting the support which the glacial till provides directly to the structure. Vertical differential foundation settlements have very little effect on the stresses in the arches. However, rotations and movements due to lateral thrust may induce considerable stresses.

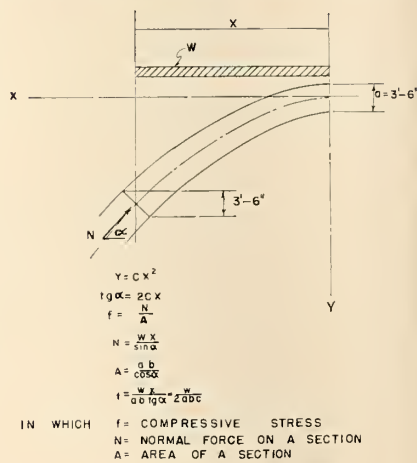
Secondary Stresses

In computing stresses caused by the several factors as discussed above, the arches were assumed to maintain a truly parabolic shape. In reality, however, the arches will deflect and therefore deviate from the parabolic shape. The deflection in any one point of an arch times the thrust at such point results in a moment. Such moments are to be corrected for the influence of the redundant reactions. After this first cycle in the computation of the secondary stresses is completed, the deflections caused by these newly established moments can be computed again and a second cycle of computations of the secondary stresses can be made. This can be repeated until the increase in moments between two successive cycles becomes negligible, in which case the series of successive secondary moments is convergent, which is also proof that the arch is stable. In case it is found that the series of successively computed secondary moments is divergent, the arch is unstable and the proportions of the arch have to be revised.

Stability of the Arches

When working on some early trial sections of the arches, it was found that successively computed secondary moments were divergent, which indicated that the arches which were being studied at that time were unstable. To improve the stability, the size of the arches was increased thus increasing not only the stiffness but also the weight. The advantages gained by the increased stiffness were to a great extent lost due to the increased thrusts. To overcome this problem, circular voids, 2 to 3 ft. in diameter, were introduced in the arch cross section, to reduce the weight and therefore the thrusts, without appreciably reducing the stiffness of the arches. The use of these voids is illustrated in Fig. 9. As a final check, the German Specifications "Massive Brücken, Berechnungsgrundlagen",[9] were applied to the arch section

Fig. 6. Vertical projection of the depth of the arches is constant, resulting in uniform stresses under uniform load.



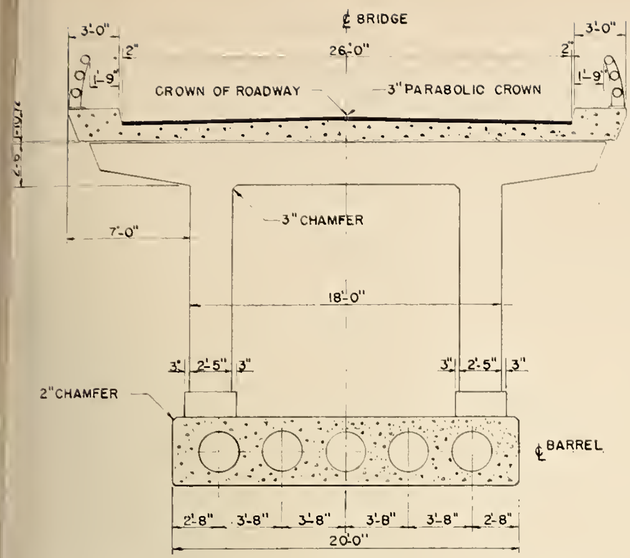


Fig. 7. Typical Cross Section throughout Arch and Deck.

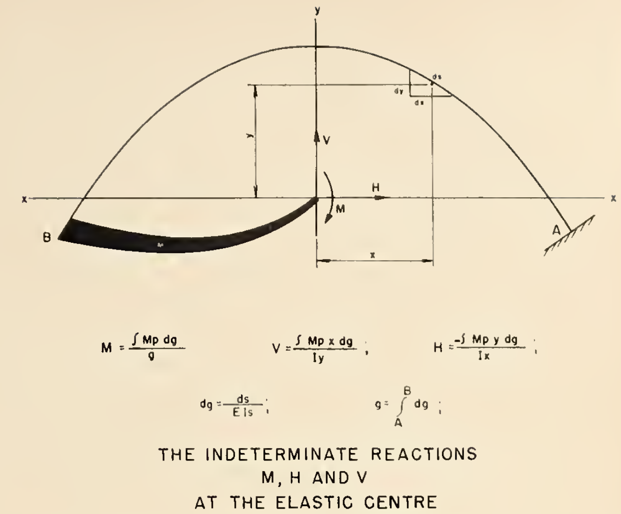


Fig. 8. The indeterminate reactions M, H and V at the elastic centre.

adopted.

Design of the Piers

In the completed structure, the resultant of all forces acting on a pier is virtually a vertical force. The horizontal thrusts from two arches on a pier counteract each other. During construction, however, some of the piers were loaded by an arch barrel from one side only.

One arch exerts, due to its own weight, a horizontal thrust of approximately 800 tons. Our first idea for dealing with such unbalanced forces was to tie the arches back to the west arch abutment by means of cables. Each pier was to be fitted with anchorages for these cables so that any one of the piers could be tied back at any time. This had the advantage that the substructure would not restrict the order in which the arches were to be built.

The disadvantages of the use of cables were that they would be in the way of the contractor and that their stress would have to be checked and adjusted as long as they were in place. There was also the danger that a heavy ice run would result in an ice jam, which might endanger the cables. This last consideration was decisive in abandoning the idea of using cables.

Instead of using cables, piers 2 and 4 were reinforced to resist the unbalanced thrust on their own.

The bases of these piers below ground level were widened from the standard 27 ft.-6 in. to 45 ft.-3 in. (Fig. 4). The steel piles supporting these piers were spread out accordingly and in order to reinforce the shafts of these piers, some of the bearing piles were extended into the shafts. With this arrangement the contractor was required to organize the stripping of the falsework in such a manner that only piers 2 and 4 would at any one time be exposed to unbalanced horizontal thrusts. This also placed on the contractor the requirement of using at least three sets of falsework.

Construction

The construction of this bridge was divided into two contracts:

a) Contract No. 1, for the construction of the complete substructure and the approach spans, and
b) Contract No. 2, for the construction of the arches.

The first contract was awarded in February, 1958, preparations started for the construction in March, 1958.

A concrete plant with two one-half yard mixers was ereeted on sloping terrain on the west bank. The capacity of the plant was at the very best 20 cu. yd. per hour, which was rather low for this type of job. The biggest pours in the first contract were 334 cu. yd. which took approximately 17 hours.

The contractor excavated his sand and gravel by scraper from the river bed and hauled it up the west bank, where it was separated into sand (sizes below ⅜ in.), gravel from ⅜ in. to ¾ in., gravel from ¾ in. to 1½ in. and coarse gravel of 1½ in. and bigger. The coarse gravel was used for grout concrete in the bases of the piers. The fine sand which is required for grout concrete was hauled in separately. The sand and the two remaining gravel sizes were used for reinforced concrete.

The contractor planned to build all piers from causeways. This in itself was a logical decision, since the river bed is very shallow for the better part of the year. The summer of 1958 proved, however, to be extremely wet, so that the contractor had great difficulty to keep the causeways above water.

The progress of the substructure construction in July, 1958, is shown in Fig. 10. On April 4, 1959, all piers were completed except for the last few cu. yd. of pier 6. This pour had to be interrupted on that day due to the rising water level of the Saint John River. The second contract, for the construction of the superstructure, was awarded to the same company whieh started work in July, 1958.

From the unit price bids which were received for this contract, it was clear that the governing factor determining who was to be the successful contractor was the unit price for the falsework.

The bidding highlights for the second contract (superstructure) compare as follows:

	Total bid	*Falsework*	*Total bid less Falsework*
Contractor #1	$1,310,000	$220,000	$1,090,000
Contractor #2	$1,400,000	$340,000	$1,060,000
Contractor #3	$1,570,000	$480,000	$1,090,000

This comparison shows that the differences in the various bids result directly from the differences in cost of the various types of falsework.

The successful contractor had devised a scheme by which the falsework consisted of braced bents at 20 ft. centres. The bents rested on wood piles. The 20 ft. span between bents was bridged by means of a series of plywood box girders. The bents were made up of five verticals of 10 x 10 spruce, with hardwood caps and sills. The plywood box girders consisted of two plywood webs which were glued to the sides of a timber frame. The timber frame was made up of 6 x 6 spruce top and bottom chords interconnected with 6 x 6 spruce verticals. The webs consisted of ½ in. and ⅝ in. plywood. The plywood, glued and nailed to the timber frame, provided the only connection between the members of the frame.

The presence of two "strong piers", piers 2 and 4 as described previously, governed the construction schedule for the arches proper. By November 30, 1958, arch No. 1 was virtually completed. In planning his operations, the contractor had to take into account that the ice could move out as early as the middle of March, 1959. By that time all falsework had to be out of the river and whatever arches were built would have to be able to stand on their own. Only piers 2 and 4 were capable of resisting unbalanced horizontal thrusts from free-standing arches. This meant that by the middle of March, 1959 the construction of the arches had to be completed up to either pier 2 or 4. Therefore the contractor had the choice of building arches 1 and 2, or all of arches 1, 2, 3 and 4 before the freshet.

Due to the slow progress of the substructure, it was considered too much of a risk to try and build the arches up to pier 4 before the freshet. The contractor therefore concentrated on the completion of the substructure during the winter months. When the 1959 spring freshet came on April 4, arches 1 and 2 were completed, all falsework was removed from the river and the substructure was virtually completed. On May 25, 1959, following the freshet, the contractor moved back into the river. During the summer of 1959 all operations went smoothly and efficiently. Progress of the work in June, July and October, 1959 is shown in Figs. 11, 12 and 13 respectively.

The decks on arches 1 and 2 were poured in August, 1959. To avoid unbalanced horizontal forces on pier 1, the deck pours on arches 1 and 2 proceeded symmetrically about pier 1, and to eliminate excessive bending moments in the arches, the pours on each arch proceeded symmetrically about the centre line of each arch as well. The contractor was therefore forced to pour his decks in a rather complicated pattern which, however, did not cause undue difficulties. For supporting the deck forms, the contractor used "span-alls" which proved quite successful.

All concrete work on the structure was completed just before Christmas, 1959. Patching of the holes left by form ties, asphalt paving and installation of railing was done in the early summer of 1960.

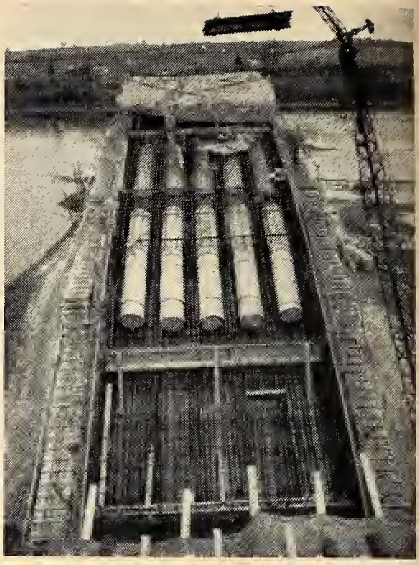


Fig. 9. The arches were made hollow by means of timber barrels. The diameter of the barrels varied from 2 ft. to 3 ft.

Acknowledgments

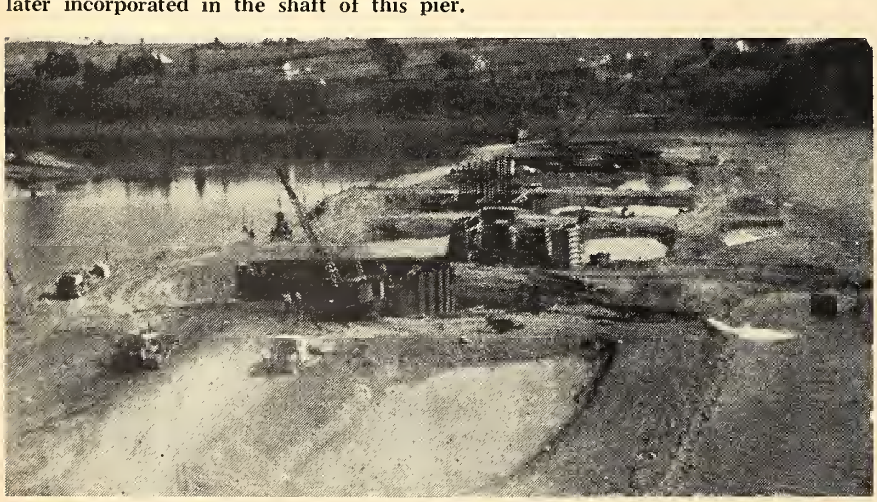
The Province of New Brunswick, in all matters concerning this structure, was represented by the Hon. J. Stewart Brooks, Minister of Public Works; Mr. R. Palmer, Deputy Minister of Public Works; Mr. B. H. Hagerman, Chief Bridge Engineer.

The Development Engineering Branch of the Department of Public Works in Ottawa was represented by Col. V. S. Thompson, then Chief—Structures Division, and by Messrs. G. D. Reid and H. A. Nason, Supervising Engineers, Trans-Canada Highway, during the early and later phases of construction respectively.

Mr. V. Landriault, Atlas Construction Company Limited, was the Project Manager.

This structure was designed in FENCO's Montreal Office through the joint efforts of Mr. Per Hall, President, Mr. D. F. Murphy, Chief Structural Engineer, Mr. T. J. Sluymer, Design Engineer, and E. van Walsum as Project Engineer.

Fig. 10. Construction of Substructure, July 1958. From foreground to rear, cofferdams of piers 1, 2 and 3. The piles protruding from the cofferdam of pier 2 were later incorporated in the shaft of this pier.



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TWO-WAY SLABS and their Supporting Beams

E. M. Rensaa, M.E.I.C.
Rensaa & Minsos, Architects & Consulting Engineers, Edmonton

THE OBJECT of this paper is to give a brief non-mathematical discussion of stress distribution in two-way slabs and their supporting beams. Tables of bending moment coefficients, collected or adapted from other sources, are given. These tables are based on the equations developed by Dr. H. Marcus. A somewhat different form of tables, also based on the equations by Dr. Marcus, are included in the 1960 issue of the National Building Code. This paper is otherwise intended for clarification of that section of the Code and as a brief survey of two-way slab problems. There seems to be a scarcity of literature of this kind. The more scientific approach used in advanced literature is not sufficiently useful for those who have not made a special study of two-way slab theory and have too little time available to do so when a problem is encountered.

The writer was a member of the revision committee who decided to adopt the Marcus theory for the new edition of the National Building Code. It should be pointed out, however, that the responsibility for statements and opinions expressed in this paper are the writer's own and that the opinions may not in every detail be shared by other committee members.

Introduction

The mathematical theory of stress distribution in two-way slabs is quite complex even for a simply supported slab. When, in addition, such slabs are more or less continuous and of variable span ratios, an exact calculation of bending moments and stresses becomes impracticable for design purposes. Many of the most able engineers in Europe beginning with Lagrange in 1813 have worked on these problems and obtained correct solutions for specific cases. Valuable contributions to the theory and its practical application have also been given by North American engineers particularly during the last decades. Among these contributors may be mentioned H. M. Westergaard,[1] S. D. Lash,[2] N. M. Newmark,[3] C. P. Siess,[4] and others. A bibliography on two-way slab publications has been collected by the Department of Civil Engineering, University of Illinois.

An exact mathematical solution generally involves integration of a partial differential equation of the 4th order. Usable particular solutions may also be obtained by dividing the slabs into narrow strips in two directions and writing an equation for each point of intersection of these strips. Since deformation at these intersections are interdependent, a statically indeterminate system will result requiring the solution of a large number of simultaneous equations.

For those who are interested in the study of the mathematical theory of two-way slabs, reference is given to the books by S. Timoshenko and S. Woinowsky-Krieger,[5] H. Marcus,[6] and K. Girkman.[7]

To obtain mathematically correct values of bending moments and shears by means of the theory of elasticity is both difficult and time absorbing. Many attempts have, therefore, been made to work out approximate methods of solution. In order to be usable, such methods should give stresses in substantial agreement with actual ones and should not have too limited applicability. Several such approximate methods have been proposed and used.

Load Distribution from Equal Deflection

An early method of calculating bending moments in two-way slabs was based on the fact that when two centrally located slab strips cross each other, the deflection at the point of intersection must be the same for both strips. Fig. 1 a), b), and c) shows details of this method and formulae for load distribution coefficients for different fixities of supports.

Actual Conditions

The above equal deflection method assumes that the load on each strip is uniform along its complete length. That is not true, however. The load carried by the strip decreases in some manner from the full slab load at the support to a minimum load somewhere near the centre of the span. It is clear that under these circumstances the actual deflection of a slab cannot generally be found by means of an assumed uniform loading along the complete length of the strip. The method gives, however, bending moments that err on the safe side for the ordinary span length ratios of 1 to 2.

The bending moment does not necessarily depend on the actual deflection, but more on the curvature of bending at the section in question. In a very long slab we may have a considerable deflection at the centre of the long span strip, but there will be little or no longitudinal bending moment at the centre of span if there is little or no curvature of bending at that point in the longitudinal direction such as is indicated on Fig. 2. If there is no curvature of bending, there is evidently no longitudinal loading along such part of a strip and this indicates that the complete load on this centre portion is carried by the strip spanning in the transverse direction. However, even in such a case where there may be no two-way slab action at the centre portion of slab, such action will occur near both ends of the long span and the slab will still need reinforcement on these portions. The approximate value of such bending moments is indicated on Fig. 2. The maximum positive bending moment in the longtiudinal direction for a long slab is, according to Dischinger,[8] located at a distance of about lx/4 from the support regardless of support restraint. For a slab with ly/1x = 2 simply supported, Marcus[6] gives the location of maximum positive bending moment from the support as lx/2. This location will likely apply also to slabs with lesser span ratios than 2.

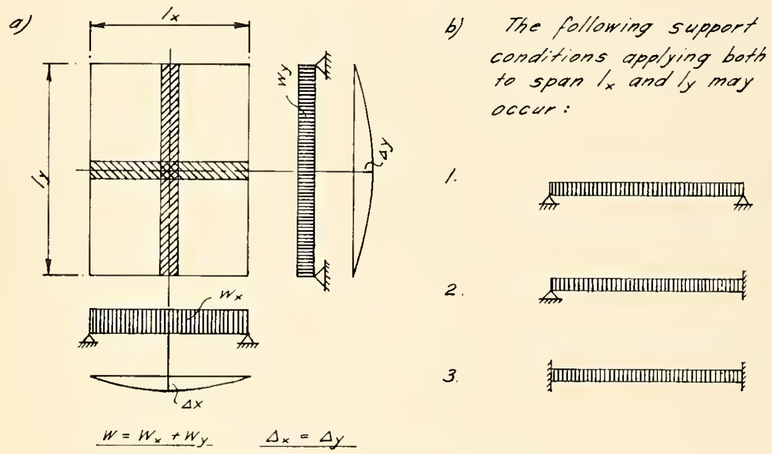
Both the exact and approximate theories assume the material to be homogeneous and the slab to have the same moment of inertia in both directions. This assumption is not correct for reinforced concrete. The moments of inertia are influenced by the extent of cracking of concrete in the tension zone and by the amount and location of reinforcement. These properties are of necessity different even for square slabs because the steel in one layer is placed on top of the reinforcement placed in the opposite direction.

We usually determine the amount of reinforcing steel in each direction on basis of the bending moments and allowable steel stresses. This is not generally correct for two-way slabs. We can only get the calculated stress if the curvature of bending and the effective depth correspond to the assumed steel stress. The angular curvature of bending is generally less in the long direction and the steel stress cannot, therefore, simultaneously reach the same value as in the short direction. It can only reach working stress intensity after the short span steel has been stressed to a higher value. The ultimate strength of the slab may not, however, be greatly affected by this condition. The reason for this is that the reinforcement having the least stress will receive additional load after the most highly stressed reinforcement has started to yield.

Plastic deformation of concrete, being approximately proportional to the compressive stress, will also tend to transfer stress to the least stressed reinforcement. This plastic deformation is also beneficial in other respect. It makes it unnecessary to reinforce for the absolute maximum positive and negative bending moments, but allows the use of a more average bending moment on a certain width of slab. This is a condition utilized in some code provisions for stipulation of bending moment coefficients.

In the case of a slab continuous over supports we have the additional condition of variable torsional resistance of the beams supporting the slab. Near the intersection of two beams or at a column the torsional resistance will be largest and will decrease towards the centre of the beam span. This will influence the effect of uneven loading on adjacent slab panels and the assumption of knife edge support is in most cases even less true than for one-way sla[illegible] In general it may be said th[illegible] influence of uneven loading is [illegible] a two-way slab system th[illegible] way slabs because of th[illegible] of loading in two directions.

It should be mentioned that the Poisson ratio of transverse deformation has an effect on the magnitude of bending moments. There is some uncertainty what the Poisson ratio is for concrete as this will depend to a certain extent on concrete strength and stress intensity. Figures of $\frac{1}{5}$ to $\frac{1}{8}$ are sometimes given. Assuming a ratio $\frac{1}{6}$ and a square panel simply supported, the effect would increase the bending moment as derived from Table I from $wL^2/27.4$ to $wL^2/23.4$. For steel with a Poisson ratio of 0.3 the corresponding bending moment would be $wL^2/21.1$. In cases where very accurate stress analysis is required it may be advisable to investigate the effect of the Poisson ratio. A study of such problems has been made by F. Czerny and other.[9] Considering the beneficial effect of plastic deformation and of torsional resistance of supporting beams, it is probably sufficiently safe in most cases of building construction to assume the Poisson ratio equal to zero. Furthermore, it is also usual to design for an average bending moment in a panel strip instead of the absolute maximum value of the bending moment. Most of the published tables of coefficients are based on Poisson's ratio being zero and this simplification also applies to the tables given in this paper.



Maximum bending moments and deflections for uniform loading will be as follows for the above support conditions:

Span l_x:

1. $M_x = \frac{w_x l_x^2}{8}$ $\quad \Delta_x = \frac{5 w_x l_x^4}{384 EI}$

2. $M_x = \frac{9 w_x l_x^2}{128}$ $\quad \Delta_x = \frac{2 w_x l_x^4}{384 EI}$

3. $M_x = \frac{w_x l_x^2}{24}$ $\quad \Delta_x = \frac{w_x l_x^4}{384 EI}$

Equations for M_y and Δ_y can be obtained in a similar manner.

c) When deflections for spans l_x and l_y are equated we get: $w_x = C\,w$ and $w_y = (1-c)\,w$.

C may be obtained from the following table:

Support Condition	1	2	3	4	5	6	7	8	9
C	$\frac{l_y^4}{l_x^4+l_y^4}$	$\frac{5l_y^4}{2l_x^4+5l_y^4}$	$\frac{2l_y^4}{5l_x^4+2l_y^4}$	$\frac{l_y^4}{l_x^4+l_y^4}$	$\frac{5l_y^4}{l_x^4+5l_y^4}$	$\frac{l_y^4}{5l_x^4+l_y^4}$	$\frac{2l_y^4}{l_x^4+2l_y^4}$	$\frac{l_y^4}{2l_x^4+l_y^4}$	$\frac{l_y^4}{l_x^4+l_y^4}$

Fig. 1.

The Effect of Torsion

The principal source of error in the "Equal Deflection Method" is the neglect of the influence of torsional resistance of the slab against deflection. If we assume a strip of a certain width located in a position away from the centre line of slab, it is clear that the deflection on both sides of the strip is not the same excepting at its supports. The reason for this is the inter-connection with the adjacent strips which do not have an equal deflection. The deflection at any point must correspond to the general curvature of deformation of the slab in a transverse direction, but the deflection on each side of a strip will in general not be equal excepting at a valley of deflection and at an unflexed support. This applies, of course, only if the strip ends are

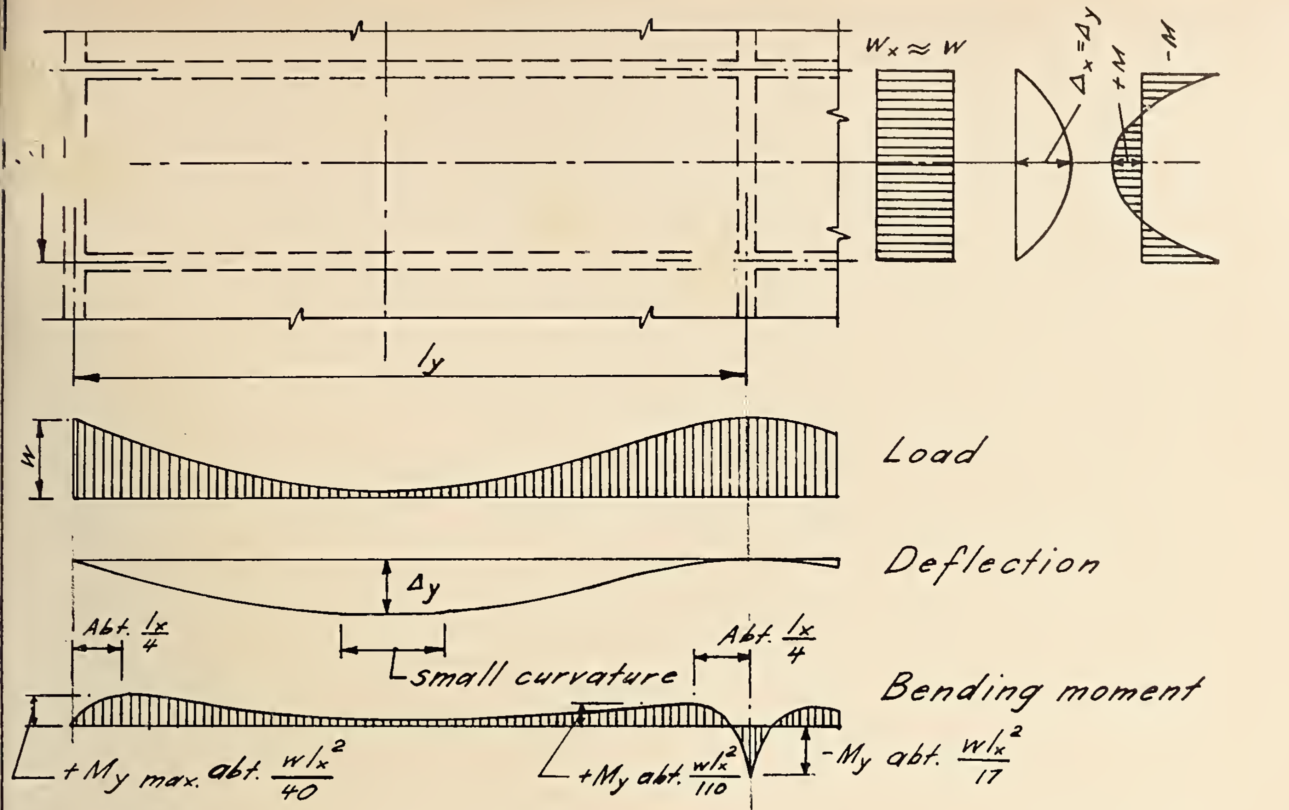


Fig. 2

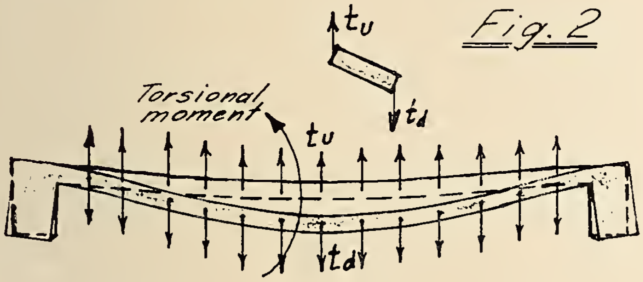


Fig. 3

Deflection and Torsion.

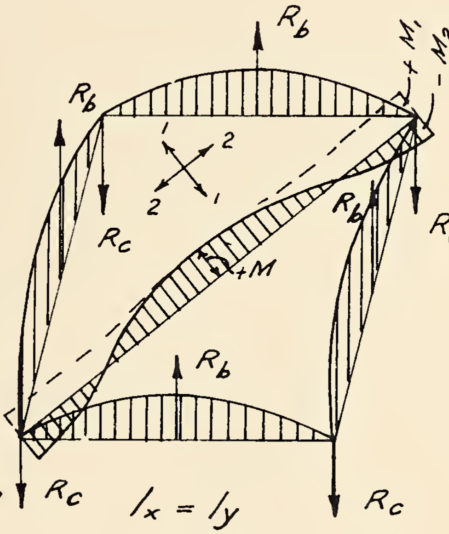


Fig. 4

Slab reactions on beams from a freely supported two-way slab with slab corners tied to beams. Also bending mom. diagram along a diagonal.

For Poisson's ratio = 0.3

$+M_1 = -M_2 = \frac{1}{34} wl^2$

$+M = \frac{1}{21.1} wl^2$

$R_b = +1.2375 \frac{W}{4}$

$R_c = -0.2375 \frac{W}{4}$

$R_b + R_c = \frac{W}{4}$

W = Total Load

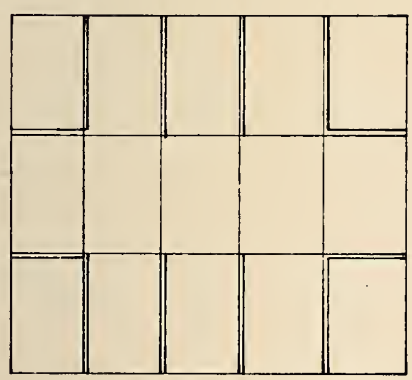


Fig. 5

fastened to the supports in such a manner that they cannot rotate freely, but are forced to follow the same elevation as the supporting beam. Fig. 3 illustrates this condition.

The result is that in most locations each strip in addition to longitudinal bending is also subject to torsion. The sum of torsional resistance of the slab strips will decrease the total deflection and consequently also decrease the bending moment in the slab. This reduction is sometimes very considerable. For instance, in the case of a square slab simply supported, the load distribution is equal in both directions. If we disregard the effect of torsion, the maximum bending moment for uniform loading would then be: $M = wL^2/16$. The effect of torsion, however, with Poisson's ratio equal to zero reduces the bending moment to $wL^2/27.4$. This torsional effect is greatest for simply supported slabs and decreases for continuous construction due to a much smaller total deflection and consequently a smaller angular rotation. The effect of torsion on a square slab uniformly loaded and with simple supports (Case 1) is to reduce the bending moment by about 49% while in a case with built-in edges (Case 9) the maximum positive bending moment reduces from $wL_x^2/48$ to $wL_x^2/55.7$ or only about 15%.

It will be understood from the above discussion that it is not practicable to carry out exact calculations of bending moments in two-way slabs for design purposes. The best we can do is to obtain by some approximate method design figures which are fairly realistic and which will give about equal safety factors for different cases of span proportions and support restraints. Several attempts have been made to work out acceptable approximate methods. Some such have proven to be fairly accurate but rather work absorbing. That applies for instance to Method I of the American Concrete Institute Building Code (A.C.I. 318-56). Method II of the same code is easier to apply but is not very satisfactory as far as accuracy is concerned. Method II which was used in the National Building Code of 1953 will, therefore, not be included in the 1960 edition of that code.

The Marcus Method

Dr. H. Marcus has made an extensive study of two-way slab problems and published a number of papers on the subject. In a book first published in 1924 and in revised form in 1932[6] he outlines the mathematical theory and gives his own particular method for solving such problems. A paper published by him in 1924 contained approximate methods for solving two-way slab problems.[10] This method was adopted for the German reinforced concrete code of 1925 and is still in use in that country. An outline of the method was given in the September 1944 issue of the Journal of the American Concrete Institute.

The approximate equations by Dr. Marcus were used to work out tables of coefficients for different span ratios and support conditions. Such tables may for instance be found in the German "Beton-Kalender."[11] The tables there are made up for six support conditions. This makes it necessary to reverse some cases of span proportions which increases the possibility of making mistakes. It is much more convenient to use nine support conditions and that has been done for the tables contained in the new reinforced concrete specifications of the 1960 National Building Code. The tables contained in that code are based on the Marcus theory and have been supplied by Mr. Paul Rogers, Member of the American Concrete Institute.

Tables of coefficients based on the more mathematically exact theory by Kirchhoff have been worked out by F. Czerny and may be found in the 1959 edition of the "Beton-Kalender". The figures, even though more accurate, do not seem to differ materially from those found by the more approximate Marcus theory.

Dr. F. Dischinger published in 1942 a very thorough discussion of load intensity and distribution on supports for two-way slabs.[12] He also included new tables of coefficients for slab moments based on the Marcus theory. These tables are set up in a somewhat different form from those in the National Building Code and are worked out for much closer intervals so that interpolation becomes unnecessary. The coefficients for bending moments in both directions are made a function of the short span only and that makes it necessary to square one length only when calculating bending moments. The coefficients in the Dischinger tables are divisors which contain only one decimal figure and for that reason appear to be best suited for ordinary slide rule calculations. Tables 1 and 4 have been adopted from Dischinger's work. The tabulated coefficients in Table 3 are for calculation of negative bending moments across the supporting beams. This table has been worked out by the writer from the basic equations for negative bending moments in Table 5.

It should be mentioned that the negative bending moments from the Marcus equations do not represent maximum theoretical values but are more like an average on the middle strip over the supports. The decrease from the maximum value is about 15%. The positive bending moments represent, however, maximum values for zero Poisson's ratio. Considering the middle strip as a whole, there is about an average balance of moment at support and some average over-design at the centre of span. Such an adjustment in bending moments is considered to be quite in order.

Table 2 contains coefficients for live load positive bending moments. The condition for such bending moments is checkerboard loading on adjacent spans and knife edge supports are generally assumed. These load and support conditions are not very likely to occur, so the coefficients should only be considered as approximate. This table has been worked out by the writer on basis of the corresponding table 4.5.5.C contained in the National Building Code, but has been changed into the same form as used by Dischinger. All bending moments are functions of the short span only and intervals have been determined from graphs.

The resulting bending moments found by means of all the tables should be in a substantial agreement with those obtained by using the Rogers tables. It might be pointed out that the coefficients contained in these tables need adjustment if adjacent spans differ much in length.

Table 5 gives equations for both positive and negative bending moments in accordance with the approximate Marcus theory.

Table 4 shows dead load bending moment coefficients for four support conditions. These apply where there are one or more free corners which are not fixed to the supports in such a manner that the existing bending moment in the slab can be taken and where the slab is not securely held down to prevent uplift of the corner. There may be cases where omission of such reinforcement is most convenient. Corner cracks, are, however, likely to occur under such conditions. The coefficients in Table 4 can be derived from the general equations in Table 5 as follows. The parts of the equations inside the brackets represent the torsional effect which we may call T. To get the coefficients in Table 4 substitute a new function $(1 + T)/2$ instead of T. In the case of a so-called waffle slab, these terms should be assumed as $T = 1$, since such a slab cannot be assumed to have an equal torsional resistance to a solid slab.

The Code allows concrete joists with fillers of hollow concrete units or clay tile with or without concrete top slabs and concrete joists with top slabs placed monolithically with the joists to be treated the same as solid slabs in calculating bending moments. The writer does not consider this to be justified, because such hollow slabs will evidently have far less torsional rigidity than solid slabs. It would seem advisable in such cases to neglect the effect of torsion.

Conditions at Free Corners

Bending conditions at corners would seem to justify some detailed explanation. Fig. 4 indicates how the bending moment acts along a diagonal. M_1 is the bending moment in a transverse direction to the diagonal. It is a positive bending moment giving tension in the bottom of the slab. M_2 is a negative bending moment in the direction of the diagonal giving tension on top of the slab at or near the corner. At centre of slab, both M_1 and M_2 are positive and of equal magnitude to the positive bending moment parallel to the sides of slab. It should be noted that both M_1 and M_2 are of the same magnitude but with opposite signs at the slab corner. From there M_1 increases slowly towards the centre of slab while M_2 decreases until it reaches a point of inflection from which it becomes positive. Unless sufficient reinforcement exists in the slab both at bottom and top to resist M_1 and M_2 cracking may result which will destroy the lever action of the corner and this will result in an increased positive bending moment at the centre of slab. The same will occur in case the corner is not held securely to the marginal beam and, therefore, can lift free off the beam. It may be noted that M_1 remains relatively large all the way to the corner and will generally require more positive reinforcement near this than what corresponds to a bending moment parallel and close to a marginal support.

The Code states that "where the slab is not securely attached to the supporting beams or walls, special reinforcement shall be provided at exterior corners in both the bottom and top of the slab". It would appear that this clause is somewhat unclear. It is in the writer's opinion not sufficient to attach the slab to its support unless the support has a sufficient torsional resistance to provide a near fixity against rotation in the vicinity of the corner. That is not always the case if the slab is supported on a steel beam or on a brick wall. In the case of concrete beams of ordinary proportions, we will in most cases have near fixity at a corner against rotation. The code provision will then, as a rule, suffice provided, of course, that there is a sufficient amount of positive and negative reinforcement present on top and bottom and of slab. Fig. 6 will illustrate why the corner reinforcement is so important. The contours of deflection will not be parallel to the sides, but follow a circular pattern near the corners. The slab here is quite rigid in a direction transversely to the diagonal because the slab span here is short. A kind of "beam" will, therefore, form across the slab at and near the corner. This "beam" will not only carry its own direct load, but will also receive load from the central portion of slab. Furthermore, since the slab corner generally is held down, it will, in addition, load the "beam" by adding a negative bending moment parallel to the diagonal.

The negative bending moment may be thought of as a force couple of which the innermost force will be a direct load on the "beam". This load condition creates the bending moment shown on Fig. 4 as M_2. If there is insufficient reinforcement at the bottom of slab, a diagonal crack may form, the slab will settle and M_2 will disappear since there is no longer a "beam" to carry the load mentioned above. If on the other hand there is sufficient steel at the bottom of slab but none at the top, a crack may form there perpendicular to the diagonal. The "beam" would still carry some load but there would be no reduction of positive bending moment at the centre from the destroyed force couple equal to M_2.

The Code requires an amount of negative reinforcement equal to ¾ of that for the positive bending moment along discontinuous edges. This relatively high requirement would not appear to be necessary for the centre strip unless the support has an unusual torsional rigidity and we want to avoid a visible crack between slab and beam. It is the writer's opinion that such cracks should be avoided but it is difficult to give a definite rule how much reinforcement is necessary for that purpose. For the centre strip of half the slab width one-half of the positive reinforcing should suffice in most cases. It is a different case with the side strips. Here the three-quarter reinforcement for negative bending moment is not too high as is evident from an inspection of the bending moment diagrams on Fig. 4. The high bending moment at free corners cannot evidently be taken proper care of without addition of extra corner reinforcement. In doubtful cases of support restraint it would seem ad-

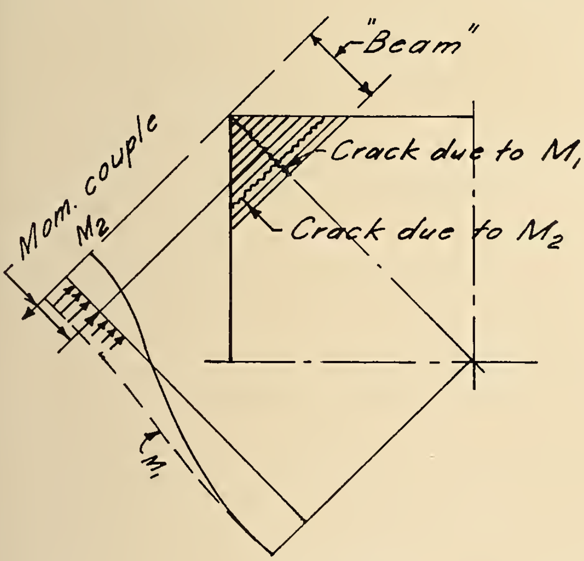


Fig. 6

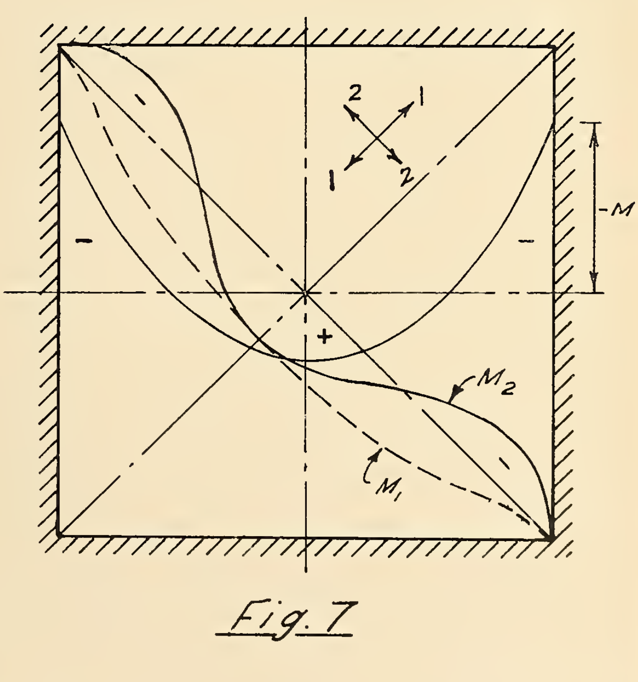


Fig. 7

visable to use Table 4 for calculation of positive bending moments.

It might be of interest to compare the freely supported slab with a square slab fixed against rotation along all edges and loaded uniformly. The bending moments along a diagonal and transversely to this are shown on Fig. 7. It may be noted that both M_1 and M_2 are zero at the corner. M_1 increases slowly from the zero value at the corner and can be taken care of by the ordinary negative reinforcement. There is no problem in this case with the slab lifting free of its support.

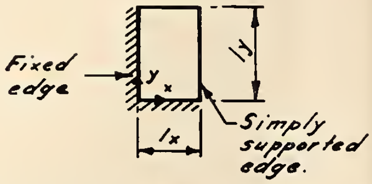
Concentrated Loads on Two-Way Slabs

The exact mathematical analysis of two-way slabs with concentrated loads is far more difficult than an analysis for uniform loading. Neither is there, as far as the writer knows, any approximate method of analysis comparable in accuracy to the Marcus equations for uniform loading. There is, of course, no real point loads but rather loaded areas of variable extent and shape. One special type is the line loading such as may be caused by partition walls in a building.

The problem of stress analysis due to concentrated loading is of considerable importance in connection with design of bridge decks and a great deal of analytical work has been done in this connection. Since it is not possible to express bending

TABLE 1: COEFFICIENTS FOR DEAD LOAD POSITIVE MOMENTS.

$$Max. M_x = \frac{w l_x^2}{n_x}. \quad Max. M_y = \frac{w l_x^2}{n_y}.$$



Type of Slab	1		2		3		4		5		6		7		8		9	
$\varepsilon = l_y/l_x$	n_{1x}	n_{1y}	n_{2x}	n_{2y}	n_{3x}	n_{3y}	n_{4x}	n_{4y}	n_{5x}	n_{5y}	n_{6x}	n_{6y}	n_{7x}	n_{7y}	n_{8x}	n_{8y}	n_{9x}	n_{9y}
1.00	27.4	27.4	29.9	36.8	36.8	29.9	37.2	37.2	37.5	55.7	55.7	37.5	44.2	50.6	50.6	44.2	55.7	55.7
1.02	26.4	27.4	29.0	37.2	34.9	29.7	35.7	37.2	36.7	57.0	52.4	36.8	42.9	51.1	48.3	43.8	53.6	55.8
1.04	25.4	27.4	28.2	37.7	33.3	29.5	34.4	37.2	36.0	58.4	49.4	36.2	41.8	51.8	46.0	43.4	51.8	55.9
1.06	24.5	27.5	27.4	38.2	31.8	29.3	33.2	37.3	35.4	59.8	46.8	35.7	40.7	52.5	43.8	43.1	49.9	56.1
1.08	23.6	27.5	26.7	38.8	30.3	29.2	32.1	37.5	34.7	61.2	44.2	35.1	39.7	53.2	42.0	42.8	48.3	56.3
1.10	22.8	27.6	26.0	39.3	29.0	29.0	31.1	37.6	34.2	62.6	41.8	34.7	38.8	53.9	40.2	42.6	46.8	56.6
1.12	22.0	27.6	25.4	40.0	27.9	28.9	30.1	37.8	33.7	64.1	39.8	34.2	38.0	54.8	38.7	42.5	45.4	57.0
1.14	21.3	27.7	24.8	40.6	26.8	28.8	29.3	38.0	33.2	65.7	37.8	33.8	37.3	55.7	37.2	42.4	44.1	57.4
1.16	20.7	27.8	24.3	41.3	25.7	28.7	28.5	38.3	32.7	67.3	36.0	33.5	36.5	56.6	35.9	42.3	43.0	57.8
1.18	20.0	27.9	23.8	42.0	24.8	28.7	27.7	38.6	32.3	68.9	34.4	33.2	35.9	57.5	34.6	42.2	41.9	58.3
1.20	19.4	28.0	23.3	42.7	23.9	28.6	27.0	38.9	31.9	70.6	32.9	32.9	35.3	58.5	33.5	42.2	40.9	58.7
1.22	18.9	28.1	22.9	43.5	23.1	28.6	26.4	39.2	31.6	72.4	31.5	32.6	34.7	59.6	32.4	42.3	40.0	59.4
1.24	18.4	28.3	22.5	44.2	22.3	28.6	25.8	39.6	31.2	74.1	30.2	32.4	34.2	60.6	31.4	42.3	39.1	60.1
1.26	17.9	28.5	22.1	45.0	21.6	28.6	25.2	40.0	30.9	76.0	29.0	32.2	33.7	61.7	30.5	42.5	38.3	60.9
1.28	17.4	28.6	21.8	45.9	21.0	28.6	24.7	40.4	30.6	77.9	27.9	32.0	33.2	62.9	29.7	42.6	37.6	61.6
1.30	17.0	28.8	21.4	46.6	20.3	28.6	24.2	40.8	30.3	79.8	26.8	31.8	32.8	64.1	28.9	42.7	36.9	62.3
1.32	16.6	29.0	21.1	47.5	19.8	28.6	23.7	41.3	30.1	81.7	25.8	31.7	32.4	65.3	28.2	42.9	36.2	63.2
1.34	16.2	29.2	20.8	48.4	19.2	28.7	23.3	41.8	29.8	83.7	24.9	31.6	32.0	66.5	27.5	43.2	35.7	64.0
1.36	15.9	29.4	20.6	49.3	18.7	28.7	22.9	42.3	29.6	85.7	24.1	31.4	31.7	67.8	26.8	43.4	35.1	64.9
1.38	15.5	29.6	20.3	50.3	18.2	28.8	22.5	42.8	29.4	87.8	23.3	31.4	31.3	69.2	26.2	43.7	34.6	65.8
1.40	15.2	29.8	20.0	51.2	17.8	28.9	22.1	43.4	29.2	89.8	22.6	31.3	31.0	70.5	25.7	44.9	34.1	66.8
1.42	14.9	30.1	19.8	52.2	17.4	28.9	21.8	43.9	29.0	91.9	21.9	31.2	30.7	71.9	25.1	44.3	33.6	67.8
1.44	14.6	30.4	19.6	53.2	17.0	29.0	21.5	44.5	28.8	94.1	21.2	31.2	30.4	73.3	24.6	44.6	33.2	68.8
1.46	14.4	30.6	19.4	54.3	16.6	29.1	21.2	45.1	28.6	96.2	20.6	31.2	30.2	74.7	24.2	45.0	32.8	69.9
1.48	14.1	30.9	19.2	55.3	16.2	29.2	20.9	45.8	28.5	98.5	20.1	31.1	29.9	76.2	23.7	45.4	32.4	71.0
1.50	13.9	31.2	19.0	56.4	15.9	29.4	20.6	46.4	28.3	100.8	19.5	31.1	29.7	77.7	23.3	45.8	32.0	72.1
1.52	13.6	31.5	18.9	57.5	15.6	29.5	20.4	47.1	28.2	103.1	19.0	31.1	29.5	79.2	22.9	46.2	31.7	73.3
1.54	13.4	31.9	18.7	58.6	15.3	29.6	20.1	47.8	28.0	105.4	18.6	31.2	29.3	80.8	22.6	46.7	31.4	74.5
1.56	13.2	32.2	18.5	59.7	15.0	29.8	19.9	48.5	27.9	107.8	18.1	31.2	29.1	82.4	22.2	47.1	31.1	75.7
1.58	13.0	32.6	18.4	60.9	14.7	29.9	19.7	49.2	27.8	110.3	17.7	31.2	28.9	84.0	21.9	47.6	30.8	76.9
1.60	12.9	32.9	18.2	62.0	14.5	30.1	19.5	49.9	27.7	112.7	17.3	31.3	28.7	85.7	21.6	48.1	30.5	78.2
1.62	12.7	33.3	18.1	63.2	14.2	30.3	19.3	50.7	27.5	115.2	16.9	31.4	28.6	87.4	21.3	48.6	30.3	79.5
1.64	12.5	33.7	18.0	64.4	14.0	30.5	19.1	51.4	27.4	117.8	16.6	31.4	28.4	89.1	21.0	49.2	30.0	80.8
1.66	12.3	34.1	17.9	65.6	13.8	30.6	19.0	52.2	27.3	120.3	16.2	31.5	28.2	90.6	20.8	49.7	29.8	82.2
1.68	12.2	34.5	17.7	66.8	13.6	30.8	18.8	53.0	27.2	122.9	15.9	31.6	28.1	92.6	20.5	50.3	29.6	83.5
1.70	12.1	34.9	17.6	68.1	13.4	31.1	18.6	53.8	27.1	125.5	15.6	31.7	28.0	94.3	20.3	50.9	29.4	85.9
1.72	11.9	35.3	17.5	69.4	13.2	31.3	18.5	54.7	27.0	128.1	15.3	31.8	27.8	96.2	20.1	51.5	29.2	86.4
1.74	11.8	35.7	17.4	70.7	13.0	31.5	18.3	55.5	26.9	130.8	15.0	31.9	27.7	98.0	19.8	52.1	29.0	87.9
1.76	11.7	36.2	17.3	71.9	12.8	31.7	18.2	56.4	26.9	133.6	14.8	32.1	27.6	99.9	19.6	52.7	28.8	89.4
1.78	11.6	36.6	17.2	73.3	12.7	32.0	18.1	57.3	26.8	136.4	14.5	32.2	27.5	101.8	19.5	53.4	28.7	90.9
1.80	11.5	37.1	17.2	74.6	12.5	32.2	17.9	58.2	26.7	139.2	14.3	32.3	27.4	103.7	19.3	54.1	28.5	92.4
1.82	11.3	37.6	17.1	76.0	12.3	32.5	17.8	59.1	26.6	142.0	14.1	32.5	27.3	105.7	19.1	54.8	28.4	93.9
1.84	11.2	38.1	17.0	77.4	12.2	32.8	17.7	60.0	26.6	144.9	13.9	32.7	27.2	107.6	18.9	55.5	28.2	95.6
1.86	11.1	38.6	16.9	78.9	12.1	33.1	17.6	60.9	26.5	147.9	13.7	32.8	27.1	109.5	18.8	56.2	28.1	97.2
1.88	11.0	39.1	16.8	80.3	11.9	33.4	17.5	61.9	26.4	150.8	13.5	33.0	27.0	111.7	18.6	56.9	27.9	98.8
2.00	11.0	39.6	16.8	81.8	11.8	33.7	17.4	62.9	26.4	150.8	13.3	33.2	26.9	113.8	18.5	57.7	27.8	100.5
2.02	10.9	40.1	16.7	83.2	11.7	33.8	17.3	63.9	26.3	156.8	13.1	33.4	26.8	115.9	18.4	58.4	27.7	102.2
2.04	10.8	40.6	16.6	84.7	11.6	34.3	17.2	64.8	26.3	159.8	12.9	33.6	26.7	117.9	18.2	59.2	27.6	103.9
2.06	10.7	41.2	16.6	86.1	11.5	34.6	17.1	65.9	26.2	162.9	12.8	33.8	26.7	120.0	18.1	60.0	27.5	105.6
2.08	10.6	41.7	16.5	87.6	11.4	34.9	17.1	66.9	26.1	166.1	12.6	34.0	26.6	122.2	18.1	60.8	27.4	107.4
2.10	10.6	42.3	16.5	89.2	11.3	35.2	17.0	67.9	26.1	169.3	12.6	34.3	26.5	124.4	17.9	61.6	27.3	109.1

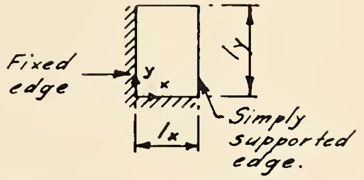
moments explicitly in formulae, a complete analysis has to be made for any particular load position. From a series of such analyses, it is possible to draw area influence contour lines for bending moments at significant points of slab. Several such influence area diagrams have been worked out and published. Of such publications might be mentioned that by Pucher.[13] (See also Reference 5 Chapter 10.)

For ordinary building design an exact analysis of bending moments in two-way slabs due to concentrated loading would be too time absorbing, but it is necessary even here to get some idea of the bending moments and shearing stresses. The writer thinks that in the case of walls this might be done about in the same manner as outlined on Fig. 1 for uniform loading. Two strips perpendicular to each other can be assumed to carry the load. There is considerable uncertainty how wide a strip parallel to a wall can be considered as effective. Perhaps a reasonable assumption is a width of one-third the span length on each side of the wall plus the thickness of the wall itself. Transversely to the wall the effective width would, of course, be the length of the wall. One strip would then have a uniform load and the other a concentrated load. By equating the deflection at the point of intersection the approximate load distribution could be found. If in addition we disregard the effect of torsion, the result should err on the safe side.

It is evidently impracticable in most cases to obtain an accurate analysis of partition wall loading. The walls, even if of tile or other kinds of masonry, will not follow the floor slab completely if the slab deflects either due to live loading or due to long time plastic deformation. It is not unusual to see the floor deflect free of the base of wall for a compartively long stretch. This bridging effect may

TABLE 2: COEFFICIENTS FOR LIVE LOAD POSITIVE MOMENTS.

$$Max.\ M_x = \frac{w l_x^2}{n_x}. \quad Max.\ M_y = \frac{w l_x^2}{n_y}.$$



Type of Slab	1		2		3		4		5		6		7		8		9	
$\varepsilon = \frac{l_y}{l_x}$	n_{1x}	n_{1y}	n_{2x}	n_{2y}	n_{3x}	n_{3y}	n_{4x}	n_{4y}	n_{5x}	n_{5y}	n_{6x}	n_{6y}	n_{7x}	n_{7y}	n_{8x}	n_{8y}	n_{9x}	n_{9y}
1.00	As in Table 1		28.6	31.3	31.3	28.6	31.3	31.3	31.3	37.1	37.1	31.3	33.4	35.8	35.5	33.4	37.0	37.0
1.02			27.8	31.4	29.9	28.4	30.3	31.3	30.5	37.2	35.3	31.2	32.4	35.9	34.1	33.4	35.4	37.0
1.04			26.9	31.5	28.5	28.2	29.3	31.3	29.8	37.3	33.5	31.0	31.4	36.0	32.9	33.3	33.9	37.0
1.06			26.0	31.6	27.3	28.1	28.3	31.3	29.0	37.5	31.9	30.8	30.4	36.1	31.6	33.3	32.5	37.0
1.08			25.1	31.7	26.3	28.0	27.3	31.3	28.3	37.7	30.6	30.6	29.4	36.2	30.4	33.2	31.2	37.0
1.10			24.2	32.9	25.4	28.0	26.3	31.3	27.5	37.9	29.3	30.4	28.4	36.4	29.1	33.2	30.0	37.0
1.12			23.5	32.2	24.5	28.0	25.3	31.3	26.7	38.1	28.1	30.2	27.5	36.6	28.0	33.2	29.0	37.0
1.14			22.8	32.5	23.7	27.9	24.6	31.4	25.9	38.3	27.0	30.0	26.9	36.8	26.9	33.1	28.2	37.0
1.16			22.2	32.8	22.9	27.9	23.9	31.5	25.2	38.5	25.9	29.8	26.3	37.0	25.8	33.1	27.4	37.2
1.18			21.6	33.1	22.2	27.9	23.2	31.6	24.5	38.7	25.0	29.7	25.7	37.1	24.8	33.0	26.7	37.2
1.20			21.0	33.4	21.6	27.8	22.5	31.7	24.0	39.0	24.1	29.6	25.2	37.3	24.2	33.2	26.0	37.3
1.22			20.4	33.7	20.7	27.8	21.9	31.9	23.5	39.4	23.5	29.5	24.6	37.5	23.6	33.4	25.3	37.4
1.24			19.8	34.0	20.0	27.9	21.2	32.1	23.0	39.8	22.6	29.4	24.1	37.7	23.0	33.6	24.7	37.5
1.26			19.4	34.3	19.4	28.0	20.6	32.3	22.5	40.2	21.9	29.4	23.5	38.0	22.4	33.8	24.1	37.6
1.28			19.1	34.6	18.9	28.1	20.3	32.6	22.1	40.6	21.3	29.4	23.0	38.4	21.9	34.0	23.6	37.8
1.30			18.7	34.9	18.5	28.2	19.9	32.9	21.7	41.1	20.6	29.5	22.6	38.8	21.3	34.2	23.1	38.0
1.32			18.4	35.2	18.1	28.3	19.5	33.1	21.4	41.6	20.0	29.6	22.1	39.2	20.7	34.4	22.6	38.2
1.34			18.1	35.4	17.7	28.4	19.1	33.5	21.1	42.1	19.4	29.7	21.6	39.6	20.2	34.6	22.1	38.5
1.36			17.8	36.9	17.3	28.5	18.7	33.8	20.8	42.6	19.0	29.8	21.3	40.0	19.8	34.9	21.7	38.8
1.38			17.4	36.4	16.9	28.6	18.4	34.2	20.4	43.1	18.5	29.9	20.9	40.4	19.5	35.2	21.3	39.1
1.40			17.1	36.9	16.5	28.7	18.1	34.5	20.1	43.6	18.1	30.0	20.5	40.8	19.1	35.5	20.9	39.4
1.42			16.8	37.4	16.1	28.8	17.7	34.8	19.8	44.1	17.7	30.1	20.1	41.5	18.7	35.8	20.6	39.7
1.44			16.6	37.9	15.7	28.9	17.4	35.2	19.5	44.6	17.3	30.2	19.8	42.2	18.4	36.1	20.3	40.0
1.46			16.4	38.4	15.4	29.1	17.1	35.6	19.2	45.1	17.0	30.3	19.5	42.8	18.1	36.4	20.0	40.4
1.48			16.2	39.0	15.1	29.3	16.9	36.0	18.9	45.6	16.8	30.4	19.3	43.6	17.8	36.8	19.7	40.8
1.50			16.0	39.7	14.8	29.6	16.6	36.4	18.6	46.1	16.3	30.5	19.0	44.2	17.5	37.1	19.4	41.2
1.52			14.9	40.4	14.5	29.9	16.3	36.8	18.4	46.6	15.9	30.6	18.8	45.0	17.2	37.4	19.1	41.6
1.54			15.8	41.1	14.2	30.2	16.1	37.2	18.2	47.1	15.6	30.7	18.6	45.7	16.9	37.7	18.8	42.0
1.56			15.7	44.6	14.0	30.5	15.9	37.6	18.0	47.6	15.3	30.9	18.3	46.4	16.6	38.0	18.6	42.4
1.58			15.5	42.3	13.8	30.7	15.8	38.0	17.8	48.1	15.0	31.1	18.0	47.0	16.4	38.4	18.4	42.8
1.60			15.3	43.0	13.7	30.9	15.6	38.4	17.6	48.6	14.8	31.3	17.8	47.7	16.2	38.7	18.2	43.2
1.62			15.1	43.7	13.5	31.1	15.4	38.8	17.4	49.1	14.5	31.4	17.6	48.4	15.9	39.0	18.0	43.6
1.64			14.9	44.3	13.3	31.4	15.2	39.2	17.2	49.6	14.2	31.4	17.3	49.1	15.7	39.3	17.8	44.0
1.66			14.7	44.9	13.1	31.6	15.1	39.6	17.0	50.1	14.0	31.5	17.1	49.8	15.5	39.6	17.6	44.5
1.68			14.5	45.5	12.9	31.9	14.9	40.0	16.8	50.6	13.7	31.6	16.9	50.5	15.3	40.0	17.4	45.0
1.70			14.3	46.0	12.7	32.1	14.7	40.4	16.6	51.2	13.5	31.7	16.7	51.3	15.1	40.4	17.2	45.5
1.72			14.2	46.6	12.5	32.4	14.5	40.9	16.4	51.8	13.3	31.8	16.5	52.0	15.0	40.9	17.0	46.0
1.74			14.1	47.2	12.3	32.6	14.4	41.4	16.3	52.6	13.1	31.9	16.4	52.8	14.8	41.3	16.8	46.6
1.76			14.0	47.8	12.1	32.9	14.2	41.8	16.2	53.4	12.8	32.1	16.2	53.5	14.7	41.8	16.6	47.4
1.78			13.9	48.4	12.0	33.1	14.0	42.3	16.1	54.2	12.6	32.2	16.0	54.3	14.6	42.2	16.4	48.2
1.80			13.8	48.7	11.9	33.4	13.9	42.7	16.0	55.0	11.4	32.3	15.9	55.0	14.4	42.7	16.2	49.2
1.82			13.7	49.0	11.8	33.6	13.8	43.2	15.9	55.8	11.3	32.5	15.7	55.8	14.3	43.2	16.1	50.2
1.84			13.6	49.2	11.7	33.9	13.7	44.0	15.8	56.5	12.2	32.7	15.6	56.5	14.1	43.9	16.0	51.4
1.86			13.5	49.3	11.6	34.2	13.6	44.7	15.7	57.2	12.1	32.8	15.5	57.2	14.0	44.7	15.9	52.6
1.88			13.4	49.4	11.4	34.4	13.5	45.5	15.6	58.0	12.0	33.0	15.4	58.0	13.9	45.4	15.8	53.8
1.90			13.3	49.5	11.3	34.6	13.4	46.2	15.5	58.7	11.9	33.2	15.3	58.7	13.8	46.1	15.7	55.0
1.92			13.2	49.6	11.2	34.9	13.3	47.0	15.4	59.5	11.7	33.4	15.2	59.5	13.7	46.9	15.6	56.2
1.94			13.1	49.7	11.1	35.1	13.2	47.7	15.3	60.2	11.6	33.6	15.1	60.2	13.5	47.7	15.5	57.5
1.96			13.0	49.8	11.0	35.3	13.2	48.4	15.2	61.0	11.5	33.8	15.1	61.0	13.3	48.4	15.4	58.8
1.98			12.9	49.9	10.9	35.6	13.1	49.2	15.1	61.8	11.4	34.0	14.9	61.7	13.2	49.2	15.3	61.2
2.00			12.8	50.0	10.8	35.8	13.0	50.0	15.0	62.6	11.3	34.3	14.9	62.5	13.1	50.0	15.2	62.6

Table 3: Coefficients for Negative Moments.

$$M_x = -\frac{w l_x^2}{n_x}. \qquad M_y = -\frac{w l_x^2}{n_y}. \qquad \underline{\text{Note}}: w = D.L. + L.L.$$

Type of Slab	2		3		4		5		6		7		8		9	
$\varepsilon = l_y/l_x$	n_{2x}	n_{2y}	n_{3x}	n_{3y}	n_{4x}	n_{4y}	n_{5x}	n_{5y}	n_{6x}	n_{6y}	n_{7x}	n_{7y}	n_{8x}	n_{8y}	n_{9x}	n_{9y}
1.00	11.2			11.2	16.0	16.0	14.4			14.4	18.0	24.0	24.0	18.0	24.0	24.0
1.02	11.0			11.0	15.5	16.0	14.3			14.1	17.6	24.4	23.0	17.8	23.3	24.1
1.04	10.8			10.9	15.0	16.1	14.1			13.8	17.2	24.8	22.0	17.6	22.5	24.2
1.06	10.6			10.8	14.5	16.2	14.0			13.4	16.9	25.2	21.0	17.4	21.7	24.3
1.08	10.4			10.6	14.0	16.2	13.8			13.1	16.5	25.6	20.0	17.3	21.0	24.4
1.10	10.3			10.5	13.5	16.3	13.6			12.8	16.1	26.0	19.0	17.2	20.2	24.5
1.12	10.1			10.4	13.2	16.4	13.6			12.6	15.9	26.5	18.3	17.2	19.7	24.7
1.14	9.9			10.4	12.9	16.6	13.5			12.4	15.6	27.0	17.6	17.1	19.2	24.9
1.16	9.7			10.3	12.5	16.8	13.4			12.2	15.4	27.5	17.0	17.1	18.8	25.1
1.18	9.6			10.2	12.2	16.9	13.3			12.0	15.1	28.0	16.3	17.0	18.3	25.3
1.20	9.5			10.2	11.9	17.1	13.2			11.8	14.9	28.6	15.6	17.0	17.8	25.6
1.22	9.4			10.1	11.7	17.3	13.1			11.6	14.8	29.2	15.2	17.0	17.5	25.9
1.24	9.3			10.1	11.5	17.5	13.0			11.5	14.6	29.9	14.8	17.1	17.1	26.2
1.26	9.2			10.1	11.2	17.8	13.0			11.4	14.4	30.5	14.4	17.1	16.8	26.6
1.28	9.15			10.1	11.0	18.0	12.9			11.3	14.3	31.2	14.0	17.2	16.5	27.0
1.30	9.1			10.1	10.8	18.3	12.8			11.2	14.1	31.8	13.6	17.3	16.2	27.4
1.32	9.1			10.2	10.7	18.6	12.8			11.1	14.0	32.6	13.3	17.3	16.0	27.8
1.34	9.0			10.2	10.5	18.9	12.8			11.0	13.9	33.5	13.0	17.4	15.8	28.3
1.36	9.0			10.2	10.4	19.2	12.7			10.9	13.8	34.0	12.7	17.5	15.5	28.8
1.38	8.9			10.3	10.2	19.5	12.7			10.8	13.7	34.8	12.4	17.7	15.3	29.2
1.40	8.8			10.3	10.1	19.8	12.6			10.8	13.6	35.5	12.2	17.9	15.1	29.7
1.42	8.8			10.4	10.0	20.1	12.6			10.8	13.5	36.4	12.0	18.0	15.0	30.2
1.44	8.8			10.5	9.9	20.5	12.6			10.8	13.4	37.2	11.8	18.2	14.8	30.7
1.46	8.7			10.6	9.8	20.8	12.6			10.8	13.3	38.0	11.6	18.4	14.7	31.3
1.48	8.7			10.7	9.7	21.2	12.5			10.8	13.3	38.5	11.3	18.6	14.5	31.8
1.50	8.6			10.7	9.6	21.6	12.5			10.8	13.2	39.5	11.1	18.8	14.4	32.3
1.52	8.6			10.8	9.5	22.0	12.5			10.8	13.2	40.5	11.0	19.0	14.3	33.0
1.54	8.6			11.0	9.4	22.4	12.4			10.8	13.1	41.4	10.9	19.3	14.1	33.6
1.56	8.6			11.2	9.4	22.8	12.4			10.8	13.0	42.3	10.7	19.5	14.0	34.2
1.58	8.5			11.2	9.3	23.2	12.4			10.8	13.0	43.2	10.6	19.7	13.9	34.8
1.60	8.5			11.3	9.2	23.6	12.4			10.8	12.9	44.1	10.4	20.0	13.8	35.4
1.62	8.5			11.4	9.2	24.1	12.3			10.9	12.9	45.1	10.3	20.3	13.7	36.1
1.64	8.4			11.6	9.2	24.6	12.3			10.9	12.8	46.1	10.2	20.6	13.6	36.7
1.66	8.4			11.7	9.1	25.0	12.3			11.0	12.8	47.1	10.1	20.9	13.6	37.4
1.68	8.4			11.9	9.1	25.5	12.3			11.0	12.8	48.0	10.0	21.2	13.5	38.1
1.70	8.4			12.0	9.0	26.0	12.3			11.1	12.7	49.0	9.9	21.5	13.4	38.8
1.72	8.3			12.2	9.0	26.5	12.3			11.1	12.7	50.0	9.9	21.8	13.3	39.6
1.74	8.3			12.3	8.9	27.0	12.3			11.2	12.7	51.0	9.8	22.1	13.3	40.3
1.76	8.3			12.5	8.9	27.5	12.3			11.3	12.6	52.1	9.7	22.5	13.2	41.0
1.78	8.3			12.7	8.8	28.0	12.3			11.4	12.6	53.2	9.6	22.8	13.2	41.8
1.80	8.3			12.8	8.8	28.4	12.25			11.5	12.6	54.3	9.5	23.1	13.1	42.6
1.82	8.3			13.0	8.8	29.0	12.2			11.6	12.6	55.4	9.5	23.5	13.1	43.4
1.84	8.25			13.2	8.7	29.5	12.2			11.7	12.6	56.6	9.4	23.8	13.0	44.2
1.86	8.25			13.4	8.7	30.0	12.2			11.8	12.6	57.7	9.3	24.2	13.0	45.0
1.88	8.25			13.6	8.6	30.5	12.2			11.9	12.5	58.8	9.2	24.6	12.9	45.8
1.90	8.25			13.8	8.6	31.1	12.2			12.0	12.5	60.0	9.2	25.0	12.9	46.6
1.92	8.2			14.0	8.6	31.7	12.2			12.1	12.5	62.6	9.2	25.4	12.8	47.5
1.94	8.2			14.2	8.6	32.3	12.2			12.2	12.5	65.2	9.1	25.8	12.8	48.4
1.96	8.2			14.4	8.6	32.8	12.2			12.3	12.4	68.0	9.1	26.2	12.8	49.2
1.98	8.2			14.6	8.5	33.4	12.2			12.4	12.4	70.8	9.0	26.6	12.7	50.1
2.00	8.2			14.8	8.5	34.0	12.15			12.6	12.4	73.2	9.0	27.0	12.7	51.0

continue until a crack forms in the wall and that occurs particularly at door openings. A lot of cracking has been experienced in this connection with two-way slabs because of too great flexibility. Since the compressive strength of the concrete can be utilized in two directions there is a tendency to make such slabs too thin. The ultimate strength of a properly designed two-way slab will, therefore, almost always depend on the strength of the steel reinforcement.

Another problem encountered is to find the bending moment from load concentrations such as file cabinets and accounting machinery. A somewhat similar method to that proposed for distribution of wall load might be used. The effective slab strips can, according to some code rules, be assumed as either the width of the load plus two-thirds the span length, or alternatively as twice the distance from the load centre to the closest support in the direction of span. The smallest of these values to be used. Solving equations for equal deflection of two perpendicular slab strips will then give the load distribution between the two strips. Any great accuracy by such a method can hardly be expected but the result will likely be safe.

Beam Loading From Two-Way Slabs

The load distribution obtained from the equations in Fig. 1 was used for some time to obtain the loading on the supporting beams. The result was not bad as far as the beams in the long direction were concerned. For the short span beams the uniform loading found by this load distribution method was far from correct and the corresponding bending moment in the beams might only be a small fraction of the true values. A better division is to assume load distribution to each beam from the tributary areas of the panel bounded by the intersection of 45° lines from the corners with the median line of the panel parallel to the long side. This is an approximate load distribution used in most building codes. Even this method is not accurate especially for the short span beams. The method makes the loading of the short span beam independent of the slab length and that is not quite correct. The actual conditions are as follows:

We have found that the effect of torsion is to reduce the bending moment in the slab greatly. However, this effect is not obtained without some extra loading of the supporting beams. Considering Fig. 3 it is clear that in addition to the direct load from the slab each slab strip superimposes a torsional effect on the beams. This effect tends to transfer the reaction of each strip in the same direction as the slab twists, that is, towards the centre of span. Each strip presses down at one edge of its support and has an uplift effect at the other edge. The total effect of twisting of all the slab strips is to transfer the load on the beam to some extent towards its centre. This effect is, of course, only present where there is a torsional effect and would, for instance, not be of any importance on the central portion of a long slab such as is shown on Fig. 2. The shifting of load towards the centre of beam will, of course, increase the bending moment in the beam.

In the case of a rectangular slab simply supported it can be proven that there is a force creating uplift at the corner and there must, therefore, be a corresponding increase in the downward reaction of the slab on the beam since the algebraic sum of all the loads and forces acting on the beam must be equal to the weight of slab and its superimposed load. This can only be the case when the load on the beam, apart from the corner force, is greater than the gravity load. The loads shown in connection with Fig. 4 have been taken from Dischinger's work. An elementary consideration of Fig. 6 will also make it clear that the central loading must be greater than the gravity loading.

It should be noted that the corner force indicated on Fig. 4 is not present at continuous corners and we do not, therefore, have the same increase in beam loading where the slab is continuous. Even with continuous slabs there may be some shifting of load towards the centre caused by torsion, but the effect is generally small due to less deflection.

The correct way of calculating the bending moment in a beam would be analyze the slab panel with the parallel supporting beams as a unit. The bending moment carried by the slab in that direction would then be subtracted from the total bending moment in order to find how much of the total bending moment the beams have to carry. Such analyses have been made by Dr. Dischinger. They show that the triangular and trapezoid loadings as contained in the codes will give substantially correct results for interior panels of two-way slab systems but should be corrected for exterior panels. Referring to Fig. 5 Dr. Dischinger proposed that the beams marked with double lines should have the bending moments increased as follows:

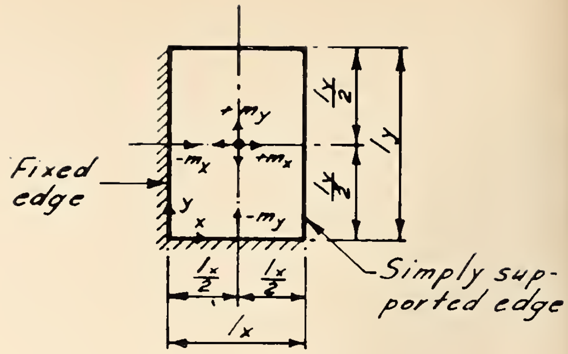
In the X-direction for Ly Lx = 1

Table 4. Coefficients for dead load positive moments for condition of no attachment to supports and no special corner reinforcement.

Type of Slab	1		2		3		4	
$\varepsilon = \frac{l_y}{l_x}$	n_{1x}	n_{1y}	n_{2x}	n_{2y}	n_{3x}	n_{3y}	n_{4x}	n_{4y}
1.00	20.2	20.2	23.9	31.8	31.8	23.9	32.2	32.2
1.02	19.4	20.2	23.3	32.3	30.1	23.6	31.0	32.2
1.04	18.7	20.3	22.8	32.8	28.6	23.3	29.9	32.3
1.06	18.1	20.3	22.3	33.4	27.2	23.1	28.9	32.4
1.08	17.5	20.4	21.8	34.0	26.0	22.9	27.9	32.6
1.10	16.9	20.5	21.4	34.6	24.8	22.7	27.0	32.7
1.12	16.4	20.6	21.0	35.2	23.8	22.6	26.3	32.9
1.14	16.0	20.8	20.6	35.9	22.8	22.4	25.5	33.2
1.16	15.5	20.9	20.2	36.6	21.9	22.3	24.9	33.5
1.18	15.1	21.0	19.9	37.3	21.1	22.2	24.2	33.8
1.20	14.7	21.2	19.6	38.1	20.3	22.2	23.7	34.1
1.22	14.4	21.4	19.4	38.8	19.6	22.1	23.2	34.5
1.24	14.1	21.6	19.1	39.6	19.0	22.1	22.6	34.9
1.26	13.8	21.8	18.9	40.5	18.3	22.1	22.2	35.3
1.28	13.5	22.1	18.7	41.4	17.8	22.1	21.8	35.7
1.30	13.2	22.3	18.5	42.2	17.3	22.1	21.4	36.2
1.32	13.0	22.6	18.3	43.1	16.8	22.2	21.0	36.7
1.34	12.7	22.9	18.1	44.0	16.4	22.2	20.7	37.2
1.36	12.5	23.2	17.9	45.0	15.9	22.3	20.4	37.7
1.38	12.3	23.5	17.8	45.9	15.5	22.4	20.1	38.2
1.40	12.1	23.8	17.6	46.9	15.2	22.5	19.8	38.8
1.42	11.9	24.1	17.5	47.9	14.8	22.6	19.5	39.4
1.44	11.8	24.4	17.3	49.0	14.5	22.7	19.3	40.0
1.46	11.6	24.8	17.2	50.0	14.2	22.9	19.1	40.7
1.48	11.5	25.1	17.1	51.1	13.9	23.0	18.9	41.3
1.50	11.3	25.5	17.0	52.1	13.6	23.2	18.8	42.0
1.52	11.2	25.9	16.9	53.3	13.4	23.3	18.5	42.7
1.54	11.1	26.3	16.8	54.4	13.2	23.5	18.3	43.4
1.56	11.0	26.7	16.7	55.5	12.9	23.7	18.1	44.1
1.58	10.8	27.1	16.6	56.7	12.7	23.9	18.0	44.8
1.60	10.7	27.5	16.5	57.9	12.5	24.1	17.8	45.6
1.62	10.6	27.9	16.4	59.1	12.3	24.3	17.7	46.4
1.64	10.5	28.3	16.4	60.3	12.2	24.6	17.5	47.1
1.66	10.4	28.8	16.3	61.6	12.0	24.8	17.4	48.0
1.68	10.4	29.3	16.2	62.9	11.8	25.1	17.3	48.8
1.70	10.3	29.7	16.2	64.1	11.7	25.3	17.2	49.6
1.72	10.2	30.2	16.1	65.4	11.5	25.6	17.1	50.5
1.74	10.1	30.7	16.0	66.7	11.4	25.9	17.0	51.4
1.76	10.1	31.2	16.0	68.1	11.3	26.1	16.9	52.2
1.78	10.0	31.7	15.9	68.5	11.2	26.4	16.8	53.1
1.80	9.9	32.2	15.9	70.8	11.0	26.7	16.7	54.0
1.82	9.9	32.7	15.8	72.2	10.9	27.0	16.6	55.0
1.84	9.8	33.2	15.8	73.7	10.8	27.4	16.5	55.9
1.86	9.7	33.7	15.7	75.0	10.7	27.7	16.4	56.9
1.88	9.7	34.3	15.7	76.5	10.7	28.0	16.4	57.9
1.90	9.6	34.8	15.6	78.0	10.6	28.3	16.3	58.8
1.92	9.6	35.4	15.6	79.4	10.5	28.7	16.2	59.8
1.94	9.5	36.0	15.6	80.8	10.4	29.0	16.2	60.8
1.96	9.5	36.5	15.5	82.4	10.3	29.4	16.1	61.9
1.98	9.5	37.1	15.5	84.0	10.2	29.8	16.0	62.9
2.00	9.4	37.7	15.5	85.4	10.2	30.1	16.0	64.0

TABLE 5: EQUATIONS BY H. MARCUS FOR BENDING MOMENTS IN TWO-WAY SLABS CARRYING A UNIFORMLY DISTRIBUTED LOAD.

Note: The equations are based upon Poisson's ratio being equal to zero.



$$\varepsilon = \frac{l_y}{l_x}$$

TYPE OF SLAB	MAXIMUM BENDING MOMENTS			
	POSITIVE BENDING MOMENTS		NEGATIVE BENDING MOMENTS	
	$+m_x$	$+m_y$	$-m_x$	$-m_y$
1	$\frac{1}{8}\cdot\frac{\varepsilon^4}{1+\varepsilon^4}\left(1-\frac{5}{6}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}\right)wl_x^2$	$\frac{1}{8}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}\left(1-\frac{5}{6}\frac{\varepsilon^2}{1+\varepsilon^4}\right)wl_x^2$	—	—
2	$\frac{45}{128}\cdot\frac{\varepsilon^4}{2+5\varepsilon^4}\left(1-\frac{75}{32}\frac{\varepsilon^2}{2+5\varepsilon^4}\right)wl_x^2$	$\frac{1}{4}\cdot\frac{\varepsilon^2}{2+5\varepsilon^4}\left(1-\frac{5}{3}\frac{\varepsilon^2}{2+5\varepsilon^4}\right)wl_x^2$	$-\frac{5}{8}\cdot\frac{\varepsilon^4}{2+5\varepsilon^4}wl_x^2$	—
3	$\frac{1}{4}\cdot\frac{\varepsilon^4}{5+2\varepsilon^4}\left(1-\frac{5}{3}\frac{\varepsilon^2}{5+2\varepsilon^4}\right)wl_x^2$	$\frac{45}{128}\cdot\frac{\varepsilon^2}{5+2\varepsilon^4}\left(1-\frac{75}{32}\frac{\varepsilon^2}{5+2\varepsilon^4}\right)wl_x^2$	—	$-\frac{5}{8}\cdot\frac{\varepsilon^2}{5+2\varepsilon^4}wl_x^2$
4	$\frac{9}{128}\cdot\frac{\varepsilon^4}{1+\varepsilon^4}\left(1-\frac{15}{32}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}\right)wl_x^2$	$\frac{9}{128}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}\left(1-\frac{15}{32}\frac{\varepsilon^2}{1+\varepsilon^4}\right)wl_x^2$	$-\frac{1}{8}\cdot\frac{\varepsilon^4}{1+\varepsilon^4}wl_x^2$	$-\frac{1}{8}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}wl_x^2$
5	$\frac{5}{24}\cdot\frac{\varepsilon^4}{1+5\varepsilon^4}\left(1-\frac{25}{18}\cdot\frac{\varepsilon^2}{1+5\varepsilon^4}\right)wl_x^2$	$\frac{1}{8}\cdot\frac{\varepsilon^2}{1+5\varepsilon^4}\left(1-\frac{5}{6}\frac{\varepsilon^2}{1+5\varepsilon^4}\right)wl_x^2$	$-\frac{5}{12}\cdot\frac{\varepsilon^4}{1+5\varepsilon^4}wl_x^2$	—
6	$\frac{1}{8}\cdot\frac{\varepsilon^4}{5+\varepsilon^4}\left(1-\frac{5}{6}\frac{\varepsilon^2}{5+\varepsilon^4}\right)wl_x^2$	$\frac{5}{24}\cdot\frac{\varepsilon^2}{5+\varepsilon^4}\left(1-\frac{25}{18}\frac{\varepsilon^2}{5+\varepsilon^4}\right)wl_x^2$	—	$-\frac{5}{12}\cdot\frac{\varepsilon^2}{5+\varepsilon^4}wl_x^2$
7	$\frac{1}{12}\cdot\frac{\varepsilon^4}{1+2\varepsilon^4}\left(1-\frac{5}{9}\frac{\varepsilon^2}{1+2\varepsilon^4}\right)wl_x^2$	$\frac{9}{128}\cdot\frac{\varepsilon^2}{1+2\varepsilon^4}\left(1-\frac{15}{32}\frac{\varepsilon^2}{1+2\varepsilon^4}\right)wl_x^2$	$-\frac{1}{6}\cdot\frac{\varepsilon^4}{1+2\varepsilon^4}wl_x^2$	$-\frac{1}{8}\cdot\frac{\varepsilon^2}{1+2\varepsilon^4}wl_x^2$
8	$\frac{9}{128}\cdot\frac{\varepsilon^4}{2+\varepsilon^4}\left(1-\frac{15}{32}\cdot\frac{\varepsilon^2}{2+\varepsilon^4}\right)wl_x^2$	$\frac{1}{12}\cdot\frac{\varepsilon^2}{2+\varepsilon^4}\left(1-\frac{5}{9}\frac{\varepsilon^2}{2+\varepsilon^4}\right)wl_x^2$	$-\frac{1}{8}\cdot\frac{\varepsilon^4}{2+\varepsilon^4}wl_x^2$	$-\frac{1}{6}\cdot\frac{\varepsilon^2}{2+\varepsilon^4}wl_x^2$
9	$\frac{1}{24}\cdot\frac{\varepsilon^4}{1+\varepsilon^4}\left(1-\frac{5}{18}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}\right)wl_x^2$	$\frac{1}{24}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}\left(1-\frac{5}{18}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}\right)wl_x^2$	$-\frac{1}{12}\cdot\frac{\varepsilon^4}{1+\varepsilon^4}wl_x^2$	$-\frac{1}{12}\cdot\frac{\varepsilon^2}{1+\varepsilon^4}wl_x^2$

Increase by 25%
for Ly/Lx = 2 Increase by 35%
In the Y-direction for Ly/Lx = 1 Increase by 25%
for Ly/Lx = 2 Increase by 0
For values between these limits obtain the percentage increase by interpolation.

Since the actual loading on the beam in certain cases is greater than the gravity loading and generally greater than the load triangle on the short span beams, it follows that the shear in such beams is correspondingly higher. It is, therefore, recommended that the shear reinforcement be increased corresponding to the greater loading.

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EIC

Discussion

FORMATION OF CONTINUOUS CHIPS IN METAL CUTTING

W. B. Rice, M.E.I.C.
Assoc. Prof., Dept. of Mechanical Engineering, Queen's University, Kingston

The Engineering Journal, February 1961, page 41.

Discussion by J. C. Millson

Although considerable work has been done in the metal cutting field in the U.S.A. and elsewhere, there has been little or none done in Canada and, having in mind its importance to all our industry, this is a rather surprising state of affairs. Your work is interesting both from the standpoint of the material used, aluminium, and the fact that it adds considerably to our knowledge of metal cutting behaviour.

I would like to ask if you would care to expand on your conclusion that "the chip is not peeled off" under orthogonal cutting conditions, since it has been found that the chip thickness is usually greater than the depth of the cut. It seems to me that it might be possible for the upsetting occurring in the chip as a result of the friction force applied to a relatively plastic material to give rise to sufficient thickening to account for this condition and still make it possible for the chip to literally "peel off." Is not the "ribbon-like chip" an example of this?

When considering the formation of this ribbon-like and segmented continuous chips, the statement was made that similarity of chips was apparent when working with a variety of materials, including aluminium-steel and wax. Although this represents a very wide range in properties, I hope it will be possible to expand your work to include materials which demonstrate a distinct variation in shearing yield strength to shearing ultimate strength, as well as work hardening rate. If materials such as aluminium, specifically one of the aluminium magnesium class, were compared with steel, the difference in mechanical properties could be evaluated systematically by the usual mechanical tests. In the case of the aluminium-magnesium alloy, with its high work hardening rate and high yield to tensile strength ratio, the plastic behaviour should show a marked difference to that of mild steel, with its low yield to tensile strength ratio and lower rate of work hardening. Differences in shearing strength could also be taken into account when comparing machining behaviour.

I expect the difficulty is not only to find time for such extensions of this programme, but also to sort out the many interesting avenues of investigation.

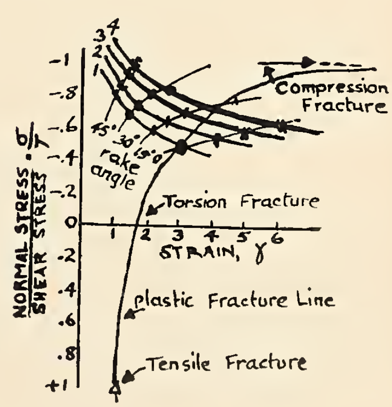
Discussion by N. H. Cook

There is little doubt that many of our commercial cutting operations produce segmented chips as described by the author. However, I believe that the author's conclusions are much too general to be supported by the experimental evidence shown.

In concluding that the transition from "segmented" to ribbon-like" chips is the result of a decrease in frietional force with increase in rake angle, the author presented a "black and white" solution for a situation which at best is a very muddled gray! Cook, Finnie and Shaw* have shown that the initiations of fracture in the cutting process is in good agreement with the initiation of fracture in tensile, torsion, and compressive tests. Correlation is made on the basis that the maximum plastic strain a material may undergo before fracture varies with the hydrostatic stress component, i.e., the position of the center of the Mohr's stress circle. Because strain hardening varies the size of the Mohr's stress circle, the ratio of the hydrostatic stress component to the maximum shear stress is taken as the quantity which will control the amount of plastic deformation before fracture. Figure 1 is a plot of plastic shear strain versus this stress ratio. Tensile fracture, torsion fracture, and compression fracture are used to fair in a curve representing plastic fracture for the material used (B1112) at room temperature. Also shown are cutting data points representing 4 rake angles and 4 fluids (1—CCl_4; 2—Ethanol; 3—dry; 4—benzene). The points to the left of the line represent continuous (ribbon-like) chips while the x's to the right represent segmented chips. Any change in material properties can shift the plastic fracture line. For instance, an increase in workpiece temperature generally moves the line to the right and results in more continuous chips. Thus, although the reduction of the friction force with increased rake angle is one of the factors affecting chip type, there are many other factors to be considered.

In segmented chips, the chip curl mechanism described can be influential, but is not the entire answer. For instance, the application of effective cutting fluids such as carbon tetrachloride, or ethanol, will reduce the friction force, reduce the degree (if any) of "segmentism" but will increase the chip curl.

Fig. 1. Correlation of Data with Materials Tests. (Trans. ASME, Feb. 1954)



*"Discontinuous Chip Formation." N. H. Cook, I. Finnie, M. C. Shaw, Trans. ASME, February 1954.

The mechanism of crater wear has previously been based upon the interacting effects of chip curl and the tool-chip interface temperature distribution. The author's mechanism is an interesting addition. If the crater occurs within the contact zone between the first segment (the static friction segment) and the tool, the proposed mechanism can be effective. However, if the crater occurs further away from the tool tip, under the second segment, for instance, it is difficult to see how this mechanism could function. The state of "static friction" under high pressure is conclusive to substantial welding between chip and tool which will result in severe wear when rupture occurs and the segment slides up the tool face. The second, third, fourth, etc., segments cannot bear as strongly upon the tool—particularly if they are being rotated away from the tool by the chip-curl mechanism described.

Discussion by John Convey

The paper serves to acquaint engineers with one facet of the research that is increasingly engaging the attention of universities and research institutions and which has to do with the machineability of metals. During World War II the speed of machining greatly advanced through applying new metals in cutting tools, such as tungsten carbide. How much greater are the needs of today with the advent of automation and the space-age requirements in high-temperature and high-strength metals! On the one hand there is need for better understanding of the mechanism of cutting and on the other hand for the metallurgist to know the factors of composition and structure that contribute to good machineability of metal.

The present contribution of Professor Rice gives engineers only a very brief summary of some phenomena of cutting action observed by him and he offers explanation for the mechanisms that he concludes are applicable in the formation of continuous chips in metal cutting. His distinction in this field of research arises from the doctoral theses which he presented to the Université de Montreal and it will be noted that his research has been supported in part by a grant of the Defence Research Board of Canada. It will be highly advantageous to have more such research conducted in Canadian universities and Professor Rice is to be commended for his design of equipment, including instrumentation and photographic methods that have made his observations possible despite a limited budget.

Professor Rice has shown initiative and resourcefulness and has given much greater study to the science of metal cutting than is indicated by the short list of references annotated from his extensive bibliography of the work of other researchers. He can be of assistance to engineers seeking information in this field and his research equipment should arouse considerable interest. It has been impossible for him in such a brief paper to do more than highlight some of his observations and conclusions in a field of research that is open to much controversy. It is good to have a Canadian professor add his theories to the melting pot, for it is from design of research equipment, careful observation of experiment, and publication of observations and theories, that science moves forward and practicable results are achieved.

It is hoped that Professor Rice in future work will be able to give consideration to microstructure of metals in relation to the bearing of structure on the mechanism of cutting.

Author's reply

The author wishes to express his appreciation to Mr. Millson, Professor Cook, and Dr. Convey.

The author visualized the "ribbon-like" chip as a "segmented" chip consisting of very small segments, the segment size and shape corresponding to the configuration of the stress field for values of the frictional force less than the critical value associated with transition from "segmented" to "ribbon-like" chips. However it may be, as Mr. Millson and one of the author's colleagues Mr. Salmon suggest, that the "ribbon-like" chip is "peeled off" and that the upsetting of the chip due to the frictional force accounts for the slight increase in the chip thickness. Indeed Kronenberg[1] focussed attention upon this upsetting force in a recent paper.

As suggested by Mr. Millson, Dr. Convey and by Professor Alexander the program is being extended to include other materials and to investigate the effect of microstructure upon chip formation.

The author feels that there is no real conflict between his concept of the mechanism of chip formation and that of Cook, Finnie, and Shaw. The author contends that he decrease in frictional force with increase in rake angle is a major factor in determining the nature of the stress field, and thus the ratio of the hydrostatic stress component to the maximum shear stress on the shear surface. Other factors such as temperature cannot be overlooked thus the author agrees with Professor Cook that a completely "black-and-white" solution is a simplification.

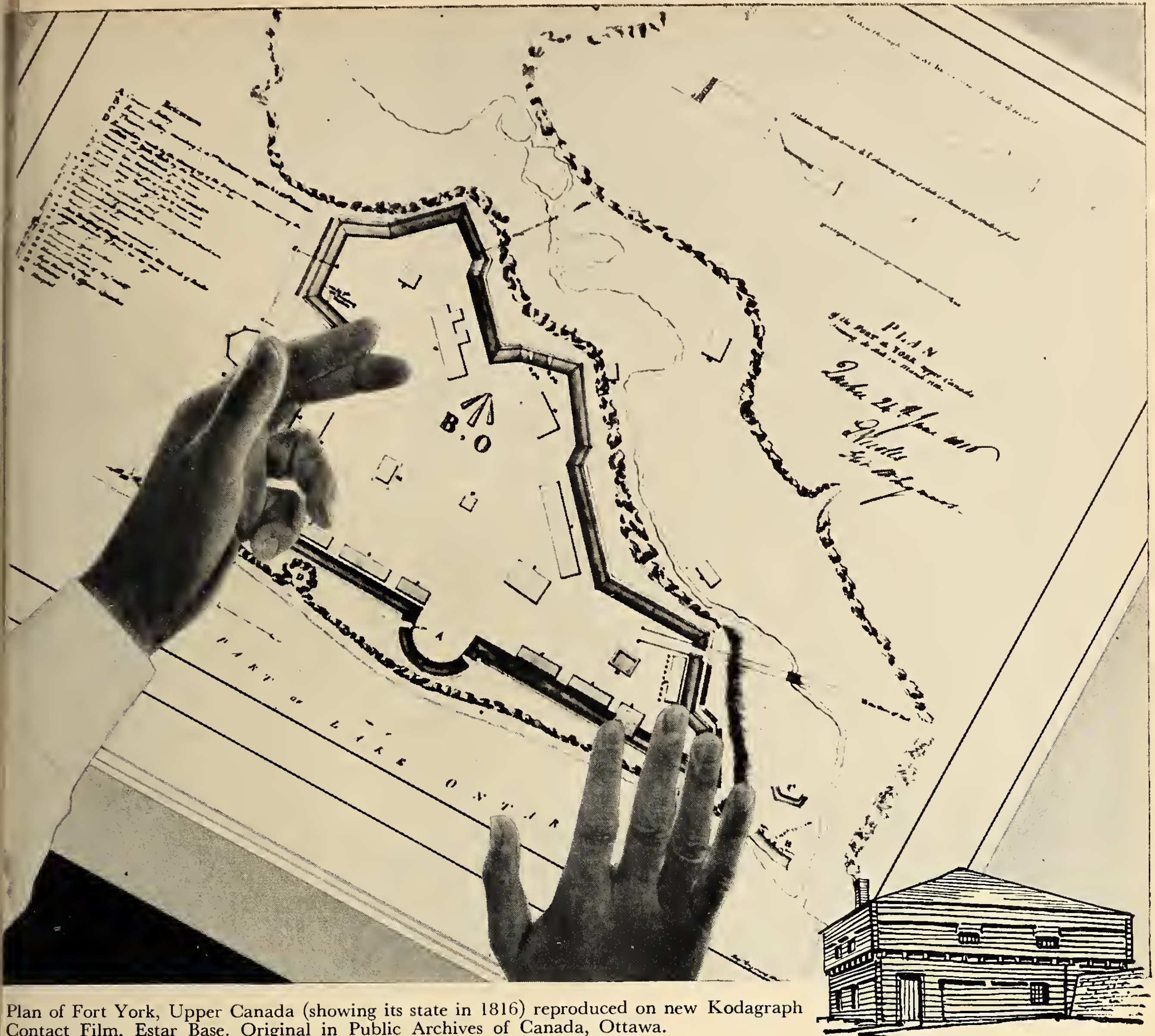
In a recent paper Shaw[2] pointed out that while carbon tetrachloride apparently gives relatively high friction in sliding experiments it gives very low values of cutting energy in cutting experiments. Carbon tetrachloride most likely affects the tool face friction (how, must await further experiments) which in turn affects the stress field, the ratio of the hydrostatic stress component to maximum shear stress, and the degree of curl.

With the dynamometer used in this work the interaction or "cross-talk" between horizontal and vertical components was indiscernible. According to calculations made in connection with a recent study of the force variation during the production of single "segments" the dynamometer is adequate for force variations of frequencies of less than 150 cycles per second. The design or selection of a dynamometer is a difficult task thus the author intends to gain access to Professor Cochkanoff's data. (Research project at Nova Scotia Technical College.)

1. Max Kronenberg, "Effects of Chip Compression on Cutting Forces", Tool Engineer, Vol. 40, April 1958, pp. 89-93.

2. M. C. Shaw, "On the Action of Metal Cutting Fluids at Low Speeds", Wear, Vol. 2, 1959, p. 222.

EIC



Plan of Fort York, Upper Canada (showing its state in 1816) reproduced on new Kodagraph Contact Film, Estar Base. Original in Public Archives of Canada, Ottawa.

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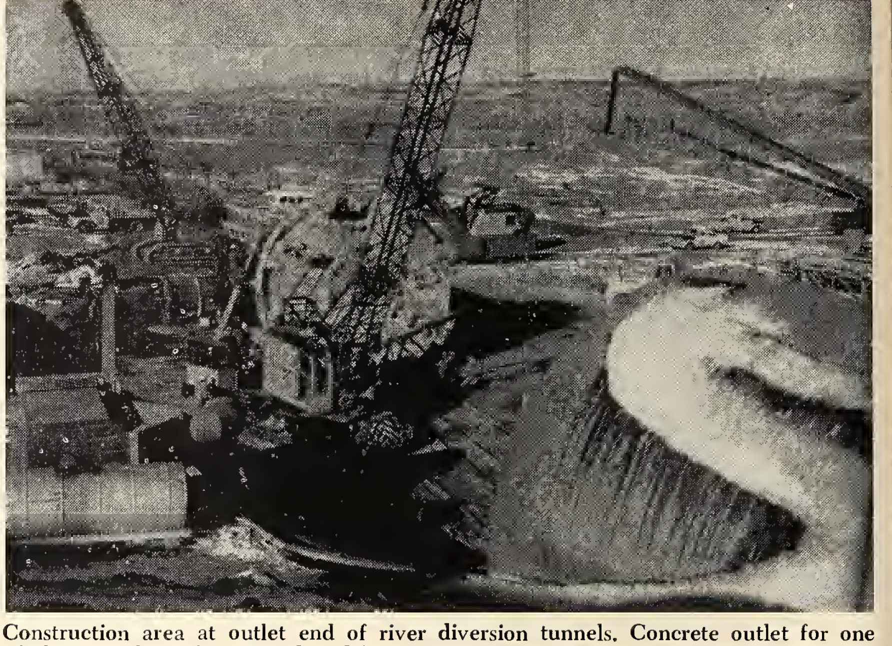
Canadian Developments

South Saskatchewan River Dam Progress

When Professor H. Y. Hind recommended a dam for the elbow of the Saskatchewan River more than 100 years ago, he could not have forseen the vast amount of equipment and manpower that would be used to build the structure. Professor Hind's proposed dam was 85 ft. high and 800 yd. long. The dam presently under construction will rise 210 ft. above the riverbed and will extend across the valley for a distance of about three miles. Five diversion tunnels of reinforced concrete construction are being built running through the west abutment of the dam. Over 19 million cu. yd. of earth have been excavated at the main damsite and 10 million of the 45 million cu. yd. of material have been placed on certain contract sites. By 1962-63 employment is expected to rise to a 1,500 peak at the damsite.



Construction area at outlet end of river diversion tunnels. Concrete outlet for one of the tunnels in foreground and Mole equipment in centre for drilling operations.

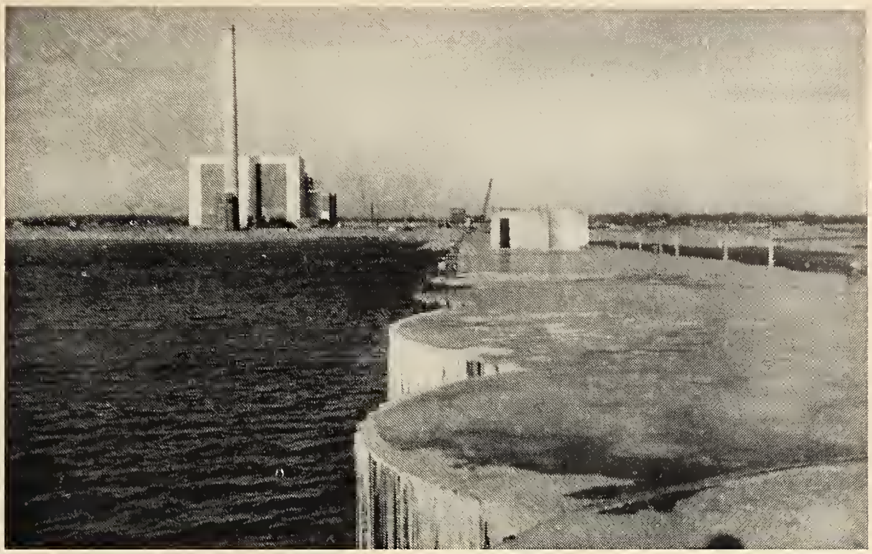
Work on the present tunnelling contract, which involves the driving and reinforcing with concrete of 10,000 ft. of 20 ft. diameter tunnel, the installation of steel lining in tunnels, and construction of outlet structures for the five diversion tunnels, has been primarily concerned to date with the batching and placing of concrete for the outlet structures. With this work now completed, the contractor can proceed with the actual tunnelling operations, says the Prairie Farm Rehabilitation Administration. The tunnels will carry the flow of the river after closure of the river channel has been made.

Lowering Mole by cable into tunnel entrance.

Recently the "Mole" equipment, which will be used to drive the river diversion tunnels in the downstream section of the dam was moved into place. Every available piece of machinery on the job had to be brought into use to anchor and control the descent of the 200-ton drill as it was gradually lowered by cable into the tunnel entrance. In operation, the massive electrically powered cutting head of the machine rotates slowly, grooving and pulverizing the shale face of the tunnel before it; the crushed material dropping into metal buckets that elevate and dump the material by way of a continuous conveyor belt, into awaiting cars for disposal. The over-all diameter of the cutting head, adapted for use on the South Saskatchewan River Dam, is 25 ft.

This particular unit is owned and was previously used by Peter Kiewit and Sons on the Oahe Dam Project of the Missouri River in South Dakota. Modification to the design of the machine was carried out by a firm in Brandon, Man., to meet the specific requirement of this contract. Although not the first time the machine has been used in Canada, this will be by far the largest construction job on which a Mole has been employed in this country.

As the tunnelling goes forward, steel ring beams, presently stockpiled at the site, will be installed as reinforcing in the tunnel along the connecting steel supports and wire mesh. This will then be covered with blown Cunite, to prevent shale walls in the tunnel from drying.



Looking toward shore from the lake end of a 1000 ft. long cellular dock built to serve the Ontario Hydro Lakeview Generating Station nearing completion.

Cellular Dock for Ontario Hydro Lakeview Generating Station

A cullular dock jutting 1600 ft. out into Lake Ontario has recently been completed by Dravo of Canada Limited, Toronto. The dock is to serve the new $250 million Ontario Hydro Lakeview Generating Station, scheduled to go into service this year. Located about 10 miles southwest of Toronto, the station will have an ultimate generating capacity of 1.8 million kw.

The dock consists of 21 steel sheet pile cells, interconnected with steel sheet pile arcs. They stand in water ranging from 10 to 35 ft. in depth. The 1,000 ft. long dock is an extension of a 600 ft. long, 40 ft. wide rock causeway. The causeway projects from a new shoreline, created by reclaiming a 600 ft. wide strip of lakefront with fill taken from the excavation for the generating station.

Each of the dock's 21 cells is 44 ft. in diameter and is filled with crushed limestone into which grout has been intruded to form a solid concrete core inside the sheet piling. Approximately 45,000 cu. yds. of intruded aggregate were used. Mass concrete was poured over the intruded base to form caps for the cells and a 16 ft. wide, 8 ft. high conveyor tunnel, which extends along the top of the dock 750 ft. from the end of the causeway. Required were 10,600 cu. yd. of ready-mix concrete, placed by pumpcrete methods, and 150 tons of reinforcing steel.

Galbraith Building

The University of Toronto's new engineering building, named after former Dean John Galbraith, was officially opened March 7. Special ceremonies marking the occasion began March 6 with a Convocation, at which honorary degrees were presented to four outstanding members of the engineering profession. These were: William Percy Dobson, Hon. M.E.I.C., director of research for the Ontario Hydro-Electric Power Commission until his retirement in 1955; Henri Gaudefroy, M.E.I.C., Dean of Ecole Polytechnique since 1953; John Hamilton Parkin, director of the Division of Mechanical Engineering, N.R.C., since 1937, and since 1951 director of the National Aeronautical Establishment; and John Bertram Stirling, Hon. M.E.I.C., president of E. G. M. Cape and Company, engineers and contractors, and a past president of the EIC. The Convocation address was given by Paul G. Hoffman who received the honorary degree of Doctor of Laws. Mr. Hoffman is the first managing director of the United Nations Special Fund, a U.N. special agency designed to aid investment in underdeveloped countries.

On Tuesday morning three special scientific lectures were delivered by Robert F. Legget, M.E.I.C., J. R. Pierce and Dr. G. V. Bull. Their respective papers were "Civil Engineering—Yesterday, To-day and Tomorrow", "The Many Problems of Communication Satellites", and "Hypervelocity Re-entry Studies at Canadian Armament Research and Development Establishment, Defence Research Board".

In the afternoon the Lieutenant-Governor of Ontario, the Honourable J. Keiller Mackay, opened the Galbraith Building. The building houses civil, electrical and aeronautical engineering and the administrative offices for the Faculty of Applied Science and Engineering. The University allocated $7 million for its construction and equipment and for renovation of existing buildings for applied science and engineering. In addition to modern expanded office and teaching space, departments now have much greater facilities for research. Civil engineering facilities include a one million pounds universal testing machine and a modern photostress laboratory. The building brings together sections of the civil engineering department previously spread over three buildings. New electrical engineering facilities include an antenna laboratory in a penthouse and a computer area housing both a digital and an analog computer.

Dean Galbraith was Ontario's first Professor of Engineering in 1878, first Principal of the School of Practical Science and, after that body became part of the University of Toronto in 1906, first Dean of the Faculty of Applied Science and Engineering. He died after guiding the growth of Ontario engineering education for 36 years.

University of Toronto's new engineering building, named after Dean John Galbraith.

International News

International Prize

The Association des Ingénieurs de la Faculté Polytechnique de Mons is to offer an international prize of fifty thousand Belgian francs which will be awarded for the first time in 1965. The prize is to be entitled "Prix International de l'Association des Ingénieurs de la Faculté Polytechnique de Mons" and will be quinquennial. It is to be awarded to the author of an outstanding and original work on the art of engineering. The jury will be composed of five members chosen by the Board of Directors of the Association. The jury may call upon specialists, who will be requested to make their reports on the papers that are submitted.

Engineers holding diplomas from universities and from recognized schools on university level are eligible for the prize. Only work submitted during the period of five years preceding the first assembly of the jury, before Sept. 1, 1965, will be accepted. The title of "Laureat du Prix International de L'Association des Ingénieurs de la Faculté Polytechnique de mons (A.I.MS)" will be conferred upon laureates. Work should be submitted in either French, Dutch, English or German. It should be typewritten in four copies and should bear a pseudonym signature. It should be sent to Monsieur le President de l'Association des Ingénieurs de la Faculté Polytechnique de Mons, 9 rue de Houdain, Mons, Belgium.

European Symposium on Space Technology

The British Interplanetary Society is organising the First European Symposium on Space Technology. It will be held in London June 26-28. The purpose of the Symposium is primarily to bring together engineers and scientists from Western Europe to discuss the possibility of formulating a joint program of space research.

The Symposium will be open to participation by countries in Western Europe, particularly those who belong to the Organization for European Economic Co-operation. It is also envisaged that Commonwealth countries, particularly Australia and Canada, will be concerned in any future program. The Conference will have heavy industrial overtones and will discuss the most fruitful lines of approach, bearing in mind the resources in men and materials available for participating nations.

Besides consideration of technical projects, there will be matters of finance and organisation to be dealt with, leading eventually to final decisions and recommendations for future consideration. It is hoped that this may lead to an expanding program of space exploration undertaken on the widest possible international basis and the closest possible collaboration with America and, if possible, the Soviet Union.

Sweden's Prefab Underwater Tunnel

A concrete underwater tunnel, 407 ft. long, was lowered in Stockholm recently. Claimed to be the world's first uninsulated and prestressed monolith of this type, the tunnel was built in two separate sections, 86 and 38 metres each. The tunnel was joined at a site nearby its destination.

The lowering of the tunnel on its site took place in stages. The monolith was suspended in four wire stays, one end of the tunnel being lowered 12.5 cm. at a time. Before the tunnel was finally positioned, two steel rollers were drawn along the entire length of the lake bottom to ensure that the bed was free from stones or other obstacles. In order to keep the tunnel submerged some 60 concrete slabs of a total weight of 1,700 tons were gradually placed on the tunnel roof. At the same time water was pumped into built-in tanks and into likewise built-in water mains with a diameter of 1.2m.

The tunnel rests on concrete plinths at both ends, the bottom being 14 metres below water level. Intermediate plinths will later be provided by pouring concrete through open shafts on both sides of the tunnel in its central part, thus casting pillars which will securely lock the monolith to the rock bottom. The connecting of the tunnel to both shores, where dams have been built, is estimated to take several months.

Israeli Tracking Station

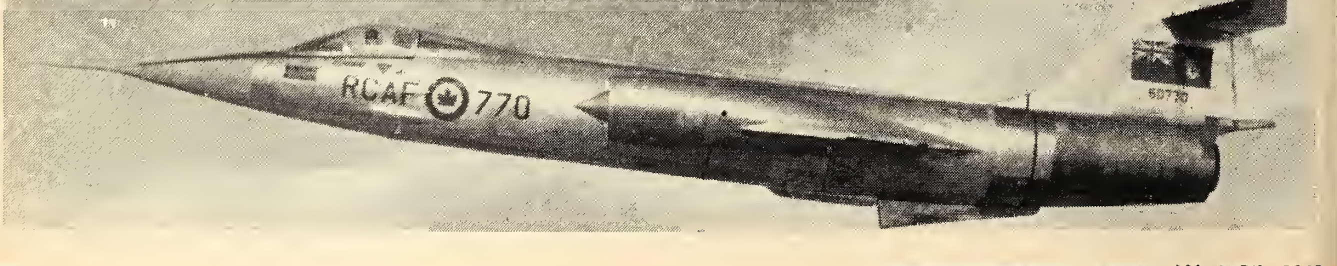
A satellite tracking station is to be set up on the roof of the Aeronautical Engineering Building at the Technion, Israel Institute of Technology. The apparatus is on hand, the staff to man the station is now being trained and it is planned to start operations in April.

The program has been planned by the Haifa members of the Israel Astronautical Society and the operations will be directed by Jerome Shafer, Senior Lecturer in aeronautical engineering at the Technion.

The station will be one in a series ringing the world, operated in conjunction with the Astro-Physical Observatory of the Smithsonian Institution, Cambridge, Mass. Information on the paths of satellites crossing Israel or within the range of the telescopes is transmitted to the Cambridge laboratory. There it is coordinated with similar reports from other stations, and a full picture is obtained on trajectories and other data of interest to the scientists. The Smithsonian Institution makes this information available to any scientific body or agency concerned which may request it.

All stations in the network are manned by volunteers. The setting up of the Haifa station was made possible by a gift received from a friend of the Technion, Mr. Sam Sklar, and an additional gift from the Haifa Municipality.

CF-104 multi-mission Super Starfighter in its first flight. In an international production program involving Germany, Canada, The Netherlands, Belgium, Italy and Japan — more than 1000 Super Starfighters are programmed for manufacture. Canada is scheduled to produce, under Lockheed licence, 8 squadrons for integration into R.C.A.F.'s European Air Division supporting NATO units in Europe. These are being manufactured by Canadair Ltd. First production is scheduled to fly April.




every
SPARLING
job is a
big job!

Month to Month

Vancouver, City of Opportunity

As you will see, the emphasis in this issue of the Journal is on your Annual General and Professional Meeting which will be held in Vancouver from May 31 until June 2. If you have not already made plans to attend, perhaps we can interest you in so doing.

Those of you who have attended past Annual Meetings are aware they consist of two broad activities. One is the annual general meeting of the Institute with attendant business meetings of various committees. This is your opportunity to investigate the workings of the Institute in person, to see what has been accomplished in the past year, and to learn what programs your Institute plans to foster with vigor next year.

Your presence and voice are not only welcome; they are essential if the Institute is to continue its strong upward growth.

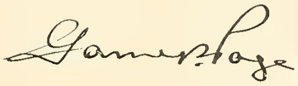
The technical program comprises the other broad phase of the meeting. More than 60 papers covering all phases of engineering will be presented during the three-day meeting. As an engineer you owe it to yourself and to your profession to keep abreast.

Personal contacts made at such meetings are both valuable and numerous. At least we can attest to the number of opportunities: last year more than 1,000 persons attended the Annual Meeting at Winnipeg.

The Annual Meeting is held each year in a different part of Canada to permit as many of our far-flung members as possible to participate actively in the work of the Institute. This year, Vancouver is the City of Opportunity. Western members should be able to attend with relative ease.

The ladies, too, should be delighted with the time and place of the meeting. We know Vancouver to be a visitor's delight. And we have been informed, in some confidence, that the city plans to be at its loveliest late this Spring.

Why not plan a few days off this Spring? Help the Institute help you. Be in Vancouver and combine pleasure with opportunity.



Executive Committee Meeting

The Executive Committee of Council met Feb. 25 at Headquarters in Montreal. President Dick was chairman. The following are highlights of the meeting.

Life Members Fund

Finance Committee Chairman F. L. Lawton reported that it has been agreed that a simple statement of practice governing the operation of the Life Members Fund should be adopted, as follows: (i) The Life Members Committee submits a report of its activities to Council annually. (ii) The funds paid into the Life Members Fund shall be within the care of Council but designated as a special fund separate from the general funds of the Institute. (iii) The disbursal of funds from the Life Members Fund for the purposes recommended by the Life Members Committee is authorized by vouchers signed by two members of the Life Members Committee.

Technical Operations Manual

It was noted that the Technical Operaitons Manual now is in final form for publication and the Executive Committee was pleased to authorize its immediate publication.

Technical Program — 1961 Annual Meeting

It was agreed that the Civil Engineering Division program for Friday Afternoon June 2, 1961, be devoted to a visit to the University of British Columbia to inspect the Fraser River Model.

Branch Operations

Mr. Lawton presented an analysis of replies to President Dick's policy letter to Councillors of Jan. 6, and it was resolved that recommendations contained therein be adopted and appropriate action taken to implement them.

Port Credit Branch

A petition was granted to form a Branch of the Institute at Port Credit, Ont., and that an initial rebate of $50. be made to this new Branch pending the establishment of the regular rebate. President Dick presented the Chapter to the Branch on March 24.

University of Western Ontario

A petition to form a Student Section of the E.I.C. at the University of Western Ontario was granted.

Branch Achievement Awards

Subject to the approval of Council at its April 22 meeting, two awards are to be established to be known as "The George McKinstry Diek Branch Achievement Award". They are to be presented annually to one large and one small Branch. Branehes will be judged on overall operations, membership growth and technical activities.

Interpretation of Procedures followed by Admissions Committee and Board of Examiners

An ad hoc committee is to be established to investigate present policy and practices of the Board of Examiners and to recommend to Council regarding desirable policy and practices to be followed by the Board of Examiners when dealing with applications for membership referred to it by the Admissions Committee.

The Engineering Journal

A regular editorial poliey is to be adopted regarding the insertion of four pages of a tinted stock in each issue of the Journal to be devoted to Presidential views, Council, activities, reports and contributions of the Committee on Technical Operations, the Committee on Membership, the Committee on Branch Operations and other vital contributions concerning the activities of the E.I.C. at all levels.

Membership Directory, 1961

The 1961 E.I.C. Directory is to be published in two sections. The first section is to contain a complete list of names in alphabetical order, with the member's branch indieated by number, a numerical code is to be established for all branches. The second section is to contain details about each member, with the names listed alphabetically under each branch. The present grade of membership and field of technical interest will be given.

1961 Annual General Meeting

It was agreed that the Annual General Meeting will commenee at 9.00 a.m., Wednesday, May 31, rather than at 10.00 a.m., and will adjourn at 12.00 noon. The extra hour will be devoted to the subjeet of Confederation. The Executive Committee approved the pub-

(Continued on page 105)

75th ANNUAL GENERAL AND PROFESSIONAL MEETING of

THE ENGINEERING INSTITUTE OF CANADA

May 31, June 1—2, 1961 Hotel Vancouver, Vancouver, B.C.

Registration

Advance registration through E.I.C. Headquarters closes May 20th.
Registration opens at 12 noon Tuesday May 30th, at the Hotel Vancouver.

Accommodation

The Hotel Vancouver is headquarters for the meetings and other events, but alternate accommodation will also be available at other hotels and motels in the area.

Technical Program

The technical program is listed on the following 2 pages.

Ladies Program

Early plans for this include the following:

2:30 p.m. Wednesday, Tea followed by a tour of the Japanese Gardens at U.B.C.

10:00 a.m. Thursday, Engineers Wives Association Meeting

12:30 p.m. Thursday, Luncheon, Royal Vancouver Yacht Club, followed by a tour of Marine Drive.

Friday evening — the Annual Banquet and Dance

Vancouver Diary

The events for all four days at the Hotel Vancouver are listed on the back of this program.

Committee

Chairman: Dean D. M. Myers, M.E.I.C.
Vice Chairman: Professor W. Heslop, M.E.I.C.
Secretary: F. M. Cazalet, M.E.I.C.

TECHNICAL PROGRAM Wednesday, Thursday, Frid

Wednesday, May 31

Mechanical

Side Tipping Log Barges
T. A. McLaren, M.E.I.C.

The Factors Involved in the Design of a Canadian Gangsaw
E. N. Parker, M.E.I.C.

Douglas Fir Plywood Manufacture
J. S. Abel

Bridge and Structural

Revision of the Reinforced Concrete Section of the National Building Code
M. W. Huggins, M.E.I.C. and W. G. Plewes, M.E.I.C.

Current CSA Specifications on Engineering Design in Timber
J. W. Wynand

Commentary on CSA Standard S16-1961
W. G. Mitchell, M.E.I.C. and D. L. Tarlton

Hydro-Electric

Outlook on the Relationship between Load-Frequency Control and Turbine Governors on Interconnected Power Systems
L. O. Long

EIC 1961 Annual Meeting

Use of an Electronic Analog Computer for Determining Optimum Settings of Speed Governors for Hydro Generating Stations
L. M. Hovey, M.E.I.C.

Economic Development of Hydro-Quebec Power Resources—System Studies Utilizing an IBM 704 Computer
J. Bourbeau, M.E.I.C., F. H. Jonker and J. G. S. Thomson

Civil

Sewage Lagoon for City of Saskatoon
D. R. Stanley, M.E.I.C. and E. Cole, M.E.I.C.

The Hydraulic Capacity of Large Corrugated Metal Culverts
C. R. Neill, M.E.I.C.

Marine Waste Disposal
E. A. Pearson

Electrical

Electronic Aids in Canadian Mapping
J. T. Henderson, M.E.I.C.

The D.R.B. Topside Sounder Satellite
R. C. Langille

Design Considerations for Large Radio Telescopes
J. L. Locke

Thursday, June 1

Mechanical

The Combustion of Gasoline during Engine Starting at Low Temperature
F. D. Hamblin, M.E.I.C.

An Evaluation of Plywoods and Plastics in Boat Construction
J. Brandlmayr, M.E.I.C.

The Thermal Wedge Effect in Hydrodynamic Lubrication
J. Young

The N.A.E. Five Foot Supersonic Wind Tunnel
K. F. Tupper, M.E.I.C., P. B. Dilworth, M.E.I.C. and L. A. Jenkins

Bridge and Structural

Weaknesses of the Theory of Plastic Design
A. Hrennikoff, M.E.I.C.

Unique Design in Glulam
B. Madsen

The Limit Design of Reinforced Concrete Continuous Beams
C. Berwanger, JR.E.I.C.

The Champlain Bridge—Steel and Prestressed Concrete Crossing of the Saint Lawrence River
B. A. Hesketh, M.E.I.C.

The Inspection, Repair & Maintenance of Highway Bridges in the City of London, Ontario
R. M. Dillon, M.E.I.C. and P. H. D. Edwards

Design of the Superstructure of the Port Mann Bridge
G. Hardenberg

Chemical

The Behaviour of Rarified Gases
D. S. Scott

The Production, Handling & Uses of Tonnage Oxygen by Cominco
C. H. Simpkinson

Hydro Electric

Engineering Research on the Fish and Power Problem
E. Ruus, and J. F. M. Muir, M.E.I.C.

The Beechwood Fish Hoist
J. D. Denovan, M.E.I.C.

Watershed Resource Value — The Associated Development of Fish and Power
V. Gwyther, M.E.I.C.

Geotechnical

Landslides in Over-Consolidated Clays
R. M. Hardy, M.E.I.C. and E. W. Brooker, M.E.I.C.

Carillon Foundation Studies
C. H. Pigot, M.E.I.C. and I. D. MacKenzie, M.E.I.C.

The Planning of Avalanche Defence at Rogers Pass
P. Schaerer, M.E.I.C.

TECHNICAL PROGRAM

Management

The Saskatoon Productivity Program
I. S. Evans, M.E.I.C.

The Economic Advantage of a Systematic Mapping Program of Outside Facilities to a Public Utility
J. S. G. Shotwell, M.E.I.C., W. C. Fisher, M.E.I.C. and V. J. Feeney

Effects of Changing Technology on Labor and Employment
W. Bruce, M.E.I.C.

NRC-EIC Symposium on Automatic Control

The Optimization of the Performance of an Ore Bridge, An Analogue Computer Study
J. A. Field, JR.E.I.C.

The Determination of Linear Multivariable Models for Complex Processes
R. J. Kavanagh, M.E.I.C.

Economic Performance Criteria for Optimizing Control Systems
J. H. Milsum

A Continuously Acting Adaptive Analog Computer for Determining the Impulse Response of Control Systems with Gaussian Signals
E. V. Bohn

The Control System of an Automatic Stereo Mapping Machine
J. M. Ham and G. L. Hobrough

Process Loop Optimization Through Valve Characterization Techniques
G. L. d'Ombrain and S. M. Lyle

The Optimal Gain of Manually Controlled Machines
C. B. Gibbs

Reliable Networks from Unreliable Components
Miss O. Boshko, G. S. Glinski, M.E.I.C. and J. Therrien

Friday, June 2

Joint Chemical-Mechanical-Management

Non Linear Control for Distillation Columns
G. A. McNeill

Some Engineering Applications of Analog Computors
P. N. Nikiforuk, and T. W. McDonald

The Need for Research in Planning Mechanization
J. C. Clapham

The Pipeline Transport of Solid-Liquid Mixtures
G. W. Govier, M.E.I.C.

Forced Variation During the Formation of Continuous Segmented Chips in Metal Cutting
R. Salmon, JR.E.I.C.

A Simulation of the Economy of British Columbia — A Guide to Industrial Development
R. E. Boston, JR.E.I.C.

Hydro-Electric

Speed Regulation for Hydraulic Turbines
J. L. Gordon, JR.E.I.C. and W. J. Smith, M.E.I.C.

On the Treatment of Stochastic Variables in Engineering Design
J. H. Milsum

Joint Engineering Education — Civil

Some Reflections on Trends in Engineering Training
A. Porter, M.E.I.C.

Urgent Tasks in Engineering Education
D. M. Myers, M.E.I.C.

Modern Techniques Solve Unusual Log Driving Problem
D. M. Foulds, M.E.I.C. and C. E. Davidge

Civil Engineering Education
S. D. Lash, M.E.I.C.

Have We a Problem in Engineering Education?
W. F. McMullen

A Research Viewpoint on Engineering Education
B. G. Ballard, M.E.I.C.

Civil

Three-Dimensional Photoelastic Analysis of a Diamond Head Buttress Dam
C. R. Jones and J. B. Mantle, M.E.I.C.

EIC Vancouver, May 31, June 1-2

The Structural Design of the Tunnels for the South Saskatchewan River Dam
C. Booy

Geology of the South Saskatchewan River Project
D. H. Pollock, M.E.I.C.

Electrical

New Uses for Ceramic Materials in Microwave Tubes
G. B. Walker

Rearward Communications for BMEWS
L. J. Hammerschmid, M.E.I.C.

Some Problems Encountered in Underwater Sound Research
H. H. A. Davidson

Electrical Installations in Modern Jet Aircraft
R. W. Farren

The Hows, Whys and Wherefores of EHV Transmission
C. M. Stairs

Concepts and Economics of Extra Long Distance Direct Current Transmission and System Interconnections
H. L. Briggs, M.E.I.C.

ANNUAL MEETING

Monday, May 29

Annual Meeting of Council	8:00 p.m.

Tuesday, May 30

Committee on Branch Operations	9:00 a.m.
Joint Luncheon, all conferences	12:30 p.m.
Continuation of Annual Meeting of Council	2:00 p.m.
Continuation of Committee on Branch Operations	2:00 p.m.
Press Conference	4:30 p.m.
Informal reception, all visitors welcome	8:30 p.m.

Wednesday, May 31

Authors' Breakfast	7:45 a.m.
Annual General Meeting	9:00 a.m.
Muriel's Room	12:00 noon
Opening Luncheon	12:30 p.m.
Students' Conference — opening session	2:00 p.m.
Muriel's Room	6:30 p.m.
Informal Dinner, Address by President Dick	7:00 p.m.
Social evening — informal	9:00 p.m.

Thursday, June 1

Authors' Breakfast	7:45 a.m.
Consulting Engineers — Directors' meeting	9:00 a.m.
New Council Meeting	10:00 a.m.
Muriel's Room	12:00 noon
Honours and Awards Luncheon	12:30 p.m.
Students' Conference — second session	2:30 p.m.
E.I.C. Committee on Membership	2:30 p.m.
Association of Consulting Engineers — Annual Meeting	2:30 p.m.
Association of Consulting Engineers — Annual Dinner	7:00 p.m.
Panel Discussion on Automatic Control	8:00 to 10:00 p.m.
Evening cruise by steamer "Princess Patricia"	9:00 p.m.

Friday, June 2

Authors' Breakfast	7:45 a.m.
Joint A.S.M.E.-E.I.C. International Council	9:00 a.m.
Students' Conference—final session	2:00 p.m.
Muriel's Room	6:30 p.m.
Annual Banquet	7:30 p.m.
Annual Dance	10:00 p.m.

EIC

the Engineering Institute of Canada

MONTH TO MONTH

(Continued from page 100)

cation of the Meeting and Conference Ianual which has been prepared by the aff, with the valuable assistance of revious Annual Meeting Committees.

Open House"

The proposal that E.I.C. Branches hold n "Open House" for graduating engieers was adopted. It is to be implemented by the Committee on Branch perations and the Student Policy Committee.

dministration

President Dick has visited the Monteal Branch on two occasions since the ast meeting, for its Annual Meeting an. 30 and for its Ladies' Night Feb. 7. On Feb. 8 he presented the new Dakville Branch with its Charter and isited the Toronto Branch and the University of Toronto Feb. 9. Vice-President Lawton will visit the Ottawa Branch, he St. Maurice Valley Branch and the Quebec Branch. Vice-President Higginon will be making visits to Branches in he Maritime Provinces during April and May. Vice-President Miller has received encouraging reports from the North Shore-Lower St. Lawrnece and Lower St. Lawrence Branches. The General Secretary recently visited the Halifax, Moncton and Prince Edward Island Branches and had extremely useful meetings, not only with members of the Branches concerned but with representatives from other Branches in the area. Mr. Luke visited the Border Cities and Peterborough Branches.

A luncheon was held for the President of the Institution of Civil Engineers and his lady when they visited Montreal March 28.

International Agreements

An ad hoc committee is to be established to recommend regarding an overall policy for the E.I.C. concerning cooperative agreements with other engineering societies.

Mr. Luke presented a report on the 1961 Annual Meeting of the International Association for the Exchange of Students for Technical Experience. He stated that between 50 and 60 students now are interested in participating in the exchange this year. Dr. W. B. Lewis of Atomic Energy of Canada Limited, Chalk River, Ont., has been nominated for the Neils Bohr International Gold Medal.

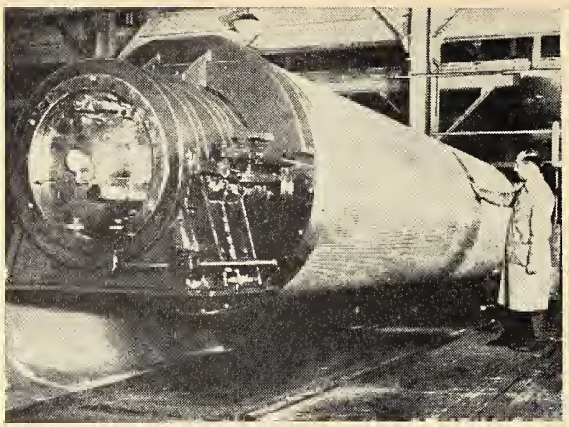
Faculty Advisor—The University of Alberta

Professor H. R. McArthur is to be appointed E.I.C. faculty advisor for the University of Alberta's engineering student body in Calgary. EIC

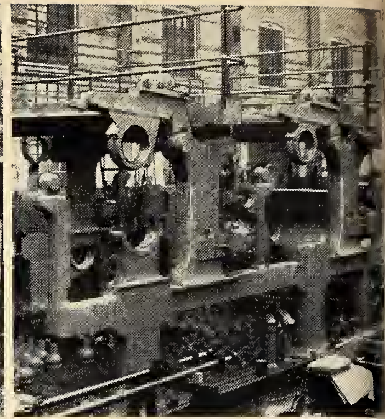
Have you played your part as a member of the Membership Committee?

Stan Cassidy

12" pipe



Cantilever head



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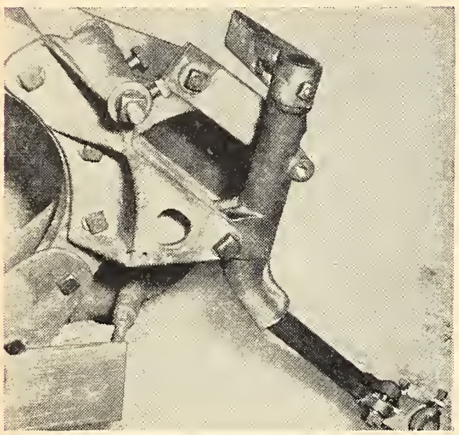
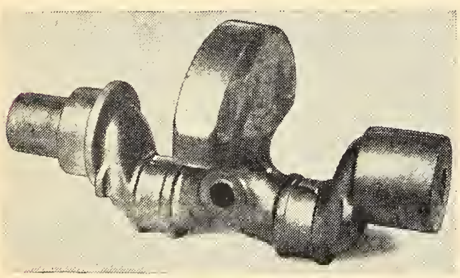
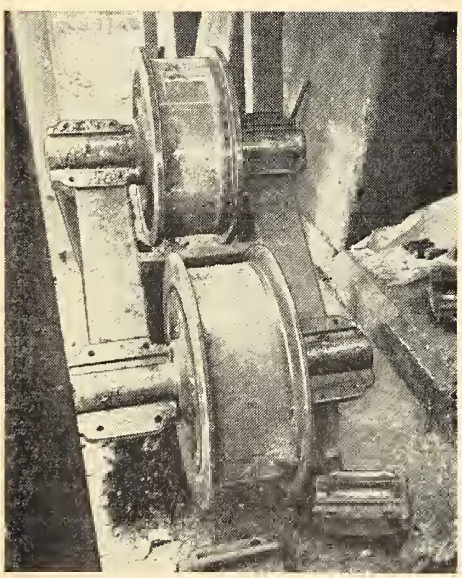


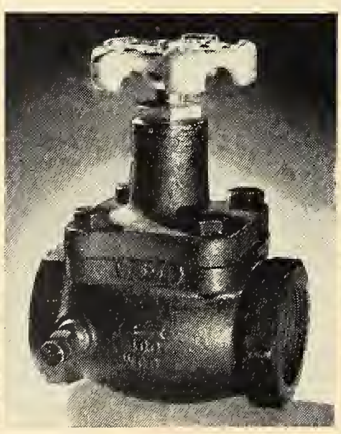
Plow tail wheel mounting



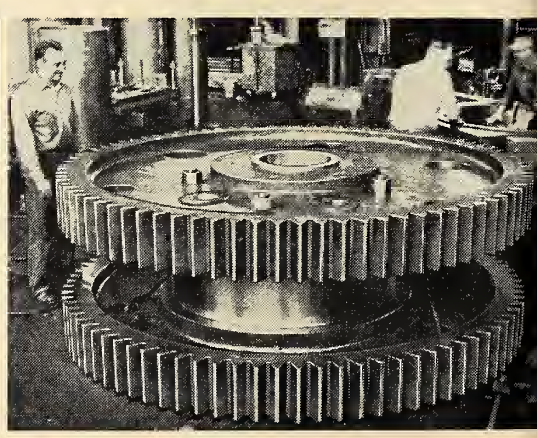
Crankshaft



Barking drum rollers



Valve



Nickel-alloyed gears

Personals

Dr. Otto Holden, HON. M.E.I.C. (Toronto '13), was presented with an Honorary Membership Certificate by President Dick at a Dinner held by the Toronto Branch Feb. 9. The Council of the EIC elected Dr. Holden to Honorary Membership at its meeting April 30, 1960, but Dr. Holden was unable to be at Winnipeg to receive it at the Annual Meeting, May 26. The honour was an acknowledgment of Dr. Holden's achievements in the field of learning and of the steadiness which he has exhibited in times of stress in engineering affairs.

Formerly Ontario Hydro's Chief Engineer, Dr. Holden is a man whose record of achievement in the field of hydraulic engineering has brought distinction not only to himself but it has served to enhance the world-wide renown of the organization he has served since 1913. In helping to carry out Ontario Hydro's tremendous post-war expansion program Dr. Holden had a major part in further harnessing the waters of the Ottawa River through the completion of three important generating stations — Des Joachims, Chenaux, and the LaCave plant, the latter renamed in his honour, the Otto Holden Generating Station. Dr. Holden's services were enlisted in examining and reporting on plans for the construction of a hydro-electric project in the Snowy Mountains in southeastern Australia. He joined the Institute as an associate member in 1921 and has been a life member since 1956.

T. H. Dickson, M.E.I.C. (N.S.T.C. '22), former electrical engineer of the CNR's Atlantic region has retired after 35 years with the railroad. Mr. Dickson's last major project was the installation of the power distribution system and floodlights in the railroad's $15 million automatic classification yard.

C. W. E. Locke, M.E.I.C. (British Columbia '30), has been appointed vice president in charge of Asian operations of Sandwell International Limited, Vancouver. Mr. Locke recently returned from Asia and will be based at the company's Vancouver office.

Gordon A. Dysart, M.E.I.C. (McGill '51), has been appointed electrical superintendent of the KVP Company Limited, Espanola, Ont.

Allan Jackson, S.E.I.C. (Queen's '59), has been appointed Township Engineer of Tarentorus. Mr. Jackson has been with the Department of Highways since his graduation, connected with the MacNamara contract on Highway 17N.

Obituaries

Francis Caldwell Ball, M.E.I.C. (Toronto '23), chief sewer engineer of the London, Ont., city works died Jan. 15. He was 64. Mr. Ball has been an engineer with the City of London for the past 37 years. He joined the Institute as student member in 1920 and became a member in 1940. He was made a life member this year.

Thomas Arthur Barnett, M.E.I.C. died Dec. 12, Niagara Falls, Ont. He was 86. Mr. Barnett, a civil engineer, worked on construction jobs across Canada with such firms as the Hydro Electric Power Commission of Ontario, Foundation Company of Canada, International Nickel Co. of Canada Ltd. and the Wallburg Construction Company. He joined the Institute in 1922 as an associate Member and became a life member in 1952.

Robert Jones Bethune, M.E.I.C. (Dalhousie '07), well known civil engineer died Jan. 9, New Glasgow, N.S. He was 75. Mr. Bethune began his career in railway construetion work. He joined the Nova Scotia Highways Department in 1914 and was appointed division engineer for Guysborough, Antigonish and Pictou counties. He retired in 1952. He joined the Institute in 1940 and became a life member in 1957.

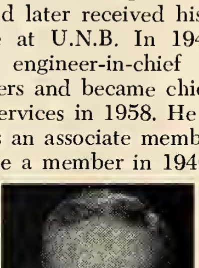
Edward Lancelot Cousins, M.E.I.C. (Toronto '07), died Feb. 9. He was 77. In 1912 he played an important part in the development of Toronto's harbour and waterfront. Mr. Cousins became general manager for the Harbour Commissioners in 1935. After his retirement in 1946 he continued as consultant. He joined the Institute as a student member in 1907 and became a life member in 1961.

Nathan L. Engel, M.E.I.C. (McGill '07), prominent electrical engineer, died Dec. 31, 1960. He was 77. Mr. Engel was born and educated in Montreal and began his career in the electrical power industry in 1907. He was manager of Hydro-Quebec's Industrial Department when he retired in 1949. He joined the Institute as an Associate Member in 1921 and became a life member in 1954.

G. E. Smith, M.E.I.C.

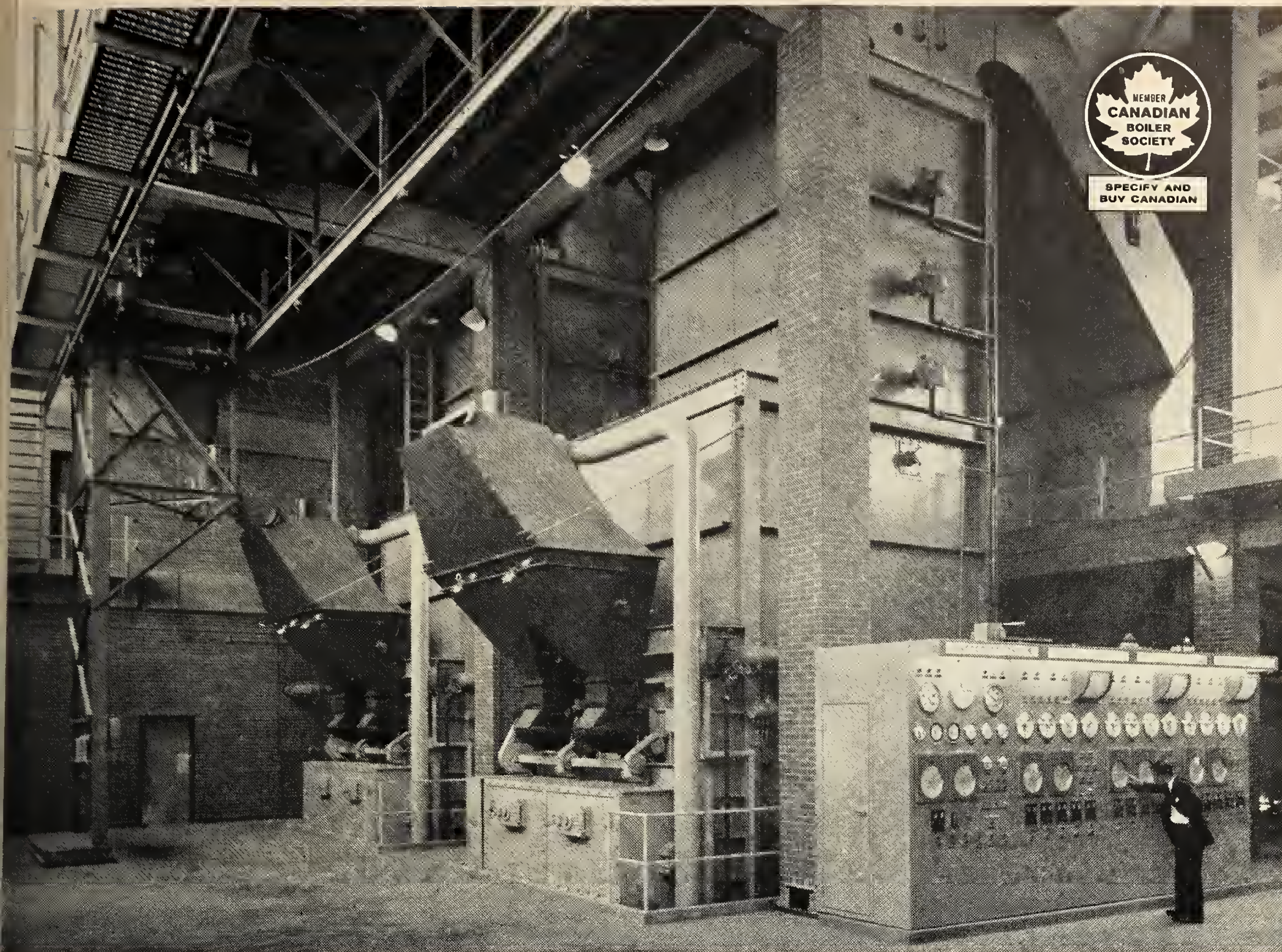
George Ellis Smith, M.E.I.C. (New Brunswick '12), civil engineer, died Jan. 28, Moncton, N.B. He was 71. In 1919 Mr. Smith joined the Canadian National Railways, and in 1951 became regional manager of the Real Estate Department for the Atlantic Region. He held this position until his retirement in 1954. He joined the Institute as an associate member in 1921 and in 1956 he became a life member.

Rear-Admiral Brian Roff Spencer, M.E.I.C., chief of naval technical services at Naval Headquarters, died Jan. 22, Rockcliffe, Ont. He was 54. Rear-Admiral Spencer entered the Royal Canadian Naval College at Halifax as a cadet and later received his engineering degree at U.N.B. In 1946 he was appointed engineer-in-chief at Naval Headquarters and became chief of naval technical services in 1958. He joined the Institute as an associate member in 1939 and became a member in 1940.



W. Taylor-Bailey, M.E.I.C.

Frank Whitham Taylor-Bailey, M.E.I.C. (McGill '16), director and former president of Dominion Bridge Ltd., died Feb. 28. He was 69. While overseas with the Canadian Engineers and Royal Air Force, he was awarded the Military Cross. In 1919 he joined the sales staff of Dominion Bridge Ltd. Mr. Taylor-Bailey was appointed president and managing director in 1951. He became chairman of the board in 1958. He joined the Institute as a student member in 1915 and became a life member in 1955.



H.T.W. system supplies ten separate buildings...

Three Dominion Bridge 40 million B.T.U. high temperature water boilers are being used in Ottawa to supply heat to ten large Department of Public Works buildings spread over several acres.

In applications of this kind, where heat must be distributed over a wide area, H.T.W. offers very definite advantages. These are evident in lower overall costs due largely to the absence of corrosion, elimination of condensate traps and separators, and the fact that mains may be laid with minimum regard for levels or grades. Because of the high thermal storage of the system a smaller capacity plant is possible thus reducing fluctuation in the firing rate to give better overall efficiency. Capital costs are comparable with H.P.S. installations.

The new plant, located on Riverside Drive, operates at 350°F. and 200 psig with an inlet water temperature of 220°F. One and a half inch drainable tube circuits are arranged for continuous upward flow and the water is distributed, according to the heat absorption capacity of the circuits, through stainless steel metering orifices. The boilers are coal fired and equipped with continuous discharge spreaders. Consulting engineers were J. Klassen and Associates, Ottawa.

Dominion Bridge design and manufacture water tube and fire tube boilers for a wide variety of applications. Assess 'Canadian-Made' first—call the Boiler Products Division at any of its offices across the country. Their experience is at your service.

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Other Societies

The American Society of Mechanical Engineers

The Production Engineering Division of the ASME will be conducting its annual division conference in Toronto, May 9-12 under the theme "International Co-operations for Productivity". The EIC is a co-sponsor of this conference. It will be held concurrently with the National Industrial Production Show of Canada.

In addition to the general production engineering and metal processing program, there will be two international panel sessions. The Wednesday afternoon, May 10, session will include discussions on machine and tool programming data preparation, problems evaluation and requirements of machine data for use in self controlling machines. The development of new concepts and schemes in the field of metal cutting, will also be discussed. On Thursday afternoon, unification of instruction media for production machines will be the topic under discussion.

Canadian Aeronautical Institute

The mid-season meeting was held Feb. 27-28 at the Marlborough Hotel, Winnipeg. The first session was devoted to Landing Engineering and included papers on "The Long and the Short of Runways", "Review of the Present and Future Aircraft Brake" and "A Review of Landing Gear on the Caribou Aeroplane". Monday's afternoon session was on Runways—Prepared and Otherwise. Two papers were presented, "R.C.A.F. Snow Removal and Ice Control" and "Operation of Wheel Equipped Fixed Wing Aircraft on Unprepared Land and Snow Surfaces in the Arctic Islands". On Tuesday, Feb. 28 Air Traffic and Flight Control was the theme. Three papers were presented, "Airspace Management in High Density Areas", "An Evolutionary Approach to Instrument Flare Out and Landing", and "The Pilot and Air Traffic Control". The final session Tuesday afternoon was a panel discussion on Training by Simulation.

Canadian Construction Association

Twenty-five senior members of the architectural profession in Ontario joined thirty-five sales managers and top personnel from the building products industry in a special two-day seminar at Scarborough, Ont., Jan 9-10. The meeting was designed to focus attention on mutual problems affecting architects and suppliers. The convention chairman was Dr. Thomas Howarth, Director of the School of Architecture, University of Toronto, and a stimulating keynote address was given by Robert F. Legget, Director, Division of Building Research, National Research Council.

The Canadian Institute of Steel Construction Inc.

The Institute maintains a library of 16 mm. color, sound films of interest to architects, engineers and contractors. Films include "Adventure in Steel", portraying the operations at the modern steel mills of Algoma Steel Corporation Ltd.; "Fury of the Winds"; "Men, Steel and Earthquakes"; "Skyway to the Future" (Burlington, Ontario Skyway) and "History of American Architecture".

International Institute of Welding

For the first time in the 13-year history of the International Institute of Welding the Annual Congress is being held outside Europe. In 1961 the American Council of the I.I.W. in conjunction with the American Welding Society, will sponsor the Annual Congress in New York.

On April 20 the Canadian Council is sponsoring a one-day industrial tour in the Welland-St. Catharines area. Delegates will be flown from New York to Niagara Falls, N.Y., where they will be met by buses supplied for the day by the Ontario Hydro Commission. In the morning the delegates will visit Ontario Hydro's Sir Adam Beck Power plant and in the afternoon they will tour local industries.

Society for Experimental Stress Analysis

Dr. C. B. Craig gave a talk on "Plastic Deformation" at a meeting held March 14 at the University of Toronto. Dr. Craig described the production of metal crystals, the basic mechanism involved in plastic flow, why the elastic theory is not applicable in the plastic range, and other associated subjects.

The Institution of Mechanical Engineers

The Council of The Institution of Mechanical Engineers, London, England, has awarded the 1961 James Watt International Medal to Professor Dr. Theodore van Karman, Ph.D., in recognition of his important contributions to the advancement of mechanical engineering science, which have extended the frontiers of engineering knowledge particularly in the field of aeronautics.

The nomination of Professor van Karman for this award was sponsored by the A.S.C.E. The James Watt International Medal was founded to commemorate the bi-century of the birth of James Watt, which took place Jan. 19, 1736.

Second International Heat Transfer Conference

The five day International Heat Transfer Conference is to be held Aug.

(Continued on page 113)

The Associations and Corporation

Prime Minister Diefenbaker, P.C., Q.C., is to address members of the Corporation of Professional Engineers of Quebec and their wives at the closing banquet of the 41st Annual General Meeting in Montreal, April 8.

The Committee on Professional Training has recommended to Council to sponsor the organization of a banquet where graduating engineering students would be presented with their certificates of membership in the Corporation. The banquet is planned for May 29 and it is the intention of the Committee to have a prominent engineer as guest speaker.

Ontario

The February journal of the Association of Professional Engineers of the Province of Ontario reports on Canadian Council's seventh survey of annual rate of remuneration of Canadian professional engineers. Table I shows a comparison of annual earnings across Canada as of December 1, 1960. Table II offers a comparison of the Dec. 1, 1960 survey with the one made in 1959.

▸ OTHER SOCIETIES

28-Sept. 1 at Boulder, Colorado. The conference, sponsored by four engineering societies, two American and two British, with participation by eight others, will be held on the campus of the University of Colorado. Great Britain is represented by the Institution of Mechanical Engineers and the Institution of Chemical Engineers. Sponsors and co-hosts of the conference in the United States are The American Society of Mechanical Engineers and American Institute of Chemical Engineers. Also participating are the American Society of Refrigerating and Air Conditioning Engineers, Chemical Institute of Canada, the Engineering Institute of Canada, the Institute of Aerospace Sciences, the Society of Automotive Engineers and the University of Colorado.

Papers have been submitted by engineers from the United States, Canada, England, U.S.S.R., Japan, Poland, Australia, France, Switzerland, Scotland, Sweden, Germany, and Yugoslavia. More than 100 papers on recent original work and new applications in heat transfer theory and practice have been accepted. To afford the opportunity for a full discussion of these papers, there will be no individual presentation by authors, but groups of related papers will be reviewed by special reporters and then followed by general discussions. Full opportunity to study the papers before the conference will be provided by supplying advance registrants with a bound copy of all the papers, well ahead of the meeting.

A special feature of the conference will be talks by four visiting lecturers who will review and synthesize the most recent developments in research and application.

The EIC representative on the organizing Committee is Professor J. W. Stachiewicz, M.E.I.C. and further information can be obtained by writing to him c/o Dept. of Mechanical Engineering, McGill University, Montreal 2.

National Industrial Production Show of Canada

The Hon. George H. Hees, Minister of Trade and Commerce is to open the third biennial National Industrial Production Show of Canada, to be held May 8-12 in the Industry and Coliseum Buildings, Toronto.

The Exhibition is in line with Federal Government decision to establish a National Productivity Council, which will co-operate with secondary industries to promote productivity and thus increase employment. The show will provide an opportunity for plant managers and owners, technicians, engineers, supervisors and executives to examine in one place the latest improvements in industrial production equipment, study methods and techniques, and select what they can use to improve their own production. There will be approximately 400 exhibits of production equipment, in different branches.

Royal Architectural Institute of Canada

The 1961 Convention of the Royal Architectural Institute of Canada will be held May 17-20, Chateau Frontenac, Quebec City. The 1961 convention theme is "The Building Community" and keynote luncheon speaker will be Philip Will, Chicago, President of the American Institute of Architects. A feature of the Assembly will be a special panel discussion covering the "Building Community" theme with prominent members of the Canadian building industry taking part. A post-convention tour of five European countries will follow.

National Electrical Day

Delegates from across Canada met at Halifax Feb. 6 to observe Canada's Electrical Day commemorating the birth of Thomas Alva Edison at Milan, Ohio, Feb. 11, 1847. Delegates were flown from Charlottetown, Moncton and Fredericton for the Luncheon attended by 257 at the Nova Scotian Hotel.

The luncheon was under the joint sponsorship of Canadian Electrical Council and the Power Committee of the Atlantic Provinces' Economic Council. The main address was given by J. W. Kerr, President, Canadian Electrical Manufacturers Association. Before the Luncheon a reception was given to the delegates through the courtesy of Nova Scotia Light and Power Company.

Coming Events

British Columbia International Trade Fair, Exhibition Park, Vancouver, May 3-13.

Hydraulic Conference, ASME-EIC, Montreal, May 7-11.

Symposium on Titrimetric Methods, The Chemical Institute of Canada, Analytical Division, Cornwall, Ont., May 8-9.

National Industrial Production Show of Canada, Industry and Coliseum Buildings, Toronto, May 8-12.

Annual Division Conference, Production Engineering Division ASME, Toronto, May 9-12.

ASME Production Engineering Conference, Toronto, May 10-12.

First Eastern Regional Convention, Society for Nondestructive Testing, Montreal, May 17-19.

17th Canadian Regional Conference, Illuminating Engineering Society, Montreal, May 14-16.

1961 Convention of the Royal Architectural Institute of Canada, Quebec City, May 17-20.

75th Annual General and Professional Meeting, Engineering Institute of Canada, Vancouver, May 31-June 2.

Canadian International Conference and Exhibit, Instrument Society of America, Toronto, June 6-8.

27th Annual Meeting, The National Society of Professional Engineers, Seattle, Wash., July 4-7.

44th Canadian Chemical Conference and Exhibition of the Chemical Institute of Canada, Montreal August 3-5.

News of the Branches

Chalk River

R. O. Sochaski, M.E.I.C.
Correspondent

Approximately 40 members, wives and guests attended the dinner meeting Feb. 14. Vice-President E. A. Cross was present and R. D. Blake of CARDE was the main speaker.

Vice-President Cross reviewed technical societies and their growth through the early days to the present, pointing out that the EIC is one that engulfs every branch of the engineering profession across Canada. He also mentioned that the Branch's members, being in contact with the atomic industry, should be in an ideal position for teaching other engineers about this expanding and important field.

Mr. Blake spoke on rockets. His talk was based on the Black Brant I and II rockets, which are manufactured at CARDE by the Canadian Government. Both these rockets consist of one motor, a nose cone, three fins and the necessary instrumentation. Mr. Blake described the process by which fuel is loaded into the engine casing and how these engines are tested on the 1,000,000 pound thrust test bed. The Black Brant I was designed for testing of solid propellant while the Black Brant II was designed as a research vehicle.

The meeting ended with a film on rockets.

Central B.C.

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

"Corrosion costs United States and Canada $5.5 billion a year", said Mr. E. C. Halawell, Corrosion Maintenance Supervisor, Trans Mountain Oil Pipeline Company, at a joint meeting of the Central B.C. Branch of the Engineering Institute of Canada and the Association of professional Engineers, at the Round Up in Vernon Feb. 10.

Since joining Trans Mountain Mr. Halawell has devoted himself to the study of pipeline protection, a field of study as yet not fully explored, although a method of galvanic cathode protection for the British Navy's iron and steel ships was first advanced by Sir Humphry Davies about 100 years ago. In addition to galvanic cathodes, pipelines are also protected by special coatings and electrolitic cathodic protection by outside source of dc. current. The methods of applying this protection to oil pipelines with particular reference to the Trans Mountain Pipeline were explained in some detail. A lengthy question period followed.

Members attending from the major centres in the Okanagan as well as Revelstoke and Kamloops also heard this years Chairman, J. Nelson, M.E.I.C., City Engineer of the City of Kamloops, outline the years program which will include a visit to the smelter city of Trail, April 17., a meeting with the President of the EIC in Kelowna, May 26, and meetings at Kamloops Sept. 8, Penticton Oct. 6, and Vernon, Nov. 7. Western Field Secretary of the EIC, Cmdr. A. C. M. Davy was present at the meeting.

Corner Brook

Robert G. Scott, JR.E.I.C.
Correspondent

At a meeting held Feb. 7, John Fordham, Resident Engineer, Foundation of Canada Limited, gave a talk "Wharf Construction". The speaker was introduced by R. Goosney, JR.E.I.C., Project Engineer, Bowater's Newfoundland Pulp and Paper Mills Limited.

Mr. Fordham first discussed the factors which must be taken into account in the design of wharves in general. He then covered the four main types of wharf construction: trestle, sheet piling and fill, floating structure and coffer dam. Materials used, field of application and step-by-step building methods, received attention in each case. Throughout his talk the speaker made extensive use of diagrams and at its conclusion showed excellent coloured slides of wharves in construction at sites throughout eastern Canada.

Kitchener

A. R. LeFeuvre, M.E.I.C.
Correspondent

The 11th annual meeting was held Jan. 27 and members heard Howard Smith, President of Dryden and Smith Planning Consultants, give an interesting talk on "Community Planning in Waterloo Township, Past, Present and Future". Mr. Smith outlined the need for increased community plannng based on the large influx of people expected in the next twenty years. With the aid of wall chart maps, he outlined some of the early planning of the township with regard to land use, roadways and parklands. In conclusion Mr. Smith appealed to engineers for ideas and assistance in future planning. L. Irwin Walle of Homar B. R. (Canada) Ltd. gave a talk at a meeting March 3. Mr. Walle's paper was entitled "Pneumatic Systems". He presented an interesting talk on applications and control of power pneumatic systems. He compared hydraulic and pneumatic methods of machine control. The short run Canadian operation favoured pneumatics because of low first cost. The speaker demonstrated a method of simplifying pneumatic installations by actuating a series of valves by a timed cam.

At this meeting the student executive was introduced to members. The executive for the winter-summer terms at the University of Waterloo are: President—John Rooroa, Vice-President—Mervyn Lumley, Sec. Treas.—Rodney McMurray.

Kootenay

I. Waterlow, M.E.I.C.
Correspondent

Mr. M. Phillips, Research Engineer at Cominco, gave a talk entitled "Cathodic Protection" to members Jan. 23.

Mr. Phillips described general principles of cathodic protection including the cathodic scale of metals. The suitability of various metals for cathodic protection was also described as well as the uses of zinc as a cathodic protective anode. Mr. Phillips completed his talk by showing slides of installations of zinc for this purpose in Port Coquitlan docking facilities.

Loyola Student Section

Richard Kind, S.E.I.C.
Correspondent

The section held its first annual dinner and stag Feb. 23 which was very successful. Approximately 65 members tended the dinner at which there ere three guest-speakers. J. C. Brodeur, . Johnson Company of Canada Ltd., poke briefly on civil engineering; . E. J. Layton, T. Pringle and Sons td., spoke on mechanical engineering nd W. J. Riley, chief engineer at perry Gyroscope Company of Canada td., spoke on electrical engineering.

Following the dinner there was an nformal gathering at which members ere able to meet and talk with guests nd professors.

Viagara Peninsula

. Jacox, JR.E.I.C.
Correspondent

"Nuclear Power Plants" was the title f a talk given by J. E. Holt, Canalian General Electric Company, Feb. 16. The speaker presented an excellent ddress on nuclear power plants with particular emphasis on the ones now being built in Ontario. Slides were shown and samples of uranium in various stages of processing were passed round. Mr. Holt was introduced by W. O'Reilly, JR.E.I.C. and thanked by R. McKimmie, M.E.I.C.

Newfoundland

Anthony O. Nemac, JR.E.I.C.
Correspondent

The Branch held a joint banquet with the student engineering society of Memorial University of Newfoundland Feb. 28. The guest speaker was T. J. Hobson, project engineer for Twin Falls hydro electric project in Labrador. Mr. Hobson gave an interesting and informative talk on the work in progress at Twin Falls and described the project as it would be when completed. The Twin Falls Hydro-electric operation is designed for an output of 120,000 h.p. which is expected to supply the needs of Labrador. Mr. Hobson also described the larger project of the Hamilton River development which is planned to have a continuous output of 4,000,000 h.p. The talk was accompanied by a showing of slides which vividly illustrated the magnitude of these projects. Mr. Hobson also displayed a scale model of the Hamilton River power project.

The banquet was attended by 80 persons—40 students and 40 members.

Nipissing and Upper Ottawa Branch

J. W. Millar, M.E.I.C.
Correspondent

A dinner meeting was held Feb. 10 to entertain students in the upper grades at local secondary schools who had shown an interest in becoming engineers. Each member sponsored a student for the evening, including the dinner. The guest speaker was W. G. Mann, president of W. G. Mann Associates, personnel advisers and consultants in Montreal.

Mr. Mann emphasized the importance of communicating with employers and employees, stressing the part the ability to communicate efficiently plays in a career. He used examples and anecdotes to illustrate his point. He recommended that students not making 75 per cent in high school think hard before entering engineering because such a student will have a hard time at university. Other requirements to make a good engineer, he said, are, to have some abstract reasoning ability and be good at space relations. The speaker was introduced by H. R. D. Graham, Northeastern regional manager, Ontario Hydro and was thanked by J. W. Millar.

Victoria

W. Tivy, M.E.I.C.
Correspondent

A. H. Paget, Comptroller of Water Rights of B.C. gave a talk Jan. 31 about his recent tour of Japanese hydro-electric projects and dams, which was in connection with the annual executive meeting of the International Committee on Large Dams in Tokyo.

Mr. Paget was impressed by the great activity in dam construction in the country. Earth-fill dams have been in use for well over a thousand years but the application of new techniques and use of new materials has brought a tremendous surge of heavy construction activity. Between 1950 and 1958, no fewer than 40 dams over 200 ft. high were constructed; since 1958, about the same number have been built or are under construction. Several of these dams are between 500 and 600 ft. high—among the highest in the world. It was evident from photographs shown by Mr. Paget, that modern methods of construction are prevalent in Japan. The experience and hard work of Japan's engineers and contractors has shown that they are capable of undertaking many of the world's large construction projects once the basic needs of their own country have been met.

Vancouver

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

The Branch started 1961 with the theme "Tuesday Night is Engineering Night". A program of specialized technical meetings under the Chairmanship of Alan Kay, M.E.I.C., has been very successful. Civil-Structural, Management, Natural Resources Development and Mechanical Sections have meetings on the first, second, third and fourth Tuesdays, respectively. The meetings have been well attended and appear to be filling a need for more technical rather than general meetings.

Civil-Structural Section—Jan. 10. Panel discussion on glulam structures entitled "New Horizons in Timber Structures". John McKenzie, Regional Officer, Canadian Institute of Timber Construction, was moderator. Feb. 7. Charles F. Ripley M.E.I.C., Consulting Civil Engineer, gave a talk on "Glimpses of Civil Engineering in Japan".

Management Section—Jan 17. Richard A. Mahoney, Management Consultant, spoke on "Management and the Facets Relating to Objectives, Policy and Control". Feb. 14. Conrad M. Lamond, Management Consultant, gave a talk entitled "Selection and Development of Personnel".

Natural Resources Development—Jan. 24. C. Riley, Consulting Geologist, spoke on "Potentialities of Natural Resources in British Columbia". Feb. 21. L. Edgeworth, of the Federal Dept. of Fisheries, gave a talk "The Salmon's Struggle for Survival."

Mechanical Section—Jan. 31. Dr. H. M. Ellis of I.P.E.C. gave a talk entitled "Electrical Utilities in the U.S.S.R." Feb. 28 W. B. Weston, Marine Superintendent, B.C. Toll and Highways Authority, spoke on "The Proposed 1,000 Complement Provincial Government Ferry."

The Professional Development Course has enrolled 45 members. The lectures started Feb. 8 and run throughout March. The theme for the 1961 course is "The Canadian Economy".

Winnipeg

P. M. Abel, JR.E.I.C.
Correspondent

The annual meeting was held Feb. 16. The Sec.-Treas., W. N. Isberg, gave a report on the past season's activities and the auditor's report of Branch finances was presented. Prof. V. L. Dutton, M.E.I.C. was the guest speaker and gave a talk entitled "Thin Shell Structures".

Prof. Dutton gave a general discussion on the relative advantages and disadvantages of the use of thin shells for building construction, dealing first with theoretical considerations and a description of hyperboloids and hyperbolic paraboloids. The talk was profusely illustrated with slides of diagrams and photographs of many buildings under construction and those already completed. The talk was concluded with a description and illustration of two projects carried out by students of the Faculty of Architecture on the University campus grounds: one a thin shell concrete hyperbolic parabloid, and the other a timber hyperboloid.

The speaker was introduced by Prof. H. E. T. North of the University of Manitoba Engineering Faculty, and was thanked by R. Drysdale of the Manitoba Department of Industry and Commerce. A question and answer period followed the address. Also on display were a number of models and drawings executed by architecture students, and printed literature and pamphlets on the subject of thin shells.

The **BELLEVILLE BRANCH** heard T. V. J. Cudbird, Manager, Anti Corrosion Division, Canadian Hanson and Van Winkle Company Ltd., speak on "Corrosion and Materials of Construction", Feb. 12. This talk was illustrated by a 16 mm sound film. The **BORDER CITIES BRANCH** held a joint dinner meeting with local members of the A.P.E.O. Feb. 15. Approximately 85 attended dinner. Guests included L. C. Sentance, President of the A.P.E.O.,

E. C. Luke, M.E.I.C., E.I.C. Headquarters staff, and P. Ryan, A.P.E.O. Headquarters staff. Ladies Night at the **BROCKVILLE BRANCH** took place Feb. 6. A dinner and dance was held at the Prescott Golf Club. Garnet T. Page, M.E.I.C., General Secretary of E.I.C., gave an illustrated talk on his visit to Russia. A meeting held Feb. 9 was sponsored jointly by the **HAMILTON BRANCH** and the Student Engineering Society. Dr. W. W. Sawyer presented a most practical and interesting talk on "Maths for Engineering". The **KINGSTON BRANCH** held a meeting Feb. 22. This was 'Students Papers Night' and four papers were presented. The **UNIVERSITY OF MANITOBA STUDENT SECTION** has been holding meetings since January, connected with the student paper competition. The **UNIVERSITY OF ALBERTA STUDENTS SECTION** heard an address Feb. 21 by Murray Stewart, General Manager, Northwestern Utilities. Mr. Stewart gave a talk entitled "The Poor Benighted Engineer" and dealt with the role of an engineer in the community and as a manager.

Engineers' Wives Associations

The Annual Business and Dinner meeting of the **Border Cities Auxiliary** was held Jan. 30. Sixty members were present when the new executive took office. Mr. A. J. Gervais gave a talk on "Purchase and Care of Furs".

The recently formed **Corner Brook Club** met Jan. 16. Mrs. Murley and Mrs. Langens, described their recent European tour and illustrated their talk with slides. Public Speaking was the main topic for the February meeting.

The Hamilton Association heard an enlightening talk on Africa at their February meeting. Mrs. Glen Dawson illustrated her talk with slides taken on a recent trip.

A dinner meeting was held in Waterloo in January by the **K.W.G.P. Association.** Plans are being made for the Annual Meeting in May.

The second meeting of the **Kingston Auxiliary** was held Jan. 31. This was a successful evening with eight bridge tables playing.

The **Lethbridge** Association held an interesting gathering in January. The group toured Automotive Electric Canada Ltd., a firm engaged in assembling telephones for export.

The membership of the **London Association** has now reached approximately 200. It has been divided into eight sections and each section is responsible for the complete planning of one program during the year. The Annual Dinner Meeting was held in January with guests from Woodstock present. In March the Spring Tea was held at the London Art Gallery.

In January a Smorgasbord Supper was held by the **Regina and Area Association.** Its Annual Meeting was held March 14.

The **Sault Ste. Marie Club** held a supper Dance Feb. 17 which was well attended. It was held in the Officers' Mess of the Armouries. Mrs. Lillian Robertson of the Toronto Office was a guest.

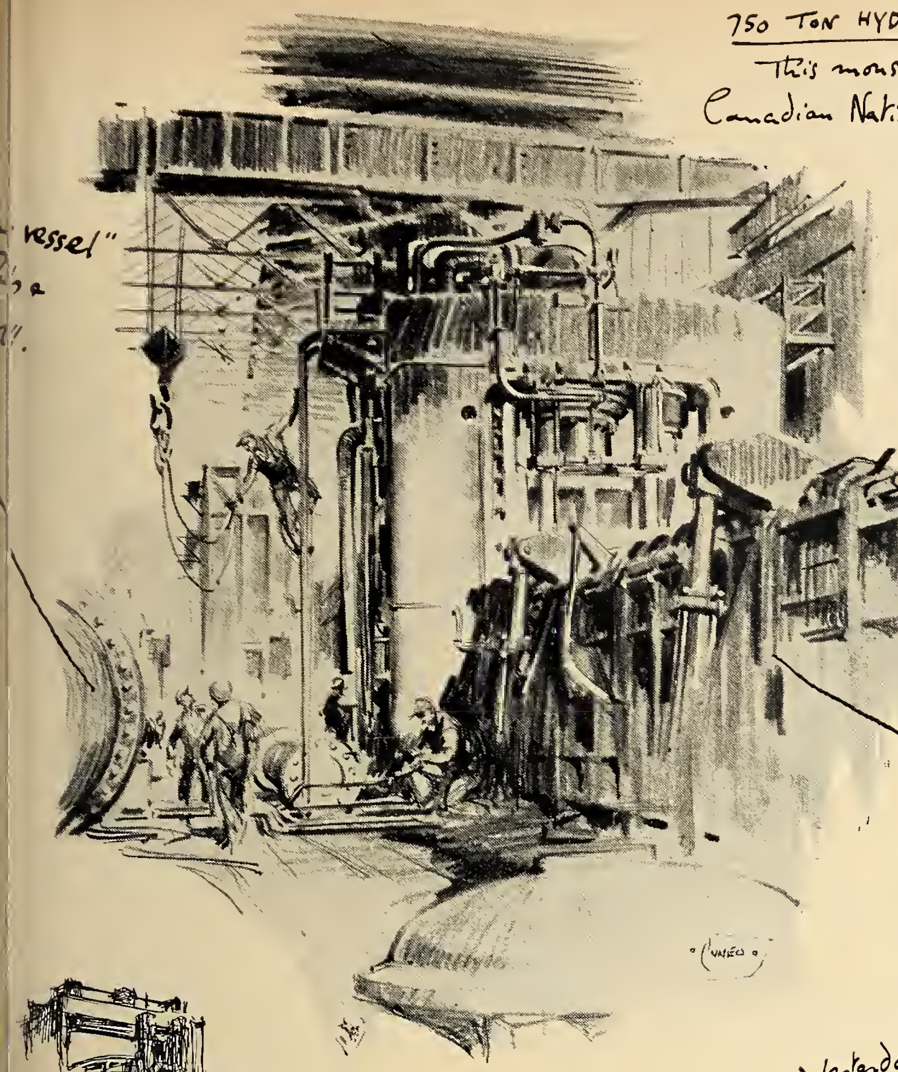
Plans are being made for the Spring Tea to be held by the **Sarnia Association.**

The Annual Meeting and Luncheon of the **Toronto Auxiliary** was held Jan. 11. The Auxiliary is making a $1,000. donation to the new Engineering Building at the University of Toronto. They have purchased curtains and an oil painting. Representatives from the Royal Doulton Company showed a film and explained the processing of this fine china. The Executive entertained Mrs. G. McK. Dick and Mrs. G. T. Page at luncheon Feb. 9. The Spring luncheon was held March 1 at the Granite Club with displays of costumes from the Stratford Festival.

The **St. John's Club** held a 'Musical Evening' in February and presented $100. scholarship to a student at Memorial University. A Dance and Bridge tournament was held in March.

The **Victoria Association** visited the Growers' Wine Company in February. This was followed by a luncheon.

A luncheon was held by the **Vancouver and Lower Mainland Association** in February. In March a Bridge and Tea was held at the Point Grey Golf and Country Club. The Annual Meeting and Luncheon is being held May 25. EIC



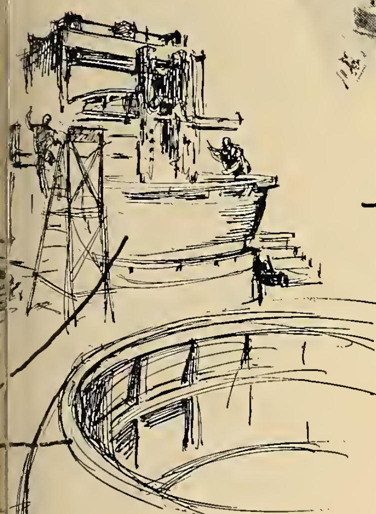
750 TON HYDRAULIC "SCRAP SHEAR"

This monster is to be installed in the Canadian National Railroad Yards, London Ontario. Its job is to crush, actually, bite up old steam locomotives. Its great guillotine blades can sever 6 inch steel with ease. For this I hate it. Yesterday I toured the C.P.R yards at St Luc, & saw the endless rows of proud rusty locomotives silently waiting their call to this modern madame Guillotine

"Vive le Progrès"

The hopper for loading.

" vessel"



This is a Vertical Boring Mill

It is turning a ball & socket expansion joint for the HUMBER RIVER SEWAGE TREATMENT PLANT (Romantic!) The reason for such a joint is to compensate for ground movement in the area. In other words the pipe may shift under the ground after its installation.

Yesterday I was taken over a number of the locks of the St Lawrence Seaway & saw the massive gates that were made here in Canadian Vickers, Remarkable place this. It seems that they can take on anything from a ship to a "candy cooker".

commission:-
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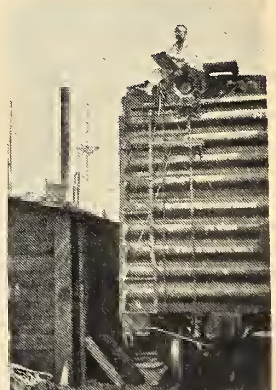
ury St. Edmunds.

Overseas Companies make a vital contribution to the world-wide engineering resources of the Vickers Group. Whilst in Canada last year, Terence Cuneo paid a visit to Canadian Vickers Limited in Montreal, and these drawings give some idea of the part the company plays in Canada's shipbuilding and heavy engineering industries. The artist is shown in a typical sketching position.



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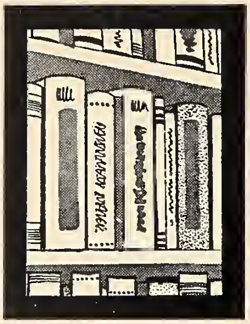

Prepared by the Library, The Engineering Institute of Canada

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

RECTIFICATION, SUPERFINITION.

Of interest to all those engaged in metal working and finishing, the larger part of this volume is concerned with various methods of metal finishing and grinding. It covers the various types of abrasives used, the different types of grinding machines, and their manufacture and testing, different methods of machining, and safety precautions. A final chapter discusses methods of obtaining a superfine finish. Many useful illustrations and diagrams are included. (F. Henry and H. Pouret. Paris, Eyrolles, 1960. 146p., 23 NF.)

LA COMMANDE HYDRAULIQUE, 2. ed.

Although the field of application of hydraulic control is vast, its basic principles are the same, and the author presents these principles in his introductory chapters, which also include a comparison between electric and hydraulic control. The various machines and systems available are considered, and their application in regulators, controls and servomechanisms. The final chapters cover the use of hydraulic control equipment in aircraft, vehicles, vessels, presses, machine tools, etc. (C. R. Himmler. Paris, Dunod, 1960. 424p., 68 NF.)

***1301 REVIEW PROBLEMS.**

The purpose of this book is to provide an intensive practical review for persons planning to take the PE registration examination and the prerequisite EIT (Engineer-in-Training) exam which follows graduation and generally precedes practical experience. Individual problems selected from actual state registration exams form the basis of the review, and are arranged in two sections, corresponding to the two parts of the EIT exams. The "General" section (Chapters 1-11) covers such subjects as mathematics, chemistry, statics, thermodynamics, fluid mechanics, electricity, engineering economy, ethics, and contracts. The "Applied Engineering" section (Chapters 12-19) covers aeronautical, chemical, civil, mechanical, electrical, industrial and mining engineering, and surveying. The remainder of the book (Chapter 20), contains nine complete typical state examinations. Appendices give answers, symbols and abbreviations, addresses of state Registration Boards, and recommended reference books. (R. C. Brinker and others. Scranton, International, 1960. 388p., $7.50.)

***BIBLIOGRAPHY AND ABSTRACTS ON ELECTRICAL CONTACTS, 1959 SUPPLEMENT.**

The seventh annual supplement to a bibliography which now covers published material on the subject from 1835 through 1959 (STP's 56-G to 56-N inclusive). All include subject and author indexes, and annotated, fully-cited items arranged chronologically by date of publication. The effects which take place in the operation of electrical contacts are very complicated, involving the microphysics of the electric arc, the metallurgy of the contact materials, the mechanics of the operating mechanism, the physical and chemical properties of all materials and the ambient conditions. Limitations of ranges of titles and subject matter is a practical necessity, but all references of reasonable connection with the subject have been included. (Philadelphia, American Society for Testing Materials, 1960. 63p., $3.50 s.t.p. 56-N.)

***REPORT ON THE ELEVATED-TEMPERATURE PROPERTIES OF ALUMINUM AND MAGNESIUM ALLOYS.**

Contains data compiled by the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. Summarized are elevated temperature, tensile and creep rupture properties of current commercially established aluminum and magnesium alloys. Both wrought and cast alloys are covered in various forms including rolled, forged or extended rod, plate, sheet and castings, both sand and permanent molds, and some data on alclad aluminum alloys. Data is given for each alloy in the form of a title sheet, giving its designation, chemical composition and specifications; while data sheets give a description of the material, the strength values for the mechanical properties, and tables and graphs of physical properties. By spotcheck, the top test temperature for which data is given appears to be 1000°F. (Philadelphia, American Society for Testing Materials, 1960. 308p., $7.00 s.t.p. no. 291.)

***SYMPOSIUM ON SPECTROSCOPIC EXCITATION.**

At the 62nd Annual Meeting of ASTM in Atlantic City, June 1959, this Symposium considered some of the parameters involved in obtaining reproducibility and accuracy in spectroscopy. The three papers included here discuss the matrix effect in excitation, the effects of gaseous atmospheres on excitation, and some properties of excitation sources such as flames and electric discharges, including hydrocarbon flames, plasma jets, and high-frequency, interrupted, continuous, and fluid-controlled arcs. (Philadelphia, American Society for Testing Materials, 1960. 62p., $2.50. s.t.p. no. 259.)

DESIGN OF CONCRETE PAVEMENTS FOR AIRPORTS.

This manual is intended for engineers responsible for the structural design of concrete pavements for airports, and presents the design criteria and practices already in use. The topics covered include: design criteria; subgrade and drainage; pavement thickness; joints; reinforcement design; construction practices; welded wire fabric steel reinforcement. (Washington, Wire Reinforcement Institute, 1960. 96p., $3.00.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 1050 Mansfield Street, Montreal.

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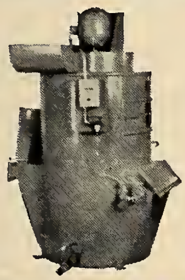

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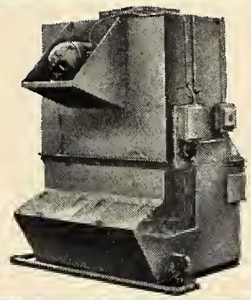

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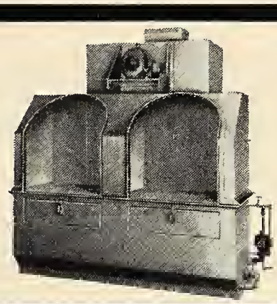

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TECHNICAL BULLETINS & PAMPHLETS RECEIVED

Space limitations do not enable us to record these in the Library Notes. A mimeographed list of the Bulletins and Pamphlets received during the last month is available free on request to the librarian.

*SYMPOSIUM ON ROAD AND PAVING MATERIALS-1959.

The first section of this book contains a comprehensive progress report, and two papers discussing results of extensive tests on asphalt, including the microfilm durability test, all relating to research work carried out on the Zaca-Wigmore Experimental Test Road, a project of the California Division of Highways and Pacific Coast asphalt producers, begun in 1954. The second section contains four papers which discuss the prediction of performance of asphalt in terms of chemical composition, the flexibility characteristics of asphaltic paving mixtures as influenced by temperature, and degradation of aggregates employed in asphalt pavement structures. (Philadelphia, American Society for Testing Materials, 1960. 126p., $3.50. s.t.p. no. 277.)

GEORGE AND ROBERT STEPHENSON: THE RAILWAY REVOLUTION.

Deeply interested in tthe history of the Industrial Revolution, Mr. Rolt has already published biographies of two engineers connected with that period, Brunel and Telford. He has now written the story of the two Stephensons, father and son, and of the birth of the railway. Robert was also the designer of many famous bridges. Although most of their work was done in England Robert Stephenson worked for a time at the mines of Santa Ana in Columbia, and it was he who was the Engineer-in-Chief for the construction of the first, tubular, Victoria Bridge at Montreal. The book is illustrated with contemporary drawings. (L. T. C. Rolt. Toronto, Longmans, 1960. 356p., $6.00.)

A.R.R.L. ANTENNA BOOK.

This revised edition contains the information required by amateur radio operators on the theory and practice of antennas. It includes information on wave propagation, longwire and multiband antennas, rotary beams, antennas for very high frequencies, and mobile antennas. A useful bibliography is included. (West Hartford, Conn., American Radio Relay League, 1960. 320p., $2.25.)

HEAT TREATMENT OF METALS.

A practical text by a well-known author, giving in simple terms basic information on annealing, hardening and tempering. The first volume gives definitions of the various processes, and discusses grain size, the heat treating of aluminum and other non-ferrous alloys, steel treating and tempering, and case hardening. The second volume covers hardenability, isothermal transformation, heating for manufacturing processes, the choice and treatment of tool steels, heating and cooling, furnace types, and the design of components for heat treatment. (P. S. Houghton. Toronto, General, 1960. 2 vols., $3.75 each.)

BROACHING.

A discussion of a method of machining which now ranks as a major production process, showing the working of modern broaching machines, and giving details of the specialized cutting tools used, for both internal and surface broaching. The author has illustrated his text with examples of the practice found in modern factories. The various types of machine are illustrated, and there is a bibliography. (C. Monday. Toronto, General, 1960. 162p., $3.75.)

SPARK-MACHINING.

Much of the information in this volume previously appeared in the British periodical Machinery, and has been supplemented with that supplied by the manufacturers of spark-machining equipment. This method of finishing has developed rapidly over the past eight years, and much of that development has taken place in the U.S.S.R. The three chapters in the book cover basic principles, equipment and operation. (Toronto, General, 1960. 72p., $1.00.)

DIE-SINKING AND ENGRAVING MACHINES.

Machining by automatic duplication has now superseded hand methods, and has led to greater accuracy and increased production. This book covers the various die-sinking and engraving machines available, the electrical and electronic control of die-sinking, and hydraulic control. A final chapter discusses pantograph machines and their uses, including optical control. (H. C. Town. Toronto, General, 1960. 70p., $1.00.)

DISTRIBUTION SYSTEMS.

This most useful volume is intended primarily for the electric utility distribution engineer, but it will also be useful for all electric utility and industrial power systems engineers, as well as for students. It covers all aspects of distribution, including: load characteristics; substations; primary and secondary distribution; secondary network systems; distribution transformers; system voltage regulation; application of capacitors; voltage fluctuations on power systems; protective devices; metering; street lighting. Useful lists of references are included in each chapter.

This volume has been written by electric utility engineers of the Westinghouse Electric Corporation, and has grown out of the Corporation's Electrical Transmission and Distribution Reference Book, the first edition of which was published in 1942, which it is now planned to issue in three volumes, as an Electric Utility Engineering Reference Book. The other two volumes will cover system analysis and generation, and transmission and system protection. (Hamilton, Canadian Westinghouse, 1959. 567p., $15.00, $10.00 to students.)

MAGNETIC AMPLIFIERS; PRINCIPLES AND APPLICATIONS.

A presentation of the fundamentals of magnetic amplifiers intended for technicians and students, as well as a review of the subject for electrical engineers. Introductory chapters review the fields of magnetism, electromagnetism and magnetic circuitry necessary for an understanding of the subject. The author then discusses saturable reactors, self-starting and three-legged core magnetic amplifiers, compensating and polarized magnetic amplifiers, and variations of them. The text also covers amplifier gain, feedback, general uses and construction, maintenance, applications and circuitry. (P. Mali. New York, Rider, 1960. 101p., $2.45.)

THE CHORD OF STEEL.

The well-known novelist and historian has here written an interesting account of Alexander Graham Bell's early years in Brantford, where he made his great invention of the telephone, and where the first tests were carried out between Brantford and nearby Ontario towns. Mr. Costain was himself raised in Brantford, and thought that that city's connection with Bell should be more widely known. (Thomas Costain. Toronto, Doubleday, 1960. 238p., $3.95.)

THE DESIGN OF SEA DEFENCE WORKS.

Written by an expert, this is the first scientific treatment of a subject which has long been approached by a trial and error method. The author has included in his book both the results of research and his own experience, and points out that much research is still being carried on. The first chapter discusses tides and waves, and includes in an appendix a mathematical treatment of wave run-up on composite slopes, written by Thorndike Saville of the U.S. Beach Erosion Board. Other chapters cover natural sea defences, sea walls, estuary walls and counterwalls, hydraulic design of sea walls, and examples of sea, estuary and tidal river walls. Lists of references are included. (R. B. Thorn. Toronto, Butterworth, 1960. 106 p., $5.00.)

PULP AND PAPER MANUAL OF CANADA.

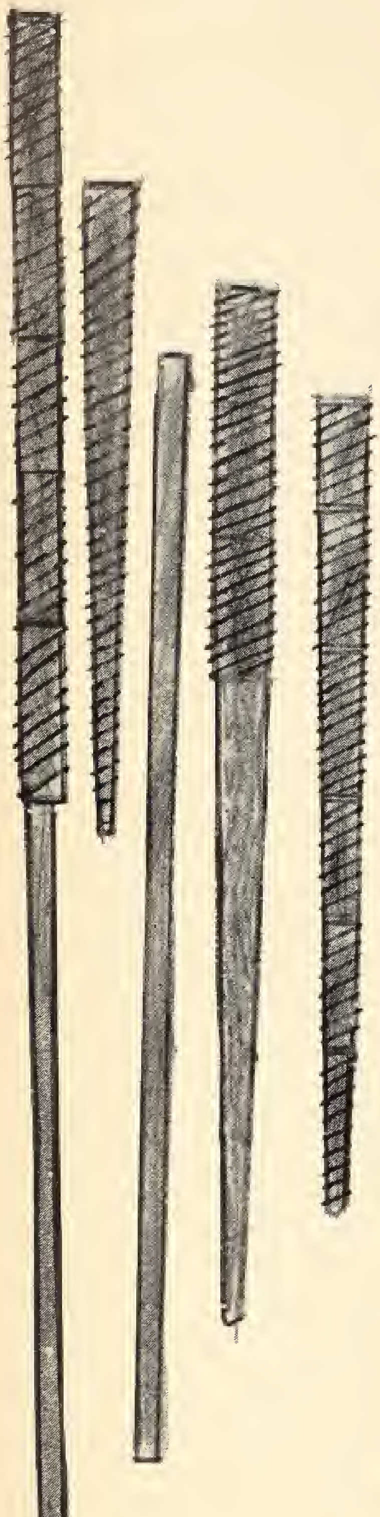
This twenty-eighth edition follows the pattern of earlier editions, being divided into four sections, General information, Operating information and techniques, Mill operating personnel and flow sheets, Service and suppliers listings. Several interesting papers, and useful statistics are included as usual. Anyone connected with the industry will find this Manual essential. (Ed. by J. N. Stephenson. Gardenvale, National Business Publications, 1960. 460p.)

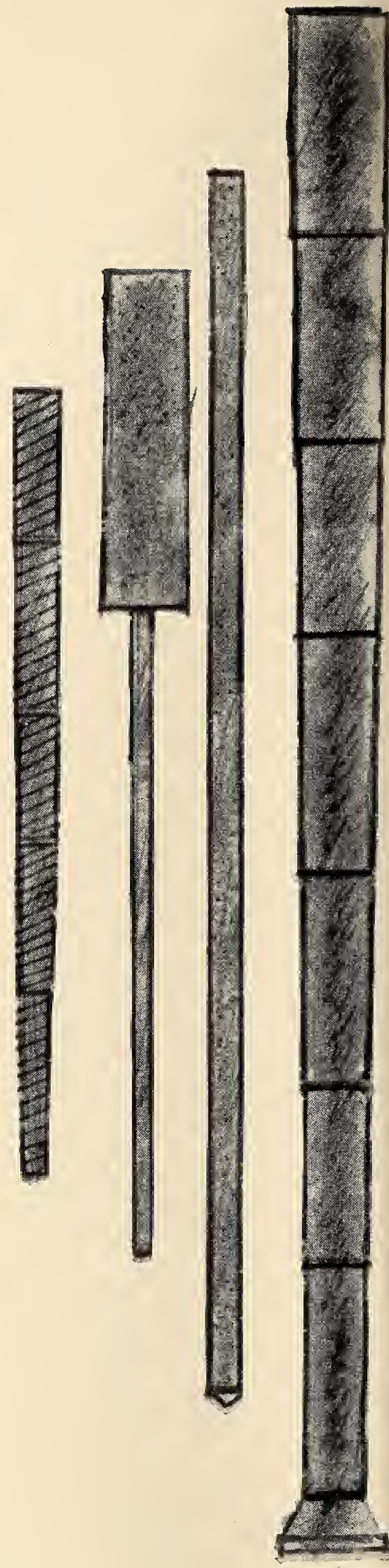
A CENTURY OF OIL AND GAS IN BOOKS.

It is fitting that the centennial of the oil industry in 1959 should be marked by the publication of this annotated bibliography of books written during the last 100 years, in English, on oil and gas. The compiler has personally examined almost all the 2000 items included, and has arranged the entries by subject, covering everything from prospecting to marketing. An author index is included. (Comp. by E. B. Swanson. Toronto, Saunders, 1960. 214p., $5.95.)

RADIOACTIVE WASTES: THEIR TREATMENT AND DISPOSAL.

The increasing use of radioisotopes in industry and medicine, and the growing number of nuclear power stations mean that the problem of the safe disposal of radioactive wastes must be solved now, and not be permitted to





assume the proportions that non-radioactive environmental pollution has.

This is a technical discussion of the problem and its solution by a group of British experts. The first half of the book explains the problems to be dealt with, the nature and sources of radioactive wastes, the hazards of radiation, the measurement of radioactivity. The second part deals with the treatment and disposal of liquid, solid and gaseous wastes. There is also a chapter on British law on radioactive wastes. (Ed. by J. C. Collins. London, Spon, 1960. 239p., 55/-.)

UNFIRED PRESSURE VESSELS.

This commentary on the A.S.M.E. Unfired Pressure Vessel Code, is now in its fourth edition, and it gives supplementary information intended to make easier the use of the Code. The book gives the history of the Code, methods of obtaining Code authorization, a description of the Code, basic causes of pressure vessel accident and failures. It also covers inspection and quality control, and welding requirement. A brief outline of Canadian pressure vessel requirements is also given. (Robert Chuse. New York, Dodge, 1960. 154p., $8.75.)

MACHINE DRAWING AND DESIGN, 7th ed.

Now in its seventh edition, and largely re-written, this text is intended for an intermediate course in machine drawing and design for mechanical engineering students. After an introductory chapter on the principles of projection, the following chapters cover the drawing and design of various components, etc., castings, fastenings, shafts, brakes, bearings gearing, valves, aircraft components, etc. Information is also given on factors influencing design, and toleranced dimensions. Exercises and examination questions are included. (W. Abbott. Glasgow, Blackie, 1960. 281p., 21/-.)

INFORMATION PROCESSING.

This volume contains the Proceedings of the International Conference on Information Processing organized by UNESCO in 1959. Some 2,000 delegates from 37 countries attended the meetings, at which more than seventy papers were read.

These papers have been grouped into seven sections, the first of which is concerned with methods of digital computing, and the uses of digital computers. The second section deals with a common language for computers, and the third contains seven papers on the automatic translation of languages. The next sections cover pattern and character recognition, and machine learning and thinking, and the logical design of computers. There was a special session on computer techniques of the future, and three symposia on the relation between analog and arithmetical calculation, error detection and correction, and the collection, storage and retrieval of information. All the papers are in French or English, and abstracts of each are given in English, French, German, Russian and Spanish. (Unesco. Toronto, Butterworth, 1960. 520p., $25.00.)

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RAPPORTS FINANCIERS DANS LES ENTERPRISES.

A French translation of the American Management Association publication, Reporting Financial Data to Top Management, this book covers the preparation of financial reports, with examples drawn from the experience of the authors. The topics covered include the organization of reports; reports on investment programmes, and economic situations; the financial report in a time of transition or organization, etc. (Paris, Dunod, 1960. 213p., 19 NF.)

***SYMPOSIUM ON NONDESTRUCTIVE TESTING IN THE MISSILE INDUSTRY.**

This volume contains seven of the eight papers presented at the Symposium, held in San Francisco on October 12, 1959. Included are papers on radiography of rocket motors, of weldments in motion, and in the 6-to 30-Mev range; ultrasonics in sandwich structures inspection, fluid-contaminating particle detection, and evaluation of missile materials and components; and mobile field inspection of missiles and aircraft. (Philadelphia, American Society for Testing Materials, 1960. 71p., $2.00 s.t.p. 278.)

COBALT MONOGRAPH.

Compiled primarily by staff members of the Battelle Memorial Institute, this monograph is a survey of the available literature on cobalt. In the chapters dealing with the mining, metallurgy, and physical, mechanical and chemical properties of cobalt, and with cobalt alloy systems, as much detailed information as possible is included. The second part of the volume considers the uses of cobalt in high-temperature materials, magnetic alloys, tool and die steels, cemented carbides, coatings, glass and ceramics, catalysts and pigments. Also covered are radioactive cobalt and its industrial applications, and medical and agricultural uses of cobalt. These chapters are less detailed, but extensive bibliographies refer the reader to sources of additional information. There is no index but a very detailed table of contents partially takes its place. (Brussels, Centre d'Information du Cobalt, 1960. 515p., 750 Belgian Francs.)

CORROSION PROBLEMS OF THE PETROLEUM INDUSTRY.

Nine papers presented at a 1959 symposium on this subject are published in this volume, together with the discussion on them. The papers cover: the corrosion of production equipment and gathering lines, and its prevention; corrosion problems in Lake Maracaibo; corrosion of tanker hulls; protection of storage tanks and pipelines; corrosion prevention in salt water cooling systems; non-destructive testing in the oil refinery; developments in corrosion-resistant materials, both metal and non-metal.

The Symposium was organized by the Society of Chemical Industry and the Institute of Petroleum. (London, Society of Chemical Industry, 1960. 235p., 30/-. S.C.I. Monograph no. 10.)

MODERN WORKSHOP TECHNOLOGY: PART II MACHINE TOOLS AND MANUFACTURING PROCESSES, 2nd. ed.

The many developments in the last ten years have led the editors to completely recast this work, which provides a survey of the principles and methods of modern mass production. The various chapters have been written by specialists.

The first two chapters cover the general principles common to all machine tools, and the theory of cutting. The remaining chapters discuss specific machine tools and techniques, turning; milling; broaching; grinding; presswork; measurement; inspection; lubrication; heat treatment; production planning, etc. New developments such as ultrasonic machining and spark erosion are discussed, there are many illustrations, and a useful bibliography.

The first part, already published, covered materials, and a third volume, now in preparation, will deal more extensively with production planning and automatic machines, thus completing a most useful series. (Ed. by H. W. Baker. London, Cleaver-Hume, 1960. 650p., 55/-.)

EXPERIMENTAL PLASTICS, 2nd. ed.

A practical undergraduate text, containing a variety of experiments in plastics technology, including all those which a student should have performed for the examinations of the Plastics Institute (London). The experiments are divided into four sections: the production of synthetic resins and polymers; the conversion of these into plastic materials; methods of fabrication by moulding, extruding, casting, etc.; the identification of plastics, and methods of testing. (C. A. Redfarn and J. Bedford. Toronto, British Book, 1960. 140p., $5.50.)

BASIC HUMAN FACTORS FOR ENGINEERS.

An introduction to the field of human engineering, in which the author discusses the design of systems and equipment for optimum human use, the organization of a human engineering department, task analysis, human-factors working forms, performance-test scoring and diagnosis, and personnel evaluation. A final chapter considers the part human engineering will play in astronautics.

The author, now resident in the U.S., formerly worked with the N.R.C. in Ottawa, and was a member of the E.I.C. (P. A. Verdier. New York, Exposition Press, 1960. 103p., $4.00.)

SPANNBETONBEAU, teil 1, 2. auf.

This text on prestressed concrete construction, intended for both practising engineers and students, commences with an historical introduction, followed by a brief section on theory. The remaining chapters cover materials, structural and fire tests performed in various countries, and detailed calculations for the design of prestressed concrete construction. In an appendix are lists of prestressed concrete bridges and buildings, giving for each the method of construction, and reference to any published descriptions. There is also a useful general bibliography, mostly of German publications.

This second edition has been brought up-to-date, and mention made of developments in different countries during the past four years. (W. Herberg. Leipzig, Teubner, 1960. 342p., 21.80 DM.)

DICTIONARY OF NUCLEAR PHYSICS.

A German-English, English-German dictionary containing some 5,000 words, giving both the U.S. and British terms where these differ. The terms included are used in uranium mining, reactors, nuclear fission and fusion, isotope research, and in other fields of nuclear physics. There is a useful list of English abbreviations, with their English and German meanings. (Hans Rau. Wiesbaden, Brandstetter Verlag, New York, Heinman, 1957. 247p., $5.00.)

PRAKTISCHE SCHALENSTATIK. Bd. 1 DIE ROTATIONSSCHALEN.

A mathematical treatment of the design of shells, intended for the design engineer. It covers the membrane theory of cylindrical, conical and spherical shells, and the deformation, bending

theory, heating and expansion of shells. The second section of the volume contains worked examples of the design of different shell structures. (J. Born. Berlin, Ernst, 1960. 218p., 50 DM.)

ORGANIZATION DES STRUCTURES DE DIRECTION.

Subtitled Top Management, this text presents the French theory of the organization of management. The first, theoretical, section of the book covers definitions of terms used, company structure, main and subsidiary operations of a company, staff functions and horizontal and vertical organization. The second part of the book discusses applications of the theories in various companies; electrical equipment manufacturing, chemical industry, ship yard, service station chain and a bank. (A. Vidal and J. Beaussier. Paris, Dunod, 1960. 144p., 11 Fr.)

NEW HOUSING IN GREAT BRITAIN.

A brief account of city planning, housing projects and suburban redevelopment in England during the last fifteen years. The text covers the growth of four "New Towns", all planned as a unit, and designed to be self-sufficient; residential areas designed as a unit; and individual blocks of flats and houses. The greater part of the book is a collection of plans, illustrating the points made in the text, which is in parallel columns in English and German. (H. Bruckmann and D. L. Lewis. Toronto, Burns and MacEachern, 1960. 131p., $9.50.)

REINFORCED CONCRETE PILING AND PILED STRUCTURES, 2nd. ed.

A description of current British practice in designing, manufacturing and driving reinforced concrete piles, with design data given in accordance with British Codes of Practice. Topics in this edition, for which new or additional material has been added, include the bearing capacity of piles; loading tests; pressures on sheet-pile retaining walls; stresses occurring during driving; the design of pile-caps for single piles and groups of piles and specifications and quantities. Other subjects covered are design, piled wharves and jetties, manufacture of piles, driving piles, piles cast in places. (F. E. Wentworth-Sheilds, W. S. Gray and H. W. Evans. London, Concrete, 1960. 149p., $4.00.)

***METHODS OF REGIONAL ANALYSIS.**

This volume presents some operational and some untested techniques for the analysis of geographical regions, as used in regional science. These techniques will supplement the general theory developed in the author's previous volume, "Location and Space Economy". Engineers will be interested chiefly in those operational techniques dealing with industrial location, land use, and urban structure, and such newly-developed bu untested techniques as interregiona linear programming, and gravity, poten tial and spatial models. (Walter Isarc New York Wiley, 1960. 784p., $9.50.)

HOW TO CHART DATA.

A guide to the use of charts in th areas of work measurement, plant sched uling and cost control. Six types of chart are covered, including straight-lin curves, monographs, two-way charts an multi-variable charts. The author dis cusses the different data required f each type of problem, and the cha best suited to the solution of the prob lem. This is a useful, entirely practica treatment of the subject by an autho who is outstanding in the field. (Ph Carroll. Toronto, McGraw-Hill, 196 260p., $8.75.)

ENGINEERING MECHANICS: STATICS.

The authors believe that the funda mental principles of engineering mech anics are best learned by studying th theory of each principle, and applying i to a practical problem. Consequently numerous problems and their solution are included in each chapter. The topic covered include equilibrium; coplana forces; plane framed structures; friction linkages; three-dimensional systems centre of gravity; moment of inertia fluid statics; virtual work; graphica solutions. (D. I. Cook and D. N. Pierce Scranton, Pa., International Textbook 1960. 227p., $6.25.)

TECHNIQUE ECONOMIQUE ET GESTION INDUSTRIELLE.

A study of economic techniques whicl can be used by businesses in their man agement. After a brief introduction t the subject of economic techniques, th book is divided into three parts, th first of which discusses the applicatio of economics to business, the differen types of sales, and demand theory. Th second part contains an analysis of pric structure, the relation between account ing and economics, depreciation. The las part considers stock regulation, opera tions research, linear programming, pric determination. Useful bibliographies ar included in which many of the article listed are in English. The author ha studied in the United States. (J. Le sourne. Paris, Dunod, 1960. 627p. 58 fr.)

LES CHOIX ECONOMIQUES: DECISIONS SEQUENTIELLES ET SIMULATION.

A bilingual volume, in which the first chapter is in both French and English and the remaining chapters are in either French or English, the latter being used when the material is taken from a study in that language. The topics covered include economic processes and sequential decisions; dynamic programming; Monte Carlo method; analogic simulation of air traffic control operations; simulation in logistics policy research; war games; application of games theory to company operation. Useful bibliographies are in-

MESSAGE FROM THE PRESIDENT

In the Annual Report which follows, you will note a record of a very active year in the history of the Institute. A considerable amount of study has been going on as to where the Institute is heading and what will be its requirements in these various possible directions.

No organization can remain stationary for very long. It must either be rising or it must be falling. Those leading the Institute this year have felt that we must put special emphasis on pushing the Institute into broader and more effective fields. More members, more branches, more technical activities, more publicity —all are necessary to help us on our upward path. New and active Committees of Council are implementing our targets. We are facing changing conditions on many of our engineering fronts. We must analyse these transitions and be prepared to meet them. We must render to our members, under all possible methods of operation, whatever they need to make them more capable than ever of raising the standard of technological activity in Canada. We must encourage our engineers, technicians and scientists to do their share in the pressing need for accelerated development of Canada's natural resources with which is so directly integrated the growth of Canada's natural economy.

Vous trouverez dans le rapport annuel de notre Institut toutes les raisons de qualifier d'année record celle qui vient de se terminer. Nos activités ont été très nombreuses et nous avons en particulier considéré l'avenir de l'Institut en explorant toutes les possibilités de son développement.

Une organization telle que la nôtre ne peut rester stationnaire longtemps. Il lui faut évoluer et dans cette évolution, si elle n'avance pas, elle recule. Les officiers de notre Institut sont convaincus que nos activités doivent devenir plus variées et s'étendre de façon efficace en maintes directions. Il nous faut plus de membres, plus de chapitres, plus de dynamisme dans nos activités, une meilleure reconnaissance au sein du public,—tout ceci est nécessaire à notre ascension vers de plus hauts sommets. Plusieurs nouveaux comités du conseil sont à l'oeuvre dans ce sens.

Nos conditions de vie se modifient de jour en jour, sur tous les fronts. Nous ne manquons pas d'analyser de façon précise cette période transitoire et de nous préparer à en tirer le meilleur profit. Nous devons assurer nos membres, dans quelque circonstance que ce soit, de toute notre aide en vue de rehausser la valeur de notre contribution à la vie scientifique, technique et industrielle du Canada. Notre Institut se doit d'encourager nos ingénieurs, nos techniciens, nos hommes de science, à participer de façon totale au développement et à la mise en valeur des ressources naturelles du Canada, base de la croissance de l'économie de notre pays.

George M. Dick

GEORGE MCK. DICK, D.SC., M.E.I.C.,
President, 1960-1961.

THE ENGINEERING INSTITUTE OF CANADA

annual report

for the year ended December 31 1960

REPORT OF COUNCIL

YOUR INSTITUTE IN 1960

Nineteen hundred and sixty was a year of real accomplishment for The Engineering Institute of Canada. This annual report lists the significant achievements of the past twelve months. Success does not just happen—it is the result of much careful planning and painstaking work by many officers, councillors, committees and individual members at all levels within the organization. The co-operation of many members made this progress possible, and the continuation and extension of this attitude will lend to even greater progress in 1961.

The continued growth of the Institute naturally has created some problems, and these are receiving diligent attention by the officers and staff. Prime among these problems is that of member communications and the need for every member to be aware of, and justly proud of, the fine record of achievement which is recorded each year in this series of annual reports.

In an organization as large and complex as The Engineering Institute of Canada, the report which follows does little more than highlight matters of importance. We trust that each member will derive much satisfaction from it, but at the same time will realize that much more remains to be done. It is through their efforts that 1961 will be an even better year.

Major targets for continuing concentrated effort are: to continue to improve BRANCH OPERATIONS, to increase MEMBERSHIP and to bring the best possible TECHNICAL PROGRAM to every member of the Institute. Many members are involved in the work of the Committee on Branch Operations and the Committee on Technical Operations, and EVERY MEMBER should consider himself an active worker on the Committee on Membership.

ACTIVITIES OF THE PRESIDENT

In the spring of 1960, Mr. J. J. Hanna completed his presidential visits to a large number of branches and student sections. During the summer, Dr. George McK. Dick visited engineers at work at The Canadian Armament Research and Development Establishment at Valcartier, Quebec, the laboratories of The National Research Council and The Bureau of Mines in Ottawa, and at The Ontario Research Foundation in Toronto.

Later in the year, Dr. Dick visited branches and student sections in the Atlantic Provinces and central Canada, and was honored by the bestowal of an Honorary Doctor of Science degree by the University of Sherbrooke in October. He represented the Institute at the annual meeting of The American Society of Mechanical Engineers in New York in December, and was host to a reception for Canadian engineers and their wives present at that meeting. He has held many meetings with senior officers of The Canadian Council of Professional Engineers and the provincial associations and corporation of professional engineers, in an effort to continue and further the best possible relationships between the Institute and these sister organizations.

INSTITUTE ADMINISTRATION

Major improvements in administration were made by the creation of an Executive Committee of Council on a trial basis to deal with administrative matters between Council meetings, thus allowing Council to spend more time on matters of basic policy. The Vice-Presidents have assumed a very active role in visiting and assisting branches and student sections in their territories, and the re-organization of headquarters' staff in functional groups parallel to the Institute's activities made 1960 a busy year indeed.

The By-Laws were amended by ballot of the membership to bring them in line with current practices and needs. The financial operations were transformed to an accrual system and purchasing, expenditures and other financial operations were put onto a system of close budgetary control after more than two years of intense work to bring this about.

The Committees and Representatives appointed by Council continued to make very important contributions to the efficiency of the Institute's operation. Not only do they study proposals which have been referred to them by Council, but each keeps in touch with situations and attitudes within its terms of reference and, when necessary, recommends considered action.

Among the staff changes during the year, Mr. J. H. Legere left to accept an appointment with the International Air Transport Association; Miss Maudie Abraham retired after the longest period of service of any employee in the Institute's history; and Mr. G. LaFontaine was appointed Associate Editor of EIC publications. Mr. T. R. Montgomery was appointed Controller and Office Manager and Mr. John Donovan was selected to serve as Manager of Advertising Sales following the sad passing of E. J. "Ted" Blandford, who had been our hard-working and popular Publications Manager for many years.

Both the Toronto Office, headed by Mrs. L. Robertson, and the Western Field Secretary, Commodore A. C. M. Davy, were kept extremely busy rendering on-the-spot service and assistance to the branches and individual members in the areas for which they are responsible.

The General Secretary has taken steps to increase the contact between branch executives and headquarters staff, by additional staff visits to all parts of the country. In addition, he and his personal staff, in co-operation with the secretariat of the CCPE, have devoted a great amount of time to the work of the Engineers Confederation Commission. In April he visited England to arrange final details of the co-operative agreements between the United Kingdom Institutions and the Institute, and had useful meetings with the Danish Institution of Civil Engineers and La Société des Ingenieurs Civils de France.

MEMBERSHIP

Institute policy with regard to membership was the subject of months of serious and intensive study during the year.

The program was undertaken in two stages. The first step was the creation of an ad hoc Committee on Membership Procedures. During the summer and early fall this committee made a thorough examination of all EIC membership policies and procedures. Many important changes were recommended and adopted by Council, all designed to increase membership and improve membership administration. Included in these measures, subject to By-Law ratification, are provisions to make transfer from Junior to Member automatic after five years, and to change the title Junior to Associate Member.

The second stage, started in the fall, was the activation of a national Committee on Membership, with representation from nearly all areas of the country. The object of this committee is to promote the growth of EIC membership by every possible means, with special emphasis on assisting and encouraging branch activity in this field. Council looks to this group for advice on membership development policy, and it acts as a co-ordinating centre for information and guidance.

The total enrolled membership at the end of 1960 stood at 21,536 which is a 7% increase over 1959. The detailed breakdown of this figure is given in the finance committee report.

In 1960 the Council examined several proposed methods for the preparation of a directory of members, and finally decided that a supply of a very economical form of directory should be published in 1961, for distribution to national and local officers and committees and for sale to interested members.

The policy regarding the provision of membership certificates was changed to provide for the free distribution of an improved form of membership certificate to all new members and to other members who request it.

Deceased Members

During the year 1960 the deaths of members of the Institute, including two Honorary Members, have been reported as follows:

Honorary Members: Angus, Robert W., Toronto; Killaly, A. Laurence, Peterborough.

Members: Adams, W. D., Grimsby, Ont.; Barnes, Charles T., Winnipeg; Bate, C. B., Sillery, Que.; Belanger, Alex. A., St. Antoine de Padoue, Que.; Bennett, J. E., Regina; Bolton, Fred S., Winnipeg; Branch, Alec. J., Lethbridge; Brydone-Jack, Ernest E., Joshua Tree, Calif.; Cochrane, M. F., Ottawa; Coward, George W., Cordoba, Argentine; Clement, Sheldon B., Sarnia; Cunha, S. H., Montreal; Dargie, A. H., Halifax; Darling, A. B., Montreal; Dobbin, W. L., Toronto; Edwards, C. P., Ottawa; Ford, J. W. H., Preville, Que.; Fraser, W. L., Cornwall; Gifford, F. D., Colborne, Ont.; Haffey, J. J., Valleyfield, Que.; Hammersley-Heenan, John, North Hollywood, Calif.; Hutchinson, T. P., Montreal; Jones, L. M., Islington, Ont.; Karn, H. C., Woodstock, Ont.; Kemp, J. Colin, Montreal; Kennedy, T. Dowsley, Owen Sound, Ont.; Kindersley, Charles St. B., Calgary; Kirby, Thomas H., Winnipeg; Lazier, Francis Stuart, Toronto; LeClair, Camille, Durham, England; Love, Alexander, Hamilton; MacKay, James J., Burlington, Ont.; MacKenzie, A., Winnipeg; MacKintosh, James, Toronto; MacLachlan, Wills, Maple, Ont.; Martin, Oskar, Kingston; Michell, H. G., Montreal; Miles, Harold R., Calgary; Milne, A. H., Montreal; Morrissette, Romeo, Cap de la Madeleine, Que.; Murphy, E. P., Ottawa; Newhall, Vivian B., Edmonton; Paulson, Frederick H., Warwick, R.I.; Pearce, K. K., Dewittville, Que.; Peden, Alexander, Montreal; Perry, A. H., Vancouver; Redfern, W. B., Toronto; Rice., J. Donald, Toronto; Riley, Thomas M., Evanston, Ill.; Serson, H. V., Ottawa; Smith, E. L., Edmonton; Steinman, D. B., New York, N.Y.; Stevenson, W. F., Edmonton; Stockton, Robert S., Spokane, Wash.; Swabey, H. W. B., Pointe Claire, Que.; Taylor, John, Hamilton; Treadgold, W. M., Toronto; Tremain, K. H., Montreal; Underwood, J. E., Saskatoon; Wakefield, William E., Ottawa; Warner, John E., Milford, Conn.; Watson, J. T., Lethbridge; White, Robert, Town of Mt. Royal, Que.; Wilson, Alexander, Montreal; Wilson, A. McD., Sault Ste. Marie; Wurtele, John S. H., Westmount, Que.; Wyatt, Digby, Toronto.

Junior: Hill, Ralph T., Kenilworth, Ont.

Students: Brosseau, Rejean, Granby, Que.; Cummings, G. E., Middleton, N.S.; Fortin, Gilles, Ottawa; Herbertson, Richard, Winnipeg; Stein, Lionel, Town of Mt. Royal, Que.

Affiliates: Annett, Fred A., New York, N.Y.; Baldry, G. E., Winnipeg; La Bissonierre, Alfred, Montreal.

ANNUAL AND REGIONAL MEETINGS

The 1960 Annual General and Professional Meeting held in Winnipeg was an outstanding success. Attendance was high, the local committee did a grand job, and the technical program arranged by the Committee on Technical Operations was judged to be one of the best in the Institute's history. The schedule of dates and places for future Annual Meetings is:

1961 Vancouver May 31-June 2 Hotel Vancouver
1962 Montreal June 13-June 15 Queen Elizabeth
1963 Quebec May 22-May 24 Chateau Frontenac
1964 Banff May 27-May 29 Banff Springs
1965 Toronto May 26-May 28 Royal York
1966 Winnipeg May 25-May 27 Royal Alexandra
1967 Montreal May 31-June 2 Queen Elizabeth
1968 Halifax

Since the completion of seventy-five years of service to the engineering profession will be the feature of the 1962 annual meeting in Montreal, a special committee was appointed to recommend regarding the nature of this event with Dean H. Gaudefroy as Chairman and members representative of all parts of Canada.

During the year regional technical meetings were held at Kingston, Ontario, and St. Andrews, N.B. (Maritime Professional Engineers Conference jointly with the Associations of Professional Engineers in the Atlantic Provinces). The Institute held a joint conference on Engineering Education with the A.S.M.E., and was host to the Annual Meeting of The Engineers Council for Professional Development.

Each of the regional technical meetings was arranged by a local committee, and engineers in neighbouring localities were invited to attend. The main attraction was a technical program which was in each case augmented by social events.

These meetings were well attended, and the concensus is that they serve a useful function in broadening the technical activities of the Institute by making it possible for larger numbers of members to attend a major meeting each year.

Plans have been initiated for the following conferences in 1961:

Joint Meetings

May 7-10	ASME-EIC Hydraulic Division Conference, Queen Elizabeth Hotel, Montreal, Que.
May 9-12	ASME (Co-sponsor EIC) Production Engineering Conference, Toronto, Ont.
Aug. 28-Sept 1	International Heat Transfer Conference, Boulder, Colorado (Co-sponsor EIC).
November,	EIC-CIMM Regional Technical Conference, Newfoundland.
November 9-11	Canadian Soil Mechanics Conference, Queen Elizabeth Hotel, Montreal, Que.

Regional Meetings

March 25	Third Southern Ontario Regional Conference, Sheraton Brock Hotel, Niagara Falls, Ont.
April 6-7	Montreal Regional Meeting, (Theme "Urban Transportation"), Mount Royal Hotel, Montreal, Que.
May 6	Northern Ontario Regional Conference, North Bay, Ont.
November 2-4	Quebec City Regional Conference, Chateau Frontenac, Quebec City, Que.

HONOURS, AWARDS, MEDALS AND PRIZES

These awards were presented during the 1960 annual meeting to those who could be present:

Honorary Memberships
Bristow Guy Ballard.
William Percy Dobson.
John Norison Finlayson.
Richard Lankaster Hearn.
Otto Holden.

Julian C. Smith Medals
Clarence Decatur Howe.
Hugh Andrew Young.

Plummer Medal
John Templeton Hugill

Leonard Medal
Victor Dolmage
J. W. Stewart

Duggan Medal and Prize
Alan Garnett Davenport

Robert W. Angus Medal
John James Traill

The following medals and prizes were not awarded in 1960: Gzowski Medal, Ross Medal, Sir George Nelson Award, Canadian Lumbermen's Association Prize, H. N. Ruttan Prize, John Galbraith Prize, Ernest Marceau Prize, Phelps Johnson Prize, Martin Murphy Prize.

BRANCH OPERATIONS

Another successful Branch Officers' Conference was held during the 1960 Annual Meeting in Winnipeg. In an effort to provide all possible assistance and information to branch executives, the Council authorized the formation of a Committee on Branch Operations in the latter part of the year. The manual of branch operations was again improved after another year of experience, and will be revised and re-issued early in 1961.

An interesting development was the action taken by the Toronto Branch to create a series of smaller branches in its territory but outside of Metropolitan Toronto. A new branch at Oakville was formed, and new branches are in process of formation at Port Credit and other centres. By this means local services will be made available to the many members who did not find it possible to participate in the activities of the Toronto Branch.

The officers, council and staff sincerely appreciate the great amount of voluntary work done by branch officers and committee members in rendering direct local services to the membership, and for their co-operation in supporting the many national and international projects which depend in large measure on branch support for their success.

CONFEDERATION

1960 was an extremely busy year for the Institute's representatives to The Engineers Confederation Commission and the Headquarters' staff concerned with serving the Commission. A large number of meetings were held ranging from full meetings of the Commission to the many committees and sub-committees engaged in making special studies and reports on behalf of the Commission.

During the year the Commission forwarded two progress reports to the Institute, the full texts of these reports are published on page 114 of the April 1960, and on pages 76, 77 and 78 of the January 1961 issues of The Engineering Journal. It is the stated intention of the Commission to present its final report to the C.C.P.E. and the E.I.C. prior to their 1961 annual general meetings, and a great deal is owed by all members to those whose unfailing work as participants in the work of the Commission will have made this possible.

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 U.P.A.D.I. and the Conference of Engineering Societies of the British Commonwealth, the Institute maintained 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 worked closely with The Canadian Council of Professional Engineers, The Canadian Aeronautical Institute, the Canadian Institute of Mining and Metallurgy, and the Chemical Institute of Canada, and others on a number of important government-sponsored or inter-society projects. There was no change in the agreements between the institute and seven provincial registering bodies in 1960.

An important activity in this area during 1960 was the signing of co-operative agreements between the Institution of Civil Engineers, the Institution of Mechanical Engineers, the Institution of Electrical Engineers and The Engineering Institute of Canada. These reciprocal agreements provide members of any one of the participating bodies with the opportunity for participating in the technical activities while in the country of the host body, on payment of a nominal fee. In addition to providing a technical home for such members, full membership in the host society will be more readily sought after.

The Institute was pleased to learn that its invitation to hold the next Conference of Engineering Institutions of the British Commonwealth in Canada in 1962 had been accepted, and plans are being developed to make this important conference an outstanding success.

The Institute was fortunate in the presence of a large delegation of senior Canadian engineers in Buenos Aires at the time of the VI U.P.A.D.I. Congress. Led by Past-Presidents J. A. Vance and K. F. Tupper, the large EIC delegation made a significant contribution to the work of this important organization, which is unique in providing a forum between national engineering societies in all North, Central and South American countries.

Vice-President F. L. Lawton represented the Institute at the Centenary celebrations of La Société Royale Belge des Ingenieurs et des Industriels and presented the Institute's greetings.

The Institute was pleased to entertain representatives of Mexican engineering organizations for two weeks during October, and to assist representatives of the Argentine Society of Engineers while in Canada.

EMPLOYMENT SERVICE

The following statistical report compares the trend of activity in employment conditions over the past four years.

Jobs listed in 1960 in comparison to applicants seeking employment indicated a healthy supply and demand relationship. Eighty-six under-graduates registered for summer employment, and with a few exceptions these were satisfactorily placed.

To assist with expenses associated with the Employment Service, "Situations Vacant" advertisements are now sold to those wishing to advertise vacancies. As in the past, members may insert a "Situations Wanted" advertisement of up to sixty words without charge.

ENGINEERING EDUCATION

To enable more members to participate in and contribute to the development of the Institute's active interest in engineering education, the Committee on Engineering Education was transformed into a Technical Division Committee, within the structure of the Committee on Technical Operations.

The second national meeting of the Canadian Conference on Education will be held in Toronto in February 1962. The Institute is actively engaged in participating in the preparations for this important event.

The 1960 meeting of engineering educators, attended by over 70 deans and professors of engineering from every faculty of engineering in Canada, was held for two days at Queen's University in Kingston, during the Conferences of Learned Societies.

The Fourth Biennial ASME-EIC Conference on Engineering Education was held at Ecole Polytechnique in October. Delegates were also entertained by McGill University. This was very successful, and pointed out a basis for future meetings and the need for the preservation of the valuable material presented at such meetings.

The Institute was represented by Dean H. G. Conn and Dean R. R. McLaughlin at the First Pan-American Congress on Engineering Education, held in Buenos Aires, Argentina, in September.

On a continuing basis, the Institute maintains a close and effective relationship with universities, appropriate agencies of the federal and provincial governments, with the Canadian Education Association and the Canadian Teachers Federation.

GOVERNMENT LIAISON

In 1960 the Institute 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

Employment Service Section
Yearly Report
1960

	Atlantic	Central	Prairies	West Coast	USA	Foreign	Total
"SITUATIONS VACANT"							
Classified Ads	23	285	38	16	3	2	367
Display Ads	2	72	8	8	9	—	99
Replies to Ads	33	567	94	11	20	22	747
"SITUATIONS WANTED"							
Classified Ads	31	234	46	6	14	16	347
Replies to Ads	5	721	45	13	31	4	819

VISITORS TO THE OFFICE — Employers 47 — Employees 769

REVENUE FROM ADVERTISING — $21,512.15

DISPLAY		
	Gross	$17,924.00
	Com.	1,445.85
	Net	16,478.15
CLASSIFIED		5,034.00
	Total:	$21,512.15

ADVERTISEMENTS THAT APPEARED FOR THE FIRST TIME "Situations Vacant"
Classified — 205 Display — 57

REPEAT ADVERTISEMENTS FROM PREVIOUS ISSUES "Situations Vacant"
Classified — 161 Display — 44

helping to solve problems referred to the Institute either directly or by virtue of the Institute's membership on committees and boards established by the government.

During the year the Council approved action leading to the presentation of briefs to the Royal Commission on Publications, the Senate Special Committee on Manpower and Employment, and to the Tariff Board regarding Tariff Item 180(e). Special attention was given to participation in the work of the Advisory Committee on Professional Manpower, the Canadian Vocational Training Advisory Council, and the Canadian National Commission for UNESCO.

LIBRARY AND FILM SERVICE

The statistics for 1960 indicate that use of the library has remained at approximately the same level as in previous year. On an average, the library staff handled 27.8 requests a day, but during the last three months of the year this rose to 31.5 a day.

Statistics of Library Use

	1960	1959
Mail enquiries	1817	1541
Telephone enquiries	2887	2932
Total	4704	4473
Persons using library	2656	2613
Borrowers registered	624	581
Circulation:		
Books	2557	2307
Periodicals	1122	1314
Pamphlets	186	221
Total	3865	3842
Books acquired	454	452
Value of books acquired	$4307	$4125

Increasing numbers of student members continue to use the library, both to request help in writing theses, and to supplement the book collections in their university libraries.

During the summer months a complete examination of the book and periodical collection was undertaken. Almost a thousand obsolete or little used books were discarded, and some collections of periodicals were discarded in toto, and only the most recent years of others retained. Much of this material was sold to book dealers.

Some four hundred books valued at over $4000 were added to the library collection, which now contains approximately 6100 volumes. Over five hundred periodicals are received regularly.

It was found uneconomical to care for the film collection adequately in the EIC library, and arrangements were made for the Canadian Film Institute to take over the distribution and servicing of the Institute's film collection. The branches have been notified of this change, and will be advised of new films of interest as they are issued. All members are invited to take advantage of the greatly extended service now made available by the Canadian Film Institute's large collection.

PROFESSIONAL DEVELOPMENT

In October, the Institute was host to over two hundred delegates to the 1960 Annual Meeting of The Engineers Council for Professional Development. Lasting three days, this meeting was devoted to an intensive and stimulating program, backed up by an efficient hard-working committee of members from the Montreal Branch.

The Institute was represented at all meetings of the Executive Committee and Council of E.C.P.D. during the year, and a further report appears on a following page.

At the Branch level, there is increasing interest in local P.D. courses in many parts of Canada, co-ordinated by the Institute's national Committee on Professional Development Programs.

PUBLICATIONS

With its terms of reference expanded and in more detail, the Publications Committee had an extremely busy year. The major effort was to ensure that the characteristics of the Institute's publications are in line with the objectives of the Institute and the needs of the membership.

In January 1960 the circulation of The Engineering Journal was expanded to include all practicing engineers in Canada whose names and addresses were known to the Institute at that time. By the end of the year, over 36,000 engineers were receiving the Journal. The reader response and financial results of this change are encouraging, particularly since the Journal was enabled to carry more technical papers in 1960 than in any other year in its history.

Late in 1960 the Institute was saddened by the death of its Publications Manager, Mr. E. J. Blandford, whose long and outstanding contribution to the Institute's publications were greatly appreciated. His passing necessitated a major reorganization of the advertising sales program of the EIC, which is now being conducted as a staff function.

"Transactions of the EIC" has continued to improve, and is now an accepted medium in which Canadian engineers publish the results of their fundamental research.

The fourth edition of "Engineering Careers in Canada" was distributed in December on a self-supporting basis. There has been a large demand for this publication from those interested in student guidance, and from students at high schools and universities. It is distributed free of charge on request.

A number of administrative publications were produced and are referred to elsewhere in this report.

SPEAKERS FOR BRANCHES

Speakers for Branches were arranged by Headquarters whenever feasible. Some difficulty is being experienced in the provision of good speakers for the smaller or more remote branches, and members agreeable to undertaking such assignments are urged to contact Headquarters. Approximately thirty-four speakers addressed a total of thirty-nine Branch meetings during the year under arrangements completed through Headquarters.

STUDENT AFFAIRS

Interest in the Institute continued at a high level in 1960 among Canadian engineering students. This enthusiasm is always given strong fillip by the Student Conference at the Annual Meeting, and the one held in Winnipeg in May was most successful. Through the co-operation and fine work of the Student Policy Committee, Faculty Advisers, and EIC student representatives, 1960 was another good undergraduate membership year. There are now nine EIC student sections on Canadian campuses, four having been established during the year at Assumption University, Loyola College, Ontario Agricultural College, and the University of Waterloo. More are under consideration.

Authorized annual grants were made to the Faculty Advisers, and to some branches in university centres. These funds were used in a wide variety of ways to promote and foster engineering student activities, according to local needs and ideas.

Institute material distributed through the universities during the year consisted of a new edition of the pamphlet "The EIC and You", the popular publication "Engineering Careers in Canada, 1960-1961", slide rule tie clips to every new student member, and hundreds of sample copies of The Engineering Journal.

The year also saw the appearance in printed form of the EIC Student Section Manual. This book was distributed for use to university student bodies, Faculty Advisers, and to secretaries of branches in university centres.

The EIC continued to lend its active support to the administration of the Athlone Fellowships during the year. It was of much assistance to Canadian Athlone Fellows during their time in the United Kingdom, by virtue of its close relationships with the Institutions of engineers in England.

The Institute continued active participation in and provided the secretariat for the International Association for the Exchange of Students for Technical Experience. The 1960 season completed the eighth year of Canadian support of the Association, and during the year the terms of reference of the Canadian IAESTE Committee were reviewed and brought up to date.

During the summer 107 foreign students visited Canada to work, and 24 Canadian students took advantage of job opportunities abroad. Financial difficulties are still the most important reason for the number of Canadian students to be below the incoming total. Further details will be found elsewhere in this report.

TECHNICAL OPERATIONS

National: The work of the Committee on Technical Operations was increasingly active during the year. A summary of its organization and method of operation appears on pages 127 to 130 of the March 1961 issue of The Engineering Journal. Action was taken to classify every member by his field of technical interest, so that the membership at large may participate more fully in the activities of the ten Technical Divisions. A manual of technical operations was prepared for the guidance of Technical Division Committee members, Branch Officers and staff.

Through this Committee, the Institute supports and assists many agencies of the government, and also co-operates with sister societies in Canada, on technical activities of major importance. Examples are the Committee on Wintertime Construction of the Canadian Construction Association, Committees of the Canadian Standards Association, the Canadian Radio Technical Planning Board, the Canadian Management Council, the Joint Committee on Renewable Resources and others.

An interesting new development, which promises to provide interesting and useful results, was the formation of a joint committee with The Canadian Institute on Sewage and Sanitation on the Use, Conservation and Pollution-Control of Canada's Water Resources.

International: The Institute actively participates in the sponsorship of programs of international technical organizations. Once again the Institute took an active part in the Sixth Nuclear Congress which was held in New York City early in the year.

The Institute representative to the International Heat Transfer Congress (1961) is actively promoting this work.

Other international activities include participation in the work of the ASME Committee on Air Pollution Controls, the Column Research Council, the International Association for Bridge & Structural Engineers, the International Federation of Chemical Engineers, the International Electrochemical Commission, the Society of Technical Writers and Publishers, and the Inter-Society Management Engineering Conference.

VOCATIONAL INFORMATION

Many of the branches continued their excellent work in the important field of vocational guidance. This consists mostly of speaking visits to students at junior colleges and secondary schools, and assistance to their staffs.

At Headquarters, guidance inquiries are usually in the form of written requests for literature, although a few interviews were held. Four pamphlets were in use during the year: "After High School What?", the French language piece "Science Genie", "Careers in Natural Science and Engineering", issued by the Department of Labour from Ottawa, and "Engineering, a Creative Profession" published by E.C.P.D. Many sample copies of the Engineering Journal were distributed as in previous years.

The very popular Institute publication "Engineering Careers in Canada" was again issued in 1960-1961. Its primary purpose is to serve the needs of first and final year engineering students at Canadian universities, to whom distribution is made without charge. This booklet is also sent free to all Canadian high school libraries, most public libraries, government departments and individuals, and to a growing list of interested recipients abroad.

The Institute co-operated with other national professional and technical bodies in sponsoring the Canadian Science Fairs Council, which co-ordinates the holding of science fairs at high schools in many parts of the country.

WIVES ORGANIZATIONS

Although not an official activity of the Institute, the E.I.C. attaches great importance to the activities of the engineers' wives associations. During 1960 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.

Respectfully submitted on behalf of the Council,

GEORGE MCK. DICK, D.SC., M.E.I.C.,
President

GARNET T. PAGE, M.E.I.C.,
General Secretary

REPORT OF OFFICIAL AUDITO[illegible]

Statement of Revenue and Expenditure

Year ended December 31, 1960
with comparative figures for 1959

REVENUE

	1960	1959
Membership Fees:		
including, in 1959, $54,660.20 for subscriptions to The Engineering Journal	$175,051.39	$223,367.34
Publications:		
Advertising and Sales	428,879.74	320,731.45
Income from Investments	12,715.88	12,961.06
Miscellaneous	2,430.63	1,276.56
Total Revenue	619,077.64	558,336.41
Deficit for the Year	55,772.16	5,775.20
	$674,849.80	$564,111.61

EXPENDITURE

	1960	1959
Administrative Expenses:		
Salaries	$104,813.87	$105,514.67
Travelling	7,982.90	8,378.09
Other, including depreciation in 1960, $4,195.62, 1959, $2,715.44	33,901.22	30,462.26
	146,697.99	144,355.02
Direct Services:		
Annual and regional meetings	2,238.14	7,124.46
Awards, medals and prizes	415.80	488.18
Branch rebates, stationery, manuals	32,656.94	31,813.19
Certificates for members	861.98	412.44
Committees	915.26	933.00
Council meetings	4,050.04	4,342.30
Employment service — net	11,428.81	9,743.59
Engineering education and government liaison	1,563.15	1,679.53
International activities	1,870.77	2,619.38
Library — net	15,361.64	15,018.60
Official reception and hospitality, etc	1,763.77	1,522.69
Professional development	2,898.40	3,050.76
Publicity and membership promotion	2,303.56	1,205.60
Student affairs	8,705.29	7,078.47
Travelling — president and officers	3,370.92	3,316.79
	90,404.47	90,348.98
Publication Expenses:		
Salaries	50,603.98	47,338.48
Commissions	106,973.11	79,359.73
Printing and mailing	238,641.24	164,203.92
Other	20,784.34	18,006.24
	417,002.67	308,908.37
Building and Rental Expenses:		
Headquarters	9,622.15	11,123.82
Toronto	1,010.00	2,042.50
	10,632.15	13,166.32
Extraordinary Expenses:		
Confederation	6,000.00	9,732.92
Participation in international conferences	1,800.00	—
Major repairs to building	2,312.52	—
	10,112.52	9,732.92
Total Expenditure	674,849.80	566,511.61
Transfer from Reserve for Pensions	—	(2,400.00)
	$674,849.80	$564,111.61

D TREASURER'S REPORT

Balance Sheet

December 31, 1960 with comparative figures for 1959

ASSETS

	1960	1959
urrent Assets:		
Cash	$25,553.58	$ 900.00
Accounts receivable, less allowance for doubtful accounts	48,829.60	31,104.80
Arrears of membership fees, estimated	6,500.00	6,500.00
Sundry advances and deposits	5,470.00	3,362.20
Miscellaneous supplies and prepaid expenses	6,416.77	—
	92,769.95	41,867.00
nvestments, at Cost:		
Marketable securities (market value, 1960, $296,980.00)	317,329.55	317,329.55
Less held for special funds	37,414.13	47,884.51
	279,915.42	269,445.04
ixed Assets at Cost Less Amounts Written Off:		
Land and building	36,000.00	36,000.00
Furniture and equipment	27,060.93	24,438.96
Library	1.00	1.00
	63,061.93	60,439.96
ssets of Special Funds:		
Equity in investments shown above	37,414.13	47,884.51
	$473,161.43	$419,636.51

*Includes $731.73 transferred from unexpended provision for publication expense in prior years.

LIABILITIES

	1960	1959
Current Liabilities:		
Bank loan — secured	$ 40,000.00	—
Bank overdraft	—	11,630.51
Accounts payable and accrued charges	105,103.79	49,174.25
Library deposits	3,797.50	3,797.50
Fees paid in advance	26,501.83	3,000.00
	175,403.12	67,602.26
Other Liabilities:		
Life members' voluntary contributions	8,522.18	7,759.32
Other unexpended contributions for special purposes	4,369.86	5,320.68
	12,892.04	13,080.00
Reserves:		
Building	184,000.00	184,000.00
Building maintenance	1,500.00	1,500.00
Pensions	—	1,388.90
Contingencies	29,500.00	29,500.00
Publications	27,231.73*	26,500.00
	242,231.73	242,888.90
Surplus:		
Balance at beginning of the year	48,180.84	53,956.04
Add:		
Transfer of Past Presidents' fund from special funds	11,422.83	—
Transfer from reserve for pensions — unexpended portion of appropriations in prior years	1,388.90	—
	60,992.57	53,956.04
Deduct deficit for the year	55,772.16	5,775.20
Balance at end of the year	5,220.41	48,180.84
Special Funds:		
Medal and prize funds	5,530.75	17,039.77
Other trust funds	31,883.38	30,844.74
	37,414.13	47,884.51
	$473,161.43	$419,636.51

AUDITORS' REPORT

We have examined the balance sheet of The Engineering Institute of Canada as of December 31, 1960 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.

During the year the Institute changed from the diminishing balance method of computing depreciation on furniture and equipment to the straight line method, and adopted the policy of setting up as an asset the inventory of miscellaneous supplies and other prepaid expenses, which in prior years had been written off in the year of expenditure. As a result of these changes the deficit for the year was approximately $4,800.00 less than it would have been under the previous methods.

In our opinion, and according to the best of our information and the explanations given to us and as shown by the books of the Institute, 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, 1960 and the results of its operations for the year ended on that date, in accordance with generally accepted accounting principles which, except for the changes (of which we approve) described in the preceding paragraph, have been applied on a basis consistent with that of the preceding year.

PEAT, MARWICK, MITCHELL & CO.,
Chartered Accountants.

Montreal, P.Q., February 21, 1961.

TREASURER'S REPORT

Although the operations of the Institute for 1960 resulted in a deficit of $56,000 this was due to a combination of circumstances that will not recur, and we confidently expect that in 1961 we will operate at a surplus.

The decision taken by Council in 1959 to distribute the Journal free to all Engineers in Canada, starting with the first issue in 1960, resulted in a direct loss of revenue from Journal subscriptions of $54,000, which is approximately the deficit on the year's operations. The larger circulation of the Journal involved much greater printing and mailing cost, and although advertising rates were increased, advertising revenue could not be built up in such a short space of time to fully compensate for the loss in revenue and increased expense. Moreover, due to the death of Mr. Blandford, changes had to be made in our sales organization towards the end of the year.

The deficit was financed mainly by means of a bank loan of $40,000 guaranteed by securities owned by the Institute. It was decided that this method of financing would be preferable to liquidating investments, as it is expected that it will be possible to repay the loan out of revenue before too long.

As far as the regular expenses for administration and services of the Institute are concerned, a very close watch has been kept on all items. In spite of greatly increased activity, the total cost of administration and direct services has risen by only 1%, over 1959. This close control of all accounts is being continued and extended.

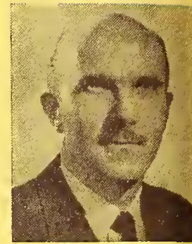
The Balance Sheet as at December 31, 1960 and 1959, the Statement of Revenue and Expenditure for the years 1960 and 1959, the Statement of Special Funds as at December 31, 1960, together with the Auditors' Report, are submitted herewith.

E. D. GRAY-DONALD, M.E.I.C.,
Treasurer.

REPORTS OF THE COMMITTEES

STANDING COMMITTEES

ADMISSIONS COMMITTEE



1. *Statistical Review*

During 1960, the Admissions Committee held eight regular meetings.

In all, 1145 candidates were considered:

Admitted for corporate membership		200	
Admitted for Affiliate		1	
Transferred from Junior to Member		870	
*Transferred from Student to Junior		11	
Transferred from Student to Member		1	
Special Cases		62	
(Referred to Board of Examiners	5		
(Rejected	28		
(Held for further investigation	29		
**Student Admissions		1813	
Total			2958
**Admissions and transfers through Provincial Associations:			
Admitted for corporate membership		137	
Transferred from Junior to Member		194	
Transferred from Student to Member		2	
*Transferred from Student to Junior		42	
Student Admissions		334	
Total			709
Grand Total			3,667

* Automatic transfers are not included in these figures.

** These figures are included for the sake of completeness, although these categories are not reviewed by the Admissions Committee.

The increase in the number of transfers from the grade of Junior to Member is due to the efforts of headquarters in encouraging those people to apply for full membership who had reached the limits as established by the by-laws.

2. *Procedures*

(a) The committee recommended to Council the reinstatement of the procedure of obtaining references in writing from all sponsors.

(b) The committee commenced the preparation for Council of a description of its complete operating procedures with reference to the by-laws under which it operates.

PETER GOOCH, M.E.I.C,
Chairman

FINANCE COMMITTEE

During the year your Finance Committee met 10 times, with much of its time devoted to the financial aspects of publications operations. Another feature of Institute financial problems which necessitated close attention was the changeover late in the year from a "cash basis" of accounting to an "accrued basis".

The financial outcome of the year's activities was a deficit of $55,772. This resulted from:

(1) Budgetary provision for a deficit of $18,100.

(2) The decrease of about $54,000 in income due to the remission of the Journal subscription charge.

(3) The late decision in 1959 to change the Journal distribution policy, so that the advertising sales staff could not secure the full increase in advertising sales anticipated.

(4) The necessity of a higher average press run than anticipated, in order to provide the guaranteed circulation, 34,000 copies as compared with 32,000.

Members will be pleased to know that the outcome for 1961, as anticipated in the budget, is a surplus, after allowing for extraordinary expenditures associated with the work of the Engineers Confederation Commission at $4,500, of $22,610.

The outlook for improved financial results from publication activities, essentially the Journal, looks reasonably good. It should be noted here that, with the demise late in the year of Mr. E. J. Blandford, the sales of advertising space were made a direct Institute responsibility with a suitable incentive provision in the remuneration of space-sales personnel.

With the completion of the 11 years ending December 31st, 1960, it is desirable that members have an opportunity of comparing financial and other vital Institute statistics.

Fig. 1 shows the growth in total membership over the past 50 years. On December 31st, 1960, total membership stood at:—

Hon. M.E.I.C.	42
M.E.I.C.	8,897
Jr.E.I.C.	5,576
S.E.I.C.	6,966
Affiliates	55
Total	21,536

Changes in composition of the membership, 1950-1960, are shown in Fig. 2. Growth in the proportion of students will

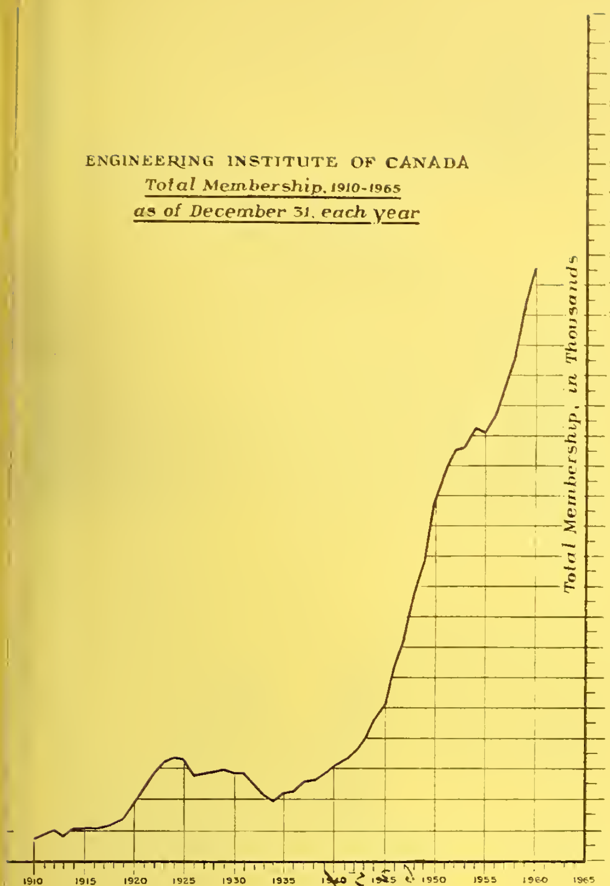


Fig. 1.

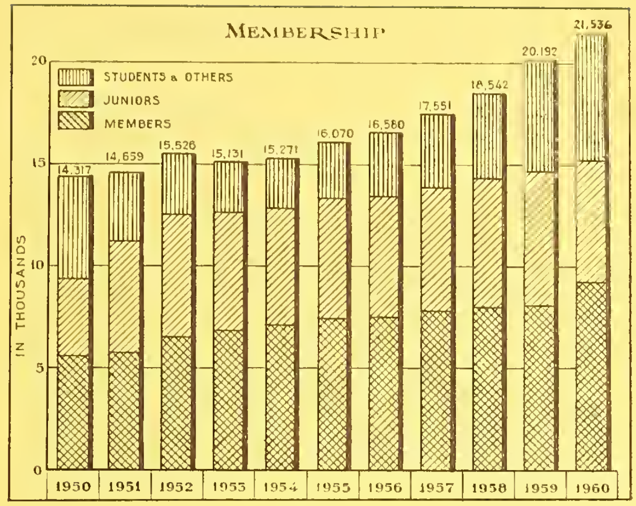


Fig. 2.

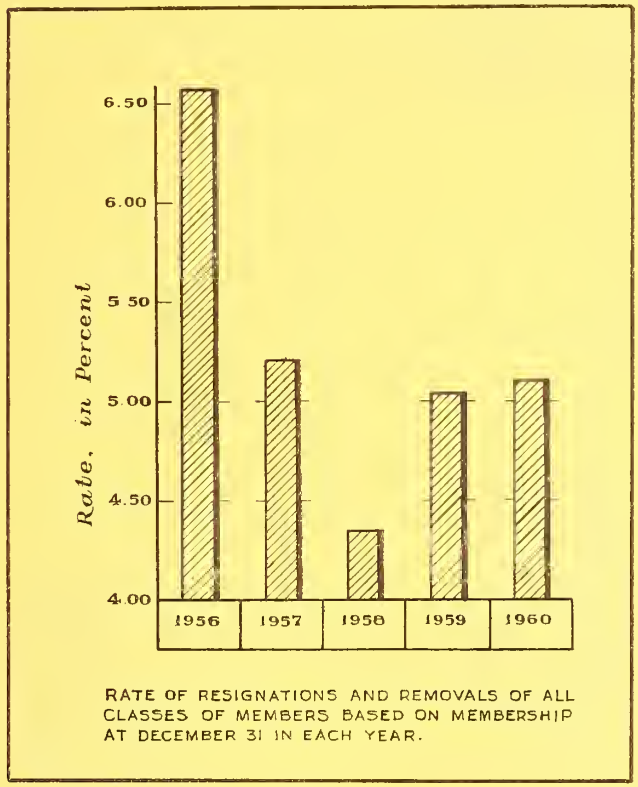


Fig. 3.

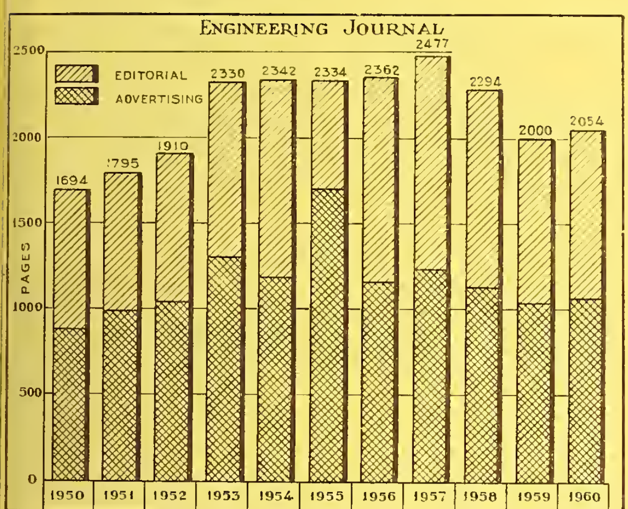


Fig. 4.

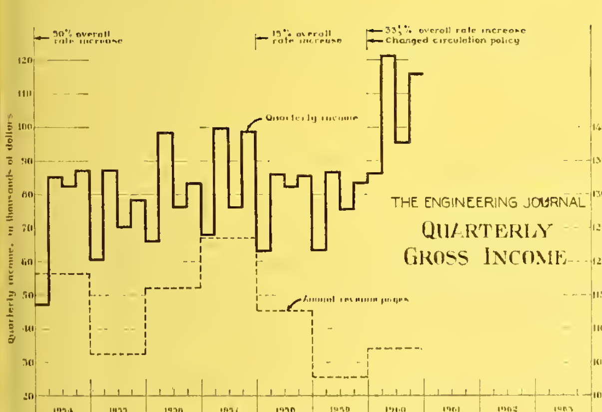


Fig. 5.

Fig. 6.

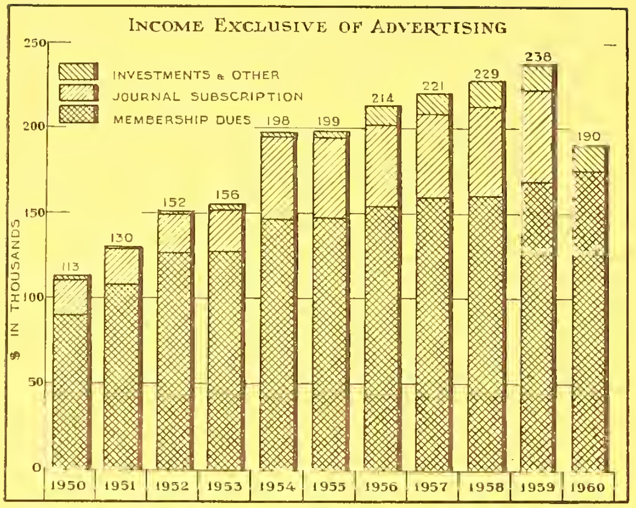


Fig. 7.

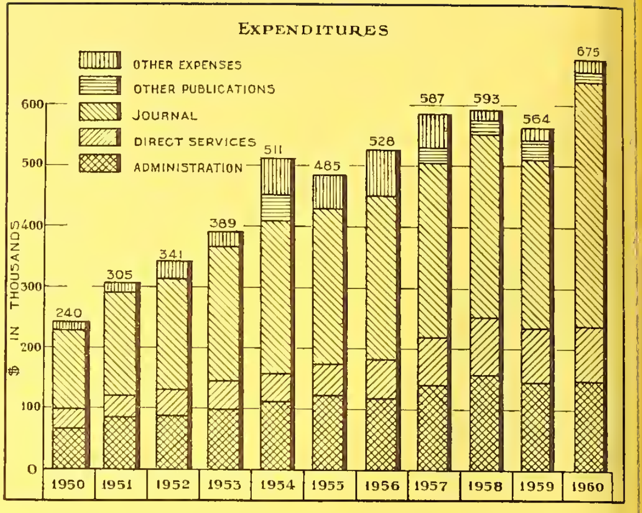


Fig. 8.

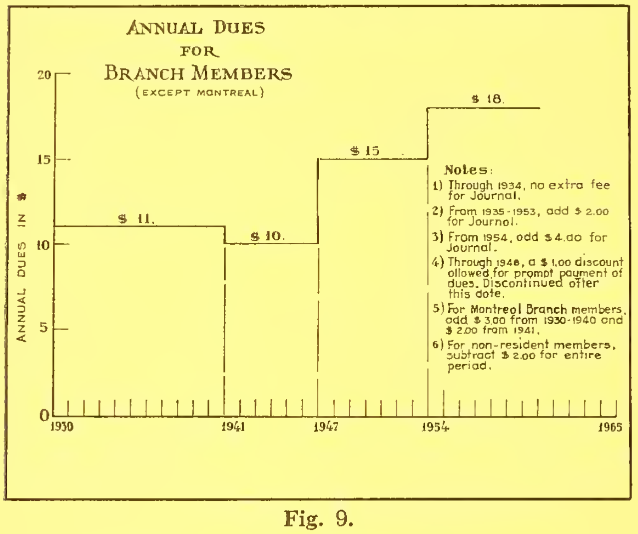


Fig. 9.

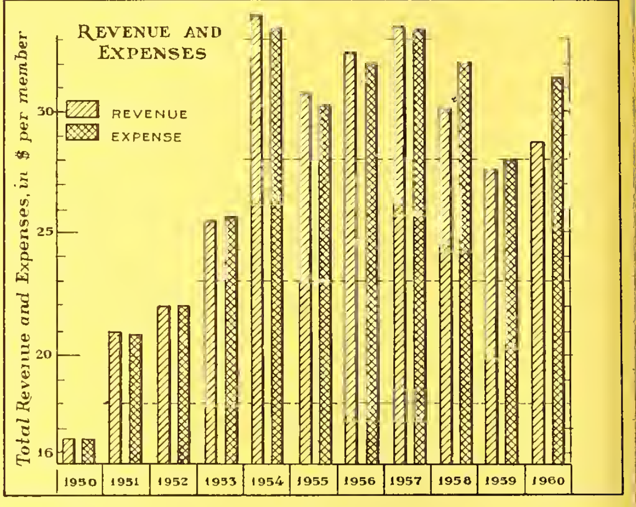


Fig. 10.

Fig. 11.

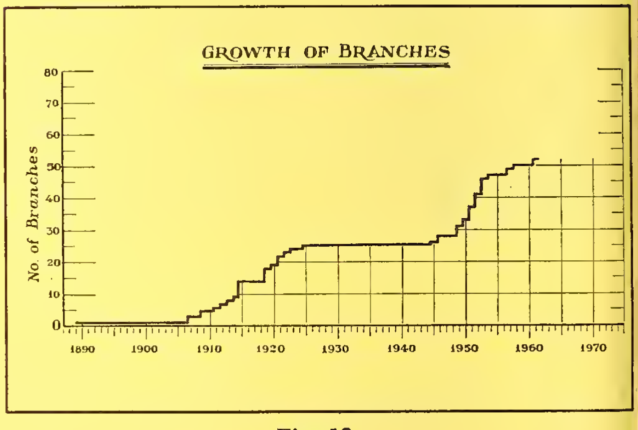


Fig. 12.

be noted. Fig. 3 indicates the rate of resignations and removals of all classes of members based on membership at December 31 in each year. It compares very favourably with the experience of sister societies. Nevertheless, its impact on E.I.C. activities should not be overlooked. An equal percentage of new membership is necessary to make up losses alone.

The Engineering Journal is influenced by general economic conditions, fluctuations in editorial and advertising content being displayed by Fig. 4. A comparison of advertising space and gross income for 1954-1960 is afforded by Fig. 5. The fluctuations in gross income appear to be characteristic; they play a substantial role in the Institute's cash position at any given time.

The trend in total income, from all sources, during 1950-1960, is shown by Fig. 6. Note the proportion of income from advertising. Breakdowns of income exclusive of advertising is illustrated by Fig. 7.

The breakdown of expenditures is clearly indicated by Fig. 8.

Changes in the basic membership dues over the period 1930-1960 are set out in Fig. 9.

In order to ascertain the real trend in income and costs, it is necessary to reduce them to a per-member basis. This has been done in Fig. 10.

A measure of the service afforded members is shown by Fig. 11. Numbers alone do not indicate quality. This, nevertheless, has been achieved in greater measures than ever, if many members' comments are valid.

An additional measure of the service afforded members is shown by Fig. 12, the increase in the number of Branches throughout Canada.

The Committee consists of the following:

J. M. BREEN, M.E.I.C.
J. H. BUDDEN, M.E.I.C
R. L. DUNSMORE, M.E.I.C.
T. W. EADIE, M.E.I.C.
R. A. EMERSON, M.E.I.C.
E. B. JUBIEN, M.E.I.C.
G. N. MARTIN, M.E.I.C.
E. D. GRAY-DONALD, M.E.I.C.
Treasurer, Vice-Chairman

F. L. LAWTON, M.E.I.C.
Chairman

COMMITTEE ON BRANCH OPERATIONS

On October 29th, 1960, Council decided on the establishment of a Committee on Branch Operations, "with the object of studying and recommending regarding Branch operations, and providing a focus of activity for rendering maximum assistance to Branches". Council, at the same time, noted the initial objective of the Committee would be the study of the over-all problem with the eventual purpose, if it is found necessary, of establishing a permanent committee with approved terms of reference.

A committee was promptly appointed. At the same time, consideration was given as to the best method of ascertaining that information relevant to Branch operations which the Committee required in order to carry out its assignment.

Subsequently, on December 20th, 1960, an extensive questionnaire was sent out to all Branches and Sections (6 Sections in Saskatchewan and one in Manitoba), with the request a meeting of Branch Executive Committees be called to consider the replies and that these be returned by February 15th, 1961.

At time of writing, returns to the questionnaire total 94.6%. They will be analyzed as promptly as possible and recommendations arising therefrom made known.

The following have agreed to participate in the work of the Committee:

G. M. Boissonneault, M.E.I.C.
F. M. Cazalet, M.E.I.C.
Edgar A. Cross, M.E.I.C.
George Desjardins, Jr.E.I.C.
Roger Desjardins, M.E.I.C.
J. R. Eason, M.E.I.C.
R. H. Stevenson, M.E.I.C.
C. L. Thompson, Jr.E.I.C.
G. F. Vail, M.E.I.C.
A. W. Wirth, M.E.I.C.

F. L. LAWTON, M.E.I.C.
Chairman

LIBRARY AND HOUSE COMMITTEE

Library

At the request of Council, the Committee studied retention of the Library versus arrangements to obtain similar services elsewhere. The recommendation adopted by Council and supported by the Branch Officers, was to retain the present facility and to increase its use by the members.

To this end, efforts were made to publicize the Library; the President contacted the Branches in this respect and inserts in the Journal were intiated to encourage increased usage. Corresponding members were added to the Committee to permit broader appreciation of servces which might be rendered.

An endeavour was made to lower the cost per unit of service. Progress was achieved in this direction by the effecting of a non-recurring saving accruing from the sale of an above average quantity of obsolete material and the elimination of the Film Library by a transfer of holdings to the Canadian Film Institute.

On the debit side, the staff has for some years been unable to keep up-to-date on cataloguing. This situation has reached serious proportions. It is attributable to staff problems, floor space shortages and the probable necessity for redefinition of Library policy. It is the intention of the Committee to review policy and make such recommendations to Council as are considered necessary.

House

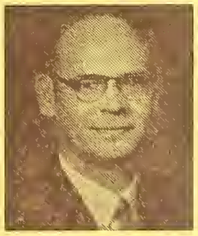
Demolition of the building to the north exposed the mitoyen wall. Although patched up by the adjacent owner, a recent inspection by the Committee disclosed hazardous conditions which were remedied on a split cost basis.

A wiring control panel and light fixture survey resulted in action which corrected overload conditions and resulted in improved lighting.

Further inroads on auditorium space for Headquarters office requirements is a distinct possibility. A report of immediate and short term space requirements will be made by the Committee to Council, shortly. The Committee indicated this situation would arise in the data it prepared for the longer term report on space submitted to Council by the Property Committee.

T. N. DAVIDSON, M.E.I.C.
Chairman

PUBLICATIONS COMMITTEE



The membership of the Committee for 1960-1961 was enlarged to include a representative of each of the nine technical divisions and, in addition, a vice-chairman. Geographical representation was provided as well with members residents of Toronto, Ottawa, Quebec and Montreal.

The first special task undertaken was to formulate terms of reference for the Committee. Revisions to the terms of reference, Section 49 of the Bylaws of the Institute appear desirable because of the growth of the Institute and its publications and because of changes in organization of the Institute. The new terms of reference, which were approved by Council in November 1960, assign specific responsibility to the Publications Committee for recommending to Council publication policies for technical journals, transactions, directories, books and related media in addition to the previously assigned responsibilities for approving articles for publication.

With the many people involved, either directly or indirectly, in the soliciting, approving, editing and publishing of Institute literature it is essential that policies be in writing if all concerned are to be expected to work to a common objective. With this in mind the Publications Committee has been working toward the establishment of a set of objectives for the Journal.

Concurrently with the study of objectives the Committee has made a study of the desirability of conducting a thorough survey of those receiving the Journal to ascertain what type of information is of greatest value to them.

The Journal competes with a multitude of other communication media for the time of its readers and therefore it stands to reason that the Journal should be as attractive and as easy to read as it can. With the objective of improving both its aesthetic and functional design a program of gradual change in the Journal has been undertaken commencing with the January 1961 issue.

R. A. PHILLIPS, M.E.I.C.
Chairman

SPECIAL COMMITTEES

75th ANNIVERSARY COMMITTEE

The Committee was appointed by Council in the spring of 1960 to make recommendations to Council regarding the planning of the annual meeting of 1962 which will mark the 75th Anniversary of the foundation of the Institute. The members of the Committee were appointed as follows:

F. M. Cazalet	Vancouver	S. B. Cassidy	Fredericton
A. C. Davidson	Toronto	P. Duchastel	Quebec
C. V. Antenbring	Winnipeg	E. T. W. Bailey	Hamilton

H. Gaudefroy, Chairman, Montreal

Due to the wide spread distribution of the membership of the Committee, it was not considered advisable to call a meeting of the group. Each member was requested to form a sub-committee in his own region to study the matter locally and to report to the Chairman in Montreal who himself operated with the support of a Montreal sub-committee. Through this action, we estimate that at least 40 members of the Institute have dealt with the matter. Ideas forwarded by one sub-committee to the Chairman were immediately dispatched to all sub-committees and discussed at large.

A great number of suggestions have thus been studied and those carrying the general support of all sub-committees were retained.

The report was handed to Council at its meeting of January 28, 1961. It was proposed that the program for 1962 be similar to that of other regular annual meetings and that emphasis in any possible way be put on the 75th Anniversary theme. Special ceremonies will be held subject to approval by Council.

The Committe has fulfilled its duties by reporting its findings to Council. It was discharged January, 1961.

HENRI GAUDEFROY, M.E.I.C.,
Chairman.

BOARD OF EXAMINERS

The Board of Examiners held two meetings during 1960, at which nineteen (19) candidates were considered.

Four (4) candidates were referred to Council with recommendation for acceptance as Members, after assessing and verifying their qualifications. One (1) candidate was referred back to the Admission Committee for acceptance Four (4) candidates were referred to the Corporation or provincial Associations of Professional Engineers for completion of their qualifications. One (1) candidate requested transfer to Member grade, but was not eligible. One (1) candidate has been given an oral examination and report is awaited. One (1) candidate is to be given an oral examination. Including these two candidates, at the end of 1960 nine (9) candidates were still under consideration.

J. L. DE STEIN, M.E.I.C.
Chairman

THE CANADIAN COMMITTEE OF THE INTERNATIONAL ASSOCIATION FOR THE EXCHANGE OF STUDENTS FOR TECHNICAL EXPERIENCE

So far as Canadian participation in the IAESTE plan is concerned 1960 is reported as a fairly normal year. 107 foreign students visited Canada, for work with 45 employers, and 24 Canadian students went abroad to 7 different European countries. The total exchange for Canada was therefore a 21% increase over 1959, which is a most encouraging result.

The only unusual item to report is that administrative trouble developed in attempting to place Canadian students in one European country, resulting in cancellation and disappointment for a considerable number of them, mostly at Ecole Polytechnique. This difficulty was traceable to our inability to consummate the exchanges concerned at the previous IAESTE Conference. Otherwise, Canadian student participation would have been at a record high.

Interest in IAESTE is increasing gradually throughout industry in Canada, particularly in the Eastern part of the country, and I am hopeful of growing participation. However, it was apparent during the late Fall months that general business conditions will have an adverse effect on prospects for 1961. Financial difficulties continue to provide the largest obstacle against wider participation by Canadian students.

N. S. Rogers and S. R. Whipple visited Canada during the summer as representatives of the IAESTE Committee in Great Britain.

L. A. DUCHASTEL, M.E.I.C.
Chairman

HONOURS AND AWARDS COMMITTEE

This committee was appointed in the fall of 1959 to review the rules governing the Institute honours, awards and prizes and to recommend any appropriate revisions or clarifications to Council. In our Interim Report forwarded to Council in November, we recommended that a National Committee for Prizes and Awards, preferably headed by the Immediate Past President, be established. This committee would be charged with the responsibility of recommending the appointment of the Chairmen of all individual Prizes and Awards Selection Committees for technical papers. It would also serve in an advisory capacity to the selection committees and would maintain a continuing study of areas where new prizes or awards are desirable. A prestige booklet covering all of the Institute's Prizes and Awards is recommended. Such a booklet could give biographical data about each individual in whose honour the award is made and would also serve to make these prizes and awards better known. The following members served on this committee:— Mr. V. A. McKillop of London, Mr. J. W. Dolphin of Kingston, and Mr. J. H. Legere of Headquarters Staff.

W. P. WHELEN, M.E.I.C.
Chairman

LEGISLATION COMMITTEE

No meetings of the Legislation Committee were held in 1960 and no matters have been referred to the committee. It is hoped that a meeting of the committee can be held during the opening day of the Annual Meeting in Vancouver and as a result of the meeting a report forwarded council for consideration.

W. B. PENNOCK, M.E.I.C.
Chairman

LIFE MEMBERS COMMITTEE

The committee is able to report another successful year. The annual contributions from members was substantial; the distribution of funds was much the same as for 1959; the committee was enlarged by the addition of four new members.

The year end total of Life Members was 760. There has been some confusion about numbers and an adjustment has been made recently so that the total membership appears to have been reduced, but such is not actually the case. During the year 54 died. A list of these is being sent to the Life Members along with a new list of all members with their addresses.

The membership is divided geographically this way. Canada 702; United States 43; Great Britain 18; Others 3. By branches Montreal has by far the greatest number — 173; Toronto has 99; Ottawa 77, Vancouver 39, Vancouver Island 39. Halifax and Winnipeg 25 each.

The funds are at a new high, now standing at $8,522.18. Contributions for 1960 amounted to $2,209.00. The Institute has made some suggestions recently as to projects that might be aided by the Life members which, if approved by the committee, would reduce the funds by about $5,000.00.

Again, the sum of $500.00 was donated towards theexpenses of delegates to the annual Students Conference. Towards student prizes the sum of $375.00 was made available, andcopies of the Institute's publication on the life of Sir Casimir Gzowski were purchased for distribution to those attending the Students Conference and to the libraries of the universities. In all, the total of expenditures was $1,133.39.

Early in 1960 the committee requested of the Council of the Institute that the funds of the Life Members be set aside from Institute funds and be clearly designated as a trust fund so there could be no possibility of confusion, and also that the interest earned by this money be credited to the account. Although it does not rightly belong in the report for 1960, the committee is able to report that early in 1961 Council agreed to the committee's request.

High on the list of possible projects for 1961 is a proposal to establish a memorial to one of Canada's most outstanding engineers. As well, consideration is being given to the projects proposed by Council and referred to earlier.

The personnel of the enlarged committee for 1961 is —

N. M. CAMPBELL
deGASPE BEAUBIEN
J. A. FREELAND, *Secretary*
P. S. GREGORY
HUET MASSUE
J. A. MCCRORY
C. K. MCLEOD, *Vice-Chairman*
BRIAN R. PERRY
J. B. STIRLING
I. R. TAIT
L. AUSTIN WRIGHT, *Chairman*

J. A. FREELAND, M.E.I.C.
Secretary

COMMITTEE ON MEMBERSHIP

During the fall of the year Council approved the re-activation of the Committee on Membership, on a broad new basis. Its principal functions are to promote the growth of E.I.C. membership, and to advise and assist Council on matters of membership policy. In the latter function it will continue the work started by the ad hoc committee on membership procedures during the summer of 1960.

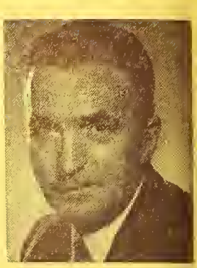
The first meeting of the committee was held in Toronto on November 19th, with ten members attending, from widely separated parts of the country. It was recognized at the outset that membership promotion activity must take place essentially within the Branches, working with Headquarters' guidance and assistance. The discussions of the first meeting can be summed up in a three point program:

1. Obtain from the Branches details of their membership organization and problems;
2. Provide them with as much guidance and assistance as possible;
3. Follow this up through personal visits, and use of the Engineering Journal.

During December plans were developed for close co-ordination between the committee and Headquarters' staff, and the next meeting of the full committee was scheduled for early February.

STAN B. CASSIDY, M.E.I.C.
Chairman

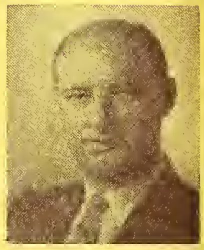
NOMINATING COMMITTEE



Amherst, G. C. L. McEnery
Baie Comeau, A. H. C. Carson
Belleville, A. O. Drysdale
Border Cities, C. G. R. Armstrong
Brockville, G. M. Woods
Calgary, J. S. Neil
Cape Breton, William Dodson
Central B.C., H. A. Price
Calk River, Arthur J. Summach
Corner Brook, M. G. Green
Cornwall, W. Rothwell
Eastern Townships, J. P. Champagne
Edmonton, S. J. Hampton
Fredericton, Ottis I. Logue
Halifax, J. G. Belliveau
Hamilton, W. Filer
Huronia, A. H. Pangman
Kingston, W. M. Campbell
Kitchener, M. A. Montgomery
Kootenay, L. S. Piper
Lakehead, V. B. Cook
Lethbridge, C. S. Clendening
London, D. J. Matthews
Lower St. Lawrence J. C. Hurtubise
Moncton, R. G. Cowan
Montreal, C. Frost
Newfoundland, R. M. French
Niagara Peninsula, C. G. Cline
Nipissing & Upper Ottawa, J. S. Cooper
North Eastern Ontario, No Nominee
Northern Nova Scotia, F. C. Morrison
North Shore Lower St. Lawrence, M. Michaud
Northern New Brunswick, T. H. McSorley
Oakville, O. Meyer
Ottawa, Col. W. A. Capelle
Peterborough, W. H. Powell
Port Credit, D. S. Moyer
Port Hope, E. M. Wynn
Prince Edward Island, J. D. MacDonald
Quebec, Guillaume Piette
Saint John, H. W. Townshend
St. Maurice Valley, J. P. Woods
Saguenay, F. A. Brown
Sarnia, R. Routledge
Saskatchewan, Dr. J. D. Mollard
Sault Ste. Marie, F. H. MacKay
Sudbury, J. E. Quance
Toronto, M. P. Whelen
Vancouver, A. D. Cronk
Vancouver Island, R. Bowering
Winnipeg, J. B. Striowski
Yukon, J. E. Kellett

Chairman: R. F. Legget, Ottawa.

PROPERTY COMMITTEE



An enlarged Property Committee was established by Council on May 26th, 1960, with instructions to investigate and report on the provision of adequate accommodation for Headquarters, Publications, Library, Montreal Branch meetings and possibly those of sister societies. Council expanded the terms of reference to permit locations other than Montreal to be considered.

The report, prepared with the assistance of the Library and House Committee, was submitted to Council on October 29th, 1960. It was ratified January 28th, 1961 and was made available to the Engineers Confederation Commission at that body's request.

Aspects covered were real estate considerations, functional requirements, including consideration of club type facilities, projections of membership and of space requirements in detail for twenty years, joint use of building and services with other engineering societies, pros and cons of Ottawa and Montreal including reactions of Branch Executives in the two locations.

From this investigation, five major factors formed the basis for the Committee's recommendation. These are:

1. The future of the Institute is not clear (Confederation) therefore further consideration of relocation in another city is not warranted at the present time.

2. There is no particularly advantageous real estate situation to warrant sale of the 2050 Mansfield Street, Montreal property for monetary reasons.

3. The Montreal Branch prefers to continue to use facilities in the Headquarters building rather than to try to arrange meetings at hotels, universities, etc.

4. The Headquarters building is inadequate for Branch and Headquarters use, but the situation will not involve acquisition of additional rented space in the immediate future, although further inconvenience to the Branch is likely.

5. Sale of the present premises and temporary relocation in a good quality building in the downtown area would probably involve a net outlay increase of $20,000. to $30,000. per year over present rent plus return from investment of the capital realized by the sale.

The Committee's recommendation, therefore, is to take no action at present. Changes to the status of any of the factors enumerated above will necessitate reassessment of the situation.

T. N. DAVIDSON, M.E.I.C.
Chairman

STUDENT POLICY COMMITTEE

Your committee again organized a Student Conference, which was held in conjunction with the Annual Meeting in Winnipeg, where thirty-two (32) delegates from seventeen (17) universities discussed their problems and planned how the Institute might become a more vital force in the development of the engineering undergraduates.

At the close of the year our student membership was 6262, or almost 29% of the entire membership. This represents an increase of 72% over the last three years, during which time enrollment in the other membership grades increased by approximately 10%. The enthusiasm of our faculty advisers is a continuing source of satisfaction and this progress is a tribute to their efforts.

The committee has investigated several problems referred to it by Council and continues to explore ways and means whereby the Institute can work effectively at each campus.

C. G. SOUTHMAYD, M.E.I.C.
Chairman

COMMITTEE ON TECHNICAL OPERATIONS

The results of the EIC Annual Meeting in Winnipeg in 1960 have encouraged the Committee to continue the policy of making a careful selection from a broad survey of potential technical papers, and then providing full scope for discussion. The success of that meeting appears to have engendered a more active participation by members, and so many outstanding papers have become readily available for the 1961 Annual Meeting that the Committee felt compelled to increase the number of concurrent sessions. Arrangements have been made to accommodate at the Vancouver meeting the National Research Council Associate Committee on Automatic Control, and that Committee will conduct a symposium and present papers for open discussion by the EIC membership.

Two new technical divisions were approved by the EIC Council during the year—the Geotechnical Engineering Division under the Chairmanship of Mr. R. F. Legget, and the Engineering Education Division under the Chairmanship of Dr. Arthur Porter.

A joint EIC-CISS Committee on the Use, Conservation and Pollution Control of Water Resources has been created. This Committee has been very active and it is an excellent example of the manner in which the talents of the profession can be enlisted to serve our national interests. It is planned to enlarge the scope of this type of activity.

An increasing collaboration with other engineering societies has developed during the year. Arrangements have been made for a joint ASME/EIC Technical Conference on Hydraulics in May, 1961 in Montreal. A second joint conference with ASME is scheduled for the same month in Toronto on the subject of Production Engineering. A joint ASME/EIC Railroad Conference is planned for Toronto in 1962, and a Conference on Heat Transfer is under discussion for a later date.

Co-operative undertakings with our Sister Societies have not been confined to joint conferences. Agreements have been reached with the Institution of Civil Engineers, The Institution of Mechanical Engineers and The Institution of Electrical Engineers so that the members of those bodies residing in Canada may participate in our technical programs.

Throughout the year an effort has been made to interest the Branches in greater participation in our technical programs not only at Branch level, but at Regional and National level. Regional conferences have been scheduled for Niagara Falls and North Bay in March and May of this year. This is an encouraging development, and it is believed that the participation of Branch representatives in the technical activities of the Institute will result in increasingly important and stimulating contributions.

B. G. BALLARD, HON. M.E.I.C.
Chairman

TRUSTEES

JAMES H. BRACE BEQUEST COMMITTEE

The James H. Brace Bequest consists of the sum of $25,000., the income derived from this sum to be applied by the Institute for the benefit of unemployed and needy engineers. A committee to administer the fund has been appointed consisting of A. Deschamps, E. Mason, C. N. Murray, A. T. E. Smith, O. M. Solandt, and with D. M. Stephens as Chairman.

The principal sum of this bequest is $25,000. Interest has accrued in the amount of $1,920.34 to Dec. 31, 1959, plus $807.61 for the year 1960. The balance in the fund at Dec. 31, 1960, was $27,727.95. No disbursements have been made from the fund.

The main activity of the Committee during the year under review had to do with the enunciation of general principles which should govern the administration of the Brace Bequest. Progress was made toward this end and it is anticipated that a draft of the proposed "governing principles" will shortly be in shape for consideration by Council.

A further project contemplated by the Committee and to be undertaken as soon as "governing principles" have been established will have to do with the preparation of draft rules of procedure.

D. M. STEPHENS, M.E.I.C.
Chairman

HARRY F. BENNETT EDUCATIONAL FUND

During the year 1960 loans to a total of $2250.00 were made and repayments of $11,300.00 received. This along with a bank balance of $5,092.85 as of December 31st, 1959, resulted in a bank balance at the end of 1960, after allowing for outstanding cheques, of $14,069.16. This improvement in the cash position is due in most part to a reduction in the amount loaned and in the increase in repayments. This latter factor is most encouraging as it evidences the appreciation of those students receiving loans and of the benefit derived from their engineering education. The purpose of the fund is, it is felt, being accomplished by the assistance given.

It should be noted that on December 31st, 1959 the loans outstanding amounted to $27,709.50 whereas at December 31st, 1960 this figure stood at $18,718.96. One loan of $125.00 was written off due to death of the applicant and a voluntary subscription of $100.00 received. Interest on loans was received to the amount of $409.35 which was considerably more than the amount written off.

Very few of the loans now outstanding are of dates that would indicate that they will not be repaid and your trustees are of the opinion that the fund can be kept in a solvent position and with funds available for approved loans. While it is realized fully that the purpose of the fund is to make loans available to worthy students to assist them in acquiring an engineering education, it must be borne in mind that to keep this revolving fund available for future applicants every reasonable effort must be made to secure repayment where circumstances permit.

The trustees wish to express their appreciation of the efforts of the officers and staff of the Institute for their unfailing co-operation and sincere interest in the administration of the fund.

It has been a continuing source of pleasure and satisfaction to have had the opportunity of associating with my fellow trustees, Mr. Eric Smith and Dr. Jas. F. MacLaren and to them I tender my sincere thanks.

OTTO HOLDEN, HON. M.E.I.C.
Chairman

REPORTS OF REPRESENTATIVES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

The Council of the American Society of Mechanical Engineers

As the E.I.C. representative on the ASME Council I attended the series of Council Meetings held druing the ASME Annual Meeting in New York late in November, 1960.

The meetings were informative but there was no business of particular interest to the E.I.C. You will recall that there is reciprocal membership on the Councils of the two organizations though the E.I.C. representative does not have voting privileges on the ASME Council. At the present time this is not considered an important point, merely one with which you should be familiar.

H. G. CONN, M.E.I.C.
Representative

ASME-EIC International Council

During the year the Council met twice – in conjunction with the Annual Meetings of E.I.C. and A.S.M.E. respectively.

The Council considered a number of areas in which co-operation and co-ordination could be encouraged, including reciprocal representation on the respective Councils and certain technical divisions of each organization, joint meetings and conferences, interchange of technical papers, and student activities.

During the year, the ASME-EIC Biennial Conference on Engineering Education was held on the campus of Ecole Polytechnique on October 5 and 6, 1960, with an encouraging attendance. Continuation of this conference was discussed at length and the decision made that, in future, there would be no pre-determined designation of time or place, but the conference would be organized whenever either of the educational boards of the two organizations considered it to be appropriate.

Plans were reported for the holding of a Joint EIC-ASME Hydraulic Division meeting in Montreal in May, 1961.

As EIC is now a co-sponsor of the Inter-Society Engineering Management Conference, consideration was given to the possibility of holding the 1963 conference in Toronto.

In order that tenure of office for the Council may be brought into line with the latest regulations of the two bodies, the term of office for the current Councillors was extended to June, 1961.

While the activities of the Council itself are limited, it has observed in its meetings the progressive development of more complete understanding and co-operation between the two Societies.

L. C. SENTANCE, M.E.I.C.
Chairman, ASME-EIC International Council

Air Pollution Controls Committee

At the meeting of the above Committee was held in New York on December 1st, 1960, when the following matters were dealt with:—

(A) A report on Control Equipment, embodying a list of manufacturers of such equipment, was approved;
(B) No new list of instruments for measuring air pollution will be issued in 1961, as the present list is still up-to-date;
(C) A third edition of "Research Projects" will be ready in a few months;
(D) In future, the Air Pollution Control Committee will be aligned with the Power Department of the A.S.M.E.;
(E) An Inter-Society Co-ordinating Committee on Air Pollution will be established, to initiate and organise a symposium in which the existing state of knowledge and the need for additional knowledge will be discussed;
(F) A report was presented on the status of a revised Model Smoke Ordinance.

It may also be remarked that a meeting was held on Jan. 20, 1961, of the Sub-Committee on Air Pollution Control of the Canadian Standards Association. The Report of the Engineering Joint Committee, published in the "Engineering Journal", May 1951, was discussed as a possible basis for a Canadian Standard. Reports on this matter were considered and, after much discussion, a tentative form of report was agreed upon for further consideration at a later meeting.

A. E. ALLCUT, M.E.I.C.
Representative

CANADIAN GOOD ROADS ASSOCIATION JOINT COMMITTEE ON UNIFORM TRAFFIC CONTROL DEVICES

The preparation of the "Manual on Uniform Traffic Control Devices for Canada" has been a great task and a great accomplishment is beyond question. That its acceptance will be general has been assured by the fact that every Canadian authority concerned had the opportunity to express its views during the course of its many revisions, and before its final acceptance.

The great number of experts, members of the Joint Committee, who worked on its preparation, is a guarantee of its reliance as a true Canadian standard.

This masterpiece is the result of the endeavours of the Canadian Good Roads Association, but it is also that of others who have participated in its production, including the Engineering Institute of Canada.

A copy of the manual may be obtained from the Canadian Good Roads Association, 270 MacLaren Street, Ottawa.

J. O. MARTINEAU, HON. M.E.I.C.,
Representative

CANADIAN STANDARDS ASSOCIATION

Technical Committee

Since being appointed E.I.C. Representative to the Technical Council of the C.S.A. in April, 1960, I have endeavoured to obtain some background information as to the workings of this Council and to vote on the various proposed standards that are submitted from time to time to all the members of this Council.

On checking back through my files, I find that I voted in the affirmative on 24 separate standards and one vote in the negative. In addition, there was one standard on which I did not vote either way.

It is not always easy to make a decision in voting on these various proposed standards, as the range of subjects is very ide and one's knowledge is necessarily very limited. Consequently, I think it is only fair to state that had it not been for the services of a very competent staff in my own company it would not have been possible for me to vote intelligently on a great many of the proposed standards and changes to them.

In addition to the votes that were registered above, I find that there was correspondence with the Secretary of the Council on three proposed standards and that in each case, I received from the Chairman of the Committee concerned, very satisfactory replies to my questions.

E. B. JUBIEN, M.E.I.C.
Representative

COLUMN RESEARCH COUNCIL

The Column Research Council of the Engineering Foundation concerns itself with problems relating to the strength, design, and behaviour of columns and other compression elements in metal structures. A review of the work of the Council was given to the Annual Meeting of the Engineering Institute in Winnipeg in 1960.

Towards the end of 1960, the Column Research Council published a "Guide to Design Criteria for Metal Compression Members" incorporating the results of researches in North America and abroad over the past several years. The Guide provides an authoritative summary of knowledge on the field, and would be of use to specification writing bodies, and engineers in practice requiring special information on instability in metallic structures. Copies of the Guide may be obtained through the office of the General Secretary of the Engineering Institute in Montreal.

Following upon the publication of the "Guide", the research committees preparing material for publication have mostly been disbanded. In their place have been formed a number of "Task Groups" to undertake further new studies. Reports will be made on these from time to time as work progresses. It is perhaps interesting to note that the undersigned reported has been named Chairman of one of these new Groups.

D. T. WRIGHT, M.E.I.C.
Representative

REPORT OF THE LIAISON OFFICER FOR THE ENGINEERING INSTITUTE OF CANADA TO THE EMERGENCY MEASURES ORGANIZATION OF THE FEDERAL GOVERNMENT OF CANADA

Two separate projects were considered during the past year, both of which will be issued as specifications by the Canadian Government Specification Board.

The first project covered the development of a hydropneumatic pumping system for use with mobile emergency hospitals. Several meetings were held to discuss a desirable specification and this has now been completed and will be issued by the Canadian Government Specification Board under their No. 100-GP-1a.

This equipment is designed to be used in conjunction with portable power equipment for the supplying of potable water for emergency hospitals. It is to be capable of being used under a wide variety of conditions and types of water supply

The second project, which is still under consideration, covers the development of a lightweight 10 KW single phase internal combustion engine driven generator set for the supply of electric power to emergency hospitals. The factors involved in the design of this equipment are portability, reliability and capable of operating under a wide range of climatic conditions on an emergency basis.

The above equipment will be used in conjunction with hospital equipment which is being packaged and stored in strategic locations across Canada and will include everything from surgical equipment, X-ray equipment down to the water supply and power supply described above.

The specification for this plant will also be issued by the Canadian Government Specification Board on completion of the study.

R. E. HAYES, M.E.I.C.
Representative

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

During the year 1960 the Engineering Institute of Canada, in addition to participating in the regular activities of the Engineers' Council for Professional Development, had the opportunity of acting as host in Montreal at the Annual Meeting of E.C.P.D. on October 3rd and 4th. The meeting was an excellent one, well attended, with good papers and all present, mostly from the U.S.A., were greatly pleased with the excellent arrangements made by the Institute for the meeting in the Queen Elizabeth Hotel. Amongst the other functions of the gathering was the Annual Dinner at which Colonel L. F. Grant had been chosen as the speaker, always a happy choice on any E.C.P.D. occasion. It will be recalled that Colonel Grant represented the E.I.C. on the Council of E.C.P.D. for a number of years, and for three years was its President. His unique qualities as a Canadian representing E.I.C. on E.C.P.D. has left an imprint that will remain for a long time. The Annual Meeting was a very profitable one and the representatives of the other constituent members of E.C.P.D. are always happy to share in Canadian hospitality.

The expansion of E.C.P.D. membership is a problem which has been under consideration for several years and during 1960 the Council of E.I.C. has approved of the applications of the Institute of Aeronautical Science (I.Ae.S.), the Institute of Radio Engineers, (I.R.E.), and the National Society of Professional Engineers (N.S.P.E. for admission to E.C.P.D. and the way has been cleared for appropriate action to be taken.

The Council of the Institute during the year also went on record as favouring the proposed amalgamation of E.C.P.D. and E.J.C. (Engineers Joint Council) and the necessary steps are being taken to bring this about.

E.C.P.D. was one of the sponsors of the U.P.A.D.I. (Pan-American) Conference on Engineering Education in Buenos Aires in September and the E.I.C. was represented by Dean H. G. Conn of Queen's University and Dean R. R. McLaughlin of the University of Toronto who presented papers dealing with some Canadian aspects of Engineering Education. Immediately following the Engineering Education Conference a regular U.P.A.D.I. meeting was held and quite a number of prominent members of E.I.C. attended.

Much of the activity of EI.C. in the work of E.C.P.D. centres in the work of the committees and therefore is never in the limelight and passes un-noticed. However, E.I.C. is represented on all E.C.P.D. standing Committees. Guy Savard of Montreal is Chairman of the Recognition Committee and J. C. H. Dessaulles also of Montreal is one of the members. Georges Demers of Quebec City serves on the Ethics Committee; Garnet Page is on the Information Committee and E. J. Muszinski of Montreal acts on the Student Development Committee. Dean H. G. Conn of Queen's University has become a member of the Education and Accreditation Committee and Roger Lessard of Montreal is on the Guidance Committee.

The Committee on Development of Young Engineers has three E.I.C. members, W. J. O'Reilly of Niagara Falls, W. E.

Lardner of Toronto and K. R. Crean of Hamilton. (The E.I.C. Young Engineers Development Program has progressed a long long way since Colonel Grant carried the spark from the E.C.P.D. Annual Meeting in Cleveland ten years or more ago that kindled the flame which has spread so widely through the E.I.C. Branches to the benefit of so many young engineers).

Dean Donald MacNeil of St. Francis Xavier University, Antigonish, Nova Scotia has joined Gordon R. Henderson of Sarnia and W. S. Wilson of Toronto to make up the three representatives of the Institute on the Council of E.C.P.D.

I believe that E.I.C. is assuming its full share of the work in carrying out the various activities of E.C.P.D. and that we are not shirking our responsibilities. On the other hand I am convinced that E.I.C. is well repaid for the support it affords E.C.P.D. as one of its constituent members.

W. S. WILSON, HON. M.E.I.C.
Representative on Executive Committee, E.C.P.D.

NATIONAL JOINT COMMITTEE ON WINTERTIME CONSTRUCTION

The C.C.A.-sponsored National Joint Committee on Wintertime Construction continued to function during 1960, its sixth year of operation. Full-fledged meetings were held in Construction House, Ottawa, on February 17th and September 9th. In addition, a brief, factual submission was made to the Senate Committee on Manpower and Employment. The first meeting of the Committee was deliberately held during the middle of the winter to assess the seasonal unemployment situation and the effectiveness of wintertime construction promotion activities.

Members recommended that the Federal Government make its announcement concerning any Municipal Winter Works Incentive Program for the 1960-61 winter at an earlier date in order to enable municipal officials to do the necessary planning for participation. It was also recommended that the municipal program be given wider coverage as to the type of project to be included. These recommendations were passed on to the Federal Government and it was most gratifying that the announcement was made on July 25th and that the effective date of the Program was set at October 15th rather than December 1st as in previous winters. Moreover, the Program was expanded in scope so as to include municipal buildings other than schools and hospitals and additional types of engineering construction. The response from the municipalities has increased appreciably. The Committee has advocated an extension of the incentive principle into the field of industrial and commercial construction.

Further discussions were held concerning the hours of work provisions on Federal Public Works projects which sometimes tended to reduce employment and earnings rather than increase wintertime employment. Subsequently, the Federal Government issued an Order-in-Council during the summer providing for greater flexibility in this field inasmuch as permits may now be granted allowing work to continue for more than eight hours a day if the weekly number of hours worked still does not exceed forty-four.

The National Joint Committee also devoted a good deal of its attention to the subject of publicity promoting more wintertime construction and employment. The National Research Council reported that it plans to prepare a new film covering wintertime construction of houses and smaller building projects which will serve as a companion piece to Wintertime Construction—It Can Be Done", which relates to larger buildings. Some smaller technical films are also being considered. The Canadian Construction Association has cooperated with the Department of Labour in furnishing textual material for an illustrated brochure on wintertime construction scheduled for use in 1961. The N.R.C. Division of Building Research Bulletin on Wintertime Construction has been revised and remains a "bestseller" for this type of technical note. The constituent national organizations of the N.J.C.W.C. have all been most cooperative in promoting wintertime construction in speeches, bulletins, briefs and other media. The seasonal unemployment problem in construction activity remains extremely serious in spite of substantial gains. All possible assistance by members of the Institute to reduce these seasonal swings would be most welcome.

Member Organizations of the N.J.C.W.C.

The Canadian & Catholic Confederation of Labour
Canadian Chamber of Commerce
Canadian Labour Congress
Canadian Manufacturers Association
Canadian Construction Association
Engineering Institute of Canada
National House Builders' Association
Royal Architectural Institute of Canada

Associates:

Central Mortgage & Housing Corporation
Department of Labour
National Research Council.

S. D. C. CHUTTER
Representative

SECOND INTERNATIONAL HEAT TRANSFER CONFERENCE

The 'Joint Committee on North American Participation' which is organizing the five day International Heat Transfer Conference to be held at Boulder, Colorado on August 28th to September 1st, 1961, consists of representatives of the two host societies (ASME and AIChE) and eight other co-sponsoring societies, including the Engineering Institute of Canada.

Most of the work of the Committee in 1960 was concerned with the selection of abstracts of proposed papers and subsequently with the revision of the papers submitted by those whose abstracts were accepted. Papers from thirteen countries were submitted and the final number accepted for the Conference will be about 130.

The work has progressed well and it is hoped that advanced programs should be available before the end of April 1961. It is also planned to have the pre-prints ready and distributed to pre-registrants well ahead of the Conference date.

JULES W. STACHIEWICZ, M.E.I.C.
Representative

CANADIAN RADIO TECHNICAL PLANNING BOARD

1960 was a year of accelerated activity in Canadian Radio Technical Planning Board affairs. The Board is a non-political, non-profit organization of users of radio communications and allied equipment, manufacturers, engineering and educational societies and other interested groups, and it continued investigations into the conservation and effective use of the radio frequency spectrum, acting as a technical advisory body to the Telecommunications and Electronics Branch, Department of Transport.

The Land Fixed and Mobile Committee gave priority consideration to split channel operation of 150 MC land mobile equipment and the Maritime Committee dealt wth D.O.T. Spec. 134 covering AM radiotelephone transmitters and receivers n the 1605-5000 Kc/s band.

Investigation of scatter techniques, interference, hazards, and frequency allocations was carried out by the Tropospheric Scatter Committee. The Television Committee completed its draft revision of D.O.T. Broadcast Procedure No. 5, Issue I: "Protection and Coverage Rules for V.H.F. Television". It also commented on other Specifications. The Railroad Frequency Allocation Plan recommending narrow channel Allocations, was circulated to sponsors. The Microwave Committee completed its recommendations on telephone channel parameters and microwave frequency allocations.

The Broadcast Committee commenced investigation of Spec. 150 and 151 covering AM broadcast transmitters and its Sterephonic Subcommittee held several meetings on stereophonic radio broadcast standards.

A suitable amortization period for non-type approved Ship Station Radio Equipments covered by Spec. 112 was investigated by the Amortization Committee. A sponsor vote by letter ballot approved the Committee's recommendations.

E. H. HAYES, M.E.I.C.
Representative

UPADI

The Union Panamericana De Asociaciones De Ingenieros continues to be active and it is my privilege, as your representative, to report to you at this time.

When UPADI was first organized in 1950, the purpose was to promote better understanding between the Engineers of the Western Hemisphere.

The 6th. Pan-American congress on education was held in Buenos Aires on September 12-17, 1960. It was followed by UPADI Convention September 19-22. Host to both meetings was the Union Argentina de Asociaciones de Ingenieros.

The Canadian delegation which included 15 Engineers, were also members of the Canadian Trade Mission to South America. We were well represented at all UPADI functions, including plenary sessions, round table conferences, committee meetings and the final meeting and banquet. The more important roles in this convention were taken by Past President Dr. K. F. Tupper and Professor Morrison of Toronto. The Canadians were well received at this conference. We met many old friends.

The representative of the Engineering Institute of Canada was again re-elected to the Board of Directors. Mr. Carols Vegh Garzon was again asked to represent us as an alternate.

A suitable occasion was arranged to pay tribute to the long and faithful services of Mr. Vegh Garzon on our behalf. This occasion was a reception held at the residence of Mr. C. A. Bissett, Commercial Consul of the Canadian Embassy in Buenos Aires, at which about 100 were present. The President's letter was read and a watch, with a suitable inscription, was presented to him by the Canadian Ambassador, Mr. R. P. Bower. This presentation was the highlight of the reception.

UPADI Fund Inc. also held a meeting. There was some change on the Board of Directors—Mr. George Browne of New York replaced Mr. James Todd of New Orleans, as President. The writer was re-elected as a member of the Board.

It was arranged that the next conference be held in Puerto Rico in 1962. The UPADI headquarters is to remain in Montevideo in the meantime.

There were discussions relating to interchange of students, the employment of students in Canada and scholarships. Many students attend convents and Junior Colleges in Canada.

In connection with these activities, it is recognized that few Canadians are well informed about UPADI affairs or Engineering, generally, in these countries, I would like to suggest that a committee be formed to keep the members of the Institute advised on UPADI matters and participation. Perhaps the E.I.C. would be interested in forming its own committee of International Relations at a later date to look after all Canadian Engineering activities in the International field.

In conclusion, may I say that I am very strongly in favour of our participation in UPADI activities, in financing these activities and encouraging Canadian Engneers to become interested in Latin-America. It is important, as it will provide opportunities for Canadian Engineers. It will help open the way for closer associations in a natural market for Canadian goods and services.

JAMES A. VANCE, HON. M.E.I.C.
Representative

TABULATION OF BRANCH ACTIVITY ANNUAL REPORTS

Branch	No. of Meetings	Technical Meetings — Field	Technical Meetings — Attendance	Social and Other Activities — Nature	Social and Other Activities — Attendance	Joint Meetings	No. of Executive Meetings	Other Activities
Baie Comeau	8	General Film (1) Aero-Dynamics (1) Hydraulics (2) Oil Industry (1)	35 30 30 35	Annual Dance President's Visit Annual Election	90 60 12		4	High school seniors were given lectures on engineering.
Belleville	8	Plastics (1) Minerals (1) Concrete (1) Atomic Reactor (1)	10 40 25 30	President's Visit (J. Hanna) "Communist Brainwashing" C.A.P.E. President's Visit (Dr. Dick)	40 25 25 35		10	Chairman H. T. Floyd presented Branch Prize of $75 to Jens Hansen, Queen's University.
Border Cities	9	Civil (2) Industrial (1)	70 120	Two Dances Joint meeting with Sarnia and London Stag Annual Meeting	180 35 40 60	Meeting with A.P.E.O. President of A.P.E.O. in attendance	9	A Student Section has been formed—a vigorous group showing promise of being a valuable asset to the branch. The Ladies Auxiliary is a thriving group, they have accompanied members on several tours.
Brockville	6	General Industrial (1) Plant Industrial (1) Plant Tour—Power (1) Computers (1)	34 50 32 32	Annual Regional Meeting Social Night	15 50		7	The 1960 Professional Development Course comprised of a series of 8 lectures on corporation finance and investments. Enrollment included 12 EIC members.
Calgary	46	City Planning (1) Civil (1) Power (1) Electronic (1)	40 50 55 35	Luncheon Meetings (33) Annual Barbeque Annual Soiree Dinner Dance President's Visit Annual Meeting	38 300 324 100 100 65		7	Professional Development activities included a joint program with CIMM and ASPG and courses of 5 lectures each. Average attendance was 40. A successful High School Engineering Night was held in April. The Branch has joint membership of a Technical and reference library. They contributed $200 to it. The Wives' Club has a membership of 232.
Cape Breton	8	Petroleum (1) Mechanical and Electrical (1) Metallurgical (1)	20 37 42	Dances (2) Lobster Party Talk—"National Survival" Annual Business	80 85 25 19		12	The Branch is building a scholarship fund and expects to have it in operation in Sept. '61 or '62. The Wives' Association met 4 times.
Central B.C.	5	Civil (1) Hydraulics (1) Electrical (2)	22 28 57	President's Visit Kootenay Branch Visit	57		5	The Branch organized addresses in all the major local high schools.
Chalk River	7	Hydraulics (1) Nuclear (1) Meteorology (1)	25 30 30	Film President's Visit Members' Talks "Trip to Russia" Talk	10 35 25 250		13	Two field trips were held; one was to the NPD Reactor at Rolphton, and one to the RCMP Crime Laboratory, Ottawa.
Corner Brook	4	Civil (3)	15	Annual Dinner Dance	40		4	The Engineers' Wives Club held 8 meetings during the year.

Branch	No. of Meetings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Executive Meetings	Other Activities
		Field	Attendance	Nature	Attendance			
Cornwall	9	Mechanical (3) Civil (1) Industrial (1)	25 14 25	President's Visit Ladies' Night Talk	45 74 30		10	The Branch provided speakers for the School Careers Day in both High Schools in the town. It also assisted the C.I.C. in the organization of their "Sojourn on Science" programs.
Eastern Townships	9	Electrical and Mechanical (1) Mechanical (1) General (2)	53 28 49	President's Visit Ladies' Night University Visit Golf Tournament	133 86 42 29		8	A member of the Branch is chairman of the Student Councilling Committee. The Branch sponsors a Public Speaking competition for students.
Edmonton	10	Electrical and Mechanical (1) Mechanical (2) Civil (1) Hydraulic (1) Management (1)	89 60 65 66 57	Dance Picnic President's Visit Annual Business Meeting	172 300 150 68		8	The Engineer's Wives Club has had an active year.
Estevan Section	11	Chemical (1) Management (1) Hydro (1) Geology (1) Civil (2) General (2) Pipeline (1)	26	Spring Banquet Annual Meeting			4	The Section has had a successful first year.
Fredericton	11	Physics (1) Transportation (1) General (1) Meteorology (1) Sanitation (1)	18 30 44 40 24	Smoker at UNB Lobster Boil and Dance Dance (2) President's Visit	35 70 100 48	A.P.E.N.B. members invited to Branch Meetings	7	The Branch awarded prizes in the Student Paper Competition.
Halifax	8	Electrical (1) Hydraulics (1)	65 65	Lobster Party President's Visit Annual Meeting	220 130 50	Joint Meetings with Military Engineers. Meeting with Nova Scotia Technical College Students. Joint Banquet with A.P.E.N.S.	6	Panel discussion with graduates of N.S.T.C. on problems of new graduates.
Hamilton	12	Civil (2)	40	Annual Ball Christmas Function				The Professional Development Program is attracting interest from approximately 100. Counsellors have been detailed to first year engineering students at McMaster University.
Huronia							2	Counselling Committee available to High Schools and students.
Kingston	9	Automation (1) Mining (1) Natural Gas (1) Aluminum (1) Patents (1) Hydraulics (1) Radio (1) General (1)	50 25 20 15 35 85 28 18	President's Dinner Annual Dinner Dance	47 99		10	The Branch assisted in the organization of the Science Fair, Mar. 1961. Three awards totalling $75 were given for papers presented by under graduate students. Wives Group held organizational meeting.
Kitchener	10	Civil (1) Mechanical (1) Electrical (2)	50 29 67	Student Night Golf Tournament Annual Stag Ladies' Night	78 15 49 136	77 attended meeting with Grand Valley engineers 60 attended meeting with Canadian Welding Society and A.S.T.E.	9	The Branch is giving active support to the O.A.C. student branch and the University of Waterloo student branch. The activities of the Engineers' Wives included 4 meetings.

Branch	No. of Meetings	Technical Meetings — Field	Attendance	Social and Other Activities — Nature	Attendance	Joint Meetings	No. of Executive Meetings	Other Activities
Kootenay	8	Chemical (1) Civil (1) Automation (1) Electric (1)	40 45 30 45	President's Visit Field Trip	45 13	Meeting with C.I.C., C.I.M.M.	10	Donated $100 to Trail Scholarship Fund.
Lakehead	6	General (3)	30	Annual Dance Annual Meeting Sister Profession	76 34 30		9	Presentation of a set of Encyclopedias to Lakehead College of Arts, Science and Technology.
Lethbridge	5	Chemical (1) Civil (2) Electrical (1)	30 30 30	Engineers Ball Presidents' Meeting	70 38		10	Ladies' Auxiliary has been holding monthly meetings.
London	8	Chemical and Mining (1) Transportation (1)	45 25	Annual Dance Feather Party Golf Tournament President's Visit	105 40 30 30	Joint Meeting with A.I.E.E. and A.M.I. Tour of facilities for new Wellington Square.	10	Active support towards formation of a student section at University of Western Ontario. The Ladies' Auxiliary held 7 meetings.
Lower St. Lawrence	5	Electronic (1) Power (1)	20 18	Social Party Elections President's Visit	30 21 35	All Meetings are joint with the Corporation of Engineers		Members visited graduating students at local schools and colleges. $10 bursary to student.
Moncton	5	Education (1) Electrical (1) Hydraulic (1)	30 33 58	Annual Meeting President's Visit	14 99		6	The Wives' Association has been very active and is now numbering about 40.
Montreal	45	Special (2) Management (5) Chemical (4) Civil (6) Electrical (10) Mechanical (7) Junior Section (4)		Special Functions (4) Students Night		Electrical Section Meetings with A.I.E.E. Chemical Section Meetings with C.I.C.	11	The Student Guidance Committee held 2 forums for High School students, one French, one English.
Newfoundland	7	Civil (2)	25	Field Trip Student Public Speaking Contest Business Meeting General Dinner	30 25 30 80		11	$50 prize awarded to winner of the Engineering Students' Public Speaking Contest. The Wives Club held regular meetings throughout the year. They presented $100 scholarship to a student at Memorial University.
Niagara Peninsula	6	Electrical (1) Civil (1) Metallurgical (1) General (1) Soil Mechanics (1)	100 102 150 120 175	Dance Ladies' Night	400 120	All meetings jointly sponsored with A.P.E.O. Electrical meeting held with A.I.E.E.	7	Registration in the Professional Develop-Program now totals 64. Junior Engineers Night held March 17 was directed at recent graduates and senior high school students.
Nipissing and Upper Ottawa	6	Civil (2)	30	President's Visit	60		3	Wives' Association held four meetings.
North Eastern Ont. Section				Councillors' Visit	10			
North Nova Scotia	2	General (1)	25	Social	80			
North Shore Lower St. Lawrence	5	Electrical (1) General (2) Civil (1)	20 25 15	Vice-President's Visit	30		6	Offered talks in different fields of engineering to High Schools.
Northern N.B.	2			General Annual Social	25 33		2	

Branch	No. of Meetings	Technical Meetings Field	Attendance	Social and Other Activities Nature	Attendance	Joint Meetings	No. of Executive Meetings	Other Activities
)ttawa	13	Survey (1) Mining (1) Petroleum (1) Hydraulics (1) Construction (2) Electrical (1)	60 30 50 75 60 60	Dance Golf Tournament Law Economics Philosophy Annual Meeting	250 75 60 60 60 60	Two meetings held with A.I.E.E., and one each with A.P.E.O. and C.P.E.Q.	9 9	A steering committee has been elected to initiate a Professional Development program. Twenty-five members and 7 wives are now participating.
'eterborough	8	Civil (2) Automotive (1)	48 45	Golf Tournament Ladies' Night Stag Viking Ball Business	25 40 28 160 29		18	Awarded 3 certificates of merit together with $15 for the achievement of proficiency in Maths and Science subjects in the High Schools. $50 donation to Community Service Committee.
Port Hope	4	Civil (2)	26	Dinner Dances (2)	30		2	The Professional Development Program has been active.
Prince Albert Section		Weekly Meetings		Social Evening				
Prince Edward Island	5	Marine (1) Civil (3)	30 30	Annual	25	All meetings joint with A.P.E.P.E.	8	
Quebec	10	Civil (2) Electrical (3)	25 20	Annual Meeting Iron Ring Ceremony Golf Tournament Oyster Party	29 35 115 38	Three technical meetings held with the American Institute of Electrical Engineers. A dinner meeting was held with the local Chapter of the C.P.E.Q.	7	Professional Development activities included sponsorship of advanced courses in structural engineering
Regina Section		Monthly Meetings	30-110	Golf Tournament Fall Frolic Christmas Caper Engineer's Ball	65 112 166 126			Professional Development program includes group I and supplementary course. Group I is comprised of 24 lectures and discussions. The supplementary course consists of 20 sessions.
Saguenay	12	Computers (1) Atomic (1) Biochemical (1) Chemical (1) Management (2) General (1) Power (1)	35 50 80 80 46 17 120	Field trip Annual Meeting President's Visit Annual Ball	60 50 47 270	The Saguenay Chapter of the C.P.E.Q. was invited to all meetings except the President's Visit and some of the technical sessions were presented jointly.	7	Professional Development activities included three courses. Student counselling activities were carried out in both French and English throughout schools of the area.
Saint John	7	Chemical (1)	18	Convention Dinner (4) Coffee Party	275 80 40		12	
Sarnia	12	Chemical (1) Aeronautical (1) Mechanical (1) General (1)	40 69 37 34	Ladies' Night Annual Dance President's Visit Annual Meeting	60 106 31 49	Joint APEO Meeting and also joint field trip. Joint meeting with CIC, March 9.	15	The Professional Development course consisted of 8 weekly meetings on "Investments." $40 prize was presented to high school student now attending university.
Saskatchewan		See Sections—Prince Albert, Saskatoon, Yorkton, Regina Estevan					9	

Branch	No. of Meetings	Technical Meetings		Social and Other Activities		Joint Meetings	No. of Executive Meetings	Other Activities
		Field	Attendance	Nature	Attendance			
Saskatoon Section	4	Computers (1) General (2) Hydraulic (1)	30 60 40	Film	30			
Sault Ste. Marie	8	Town Planning (1) Standards (1) Steel (1)	16 16 20	Annual Report President's Visit Discussion (2)	16 36 20	Meeting with A.P.E.O.	7	The Wives' Association held two meetings.
Sudbury	8	Automotive (1) Civil (1) General (2) Field Trip (1) Mechanical (1)	31 35 36 50 40	Ladies Night Annual Dinner	94 39		11	Members have taken an active part in student counselling.
St. Maurice Valley	10	Automotive (1) Electrical (1) Chemical (1) Architecture (1) Electronics (1) Industrial Relations (1) Construction (1)	35 40 30 45 30 25 50	Guests of C.I.C. at talk on "Demolition of Ripple Rock" Estate Planning E.S.I.C. Dance President's Visit	 35 50 50		6	
Toronto	21	Hydraulic (1) General (1) Power (4) Electrical (7)		Annual Meeting President's Visit Demonstration Plant Visits (2) Ladies' Night		Joint meetings with A.S.M.E. and Institute of Traffic. The Joint Area Committee, E.I.C., American Society of Civil Engineers, Institution of Civil Engineers, held 5 meetings		
Vancouver Island	6	Petroleum (1) Naval Diving (1) Metallurgy (1) Hydraulics (1)	75 80 110 80	President's Visit Ladies Night	40 50	Joint meetings held monthly with A.P.E.B.C.	11	$100 scholarship given the most promising engineering student at Victoria College
Vancouver	8	Civil (6) General (2)	35 45	Ladies Night	96	Meeting held with A.P.E.B.C.	10	The Professional Development activities included a course on the theme "Beyond the Engineering Horizon—The Arts". An "EIC Vancouver Branch Prize" of $100 is being set up to be awarded to E.I.C. 2nd year outstanding student.
Winnipeg	7	Civil (8) Electrical (6)	35 44	Annual Dance Electrical Section Dance Spring Wind-up Dance	600 200 180		10	A committee has been set up for a Professional development
Yorkton Section	8			Talk Spring Banquet	30 40			
Yukon	7	Civil (6)	15	Annual Meeting President's Visit	8 52		3	

MEMBERSHIP AND FINANCIAL STATEMENTS OF THE BRANCHES AT DECEMBER 31, 1960

BRANCHES	Amherst	Baie Comeau	Belleville	Border Cities	Brockville	Calgary	Cape Breton	Central British Columbia	Chalk River	Corner Brook	Cornwall	Eastern Townships	Edmonton	Fredericton	Halifax
MEMBERSHIP															
on. Members	..	..	..	..	..	1	..	..	..	..	..	..	..	1	1
e Members	4	1	..	10	2	16	6	7	..	..	2	7	6	7	19
embers	21	14	34	81	27	413	53	31	17	14	43	45	359	90	345
niors	7	14	22	57	29	201	17	17	39	19	25	66	305	49	87
udents	11	4	23	110	21	58	29	17	11	12	15	187	302	151	245
filiates	..	3	1	..	..	2	1	1	..	..	..	..	1	..	..
Total	43	36	80	258	79	691	106	73	68	45	85	305	973	298	697
FINANCIAL STATEMENT															
Iome	†														
ebates from E.I.C. Hq.	..	90.00	170.00	618.20	240.70	189.78	61.40	197.00	105.00	107.10	205.00	290.00	220.00	250.00	175.00
ayments by Prof. Assns.	..	..	..	..	..	1,521.44	234.60	..	..	..	..	..	1,543.39	.	1,115.20
ranch Affiliate Dues	..	229.50	..	..	105.00	468.00	310.00	135.55	..	..	..	270.00	195.00	..	..
ebate re Institution Members	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
nterest	..	..	..	15.00	..	53.03	..	..	..	..	..	8.95	83.29	..	4.50
iscellaneous	..	405.85	77.65	1,719.89	37.50	106.21	1,651.10	41.88	..	273.04	702.00	690.00	..	1,233.68	1,762.02
Total Income	..	725.35	247.65	2,353.09	383.20	2,338.46	2,257.10	374.43	105.00	380.14	907.00	1,258.95	2,041.68	1,483.68	3,056.72
bursements															
rinting, Notices, Postage (1)	..	8.37	57.01	201.70	47.69	1,029.93	31.00	31.96	59.19	5.00	38.01	64.84	618.72	73.31	288.03
eneral Meeting Expense (2)	..	123.42	49.50	1,660.55	7.54	482.85	..	..	46.79	..	281.82	77.97	144.25	..	369.15
pecial Meeting Expense (3)	..	796.60	116.00	68.50	227.80	400.84	1,780.48	..	2.35	380.92	470.17	..	236.34	1,030.10	1,933.65
onorarium for Secretary	..	..	..	..	..	..	..	..	..	..	..	..	100.00	50.00	150.00
tenographic Services	..	..	..	35.20	..	335.17	..	..	..	5.00	..	..	10.00	..	50.00
ravelling Expense (4)	..	..	..	130.50	17.50	..	..	..	16.50	..	..	..	227.15	50.00	120.00
ubs. to Other Organizations	..	..	..	..	..	..	25.00	..	..	..	..	..	..	..	..
ubs. to the Journal	..	..	..	..	36.00	36.00	168.00	60.15	..	..	..	60.00	..	..	5.00
pecial Expense	..	..	18.80	168.00	..	212.21	400.00	190.98	..	..	..	25.00	..	..	92.00
iscellaneous	..	..	86.00	70.91	13.91	33.00	30.00	115.37	16.69	2.00	..	25.30	135.35	..	3.84
Total Disbursements	..	928.39	327.31	2,335.36	350.44	2,530.00	2,434.48	398.46	141.52	392.92	790.00	1,353.11	1,471.81	1,203.41	3,011.67
Surplus	..	..	..	17.73	32.76	..	..	..	..	..	117.00	..	569.87	280.27	45.05
Deficit	..	203.04	79.66	..	..	191.54	177.38	24.03	36.52	12.78	..	94.16	..	..	..
Balance at Dec. 31st, 1959	..	588.04	214.19	1,404.32	294.34	1,218.87	589.27	360.46	171.33	84.67	355.17	303.79	2,072.47	692.71	*1,133.58
Balance at Dec. 31st, 1960	..	385.00	134.53	1,422.05	327.10	1,027.33	411.89	336.43	134.81	71.89	472.17	209.63	2,642.34	972.98	1,178.63

(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 1959 figures.
† Figures not available.

embership Totals

	Total	Hon. Members	Life Members	Members	Juniors	Students	Affiliates
Total	20,441	32	641	7,697	5,256	6,760	55
Address Unknown	139	.	..	17	36	86	..
Non-Branch Members	956	9	62	480	283	120	2
Grand Total	21,536	41	703	8,194	5,575	6,966	57

BRANCHES	Hamilton	Huronia	Kingston	Kitchener	Kootenay	Lakehead	Lethbridge	London	Lower St. Lawrence	Moncton	Montreal	Newfoundland	Niagara Peninsula	Nipissing and Upper Ottawa
MEMBERSHIP														
Hon. Members	..	..	1	..	..	..	1	1	..	..	11	..	1	..
Life Members	21	2	11	6	1	4	7	10	..	4	155	2	14	..
Members	185	23	58	70	47	50	37	110	12	52	1,766	45	108	33
Juniors	186	19	66	47	15	55	19	100	24	35	1,296	54	93	25
Students	108	16	258	96	16	29	17	109	12	66	1,672	82	52	29
Affiliates	2	1	..	..	..	4	..	1	..	1	13	..	2	1
Total	502	61	394	219	79	142	81	331	48	158	4,913	183	270	88
FINANCIAL STATEMENT														
Income														
Rebates from E.I.C. Hq	829.00	105.00	537.60	300.00	195.00	290.00	30.00	671.50	100.00	226.18	9,320.75	275.00	575.00	190.00
Payments by Prof. Assns	..	..	..	..	..	..	138.32	..	..	72.00	..	..	..	..
Branch Affiliate Dues	125.00	..	56.00	..	60.00	..	83.85	..	..	50.00	23.00	60.00	..	44.00
Rebate re Institution Members	..	..	4.00	..	..	..	..	6.00	..	..	44.00	..	..	..
Interest	66.74	..	..	7.17	..	..	..	..	..	37.35	290.00	..	10.50	..
Miscellaneous	856.18	..	588.15	62.42	375.25	814.44	8.00	1,220.35	490.00	428.71	4,134.91	27.63	13.85	647.70
Total Income	1,876.92	105.00	1,185.75	369.59	630.25	1,104.44	260.17	1,897.85	590.00	814.24	13,812.66	362.63	599.35	881.70
Disbursements														
Printing, Notices, Postage (1)	603.64	10.46	78.58	93.84	22.12	215.13	96.70	403.91	20.28	33.43	4,165.19	29.19	403.11	52.60
General Meeting Expense (2)	1,015.15	..	28.18	186.70	271.24	..	8.50	218.13	780.10	16.27	38.90	8.00	75.00	..
Special Meeting Expense (3)	..	..	673.02	112.00	328.42	611.68	139.44	1,109.73	35.00	549.65	6,952.62	239.77	360.20	765.11
Honorarium for Secretary	75.00	..	..	..	..	18.00	..	12.00	..	50.00	900.00	..	..	..
Stenographic Services	..	2.00	..	..	..	..	..	..	..	..	31.12	..	..	..
Travelling Expense (4)	150.00	..	44.45	13.00	..	..	..	110.45	..	..	..	..	75.00	20.00
Subs. to Other Organizations	.	2.00	..	..	..	..	..	..	..	..	..	..	..	..
Subs. to the Journal	28.00	..	..	..	..	..	..	..	..	24.15	12.00	8.00	..	8.00
Special Expense	20.00	..	100.00	..	..	135.30	..	50.00	..	..	..	50.00	1.25	25.00
Miscellaneous	68.02	..	37.99	.30	..	62.25	31.30	89.80	30.00	83.33	147.22	39.53	..	..
Total Disbursements	1,959.81	14.46	962.22	405.84	621.78	1,042.36	275.94	1,994.02	865.38	756.83	12,247,05	374.49	914.56	870.71
Surplus	..	90.54	223.53	..	8.47	62.08	..	..	..	57.41	1,565.61	..	..	10.99
Deficit	82.89	..	..	36.25	..	..	15.77	96.17	275.38	..	..	11.86	315.21	..
Balance at Dec. 31st, 1959	1,007.90	270.82	*749.81	472.04	541.09	455.04	387.80	1,082.11	324.37	939.90	*9,435.36	363.71	997.80	496.63
Balance at Dec. 31st, 1960	925.01	361.36	973.34	435.79	549.56	517.12	372.03	985.94	48.99	997.31	11,000.97	351.85	682.59	507.62

(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.

Northern Nova Scotia	North Shore Lower St. Lawrence	Ottawa	Peterborough	Port Hope	Prince Edward Island	Quebec	Saguenay	Saint John	St. Maurice Valley	Sarnia	Saskatchewan	Sault Ste. Marie	Sudbury	Toronto*	Vancouver	Vancouver Island	Winnipeg	Yukon
1	..	3	..	..	..	2	..	..	..	..	2	..	..	4	1	..	1	..
3	..	71	11	5	..	15	1	6	1	1	9	2	1	87	38	38	26	..
23	23	398	77	16	15	113	75	67	81	82	668	20	55	941	384	86	306	11
13	36	291	63	11	14	157	81	38	98	64	145	20	23	606	220	51	272	2
23	31	365	25	6	39	218	32	46	62	18	510	13	30	487	377	96	579	2
..	..	2	..	..	2	..	..	1	..	..	..	..	1	5	5	1	1	1
63	90	1,130	176	38	70	505	189	158	242	165	1,334	55	110	2,130	1,025	272	1,186	16
25.00	193.80	1,760.83	522.90	81.75	75.00	757.25	450.00	363.70	455.00	572.70	80.00	115.00	225.00	3,320.00	1,200.00	417.96	443.13	85.00
96.30	..	..	..	..	..	..	29.57	419.59	..	..	1,867.20	..	..	224.00	..	..	1,116.00	50.00
..	..	10.00	6.00	..	..	..	7.00	86.00	..	..	..	27.00	36.00	..	..	3.00	259.00	80.00
..	..	..	2.00	..	..	..	4.00	..	..	..	..	..	..	..	22.00	..	..	..
..	2.00	24.36	..	..	..	..	6.48	..	..	..	..	..	2.32	72.56	54.67	..	77.75	..
126.50	63.00	1,094.75	48.98	86.00	..	10.20	961.45	..	221.85	1,490.53	..	38.70	879.50	2,588.40	1,277.01	..	152.20	..
247.80	258.80	2,889.94	579.88	167.75	75.00	767.45	1,458.50	869.29	676.85	2,063.23	1,947.20	180.70	1,142.82	6,204.96	2,553.68	420.96	2,048.08	215.00
5.75	2.30	900.85	86.15	..	..	183.81	65.00	85.59	166.86	277.61	266.40	41.55	221.86	2,336.80	693.19	102.71	707.42	30.07
86.19	28.00	80.54	..	26.00	..	..	364.59	..	225.62	120.00	705.00	128.55	23.50	235.25	173.00	22.55	267.70	58.65
257.50	147.16	895.25	301.06	158.00	..	231.98	823.91	685.75	355.86	1,486.81	..	1.75	1,092.50	2,895.72	951.54	110.23	50.00	81.52
..	..	100.00	..	..	100.00	150.00	60.00	..	20.00	..	400.00	100.00	50.00	273.00	100.00	100.00	250.00	..
..	..	56.88	..	..	55.00	50.00	..	10.00	..	..	100.00	..	..	..	25.00	9.00	212.37	..
..	..	..	..	56.70	..	..	73.55	..	249.38	111.00	345.80	..	..	..	..	9.50	21.50	..
..	..	410.00	..	..	..	..	..	..	..	..	..	..	..	231.97	60.00	..	5.00	..
..	..	..	..	..	..	..	..	12.15	..	..	..	..	20.00	..	..	..	108.00	..
..	..	210.65	125.00	..	..	..	..	..	..	..	..	19.52	113.54	100.00	70.75	19.40	136.00	..
11.15	..	5.00	67.25	8.60	..	48.70	33.00	9.11	14.87	..	50.00	..	..	71.69	3.68	100.00	222.25	..
360.59	177.46	2,659.17	579.46	249.30	155.00	664.49	1,420.05	802.60	1,032.59	1,995.42	1,867.20	291.37	1,521.40	6,144.43	2,077.16	473.39	1,980.24	170.24
..	81.34	230.77	42	..	..	102.96	38.45	66.69	..	67.81	80.00	..	..	60.53	476.52	..	67.84	44.76
112.79	..	..	..	81.55	80.00	..	..	..	355.74	..	..	110.67	378.58	..	..	52.43	..	..
403.84	152.12	1,470.65	425.79	108.46	55.30	354.23	719.46	774.85	593.92	925.03	2,381.89	303.39	743.51	3,225.74	1,929.15	224.46	2,535.94	188.31
291.05	233.46	1,701.42	426.21	26.91	(24.70)	457.19	757.91	841.54	238.18	992.84	2,461.89	192.72	364.93	3,286.27	2,405.67	172.03	2,603.78	233.07

***Oakville Branch** Total membership 74. (Life Members 2, Members 34, Juniors 29, Students 9).

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C. H. Conroy, St. John's, Nfld.
C. A. Crawford, Deep River, Ont.
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General Secretary
Garnet T. Page

Western Field Office
1177 W. 33rd Avenue,
Vancouver, B.C.

Headquarters
2050 Mansfield Street,
Montreal, Quebec

Eastern Field Office
160 Eglinton Avenue E.,
Toronto 12, Ontario

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Sixth World Petroleum Congress, 1963 (Canadian National Committee): G. W. Govier, Edmonton.

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Carleton University	Prof. S. G. Tackaberry, M.E.I.C.
Ecole Polytechnique	Prof. J. Dubuc, JR.E.I.C.
Laval University	Prof. Lionel Boulet, M.E.I.C.
McGill University	Dr. Andrejs Pakalnins, M.E.I.C.
McMaster University	Prof. W. R. Newcombe, JR.E.I.C.
Nova Scotia Technical College	Prof. A. E. Steeves, M.E.I.C.
Queen's University	Prof. Edgar L. Dauphin, M.E.I.C.
Royal Military College	Prof. J. Ellis, M.E.I.C.
University of Alberta	Prof. S. R. Sinclair, M.E.I.C.
University of British Columbia	Prof. S. H. de Jung, M.E.I.C.
University of Manitoba	Prof. J. P. C. McMath, M.E.I.C.
University of New Brunswick	Prof. Howard W. McFarlane, M.E.I.C.
University of Ottawa	Prof. R. P. Rowe, M.E.I.C.
University of Saskatchewan	Prof. J. B. Mantle, M.E.I.C.
University of Sherbrooke	Prof. Gaston Denis, JR.E.I.C.
University of Toronto	Prof. A. C. Davidson, M.E.I.C.
University of Waterloo	Prof. A. R. LeFeuvre, M.E.I.C.
University of Western Ontario	Prof. J. E. K. Foreman, M.E.I.C.
Non Degree Granting:	
Acadia University	Prof. G. D. Spence, M.E.I.C.
Royal Roads, Canadian Services College	Prof. A. L. C. Atkinson, M.E.I.C.
Dalhousie University	Prof. K. F. Margison, M.E.I.C.
Loyola College	David McDougall, M.E.I.C.
Memorial University of Newfoundland	Prof. A. O. Nemec, M.E.I.C.
Mount Allison University	Prof. G. Roy Pond, M.E.I.C.
Ontario Agricultural College	Prof. H. F. Theakston, JR.E.I.C.
St. Dunstan's University	Raymond MacPhee, JR.E.I.C.
St. Francis Xavier University	Prof. Anthony H. Roy, JR.E.I.C.
St. Joseph's University	Prof. J. D. McCrea, JR.E.I.C.
St. Mary's University	Dean James L. Ryan, M.E.I.C.
Sir George Williams University	R. I. McDormand, M.E.I.C.
University of Alberta Calgary Br.	Prof. H. R. McArthur, M.E.I.C.

• LIBRARY NOTES

(*Continued from page 134*)

cluded. (P. Rosenstiehl. Paris, Dunod, 1960. 355p., 47 fr.)

PRINCIPES DES CALCULATRICES NUMERIQUES AUTOMATIQUES, 2. ed.

The first part of this text discusses the principles of digital computers, binary systems, logical circuits, and actual computer operation and programming, with examples. The second part is a study of technology which is founded on the use of electronic tubes, transistors, germanium diodes, cryotrons, etc. (P. Naslin. Paris, Dunod, 1960. 243p., 13 fr.)

PHYSIQUE DES VIBRATIONS A L'USAGE DES INGENIEURS, 2. ed.

Developed from an undergraduate course given by the author, this text presents to the engineer an outline of the physics necessary for an understanding of the phenomena associated with vibrations. The first part includes a general study of vibration: oscillations; systems with one degree of liberty; shock and wave propagation. The second section deals with acoustics, sound, ultrasonics, and the application of acoustics. The third part covers optics, the nature and speed of light, diffraction, polarization, dispersion and spectroscopy. The last part discusses radiation, incandescence and photometry. Problems and their solutions are included. (A. Fouillé. Paris, Dunod, 1960. 552p., 64 fr.)

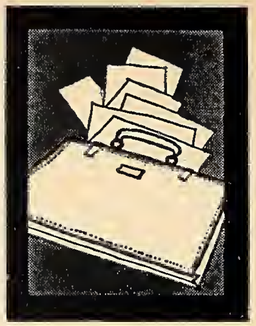
ELECTROTECHNIQUE A L'USAGE DES INGENIEURS. T. 2 MACHINES ELECTRIQUES, 5. ed.

Another text by this well-known author, this fifth edition of volume two has been revised to make use of the rationalized MKS system. It is concerned with the general theory of electric machines, particularly transformers, motors and generators. It covers such topics as flux, losses, static transformers, synchronous and asynchronous machines, direct current machines, and monophase and triphase motors. Bibliographies are included. Volume 1 is concerned with the principles of electrotechnics, and volume three with the applications of electrical energy. (A. Fouillé. Paris, Dunod, 1960. 439p., 18 fr.)

*SOLID PROPELLANT ROCKET RESEARCH.

This selection of technical papers, based mainly on a symposium of the American Rocket Society held at Princeton University in January 1960, forms the first volume of the Society's new series, "Progress in Astronautics and Rocketry". The next four volumes will appear in 1960-61. In this volume the papers are arranged in sections dealing with steady-state burning of composite propellants, combustion of metals, unstable burning in solid propellant rockets, ignition, and the mechanical properties of solid propellant grains. Most of the papers in each section deal with basic phenomena, but some papers on engineering aspects are included. (Ed. by Martin Summerfield. New York, Academic Press, 1960. 692p., $6.50.)

Business and Industrial Briefs



Appointments and Transfers

Atlas Copco Canada Ltd. has appointed **Burt Honeth** manager of the division for mining equipment sales. Mr. Honeth will make his headquarters at the company's head offic in Montreal.

J. B. Kelly has been appointed sales and technical representative of industrial films department of Du Pont of Canada. He was formerly in the marketing research division.

John R. Cann has been elected president of Raytheon-Canada Limited. He served formerly as executive vice president and general manager.

Union Carbide Canada Limited has appointed **R. S. Hughes** manager of production and engineering for the company's Chemicals and Plastics Division. Mr. Hughes has been a member of the organization since 1940, working in both Canada and the United States.

Canadian General Electric Company Limited has appointed **R. N. Fournier** a vice-president. Mr. Fournier is general manager of the company's wholesale department, with headquarters in Toronto.

J. A. Cross has been appointed vice-president of Dominion Structural Steel Limited. Mr. Cross was formerly associated with Dominion Structural Steel's parent organization.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A LINE OF ELECTRO MAGNETIC bin vibrators introduced by Jeffrey Manufacturing Company Limited, Montreal, are claimed to ensure a steady flow of materials. A wide range of sizes and types are available to suit many types of materials and bin, hopper and chute thicknesses. These bin vibrators are entirely electrical. They are supplied with variable controls and the units are available for most electric frequencies.

THREE ENGINE DRIVEN WELDERS have recently been marketed by Air Reduction Canada Limited, Montreal. A 225 amp. ac-dc engine driven welder, powered by a Kohler engine can handle stick electrode welding, Heliwelding and Aircomatic welding. The power source supplies from 15 amp. to 265 amp. d-c and 25 to 320 amp. a-c. Two d-c diesel welders are recommended by the manufacturers for field welding. The "Yellow Jacket" welder has been designed in 300 and 400 amp. rated sizes and powered by a 4-cylinder, 4-cycle injection type diesel engine. The third welder, rated at 250 amp. and utilizing a 4-cycle, 3 cylinder direct injection type diesel engine, is available both as a d-c welder, a-c power plant or solely as an a-c welder.

A BULLETIN covering natural frequency vibrating feeders is available from United Steel Corporation Limited, Toronto. The company gives design data and dimensions on their range of "Grizzly" feeders. Used in applications where feeding is combined with separation of courses and fines this feeder is reported to offer many advantages over conventional equipment.

THERMAL ELECTRIC POWER GENERATING capability in Canada increased by 36.8% in 1960 over the 1959 figure, according to a country-wide power survey released by the apparatus department of Canadian General Electric Co. Ltd. The annual survey, based on Dominion government statistics, indicated that total power generating capability at the end of 1960, both hydro and thermal, was an estimated 30.5 million hp., an increase of 13% over that of 1959.

THREE WATER-COOLED silicon rectifiers built by Canadian Westinghouse have been placed in service at the Marathon Corporation Pulp Mill at Marathon, Ont. The rectifiers, each rated 12,767 amp. at 150 v. d-c, are used to supply power for the production of chlorine for bleaching pulp. The units have replaced mechanical rectifiers, and are energized from the original mechanical-rectifier transformers. Each rectifier is 10 ft. by 4 ft. by 7 ft.

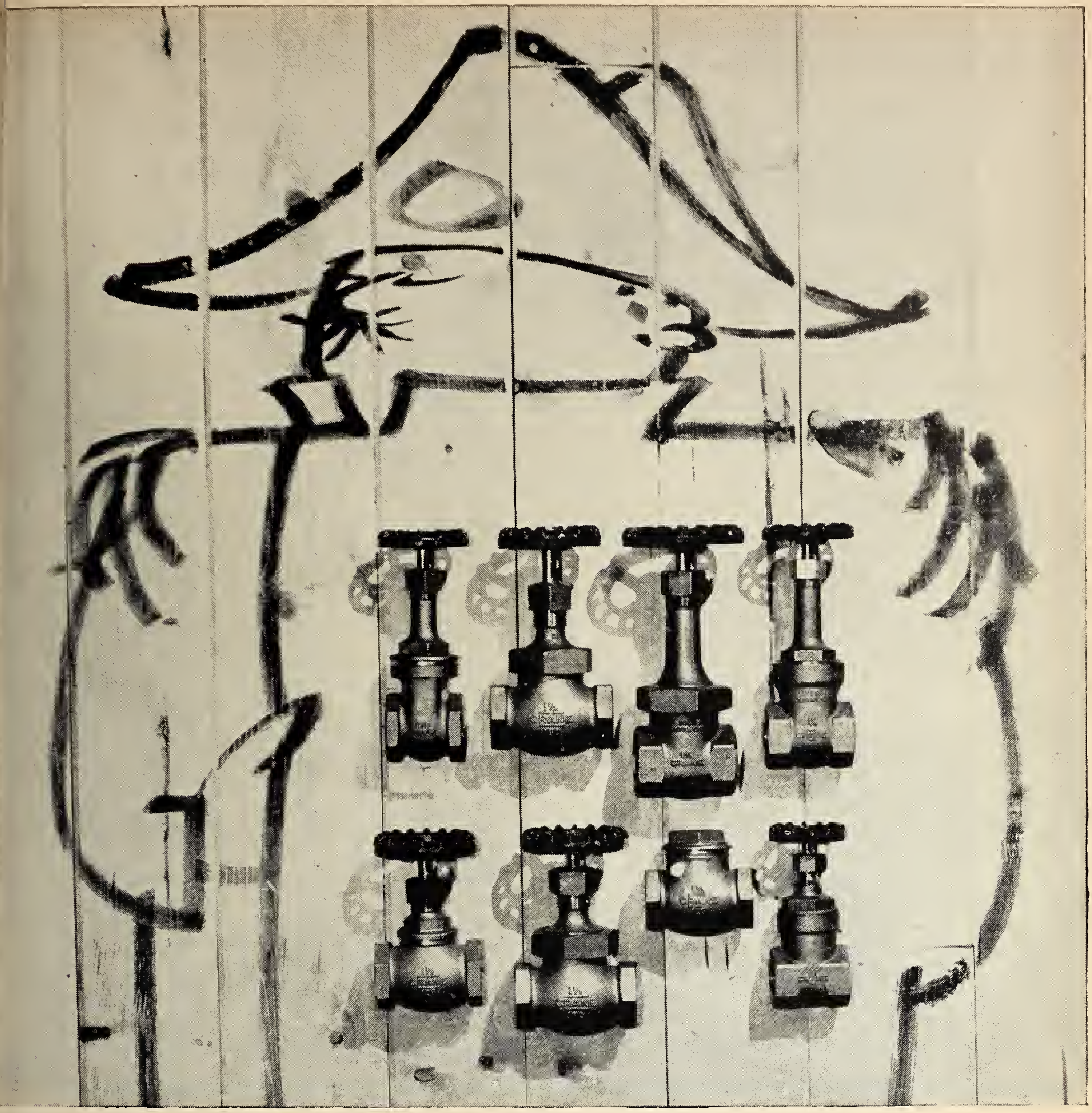
A PACKAGED AUTOMATIC FIRE-TUBE boiler is being marketed by Orr and Sembower (Canada) Ltd., Toronto. This boiler, the Powermaster Positive Flow Model, has burner and furnace located on the left side at the horizontal center line of the boiler. It is of three pass design with no tubes directly above or below the furnace. Aceording to the company, the side located furnace was found to provide the most efficient circulation of water of any feed injection and natural thermal circulation to augment eaeh other.

AN INCREASE of $500 in the Union Carbide Canada Limited's seholarships and fellowships has been announced. Henceforth the scholarships will be valued at $2,500 and the fellowships at $2,000. The company annually distributes 60 scholarships and four fellowships to students attending the 21 universities participating in the company's educational assistanee program.

AN ALUMINUM ALLOY is to be used for the first time in Canada in storage tank construction. Sparling Tank and Mfg. Co., Toronto, plans to use the alloy in building two fatty acid tanks for Polymer Corporation in Sarnia, Ont. This newly developed alloy, designated Alcan D54S, is expected to provide the optimum combination of strength, weldability and corrosion resistance for this application.

A SEVEN MILLION DOLLAR contract has been awarded British Insulated Callender's Cables Limited by the Magna Pipeline Company Limited, Vancouver, to manufacture, install and commission 53 miles of flexible submarine pipeline to transmit a supply of natural gas from the mainland of British Columbia to Vancouver Island. When completed this installation will constitute the world's longest flexible submarine gas pipeline. The laying operation of the Magna pipeline is planned to be carried out in 1963.

(More Briefs on page 184)



Top Brass: In the constant fight to maintain control over vital liquids, many a battle scar has resulted from faulty brass valves. Small wonder so many industry leaders "distinguish" their operations with Crane brass throughout. No matter how small, Crane won't sell a brass valve unless it exceeds industry-imposed standards by the widest of margins. Cheaper valves are sometimes available, but for those who won't risk valve failure for the sake of comparably meaningless first-cost savings, Crane is a "must". ■ With Crane, you not only save on operating costs. Unequalled local warehousing and fast deliveries cut storekeeping costs as well. You name the service—water, steam, oil, air, volatiles, low or high pressures, cold or hot—Crane has the brass. Screwed, flanged or solder joint ends; gate, globe and angle designs. All made in Canada . . . where a product *has* to be as good as its reputation. Crane Limited, 1170 Beaver Hall Square, Montreal, Quebec.

at the heart of home and industry

CRANE

plumbing
heating • air conditioning
valves and piping
electronic controls

E.I.C CERTIFICATE

OF ADVERTISING MERIT

For the third time in 10 months, the Canada Cement Company Limited advertisement in THE ENGINEERING JOURNAL has been judged best from the viewpoints of accuracy, information and attraction, by a 50-reader jury selected from a geographical cross section of the publication's mailing list. The certificate winning advertisement was a 2-colour, double-page spread headed, "Spectacular! New! Functional! Concrete Roofs Made With Canada Cement".

Advertising Manager of Canada Cement Company Limited is Mr. John V. Tittley. The ad was prepared by Cockfield Brown & Company Limited (Montreal). The Account Executive is Mr. Bert Churchill.

CANADA CEMENT COMPANY, WINNING ADVERTISEMENT—JANUARY, 1961

• MORE BRIEFS

A TILTING-DISC VALVE intended for general service, has been designed by Dominion Engineering Company Limited, Montreal. This 'non-slam' valve, made of stainless steel, is a single piece body casting. It is being manufactured under the trade-mark "Uni-Tilt". Elimination of all flanges is claimed to make this valve one of the lowest priced, lightest and easiest to install check valves available. The disc, an aerodynamic section, is a precision casting. Since both the disc and body are of stainless steel, the need for separate seat rings has been eliminated. It is made in a complete range of pressures and sizes.

CASE HISTORIES of more than 200 bridge concreting problems and their solutions are studied in a 16 page bulletin published by the Master Builders Company, Ltd., Toronto. Stories of the variety of job and weather conditions common to bridge construction portray the part played by Pozzolith concrete in meeting these conditions. Also included are reports on concreting piers and bridge decks for highway and railway bridges, hot and cold weather concreting data, the use of lightweight aggregate in bridge work and placing and finishing problems encountered in bridge work.

"A GUIDE TO THE SELECTION of Electrical Equipment for Overhead Cranes" is the title of a booklet recently published by the Dominion Bridge Company Limited. This publication is intended to help the crane buyer analyze his proposed application and to obtain the required performance of the crane as well as the maximum value of his purchase.

FLAME-CUTTING MACHINES of the "Oxweld" type are described in a 28-page catalogue available from Union Carbide Canada Limited, Linde Gases Division. Machines described range from handy portable units to multi-torch shape-cutting machines capable of reproducing thousands of intricate shapes and patterns in steel. Also described is the LPT Photocell Tracer which is capable of reproducing complicated metal parts from exact size pencil or ink drawings. Included are specifications for each machine together with illustrations of typical installations and accessories.

a power proposal

...that may provide the solution to your generating requirements for peak loading, standby and remote locations. The free-piston/gas turbo-generator is a unique engineering concept proven in operation, combining the best features of the conventional diesel engine and of the gas turbine, at the same time eliminating the inherent disadvantages of both. Your inquiries will receive our prompt attention.

THE FREE-PISTON GASIFIERS ARE MANUFACTURED BY THE FREE-PISTON ENGINE COMPANY, UNDER LICENCE FROM PESCARA, S.E.P. AND MUNTZ

PEACOCK BROTHERS LIMITED P.O. BOX 1040, MONTREAL, P.Q.
SYDNEY, TORONTO, SUDBURY, WINNIPEG, EDMONTON, CALGARY, VANCOUVER

A SURVEYING INSTRUMENT that utilizes the micro-wave principle to measure distances is now being used by the Shell Oil Company of Canada. Distributed by the Telurometer (Canada) Co. Ltd., the tellurometer unit weighs about 30 lb. and is powered by a heavy duty battery. It is set up over a monument transmitting a series of micro-waves towards a receiver set up over a distant location. Steady impulses are received on the receiver unit circuit and transmitted back to the original sending unit. The interval of time required for the impulses to travel is indicated on the transmitter panel. The readings are converted into feet and decimals of feet. The units are interchangeable and either one may be used as a sender or receiver and readings may be made at either end of a line. The units are designed primarily for measurement of lines from 500 ft. up to 40 miles. Under ideal weather conditions, longer distances may be measured.

A RECENTLY DEVELOPED METHOD for joining aluminum to aluminum in a permanent bond has resulted in the formation of Piston Rebuilders Limited, Toronto. Applicable to any size of worn or burnt out aluminum piston, the repairing process is fully guaranteed by the company. A special alloy is bonded to the old piston body and then the piston is machined and ground. New ring grooves are cut to any specification. No spacers are required, new metal is machined to take new rings, as in a new piston. The company is also equipped to rebore liners within the size range 3.495 in. 7.550 in., and the rebuilt pistons can then be ground to precisely fit the rebored cylinder size. New rings and pins can be supplied, wrist pin bushings can be bored.

A CATALOGUE covering Fafnir miniature and instrument precision ball bearings is available from United Steel Corporation Limited. This 40-page publication contains dimensonal data as well as engineering and application information. Also contained is a full sized picture of each bearing.

A MAGNETIC THICKNESS GAUGE has been developed in Germany and is available in Canada from Frank Koch, Ottawa. The Mikrotest is a hand-instrument for measuring the thickness of protective surfaces on steel bases. It utilizes the attraction power of a permanent magnet through the layer to be measured, which depends on the thickness of this layer. The instrument requires no electrical power source. For measuring, the instrument is placed into the specimen to be measured with its pole resting on the surface after measuring dial has been adjusted to maximum thickness. The magnet resting on the non-magnetic surface is attracted by the ferro-magnetic base. By turning the measuring dial the spring is strained until the magnetic breaks and recoils into the housing: The accurate surface thickness can then be read on the measuring dial. *(More Briefs on page 193)*

...reduces weight...cuts cost

Continuing research and development by the steel industry now provides a lighter, stronger steel for buildings and bridges. The new A36 specification for structural sections, bars and plate provides 10% greater strength and a saving of 5% or more in weight, at less than 1% increase in cost ... by comparison with CSA G40.4 and ASTM A7 now in use. Design details are covered in the revised CSA S16-1960 specification. This is another achievement by the steel industry in its constant search for improved designs, materials and methods. To keep informed on steel developments write the Canadian Institute of Steel Construction.

C. I. S. C. PROVIDES: Research and advisory service, publications, library, films.

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CANADIAN INSTITUTE OF STEEL CONSTRUCTION INC.

388 YONGE STREET, TORONTO, CANADA—Regional Engineers' Offices: Vancouver, Winnipeg, Toronto, Montreal

LIBRARY NOTES

(*Continued from page 169*)

*MECHANICAL-ELECTRICAL EQUIPMENT HANDBOOK FOR SCHOOL BUILDINGS.

This handbook is devoted exclusively to the installation, care, and use of mechanical and electrical equipment in school buildings. It describes the necessary fundamental engineering aspects, but in a language understandable to a reader without technical education. The first five sections cover heating and ventilating, plumbing, sewage disposal, kitchen and cafeteria equipment, and illumination and electric wiring. In the final section and the appendix, fire prevention and first aid are discussed, and general information given on the contractor's guarantee, his responsibilities and administrative conduct relevant to school-building contracts, and on the selection and function of the consulting engineer. (Harry Terry. New York, Wiley, 1960. 412p., $9.50.)

ANTI-CORROSION MANUAL, 1960.

The third annual volume, this edition has been completely revised, and contains much new information. The first section covers industrial problems, including corrosion in the food and oil industries. Other sections cover resistant materials and their applications, both metallic and non-metallic, and including comprehensive preparatory treatment before applying protective coatings; protective coatings, including paints and primers, mastics, metals, plastics and vitreous enamel. Other articles cover spray painting, pipe coatings and tapes, protective packaging, cathodic proteetion, and water treatment for corrosion control. Bibliographies, as well as relevant British Standards are included, as is a buyer's guide. (London, Corrosion Prevention and Control, 1960. 404p., 60/-.)

ENGINEERING MANAGEMENT, 2nd. ed.

In this second edition, notice has been taken of the changes in industrial conditions since the first edition was published in 1948, the references brought up-to-date, and information on operations research and cybernetics included. The first section covers the "art" of management, and its application in an engineering manufacturing business. Under the "science" of management are discussed scientific method, the history of engineering, the structure of industry, legal aspects, and the development of scientific management. The third, and largest, section of the book covers the practical aspects of management: market research, production planning, estimating, budget, company organization, factory planning, personnel, production and control.

Intended as a textbook, this volume will be useful for both management and students. (S. A. Robertson. London, Blackie, 1960. 467p., 30/-.)

GEOLOGY FOR ENGINEERS, 4th. ed.

A textbook of geology, with the emphasis on engineering applications. New material added in this edition includes information on permafrost, tidal surges in the North Sea, the geology of the Kariba Dam site, and methods of site investigation. The topics covered include physical geology; rock forming minerals; igneous, sedimentary and metamorphic rocks; earth movements; structural geology; stratigraphy; geological maps; geology of water supply; the geology of reservoir and dam sites; cuttings and tunnels in various parts of the world. Although the majority of the examples given refer to the British Isles, the text is useful for all civil engineers. (F. G. H. Blyth. Toronto, Macmillan, 1960. 341p., $5.00.)

HOW TO GET THE MOST OUT OF YOUR TAPE RECORDER.

Written for the user of tape recorders, this book contains information on the type of tape recorder to buy, how the machines work, features of the machines, number of heads, and cost. Adjuncts to the recorder such as microphones and tape varieties are discussed, as are good operation, frequency response, distortion, signal to noise ratio, equalization, and stereo. (Herman Burstein. New York, Rider, 1960. 170p., $4.25.) EIC

• MORE BRIEFS

A HEAVY DUTY PUSH-BUTTON switch has been introduced by Joy Manufacturing Company (Canada) Limited, Galt, Ont. Known as the Flex-tite switch, the manufacturers recommend it for any 2-station push-button application. It fits all standard FS and FD boxes and flush mounting can be achieved on metal surfaces.

A FOLDER describing an established method of integrally water-proofing concrete by adding "Anti-Hydro" to the cement during mixing has been issued by Anti-Hydro of Canada Sales Ltd. The company claims that by treating concrete in this way it provides increased density, strength and hardness, acid and alkali resistance and non-dusting properties. It is also claimed to prevent freezing and to ensure cement hydration at temperatures down to 15°F. A table is included showing mixing proportions for various mixes.

THE BRITISH COLUMBIA Power Commission has announced that five Canadian firms of consulting engineers have been named to undertake major responsibilities in relation to the preparatory work being done in connection with the Columbia River development. The firms are Canadian Bureau of Allied Engineering Limited, Crippen Wright Engineering Limited, Montreal Engineering Company Limited and H. G. Acres and Company Limited.

A 22-MILLION-POUND-YEAR phthalic anhydride plant is planned by Dominion Tar and Chemical Company Limited. The plant will cost approximately $3.5 million and will be engineered and constructed by Canadian Badger Company Limited. It is to be built adjacent to the company's present facilities in Toronto. Phthalic anhydride is used principally in the manufacture of alkyd resins for paints, varnishes and lacquers, as well as in the moulding of glass-fibre reinforced plastic products. The new plant will use the fluid bed process, which permits lower engineering and operating costs, gives higher yields and produces a higher grade product. It is planned to be in operation early in 1962.

A STRIPPING TOOL that is said to cut stripping time by 60% is available from Pyrotenax of Canada Limited, Trenton, Ont. The company claims that the 'Sheathmaster' is easy to use and will strip 7,000 ft. or more of Pyrotenax mineral insulated cables without regrinding. The blade is made of precision ground high carbon steel. Spares and replacements are of low cost. The tool is available in two sizes, ⅜ in.-½ in. and ¾ in.-1 in.

A FULLY AUTOMATIC CIRCUIT and cable tester has been developed by Sperry Gyroscope Company of Canada Ltd. The scanner isolates the circuit or connection where the fault is to be found. Previous models isolated the fault down to a group of thirty pins, and the final isolation had to be made manually.

A SERIES OF REAMER BITS manufactured by Sandvik Canadian Ltd., are available from Atlas Copco Ltd. These reamers are primarily intended for use in drilling starting holes for burn cuts when drifting. They are carbide-tipped and of six-winged design. The advantages of this design are claimed to be longer life and a smoother, more even operation. The bits come in three diameter sizes, 1⅞ in., 2¼ and 2½ in.

AN EXPANDED LINE of Dryerpacs (dryer-dust collector combinations) has been announced by Barber-Greene Canada Ltd., Don Mills, Ont. The combinations include 27 capacity ranges in both portable and stationary models. It features drum diameters and lengths from 5 ft. by 20 ft. to 9 ft. by 30 ft., 3-12 cone dust collectors, and air flow capacities from 12,500 to 54,000 cu. ft. per min.

A DIESEL GENERATING PLANT that is claimed to be light enough to be carried on highway trailers yet powerful enough to supply the power needs of small towns is available from D. Napier and Son (Canada) Limited. The Deltic Compak is a complete diesel generating plant and has a specially designed high speed. It weighs 22 tons. Four models are available producing 1200 to 3000 kw. in single units.

THE THIRD VOLUME of the World Directory of Nuclear Reactors has been published by the International Atomic Energy Agency. The new volume is a supplement to Volume II published in Dec. 1959, and contains detailed information on 96 research, test and experimental reactors currently in operation or under construction in 21 countries. The reactors have been grouped into the following main categories: light water moderated, pool type (27); light water moderated, tank type (21); liquid homogeneous (6); solid homogeneous (19); heavy water moderated (13); graphite moderated (4); and fast research reactors (6). Full details are given for one representative reactor in each group and for reactors having little similarity with any other. For the remaining reactors, similar to those described in full detail, general information and major modifications are given.

A RESIDENCE for 130 students at Memorial University, St. John's, Nfld., is being sponsored by Bowater's Newfoundland Pulp and Paper Mills Ltd. A similar residence is being sponsored by Anglo-Newfoundland Development Company Ltd. Construction of Rothmere Hall is under way and Bowater Hall will start later this year.

A CONTRACT for two 84,000 h.p. hydraulic turbines has been awarded to the English Electric Division of John Inglis Co. Ltd., Toronto, by the Hydro Electric Power Commission of Ontario. Work will start immediately.

EIC

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MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS

IN THIS ISSUE

In *"The Behavior of Rarefied Gases"*, **D. S. Scott** defines a rarefied gas as one in which the molecular free path approaches some dimension of the containing equipment. Dr. Scott's paper covers two significant uses for rarefied gases in industry and discusses the kinetic behavior of these gases. The author is an Associate Professor of Chemical Engineering at the University of British Columbia. Born in Edmonton, he received most of his education in Alberta and graduated with a B.Sc. in Chemical Engineering from the University of Alberta in 1944. After a year as Petroleum Engineer with Imperial Oil Limited at the Norman Wells plant, N.W.T., he returned to the University of Alberta in 1945 and received his M.Sc. in 1946. In 1949 he received his Ph.D. in Chemical Engineering from the University of Illinois and has been associated with the University of British Columbia since that time.

"It is customary to think of a 'rarefied' gas as a phenomena encountered in the upper reaches of the atmosphere," Dr. Scott writes, "or in very high vacuum experiments carried out in laboratories. While this was true many years ago, industrial development of the last two decades have shown the desirability of high vacuum operation on an industrial scale." Dr. Scott explains that the phenomena of rarefied behavior are not a function of pressure alone, but are really dependent on the size of the container relative to the gas pressure. In his summary the author writes that it is believed "satisfactory flow equations exist for rarefied gas flow in circular channels. Equations applicable to many other shapes could be readily derived. Heat transfer processes in rarefied gases can be less readily and less exactly calculated, but adequate empirical correlations appear to be available to allow estimation of heat flow rates for a number of situations."

"Effects of Changing Technology on Labor and Employment" by Professor **William Bruce,** M.E.I.C., covers the reaction of industry to tremendous technological advances. The application of scientific knowledge to so many aspects of man's environment calls for significant changes and adaptations in the use of manpower. New materials, processes and methods have required changes in the education and composition of the labor force. At times workers have had to learn completely new skills or techniques. Flexibility, both in the organizational structure of industry and the composition of the labor force is imperative if industry is to keep pace with technological advances. The author is a Professor of Mechanical Engineering at McGill University and head of the department of Mechanical Engineering there. He is associated with the Economics and Research Branch of the Department of Labour, Ottawa, in studies of technological change in Canadian industry. Professor Bruce received his B.A.Sc. in 1941 and his M.A.Sc. in 1948 from the University of Toronto. He first became associated with McGill University in 1946 as Assistant Professor. Previous to that time he was an Assistant Research Engineer at the National Research Council's research program on gas producers for Motor Vehicles and was both instructor and lecturer in Mechanical Engineering at the University of Toronto.

In the conclusion of his paper Professor Bruce writes that economic history has demonstrated that the "advantages to be gained from the continuing application of science and technology to industry far outweigh the effects of any disruptions which result in the labor force. These effects can be minimized by foresight, careful planning and the use of some of gain to alleviate such personal hardships as may occur. The benefits accruing from improved technology are commonly considered to be those of increased profits on financial investment, higher wages, shorter working hours, greater availability at lower cost of a growing multitude of products, the freeing of human effort from exhausting physical labor and mental drudgery, and in general, a higher standard of living for all.

Author **B. H. Lloyd** explains that statistical quality control is a term that unfortunately indicates neither the general areas of applieation nor the principles upon which it is based. If anything, he says, the term has a tendency to create a misleading notion in the mind of management. For this reason, in his paper *"Statistical Quality Control as a Management Tool"*, he discusses at least briefly the place of statistical quality in the business world. Mr. Lloyd was born in Athabasca, Alta., in 1921 and completed his early education in Woodstock, Ont. He joined the staff of the Ontario Research Foundation as Research Engineer, specializing in industrial applications of mathematics and statistics. In 1948 he was a special lecturer in the Department of Engineering and Business at University of Toronto, concentrating on industrial management and industrial statistics. Mr. Floyd joined the Industrial Engineering Department of Canadian Industries Limited in 1949 where he worked as a staff engineer until 1954. Since then he has been in management consulting work where his background of industrial engineering and statistical methods has proved extremely useful. Mr. Lloyd is a Fellow and Founding Member of the American Society for Quality Control. He was a director of the Toronto Section of the Society and Chairman of the Montreal Section on three different occasions. He was Chairman of the Society's National Convention when it was held in Canada in 1956 and until recently was a member of its Editorial Board. In his paper Mr. Lloyd writes that the "term statistical quality control . . . connotes a basic concept qualified by the implications of the work 'quality' which designates a specific area of business activity. However, the concept is suitably applicable to other areas of business such as the management of inventories and costs. Therefore it is not uncommon to encounter the expressions 'statistical inventory control' and 'statistical cost control' both of which may be developments of the same concept as statistical quality control."

COVER ILLUSTRATION

Aerial view of construction of the $25 million Port Mann Bridge over the Fraser River, 18 miles from Vancouver. A paper dealing with this bridge is to be presented at the 75th Annual Meeting of the Institute in Vancouver. (George Allen Aerial Photos).

Plant reduces lubricants from 27 to 7...processing is improved

Multi-purpose Greases Cut Lube Costs

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ENGINEERING REVIEW 1960

General

Probably the most important development in Canada's economy during 1960 was the increased export situation. Some gains made last year may well be lost in 1961, and other advances will be difficult to maintain. Prospects for export expansion continue to exist, however, and the importance of exports appears to have engrained itself as an essential part of the economy.

From 1950 to 1953 the volume of exports increased 21%. A further 13% increase was noted in the next three years. But from 1956 until 1959 there was an increase of only 4%. An increase of between 7% and 8% was noted in the first three quarters of 1960 compared with the comparable period the previous year. A final quarter decline in exports wiped out some gains, but the overall increase during the year was one of the most impressive since 1950.

Europe's increasingly-healthy economy created a situation in which many supplies ran short. Canadian industry was able to fill many of these shortages. Steel exports, mainly to Europe, accounted for about one third of steel production during 1960. Until the close of navigation caused a slowing a high degree of steel production was maintained. Other segments of the Canadian economy had similar experiences.

Demand from the United States was below that of 1959, but overseas orders more than compensated. For the entire year, exports to the United States were about 3% below those of 1959. The fact that general exports increased despite a decline in shipments to the United States raised hopes of a better trade distribution.

While exports were growing, imports held to 1959 totals until late in the year. The main reason for this was that Canadian industry was producing more goods demanded by the local market. Also playing a part, of course, was the slackened pace of Canadian activity.

This year is expected to show somewhat of an inmprovement over 1960 in consumer expenditures. The increase in 1960 compared with 1959 is expected to be only in the nature of 1%. Canada's unemployment level adds a shade of caution to an otherwise encouraging forecast of consumer spending. The character of these expenditures is expected to show greater emphasis on non-durables rather than durables. Thus, purchase of such items as automobiles or major appliances will be deferred by many until general business conditions improve.

Displaced workers are being retrained at an accelerated pace as technical training programs are enlarged. For the most part, automation hysteria has dissipated.

Balanced against unemployment which is expected to affect about

	Industrial Composite Employment (2)	Manufacturing (2)			Construction: Building and General Engineering (2)	Mining (2)	Manufacturing		Average Hours Worked per Week in Manufacturing (2)		
		Total	Durables	Non-durables			Average Weekly Wages and Salaries	Average Hourly Earnings	Total	Durable Goods	Non-durable Goods
	1949 = 100						Dollars				
1958[1]	117.9	109.8	114.8	105.6	127.6	123.5	72.67	1.66	40.2	40.3	40.1
1959[1]	119.7	111.1	115.5	107.3	129.0	123.4	75.84	1.72	40.7	41.0	40.4
1958 J	118.4	110.9	115.2	106.7	129.5	123.3	72.84	1.67	40.3	40.4	40.2
A	118.0	109.2	113.2	105.5	129.1	123.4	73.06	1.66	40.4	40.6	40.2
S	117.6	110.0	113.9	106.1	124.6	123.6	72.95	1.66	40.4	40.3	40.4
O	116.9	109.2	112.6	105.8	124.5	117.0	73.21	1.67	40.4	40.5	40.3
N	116.9	109.7	113.4	106.0	124.0	115.7	73.74	1.68	40.5	40.6	40.4
D	117.6	110.1	113.7	106.5	123.0	117.2	73.63	1.69	40.4	40.5	40.2
1959 J	118.4	110.7	114.8	106.6	124.2	124.6	74.64	1.69	40.7	40.9	40.4
F	118.2	110.0	113.8	106.1	125.7	120.4	74.99	1.70	40.7	40.9	40.5
M	119.1	110.2	114.6	106.5	125.8	120.8	74.62	1.71	40.3	40.6	40.0
A	119.5	110.7	115.2	106.9	130.3	126.3	74.94	1.71	40.6	40.8	40.3
M	119.3	111.4	116.3	107.3	129.4	124.2	75.30	1.72	40.7	40.9	40.5
J	120.2	112.2	117.4	107.7	130.2	123.9	75.58	1.72	40.8	41.1	40.5
J	118.9	110.3	113.2	107.8	129.8	123.6	75.79	1.72	40.8	41.2	40.4
A	119.5	110.9	114.1	108.1	131.7	122.2	76.03	1.73	40.8	41.1	40.5
S	121.0	112.4	118.8	106.9	132.2	123.8	76.74	1.74	40.9	41.3	40.5
O	120.5	112.0	117.5	107.3	130.8	123.7	76.92	1.75	40.9	41.2	40.6
N	119.4	110.3	113.5	107.6	128.0	123.8	76.71	1.75	40.7	41.0	40.4
D	120.0	111.3	116.1	107.2	128.4	124.3	77.77	1.76	40.7	41.1	40.3
1960 J	119.8	111.2	116.5	106.7	123.0	124.0	77.28	1.76	40.6	41.0	40.1
F	120.0	111.4	116.9	106.7	122.5	123.6	77.14	1.76	40.3	40.6	40.0
M	119.6	111.0	116.3	106.5	118.8	124.5	77.50	1.77	40.5	40.8	40.2
A	118.3	110.2	114.9	106.2	118.0	118.7	77.55	1.78	40.4	40.7	40.1
M	118.5	110.4	114.6	106.9	121.7	118.8	76.80	1.77	39.9	40.1	39.6
J	119.7	110.2	114.0	106.9	125.5	119.7	77.84	1.78	40.1	40.3	39.9
J	117.8	108.5	110.5	106.8	124.4	119.2	78.42	1.78	40.6	40.6	40.5
A	118.4	109.1	111.5	107.0	124.1	119.2	78.40	1.79	40.4	40.8	40.0
S	118.1	108.1	109.6	106.8	123.7	121.3	78.67	1.80	40.5	40.7	40.3
O	117.7	107.8	109.0	106.7	121.2	118.8	78.95	1.79	40.3	40.5	40.1
N	117.7[r]	108.5[r]	109.5[r]	107.6[r]	119.5[r]	118.3	79.08	1.80	40.4	40.7	40.1
D	116.9	107.4	108.5	106.4	120.2	115.4	80.52[p]	1.81[p]	40.9[p]	41.4[p]	40.5[p]

(1) Averages of unadjusted data. (2) Employment indexes and average hours worked are compiled from data which relate to the last pay period of the month. *The purpose of the moving average in the following charts is to indicate the underlying trend-cycle component as opposed to irregular factors. The moving averages are applied to the seasonally adjusted data and their lengths depend on a calculated measure called the M.C.D. or months for cyclical dominance. (DBS Table).

		Civilian Labor Force (3)					
		Employed					
		Total	Agricultural	Total	Agricultural	Index of Unemployed	Unemployed as a per cent of Labor Force (2)
		Thousands				1956 = 100	
1958 (1)		6,127	5,402	5,696	4,986	220	7.1
1959 (1)		6,230	5,525	5,859	5,162	188	5.9
1958	N	6,163	5,428	5,729	5,018	220	7.0
	D	6,167	5,439	5,719	5,009	227	7.3
1959	J	6,171	5,469	5,762	5,059	208	6.6
	F	6,196	5,484	5,807	5,093	197	6.3
	M	6,195	5,491	5,815	5,116	193	6.1
	A	6,203	5,499	5,857	5,156	186	5.9
	M	6,230	5,489	5,861	5,123	187	5.9
	J	6,226	5,513	5,874	5,171	179	5.7
	J	6,239	5,550	5,889	5,205	178	5.6
	A	6,239	5,557	5,862	5,195	191	6.0
	S	6,228	5,544	5,893	5,211	170	5.4
	O	6,264	5,572	5,914	5,218	178	5.6
	N	6,273	5,561	5,905	5,201	187	5.9
	D	6,292	5,577	5,894	5,196	202	6.3
1960	J	6,313	5,609	5,927	5,242	196	6.1
	F	6,333	5,658	5,924	5,252	208	6.5
	M	6,354	5,672	5,934	5,258	213	6.6
	A	6,344	5,662	5,913	5,247	219	6.8
	M	6,412	5,740	5,952	5,314	234	7.2
	J	6,382	5,731	5,962	5,315	213	6.6
	J	6,387	5,726	5,934	5,285	230	7.1
	A	6,429	5,763	5,942	5,299	247	7.6
	S	6,423	5,717	5,962	5,284	234	7.2
	O	6,488	5,774	5,997	5,312	249	7.6
	N	6,488	5,747	6,002	5,291	247	7.5
	D	6,487	5,770	5,975	5,281	260	7.9
1961	J	6,492	5,796	5,991	5,290	254	7.7

(1) Averages of unadjusted data. (2) Percentage seasonally adjusted. (3) The data printed here are revised in accordance with the new definitions of "employment" and "unemployment" which came into effect in the September, 1960 issue of *The Labour Force*. (DBS Table).

10% of Canada's labor force was a 1.7% increase in employment over 1960. The increase in the labor force during the year was 2.8%.

Employment, Earnings and Hours Worked

For the fourth consecutive month the composite index of industrial employment declined in December 1960. This reflected decreases in many of its components. Manufacturing employment was off by nearly 1 per cent. However, average weekly wages and salaries, average hourly earnings and the average work week in manufacturing all were higher in December.

Labor Force

Little increase was shown in the total labor force in January of this year. Total employment was slightly above the December figure. On a seasonally adjusted basis, the rate of unemployment amounted to 7.7% of the labor force.

Capital Expenditure and Industrial Production

Total outlays of $8.3 billion in 1961 are involved in present plans for capital spending by all sectors of the Canadian economy. These figures are taken from the results of a recent survey covering business establishments, institutions and all levels of government. Estimates of expenditure for housing are included in the total estimates. Should this program be accomplished, total capital outlays in 1961 would exceed those of 1960 by more than $100 million. A larger construction program is responsible for the increase in total capital spending.

Capital expenditures for new construction are expected to be about 4% greater than those of 1960. Plans for the purchases of machinery and equipment, on the other hand, show a decline of about 2%. About 23% of Canada's gross national product would be devoted to expanding, modernising and renewing the

NATIONAL INCOME AND GROSS NATIONAL PRODUCT IN CURRENT DOLLARS

		Salaries, wages and supplementary labour income	Military pay and allowances	Corporation profits before taxes (5)	Rent, interest and miscellaneous investment income	Accrued net income of farm operators from farm production (1)	Net income of non-farm unincorporated business	Inventory va'uation adjustment	**Net national income at factor cost (2)**	Indirect taxes less subsidies	Capital consumption allowances and miscellaneous valuation adjustments	**Gross national product at market prices (3)**
		Million dollars										
1958		16,434	491	2,483†	2,015†	1,193†	2,119	− 33†	**24,702†**	3,883†	3,923	**32,606†**
1959		17,717	496	2,836	2,094	1,108	2,150	−120	**26,281**	4,220	4,131	**34,593**
		Seasonally Unadjusted										
1958	2nd	4,104	126	658	471	133	533	15	**6,040**	968	1,002	**7,980**
	3rd	4,252	125	686	532	877	551	5	**7,028**	963	979	**9,094**
	4th	4,214	123	668	553	173	604	− 26	**6,309**	1,002	987	**8,422**
1959	1st	4,171	118	568	513	−29	453	− 33	**5,761**	1,000	962	**7,603**
	2nd	4,437	129	810	504	151	552	− 42	**6,541**	1,056	1,070	**8,564**
	3rd	4,571	127	780	517	920	543	− 42	**7,416**	1,079	1,036	**9,611**
	4th	4,538	122	678	560	66	602	− 3	**6,563**	1,085	1,063	**8,815**
1960	1st	4,382	119	595	521	− 8	440	− 34	**6,015**	1,066	1,017	**8,058**
	2nd	4,596	129	731	530	84	520	− 29	**6,561**	1,114	1,094	**8,618**
	3rd	4,741	127	694	545	974	540	− 19	**7,602**	1,089	1,029	**9,850**
		Seasonally adjusted at annual rates										
1958	2nd	16,360	500	2,260	1,948	1,280	2,064	60	**24,472**	3,828	3,936	**32,432**
	3rd	16,460	476	2,468	2,108	1,256	2,120	20	**24,908**	3,820	3,880	**32,824**
	4th	16,772	492	2,864	2,132	1,068	2,224	−104	**25,448**	4,012	3,904	**33,380**
1959	1st	17,372	500	2,800	2,112	1,136	2,140	−132	**25,928**	4,076	4,008	**33,956**
	2nd	17,640	508	2,796	2,056	1,188	2,156	−168	**26,176**	4,188	4,152	**34,528**
	3rd	17,756	488	2,816	2,088	1,108	2,128	−168	**26,216**	4,268	4,132	**34,616**
	4th	18,100	488	2,932	2,120	1,000	2,176	− 12	**26,804**	4,348	4,232	**35,272**
1960	1st	18,244	504	2,900	2,192	1,184	2,060	−136	**26,948**	4,304	4,268	**35,636**
	2nd	18,276	504	2,588	2,156	1,044	2,064	−116	**26,516**	4,436	4,256	**35,120**
	3rd	18,432	500	2,584	2,168	1,104	2,104	− 76	**26,816**	4,340	4,116	**35,272**

nation's productive facilities according to the capital program now planned. This is about the same proportion of gross national product that has been devoted for this purpose in the post-war period as a whole.

An advance of 0.3%, due to a 2.1% increase in mineral output, was shown in Canada's seasonally adjusted index of industrial production for January, 1961. Manufacturing, the electric power and gas utilities showed declines of 0.1%. The total index was 166.3, about 4% lower than the peak reached in January 1960.

In non-durable manufacturing a 1.3% advance was noted with increases in all but two of the eleven major groups. Declines were shown in tobacco products (3%,) and products of petroleum and coal (4%). A 5% decline in wood products was largely responsible for a 1.8% drop in durable manufacturing output. Declines also were reported in electrical apparatus and supplies (4%) and non-metallic mineral products (1%).

An increase of 1% was shown in non ferrous metal products while transportation equipment, reflecting increased motor vehicle production advanced 3%. Metal and fuel mining were up 2%, with non metal output advancing 6%, due largely to a similar advance in asbestos production. Increases also were recorded in iron ore (18%), zinc (2%), lead and other metals, including uranium (6%). An 8% decline was shown in nickel while gold and copper recorded smaller losses.

INDEX OF INDUSTRIAL PRODUCTION, 1949 = 100

	Total Industrial Production	Total Mining	Manufacturing: Total	Manufacturing: Non-Durables	Manufacturing: Durables	Total Electric Power & Gas Utilities
Without Seasonal Adjustment						
Jan. 1960	166.0	254.7	146.3	143.6	149.3	320.2
Feb. 1960	169.4	259.1	149.2	148.1	150.5	327.4
Mar. 1960	170.5	256.1	151.3	150.0	152.8	320.6
Apr. 1960	164.4	234.6	147.9	147.5	148.4	300.1
May 1960	169.7	250.1	153.2	152.8	153.7	284.2
June 1960	173.6	258.7	157.2	157.4	157.0	277.6
July 1960	161.7	263.9	143.8	146.5	140.7	257.9
Aug. 1960	162.5	255.0	145.2	153.7	135.2	267.4
Sept. 1960	169.8	265.7	151.8	159.4	142.8	281.4
Oct. 1960	172.1	254.6	155.3	162.7	146.6	289.3
Nov. 1960	171.4	253.4	153.0	160.4	144.3	317.0
Dec. 1960	160.1	241.9	140.0	144.6	134.5	332.6
Jan. 1961	160.0	248.8	138.4	142.8	133.3	343.3
Adjusted for Seasonal Variation						
Jan. 1960	173.5	257.5	156.7	155.8	157.7	287.5
Feb. 1960	170.1	257.6	152.5	152.3	152.8	288.9
Mar. 1960	171.9	264.0	153.3	153.3	153.4	299.6
Apr. 1960	166.6	251.0	149.2	150.4	147.7	290.4
May 1960	167.8	260.3	149.2	152.0	146.0	293.9
June 1960	167.6	255.1	149.2	152.9	145.0	300.1
July 1960	164.2	253.2	145.6	150.2	140.1	297.8
Aug. 1960	165.6	251.8	146.4	150.1	142.2	314.6
Sept. 1960	167.5	256.8	148.0	150.8	144.8	314.4
Oct. 1960	167.3	248.6	149.8	154.0	144.9	298.3
Nov. 1960	166.6	253.8	148.2	154.2	141.1	300.7
Dec. 1960	165.8	249.1	147.6	151.8	142.6	305.6
Jan. 1961	166.3	254.3	147.5	153.8	140.1	305.4

(DBS Table)

Major Industrial Areas

CHEMICAL

In common with other facets of the Canadian economy, the chemical industry failed to grow as rapidly in 1960 as forecast by economists in the spring of the year. However, relative to other economic areas, the chemical record was favorable, and in 1961 should continue to grow at a faster rate than the rest of the economy. In 1960, although the total value of sales of all of the manufacturing industries changed but little, the value of chemical shipments increased by 7%, and the physical volume increased by 12-15%. The increase in output was reflected in an increase in number of employees by 3-4% over 1959. Wholesale prices increased by 1%, and the total value of chemical materials produced and goods sold attained a new all-time record of more than $1.4 billion. This figure represents a growth of 130% based on 1949 production, compared with a growth in the other manufacturing industries of about 50% in the same time period. Trends in the various product divisions are indicated below:

(a) Acids, Alkalis and Salts: increased in value by about 5% over the 1959 figure of $307 million. A significant fraction of this gain was due to increase exports.

(b) Primary plastics, adhesives and rubber all recorded increases; the sharp declines in miscellaneous plastics exports were more than offset by

GROSS NATIONAL EXPENDITURE IN CURRENT DOLLARS

	Personal expenditure on consumer goods and services	Government expenditure on goods and services	Business Gross Fixed Capital Formation: New Construction: Residential	Business Gross Fixed Capital Formation: New Construction: Non-residential	Business Gross Fixed Capital Formation: New machinery and equipment	Value of Physical Change in inventories	Exports of goods and services	Deduct: Imports of goods and services	Residual error of estimate	**Gross national expenditure at market prices (2)**
	Million dollars									
1958	21,035†	6,161†	1,763†	2,811†	2,401†	−435†	6,332†	−7,363†	− 99†	**32.606†**
1959	22,261	6,437	1,743	2,592	2,626	+300	6,657	−8,062	+ 39	**34.593**
Seasonally Unadjusted										
1958 1st	4,834	1,360	301	532	577	−358	1,387	−1,643	+120	**7.110**
2nd	5,215	1,431	458	718	707	−265	1,616	−1,930	+ 30	**7.980**
3rd	5,166	1,763	494	852	567	+561	1,655	−1,840	−124	**9.094**
4th	5,820	1,607	510	709	550	−373	1,674	−1,950	−125	**8.422**
1959 1st	5,163	1,444	322	471	548	− 68	1,347	−1,745	+121	**7.603**
2nd	5,523	1,556	462	646	791	− 80	1,727	−2,164	+103	**8.564**
3rd	5,442	1,818	480	783	683	+774	1,779	−2,067	− 81	**9.611**
4th	6,133	1,619	479	692	604	−326	1,804	−2,086	−104	**8.815**
1960 1st	5,339	1,494	337	474	603	+ 66	1,590	−1,885	+ 40	**8.058**
2nd	5,789	1,551	351	624	735	−133	1,700	−2,150	+151	**8.618**
3rd	5,668	1,934	404	797	593	+685	1,917	−2,018	−130	**9.850**
Seasonally adjusted at annual rates										
1958 1st	20,640	5,992	1,644	2,872	2,468	−980	6,348	−7,236	+ 40	**31.788**
2nd	20,804	6,076	1,740	2,864	2,356	−332	6,344	−7,224	−196	**32.432**
3rd	21,060	6,244	1,792	2,804	2,340	− 56	6,176	−7,316	−220	**32.824**
4th	21,636	6,332	1,876	2,704	2,440	−372	6,460	−7,676	− 20	**33.380**
1959 1st	21,936	6,336	1,756	2,572	2,400	+332	6,364	−7,800	+ 60	**33.956**
2nd	22,024	6,612	1,748	2,572	2,628	+296	6,640	−7,976	− 16	**34.528**
3rd	22,304	6,444	1,720	2,580	2,772	+412	6,648	−8,268	+ 4	**34.616**
4th	22,780	6,356	1,748	2,644	2,704	+160	6,976	−8,204	−108	**35.272**
1960 1st	22,676	6,584	1,708	2,584	2,620	+656	7,224	−8,300	−116	**35.636**
2nd	23,112	6,588	1,400	2,524	2,472	+292	6,708	−8,064	+ 88	**35.120**
3rd	23,140	6,776	1,496	2,576	2,416	−284	7,140	−7,988	—	**35.272**

gains in exports of synthetic rubbers and related chemicals.

(c) Fertilizer sales were slightly higher, particularly influenced by the large production of mixed fertilizers.

(d) Paint and Varnishes: held up well, at about the 1959 level. The export market has little significance.

(e) Soaps, detergents, and toilet preparations lost considerable ground in the year.

In summary, then, the producers of chemicals for industrial uses showed considerably better progress than did the consumer chemical industries.

Indicative of the optimism of chemical management is the scale of new plant construction planned for 1961. Some idea of the scope of expansion of established product fields and invasion into new ones can be obtained from a coast-to-coast summary.

The following table illustrates the trend in capital spending in recent years in both current and constant (1949) dollars.

Year	Capital Expenditures						Capital Expenditures As Percentage of Gross National Product	
	Construction		Machinery and Equipment		Total			
	Current	Constant	Current	Constant	Current	Constant	Current	Constant
	Millions of Dollars						Per Cent	
1947[1]	1,397	1,671	1,043	1,245	2,440	2,919	18.5	18.9
1948[1]	1,824	1,905	1,263	1,343	3,087	3,248	20.4	20.6
1949	2,166	2,166	1,373	1,373	3,539	3,539	21.6	21.6
1950	2,453	2,325	1,483	1,404	3,936	3,729	21.9	21.3
1951	2,871	2,405	1,868	1,562	4,739	3,967	22.4	21.4
1952	3,434	2,731	2,057	1,703	5,491	4,434	22.9	22.1
1953	3,756	2,893	2,220	1,802	5,976	4,695	23.9	22.6
1954	3,737	2,876	1,984	1,586	5,721	4,462	23.0	22.1
1955	4,169	3,129	2,075	1,629	6,224	4,758	23.0	21.7
1956	5,273	3.775	2,761	2,041	8,034	5,816	26.3	24.4
1957	5,784	3,993	2,933	2,058	8,717	6,051	27.4	25.5
1958	5,830	3,956	2,534	1,734	8,364	5,690	25.7	23.8
1959	5,709	3,774	2,708	1,813	8,417	5,587	24.3	22.6
1960	5.487	3,541	2,713	1,786	8,200	5,327	—	—
1961	5,689	—	2,647	—	8.336	—	—	—

[1]Newfoundland not included in these years. (DBS Table)

Maritimes:

The largest new plant — the $50 million refinery of Irving Refining Limited started production in 1960, of a range of petroleum products (capacity 40,000 bbl./day). Significant addition to pulp capacity was made by Canadian International Paper, and Fraser Companies Limited, both in New Brunswick. At Wood's Harbour, N.S., seaweed chemicals were produced — alginates for use in foods. Linde Gas plans plants in Nova Scotia and New Brunswick, and Nova Scotia Pulp is constructing a $40 million plant at Point Tupper.

Quebec:

Twenty-three new chemical facilities were opened in 1960. Petrochemical production was increased (British American Oil, B.A. Shawinigan, Union Carbide) and petroleum facilities were expanded by 57,000 bbl./day (British Petroleum, Texaco, Shell). The first production in Canada of pentaerythritol tetranitrate (used in blasting explosives) was started by C.I.L. at Beloeil. New production of miscellaneous chemicals included lignin chemicals (Lignosol), maleic anhydride and polyvinyl chloride (Monsanto), and naphthalene (Record). Two new laboratories were opened (Ayerst, McKenna and Harrison, and Nichols Chemical Company). Planning is under way on a benzene plant (B.A. Oil), a new plant for titanium pigments (British Titan Products) and a plant for making columbium oxide concentrates (St. Lawrence Columbium and Metals Corpn.). C.I.L. is planning a threefold expansion of its central research laboratory ($3.5 million project).

Ontario:

Forty-four new chemical facilities began operation in Ontario, covering the whole spectrum of chemical endeavour. These included:

Atomic energy facilities: fuel test reactor, universal cell, and metallurgy "hot cave" A.E.C.L., Chalk River)

Petroleum expansion: Alkylate plant (B.A. Oil), Reformate (Regent)

Petrochemicals: Vinyl chloride (Dow), linear polyethylene (DuPont, Sarnia), ethyl chloride and ethylene dichloride (Ethyl Corpn., Sarnia), polyethylene masterbatch (Union Carbide)

Inorganic chemicals: Caustic potash (C.I.L., Cornwall), nitric acid (Cyanamid), chlorine dioxide (Marathon Corp. and Spruce Falls Paper Co.), aluminum chloride (St. Clair Chemical)

The largest chemical plant still under construction is that of Brockville Chemicals, at Maitland, to produce ammonia and hydrogen, starting with natural gas (anhydrous ammonia 200 tons/day, ammonium nitrate 150 tons/day, hydrogen 1,500,000 cu. ft/day).

Manitoba:

During the year, Border Chemical Company started to produce sulphuric acid at Winnipeg, and planning is well advanced on the Nuclear Research Centre (A.E.C.L.), and a particle board plant (Columbia Hardboard Co., Sprague).

Saskatchewan:

The major new facilities were the new refinery facilities of Consumer's Co-operative Refineries of Regina, the paint plant of International Paints (Canada) Ltd., Regina, and the commercial gas plant of Liquid Carbonic Canadian Corp., Regina.

Alberta:

Thirteen new plants commenced production, with the emphasis on petroleum products and petrochemicals. Petroleum products expansion was started by B.A. Oil Ltd., at Calgary (10,000 bbl./day of refined products) and at Rimbey (pipeline gas, propane, butane, natural gasoline, and sulphur). Canadian Oil added 7000 bbl./day capacity of natural gasoline and by-products, and Imperial Oil added to its asphalt production and opened its new alkylate plant at Edmonton. Inorganic facilities included carbon dioxide (Burns and Co., Calgary), cement (Inland Cement Co., Edmonton), and insulating wool (Fibreglas Canada, Edmonton).

Petrochemical expansion: Oxygen plant for Canadian Chemical Company, Edmonton

Sulphur plant: Canadian Fina, Windfall

Gas processing: Canadian Superiol Oil, Harmattan

Herbicides and Insecticides: Dominion Rubber Co., Edmonton

Amines, glycol, and pentachlorophenol: Dow Chemical, Fort Saskatchewan

Sulphur: Jefferson Lake Sulphur Co., Calgary, and Shell Oil Ltd., Pincher Creek

British Columbia:

The forest products industry was responsible for the largest addition to production, when the Celgar pulp mill opened, supplied with chlorine, caustic soda and caustic potash from the Cominco plant at Trail. Canadian Park and Tilford opened a new distillery at North Vancouver, and Phillips Petroleum Company completed a $5 million expansion of its refining facilities at Taylor.

Planning and construction underway testify to the great industrial activity in the province. These projects include:

Research laboratories: Columbia Cellulose Co., Prince Rupert

Iron and steel mill: Cominco, Kimberly

Phenol: Dow Chemical Co., Tilbury Island

Fluorspar: Rexspar Minerals and Chemicals Ltd.

Chemical Engineering Expansion at the Universities

Because the chemical industry in Canada is so aware of the necessity for continuous research and development, the enrolment in graduate schools continues to be heavy; the demand for chemical engineers at the baccalaureate level is high in the Spring of 1961.

Accordingly, chemical engineering teaching facilities are being expanded in several universities in Canada. A new chemical engineering department, headed by Dr. L. W. Shemilt has been announced at the University of New Brunswick, offering both undergraduate and graduate studies. New laboratory facilities are being added, too, at the University of Alberta, Essex College, University of British Columbia, and Laval.

Chemical Engineering Technical Meetings

Two chemical engineering conferences were held in Canada, both sponsored by the Chemical Institute of Canada. A total of 65 technical papers were presented, including about 15 invited papers. The first presentation was made of the R. S. Jane Award for outstanding accomplishment in the field of Chemical Engineering to E. R. Rowzee, President of Polymer Corporation. Joint meetings are scheduled with the A.I.Ch.E. in Cleveland, in May, 1961, and Boulder, Colorado, in August, 1961.

During the past year, the industry proceeded in a steady fashion with its expansion. The recognition of the importance of Canadian contributions to new technology is echoed in the opening of new research facilities right across the country; in this respect the chemical industry acknowledges the economic necessity of advanced technology to remain competitive.

This trend has resulted in the continued heavy enrolment in graduate schools, and in the stimulating activity in evidence at chemical engineering technical conferences.

The outlook for chemical industry in 1961, is that "the demand for chemicals will grow slightly faster than will total business activity, but chemical growth will be less than it was in 1960".

ELECTRICAL

This has been a year in which the "wraps" have been removed from a number of subject developments in varying degrees so that "now it can be told". As a result several papers in the forthcoming Annual Meeting will deal with subjects that have been under development for some time, but little has been published. In this category will be found papers on Electronic Aids in Canadian Mapping (Tellurometry); DRB Topside Sounder Satellite; Design Considerations for Large Radio Telescope; Telemetering Acoustic Data from a Floating Buoy to the Research Ship.

Then again, there are reports of recently accomplished achievements in the defence communications fields which is exemplified by the paper "Rearward Communications for BMEWS".

In the field of power transmission latest thinking on this subject will be covered by two papers: "The How's, Why's and Wherefore's of E.H.V. Transmission" and "Concepts and Economics of Extra Long Distance Direct Current Transmission and System Interconnection".

Two authors will give the results of their deliberations and research, one in the electronics field: "New Uses of Ceramic Materials in Microwave Tubes" and the other in the theory of Automation: "Treatment of Stockastic Variables in Engineering Design".

Few endeavours encompass as many phases of engineering as the aircraft industry and Trans Canada Airlines have always been in the forefront of developments in air transportation. In this important field there will be the paper "Electrical Installations on Modern Jet Aircraft".

To some extent the technical papers represent what has been going on or what has been accomplished in Canada in the past year. However there are perhaps three or more very important accomplishments which may be regarded as trends influencing the future of many Canadian developments. A number of large electrical companies are making important strides to develop their own products in Canada. Canadian General Electric developed and produced an Extra High Voltage Capacitor on a competitive basis in the world market for E.H.V. Transmission Line Components, and Northern Electric Company Limited did the research, design and production of a Parametric Amplifier in the one kilomegacycle Scatter field of Communications in competition with the world.

To meet competition of lower-wage-country producers the electrical industry knows it must put added emphasis on innovation. A good deal has been accomplished along these lines, but perhaps one of the major steps taken in this direction has been taken by Northern Electric Company Limited with the establishment of its Research and Development Laboratories in Ottawa. This major establishment could mean to Canada what Bell Telephone Laboratories has meant to the United States.

Electrical generation

HYDRO

The spiralling demand for power has led to the planning in recent years of hydro-electric schemes of a size which would have been ridiculed as impractical only a few years ago. Sites which are located within transmission distance of our more highly industrialized areas are being completely developed in a single stage of construction to capacities of millions of horsepower, and the ability of the larger power systems to absorb these blocks of power permits the realization of economies not available in other means of power production. This trend is typefied by hydro-electric activities during 1960.

In Quebec, construction commenced on the development of the Manicouagan and Outardes Rivers from which 6 million h.p. will ultimately be fed into the distribution system of the province. The main storage will be impounded behind a 700 ft. high multiple arch dam at the Manicouagan No. 5 site. Simultaneous development of the No. 2 site, farther down the river, will provide a source of power available at an earlier date than that from No. 5, but on which will utilize the benefits of the upper storage when it is brought into service.

Hydro-Quebec's Bersimis II plant was completed with an installed capacity of 900,000 hp. Beauharnois No. 3, with an installation of five 73,700 hp. units, also came on load. Work proceeded on the 720,000 hp. Carillon development on the Ottawa river. At the year's end, the first stage of construction was completed and a good start has been made on the second stage.

The Chute-des-Passes plant of the Aluminum Company of Canada, whose ultimate capacity will be one million hp. was completed with an initial installation of three 200,000 hp. units.

In British Columbia, studies of the Peace River development were concluded and a report was presented of schemes totalling 5 million hp. In January 1961, the Columbia River Treaty was signed culminating 16 years of study and negotiation.

Development of storage and power on the Columbia and its tributaries in Canada will yield some 4 million hp. of generation within the country and an estimated 1,750,000 hp. from the United States as downstream benefits.

High voltage transmission to enable larger blocks of power to be transmitted over greater distances continues to be the subject of very intensive study. The eventual success which will surely come from this study will make possible the economic development of huge schemes which are, at present, too far from large load centres for present day transmission capabilities.

Concurrently with the development of large hydro-electric plants, the demands of industry extending out into remote locations call for many smaller plants. Construction in Labrador, Northern Ontario and British Columbia continued at a high level.

Stations placed in operation during 1960 are listed below:

THERMAL

The bulk of the increase of thermal capacity in Canada during 1960 was in Ontario where new thermal capacity surpassed by a wide margin the amount of new hydro capacity installed. Nearly 300,000 kw. of new thermal capacity were brought into service in Ontario last year. Planned are facilities which will provide 1,136,000 kw. hydro and 2.6 million kw. thermal. Two more 200,000 kw. units were installed in Ontario's Richard L. Hearn thermal station at Toronto. When the final unit is installed this year the plant's total capacity of 1.2 million kw. will have been reached. The first 300,000 kw. unit at the Lakeview thermal station, which ultimately will have a capacity of 1.8 million kw., will be installed this year. A new thermal station near Fort William will have its first 100,000 kw. unit in service in 1961. An ultimate capacity of 1 million kw. is planned for this site.

The Manitoba Hydro-Electric Board has almost completed its Selkirk Steam Plant with one 66,000 kw. unit now in operation and the second about to go on power.

The Saskatchewan Power Corporation last year added a second 66,000 kw. steam unit to its boundary dam plant to double that unit's capacity.

Last year in Alberta new thermal capacity installed totalled 88,000 kw. Calgary Power Ltd. began installation of a 150,000 kw. steam turbine at its Wabamun plant. This plant now has two 66,000 kw. units operating. The capacity of the City of Edmonton Municipal plant was increased to 355,000 kw. with the addition of a new 75,000 kw. steam turbine.

Among major thermal projects in the Maritimes is a new steam plant at East Saint John, N.B. This plant will have an initial capacity of 50,000 kw. and an ultimate capacity of 250,000 kw. A 20,000 kw. unit was added to Nova Scotia Power Commission's Trenton steam plant to raise its capacity to 25,655 kw.

NUCLEAR

The major advance in the nuclear field last year was the beginning of work at the site of the 200,000 kw. Douglas Point Nuclear Power Station situated on the shores of Lake Huron between Kincardine and Port Elgin, Ont. The Ontario Hydro-Electric Power Commission, which is co-operating with Atomic Energy of Canada Ltd. in construction of the plant will operate Douglas Point when it goes on power in 1964.

Costs of the Douglas Point project is estimated at more than $80 million. Cost of power from the station is expected to be from 6 to 7 mills per kwh., compared with a cost of from 5 to 6 mills per kwh for power produced by coal-fired stations in Ontario.

Other projects included a 20,000 kw Nuclear Power Demonstration (NPD) station at Rolphton, Ont. where work now is nearly complete.

The relatively small size of the NPD station will not allow it to produce electricity at a competitive cost but it will serve as a prototype for full-scale power plants. Ontario Hydro also will operate this unit.

In Manitoba preliminary preparation of the site for the Whiteshell Nuclear Research Establishment began late in 1960. Canada's second research centre is expected to grow eventually to the size and importance of the research centre at Chalk River.

LISTS OF PLANTS UNDER CONSTRUCTION DURING 1960

		hp.
British Columbia	Kemano	150,000
Alberta	Brazeau	200,000
Saskatchewan	Squaw Rapids	276,000
	South Saskatchewan River Dam	255,000
Manitoba	Grand Rapids	450,000
Ontario	Otter Rapids	180,000
Quebec	Carillon	720,000
	Manicouagan No. 5	1,600,000 (ultimate)
Labrador	Twin Falls	120,000 (1st stage)
Nova Scotia	Sissiboo	8,000
	Weymouth	12,000

CAPACITY PLACED IN OPERATION DURING 1960

		hp.
British Columbia	Bridge River No. 2	164, 000
	Cranberry Creek	5,800
	Little River	6,000
Alberta	Rundle No. 2	40,000
	Spray	62,000
Saskatchewan	Wellington Lake	3,300
Manitoba	Kelsey	210,000
Ontario	Red Rock Falls	26,500
Quebec	Beauharnois No. 3	368,500
	Bersimis II	360,000
	Chute-des-Passes	400,000
	Harte Jaune	66,000
Labrador	Menihek	13,500
Newfoundland	Heart's Content	3,200
North West Territories	Snow Falls	9,700

Construction

Put-in-place construction in Canada last year totalled about $7 billion. This was not regarded as an exceptional year and most authorities feel the 1961 total will be about the same.

Jack Soules, President of the Canadian Construction Association predicted a 1961 construction volume of $7 billion, roughly 20% of the Gross National Product.

Among the soft spots in construction last year was housing which showed a disturbing decline in 1960. Heavy engineering construction show-

	New Residential Construction in Canada[2]		Value of Building Permits			
	Municipalities of 5,000 and over					
	Starts	Completions	Industrial	Institutional and Government	Residential	Commercial
	Thousands		Million dollars			
1958[1]	121.7	107.8	15.0	35.5	115.0	30.6
1959[1]	106.0	108.1	16.1	34.9	104.6	42.4
1958 J	112.6[r]	96.5	11.9	37.9	106.4	30.7
J	109.5[r]	92.1	16.6	38.4	111.2	33.7
A	116.4[r]	117.5[r]	22.3	33.5	118.3	28.3
S	117.5[r]	143.3[r]	12.9	37.3	121.4	31.6
O	129.1[r]	116.1[r]	14.2	39.1	117.9	31.8
N	131.2	117.8[r]	15.8	37.9	121.0	31.5
D	137.8[r]	106.2[r]	12.4	43.1	123.6	34.8
1959 J	134.1[r]	92.8[r]	13.1	44.3	113.6	35.2
F	117.0[r]	84.2[r]	15.4	43.4	110.6	28.7
M	111.7[r]	106.5[r]	21.2	30.4	96.6	37.2
A	98.5[r]	94.5[r]	27.6	34.6	110.4	39.4
M	97.6[r]	130.1[r]	14.0	27.1	100.7	38.8
J	98.3[r]	120.8[r]	18.8	33.8	108.2	38.4
J	98.7[r]	113.2[r]	11.5	33.2	103.0	44.8
A	98.5[r]	111.2[r]	7.7	36.0	102.3	65.7
S	96.0[r]	110.3[r]	24.2	29.8	116.5	42.5
O	108.6[r]	102.8[r]	18.6	56.1	110.2	54.8
N	125.6[r]	115.3[r]	10.6	44.7	90.2	32.5
D	112.6[r]	103.2[r]	26.9	20.3	88.0	33.2
1960 J	107.9[r]	98.9[r]	9.2	23.9	55.2	44.4
F	64.6[r]	116.7[r]	15.4	34.0	74.0	26.8
M	59.9[r]	89.2[r]	17.3	37.9	62.6	49.1
A	60.0[r]	97.9[r]	13.9	28.0	63.4	44.2
M	60.6[r]	100.2[r]	14.5	53.0	75.6	37.9
J	76.0[r]	87.3[r]	30.1	35.8	80.9	37.6
J	81.7[r]	84.7[r]	7.9	27.4	76.7	27.6
A	64.1[r]	88.2[r]	11.0	48.5	78.6	25.3
S	76.2	99.7[r]	26.6	43.9	92.5	27.2
O	87.4[r]	69.4[r]	18.5	50.2	83.3	50.3
N	90.6[r]	86.7[r]	7.8	58.9[r]	100.5[r]	45.2[r]
D	107.8[r]	74.1[r]	29.1	21.9	113.8	25.6
1961 J	109.2	79.3	—	—	—	—

(DBS Table)

ed strength in 1960 with awards being up more than 13%. Expenditure increases are forecast for road construction and gas and oil facilities. Water and sewage projects are expected to show considerable strength. A softening is anticipated in dams, power and communications, and marine facilities.

It is expected that industrial facilities will continue to show strength as they have since the 1958 recession. An indication of this continued strength is a 10% increase in awards. Institutional and commercial building during 1960 is expected to show a gain in the neighbourhood of 15%.

The Maritimes, Ontario and Western Canada are expected to show minor increases in construction last year while Quebec may be down slightly. A similar picture is expected to be shown in 1961.

Mineral Resources

GENERAL

The dollar value of Canada's mineral production in 1960 was the highest ever reported. Value of the output during the year increased 2.8% to nearly $2.5 billion. Physical volume of production was second only to 1959.

Substantial increases were shown by nickel ($55 million), copper ($31 million), zinc ($11 million), asbestos ($11 million), crude petroleum ($10 million), natural gas ($9 million) and gold ($6 million).

These increases offset serious declines in other minerals. The most serious decline was shown in uranium which was down $68 million. Iron ore declined $29 million and construction materials including cement, stone, brick and similar products were $10 million below the previous year's figures.

IRON ORE

While the unit value of iron ore shipped from most provinces increased during 1960 the general picture in the industry was one of decline. Producers shipped 19,203,378 long tons of iron ore last year, a drop of 12% from the record 1959 shipments.

Much of the softness resulted from conditions in the United States — Canada's principal iron ore market. On the basis of early predictions Canadian iron ore exports were brisk during the first half of the year, but a decline in United States steel production accounted for a sharp setback in iron ore receipts.

Conditions were more favourable in Canada's other major iron ore export markets – the United Kingdom, Western Europe and Japan. Exports to these markets remained at a high level through the shipping season and showed a total increase for the year.

Canada is experiencing increasingly stiff competition from other iron ore producing countries, particularly in South America and in Africa. This is causing extensive research on direct-shipping ores and the development of property for the production of high grade concentrates and agglomerates.

Newfoundland and Quebec continued to lead the provinces in iron ore production during 1960. Occupying lesser positions were Ontario and British Columbia.

NICKEL

An increase of more than 15% in nickel production during 1960 was responsible for a high annual record exceeding 250,000 tons. Increase in consumption of nickel in Europe was the major contributing factor to the record year. For the first time in many years North American consumption of nickel slipped below that of the rest of the free world.

Consumers of steel products in North America liquidated large inventories and retarded the production of stainless steel and nickel alloy steels during the second half of the year. This limited the consumption of nickel.

Distribution of nickel in the free world in 1960 showed Europe taking 43.5%, 0.5% more than the United States. Canada consumed 2.5% and others, 11%.

Producers of stainless steel showed the greatest increase in consumption in nickel in 1960. Another substantial increase was registered for the application of nickel in electro-plating, mainly as a result of the use by the automotive industry of improved techniques. These techniques permitted higher quality nickel plating.

Production capacities in the free

	Industrial Production	Mining										Fuels
		Mining	Metals				Non-metals		Fuels			
Base period industry weight	Total	Total	Total	Gold	Copper	Nickel	Total	Asbestos	Total	Coal	Natural Gas	Petroleum
	100.00	10.07	5.97	1.93	1.10	1.05	0.83	0.59	2.84	1.72	0.11	1.02
1957	155.4	227.8	170.0	106.7	137.1	146.8	179.0	184.3	358.2	65.4	295.1	859.5
1958	153.0†	226.8†	180.3†	109.7	131.8	110.2	163.3	168.7	330.7	56.7	433.7	782.6
1959	165.4	251.6	201.3	108.4	151.6	144.8	194.1	196.9	364.3	51.9	538.0	873.3
					Unadjusted for seasonal variation							
1958 J	150.5	234.4	189.9	106.2	139.2	117.6	137.5	136.1	330.1	43.9	297.4	817.0
A	151.7	230.6	190.8	106.2	138.0	119.8	173.0	176.1	301.5	24.5	307.1	768.7
S	157.1	240.7	199.8	108.9	127.3	111.5	196.3	206.6	316.4	52.6	379.3	755.3
O	157.1	228.8	172.8	112.4	110.9	33.7	216.2	225.5	324.9	67.9	418.2	749.0
N	160.9	225.0	164.1	111.0	94.1	30.0	211.0	225.8	341.9	69.9	558.2	778.0
D	150.7	219.0	156.1	105.9	85.1	30.2	145.5	144.9	379.1	70.8	670.4	868.5
1959 J	152.2	231.0	165.4	105.7	100.3	73.6	150.7	153.7	405.0	67.9	713.2	941.3
F	161.1	245.2	185.2	112.8	138.2	127.4	171.3	179.8	403.2	52.6	648.0	969.2
M	160.4	236.8	187.0	109.7	144.9	136.5	184.5	191.6	362.7	40.7	581.9	883.0
A	162.9	234.2	193.9	109.6	148.4	146.6	189.1	190.4	327.0	54.0	492.4	770.2
M	166.3	235.7	195.8	110.2	145.8	152.1	188.4	186.2	312.2	34.7	450.3	766.1
J	172.9	256.0	205.6	104.5	170.8	157.0	222.9	218.3	346.0	38.4	406.1	859.0
J	162.2	261.1	217.6	106.4	161.2	148.2	193.3	189.7	345.5	46.9	364.5	847.8
A	163.2	257.1	210.7	101.2	156.6	153.6	194.1	190.9	348.4	28.3	399.4	883.5
S	172.7	279.0	225.0	105.7	165.1	153.2	221.0	207.6	391.2	58.2	454.2	946.9
O	176.4	271.1	223.5	111.4	160.8	157.5	223.5	231.8	362.9	67.8	545.3	841.7
N	171.5	261.1	211.6	117.4	163.0	159.8	235.2	250.0	363.0	69.5	688.8	823.8
D	162.5	251.4	194.1	105.9	153.9	171.4	165.7	172.7	404.5	63.6	711.6	951.9
1960 J	166.0	254.7	189.7	109.8	163.2	159.6	169.1	178.6	432.7	63.5	745.8	1,022.6
F	169.4	259.1	208.0	112.8	171.4	161.0	178.1	189.7	404.8	62.1	740.0	947.7
M	170.5	256.1	197.3	109.4	171.9	163.2	195.0	213.9	409.9	59.1	740.2	970.5
A	164.4	234.6	187.1	106.7	158.7	166.1	193.8	208.8	350.3	41.3	596.9	846.8
M	169.7	250.1	189.0	110.4	165.4	157.9	208.3	217.5	379.2	42.1	541.8	931.1
J	173.6	258.7	202.4	112.8	171.3	174.2	201.8	210.7	371.5	42.5	504.9	912.8
J	161.7	263.9	211.3	114.8	172.3	163.6	173.1	174.0	380.4	45.9	467.4	936.0
A	162.5	255.0	208.0	106.9	170.4	175.7	191.2	196.5	347.3	33.6	475.9	863.4
S	169.8	265.7	207.4	107.4	160.0	172.4	219.0	233.3	378.1	62.6	526.4	895.0
O	172.1r	254.6r	202.2	117.5	162.2	165.3	217.0	222.8	352.6r	64.7	612.9r	811.0r
N	171.6	253.4r	188.7	114.6	176.2	167.6	237.6	249.9r	380.1r	70.4	744.3r	864.1
D	160.1	241.9	181.7	110.6	169.2	176.4	189.0	199.0	392.5	51.8	875.9	915.9
					Adjusted for seasonal variation							
M.C.D.(1)	1	2	2	5	4	4	5	5	3	6	3	3
1958 J	152.0	221.2	175.7	109.9	145.0	119.5	154.4	161.4	325.1	60.2	474.3	756.5
A	150.9	219.4	178.9	111.3	140.7	119.8	164.9	173.0	308.3	33.9	491.4	752.2
S	151.6	228.0	184.0	103.6	122.5	113.3	176.8	188.0	323.9	52.2	510.5	762.9
O	152.4	217.8	162.0	109.0	101.7	34.9	203.1	210.7	324.2	56.0	444.9	764.3
N	155.5	220.9	166.9	108.5	87.5	30.7	196.2	208.9	330.7	56.7	474.7	778.0
D	157.0	227.4	163.0	107.0	82.1	31.4	157.5	153.3	376.7	60.7	515.7	895.4
1959 J	159.6	237.1	179.0	110.3	111.4	70.4	176.4	172.5	367.8	59.0	497.0	875.6
F	162.0	245.3	196.1	110.4	138.5	118.5	182.4	181.4	353.6	45.9	457.0	862.3
M	161.8	246.0	197.2	106.5	140.4	132.5	193.6	191.6	353.3	44.2	482.9	861.5
A	166.2	250.5	208.4	108.3	152.2	146.6	184.7	181.5	345.2	58.6	501.4	812.4
M	165.4	247.6	203.8	113.1	151.1	151.6	183.1	184.0	349.9	39.4	565.0	851.2
J	166.1	249.9	189.9	100.7	164.2	158.3	234.3	243.4	370.9	47.9	591.1	892.9
J	164.8	250.8	206.1	110.6	167.9	149.8	219.4	225.6	341.7	64.1	580.4	785.0
A	164.2	245.8	196.7	105.3	163.3	150.3	188.6	193.2	357.3	37.9	627.0	867.9
S	168.3	264.1	204.2	103.7	157.1	154.6	190.1	188.4	402.4	59.3	595.3	961.3
O	171.9	261.3	209.2	107.7	164.9	162.4	210.0	216.6	374.8	54.0	580.1	894.5
N	166.7	260.7	220.6	114.9	155.2	163.9	219.5	231.5	351.2	56.6	584.7	823.8
D	169.5	260.9	204.1	106.9	148.3	178.7	178.2	182.2	392.9	52.6	529.1	951.9
1960 J	173.5	257.5	203.1	113.7	164.8	154.8	196.5	202.5	384.2	54.3	524.5	926.3
F	170.1	257.6	219.1	99.2	171.9	150.9	188.0	193.2	351.3	54.1	528.6	834.2
M	171.9	264.0	209.1	105.8	168.0	163.7	203.2	216.1	395.9	65.7	614.3	934.1
A	166.6	251.0	197.1	104.7	157.6	164.9	187.5	200.0	381.3	43.3	610.3	928.5
M	167.8	260.3	196.9	109.2	171.0	157.4	202.7	214.9	409.3	47.6	685.8	990.5
J	167.6	255.1	188.6	112.4	163.8	173.9	216.1	235.7	399.8	57.4	710.1	944.9
J	164.2	253.2	199.1	114.2	175.8	168.5	197.4	207.1	376.9	58.8	720.2	877.2
A	165.6	251.8	194.9	108.4	174.9	176.6	190.9	202.0	381.6	68.6	743.6	871.2
S	167.5	256.8	193.9	112.2	152.4	175.7	197.0	211.1	395.7	60.8	658.0	933.3
O	167.3r	248.6r	193.3	116.3	164.7	167.6	204.0	208.2	366.8r	51.8	652.0r	868.3r
N	166.7r	253.7r	191.2	110.4	169.9	172.1	223.0	231.6r	384.2r	57.4	631.3r	809.6r
D	166.0	249.2	195.7	111.5	172.7	184.1	202.6	209.5	365.6	42.0	658.6	880.7

Volume Indexes, 1949 = 100

Note: For detailed description of concepts, sources and methods see **D.B.S. Reference Paper (61-502) "Revised Index of Industrial Production, 1935-57."**

(1) The M.C.D. (months for cyclical dominance) measure indicates the number of months required, on average, for the emergence of the cyclical trend from the seasonally adjusted series. An M.C.D. of 4 implies that a four month moving average of the series (dated at the second month) is required in order to offset irregular movements and allow examination of the underlying cyclical trend. The series in this table are not adjusted for M.C.D. (DBS Table)

world continued to increase in 1960 and it is estimated that by the end of this year its annual productive capacity will be approximately 300,000 tons. A highlight in the Canadian nickel industry is International Nickel's new project at Thompson, Man. This project, rapidly nearing completion, will contribute substantially to the anticipated increase in the nickel production capacity of the free world.

The Thompson project, which will be the world's first fully integrated nickel producing operation, will have an annual production of approximately 75 million lbs.

It is anticipated that the free world's consumption of nickel will again be at a very high level this year despite the slowness in industrial pick-up in the United States.

ALUMINUM

Canada's aluminum industry in 1961 continued to be affected by the keen competition for international markets which first manifested itself strongly in 1957.

This competition, concurrent with a recession and the world's primary aluminum industry reaching a position of over-supply, continued to pose complex problems for Canada's aluminum industry.

Final figures for 1960 are expected to show sales and revenue at a high level but the main problem facing the industry is to continue to work toward expanding the market for aluminum throughout the world. Expanded markets would allow idle capacity to be re-activated with the attendant increase in employment opportunities.

During 1960 the Aluminum Company of Canada, Ltd., installed equipment in its Quebec and British Columbia smelters to produce metal in new forms. These include sheet ingot and extrusion billet which, while it does not increase the basic productive capacity, improves the company's competitive position.

Considerable attention is being given to the use of aluminum in new products, in building and construction, in automobiles, canning, railroad cars, packaging and in ship building.

ASBESTOS

The productive capacity of the asbestos industry was not fully employed during 1960, although most producers were operating at a high level at the end of the year. Prospects indicate a comparable level of production this year.

A major factor in the pace of asbestos production last year was the general feeling of business uncertainty in the United States. By compensation, export shipments improved to almost all overseas markets. Canadian producers improved their position in Western Europe—our second greatest market—despite keen competition from Russian asbestos. Exports to Japan were maintained at a record level and sales to other countries in Asia showed a gain over the previous year. There was no significant change in sales to South America.

Preliminary figures indicate that more than 60% of Canadian asbestos exports were in the asbestos-cement fibre range. Expansion of existing cement plants abroad and construction of new units continues and general market prospects appear favourable for some time to come. Short fibres continue to move moderately well and the prospects of using asbestos fibre in asphalt paving should provide a stimulus to this market.

Improved domestic demand for Canadian asbestos appears to be limited by the requirements of a market already amply provided for by existing plants. However, any change in the present domestic situation would result in the construction of expanded production facilities.

Exploration both in Canada and elsewhere continued on a modest scale, but apart from a prospect in far Northern Quebec, no discoveries of importance were reported. Asbestos property in the Baie Verte area of Newfoundland is to be developed and production is expected to start in 1963.

COAL

The year 1960 was a bleak one for coal. Among the factors contributing to a generally troubled industry were the ever-stiffening competition from other types of fuel and high production costs.

Coal production — nearly half from Nova Scotia mines — increased nearly 6% in 1960 from 1959. But 1959 was also a troubled year and production in 1960 was close to the lowest in the last 50 years. All coal-producing provinces except Alberta showed production gains in 1960.

Last year, natural gas from Western Canada began to hit the coal markets in central Canada with heavy impact. Residual oil at reduced prices was imported and became locked in a price struggle in the Montreal region with natural gas. Coal, of course, suffered as many of its long-established markets vanished. Canada's own oil refining capacity was increased both in the Maritimes and in the Montreal area, thus adding additional potential output of home-produced residual oil from imported crude.

Adverse geography, which imposes great distances between coal producing areas and potential markets, continued to trouble the industry.

On the other hand, 1960 was a year that saw stabilization in employment in the coal mining industry. This stabilization came after 10 years of steady decline during which nearly 1200 employees a year found themselves without jobs.

Contributing to this stabilization was the development of an export market in Japan for Canadian coal. Development of this market, however, may prove expensive in terms of assistance from public funds and the stabilization of employment may prove only temporary.

OIL

Output of crude oil in Canada during 1960 totaled more than 19 million barrels valued at $440 million. This represented an increase of about 3% from 1959. While this increase was not high a modifying effect was found in record production of butane and natural gasolines extracted from natural gas and sent to refineries.

This was the eighth consecutive year that crude oil led all minerals in value.

Bulk of the production came from Alberta (70%), and Saskatchewan (27%). While Albert's production was up only 2%, Saskatchewan increased its output by 10%, reflecting increased interest in medium gravity crudes. Saskatchewan's closer proximity to the big Eastern markets also enhanced its position.

Production of natural gas increased by more than 22% with daily production estimated at 1,380 million cu. ft. Of this Alberta supplied 76%, British Columbia 17% and Saskatchewan the remainder. Estimated value of total natural gas production was $45 million.

Domestic demand for refined petroleum products increased only slightly over the 1959 consumption 770,000 barrels a day. This was tempered by a decline in product imports of 26% to 79,000 barrels a day. At refineries, consumption of crude oil increased 5% indicating a greater reliance on Canada's refining industry to supply gasoline and fuel oils.

In the international market Canada enjoyed a fairly good year. Although imports of crude oil increased 4 million barrels to 120 million barrels in 1960, exports of crude oil increased by 20% to 42 million barrels. Completion of new refineries at Montreal and at Saint John, N.B., was responsible for most of the increase in imports.

Pipe-line activity was slow in 1960 but preparation work is well advanced toward a $300 million gas pipe-line program scheduled to start this year. Earnings reported during 1960 generally were higher than those of the previous year. These earnings reflected not only higher volumes handled but also the effect of measures taken to reduce costs and improve efficiency.

Less money was spent last year on land acquisition and survey work, while drilling footage increased both for exploration and development purposes. Exploration and development expenditures were estimated at $475 million, about 5% less than the previous year.

A favourable trend for 1961 is indicated by activity late in 1960. Increased demands for Canadian crude oil are anticipated in both the domestic and the export markets.

AUTOMOTIVE

The automotive industry in Canada enjoyed a relatively high level of business in 1960 and anticipates another favourable year in 1961. Last year, Canadians purchased more than half a million cars and trucks. Domestic production increased to an estimated 390,000 units compared to 368,000 the previous year.

Total exports were approximately 22,000 units, an increase of about 3,000 from 1959. Sale of small European cars also showed a gain, but the increase was smaller than it had been during the two previous years.

Each year a greater percentage of Canadians acquire automobiles and car owners are driving greater distances each year. These factors indicate a steady expansion of the market for cars in Canada.

Price increases on imported models could also contribute to an up-swing in Canadian production. The end of

VOLUME INDEXES 1949 = 100

	Durable Manufacturing										Durable Manufacturing					
	Iron Steel Products			Transportation Equipment				Non-ferrous Metal Products			Wood Products			Iron and Steel Products		
Base period industry weight	Primary iron and Steel	Sheet metal products	Total	Aircraft and parts	Motor vehicles	Motor vehicle parts	Railway rolling stock	Total	Brass & copper products	Smelting and refining	Total	Saw & Planing mills	Furniture	Total	Machinery	Iron Castings
	2.62	1.11	8.23	0.63	3.21	1.43	1.93	4.97	0.75	3.19	6.54	4.48	1.43	12.49	2.64	1.20
1957	149.0	126.2	151.2	350.4	162.0	121.5	92.3	127.6	105.6	141.8	127.3	128.4	141.0	139.6	146.3	129.4
1958	121.8	127.3	130.8	331.2	138.6	109.5	71.9	125.8†	105.3	138.9	131.1	134.2	143.4	126.4†	118.8†	141.4†
1959	167.7	149.8	128.7	249.4	148.8	128.0	62.4	134.9	113.2	145.7	134.7	136.9	150.1	147.7	136.0	157.5
	Unadjusted for seasonal variation															
1958 J	126.1	136.4	123.3	333.1	119.1	101.6	73.7	126.6	108.0	139.8	137.8	143.3	142.4	124.1	115.9	130.4
A	98.2	140.0	89.1	331.8	46.7	90.6	67.6	123.4	108.2	134.2	144.4	151.6	147.9	122.6	115.8	125.4
S	95.5	142.4	93.4	329.8	57.1	105.3	63.1	126.5	110.7	136.6	143.3	148.6	152.7	125.9	117.0	127.6
O	95.2	140.0	107.4	324.4	91.3	111.2	63.1	110.3	112.4	109.5	139.4	142.2	155.8	123.7	119.3	133.3
N	124.3	132.6	139.0	318.8	171.5	115.5	61.2	109.6	112.9	107.5	128.2	126.3	155.6	129.6	121.0	135.8
D	123.5	126.4	140.1	317.6	172.4	123.9	58.5	110.7	112.4	110.1	118.2	113.4	151.2	120.8	121.9	113.3
1959 J	144.4	126.4	138.0	320.2	164.6	127.1	58.8	121.3	111.9	128.2	127.4	128.5	146.6	128.0	122.5	130.0
F	147.3	130.5	148.2	259.6	198.6	129.9	60.2	124.9	112.5	133.3	139.7	146.9	145.2	134.1	124.1	143.7
M	150.7	135.4	146.2	234.6	194.1	133.1	60.9	133.2	113.1	146.0	138.6	145.5	144.3	138.4	125.7	152.9
A	168.0	142.5	154.9	241.9	209.9	137.6	62.2	136.5	113.4	150.3	128.0	129.3	144.8	145.0	129.2	159.5
M	161.5	148.3	153.0	243.0	202.0	140.6	64.1	135.4	114.0	147.8	143.8	150.6	148.2	148.5	135.1	161.7
J	171.1	156.6	157.2	245.5	212.4	142.3	64.9	137.6	113.9	149.4	162.3	176.9	148.6	155.8	140.6	164.9
J	160.8	162.9	132.9	244.3	159.3	124.8	65.0	132.5	112.9	141.6	128.3	127.2	148.8	147.6	142.3	150.5
A	159.7	165.6	79.7	241.6	32.2	110.1	63.3	131.2	114.1	138.6	124.6	120.4	153.9	149.6	140.7	146.2
S	179.6	167.4	94.5	239.7	66.0	122.8	62.6	140.5	117.0	150.6	133.9	132.7	158.8	158.0	141.4	163.1
O	194.7	161.7	121.6	241.2	130.6	132.2	64.0	142.3	115.4	152.7	140.2	141.7	159.4	164.1	144.4	193.1
N	193.2	152.3	101.4	242.3	87.9	113.7	63.2	141.8	111.4	153.7	125.1	121.1	155.5	158.4	144.6	171.9
D	180.8	141.2	117.0	238.4	128.0	121.3	59.7	141.9	109.2	156.1	123.9	122.5	147.2	145.2	141.3	152.2
1960 J	180.4	133.6	149.5	238.6	204.9	135.1	57.6	137.3	109.2	150.8	129.8	134.4	138.1	145.9	139.1	178.2
F	183.7	130.9	144.0	233.9	187.4	139.8	56.1	144.8	110.7	162.4	138.2	147.4	135.9	144.0	136.9	148.3
M	186.5	132.6	152.7	232.6	207.8	136.8	56.4	147.0	111.6	165.4	138.0	147.4	134.7	145.4	137.6	156.0
A	168.8	136.8	154.5	236.1	209.3	136.0	58.3	145.5	111.4	163.1	122.4	124.4	134.4	141.2	139.6	140.8
M	164.9	143.6	156.3	236.5	214.7	135.9	59.4	143.5	110.2	150.5	135.7	143.6	134.0	142.9	140.1	142.1
J	161.5	150.9	148.2	234.6	198.1	130.2	60.4	148.0	109.5	166.4	150.8	164.6	135.4	144.2	140.2	136.4
J	140.2	152.9	112.7	226.6	119.8	109.7	60.0	144.7	110.7	161.1	138.6	145.5	138.0	129.2	140.5	97.4
A	143.8	153.8	71.2	225.7	22.7	97.9	57.3	147.9	111.6	165.1	143.2	150.7	143.6	133.1	138.0	103.5
S	161.0	155.8	97.1	236.7	84.0	110.3	55.6	149.1	109.9	166.8	138.5	142.6	148.0	138.0	135.6	142.5
O	166.4	151.3r	118.0	245.6r	133.2	118.2	55.2	149.0r	108.6	165.7	130.0	130.8	148.1	140.4	135.9	139.3
N	159.4	144.7r	130.4r	253.5r	164.7	117.4r	54.0r	148.7r	108.2r	165.5r	116.5r	113.1r	144.9r	138.3r	135.3r	168.0
D	128.5	138.2	128.7	257.9	160.8	118.7	51.0	145.6	106.6	162.8	114.0	112.1	138.5	125.2	133.7	151.8
	Adjusted for seasonal variation															
M.C.D.(1)	3	1	4	1	5	1	1	3	1	3	2	3	1	2	1	3
1958 J	126.1	129.9	123.4	335.1	119.1	102.9	72.8	125.1	107.7	136.9	130.5	131.5	148.0	126.1	116.8	138.4
A	101.8	132.0	114.7	336.2	106.1	99.9	68.8	121.0	107.3	130.9	132.0	133.9	147.8	124.3	116.9	141.9
S	100.0	133.6	118.6	338.6	114.2	114.5	64.2	123.5	107.5	134.4	133.1	136.2	145.7	121.7	114.4	125.7
O	91.9	133.0	128.6	327.3	143.6	112.4	63.4	106.6	111.1	106.2	139.0	144.8	146.3	119.1	116.4	127.6
N	116.2	130.5	128.6	319.4	144.4	114.4	61.8	107.6	112.2	105.9	140.3	146.6	146.9	125.7	119.6	129.8
D	141.6	132.4	146.9	317.0	190.9	121.0	58.4	109.9	111.2	109.9	137.8	143.3	146.1	131.7	120.8	133.9
1959 J	150.7	134.8	135.1	319.2	156.8	126.0	58.7	122.6	113.5	129.1	139.2	144.3	148.5	137.3	123.4	145.6
F	149.2	140.3	136.6	260.7	166.9	131.2	60.4	125.2	116.1	132.2	141.4	146.8	150.6	137.3	127.4	138.8
M	149.5	143.6	132.1	236.0	157.8	133.2	61.0	136.8	117.0	149.3	135.3	138.3	149.4	138.8	128.0	146.5
A	163.1	147.8	131.8	240.0	155.5	132.6	61.8	140.4	117.1	154.0	143.4	149.3	151.6	144.0	130.4	154.1
M	155.3	148.9	131.7	242.0	155.4	128.8	63.3	136.7	115.5	147.8	141.3	145.2	153.9	143.1	135.1	137.9
J	159.6	151.9	136.5	246.7	165.9	133.1	63.2	137.6	113.4	148.5	144.1	149.2	153.7	147.5	139.5	144.0
J	164.8	153.4	137.1	244.8	169.5	129.2	63.0	131.3	112.1	139.5	120.8	116.0	152.1	151.0	142.2	159.6
A	168.1	154.4	124.6	243.3	140.0	123.3	64.3	129.0	112.7	137.7	113.4	105.5	151.3	151.9	139.6	166.7
S	180.9	157.0	131.3	240.7	153.5	132.8	64.5	137.0	113.2	147.9	124.2	121.5	150.8	153.1	139.6	161.5
O	186.9	153.6	146.2	241.0	192.1	132.6	64.8	137.6	111.5	149.0	139.2	143.8	149.4	158.2	142.8	186.9
N	184.0	149.9	96.3	243.0	74.5	112.1	63.8	138.6	110.8	151.4	136.2	140.0	147.0	154.3	143.0	165.6
D	208.1	149.6	112.4	238.4	117.4	118.0	59.6	141.0	108.1	156.1	146.7	157.1	142.4	159.6	140.0	181.0
1960 J	183.5	144.6	146.1	238.6	195.1	131.7	59.0	139.0	110.9	152.2	142.5	151.0	141.4	154.5	139.5	199.3
F	183.9	140.9	131.7	234.8	156.2	137.1	56.4	145.4	113.4	161.9	137.6	143.9	141.3	146.6	139.0	141.9
M	183.4	140.8	135.8	231.0	167.6	132.6	55.9	150.5	114.2	168.6	136.4	142.2	141.2	145.8	139.8	149.3
A	162.3	141.5	131.3	233.5	157.4	128.2	57.0	146.2	113.4	162.6	136.6	143.0	140.1	140.3	140.9	135.4
M	160.9	143.9	132.7	234.6	163.9	124.5	57.2	144.4	111.0	150.2	131.2	136.6	136.7	139.0	139.8	123.2
J	148.6	145.8	128.1	235.5	154.8	119.6	57.7	148.0	108.8	165.6	132.9	138.6	138.0	135.8	138.4	120.7
J	143.5	142.9	118.6	225.2	135.1	114.3	57.6	144.3	110.4	160.3	131.2	135.0	140.0	131.1	139.8	103.7
A	151.8	142.3	120.9	225.5	143.7	112.5	57.5	146.1	110.8	162.7	130.0	133.0	140.6	134.9	138.8	119.1
S	162.1	143.5	136.9	236.7	181.0	119.4	57.4	145.9	107.3	164.2	128.6	131.0	141.1	134.4	136.0	146.9
O	158.5	143.0r	140.1	244.1r	187.6	120.5	56.6	144.2r	105.2	161.3	129.7r	133.5	139.3	133.1	135.0	135.6
N	153.2	142.4r	121.7r	254.5r	142.0	115.6r	54.4r	145.7r	107.8r	163.1r	127.9r	132.1r	137.1r	135.1r	134.0r	162.5
D	148.2	147.3	121.6	258.2	143.6	115.2	50.9	144.8	105.6	163.0	134.6	143.3	134.1	135.3	132.5	108.7

the steel strike in the United States in late 1959 resulted in high production of automobiles early in 1960. It is not thought likely that employment in the Canadian automobile industry will reach that peak in 1961.

FARM MACHINERY

A trend towards larger farms in North America continued in 1960. This results in a demand for larger machinery, an increase in dieselization and emphasis on more business-like farm management. These trends reflect the farmer's desire to minimize labour costs and increase production.

A good crop year in 1961 would result in greater demand for more efficient farm machinery. A good crop year in 1960 gave farmers a higher cash income allowing them to invest in equipment.

A modest increase in domestic sales of farm equipment is forecast this year. Increased export sales to Germany and Australia largely offset reductions in several other countries.

SHIPBUILDING

While the Canadian ship building industry fared reasonably well in 1960 it faces a problem of reduced orders for work in the next few years.

During 1960 specialized service ships completed for the Government's fleet included a search and rescue vessel "Simon Fraser", a cargo-passenger ship "Hopedale", an icebreaker "John A. Macdonald", a sounding vessel "Beauport", a buoy vessel "Thomas Carleton", a ferry "John Guy", and three landing barges, all for the Department of Transport; a pipeline dredge, a motor launch and two scows for the Department of Public Works. Five Upper Lake type bulk freighters "John A. France", "Red Wing", "Murray Bay", "Carol Lake", "New Quedoc", with a total deadweight tonnage of 120,000, one 42,000 ton ocean-going tanker "Emerillon", two twin screw diesel passenger automobile ferries "Sidney" and "Tsawwassen", three tugs and fourteen barges were delivered to domestic commercial owners to serve differing modes of water transportation.

A general world wide slump in shipping which has persisted for several years reflected itself in the Canadian ship repairing service. Also affecting this service was the virtual disappearance of Canada's ocean going fleet. Foreign ships calling at Canadian ports continued to have only emergency repairs done in this country before returning to their home countries for major repairs.

Canada's navy has curtailed its production program although repair and conversion work on naval vessels continues to be important. There is a scarcity of commercial ships on order for domestic operators. The only orders on hand are for one tanker, one passage freighter and four bulk freighters, all scheduled for completion early this year.

VOLUME INDEXES, 1949 = 100

		Non-durable Manufacturing					
Base period industry weight		Petroleum Products	Chemicals and Allied Products	Miscellaneous Manufacturing Industries	Pulp and paper	Rubber Products	Products of Petroleum and Coal Total
		1.41	4.22	1.62	6.54	1.33	1.59
1957		236.8	183.4	153.3	133.6	147.8	223.5
1958		232.7	186.5†	160.0	131.5	137.2	216.8
1959		259.1	199.9	177.8	141.8	161.1	241.5
1958	J	253.0	178.9	160.0	127.8	122.9	235.0
	A	244.1	184.1	163.5	134.3	112.0	225.2
	S	244.3	190.8	169.2	133.5	157.8	225.0
	O	238.6	191.9	172.6	142.6	149.1	220.7
	N	249.6	193.7	174.1	140.8	170.3	231.4
	D	252.3	173.3	171.5	123.3	145.4	233.6
1959	J	253.8	180.8	166.5	130.1	146.8	235.3
	F	259.2	190.7	167.0	137.3	183.7	240.8
	M	257.9	187.1	168.9	136.2	165.7	240.2
	A	224.1	197.7	169.9	141.5	169.5	210.6
	M	248.7	203.7	172.4	147.9	171.9	233.1
	J	255.5	198.5	174.6	143.3	181.7	238.2
	J	262.8	192.3	176.8	137.7	137.8	244.7
	A	266.6	202.1	181.0	141.9	124.4	248.2
	S	276.4	214.2	187.7	141.5	171.1	256.6
	O	264.8	217.8	192.5	153.3	164.4	247.0
	N	267.7	211.1	191.5	153.5	174.7	250.1
	D	271.5	202.4	184.7	137.0	141.6	253.2
1960	J	280.6	212.5	179.6	141.0	158.0	261.0
	F	273.3	213.5	180.7	146.1	170.6	254.6
	M	264.9	218.4	184.4	150.3	158.8	248.1
	A	243.9	226.2	186.6	145.8	143.6	229.0
	M	260.2	230.2	185.4	152.2	135.1	242.7
	J	280.0	234.8	186.8	150.2	154.4	259.0
	J	279.1	222.0	189.1	143.3	121.6	258.0
	A	274.8	224.7	192.5	148.3	109.6	254.3
	S	272.5	237.5	199.3	148.5	148.3	252.3
	O	263.7	235.3[r]	205.4[r]	155.6	142.2	244.9
	N	274.8	225.9[r]	207.9[r]	160.1	152.6	254.0
	D	269.2	211.7	202.4	136.6	125.3	248.4
M.C.D.[1]		3	2	1	3	3	3
1958	J	230.8	192.0	163.4	132.2	148.8	215.2
	A	225.6	190.4	164.7	130.9	144.7	208.8
	S	229.6	183.9	164.6	133.9	147.1	212.0
	O	232.1	185.6	163.9	140.9	140.9	215.0
	N	246.6	190.8	166.4	139.3	151.1	228.6
	D	256.4	181.4	170.5	131.6	152.4	237.8
1959	J	253.0	187.5	171.3	136.5	157.8	234.6
	F	258.4	192.2	172.9	135.5	172.3	240.0
	M	271.5	189.0	172.7	132.5	163.6	252.0
	A	260.0	193.4	170.9	140.0	172.8	242.4
	M	264.6	196.9	173.6	143.0	169.2	246.9
	J	249.8	189.4	176.0	141.5	163.1	232.8
	J	238.7	204.0	178.4	142.5	159.9	223.2
	A	248.9	207.4	180.1	139.8	161.6	232.7
	S	263.2	208.4	181.4	142.6	158.0	244.9
	O	260.1	211.6	184.6	148.7	154.9	242.7
	N	264.5	207.8	183.4	152.0	154.6	247.2
	D	275.9	210.9	184.0	146.2	148.3	257.8
1960	J	274.3	221.7	184.6	147.6	173.4	255.7
	F	270.1	218.2	187.1	145.2	157.4	251.7
	M	273.1	222.3	189.5	150.3	159.0	254.9
	A	285.9	218.4	190.4	143.9	141.9	265.9
	M	275.6	217.7	187.8	145.8	130.3	255.9
	J	278.9	223.4	188.5	149.2	136.6	258.0
	J	256.1	232.4	190.4	148.3	139.9	237.7
	A	259.2	228.0	191.0	147.9	140.2	240.5
	S	259.7	229.7	192.7	148.9	137.3	241.1
	O	262.1	228.6	196.2[r]	149.6	137.0	243.5
	N	271.5	224.6[r]	199.3[r]	155.4[r]	135.0	251.1
	D	273.6	221.0	201.8	145.8	131.1	252.9

LUMBERING

The general hesitant business trend in 1960 affected the Canadian lumber industry. However, at home and abroad the industry anticipates an improved market this year.

The main home bulk market for Eastern Canadian lumber is housing, and business last year failed to match expectations. Uncertain employment conditions caused many potential home buyers to postpone their decisions and surpluses of new homes were found in some metropolitan areas.

Toward the end of 1960 however a slight buoyancy was noted in the housing industry and it is anticipated a much larger number of housing starts will be made this year. It is anticipated that the number may be in excess of 120,000.

Outside the housing field construction maintained a satisfactory volume during 1960, and the outlet for lumber in these areas was sufficient to maintain inventories at a manageable level.

The export market for Canadian lumber also was satisfactory last year. A good portion of the strength resulted from increased demand for framing and construction lumber from the United Kingdom. The export market is expected to continue at an accelerated pace in 1961.

Management and Automation

One of the most misunderstood words being used in relation to our present economy is automation. The word conjures visions of offices and factories staffed only by rows of blinking machines.

Many employees fear that automation will cause widespread unemployment and attendant ills. Many experts believe, however, that while new machines may displace people, the displacement is only temporary. New equipment brings new industries and new procedures and offices and factories continue to absorb available workers although they may use them in a different fashion.

When many people think of automation they think of the large electronic computers. The cost of these computers is so high however, that their use is limited to large corporations. All offices employ automation to some degree, even if it involves only the use of a typewriter. Smaller offices will use bookkeeping machines, while in larger offices punched card equipment or magnetic tape electronic computers and data processing machines will be employed.

The growing volume of paper work has made many business firms increasingly aware of the benefits to be gained from improved methods and machines which handle such work.

Among the latest techniques in automation, still in the development stage, are magnetic ink character recognition and the optical character sensing machines. By means of these machines it will be possible to read mechanically directly from printed documents without the need of punched cards, magnetic tape or other intermediate equipment.

This is expected to open an entirely new approach to office operations. With machines that can interpret and process the written word, much of the drudgery of paper work

		Durable Manufacturing							Electric Power and Gas Utilities		
		Electrical Apparatus and Supplies			Non-metallic Mineral Products						
Base period industry weight		Total	Heavy electrical machinery	Telecom-munication equipment	Total	Concrete products	Hydraulic cement	Domestic clay products	**Total**	Electric power	Gas
		4.40	1.52	0.44	2.46	0.30	0.36	0.24	5.11	4.60	0.51
1957		183.6	163.4	377.8	191.3	356.9	221.1	145.5	**220.3**	223.6	190.9
1958		175.5†	150.9†	413.1	205.9†	474.2	223.3	161.3	**239.1†**	240.0†	230.4†
1959		185.7	152.5	420.7	224.0	534.2	221.8	170.2	**268.7**	263.3	316.6
		Unadjusted for seasonal variation									
1958	J	166.8	153.4	362.3	234.4	640.4	266.4	180.5	**212.3**	222.0	125.4
	A	177.3	158.4	471.2	236.8	622.6	276.6	185.5	**211.1**	221.8	115.6
	S	191.1	164.2	512.3	237.2	607.9	263.7	189.0	**221.5**	230.6	140.1
	O	190.5	156.6	527.8	244.3	621.1	284.5	187.4	**238.4**	245.4	175.9
	N	193.4	152.2	539.4	226.9	526.4	240.5	197.2	**258.9**	259.1	256.8
	D	174.1	146.6	375.0	182.4	323.4	158.4	154.0	**278.0**	267.2	374.6
1959	J	174.9	143.6	407.0	166.9	258.6	122.8	131.1	**284.9**	265.5	458.8
	F	178.7	144.9	428.1	179.2	312.0	123.3	146.8	**290.1**	268.9	480.1
	M	173.3	146.8	374.0	190.2	409.9	143.5	143.5	**273.6**	260.0	395.7
	A	175.1	148.4	378.1	206.2	450.7	196.9	153.0	**269.1**	261.4	338.0
	M	179.4	151.4	379.9	235.4	584.0	254.9	178.8	**253.7**	253.4	256.3
	J	183.9	154.5	387.3	254.3	670.2	292.3	185.7	**247.1**	251.7	206.2
	J	176.5	154.1	349.1	260.4	706.9	310.0	185.2	**232.8**	239.7	170.8
	A	187.5	154.1	455.7	256.6	674.5	294.4	194.7	**235.3**	242.6	170.1
	S	202.9	158.5	490.4	266.3	732.3	304.0	185.8	**254.1**	259.0	209.8
	O	204.6	160.6	508.1	258.1	705.6	261.0	190.7	**273.8**	274.6	267.1
	N	201.7	158.1	482.7	231.3	548.7	217.7	191.3	**301.4**	291.4	391.5
	D	189.4	154.9	408.4	183.7	357.0	141.3	155.4	**308.4**	292.1	454.8
1960	J	188.5	150.7	406.6	172.0	299.7	101.4	142.7	**320.2**	296.6	531.5
	F	191.5	148.2	432.6	176.1	310.7	124.3	149.4	**327.4**	300.1	571.8
	M	188.4	147.8	403.0	177.9	364.3	131.9	144.1	**320.6**	295.9	542.6
	A	182.0	147.3	358.9	179.5	363.8	150.7	158.2	**300.1**	283.2	451.5
	M	181.2	146.5	375.5	218.5	558.7	221.4	175.6	**234.2**	279.1	330.1
	J	182.2	146.5	382.9	241.1	655.4	270.4	171.2	**277.6**	279.1	263.7
	J	170.6	146.1	304.6	236.3	656.3	262.6	164.3	**257.9**	263.3	209.1
	A	175.4	144.0	381.7	241.1	660.5	281.1	149.7	**267.4**	271.2	233.2
	S	188.2	142.3	469.6	237.9	660.6	261.7	147.6	**281.4**	284.4	254.3
	O	186.5	138.9	466.1^{r}	241.4	649.7	275.7	154.0^{r}	**289.3**	286.9	311.2
	N	179.4^{r}	133.8^{r}	439.2^{r}	228.6^{r}	599.5	222.6^{r}	144.3	**317.0^{r}**	302.6	445.9^{r}
	D	168.5	129.6	365.0	177.2	364.0	155.2	—	**332.6**	306.4	567.3
		Adjusted for seasonal variation									
M.C.D.(1)		2	1	2	2	3	4	3	**2**	2	3
1958	J	175.3	158.1	416.0	206.5	499.9	224.8	155.9	**234.9**	236.9	217.3
	A	180.6	160.8	452.2	204.9	473.5	220.4	160.5	**234.2**	236.0	218.5
	S	173.2	162.1	352.8	209.7	482.5	222.5	163.1	**238.6**	239.0	235.5
	O	174.7	152.8	390.4	213.6	484.5	244.5	166.1	**238.5**	240.1	224.1
	N	177.6	147.5	408.0	212.9	473.8	219.0	185.2	**245.1**	244.9	246.7
	D	174.5	146.6	363.4	219.9	480.5	232.9	190.1	**257.6**	253.3	296.6
1959	J	185.1	144.6	488.0	212.2	476.2	185.2	174.3	**256.3**	249.5	317.1
	F	188.1	148.2	507.2	224.9	553.2	168.4	201.1	**258.0**	253.4	298.9
	M	182.2	148.3	471.0	235.1	622.0	196.0	172.3	**258.1**	254.7	288.8
	A	183.2	151.7	448.0	230.5	555.0	224.5	164.2	**264.6**	263.2	277.5
	M	184.0	155.8	416.1	218.9	476.7	234.1	172.3	**262.0**	259.4	285.6
	J	186.4	159.3	402.2	224.6	524.8	242.2	155.5	**268.2**	266.1	286.8
	J	184.6	157.1	395.4	228.1	545.0	256.8	161.3	**260.9**	256.6	299.1
	A	189.9	154.6	425.1	220.4	512.5	228.9	163.8	**270.6**	262.3	345.0
	S	187.0	157.7	355.4	231.4	579.4	254.0	160.2	**280.7**	270.9	368.7
	O	190.6	158.5	382.0	223.6	549.1	223.5	168.2	**273.1**	270.0	350.5
	N	189.1	153.2	402.3	217.6	503.4	196.7	180.0	**285.3**	275.2	376.1
	D	193.6	154.9	433.1	222.9	533.6	214.1	195.2	**284.9**	276.6	359.5
1960	J	197.0	152.2	481.2	220.9	556.0	157.5	189.3	**287.5**	279.0	364.0
	F	201.3	151.7	518.1	222.9	555.8	182.8	204.7	**288.9**	281.5	355.2
	M	199.4	151.7	512.7	219.1	560.5	187.1	172.0	**299.6**	289.8	387.6
	A	188.9	152.2	406.0	199.2	449.1	167.4	174.4	**290.4**	281.5	370.7
	M	182.8	150.1	382.4	202.8	465.6	199.6	165.5	**293.9**	285.7	367.6
	J	182.4	148.1	389.9	207.9	499.5	198.1	146.3	**300.1**	292.3	370.4
	J	178.6	149.1	344.6	204.9	504.8	196.3	142.9	**297.8**	287.8	387.2
	A	179.1	144.0	353.4	208.5	504.2	217.9	128.9	**314.6**	297.7	466.4
	S	177.5	140.9	381.8	206.1	513.3	213.3	126.2	**314.4**	296.9	470.9
	O	175.3^{r}	136.2	378.9^{r}	209.0^{r}	514.0	220.6^{r}	139.3^{r}	**298.3**	284.1	425.7
	N	169.5^{r}	129.7^{r}	378.9^{r}	217.2^{r}	555.1	214.0^{r}	135.9	**300.7^{r}**	285.5	437.2^{r}
	D	173.7	129.6	405.6	217.0	545.7	238.8	—	**305.6**	289.9	446.7

will be removed. This will release the eyes, brains and hands of employees for more intricate, important and interesting work.

In a nation faced with such strong competition commercially and industrially, efficient management may make the difference between success and failure. Correct management may be as important to engineering works as to any other field of endeavour.

Two Canadian universities, McGill and University of Toronto, now are offering diploma courses in management which are available to engineers.

In recent years there have emerged responsible business consultants operating on scientific and engineering principles.

Another burgeoning area is that of industrial engineering which in some instances has infused new life into industrial operation. This may be done with the help of industrial engineering consultants, maintained by industrial engineering departments permanently incorporated into an industrial organization, or by individuals trained in the principles of good management and good engineering.

Engineering Education and Scientific Research

EDUCATION

It is difficult for the undergraduate engineering curriculum to keep pace with the tremendous growth and advances in technology by dealing with engineering techniques peculiar to a given field or specialty. Particularly as these techniques are constantly changing and the specialties multiplying. If we attempted to do this we should now have course packages for training nuclear engineers, automation engineers, control engineers, electronics engineers a) vacuum, b) solid state, missile and rocket engineers, space engineers, human engineers. The list could be never ending. Change and obsolescence are almost daily occurrences in our recent technological history.

It is reported that one large company has recently been successful in putting the design of gears into a programmed form for the computer. Those familiar with gear design know that it is a high form of expression of the "art of engineering". It involves a rather subjective approach and a good engineer will come up with a design in about a day. The rate at which the computer will produce designs makes the engineer's effort in this area worth 84 cents a day. This is an extreme example but it is by no means fictitious. Three good men and a computer may be able to account for a lot of engineering effort.

Under such circumstances as these a realistic approach is being sought in the undergraduate curricula in some universities by placing emphasis upon the understanding and the use of mathematics, extending to quite high levels of complexity. For, by means of the more sophisticated mathematical techniques scientific principles and data can be assembled, and what is more important, consolidated into areas of applicable knowledge which are now referred to as engineering sciences—examples are fluid mechanics which embraces hydraulics, aerodynamics, supersonics and hypersonics; thermodynamics embracing combustion and heat transfer; kinematics; strength of materials; applied mechanics; circuit theory and systems analysis. The preoccupation of physicists with newer fields of knowledge has resulted in much of the later research developments in these areas being accomplished by engineers. This is particularly true in fluid mechanics, heat transfer and applied mechanics.

Through the formal application of mathematics common patterns and techniques of analysis and synthesis can be recognized. This provides the necessary basis (which the physicist has always used) for the orderly presentation and handling of a maze of scientific data. Our technical devices have become far more refined and intricate, new scientific facts are put to use almost immediately and others are vigorously sought out so that some desired transformation can be accomplished. As a result the engineer must encompass a much more diverse and complex body of knowledge than ever before. To make such a situation manageable the undergraduate curriculum is therefore attempting to develop an understanding of and an ability to use the common language, mathematics, in conjunction with basic scientific principles for the analysis of engineering problems and for the synthesis which is their solution. At the same time it tries to foster an appreciation of the art, of design, of the ingenuity and invention which are associated with the practice of engineering. It can not produce experts in any specialty but rather by laying a good basic foundation it develops potential engineering talent. In the light of such circumstances post-graduate study, formal and informal training, specialization and experience in industry, are major factors in the full development of the engineer.

Increased emphasis is being placed upon the need for a well balanced educational program. The strengthening of portions of the curriculum dealing with humanities and social sciences is recognized as very important to the fullest development of the engineer, although there is far from complete agreement that it can be successfully incorporated within an adequate technical program in the limited time available. Proposals have been made for a five-year course of study beyond senior matriculation, but these have been resisted due to the growing need for post-graduate study and later specialization. It has also resulted in a critical view being taken of the length of the academic year. It has been suggested that its length originated in the days when our economy was based primarily upon agriculture and young men were needed at seeding and harvest time back on the farm. However, we should not underrate the benefits to be gained by the student both professionally and financially from periods of exposure to engineering practice during his academic career. Furthermore, it should be remembered that learning is basically a physiological process and that there is a limit to the possible speed up of physiological processes. Time for the digestion and assimilation of knowledge is very necessary in educational processes and also for gaining confidence in the application of it. Some industrialists imbued with production concepts frequently suggest doubling the output with two alternating groups of students each year, and the staff working in some sort of round-robin manner. Put some efficiency into this education business they say. However, it must be remembered that both students and staff need time to reflect. Staff need time to further their personal development by study, research and practice. Students need the benefit of an integrated campus life within the university, which is more than just social events.

RESEARCH

The expansion of research in recent years has been much livelier than the growth rate in other areas of the economy. An estimated $350 million was spent on research in Canada last year. This is more than double the amount spent in 1955.

The federal government was responsible for most of the research spending—about $200 million.

The remainder was spent by industry on research and development. This increase reflects the general upsurge in the use of technology.

Growing international participation is one important aspect of Canadian science. In the past, scientists always crossed international borders with little or no concern for nationality but in recent years a number of arrangements have developed wherein Canada is supporting projects which are important in the international sense.

Canadian scientists played a substantial part in the Geneva Conferences in 1955 and 1958 concerning the peaceful uses of nuclear energy. In 1960 the Canada-India nuclear station was completed near Bombay to serve as a training centre for scientists of the Colombo plan nations of South East Asia. Our scientists are assisting in the work of the international atomic agency at Vienna, which is directed towards humanitarian uses of nuclear science. They are also taking part in a joint program of research with Euraton, an organization of European countries interested in nuclear development.

Canada also has been an able participant in the field of physical standards. Last year, the National Research Council took a leading part in the adoption of a new standard of length: the international metre is now to be defined in terms of wavelengths of light emitted from the element krypton.

Following the International Geophysical Year, to which Canadian scientists supplied valuable data, international programs of research are continuing under the same auspices that sponsored the IGY. One of these, COSPAR, is a committee for space research which includes members from both sides of the Iron Curtain. Canada is a member. She also has a representative on the technical panel of the United States Committee for the Control of Outer Space.

Canadian scientists serve on a large number of international committees. Several of these — in astronomy, radio science, pure and applied physics, pure and applied chemistry, geodesy and geophysics — are members of the International Council of Scientific Unions. Since 1956 world gatherings in six distinct fields of science have been held in Canada and two more conferences, in pure and applied chemistry and in microbiology are to be held soon in Montreal. EIC

THE BEHAVIOR OF RAREFIED GASES

D. S. Scott,

Department of Chemical Engineering,
University of British Columbia.

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IT IS customary to think of a "rarified" gas as a phenomena encountered in the upper reaches of the atmosphere, or in very high vacuum experiments carried out in laboratories. While this was true many years ago, industrial developments of the last two decades have shown the desirability of high vacuum operation on an industrial scale. As will be discussed later, the phenomena of rarefied behavior are not a function of pressure alone, but are really dependent on the size of the container relative to the gas pressure. Thus, if one is talking about channels of microscopic size, then rarefied gas behavior can occur at ordinary pressures. In fact, this leads to a natural division in the field of engineering application, between those cases involving containers of "normal" dimensions in which gases are handled at very low pressures, and those instances in which the space dimensions are minute, but pressures are normal. Nevertheless, it should be clearly understood that the principles involved are identical in the two cases, and any such division is rather unrealistic from the viewpoint of the basic theory required.

Industrial Importance

Uses of high vacuum technology have multiplied rapidly in recent years. The drying of heat sensitive biological compounds, such as blood plasma, or antibiotics, from the frozen solid state has been practised extensively. The concentration of milk, fruit juices and other foods by vacuum evaporation is an important industry. Metal winning (e.g. magnesium), and metal purification by vacuum melting are well established processes, which are, nevertheless, growing and changing rapidly at the present time. The techniques applied to the purification of fissionable metals are finding rapid acceptance in metallurgical processes in general. The process of vacuum metallizing, or coating, is in wide use, and the quality of the deposited metal films is improving as advances in technique occur. This particular field of vacuum metallurgy is certain to see even wider application for protective, reflective and decorative metal coverings.

The electronics industry has, of course, employed high vacuum techniques for many years. The wide use of the much larger cathode ray tubes which have been produced in the last decade, has required the production of increasingly higher vacuum in order to ensure a collision-free path for electron beams, as compared to the larger pressures which can be tolerated in the smaller receiving tubes.

Perhaps the metal industries will show the most rapid progress in vacuum technology in the next few years. Vacuum melted steels, alloys, copper, etc. have been found to have superior physical properties. The production of high melting and reactive metals such as titanium, zirconium and molybdenum requires vacuum melting as a standard technique. Heat treating, sintering and brazing of these and other metals under vacuum has become accepted procedure.

Finally, the vacuum drying of hermetically sealed moving machinery has been brought to standard practice for small refrigeration and air conditioning units in which easily clogged capillaries are used. The advantages of this technique are sure to be extended to units of larger size, and for different purposes.

Nature of Rarefied Gas

In a body of gas at normal conditions, molecules of the gas can be simply pictured as being in ceaseless random motion, with a high average velocity. This motion results in a very large number of collisions between molecules in short times, so that a given molecule travels only a short distance before it collides with another molecule. Obviously, some of the molecules, which happen to find themselves very close to the wall of the container, will strike the wall. The average distance travelled by molecules between collisions is called the "molecular mean free path", and its exact magnitude depends very much on the picture that one proposes for the mechanics of an intermolecular collision. In general, however, the mean free path will increase as the pressure decreases, and it will also increase at higher temperatures.

If the mean free path is very much smaller than the dimensions of the container (it has a value of about 10^{-5} cms. for air at normal temperatures and pressures), then there will be many intermolecular collisions for every wall collision, and the properties of the gas, such as viscosity, diffusivity, and thermal conductivity will be determined by these intermolecular collisions. However, if the container dimensions and the mean free path begin to be of the same order of magnitude (it is immaterial whether this occurs because the container dimensions are reduced, the pressure lowered, or the temperature raised), then the proportion of intermolecular collisions to wall collisions will become much less. Whereas at ordinary conditions one can ignore the wall collisions completely, under these circumstances what happens at the wall must be taken into account. In the final limit, where the mean free path becomes much greater than the container dimensions, a molecule will suffer many wall collisions before it strikes another molecule, and the gas properties will now depend entirely on the nature of these wall collisions. In this region, which is called the "Knudsen flow" region or "region of molecular streaming", each molecule behaves independently, the phenomena of viscosity disappears, and flow and diffusion are identical processes.

In general, the field of gas dynamics which has been described above is divided into three regions. This division is perhaps arbitrary to some extent, inasmuch as the transition is a smooth and gradual one, but it lends itself to the formulation of mathematical equations describing gas behavior. The first regime is that in which intermolecular collisions predominate and the gas can be treated as a fluid continuum. Gas flow is streamline in character in nearly all cases. The low densities or small flow channels result in low Reynolds numbers, which are well within the laminar region, and the Hagen-Poiseuille equation applies with good accuracy. Heat transfer and material transfer can be described by the correlations available for natural convection processes, and by the well known equations for heat conduction or for mutual diffusion.

Gas behavior in the second regime is usually characterized by the term "slip" flow. This term arises from the concept that a certain fraction of the gas volume adjacent to the container walls is now concerned with wall collisions only, and this volume is not a negligible fraction of the total. In flow, this results in the assumption of a velocity discontinuity at some distance from the wall (usually taken as 2/3 of one mean free path in length), or in other words, a "slip" occurs near the wall. This "slip" is responsible for the observed fact that flow rates in this region may be many hundreds or thousands of times as great as those predicted by the Hagen-Poiseuille law for the same conditions. This same discontinuity will exist also as a temperature discontinuity in heat transfer, and as a concentration jump in mass transfer. For these processes, this region is usually called the "transition" zone.

The third regime supposes that intermolecular collisions are virtually nonexistent, and all transfer processes occur by reason of molecular collisions with container walls. The mechanics of interchange of molecular momentum, and energy, or of molecules themselves with the walls or other surfaces of the vessel, now becomes the primary factor controlling the rates of any process in this region. In some cases (e.g. for flow and diffusion) sufficiently exact theoretical expressions exist for the calculation of the magnitude of these rates, but in other situations, empirical relationships must be used.

Overall rate equations covering all three regimes are frequently presented. In fact, the number and variety of equations involving varying degrees of empiricism, and applying within different limits, is one source of confusion for any person interested in this field of gas behavior.

The Functions of Vacuum Operation

In many instances the beneficial effects of low pressure operation are entirely analogous to those obtained by the use of high pressures. For example, chemical reactions can be influenced to proceed to a greater degree in the direction of increased molar volume. This effect is the one sought in such operations as the dissociation of some metal oxides and carbonates, or the reduction of these oxides by carbon.

In diffusional operations, such as drying, evaporation, distillation and desorption, the use of low pressure reduces the partial pressure of inert gases, and thereby increases the diffusional rate of the desired process. Heat transfer and fluid flow rates are increased because of the reduction in the number of intermolecular collisions. Some operations, especially those involving reactive or heat sensitive materials, must be carried out at lower temperatures, and these would be impractical if it were not for this increase in heat and mass transfer rates at lower pressures.

Apart from the carrying out of chemical reactions, or physical transfer processes, high vacuum provides a collision-free space which is required in radio and television tubes, and in particle accelerators. In vacuum metal coating, the surface which receives the coating is usually some distance from the metal source, and the condensation process requires an unimpeded molecular flow.

In general, high vacuum may be described as a process which operates to absolute pressures as low as 10^{-6} to 10^{-7} mm. of mercury, the lowest values employed in most modern commercial practice. However, ultra high vacuum of 10^{-10} to 10^{-14} mm. are now produced experimentally, and may be of future industrial importance.

Flow of Rarefied Gases

The two situations of greatest interest involving the flow of rarefied gases would seem to be those problems in which pipe-line flow in circular ducts is concerned, and the flow of gases through porous media of various kinds. The only difference in these two cases occurs because the geometrical shape and length of the channels in a porous solid are not usually known, and must be deduced indirectly or experimentally.

In the past the practice has been followed since Knudsen's original classic investigation[1] in 1909, of describing the flow of gases as it varied from laminar to free molecule flow in nature by means of an equation of the type,

$$G' = G/\Delta p = A\bar{p} + B \qquad (1)$$

where G is a molar flow rate, $\bar{p}$ is the mean total pressure, A is a constant for a given gas and duct describing the rate of Poiseuille flow, and B is another term, usually called a "slip" term, but in fact, being defined in different ways by various authors. One or more empirical constants were introduced in order to obtain equations which agreed well with experiment. Equation (1) suggests that the flow rate should vary linearly with the average total pressure in the system, but a flow minimum exists at low pressures in circular pipes, and some deviation from linearity also occurs at low pressures for many porous solids. Fortunately, these effects are not large, and equation (1) has served as a useful approximation, for example, as in the piping design charts presented by Brown et al,[2] or as a means of determining an equivalent circular pore radius by methods such as those proposed by Arnell.[3] Recently, however, Scott and Dullien[4] have proposed a new flow equation, one form of which can be written,

$$G' = (A\bar{p} + B)(1 - e^{-8K/\pi}) + Ce^{-8K/\pi} \qquad (2)$$

In this equation, A has the usual meaning, B is a slip flow term describing those molecules which undergo a single wall collision between intermolecular collisions, and C is the Knudsen flow term for those molecules involved in successive wall collisions. The quantity K is a dimensionless group defined as,

$$K = \frac{r\bar{p}}{\eta\bar{v}} \qquad (3)$$

where r is the pipe radius, η the viscosity and $\bar{v}$ the average molecular velocity. In equation (2), the constants A, B and C can all be determined directly from the kinetic equations given below. This flow equation was found to reproduce experimental results for pipe line flow, including the flow minimum, with an accuracy of a few percent over the entire range of pressures.

$$A = \frac{\pi r^4}{8\eta RTL} \qquad (4)$$

$$B = \frac{4\pi r^3}{3M\bar{v}L} \qquad (5)$$

$$C = \frac{16r^3}{3M\bar{v}L} \qquad (6)$$

In the above equation, R is the gas constant, T the absolute temperature, L the length of the pipe and M the molecular weight of the gas. The numerical constants given are derived from the kinetic theory of gas, and are not empirical.

A dimensionless form of equation (2), is of interest as an aid in design calculation. This can be written as,

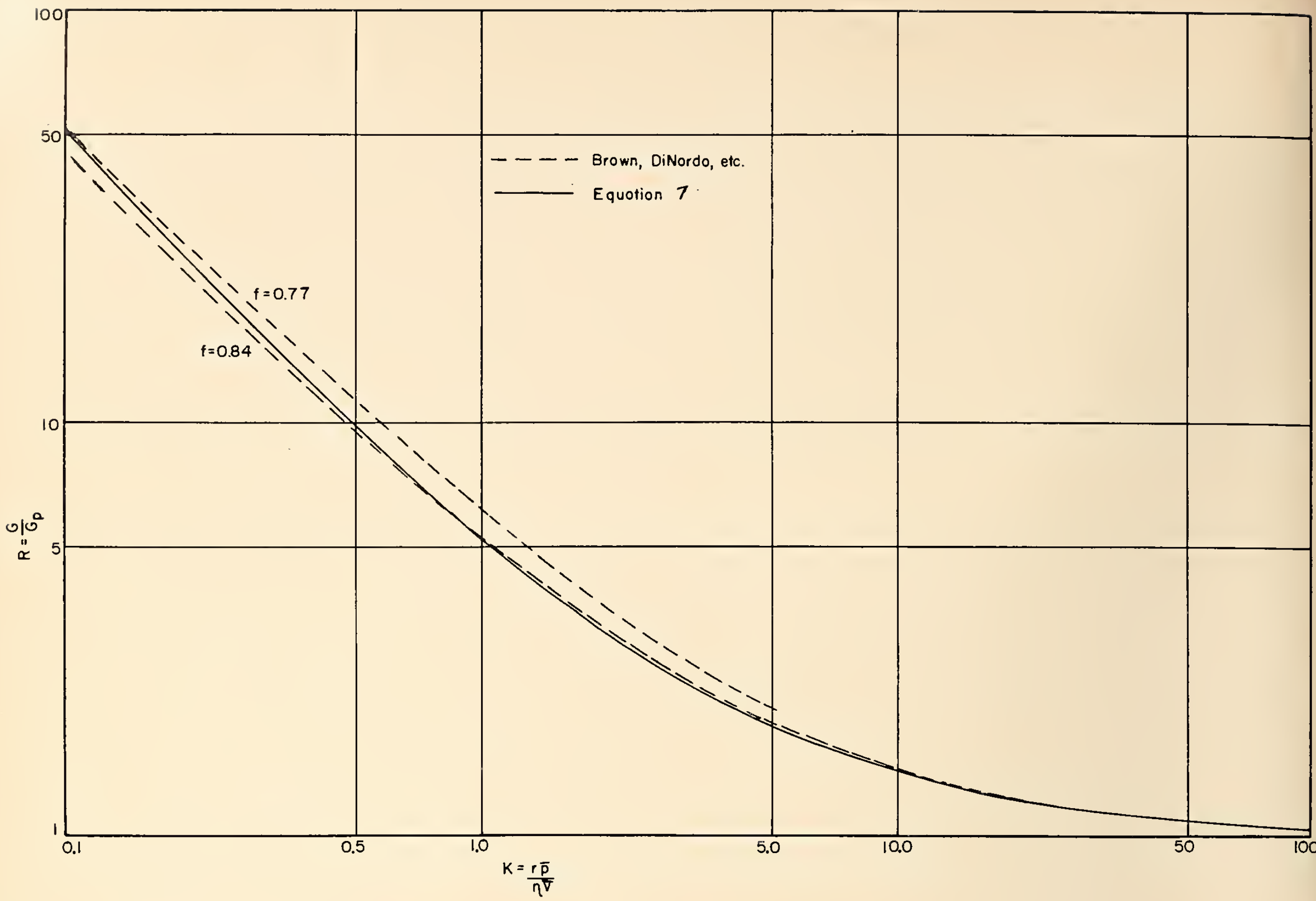

Fig. 1. Comparison of Flow Equation with earlier correlations.

$$\frac{G}{G_p} = e^{-8K/\pi}\left(\frac{1.144}{K} - 1\right) + \frac{4.189}{K} + 1 \qquad (7)$$

where G_p is the flow rate as given by the Poiseuille equation, that is,

$$G_p = \frac{\pi r^4 \bar{p} \Delta p}{8\eta RTL} = \frac{\pi r^4 (p_1^2 - p_2^2)}{16\eta RTL} \qquad (8)$$

A plot of this equation is shown in Fig. 1. It gives a satisfactory correlation of nearly all experimental data for flow in circular pipes over all three regions of flow described earlier.

It is of interest to consider the application of this equation to flow through powders or porous solids. If flow measurements are carried out as a function of pressure at pressures sufficiently high so that the term $e^{-8K/\pi}$ in equation (1) approaches zero, then a straight line is obtained. Extrapolation of this line to zero pressure gives a value for B, and the slope of the line gives the value of A. Then from equations (4) and (5)

$$\bar{r} = \frac{A}{B}\frac{4\pi\eta\bar{v}}{3} \qquad (9)$$

where r is now an equivalent radius. It has been shown[4] that the value of r so obtained agrees closely with the mercury penetration value. Further, it is possible to calculate a structural parameter for diffusion in a porous solid from these results. This "diffusion ratio", β, may be defined as the rate of diffusion which could occur in the geometric space occupied by the solid, to that which actually occurs through the pores of the solid. This ratio can be found from the expression,

$$\beta = \frac{16\pi A\eta A_s}{9B^2 ML_s} \qquad (10)$$

where A_s and L_s are the geometric cross sectional area and geometric length of the porous solid sample, respectively.

Further details of the application of equation (2) to the design of vacuum piping are discussed by Scott and Dullien.[4]

Heat Transfer in Rarefied Gases

At very low pressures, radiation may become an important factor in heat transfer. The reason for this lies in the absence of normal convection currents in the gas, and in the low rate of heat transfer by molecular conduction.

In general, for the region of laminar flow the ordinary heat transfer equations for natural convection can be used. In the slip flow and molecular flow regimes, however, the apparent thermal conductivity of the gas decreases with the pressure. Two approaches to this problem have been used, that based on an "accommodation" coefficient, due to Knudsen,[5] and one as described by Dushman,[6] suggested by Smoluchowski, which assumes a temperature discontinuity near the wall. The former assumes that when a molecule strikes a hot wall, a complete interchange of energy does not occur in a single collision, and therefore, the molecule leaves the wall with an energy somewhat less than that corresponding to the wall temperature. The accommodation coefficient is, in effect, the efficiency of the exchange process. For most substances its value lies between 0.8 and 1.0.

If a temperature discontinuity is assumed, then a trial and error solution is necessary to determine the temperature at the point of discontinuity. When this is known, the ordinary conduction or convection equations are applied to the balance of the gas. Equations for carrying out this procedure have been developed by Madden and Piret[7] and by Kyte, Madden and Piret.[8]

For heat transfer from spheres and vertical or horizontal cylinders, their equations give good agreement over very wide ranges. These equations take the form of 15 empirical correlations, each applying over a particular range, in terms of Grashof and Prandtl numbers for cases in which free molecule conductivity can be neglected (i.e. the temperature discontinuity can be neglected), but a simultaneous solution of two equations is required at low presures when free molecule conduction corresponding to the slip region of flow) begins to be of importance. While these equations appear to give good results, their use is rather laborious.

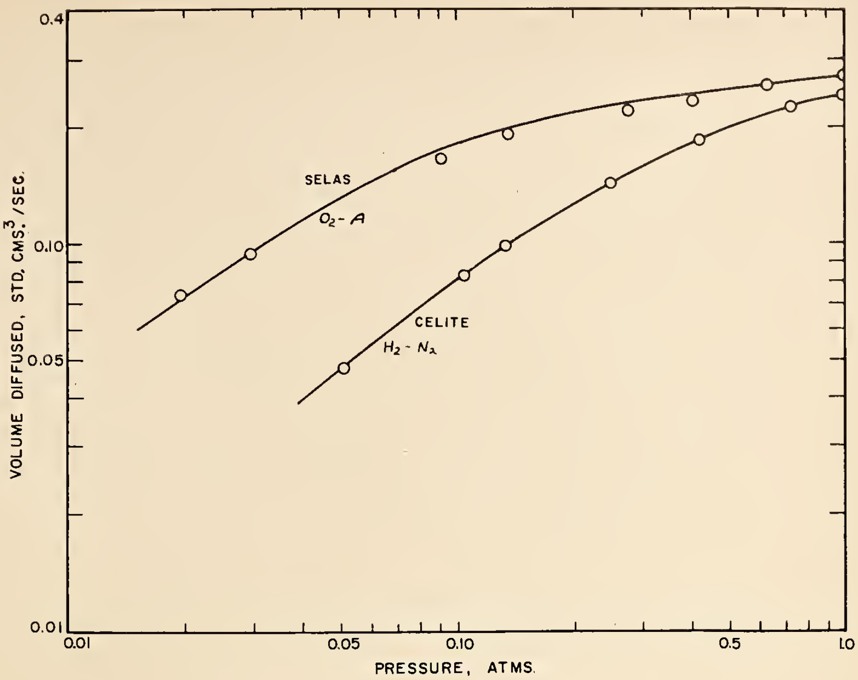

Fig. 2. Counter Diffusion of Gases through a Porous Solid at Constant Pressure.

O Experimental
— Calculated Eqn. 18

It is perhaps possible that a concept such as that used in developing equation (2) where three separate types of molecular collisions are considered, might give a single satisfactory procedure.

A brief outline of one fundamental approach due to Kennard,[9] is given below. It is well known that the apparent thermal conductivity of a gas decreases, when the mean free path length becomes an appreciable fraction of the length of the conduction path, or exceeds it. The apparent thermal conductivity k_g, can be assumed to be related to the ordinary thermal conductivity, $k_g°$, by an expression of the type

$$k_g = \frac{k_g°}{1 + (2j/L)} \quad (11)$$

where j is the distance over which the temperature discontinuity extends (i.e. the distance in which free molecule conductivity is assumed), and L is the length of the conduction path. From kinetic theory the distance, j, can be written,

$$j = \left(\frac{2-\alpha}{\alpha}\right)\left(\frac{2\gamma}{1+\gamma}\right)\left(\frac{kT}{\sqrt{2}\pi p\sigma^2 N_p}\right) \quad (12)$$

where α is the accommodation coefficient, γ is the specific heat ratio, σ is the molecular diameter and N_p is the ordinary Prandtl number of the gas.

Combining this with the previous equation,

$$k_g = \frac{k_g°}{1 + 5.08 \times 10^{-24}\left(\frac{2-\alpha}{\alpha}\right)\left(\frac{\gamma}{1+\gamma}\right)\left(\frac{T}{pL\sigma^2}\right) N_p} \quad (13)$$

This equation would apply for cases in which free molecule conduction and ordinary conduction occur. At low pressures it becomes the equation for free molecule conductivity. Inasmuch as the length of the conduction path, L, appears in the denominator of the ordinary conduction equation, that is,

$$q = kg \cdot A \frac{\Delta t}{L} \quad (14)$$

then it can be seen that for gases in the Knudsen flow range, the rate of heat transfer varies directly with the absolute pressure, and is independent of the length of the conduction path, in direct opposition to ordinary conduction.

If convection does occur in the gas space, then the more complex methods mentioned earlier must be used. On the basis of equation (13), Schotte[10] has proposed a method patterned after that of Deissler and Eian[11] for predicting rates of heat transfer in packed beds having void spaces of very small dimensions.

Some brief mention should also be made of the phenomena of "thermal transpiration" and "thermal diffusion". Thermal transpiration, also called thermomolecular flow, arises when two chambers at different temperatures are connected together. If these chambers are at low pressures and connected by tubing so that the tube diameter is about the same or smaller than the mean free path, then at equilibrium the pressures in two chambers A and B can be shown to be,

$$\frac{P_A}{P_B} = \sqrt{\frac{T_A}{T_B}} \quad (15)$$

As a consequence, this situation must be recognized when a pressure gauge held at one temperature is connected to a vacuum system at a different temperature. If the mean free path is much smaller than the tube diameter, than $P_A = P_B$. Empirical equations have been derived by Knudsen[5] for the transition region, but these are not entirely satisfactory, tending to give low answers.

Thermal diffusion is a process whereby in a gas mixture, there is a tendency for larger and heavier molecules to move to a cold surface, and for smaller and lighter molecules to move to a hot surface. In the steady state, the degree of separation resulting is determined by the mixing effect of ordinary diffusion, so that finally a concentration gradient will exist in the gas as a consequence of a temperature gradient. This process has been used on a continuous laboratory scale for the separation of isotopes, and a very considerable body of literature exists on the subject. A review of thermal diffusion is given by Dushman.[6]

Mass Transfer in Rarefied Gases

As the number of intermolecular collisions suffered by a molecule in travelling from some source to its destination is reduced, then its rate of transport will be increased. In the extreme case where the molecule can travel the entire length of the diffusion path without undergoing collision, the only limitation on the rate will be the rate of emission from the source. At higher pressures, ordinary diffusion equations will apply, and under molecular flow conditions, the equations due to Knudsen[1] or Langmuir[12] can be used. An expression for this rate of surface emission, as given by Sofer and Weingartner,[13] can be written,

$$G = P_v A_s \left(\frac{Mg_c}{2RT}\right)^{1/2} \quad (16)$$

where G is the mass rate of transfer, P_v is the vapor pressure of the solid or liquid in question and g_c is a constant, equal to the acceleration of gravity, relating force and mass units. Pressure units must be consistent throughout.

This equation gives a maximum rate of evaporation, and holds well for fresh or clean surfaces. If surface impurities are present very much lower rates will result, and it is therefore customary to include an emission coefficient in equation (16), which attempts to allow for this effect.

Little work has been done on more general expressions for mass transfer at low pressures which would include all three regimes of flow. Correlations have been attempted by Sherwood and Cooke[14] using the concept of an overall mass transfer resistance obtained by summing individual resistances, in the same manner as that employed for transfer processes at normal pressures. While a good correlation was presented, an error in the emission coefficient used has been pointed out recently by Madden.[15] It is interesting to note that this work, as well as results given by Littlewood and Rideal[16] tend to throw doubt on a great many values of emission coefficients reported in the literature. The possible error arises because the evaporating surface may have a temperature considerably different to that of the surroundings. If this temperature is not known, then the value of P_v used in equation (16) will be in error, with a corresponding error in the emission coefficient calculated.

Another problem associated with dilute gases occurs when diffusion is occurring between two chambers each at the same total pressure, but connected by small channels. A similar situation exists when the diffusion through a porous mass bathed in a flowing gas is considered. The diffusional process will be of the ordinary or mutual diffusion type when the ratio of channel radius to mean free path is large. The diffusion coefficient for this case may be calculated by means of the usual correlations, for example, those presented by Hirschfelder et al.[17] The ordinary diffusion coefficient varies inversely with the absolute pressure, and its temperature dependence is given reasonably well by $T^{1.75}$. In free molecule diffusion (which is identical with free molecule flow) the Knudsen diffusion coefficient, D_k, for a circular channel is

$$D_k = 2/3 r\bar{v} \qquad (17)$$

and hence is independent of the absolute pressure, depends on $T^{0.5}$ and varies directly as the channel radius. In the transition zone, a mixed type of diffusive behavior is observed, and the diffusion rate is not easily predictable. Empirical equations for this region have been proposed by Wheeler,[18] and recently Scott and Dullien[19] have developed e more exact expression for the constant pressure case. This equation is complicated to some degree by the fact that the steady state diffusion equations have a different functional form for the two limiting processes. The diffusion ratf for a binary mixture is given by the latter authors as,

$$G_A = \frac{D_B p}{RTL\alpha_A} \ln \left\{ \frac{1 - \alpha_A y_2 + D_B/D_K}{1 - \alpha_A y_1 + D_B/D_K} \right\} \qquad (18)$$

where G_A is the under rate of diffusion o gas A, D_B and D_E are the ordinary and Knudsen diffusion coefficients, respectively, y_2 and y_1 are the mole fractions of A at the two ends of the diffusion path of length L, and α_A is given by

$$\alpha_A = 1 + \left(\frac{M_A}{M_B}\right)^{1/2}$$

if A is the gas whose diffusion rate is being measured.

Scott and Dullien have also shown that, for all the modes of diffusion, at constant total pressure,

$$G_A/G_B = \left(\frac{M_B}{M_A}\right)^{1/2}$$

when a steady state diffusion process is occurring through small channels, or at low pressures. Results calculated from equation (18) are shown in Fig. 2, compared to experimental diffusion rates through a porous solid measured at varying total pressures. It can be seen that good agreement is obtained.

Summary

It is believed that satisfactory flow equations exist for rarefied gas flow in circular channels. Equations applicable to many other shapes could be readily derived. Heat transfer processes in rarefied gases can be less readily and less exactly calculated, but adequate empirical correlations appear to be available to allow estimation of heat flow rates for a number of situations. However, a good deal of experimental and theoretical development remains to be done before mass transfer rates can be calculated for a like number of cases.

Pumps capable of producing and maintaining low pressures in equipment of commercial size are now available in a variety of forms, and for a variety of conditions. Industrial use of high vacuum techniques is feasible, and is growing rapidly. It would be desirable, therefore, to develop adequate design procedures for transfer operations in rarefied gases, in order that this growth may be encouraged, and may have a firm basis on which to rest.

Nomenclature

A — Poiseuille flow constant given by equation (4)
A_s — Area of a solid, cm²
B — Slip flow constant given by equation (5)
C — Knudsen flow constant given by equation (6)
D_B — Ordinary binary diffusion coefficient, cm²/sec.
D_K — Knudsen diffusion coefficient, cm²/sec.
G — Molar flow rate, moles/sec.
G' — Specific flow rate, moles/(sec.) (unit pressure differential)
G_p — Molar flow rate calculated from the Poiseuille equation
j — Distance over which free molecule flow exists.
K — Dimensionless group in equation (2)
k — Boltzmann constant
k_g — Apparent thermal conductivity
$k_g°$ — Ordinary thermal conductivity
L — Length of a flow or conduction path
L_s — Length of a porous solid
M — Molecular weight
p — Absolute pressure
Δp — pressure differential
P_v — Vapor pressure
R — Gas constant
r — Radius of a circular pipe
r — Equivalent pore radius
T — Absolute temperature
$\bar{v}$ — Average molecular velocity
y — mole fraction (or volume fraction)
α — Accommodation coefficient
β — Diffusion ratio
γ — Specific heat ratio
η — Viscosity

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EFFECTS OF CHANGING TECHNOLOGY ON LABOR AND EMPLOYMENT

William Bruce, M.E.I.C.,
Professor of Mechanical Engineering, McGill University

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IN RECENT times, the tremendous expansion in the application of scientific principles and knowledge to an ever-widening range of man's activities has been strikingly displayed in the growth and development of technology. The creation of a continuous stream of new materials, processes and methods, combined with the devising, building and maintaining of devices of increasing complexity and intricacy are resulting in significant changes in the contributions required from labor at all levels. The fact that man can now produce the basic food, clothing and shelter for his needs by a relatively small expenditure of his efforts and of natural resources is bringing about the development of a more complex form of society, but at the same time it also incurs the predominant necessity for a constant generation of much more artificial forms of employment. Part of the response to the need appears in a stimulated public desire and consumption of what might be called luxury goods and services. Another part is in the development and production of devices and equipment found to be necessary for purposes of military security, and still another, in the increasing of social capital through the construction of public buildings, parks, roads and highways, urban developments, and other forms of activity which contribute to the national welfare.

The attempt is to weave such actions into what will be a fairly stable economic pattern, yet one which is capable of fruitful expansion. The effects of these happenings are being reflected in the changing nature and composition of the labor force, in the educational and skill requirements involved, and in the employment opportunities which occur. There is a decided general trend in industrial operations to demand relatively higher educational qualifications of workers, extending even to the most menial of jobs. This is quite evident in an examination of personnel selection procedures over the years. Although the impact of changing technology is apparent throughout all areas of the economy it is particularly evident in the manufacturing or goods-producing industries and it is with this aspect that the following account is mainly concerned. However, it is relevant to consider first the general structure of the Canadian labor force as well as its proportionate distribution and growth characteristics. Also, the very marked depletion of manpower which has been occurring in agricultural occupations must be recognized.

The Canadian Labor Force

With the population of the country just over 18 million, the total Canadian labor force today is about 6.5 million persons, one quarter of them being female. During the past decade, while the labor force has grown at the average compounded rate of 1.9% per annum, total employment has expanded at the rate of 1.6%.[1] Although non-farm employment increased by 2.8% per annum, jobs in agriculture decreased by 4.5% per annum[1], and this industry dropped from the second largest employer of manpower to fourth position. Therefore in addition to the increase in jobs necessary to accommodate the growing labor force, new forms of occupation were required by a significant number of workers who had to transfer from agricultural activities to some other form of employment.

A further notable feature of the last 10 years is that the employment of women has risen by a percentage almost three times that of men[2]. This has meant a substantial increase in the employment of married women. In 1949, 28% of the females in the labor force were married, whereas today the figure is over 45% [3]. Women are entering the labor force in increasing numbers because of expanding employment opportunities for them, particularly in the trade, finance and service industries. It is estimated that within the service-producing group of industries (service, trade, finance, utilities and transportation) almost 40% of the job holders are women.

The manufacturing industry is the largest supplier of jobs and is the largest contributor to the gross domestic product. This industry presently accounts for more than one quarter of the total jobs available (25.7% in 1959). The services industry which consists in general of organizations, other than those listed below, producing a service rather than a product and including all levels of government, public administration, education, etc., is second, providing slightly less than one quarter of the total jobs (23.0%). These industries are followed by the wholesale and retail trades (providing about 16.0%), agriculture (12.0%), construction (7.6%), transportation, storage and communication (7.6%), finance and insurance (3.7%), mining and quarrying (about 1.6%), followed by the very minor contributors, forestry, public utilities, fishing and trapping[1].

During the past decade manufacturing operations have not managed to keep pace with the growing labor force in supplying the same proportion of jobs. Rates of employment growth have been lowest in the primary and secondary industry groups and highest in the service, trade, finance and public utilities operations. The average annual compounded rates of employment growth in the various industries running from lowest to highest have been estimated as follows[1]:—

	Percentage
Agriculture	−4.5
Mining, quarrying, oil wells (direct mining operations only)	+0.3
Manufacturing	1.3
Transportation, storage and communication	1.8
Forestry	2.2
Construction	3.1
Trade	3.6
Finance, insurance, real estate	4.0
Service	4.5
Public utilities	4.9

Within this period the gross domestic product has risen to such a value that the percentage contribution by agriculture was almost halved, and today this represents about one-fifth of that contributed by manufacturing operations. Employment has more than doubled in such activities as the mining of oil and natural gas, truck transportation, radio and television broadcasting (actually tripled), manufacturing of aircraft and parts (declining from a peak in 1957), and almost doubled in air transportation. The telephone industry shows a substantial increase but it too is declining from a peak in 1957. In transportation operations generally, the employment today is only about 5% more than the year 1949 due to significant manpower reductions in the railway, water and urban facilities. In mining operations overall the increase has amounted to about 23% but it also is declining from a peak in 1957. Employment in coal mining has dropped to less than half of that a decade ago [5].

However, the significant factors in the growth of the labor force versus employment opportunities appear to lie in the very large drop in the number of workers in agriculture, in the failure of manufacturing which is the largest employer of labor to increase, or even maintain its proportionate absorption of workers, in the relatively large increase in female employment in the service, trade and finanee industries, and in the substantial expansion that has and is still taking place in these latter industry groups. Also, an examination of the rates of growth of the broad occupational groups shows that the professional category has been increasing most rapidly, followed by the skilled and white-collar occupations. The semi-skilled and unskilled groups are growing at considerably slower rates while occupations in the primary industries are actually declining numerically. The fastest growing occupations are those requiring the greatest skill and knowledge, and consequently relatively high levels of education and training[1].

Agriculture

The character of jobs occurring in agriculture is noticeably different from the majority in other fields of labor. About 85% of the farm labor force consists of self-employed farm operators and unpaid members of farm families [6]. Although agricultural occupations accounted for over 45% of the jobs held by the Canadian labor force at the turn of the century, today they represent about 12% and the actual number of persons so employed is considerably less than it was then. While this rate of decline (an average of 4.5% per annum in the last 10 years) cannot continue indefinitely, a levelling off is not yet apparent. Despite such a reduction in manpower the output per man-hour in terms of the gross physical product has increased 2 1/3 times in the last 30 years, while the work force has been almost cut in half. Whereas in 1931 one agricultural worker achieved the food production for about nine persons of the population he now produces for about 25 persons with surpluses occurring in many foodstuffs. This has been accomplished through larger scale operations (amalgamation of smaller farms), by increased mechanization and the use of electric power on farms, as well as to improved methods in agronomy and animal husbandry, (and also to increasing amounts of imported fruit, vegetables and other foods). Farm tractors used in Canada increased from 160,000 in 1941 to 500,000 in 1956. In 1931 only 10% of the farms had electric power but 73% were using it in 1956 [6].

Due to greater concentration of activity at seeding and harvest times brought about by the emphasis on mechanization, seasonal employment is forming a larger portion of farm labor, but because of increasing competition from other industries, the relatively low wages offered for farm work, the longer working hours, the lack of fringe benefits and unemployment insurance, it is becoming more difficult to meet requirements. A recent survey by the Department of Labor indicates between 500,000 and 600,000 seasonal jobs in all industries with about 250,000 in agriculture [6].

The big shift of agricultural workers to other forms of employment draws attention to the probable methods of their absorption and to the difficulties encountered. Rural farm areas show about 30% of the population 14 years of age and over with nine or more years of schooling contrasted to 55% in urban areas.[6] In general, the educational patterns of rural areas are considerably below those of urban communities in the extent of formal schooling achieved by the majority of the population, and the worker transfers are likely to be to those jobs demanding little or no skill or experience.

The Manufacturing Industry

General Characteristics: An examination of Canadian manufacturing industries reveals that they have undergone considerable expansion since World War II, but that much of the operations are concerned with producing goods which have been conceived and designed, and are also made outside of the country. Consequently, if the Canadian-made goods cannot be produced more or as cheaply as elsewhere, or if they do not bear a preferred stamp of originality, quality or innovation, they are not likely to be sold in outside markets and the volume of production is limited to the national consumption. At the same time the great bulk of such things as machine tools, control systems and instrumentation, automatic equipment, computers and data processing machines, do not originate in Canada, yet the development and production of these devices involves the employment of considerable numbers of workers of high technical calibre, and the growing demand for this type of equipment is bound to ensure a dynamic and continuing activity in this most important area of modern technology. Automated systems both in production and administrative phases of industry, and the use of transfer machines and numerically controlled machine tools are beoming readily accepted forms of industrial operation. To survive, in an era which is experiencing economic competition of global proportions, an industry must absorb and preferably contribute to these fast and far-reaching developments. The Canadian contribution and participation in these recent technological innovations has been of very limited proportions, yet it is mandatory that it be increased if our manufacturing industries are to be self-sustaining, to retain a Canadian character of some stature, and to prosper.

The human desire and need for a multiplicity of gadgets of constantly changing specifications with a decided trend towards those of greater and greater intricacy and refinement means that the operations of conceiving, designing, producing and marketing of these devices are a continuing and growing form of employment. This is likely to remain so for a long time to come; until mankind is surfeit with material goods. Manufacturing operations employ a large number and great diversity of people with widely varying talents and skills. In recent years many occupations are being subjected to continuous and frequently rapid evolution while others are relegated to a state of obsolescence. This is much more so than in the harvesting of natural resources from mines, lands and seas, although even in these activities a great deal more is being accomplished with far less physical effort, through the applications of newly gained knowledge, of increased sources of energy and power, of ingenuity and improved organizational effort. However, it should be remembered that it is through the further processing of these reaped natural resources by the application of imagination, knowledge and skill in manufacturing desirable goods that jobs can be most effectively multiplied; rather than by the increased disposal of little- or non-processed materials to outside markets.

Engineering and Innovation: Change and obsolescence are almost daily occurrences in recent technological history: diesels for steam engines, jets for reciprocating aero-engines, automated systems for physical and mental manpower, micro-wave apparatus for telegraph, telephone, and long-wave radio signal propagation, transistors for electron tubes, guided missiles for jet fighter aircraft, synthetic for natural fibres, plastics and resins for metals and woods. In such an atmosphere of technological change and of increasing economic competition it is imperative to stimulate, foster and develop the human talents of creativity, ingenuity and organizational ability which can be applied to industrial activity. In the area of engineering design the use of the electronic computer as an aid in rapidly carrying out the necessary and previously laborious calculations is proving a great boon. It enables optimum designs to be achieved in a very short time with a very limited staff. Standard routine design problems which often arise in a repetitive manner are being successfully reduced to a computer program form which results in tremendous savings in time and effort. Such advantages are invaluable to any manufacturing industry engaged in a highly competitive field. Methods need to be found to stimulate and develop original engineering effort in Canadian industry, and to promote research and development work which will lead to the production of new products, processes and materials, to the conception and building of improved machines, to the reduction of costs and to increased productivity. Manufacturers should be encouraged to make greater contributions, if necessary with government assistance, in these areas which are so vital to a vigorous industrial growth.

The creation and establishment of new industries deserve all possible aid. It is essential that new businesses, making new products or rendering new services which will find a ready market come into being to replace others which fail because of product obsolescence, economic competition, or other causes. Business failures can result in much more labor displacement than that due to technological change. To further the evolution of new developments strong support, mainly financial, is needed for graduate study and research in universities, particularly in science and engineering, so necessary for advancing knowledge and technique, and for the advancement of scientific and technical personnel.

Technical and Skilled Manpower: The rapid growth of technology, both in diversity and complexity and in its application to industrial activity makes it most essential that engineering efforts be backed by a large, highly-skilled, well-qualified group of technicians who are specialists in particular technical lines. The growing need for specialized manpower can be seen from the fact that between 1931 and 1951 the professional worker component of the country's labour force increased by 21% from 4.8% to 5.8% (about twice the rate of increase of the total civilian labor force) and the skilled worker component increased by 36%, from 11% to 15% of the total labor force. By 1965 these values are expected to be 6.7% and 17.2% of the labor force, respectively [7]. University graduates in science, particularly at the doctorate level, are being employed in increasing numbers by industry, usually for research and development work. In 1901 there were fewer than three engineers for every 1000 non-farm workers, today there are more than eight [7].

Until recently in Canada a considerable gap in the technical manpower available existed between the tradesman and the engineer. This was clearly evidenced by the active recruiting outside of the country carried on by many companies during the last decade since many of the persons selected were of the technician category. For the five year period 1951-55 when immigration was at a high level the skilled labor force was increased through this means by almost 11% of the number reported in these occupations in the 1951 census. Between 1953-59 immigration provided more than five times the number of craft and technical workers that came from Canadian technical school programs [1]. In a survey of skilled tradesmen in Canadian industry during 1956, covering electronic technicians, senior draughtsmen, tool and die makers and floor moulders, it was found that the more highly skilled the trade or occupation the greater was the dependence placed upon immigration as a source of workers, which suggested that training facilities in Canada were unable to keep pace with the requirements for highly skilled manpower [8]. It has also been apparent that on the average the immigrant manpower has a much higher degree of formal vocational and technical training than is characteristic of native Canadians working in similar occupations. The quick and effective assimilation of these persons into Canadian industry is ample proof of the great need for personnel of this type. On-the-job experience and upgrading appear to have been the major means of developing skilled workers in Canada with immigration being the second largest source. The first method falls far short of the demands made by modern technology and cannot continue if a healthy industrial economy is to prevail.

The contribution in numbers of skilled workers produced by apprenticeship training since 1946 appears to have been about half of that due to immigration. This is a source of skilled workers which needs stimulation for the supply of new workers which can be provided by immigration is dwindling rapidly. Apprenticeship training is recognized, particularly by the metal working industries and by specialty groups such as in printing and weaving, as a valuable method of developing skills, but it seems to be carried out in a formal manner mainly by the larger companies. This appears to be due primarily to problems of organization and cost, and to the limitations set by union practices on the allowable ratio of apprentices to journeymen in any plant.

Candidates are selected from existing young employees and more commonly from technical, vocational and high school graduates. As a method of gaining basic skills and plant experience apprenticeship is used to develop personnel for future supervisory posts in shop operations and for other occupations in methods analysis, production planning, inspection and quality control, etc., as well as for producing versatile tradesmen. Available data indicates that between 1953-56 the proportion of manufacturing establishments with apprentice training increased from 16.6% to 22%, and the ratio of apprentices to non-office employees from 1:40 to 1:33 [7]. In 1956 the percentage of firms having apprenticeship training programs varied from a low of 6% in the petroleum industry to a high of 75% in printing and publishing. A large scale survey in 1959 throughout the mining, manufacturing, transportation and communications, and public utilities industries revealed that less than 2 out of every 100 workers were engaged in formally organized training programs for skilled workers which were provided by their employer [1]. It is significant to note that in view of the relatively high wage rates achieved for unskilled and semi-skilled labor through the actions of unions it is becoming necessary to offer incentives to younger workers to get them to enter apprentice training schemes which, of course, demand much greater personal effort than the average routine job. This usually takes the form of favourable wage rates while learning but it also will require recognition by both labour and management of the need for greater financial disparity among the unskilled, skilled and highly skilled categories in order to stimulate development of technical manpower.

While the emphasis on the need for the technician has arisen due to technological development, it is also due in many respects to the restrictive actions and the limited scope of the trades. The necessary attributes of the technician are, probably a greater intellectual capacity than the average tradesman, more formal training to higher levels which can enable him to gain a sound grasp of basic theoretical concepts, and the ability to adapt readily to changing technical conditions and new industrial requirements. He must encompass a fairly wide range of knowledge in a number of fields but his main concern is with the mastery of the latest industrial techniques in his specialty and in being able to keep pace with new developments. Recognition of this sphere of activity must be made technically, financially and socially by industry, government and the public in order to encourage the youth with ability to seek a career as a technician. A number of those who presently attempt to achieve a university education in engineering and are unable to meet the academic standards (as indicated by the large number of drop-outs) have talents well-suited for the activities of a technician and could very likely make a significant contribution and gain personal satisfaction in this field of endeavor. The existence of technical institutes with programs of education of some stature, capable of challenging the mind while providing up-to-date training in teehnology, are urgently needed. The attempt should be to make this pathway to a career in industry a valued one and graduates of such institutions should receive adequate recognition. The type of curricula employed should reflect an alertness to the latest industrial techniques and the necessity of complementing the university engineering courses of study, not emulating them.

In this way the engineering faculties of the universities will be able to concentrate on the development of more advanced forms of undergraduate curricula with a general upgrading in academic standards, and to increase their efforts in post-graduate study and research, and in the furtherance of engineering knowledge. The pattern in technology today is to attempt to put the most recently discovered scientific data to immediate practical use. In many areas of rapid development the pace is too great for the engineer who has received only a traditional engineering education. As a consequence, in such fields as the electronic, aero-dynamic, nuclear and chemical which are in the forefront of technological change, the graduates of science, at the doctorate level, are leading the way and playing a major role in many engineering activities. This, in conjunction with other factors, is bringing about a definite shift in engineering curricula to place the studies still more firmly upon the foundations of science and mathematics and to carry them to higher levels.

The recent action of the federal government in making funds available for the expansion of vocational and technical training and in its extension to higher levels is most commendable. It is certain to produce very desirable results. On the other hand, the very rapid evolution of machines, methods and processes means that in-plant training programs now conducted by industry must continue and undoubtedly expand in order to keep technical manpower abreast of new developments, and to provide the necessary flexibility in the frequently required transfers of labour from one area of activity to another. In 1959 it was determined that slightly over 9% of the workers who could be classified as technicians were in formal training courses offered by the employer [1].

Plant Operations and Labor Structure

That the productivity of the work force has greatly increased there is little doubt. It is evidenced both in the increased quantity and variety as well as the increased complexity of the goods produced. However, the effects of the greater application of mechanization and automation to industrial operations have produced several changing patterns in the structure of the labor force, and in the skills and eontribution required from it. The trends that are already evident will be continuous with some becoming more significant than others, depending upon the extent of industrial expansion, upon how modern technology evolves, and upon the rate at which advantage is taken of improved technological methods. More and more automatic machines and processes with higher production rates, and machines integrated as a single, eontinuous, operational unit by automatic work transfer systems are being used, and they require much less human assistance in their functioning.

In fact, machine operators are becoming machine tenders exercising little or no control upon the operations either in a qualitative or quantitative manner. Whereas previously a worker's pay was linked to his production rate over which he had certain control, now the trend is toward a fixed hourly wage since the rate is set by the machine and the man's functional ontribution to the production process is that of observer and attendant. The main requirements are for a pronounced sense of responsibility and a state of alertness to avoid such operational difficulties as machine jamming caused by careless loading or faulty operation which can result in a high scrap loss. Even in the toolroom, with the advent of greatly improved machines, many work procedures have been broken down into narrow specialties to such an extent that frequently a machine operator with limited skill can be employed instead of a highly skilled toolmaker of broad experience. The rapid developments that are taking place in the field of operational control of machine tools by numerical methods, using magnetic tape, punched tape or cards for programming, makes it almost certain that the above trends will be greatly accentuated in the near future. Numerical control of machine tools is a form of automation which is exceedingly flexible and can be readily adapted to custom work and small production schedules as well as to large scale efforts. It is therefore well-suited for Canadian conditions. Under such circumstances, with control programs prepared by methods analysts and production planners who are remote from the fabrication area, there will be a further de-emphasis on the skills and organizational abilities required in direct production operations.

Products of a more uniform quality are an outcome of the use of more automatic machines which leave little or no control in the hands of the operator. This has resulted in inspection methods shifting to statistical sampling procedures with quality control gained through close regulation of the fabrication process. The manpower required for inspection purposes is thus noticeably reduced. As products and processes become more complex and varied, methods analysis and production planning become increasingly important, and in general the responsibility for the quality of the product is transferred from the production worker to the planning, inspection and laboratory control groups.

While some progress has been made in mechanizing product assembly operations this is more difficult and costly to achieve, and the bulk of the direct production manpower still appears in such occupations. However, the breakdown of the work into sub-assemblies in which advantage can be taken of mechanized procedures and the extensive use of synchronized material conveyor systems to produce smooth flow patterns have done much to increase efficiency in this phase of manufacturing. In fact, the increased fabrication rates approaching steady flow conditions have emphasized the need for all materials handling operations to be mechanized and have brought about the general adoption of such methods. All of this has effectively reduced the labor content required in direct production, mainly of the unskilled and semi-skilled type. Most manufacturing operations particularly the mass production kind, reflect these trends. While they have a definite result in reducing employment opportunities in this type of work, there is a counteracting effect in the production of a greater variety of goods of greater intricacy in a greater number of establishments, which is contributing towards further employment.

In a highly mechanized production facility which represents a high capital investment and which requires a steady and continuous input-output condition for efficient operation, the importance of maintenance functions looms large. The integration of machines by mechanized and synchronized transfer systems and the use of more complex automatic equipment of all kinds means that even minor breakdowns can be costly since large portions of the plant may become idle. Because operations in such systems are based upon a continuous flow pattern and are performed on the work pieces in a simultaneous and sequential manner, work can not pile up at any station and be relieved later by overtime procedures. Therefore work stoppages must be kept to a minimum. If at all possible, troubles need to be anticipated and corrective procedures taken ahead of time. This need merges the maintenance features very closely with the direct production effort. Some of these needed actions can be taken by the machine tender on a routine operational schedule, some require the attention of more skilled and more specialized personnel. The setting-up, adjustment and repair of the newer automatic machines and systems is a much more difficult task than previously, requiring a much wider range of technical knowledge and competence.

The widespread use of electronically controlled equipment places great emphasis on the need for electronic maintenance skills. Elaborate control systems involving various combinations of mechanical, hydraulic, pneumatic, electrical and electronic circuits are used. A quick diagnosis of the cause of a breakdown, its location and rapid correction requires the services of one who is completely familiar with the equipment, who combines many of the talents and skills found in several standard trades and who is able to appreciate the basic theoretical principles which govern the operation of the system and to understand elaborate and often complex circuit diagrams; in other words, one of technician calibre. Eventually, as skill in the conception and design of these machines evolves, many will contain automatic indicators which will pinpoint possible sources of trouble permitting quick corrective measures to be taken. However, until such developments are generally forthcoming reliance must be placed upon the knowledge and skill of the maintenance worker. The need for such combined talents in one man is an area of frequent controversy between union and management interests regarding job classification and content, and restrictive trade practices. The alternative procedure of sending a repair crew, each member of limited capabilities, and of co-ordinating their activities, is usually a very inefficient method and is entirely inconsistent with the principles of advanced technology. There are numerous cases of this type which arise in production and in maintenance work and they create training problems as well as those of labor displacement. It is imperative that satisfactory solutions be found or technological progress can be hindered.

The extensive use of complex machines with intricate control systems means that much larger capital investments in equipment are being made and depreciation begins to rival labor as a major cost. A balance, which shifts only in the direction of higher capital investment, is likely to be struck in the rate at which this investment occurs depending upon the rate of rising labour costs. However, it is worth pointing out that all new inventions, methods or devices are conceived and brought into being not simply to save labor; many are associated with the development of entirely new products, the improvement of quality or the reduction of costs of existing products, or with the reduction of capital investment. While the rate of technological change depends upon the availability and the capabilities of the scientific and technical manpower, upon the availability of capital for investment, and upon the productivity related to market demand, human talents can be stimulated and their effectiveness increased, market demand can be influenced by adjustments in price structure and by improved quality and innovation of the products being sold, and new markets can be vigorously sought out. Technological advancement should not be hindered. It needs to progress with all possible speed in view of its vital importance to national welfare and security in both the economic and military sense.

Effects on Office and Clerical Work

In contrast to the decreasing proportion of workers engaged in direct production there are relatively increasing proportions of professional, clerical, and other so-called white collar workers appearing in other phases of industrial operations. Evidence of this trend appears in the growth of salaried compared with hourly rated personnel [9]. University graduates are now sought to fill numerous positions and many companies actively recruit those possessing higher degrees. While some of this is due to the creation of an increasing number of supervisory jobs reflecting greater control and a more highly developed form of industrial organization, the great bulk is due to the increase in general office employment associated with present-day methods in the manufacturing and marketing of goods. More information on operations and more data tabulation are necessary adjuncts of the industrial complex. Such things as unemployment insurance, hospitalization, pensions, and other fringe benefits, the union dues check-off system, income tax collection, data accumulation for governmental statistical and taxation purposes have all contributed to the growing load of office work. It is estimated that in 1900 clerical workers formed about 3% of the working population and today it is about 25%; some 30 years ago there was one clerical worker for 12 production workers whereas now the ratio is about one to four production workers[9].

Indeed the number of persons employed in office and clerical work has reached such top-heavy proportions it appears certain that mechanized and automated systems using electronic data processing and computing machines will be effectively applied to eliminate slow cumbersome methods, to streamline and speed up data handling operations, and to reduce costs. While unit production costs have been steadily decreasing office costs have been consistently rising. Also, this approach is the obvious complement to developments within the plant where the institution of continuous flow patterns and automatically accomplished work procedures are stressed. The end result which is being sought is an integrated establishment with all areas of activity operating along similar lines and at comparable rates, with the procuring of raw materials, manufacturing, warehousing, sales and distribution being effectively scheduled and closely controlled. In this way the most efficient use can be made of natural resources, capital, labor and management. Most clerical processes have basically common patterns and much of the routine tabulation, classification and handling of office data are readily adaptable to automatic processing. Occupations such as bookkeeping, filing, invoicing, some forms of accounting, and the routine handling of data connected with any of this work are most likely to be affected. Studies which have been made of possible consequences upon employment indicate the result as likely to be a decline in the rate of expansion of the labor force in this sector rather than a drastic reduction of employment. The effect, which may be expected to be gradual, is similar to those due to many technological changes which are occurring. During a period of economic expansion, while not markedly affecting the numbers of persons employed because of the possible transfer to other types of jobs, nevertheless, they are bound to be reflected in the rates at which new entrants to the labor force can be absorbed in these areas of industrial activity.

The following are some of the observations which have been made in a recent review of the effects of office automation[9]. While eliminating certain occupations office automation also introduces some new ones, but of course the numbers are of more limited proportions. Such jobs as project planner, systems analyst, program coding clerk, console operator, peripheral equipment operator, keypunch operator, data typist and tape librarian come into being. Only the first three positions require a good knowledge of business operations and computer techniques, all others can be mastered, after a short training period, by personnel who have no special skills. For most routine office work, coding operations can be simplified so that even programming can be carried out by one who has no special mathematical background but has an ability for logical analysis.

Though all office occupations will not be affected by automation to the same extent, some scarcely at all, the general tendency is towards a more marked division between executive or supervisory functions and subordinate positions concerned with machine operations. As a result, promotion up through the ranks to the supervisory level becomes less likely since many intermediary positions will have disappeared. Promotion to new jobs is through special training rather than by experience in other work. "The need for a certain background of technical information and a fresh malleable approach to problems of work organization which office automation demands of executives is likely to result in a higher proportion of younger professional men in managerial ranks."[9] In recent years the trend is towards the university graduate being utilized more exclusively in managerial and executive positions. Vocational training schools have been largely bypassed by the rapidity of developments and this has placed the burden for technical training on the manufacturers and users of electronic office equipment; this situation is likely to continue as long as the cost of such equipment prohibits its purchase for training purposes[9]. "The same can be said for most developments in automation which have appeared in factory operations." But perhaps of greater importance is the necessity of enlisting the co-operation of educational authorities at the secondary school and university levels in an effort to provide orientation for students towards the new job opportunities created by automation, with a broad background both in general knowledge and modern office organization which will enable them to assimilate rapidly the technical skills required".[9]

Labor Displacement and Unemployment

Because of increasing use of automatic systems and the greater productivity resulting from improved technology, "saved labor" undoubtedly occurs in many phases of industrial operation. While in periods of reduced economic activity this so-called "technological displacement" could cause some unemployment it should be remembered that new adoptions of technological developments, which are requiring increasingly higher capital investment, are much less likely to occur in periods of economic recession. In a dynamic economy which is producing an ever greater variety of products, supplying a continuously expanding market, this labor displacement usually has little effect in causing unemployment of a permanent nature. By reducing the intake of new employees, displaced labor can often be reabsorbed within the establishment, although worker transfers to other activities, even within the same organization, can involve re-training or at least periods of re-adjustment for gaining new job experience.

Due to their more limited contribution to work processes, the ability of unskilled and semi-skilled labor to switch to other forms of employment seems to be less affected by technological change than in the case of skilled labor where the problems are more acute. Frequently it is difficult for such skilled workers to obtain jobs either in the same plant or elsewhere at an equivalent level of skill or status. However, the number of skilled workers displaced by technological changes appears to be much smaller than in the case of the unskilled and semi-skilled types. The most effective employment of existing skilled labor and the re-absorption of those displaced will depend more and more upon the broadening and extension of their skills and on the increasing of their technical knowledge, particularly since the "bumping" procedures, which are the basis of the seniority employment system, do not favour narrow specialization.

Seniority recognition, which can have far-reaching effects in such labor disruptions, may conflict with the selection of personnel best-fitted for particular work assignments. The ability to adapt readily to a changing environment and to absorb new knowledge or technique varies considerably from person to person and is usually a characteristic of youth rather than of age and experience. Also, the matter of the growing size of the "fringe benefits" part of a worker's financial reward is serving to identify him still more closely with the company operations causing him to wait for re-call after a lay-off rather than seek new employment. Yet it is such limitations in the mobility of labor which present a serious handicap to the rate of adoption of new technology. Flexibility in the work force, both in disposition and kind, is a necessary requirement.

To gain full advantage of the benefits of modern technology the organizational structure of industry needs to keep pace with technical developments, however, at the same time, human values must receive foremost consideration. Fears of a threatened job loss and possible unemployment because of the introduction of new devices or methods can be a serious obstacle to industrial development and a major drawback to good union-management relations. More than ever before the responsibility rests with joint management and union action in careful and intelligent planing for proposed changes, so that the possibility of external displacement is minimized or removed entirely, and in providing just settlements for job evaluation and wage rate problems which arise due to internal displacement. Satisfactory solutions to such problems can be achieved only in an atmosphere of mutual respect and trust and with full recognition of common goals. In periods of economic recession, unemployment becomes a major responsibility of the government to provide some income to the unemployed, to help them find new jobs, to stimulate such areas of the general economy that are most likely to create additional jobs, and to make certain that facilities are available for the training for other possible forms of employment of such workers as are able to profit by it.

An examination of the recent pattern of unemployment increase shows that it tends to be concentrated among male workers and is highest in the young age group, below 25 years, tapering off above this age. This reflects the reduced employment opportunities in the goods-producing industries where the labor force is predominantly male, and the expanded openings for female workers in the more rapidly growing service, trade and finance industries. It also indicates the effect of union seniority regulations which result in those with the least years of service in an organization, usually the younger workers, being relegated to the unemployed ranks. The new entrants to the labor force and those seeking entry constitute a large proportion of the unemployed. Last year the percentage rate of unemployment showed highest for laborers and construction workers, followed by transportation and primary industry occupations, and was least for clerical workers. An analysis of the educational level of the unemployed at that time revealed that 44% had not finished primary school, while 26% had finished; 22% had had some secondary school education but only 8% had completed secondary school or higher.[1] The brunt of unemployment appears centred upon those who have a relatively low level of education and training. In general it would seem that the more highly educated persons can meet the requirements of a greater number of jobs, can adapt more readily to new conditions, and when necessary can achieve job transfers more successfully. Whether or not greater proportions of highly educated workers with improved skills and advanced training can be absorbed into our economy at faster rates is perhaps debatable. There seems to be little doubt however that it is in the areas which require such kinds of workers where the most rapid employment growth is occurring, and that it is mainly from such persons that new ideas, innovation and change emanate.

Conclusion

In the light of economic history the advantages to be gained from the continuing applications of science and technology to industry far outweigh the effects of any disruptions which result in the labor force. These effects can be minimized by foresight, careful planning and the use of some of the gain to alleviate such personal hardships as may occur. The benefits accruing from improved technology are commonly considered to be those of increased profits on financial investment, higher wages, shorter working hours, greater availability at lower cost of a growing multitude of products, the freeing of human effort from exhausting physical labor and mental drudgery, and in general, a higher material standard of living for all. It is important to remember that the benefits should and must appear in other diverse ways as well, such as the reducing of the manpower necessary for the production of goods and of food and so facilitating the enlargement of service occupations as found in education, medical care, travel, entertainment, printing and publishing, the repair and maintenance of personal effects; the increasing of social capital through the development of the arts, the improvement of government and other forms of social order, the growth of parks, planned urban communities, fine public buildings, highways; charitable aid to those segments of the world's population lacking in technical prowess to help them achieve greater self-sufficiency and better living conditions through the application of technology; and in total, in the greater economic strength and military security for the nation.

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STATISTICAL QUALITY CONTROL AS A MANAGEMENT TOOL

B. H. Lloyd,
Director, Management Consulting Services,
Price Waterhouse & Co., Montreal.

The place of statistical quality control in the business world requires at least a brief explanation to overcome a misleading notion in the mind of management. The term does not indicate the general areas where it has applications, or its basic concepts.

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STATISTICAL quality control is a term that unfortunately neither indicates the general areas of application nor the principles upon which it is based. If anything, the term has a tendency to create a misleading notion in the mind of management. For this reason in a paper entitled 'Statistical Quality Control As A Management Tool' one is obliged to discuss at least briefly the place of statistical quality in the business world.

Walter A. Shewhart, formerly of the Bell Telephone Laboratories, New York, is the acknowledged creator of the term *statistical quality control.*[1] It is important to understand that the statistical implication of Shewhart's development was that of statistical methods based on the theory of probability. In this sense statistics does not refer simply to the collection and presentation of numerical data, which is a more common interpretation of the term.

Shewhart envisaged that the quality of a physical substance could be described by various characteristics and that numbers could be used to measure the effect of the characteristics on the substance. The word *control* was not meant to imply that the technique would result in direct control in the usual sense but that the use of the method would assist management to gain a better understanding of the manufacturing process. Consequently the action taken by management would result in achieving the quality objective more frequently than if they had not used the technique.

The term statistical quality control, therefore, connotes a basic concept qualified by the implications of the work 'quality' which designates a specific area of business activity. However, the concept is suitably applicable to other areas of business such as the management of inventories and costs. Therefore it is not uncommon to encounter the expressions 'statistical inventory control' and 'statistical cost control' both of which may be developments of the same concept as statistical quality control.

It is because of the common concept that we find papers on such subjects as inventory management and cost control appearing in the quality control journals. Only because of the vigorous imagination of students seeking to find useful applications of a principle do we encounter the apparent confusion caused by the use of statistical quality control in areas other than quality control.

Application of the notion of statistical quality control was so successful and gained so much publicity it was not surprisingly that theorists became interested in this new development. Mathematical statisticians commenced to turn out so many statistical tools, some practicable others badly conceived or impractical, that Dr. Shewhart could well have identified himself with the mythical sorcerer's apprentice whose fortuitous scheme for reducing work resulted in far too much production.

The growth in use of statistical quality control over the past 20 years has been phenomenal. The American Society for Quality Control, organized in 1945, has now nearly 12,000 members of whom approximately 500 reside in Canada. However, not until about 1950 did Canadian management begin to realize that statistical quality control was a technique worthy of greater recognition. In this country it is still common to find manufacturing companies with waste and defective product as high as 50% using outdated quality control techniques.

Inspection Department

Many companies still maintain inspection departments for the purpose of screening the acceptable from the unacceptable product. They rely on the final inspection to assure the consumer of an acceptable level of quality regardless of the effect on cost. There are two outstanding weaknesses to this practice. First, the inspection of all items manufactured will not guarantee outgoing product of acceptable quality particularly where inspection is subject to human error. Secondly, sorting to obtain acceptable product is economically inferior to the method of statistical quality control. One finds it difficult to understand in these times, when cost reduction is such an important element in business administration, how management can ignore or overlook quality control as a potential source of increased profits. It seems that, if the sales demand is met and if the customer is satisfied, then quality obligations have been satisfactorily discharged. However, the modern manager cannot afford to accept the existing costs of waste, defects, product repair, inspection, product testing and customer dissatisfaction unless he has thoroughly investigated the advantages of scientific techniques such as statistical quality control.

Risks in Sampling

Before management can fully realize the potential of statistical methods it must recognize that when a decision is based on a limited amount of information, there is a chance that the decision will not produce the desired result. When the element of chance can be measured, the statistician can be of help. For example, the inspection of a sample of manufactured parts taken from a lot may be used to determine whether or not the lot is acceptable for shipment. There are two risks involved in this situation. First, the sample analysis may cause the shipment to be rejected when in fact it is acceptable. Secondly, the sample may have enough acceptable parts to cause the shipment to be accepted when it should have been turned down. Since these risks are present whether management wishes to recognize them or not, management can improve the precision of its judgment by basing the sampling plan on preassigned measures of risk. It is natural to want to keep the risk of making a wrong decision small. It is also to be expected that management will want to spend as little money as possible in collecting information upon which to base a decision, but these two criteria are conflicting. For practical reasons a 10% sample is commonly used for inspection of goods for shipment when a little larger sample might result in a lower net cost to the company. It is often found that management wishes to assume very small risks of making a wrong decision but the resulting sample is so large that the increased cost is prohibitive. This dilemma is one that management must resolve. It cannot be ignored without incurring greater net costs to the company.

Control Chart

The same underlying thinking applies in the use of the statistical quality control chart. As long as the measure of a quality characteristic is within the control limits, there is a risk that variations signify a real change in the quality of the product. However, should the measure fall outside of the limits, there is a relatively high probability that this indicates a significant change. The spread of the limits varies as the degree of risk. A narrow band means that some apparent out-of-control conditions might prove to be due to chance. Wider limits would increase the probability that quality changes would go unobserved. The two risks must be balanced with the affected costs if the application of the technique is to be successful.

Development of Management's Acceptance

One cannot expect members of management, other than perhaps those directly engaged in the management of the quality control function, to understaond or even to attempt to understand the methods of statistics. However, it is perhaps just criticism of a management that does not understand in general terms the principles of statistical quality control, if the technique is being successfully applied in the company.

Dr. L. R. Hafstad[2] contended that engineering management were indulging in self-flattery in thinking that they could avoid variability. He questioned that engineers could make things so uniform that they didn't have to worry about probability distributions. In short, variability is present whether the engineer manager wishes to recognize it or not and he probably will benefit from trying to understand it rather than to ignore it.

From the original concept produced by Dr. Shewhart, in the space of 36 years noteworthy developments in applications of statistical methods have taken place in 3 major areas, namely technical research, industrial processes and business administration.

The statistical quality control chart developed by Shewhart and the later introduction of acceptance sampling in inspection operations have now become the rule rather than the exception, but it cannot be maintained that these devices have universal application. Not every manufacturing process can save money through statistical quality control. Not every inspection operation can make use of statistical sampling. The greater successes have been achieved undoubtedly in mass manufacturing processes dependent upon few variables but some ingenious methods have been devised for short run manufacturing and complex processes.

The statistical quality control chart in shop applications functions directly as a tool of the shop operator. In addition, by periodic observance of the charts, operating management can soon learn to assess the immediate quality performance and to ensure that necessary corrective action has been taken before the weekly or monthly operating report is prepared.

Quality Summary Reports

Many manufacturing plants now have eliminated detailed quality summary reports and rely on a brief weekly meeting at which quality control and production personnel discuss each operation that has been out of control during the week. It is common for the quality control manager to refer to the quality control charts at this meeting explaining, where possible, the causes of significant deviations from acceptable standards of quality. If the offending quality condition has not been corrected, management may outline the corrective action to be taken and raise the point for discussion at a subsequent meeting. The meeting not only serves as a clearing house for quality problems but eliminates delay and clerical time in the preparation of quality reports and the attendant profusion of copies.

Statistical Sampling

Management to some extent still regards statistical quality control as a kind of hocus pocus. Since considerable mathematical training would be required to understand some of the techniques, particularly where the principles of statistical sampling are concerned, this attitude is understandable. Two examples may serve to illustrate this point. In excavation work surface formation is sometimes dislodged by arranging a series of detonations in time sequence with the explosive charges placed at scientifically determined depths. It is important that detonations occur in the proper order but the time interval is very small and variations in quality of the detonator disrupt the order of firing. In one instance a statistical sampling procedure was developed for the inspection of blasting caps that enabled management to predict field performance in terms of the probability of misfires. It was through this approach that a satisfactory quality control system was established. Because of destructive testing it was necessary to use a sampling procedure but statistical sampling provided the degree of precision that helped management set quality standards and assured satisfactory performance in the field. In this case some members of management, not fully comprehending the technique, could not help regarding the results with some degree of awe.

A second example, though not so dramatic, occurred in a dairy. For some time the company had been experiencing a net plant gain in milk. Although substantial plant losses were expected due to bottle breakages and other causes, statistical sampling soon demonstrated that, on the average, but underfilling the bottles only a few cubic centimetres, which was not only practical but allowable, resulted in a net book gain in product. It was possible using this statistical approach to estimate the gain, the losses and the resulting net production, which were reasonable reflections of the book figures. It was interesting to note that although responsible members of management realized that there was a gain, it had not occurred to them that this would compensate for controllable losses which represented an appreciable amount of money relative to the net profit. In addition to this, it was fairly simple to demonstrate using statistical sampling methods, not unlike the methods of work sampling, that an overloaded maintenance program was the cause of much of the trouble. Management were impressed by the results but it is doubtful that the technique would interest many at the management level particularly in small companies having few specialized personnel. In this sense therefore it is doubtful that statistics could be considered a tool of management, but in the sense that the methods are used to solve management problems the role of the technique is properly cast.

Relative Cost of Defective Conditions

Although statistical quality control as a plant activity basically serves as a technique for detecting significant variations in quality, this in itself is often not sufficient. For example, a 10% defective level in steel washers due to burrs may be less costly to the company than a 1% defective level in bronze bushings due to oversize drilling. It is customary in some companies to determine the relative cost of defective conditions as a measure of quality control performance. This approach is of value in determining machine maintenance and repair priority.

Some companies use summaries of lost revenue due to defect conditions as a means of emphasizing the importance of operating within specifications. Thus in one company a reduction of 50% was possible in lost revenue per product unit, as a result of statistical quality control, within one month from the beginning of the program. It should not be deduced from this that concerted management effort could not have achieved this without help from statistical quality control. Nevertheless, the technique not only dramatically isolated the source of difficulty but impressed on everyone the impact on company profits.

Statistical Methods and Business Administration

There is no doubt that the concept of statistical quality control has had wider application in product and process quality than in other areas of business activity. Nevertheless useful derivatives of the technique have appeared on the horizon in business administration, among which are the more impressive applications of statistical inventory management and statistical cost control. Inventory levels are of great interest to management because of their effect on costs and customer service. It is usually of vital importance to be able to fill customer orders on time and management would prefer that this be carried out at the smallest expense to the company.

It cannot be maintained that statistical techniques are essential in all inventory problems but statistics has been helpful, for example, in studying the frequency of orders to be filled. If it is possible to establish the nature of the frequency of demand, it is then possible to prediet the movement of units from inventory which must be known before base stocks and re-order points can be established at an economic level. The statistical quality control chart has been applied to the inventory turnover index for the purpose of bringing to the immediate attention of management changes in the movement of goods.

Charles Bicking has described statistical applications to control errors on stock cards, restocking orders and discrepancies between physical stocks and stocks card records.[3] The applications helped to improve the quality of the data being used in an inventory control study and are examples of the scientific approach to the improvement of clerical performance.

Statistics in Accounting

There is some evidence that the notions of statistics are gaining popularity in the accounting profession but the exactness of accounting work is a deterrent to development in this field. This is a condition not unlike that experienced in engineering. Frequently an accountant will react to the error phenomenon with great consternation, but an engineer will often attempt to rationalize a situation in which an error has occurred.

The accountant and the engineer have much in common, both having been established practitioners for many centuries. It is not surprising, therefore, that the accountant became aware of the value of statistical sampling at about the same time that Shewhart's technique was gaining acceptance. In 1933 L. A. Carman prepared a paper entitled 'The Efficacy of Tests' which was likely one of the earlier papers on the subject of statistical sampling as it applied to auditing work.[4] Since that time progress has been made in the use of statistical sampling by the accounting profession, but there has been noticeable resistance to the acceptance of the statistical principles. The apparent reluctance cannot be attributed entirely to the accountant so much as to the lack of attention on the part of the statistical designer to the basic accounting problem.

An excerpt from a treatise prepared by Dr. Edwards Deming,[5] renowned statistician, can perhaps serve to illustrate this point. Dr. Deming's reference is to a sample of records for July, 1953 chosen for study by a group of top executives in a specific industry to provide legal evidence in a case that threatened their industry. Dr. Deming remarked "Was this a sample? Of what? Of 1953? Not in my definition. Why Because I know of no way to place limits on the degree of uncertainty of any useful inferences that might be made from the study of July". In other words the sample was not planned to answer the question asked. What should they have done? Dr. Deming suggested that a stratified random sample of the records for the full year of 1953 would have been a much better plan for little additional cost.

Techniques to Fit Purpose

As in the case of engineering, sampling techniques must be designed carefully to suit the accounting purpose and straight application of methods from statistical texts will not be tolerated. A public accounting firm cannot be texpected to stake its reputation on any plan that does not fulfil the qualifications. The statistical approach will only be practicable when the aecountant and the statistician both understand the implications and consequences of the statistical reatment. For example, careful think-ng has gone into successful projects o reduce accounting work on inter-ine settlements for both air and rail ransportation companies. Briefly, the rrangement between two companies s to agree on specified risks that ettlements may be in error to the xtent of a fixed dollar amount. Settle-nents between companies for speci-ied periods of time are then based on amples. It has been demonstrated, to he satisfaction of the companies in-olved, that the clerical savings are ubstantially in excess of the revenue hat could be lost due to sampling rror.

nterpretation of Controllable Costs

Management has been greatly im-pressed by the effect of statistical nethods on the interpretation of con-trollable costs for the cost accounting activity. One of the advantages of a conventional standard cost system is that the accounting records will reveal variations from objective levels of costs. The periodic examination of de-viations from standard may be ex-tremely time consuming if there are many products under the system of control. Many of the cost deviations are difficult to trace and it is doubt-ful that a search for assignable causes would be rewarding. In other words, costs, as in the case of quality charac-teristics, are subject to the caprices of chance causes. Management can be saved a great deal of time if they are spared the task of attempting to ac-count for cost deviations that behave in a random manner. The statistical method has made it possible for the cost accountant to place limits on the objective cost level within which the actual costs are allowed to vary with-out particular concern on the part of management. Costs deviating by more than the limits are subjected to further examination since it is expected that significant reasons could be found for variations of this order.

In a company manufacturing chemi-cal products management was faced with the formidable task of reviewing 35,000 cost figures a month. It was not unreasonable to expect that unless outstanding disparities appeared on the cost sheets the review would be cursory and in many cases decisions would be based only on the reviewer's experience and judgment. In addition to the problem of reviewing a large number of figures, the analysis of the cost variations was complicated. Pro-duction volume varied considerably over the year with commensurate variations in production unit costs which contributed significantly to the total cost variance. Statistical control techniques were applied successfully to separate the factors affecting cost variances. Consequently the time re-quired by management to interpret the cost reports was reduced consider-ably and noticeable improvement re-sulted in the effectiveness of subse-quent decisions.

Application to Industrial Engineering

In the field of industrial engineering, statistics has been useful in devising sampling plans to estimate the produc-tion time lost because of various delays and to test the validity of work standards. The advantage of the sta-tistical approach in such cases is im-measurable since the cost of otherwise obtaining the desired information often would be prohibitive. The statistical background necessary for applications of this nature in industrial engineering is equivalent to that re-quired for statistical quality control and therefore is fully within the scope of engineering trained personnel.

Mathematical Probability

There is much evidence to support the contention that developments in the theory and application of mathe-matical probability will provide man-agement of the future with interesting and beneficial recourse. Dean Arthur Porter has recently given us an indi-cation of what to expect, in a report to the *Financial Post*.[6] Dean Porter foresees the development of a "think-ing machine" which will employ the concepts of probability to predict the future. One need not tax his imagina-tion a great deal to contemplate the meaning of such an instrument in the world of management. It might seem on the surface that less will be required of management with such equipment available and that they may not even require an understand-ing of high school arithmetic. Dr. Grant Butterbaugh[7] does not adhere to a policy of mathematical illiteracy for garduates of colleges of business administration, although he admits that in general there are tendencies in this direction. How can manage-ment be expected to understand the implications of advanced thinking if they are not equipped for it? The answer probably lies in the approach to teaching and course curricula in our educational institutions. It might be more realistic to expect that man-agement of the future will need to have a greater understanding of mathematical concepts and funda-mental scientific principles if they are to achieve the utmost benefit from developments in these areas. If this is not to be so, applied scientists and mathematicians will continue to find it difficult to sell management on the value of their endeavours.

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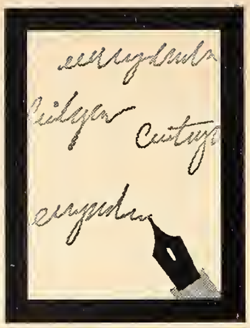
Abstracts



Papers to be presented at the 1961 EIC Annual General Meeting

AGM Paper #1

Some Reflections on Trends in Engineering Training

Arthur Porter, M.E.I.C.,
Dean of Engineering, University of Saskatchewan, Saskatoon.

In spite of the failure of academicians to recognize engineering as a true university discipline until the close of the 19th century, remarkable advances have taken place in engineering education during the past fifty years. Technological advance is essentially dynamic and the labile fringe of knowledge in the subject is necessarily highly activated because technology guards and guarantees both the economic advance and the military security of nations. This paper discusses some of the basic trends in engineering education with special reference to curricula, practical training, technological research, and the employment of professional engineers. As an example of these trends recent developments in the College of Engineering, University of Saskatchewan, are considered. A major contention is that, on account of the broad spectrum of ability of undergraduate students, two streams must be recognized and catered for in the engineering schools, there are, first the essentially technical stream, and second the engineering scientific stream. The tendency in some engineering schools, especially in departments of electrical engineering, to follow the lead of the M.I.T. experiments in electrical engineering education is considered to be an undesirable trend for reasons which are outlined.

The paper emphasizes the special importance of practical training and the part to be played by industry in establishing adequate apprenticeship schemes at all levels. Some consideration is given to the "sandwich courses" now in operation in Colleges of advanced Technology and in certain University Engineering Schools in the United Kingdom.

Technological research has gained in stature in the universities during the past few years and it is considered an essential requirement for teaching at the engineering scientist level. There is, however, some justification for the viewpoint that a high proportion of technological research may be more effectively executed in industry or in government-supported laboratories. The justification for and the nature of university technological research is considered with special reference to inter-disciplinary activities.

AGM Paper #2

Three-Dimensional Photoelastic Stress Analysis of a Diamond-Head Buttress Dam

C. R. Jones
Crippen Wright Engineering Ltd., Vancouver
J. B. Mantle, M.E.I.C.,
Head, Department of Mechanical Engineering,
University of Saskatchewan, Saskatoon

This paper elaborates on a three-dimensional photoelastic stress analysis project carried out at the University of Saskatchewan involving the diamond-head buttressess of the dam for the Squaw Rapids Power Development. The stress-freezing and slicing method was employed using one of the new three-dimensional photoelastic materials, Hysol 6000 OP. Of particular interest are the techniques used for model making by the cementing together of several machined parts and for loading the model by means of 14 Neg'ator clamps of various sizes adapted to act as compression springs. Typical calibration curves are given for these loading devices plotting force against clamp extension under operating conditions. Results provided include representative isochromatics with tangential stress distributions around the galleries and magnitudes and directions of principal stresses for the web.

AGM Paper #3

Watershed Resource Value—The Associated Development of Fish and Power

Val Gwyther
Val Gwyther & Co. Ltd., Consulting Engineers, Vancouver

The necessity to conserve the salmon resource, in the many watersheds of British Columbia has retarded the development of other resources (primarily hydro electric power) due only to present inability to ensure present production of salmon by natural spawning and rearing in fresh water. This condition exists today even though we are unable to affix a definite yearly value to salmon production due to variations in climate and other influences of nature. In order to conserve and increase production of the salmon resource in a watershed, from which we wish to obtain the benefits of power, we must provide means to protect these fish, in their entire fresh water life. This paper discusses matters vital to proper understanding of salmon production in large quantities jointly with power. With this joint development of watershed value, where large lake areas exist or are impounded, the value of the salmon resource may well exceed that of power.

AGM Paper #4

The Hydraulic Capacity of Large Corrugated-Metal Culverts

C. R. Neill, M.E.I.C.,
Hydraulic Engineer, Research Council of Alberta

In designing corrugated-metal culverts, engineers customarily use either the slope capacity charts published in the handbook of the leading manufacturer, or the head-capacity monographs issued by the U.S. Bureau of Public Roads. Both of these sources of design information have certain deficiencies, and are apt to be used indiscriminately for problems to which they are not really applicable. Believing that there was need for experimental checking of existing hydraulic design information and also for a more convenient form of presentation, the Bridge Branch of the Alberta Department of Highways recently initiated a research program into the problem, undertaken under the auspices of the Joint Highway Research Project in Alberta, which includes the Department of Highways of the province, the Research Council of Alberta, and the Civil Engineering Department of the University of Alberta as participating bodies. This paper describes the field experiments carried out to date, and the development of a method of analysis which enables head-capacity charts to be produced for all sizes, lengths, and slopes.

AGM Paper #5

Effects of Changing Technology on Labour and Employment

W. Bruce, M.E.I.C.,
Professor of Mechanical Engineering, McGill University

In recent times, the tremendous expansion in the application of scientific principles and knowledge to an ever-widening range of man's activities has been strikingly displayed in the growth and development of technology. This activity has provided a stimulation which has penetrated almost every phase of industry and its repercussions are being constantly felt. The creation of a continuous stream of new materials, processes and methods, combined with the devising, building and maintaining of devices of increasing variety and complexity are resulting in significant changes in the contributions required from labour at all levels. This is reflected in the altering nature and composition of the labour force, in the educational and skill requirements involved, and in the employment opportunities which occur.

In such an environment it is essential that man be able to adapt readily to rapid evolution and change in his working activities; to accept reduced or even complete elimination of skill or labour requirements in some areas, and in others, to exert greater work efforts in the sense of acquiring new knowledge or learning new skills and techniques. To gain full advantage of the benefits of modern technology the organizational structure of industry needs to keep pace with technical developments. Flexibility in the work forces both in disposition and in kind is a necessary requirement.

AGM Paper #6

Weaknesses of the Theory of Plastic Design

A. Hrennikoff, M.E.I.C.,
Professor of Civil Engineering,
University of British Columbia, Vancouver

As the advocates of the plastic theory of design of steel structures bring it more decisively into the field of practical application, its weaknesses become more conspicuous. While the basic or rigid plastic theory is quite simple and logical the situation changes on the appearance of buckling. Instability conditions are difficult to analyze even in the elastic range. The plastic theory, operating with loads magnified by the load factor, projects the stresses beyond the elastic limit where the problems of buckling become virtually intractable. This situation leads to the use of doubtful and inadequately substantiated formulae and procedures. Furthermore, some of the loading conditions used in the theory appear arbitrary, making the safety of design questionable.

AGM Paper #7

The Use of an Electronic Analog Computer for Determining Optimum Settings of Speed Governors for Hydro Generating Units

L. M. Hovey, M.E.I.C.,
Consulting Engineer,
The Manitoba Hydro-Electric Board, Winnipeg

The author describes the use of a small nine element electronic analog computer which can be used for analyzing dynamic problems encountered in power systems which involve the solution of differential equations. The general principles of the computer are described with examples of how the units are connected up to solve certain well known equations. The computer has been successfully used by The Manitoba Hydro-Electric Board for analyzing and demonstrating governor performance of a hydraulic turbine generator. This analysis involves the solution of three simultaneous differential equations. A description is given as to how the computer is connected up to solve these three equations and graphs will be included showing the effect on speed regulation when the parameters of the turbine and governor are varied.

AGM Paper #8

The DRB Topside Sounder Satellite

R. C. Langille,
Superintendent, Electronics Laboratory,
Defence Research Telecommunications Establishment, Ottawa

The Defence Research Telecommunications Establishment has studied the ionosphere over northern Canada for the past fourteen years in order to better understand the difficulties of high frequency radio communication in the auroral regions. The reflecting and absorbing properties of the ionosphere to high frequency radio waves prevents much knowledge from being obtained about the upper part of the ionosphere by radio soundings from the surface of the earth. Since a knowledge of the upper part of the ionosphere would be most useful in radio communication studies, it was decided to study the ionosphere from above by means of an earth satellite.

The Topside Sounder satellite will carry a sweep frequency ionospheric sounder somewhat like those used for sounding the ionosphere from the earth's surface. It will cover the frequency range 1.5 to 11.5 Mc/s and will telemeter the information to ground stations on a frequency of 136 Mc/s, which is not affected by the ionosphere. The satellite will be launched from the west coast of the USA early in 1962. It will be in an 80° inclination circular orbit at a height of about 650 miles. The design of the experiment and the construction of the 275 lb. satellite package will be described. The package is being designed and built in Canada, and will be placed in orbit by a rocket supplied by the National Aeronautics and Space Administration of the USA.

AGM Paper #9

Urgent Tasks in Engineering Education

D. M. Myers, M.E.I.C.
Dean, Faculty of Applied Science, University of British Columbia, Vancouver

Engineering education is at present in a state of flux. It is the subject of widespread discussion and recent years have brought forth a profusion of conflicting views. Some of these views are progressive and range from the mild to the extreme; others are conservative or reactionary. University engineers are now in the throes of making what are probably the most important decisions in the history of engineering education. The purpose of this paper is to stress that rigid and sometimes dogmatic adherence to what have hitherto been regarded as basic principles might very well lead to stagnation and even extinction of engineering as a profession.

The paper deals particularly with the requirements for *uniformity* and *breadth* in engineering education. The author examines these two factors and makes suggestions as to how to achieve adequacy without undue uniformity, and depth without undue sacrifice of breadth.

AGM Paper #10

The Factors Involved in the Design of a Canadian Gangsaw

E. N. Parker, M.E.I.C.,
North Vancouver, B.C.

Gangsaws are less well known than the other types of saws used in the production of lumber in Canada. They have been used in Europe for a considerable time and have also been employed extensively in North America under somewhat different operating conditions. These two types of operation are contrasted.

The various types of saws available are discussed and some of the factors affecting the user's choice of a saw are outlined. Service conditions affecting the overall design are covered and a description of the components and their function in a typical gangsaw is given.

The design considerations for the various parts of the saw are reviewed and the choice normally available concerning the selection of materials and the placement of components is outlined. Power sources and requirements for operating the saw are also mentioned.

AGM Paper #11

Current CSA Specifications on Engineering Design in Timber

J. W. Wynand
Chief Engineer, Timber Preserves Limited,
New Westminster, B.C.

During recent years, considerable improvements of design procedure and construction practice, based on intensified research and recognized engineering principles, have been achieved in the timber construction field. This development was not restricted to sawn timber construction only, but encompassed manufactured timber products, such as glued-laminated timber and structural building components made of plywood, foundation piling and pole frame construction, as well as wood preservation, timber fastenings and adhesives.

In order to make the results of this development work available to engineers and architects, it was necessary to establish new data covering materials and design procedure, in recognized specifications and codes. After presenting the complete list of CSA Specifications dealing with structural wood and wood products, a more detailed discussion of the changes and reasons for changes, of working stresses, grades, design procedures etc., follow.

AGM Paper #12

On the Treatment of Stochastic Variables in Engineering Design

J. H. Milsum,
Head, Analysis Seetion, Division of Mechanieal Engineering, National Research Couneil, Ottawa

In recent years it has become essential to consider stocrastic or random input variables in the design of many engineering systems, with consequent modification of classical design procedures which were based upon steady-state, sinusoidal or transient inputs.

Most natural signals affecting engineering systems are partially random at least. In control systems, the randomness is propagated around a closed loop. Analytic design is possible for linear system, but in the more realistic non-linear case approximate methods are required unless solution is made by computer. For engineering purposes there are two essential measures of stationary random signals — the amplitude probability density function (APD) and the power spectral density (PSD) or its Fourier transform, the autocorrelation function. Some commonly encountered APD's are presented in the paper, PSD's are introduced and the mathematical relation for filtering of PSD's by dynamic systems is discussed. The experimentally-determined characteristics of several natural signals are discussed.

AGM Paper #13

Engineering Research on the Fish and Power Problem

J. F. M. Muir, M.E.I.C.,
Head, Department of Civil Engineering, University of British Columbia, Vancouver.
Eugen Ruus,
Assistant Professor, Civil Engineering Dept., University of British Columbia.

Recent fisheries-engineering research in the United States and Canada on the safe passage of anodromous fish past dams of low and intermediate heads is described. The development of the great rivers of British Columbia for fish, power, and flood control is discussed. Fish passage facilities for a proposed dam and generating station of 700,000 horsepower near Spuzzum on the Frazer River are described. A fisheries-engineering research program is recommended.

AGM Paper #14

The Need for Research in Planning Mechanization

J. C. Clapham,
Head, Operating Researeh Section, British Columbia Researeh Council, University of British Columbia, Vancouver

Companies will be compelled to continue mechanizing because of pressure from competing companies and industries. Present methods of selecting mechanization projects normally involve the assessment of a small number of alternatives obtained by: (1) surveying latest examples in the industry (subjectively correcting for differences in application); (2) drawing parallels from other industry; (3) using creativity or ingenuity.

Operations-research overcomes the limitations of these methods by directing exploration and evaluation of alternatives in the following ways:

a) It makes possible a quantitative assessment of a proposed scheme in the particular circumstances to which it is to be applied.
b) By indicating the sensitivity to various factors, it can direct creativity by guiding its application to useful areas.
c) By a more systematic exploration of possibilities, it can arrive at near-optimum solutions.

Since many problems of mechanization are fundamental and complex, industry-wide support for research in this field is suggested.

AGM Paper #15

Unique Design in Glulam

B. Madsen,
Chief Engineer, Glulam Products Limited, New Westminster, B.C.

Potash is one of the major components of modern-day fertilizers. Until recently potash had to be imported from New Mexico and transportation constituted a great part of the cost. When Potash was discovered in Esterhazy, Sask., plans were started for development of the rich and important mine. The structures described in this paper are the Storage Buildings. The demand for fertilizer is highly seasonal and it is necessary to have storage facilities to accommodate several months production. The problem faced was to develop a design which would meet the speical requirements. The pile to be covered consisted of a 204 ft. diam. cylinder 16 ft. in height, located below the ground level. The potash would form a 62 ft. high cone on top of this. The structural frame would have to be entirely outside of this space. The paper describes the seletcion of the materials, the design, construction, testing and other pertinent factors.

AGM Paper #16

Douglas Fir Plywood Manufacture

John S. Abel,
Consulting Engineer, Taeoma, Washington

This paper gives an outline of the engineering phases of the plywood manufacturing process for Douglas Fir Plywood. It describes the general design of a plywood plant, type of buildings, steam and electrical supply, plant arrangement, and manufacturing equipment involved.

In addition to the engineering features it describes a number of the process steps with which the engineering is closely related. The manufacture of plywood involves block handling, peeling, transporting and handling green veneer through the tray system, clipping to size, storing green veneer, drying, sorting dry sheets, patching, gluing, pressing, trimming, sanding, patching and finishing. The nature of plywood manufacture is such that no two plywood plants are alike. To give a clear general picture the author has described a simple straightforward conventional plywood plant, a one lathe, one dryer, one press installation. The balancing of the stock throughout the operations will ordinarily make such simplicity impractical and this is commented on in the paper.

Moisture content of veneer and its behaviour in the make-up of plywood, and problems related to gluing panels, are mentioned. Press operation, which is the heart of the process, is treated at some length and the press is described in detail.

This paper is not intended primarily for those engaged in the business of plywood manufacture but is written to give to an engineer interested in plywood plan design an over-all idea of the technical requirements and problems involved in the design of a plant for the economical manufacture of Douglas Fir Plywood in British Columbia and the Pacific Northwest.

AGM Paper #17

The Limit Design of Reinforced Concrete Continuous Beams

C. Berwanger, JR.E.I.C.,
Assistant Professor, Dept. of Civil Engineering, University of Manitoba

The continuous beam is encountered with sufficient frequency in structural design to warrant special consideration of its solution. The most familiar of elastic solutions is the moment distribution method. However, the advantages of the more rational inelastic design methods have been established with the Plastic Design Theory for steel structures. The uniformity of safety factor leads to a more economical use of materials and the simpler methods to savings in the design office.

The inelastic or Limit Design method presented in the paper considers continuous beams to be made up of smaller segments or elements: propped cantilevers (exterior spans) and fixed beams (interior spans). A complete solution of these continuous beam elements for required moment and rotation capacities is presented for both concentrated and uniform distributed loading. The solutions are presented in graphical form to facilitate design.

The application of a safety factor to the required rotation capacity is recommended where the fixity at the continuous support is not that of a fixed end. Expressions for the moment and rotation capacities of reinforced concrete sections are presented. The use of equivalent loads replacing combinations of loading is demonstrated in a design example which also illustrates the proposed Limit Design method.

AGM Paper #18

The Beechwood Fish Hoist

J. D. Denovan, M.E.I.C.,
Assistant Office Engineer, Civil Division, The Shawinigan Engineering Company Limited

Among the rivers in New Brunswick utilized by the Atlantic salmon for spawning is the St. John River and its tributaries. When designing the Beechwood hydro electric power station on the St. John River, it was imperative that adequate fish handling facilities be provided to transfer fish from below the damp up to the forebay of the development. The elevator fish hoist selected for this purpose was developed in close co-operation with the Department of Fisheries and realized substantial economies in construction over the alternative facilities considered for the site.

This paper considers the general conditions affecting the selection of facilities and the factors establishing the criteria for design. It describes the fish handling facilities and in particular, the fish hoist, which were installed at the Beechwood Development, and relates some of the operating experience gathered since these facilities were placd in service. Modifications to the facilities resulting from this operating experience are also considered.

AGM Paper #19

Some Problems Encountered in Underwater Sound Propagation Research

H. H. A. Davidson,
Pacific Naval Laboratory, Esquimalt, B.C.

The Pacific Naval Laboratory was established by the Defence Research Board in 1948 to do research in marine physics in support of the national defence program. Early work was devoted entirely to underwater sound propagation. Echo studies with triplane and spherical targets were characterized by fluctuations of received signals over a wide dynamic range, necessitating the development of special logarithmic amplifiers for reception. In long range propagation experiments, the limiting factor was ambient noise at the receiving ship, originating both in ships' machinery and in wave action. To overcome this problem, hydrophones and pre-amplifying units were installed in a remote drifting buoy, with radio telemetering links to relay data to the receiving ship. The noise background then was found to be flow noise generated by motion of the hydrophones. Neutrally buoyant hydrophone assemblies were devised to reduce the flow noise to a minimum.

The handling of heavy targets, buoys, transmitting and receiving arrays at various depths and in rough seas presented formidable mechanical difficulties.

AGM Paper #20

Carillon Foundation Studies

C. H. Pigot, M.E.I.C.,
Assistant Chief Engineer, Power Development Division, Quebec Hydro-Electric Commission, Montreal
I. D. MacKenzie, M.E.I.C.,
Geologist, The Shawinigan Engineering Company Limited, Montreal

To verify assumptions used in the design of the Carillon Hydro-Electric Power Development, an in-situ shear test was carried out during the fall of 1960 on a particular shale bed which had been identified as the weakest in the area. This bed was located strategically some 10 to 20 ft. above the foundations of the sluiceways. A 36 in. diam. calyx drill, a wire saw, and hand labour were used so that the test blocks, five in all, could be exposed with a minimum of disturbance to the shale bed. A hydraulic jack assembly, consisting of a hand-operated jack, a ball and socket joint, and a roller path, was used, acting against a reaction beam, to apply predetermined vertical loads. The horizontal load was applied by large diameter twin hydraulic jacks arranged so that their extremely slow rate of travel was identical and independent of the resisting force encountered. In four out of five of the tests, primary consolidation was completed prior to the application of the shearing force; in Test 5, the horizontal load was applied immediately after application of the vertical load. This paper is not intended to be a profound discussion on the theories of soil mechanics or foundation design but rather a description of the methods used and the results obtained in performing in-situ shear tests on a particular altered shale bed in the bedrock at Carillon. It is hoped that this description of the tests will be of help to engineers confronted with similar problems at other locations even though the shear strength values obtained at Carillon may not necessarily be applicable.

AGM Paper #21

Side-Tipping Log Barges

T. A. McLaren, M.E.I.C.,
President and Managing Director, Allied Builders Ltd., Vancouver

The movement of logs over the exposed waters on the west coast of Vancouver Island and Queen Charlotte Island has presented a transportation difficulty. The latest development for handling these logs on exposed waters is the side-tipping log barge of which several units have been built in the past few years. The side-tipping log barge is essentially a quick turn around movement. An efficient logging camp can load approximately M'BM in 12 to 16 hours. The barge can be towed at a speed of 6½ to 7 knots loaded and about 8 knots light in fair to moderate weather. The time required for unloading varies from 10 to 30 minutes. It is not suggested that the side-tipping log barge, described in detail in the paper, is by any means the final development in log transportation. The side-tipping barge still has several disadvantages. However, the advantages gained have made other methods of transporting logs in exposed areas obsolete.

AGM Paper #22

The Production, Handling and Uses of Tonnage Oxygen by Cominco

C. H. Simpkinson,
Assistant Superintendent of Development Research
Chemicals and Fertilizers Division
The Consolidated Mining and Smelting Company of Canada Limited, Trail, B.C.

In the early thirties when The Consolidated Mining and Smelting Company of Canada Limited (Cominco) at Trail, B.C., first launched into the chemical fertilizer field the production of ammonia was a major concern. Consequently, an electrolytic plant was built for the generation of hydrogen from water and a Claude air liquefaction plant was installed to supply nitrogen from the air. The large volumes of by-product oxygen released posed a utilization problem. Transportation costs eliminated the possibility of sale to outside markets so in-plant uses were developed. These included the use of oxygen in sulphur dioxide reduction furnaces, its use as a chemical reagent in a cyclical sulphuric acid plant, oxygen-enriched air in suspension roasting of zinc sulphide concentrates, oxygen air blast in lead blast furnaces and in slag retreatment furnaces.

By far the largest tonnage of oxygen is produced from the hydrogen cells. Details of production, collection and distribution are given. Materials of construction, special operating problems and hazards are discussed. Oxygen is the breath of life if properly used, but there is danger in careless handling.

AGM Paper #23

The Inspection, Repair and Maintenance of Highway Bridges in the City of London, Ontario

R. M. Dillon, M.E.I.C.,
Dean, Faculty of Engineering Science,
University of Western Ontario, London, Ont.

P. H. D. Edwards,
Structural Design and Project Engineer,
M. M. Dillon & Company Ltd., London, Ont.

Increasingly, over the last few years, maintenance of existing concrete and steel bridges has become a major problem throughout Canada. While this is due in part to the natural aging of the large number of such bridges constructed in the 1930's, it is, however, evident that the use of de-icing salts in winter road maintenance is greatly accelerating the deterioration of these structures.

The City of London, Ontario maintains 10 major crossings of the Thames River and a number of subways, overheads and minor structures. A thorough inspection was carried out. This paper discusses certain problems and design faults encountered during this inspection and makes certain recommendations in connection with inspection routine and future new construction.

AGM Paper #24

Speed Regulation for Hydraulic Turbines

W. J. Smith, M.E.I.C.,
Chief Civil Engineer,
Montreal Engineering Co. Ltd.

J. L. Gordon, JR.E.I.C.,
Supervising Engineer, Civil Section,
Montreal Engineering Co. Ltd.

This paper outlines a procedure for determining the variations in frequency of hydro electric generating units operating in isolated systems resulting from sudden load changes. Data from tests which tend to confirm the accuracy of theoretical computations is presented.

Also, from experience gained through the installation of over forty hydro electric developments, and their subsequent performance, criteria are presented for the assessment of the inertia required in a generating unit, depending on the type of operation (base load or peak load) and on whether the unit is isolated or interconnected with a system.

AGM Paper #25

The Hows, Whys and Wherefores of EHV Transmission

C. M. Stairs,
Specialist — Power Systems Engineering, Systems Application Engineering, Apparatus Department,
Canadian General Electric Co. Ltd., Peterborough, Ontario

In this paper the general topic of Extra High Voltage Transmission is reviewed with particular emphasis being placed on its economic position in the power systems of the future, rather than on the technical struggles which have made its use possible. In order to outline the economic facts to all interested engineers the technical content is kept to an absolute minimum.

The main conclusion which is drawn from this analysis is that the advent of EHV will not, in the majority of cases, drastically influence the cost of power delivered to the ultimate user from a distant power site or over an interconnecting tie between neighbouring utilities. On the other hand the transmission line savings associated with the use of EHV can amount to many millions of dollars and therefore will fully justify a continuing research and development program.

AGM Paper #26

Commentary on CSA Standard S16-1961

W. G. Mitchell, M.E.I.C.
Chief Design Engineer Canadian Bridge Works, Dominion Steel and Coal Corp. Ltd., Riverside, Ont.
D. L. Tarlton
Development Engineer, Canadian Institute of Steel Construction, Inc., Toronto

The new Fifth Edition of CSA Standard S16, "Steel Structures for Buildings", contains several modifications and revisions when compared with the requirements of the Fourth Edition published in 1954. Technological progress in steelmaking and fabricating methods, as well as extensive research into the actual behaviour of steel members and connections, made the publication of an up-to-date specification imperative.

Rules and formulae which had been satisfactory when applied to the type of structural steel used almost exclusively heretofore had to be reviewed in the light of a trend toward improved mechanical properties and a greater number of readily available grades of steel. Of necessity, the size of the Specification had to be increased. Here the problem was to avoid giving the designer too little guidance, while at the same time trying to prevent the extension and elaboration of the specification material into a work of text-book proportions.

The treatment of unit stresses, the design of fasteners, and the incorporation of detailed requirements for plastic design all represent departures from the format of previous editions. It is the hope of the authors that this commentary may serve the structural designer by offering a logical analysis of the reasons for the major revisions and, in so doing, minimize the possibility of an incorrect interpretation of the specification requirements.

AGM Paper #27

An Evaluation of Plywoods and Plastics in Boat Construction

John Brandlmayr, M.E.I.C.,
President, John Brandlmayr Ltd., Vancouver.

This paper evaluates the place of plywoods and plastics in the construction of boats under 100 feet in length. All other hull construction materials including solid wood, and the various metals are first briefly considered. Then the physical and economic characteristics of plywood hulls are outlined and current construction practice is described. The same is done for plastic hulls which are nearly all of fiberglass reinforced polyester resin.

Manufacturing costs are compared for different materials and the results of a cost comparison study of 35′ sloops in wood compared to fiberglass construction are given in graphical form. Plywoods are displacing solid woods in power boat hulls and in the case of power boats over 20′ have a cost advantage over fiberglass. Fiberglass has become the dominant material for small power boats and for sailboats up to 40′. Further aims in boat building materials are discussed.

AGM Paper #28

Have We a Problem in Engineering Education?

W. F. McMullen
Engineering Personnel Manager, Canadian General Electric Company Limited

It has been said that the hardware, plumbing and wiring should be drastically reduced in today's undergraduate engineering curriculum. The student's time should not be wasted in teaching specialized techniques that are certain to become obsolete. Some engineering curricula in Canada are moving towards teaching only scientific and engineering fundamentals, with the expectation that industrial experience will do the rest. Is this a correct approach based on our present economy and current utilization of engineers? In Canada we are primarily concerned with building *things*, and our need is for engineers, not scientists.

For many reasons, one of which could be called geographical, the input into our engineering schools is made up of students with very little concept of what is involved in engineering or scientific work. Many students could be said to have "backed into" engineering simply because, since a University education is the thing, engineering looked as good a course as any. This appears to be compounding our problems of proper utilization.

AGM Paper #29

Revision of The Reinforced Concrete Section of the National Building Code

Mark W. Huggins, M.E.I.C.,
Professor, Department of Civil Engineering, University of Toronto
W. G. Plewes, M.E.I.C.,
Research Officer, Building Structures Section, Division of Building Research, National Research Council, Ottawa

When the Revision Committee on Concrete for the 1960 edition of the National Building Code of Canada began its work, a new Canadian Standards Association Specification on Concrete Materials was ready for publication and was considered satisfactory for the concrete materials portion of N.B.C. It was thought, however, that the C.S.A. Code on reinforced concrete was in need of revision to bring it up to date with the American Concrete Institute Standard Building Code 318-1956 and also to incorporate those changes in N.B.C. 1953 which had been issued as revision slips.

The most important changes in the Code may be listed under the headings of shear, bond and anchorage, and crack and deflection control. The section of N.B.C. 1960 dealing with shear, bond and anchorage has been considerably strengthened with a view to ensuring that there will be no repetitions of failures such as those which occured in United States Air Force warehouses in 1955 and 1956. With a view to minimizing cracking, the new Code requires more careful attention to the effects of shrinkage and temperature and to means of guarding against these effects. The Marcus method has been adopted for two-way slabs to replace the present A.C.I. method which occasionally result in designs with inadequate negative bending steel and consequent concrete cracking.

A table of permissible span to depth ratios for beams made with Standard aggregate concrete, as well as a means of adjusting for light weight concretes, has been included in the Code. The maximum permissible slenderness ratio for columns has been increased with the requirement that such increased ratios shall only be used where full allowance has been made for the effects of end conditions and shrinkage and plastic flow.

AGM Paper #30

The Port Mann Bridge Superstructure

G. Hardenberg
C.B.A. Engineering Ltd., Vancouver, B.C.

The Port Mann Bridge, now under construction, over the Fraser River is a major link in the Trans Canada Highway section between Vancouver and the Fraser Valley. The basic requirements for the design of this structure called for a four-lane, 54 ft. wide roadway with two 5 ft. sidewalks and a Main span of 1200 ft. with a vertical clearance of about 145 ft. Due to extremely poor soil conditions at the site — the foundations of the Main Piers reach about 200 ft. below ground elevation — all designs which would transmit appreciable horizontal loads to the foundations such as suspension bridges and stiff arches were accordingly ruled out.

Comparative studies indicated that a design incorporating an orthotropic steel deck was definitely more economical than any of the other types investigated. The main structure consisting of a Main span of 1200 ft. with flanking side spans of 360 ft. is a stiffened tied arch i.e. an arch designed only to sustain compression forces, the necessary stiffness and load distribution being provided by stiffening girders. The stiffened tied arch is well suited for use with an orthotropic plate, which acts as part of the Main girders (top flange of stiffening girders) in addition to its function as bridge deck. The arch ribs are riveted box sections of about 52 in. x 55 in.; the stiffening girders riveted box members with a depth of 12 ft. and the steel deck consists of a steel plate, maximum thickness of ½ in., longitudinally stiffened by box stiffeners spaced 2 ft. ctc and supported transversely by crossbeams spaced at 6 ft. 3 in. ctc. The deck panels, each about 65 ft. (the width of the bridge) by 25 ft. are completely shop welded. All field spliees except for the transverse deck splices are designed for high strength bolts. The latter will be countersunk riveted connections, in order to obtain a sufficiently flat base for the asphalt road surface. Extensive use is made of low alloy steel in the main load bearing members and for the welded deck a special notch ductile quality has been specified.

AGM Paper #31

The Behavior of Rarefied Gases

D. S. Scott
Associate Professor,
University of British Columbia, Vancouver

A rarefied gas is defined for the purpose of this article, as a gas in which the molecular mean free path approaches some dimension of the containing equipment. In general, two cases of industrial importance can arise, first, the design and functioning of high vacuum systems operating at low absolute pressures, and second, the flow and diffusion of gases in solids with a fine pore structure. In the first case, equipment dimensions are "normal" and the molecular mean free path is abnormally large, and in the second case, the container dimensions are very small. Freeze drying, vacuum distillations, and flow in porous reservoir rocks or porous catalytic solids are examples of practical importance.

The kinetic behavior of rarefied gases is discussed. Accepted flow and diffusion formulae for gases are presented for the limiting cases, and two new formulae for the "slip" flow and "transitional" diffusion range are presented. In the light of the above discussion of flow and diffusional behavior, the important correlations for heat and mass transfer processes in rarefied gases are presented and evaluated. Finally, some practical examples of possible industrial importance are given in which behavior as a rarefied gas might be expected to occur.

AGM Paper #32

New Uses for Ceramic Materials in Microwave Tubes

G. B. Walker,
Research Professor, University of British Columbia, Vancouver

At the present time low-loss ceramics, such as alumina, are extensively used in microwave tubes mainly as supports for electrodes and as vacuum windows through which the power generated may pass into an external waveguide system. The remarkable electrical and mechanical properties which can be obtained with recently developed ceramics holds some promise that these materials may find some applications in which the ceramic plays a more direct part in the operation of the tube.

At wavelengths in the centimetre and millimetre region it is necessary that the dimensions of the tube become comparable with the wavelength and this has lead to new principles of design, e.g. the klystron, the magnetron and the travelling wave tube. A large number of successful structures have been developed, but all suffer from certain disadvantages at U.H.F. operation, e.g. the size becomes minute raising constructional difficulties and cooling problems and moreover, metal losses increase with frequency so that efficiency is impaired.

Ceramics offer at least a partial solution to many of these problems, points of interest being simplicity of construction and electrical efficiency. Ceramic slow-wave structures also offer interesting possibilities for the design of high-energy electron linear aceelerators, but research in these fields is still at an experimental stage with many questions to be answered.

AGM Paper #33

Economic Development of Hydro-Quebec Power Resources—System Studies Utilizing an IBM 704 Computer

J. Bourbeau, M.E.I.C.,
Quebec Hydro Electric Commission.
F. H. Jonker and J. G. S. Thomson,
H. G. Acres & Company Limited

To facilitate the Quebec Hydro-Electric Commission's planning of the development of power sites, a model of the Commission's expanding system has been simulated on an IBM 704 computer. The nature and scope of the model, and the methods of analysis used, are described.

AGM Paper #34

Design Consideration for Large Radio Telescopes

J. L. Locke,
Officer in Charge, Dominion Radio Astrophysical Observatory,
Department of Technical Surveys, Penticton, B.C.

Recent observations of the radio emission from celestrial objects have provided the astronomer with much new information. But the observations have shown the need for radio telescopes having larger apertures than those now available. For centeimetre wavelengths the only suitable type of telescope appears to be one having a large reflecting surface, usually a paraboloid of revolution, which focusses the radiation on a small antenna. The design of telescopes of this type presents many engineering problems. The mount must allow the telescope to be pointed to any part of the sky with high precision and a drive system must be provided for the accurate tracking of celestrial objects. Severe tolerances are placed on the reflecting surface which must maintain its accuracy for all orientations.

The factors influencing the design of radio telescopes of various sizes for use at different wavelengths are discussed and the manner in which the problems have been solved in existing and planned telescopes is outline. The possibility of telescopes of extremely large aperture is discussed.

AGM Paper #35

Civil Engineering Education

S. D. Lash, M.E.I.C.,
Head, Department of Civil Engineering,
Queen's University, Kingston.

Civil engineering is a profession in which art and science are integral parts of a coherent discipline. The universities are training two groups of people, an élite — who will in due course become professional engineers, and a larger group whose activities will often be of a sub-professional or non-professional character. Undergraduate training must therefore consist of general education plus a broad programme of engineering studies, the latter consisting of applied science and technology. The heart of an engineering course is applied science and there is a danger of over-emphasizing the importance of basic science and mathematics and of under-emphasizing the humanities. There is room for variety in e technological content of civil engineering courses and me selection must be made. Although practical experience an essential part in the training of a civil engineer it is ot necessary that it be done in summer vacations and niversity courses might well be shortened for those who ish to get their degree first and their practical experience ter.

Graduate study is an increasingly important part of civil gineering education and at the Master's level greater mphasis is now being placed upon course work than ormerly. There is a danger that both Master's and Doctor's ograms may be extended over excessive periods of time.

AGM Paper #36

)utlook on the Relationship between Load-Frequency Conrol & Turbine Governors on Interconnected Power Systems.

.. O. Long

)esign Engineer with the Electrical Division, Shawinigan ngineering Company, Montreal

In view of the trend towards interconnection of power ystems for the many benefits derived therefrom, this paper eviews briefly the basic requirements of the mechanical-ydraulic turbine governors and automatic load-frequency ontrol. The basic principles of the electro-hydraulic turbine overnor are briefly outlined drawing attention to its adantages particularly with respect to area-wide load-frequency control.

Certain operating problems caused by inter-action beween governors and load-frequency control and between ontrol systems of interconnected utilities are described. ome suggestions are advanced to improve power regulation n interconnected systems.

AGM Paper #37

Non-Linear Control for Distillation Columns

G. A. McNeill,

Monsanto Chemical Company, Limited,

formerly with Canadian Chemical Company, Ltd.

A balanced distillation column has inherent non-linearity n its operation. This can be used to effect a simple optimizng controller which will optimize the separation. Only tandard control hardware is required which makes for implicity and reliability.

The method was specifically developed for use with a hromatograph analyzer but could also be adapted to conentional temperature measurement or other type of analyzers.

AGM Paper #38

Rearward Communications for BMEWS

Leo J. Hammerschmid, M.E.I.C.

Terminal Equipment Engineer, Toll Area,

The Bell Telephone Co. of Canada, Montreal

This paper deals with the communication aspects of the Ballistic Missile Early Warning System, which is designed to give the North American Air Defence Command the warning time necessary for retaliation, should an enemy ICBM attack be launched across the northern polar regions. A brief description is given of the BMEWS system, including the three Forward Detection Sites at Thule, Greenland; Clear, Alaska; and Fylingdales Moor in Yorkshire, England. This is followed by information on who is building the system, and how various Canadian communication companies are contributing. For the sake of completeness, the missile detection process is briefly described.

The Rearward Communication System, designed to convey information rapidly and accurately between the Detection Sites and the Display Facility is considered in more detail. The basic objectives are reviewed, new developments made necessary by the stringent communication requirements are mentioned, and the rearward routes from Thule and Clear are described. The route control concept is defined and the various types of circuits in each rearward "circuit package" are described. Details are given of the special Data Transmission System designed specifically for BMEWS, and include the Data Signal Format, the Triple Interleaved Parity method employed for error detection, the Operating Modes, and the Automatic Status Reporting System.

AGM Paper #39

Some Engineering Applications of Analog Computers

T. W. McDonald and P. N. Nikiforuk

Assistant Professors of Mechanical Engineering, University of Saskacthewan

This paper presents a discussion of some engineering applications of analog computers. In this paper analog computers are subdivided into two main groups: the special purpose machines, and the general purpose machines. As an introduction to the subject, a general description is first given of these two groups. Following this a detailed description is given, together with examples, of conducting sheet analogs, resistance-capacitance network analogs and d.c. electronic analog computers. These computers are compared consequently as far as accuracy, flexibility and maintenance are concerned. Some of the examples quoted are descriptions of work presently being done in the Mechanical Engineering Department at the University of Saskatchewan.

AGM Paper #40

The NAE Five Foot Supersonic Wind Tunnel

K. F. Tupper, M.E.I.C.

President, Ewbank & Partners, (Canada) Ltd., Toronto

P. B. Dilworth, M.E.I.C.

President, Dilworth, Secord, Meagher and Associates Limited, Toronto

L. A. Jenkins

Project Engineer, Dilworth, Secord, Meagher and Associates Limited, Toronto

The achievement of increasingly higher speeds in large scale conventional types of continuous operation wind tunnels entails an excessive premium in both capital and operating costs. Such wind tunnels also present serious technical problems in the design of compressors and drives suitable for operation over a wide range of operating speeds and air densities, and in the removal of the substantial quantities of heat generated during operation. As a result of these factors, a new generation of high speed wind tunnels have evolved during the past decade based on the principle of intermittent operation and "driven" by high pressure compressed air drawn from a large storage vessel. The new NAE five foot high speed wind tunnel now nearing completion at Uplands, Ottawa constitutes the latest and probably the most versatile of large wind tunnels of this type in North America. It will have a useful operating speed range from Mach 0.2 to 4.5 at stagnation pressures from 1.8 to 13.7 atmospheres. This paper presents a general description of the NAE High Speed Wind Tunnel facility and major wind tunnel components and discusses some of the basic technical problems entailed in its design.

AGM Paper #41

The Combustion of Gasoline during Engine Starting at Low Temperature

F. D. Hamblin, M.E.I.C.,
Special Lecturer in Mechanical Engineering, University of Saskatchewan, Saskatoon

The mechanical engineer with a specific interest in internal combustion engines, experiencing his first Canadian winter, finds his attention drawn to the effects of the low temperatures on engine performance. Fuel consumption of gasoline engines is increased during the winter months; yet a library study indicates that little work has been done in this field. The main part of the available information is concerned with lubrication problems, while the combustion of the fuel has been almost entirely ignored. The increased fuel consumption is no doubt partly due to the increased viscosity of the lubricants in the engine, transmission and rear axle. However, it does not seem credible that the magnitude of the increased can be attributed to lubrication alone; suggesting that poor combustion of the fuel might also be a contributing factor. The fuel consumption should be approximately constant during the running phase since the engine operates at about the same temperature in both winter and summer. Thus, the increase must occur during the starting and warm-up phases. Compared to summer temperatures, the starting phase may extend over a longer period and the warm-up phase is most definitely prolonged at low ambient temperatures.

An extensive research program, dealing with the combustion of gasoline during the starting and warm-up phases, has been started at the University of Saskatchewan. It seemed logical to consider the starting phase initially, with an extension into the warm-up phase in the light of the results of the starting tests. The initial investigation is now complete and the results are reported in this paper.

AGM Paper #42

The Thermal Wedge Effect in Hydrodynamic Lubrication

John Young
Assistant Professor, Department of Mechanical Engineering, The University of British Columbia, Vancouver

Thrust bearings composed of flat parallel surfaces can operate under fluid film conditions by the formation of a 'thermal wedge.' The general Reynolds equation and the energy equation which govern the thermal wedge mechanism are here solved in three ways, illustrating the effect of certain initial assumptions in the analysis.

The experimental results presented are shown to be in fair agreement with derived curves, showing that while the thermal wedge does exist, and is appreciable at low loads and high speeds, it cannot be depended upon to provide a load-carrying film in normal lubrication practice.

AGM Paper #43

Electrical Installations on Modern Jet Aircraft

R. W. Farren,
Electrical Systems Engineer, Trans Canada Airlines, Montreal

The intent of this paper is to cover in the fullest possible way within the limits allowed, an outline of the application of Electricity in its numerous forms on modern jet aircraft. The introduction covers briefly the historical aspects of the changeover from standard 28 volt D.C. systems to the A.C. Three Phase Constant Frequency systems now employed in jet aircraft; and a review of the environmental, climatic, chemical and physical factors which influence the design and selection of electrical and avionic equipment and systems.

An outline of the main electrical power installation is covered with special emphasis on the design and selection of the Constant Speed Drives and Alternator, in conjunction with regulating and protective systems employed. This includes such areas as Frequency and Voltage Control, Synchronising and Paralleling of multiplex systems, over and under frequency protection, reactive load sharing, under-voltage, overload and differential protection etc. The use of secondary aircraft power sources such as Rotary and Static Inverters and Emergency Battery Systems is also mentioned.

Many systems are briefly examined to illustrate the many electrical applications in use; including such systems as Engine Control, Flying Surface Control, Anti-Atmosphere, Pressurization and Air Conditioning, Instrument Systems, Galleys, Lighting and Avionic equipment for communication and navigation. In conclusion future trends for the electrification of the next generation of jet aircraft, now under construction, are examined.

AGM Paper #44

The Structural Design of the Tunnels for the South Saskatchewan River Dam

C. Booy
Design Engineer, Prairie Farm Rehabilitation Administration, Regina

Five tunnels, together 21,600 feet in length with an inside diameter of 20 feet, are required to handle the divertion flow for the South Saskatchewan River Dam. After completion of the Project the tunnels will be available for power.. The problems encountered in the design of these tunnels are discussed. The tunnels are depressed below river level in order to locate them in firm Bearpaw shale. The shale is a rather soft rock which can be excavated without blasting. It may exert a lateral pressure on the tunnel lining considerably in excess of the vertical pressure. Also, the shale shows a pronounced tendency to rebound after unloading, which complicates the design of the portal structures. During the construction period the shale is expected to behave as a rock so that the temporary ground support was designed for fall-out loads which are relatively independent of the depth of overburden. During the life of the project the shale is expeeted to behave more like a plastic material so that the concrete lining was designed for loads which are a function of the weight of overburden. Central control shafts surrounded over part of their height by steel shells will house the gates. Raised inlet structures are provided 500 feet downstream of the portals which permit the portal excavation to be backfilled. These will be used as power intake structures. The design of the portal structures and the control shafts is discussed briefly.

AGM Paper #45

Geology of the South Saskatchewan River Project

D. H. Pollock, M.E.I.C.,
Chief, Air Photo Analysis and Engineering Geology Division, Prairie Farm Rehabilitation Administration, Regina

This paper presents readers with an appreciation of geologic features and events that have exerted a significant influence on various phases of engineering of the South Saskatchewan River Project, such as the preliminary damsite-selection program, the floodplain and abutment investigation, the exploration for construction materials, and the design of the dams and their appurtenant works. The paper makes only limited reference to the significance and application of the geology as this subject matter would be better discussed under headings dealing in detail with project investigation, design and construction.

The project is a joint undertaking by Canada and Saskatchewan to utilize waters of the South Saskatchewan River for irrigation, generation of power and river regulation.

AGM Paper #46

The Saskatoon Productivity Program

I. S. Evans, M.E.I.C.,
Head, Division of Information Services, Saskatchewan Research Council, Saskatoon

The author's observations in Saskatchewan industry showed that the largest single problem facing it is to find some means of using its resources, i.e. buildings, plant, tools, raw materials and people more efficiently or increasing its productivity. Believing this to come within the sphere of competence and authority of the provincial research council nd the Technical Information Service of the National Research Council an attempt, officially a pilot experiment, was nade to examine the productivity techniques now used and o teach them to foremen and management.

The second phase of the experiment will be to see if hese conventional techniques need to and can be modified o suit Saskatchewan conditions better. This paper is an account of the activity in Saskatoon to date.

AGM Paper #47

A Simulation of the Economy of British Columbia—A Guide o Industrial Development

R. E. Boston, JR.E.I.C.,
Assistant Professor of Mechanical Engineering, University of British Columbia

This paper describes the concept of the Leontief Input-Output Analysis method as a predictive device for estimating the magnitude of changes in an economy. More specifically, the feasibility of using Input-Output Analysis is examined here as a means of evaluating a proposed industrial development program for the province of British Columbia.

Thus this presentation is to be viewed only as a first step toward the final goal of actually specifying an industrial development program over a definite time interval. Several industrial development questions are presented along with preliminary results to indicate the usefulness of the simulation. The details are to be the subject of another paper.

AGM Paper #48

Modern Techniques Solve Unusual Log Driving Problem

C. E. Davidge,
Assistant Hydraulic Model Engineer,
Hydro Electric Power Commission of Ontario, Toronto
D. M. Foulds, M.E.I.C.,
Hydraulic Model Engineer, Ontario Hydro.

This paper illustrates that techniques common to applied research work may be adapted to solve a complex log driving problem. An extension to the Cameron Falls Generating Station on the Nipigon river caused changes in the currents in the forebay, which affected the log driving operation of the Abitibi Power and Paper company. Large quantities of wood collected on the racks of the powerhouse and logs were jamming between the guide booms some distance away from the entrance to the log chute. The extent of the affected area was determined by a float survey which also indicated the magnitude and direction of the surface currents. By moving the booms so as to parallel the direction of movement, a moderate improvement was achieved, however it was evident that some additional force was required to keep the logs in motion. Flow developers were considered to offer the most promising solution but this was checked before field testing by constructing a 1:24 scale model of the headpond and of each developer. The solution derived from the model tests was verified by the field trials where one full season of operation has been successfully completed.

AGM Paper #49

Marine Waste Disposal

Erman A. Pearson,
Professor of Sanitary Engineering, University of California, Berkeley, Calif.

A marine waste dispersion system is a functional component of the total treatment facility and should receive appropriate attention in conception and design. The first step in the rational development of a waste disposal system is resolution of the beneficial uses of the receiving water and the water quality criteria necessary to protect the uses. Studies of the physical, chemical and biological characteristics as well as the waste assimilating capacity of the receiving water are necessary to locate properly the terminal facility, estimate performance and to design the dispersion system.

The significant oceanographic factors affecting the design of coastal dispersion systems are discussed, and particular attention is given quantitation of nearshore circulation systems, current structure, density-temperature structure, and eddy diffusivity coefficients.

A rational method is presented for computing the concentration of waste in waste-sea water dispersion plumes including the initial mixing as well as the subsequent eddy diffusion. Solutions to the classical diffusion equation considering both point and line sources and constant and variable diffusion coefficients are presented. Application of these equations perimts a quantitative appraisal of the cost and benefit of various degrees of waste treatment and corresponding outfall and diffuser systems for attainment of water quality criteria.

AGM Paper #50

The Champlain Bridge—Steel and Prestressed Concrete Crossing of the Saint Lawrence River

Boris A. Hesketh, M.E.I.C.,
Associate Professor of Structural Engineering,
Concrete and Structural Laboratories,
Ecole Polytechnique, Montreal

A general description of the Bridge is given and some of the methods of construction used in the building of the prestressed concrete sections examined.

The Champlain Bridge, when completed, will connect the Island of Montreal with the South Shore Communities of the Saint Lawrence River. It will constitute a greatly needed addition to the roadway traffic capacity of the three existing bridges—Jacques Cartier, Victoria and Honoré Mercier. A six-lane highway is provided for, along the entire length of the bridge, with a possibility of a seventh-lane addition between the Island of Montreal and Nuns' Island. The total length of the bridge, including the approaches, will be in excess of 4 miles and the cost is estimated as $35,000,000.

AGM Paper #51

Concepts and Economics of Extra Long Distance Direct Current Transmission and System Intereonnection

H. L. Briggs, M.E.I.C.,
Member, National Energy Board, Ottawa

This paper is an economic feasibility study relating to the place which high voltage direct current transmission would have in relation to the development of Canada's remote hydro power potential, if high capacity DC conversion and control equipment were developed for commercially dependable operation.

Studies of extra long distance (600 to 3000 mile) transmission systems indicate the need for very high annual load factor loadings of high value power if in an economic sense such a system is to be justifiable. A single line is not a consideration since its reliability is zero; on the other hand while good results can be obtained from a 2-circuit system, near optimum results are available from a 3-circuit parallel system, cross-switched at appropriate intervals. This development of DC transmission has not been proposed by others as far as is known, perhaps by reason of the lack of DC switchgear.

A conclusion reached by the author is of the real need which exists today for research into and development of direct current equipment such as will enable remote Canadian power resources to be transported to load centres, not via an all-purpose national grid, but on a point-to-point basis custom tailored for each specific project combination.

AGM Paper #52

Electronic Aids in Canadian Mapping

J. T. Henderson, M.E.I.C.,
Applied Physics Division,
National Research Council, Ottawa

A number of electronic systems, described briefly, are employed to expedite map making in this country. Their use has effected great economy of time and money. Conspicuous successes have been achieved in the case of distance measurements, as illustrated by the use made of Shoran, tellurometer and geodimeter. In an attempt to present an overall review other specialized equipment for use by the hydrographer and the photogrammetrist is also mentioned.

AGM Paper #53

Sewage Stabilization Ponds for the City of Saskatoon

D. R. Stanley, M.E.I.C.,
Consulting Engineer,
Stanley Grimble Roblin Ltd., Edmonton;
E. J. Cole, M.E.I.C.,
City Engineer, City of Saskatoon, Sask.

About twelve years ago, the State Health Department in North Dakota began approving the use of open ponds for the treatment of raw sewage and this practice has spread rapidly to many midwestern States in the United States and to Canada. These ponds have sufficient surface area to assure aerobic conditions but in the past two years, short detention ponds have been built to provide anaerobic biological treatment.

Sewage from the City of Saskatoon is discharged to the South Saskatchewan River with about 85% of the flow being comminuted prior to disposal and the rest going into the river raw. Some pressure has been exerted on the City to treat its sewage and a study of the problem has been made. The study considered the use of conventional primary treatment and aerobic and anaerobic stabilization ponds.

An analysis indicated that aerobie ponds would compare in cost to conventional primary treatment with anaerobic ponds being about one-half the cost of the other alternatives. It is feasible to construct small anaerobic ponds at a remote location to treat part of the sewage from the City and experience with the operation of these over the next few years should supply sufficient data to determine if this method can be used to treat all of the sewage from Saskatoon.

AGM Paper #54

Landslides in Over-Consolidated Clays

R. M. Hardy, M.E.I.C., *E. W. Brooker,* M.E.I.C. *and W. E. Curtis,* JR.E.I.C.

Many of the major rivers and streams in northern

Alberta, the Peace River block of British Columbia and the southern portion of the Yukon have cut through shale deposits which have been highly consolidated by the weight of glaciers many hundreds of feet thick. Engineering construction in these valleys frequently produces change in the stability conditions sufficient to precipitate major earth movements. Experience to date in the area has shown that it is very difficult to determine by conventional subsoil exploration methods where such instabilities will develop. Moreover, conventional methods of stability analysis are inadequate to accurately assess the stability of these slopes as they exist naturally or as they may be modified by engineering works.

In recent months very complete investigations have been undertaken at two locations where major instability has developed incidental to road and bridge construction. This paper describes for these two sites the conditions encountered and the investigations made; shows the inadequacies of conventional methods of stability analyses when applied to these conditions, and presents a modification to the conventional effective stress stability analysis which appears to permit a reasonably accurate assessment of the stability conditions to be made. The significance of the modified stability analysis in the design of corrective measures to improve the stability conditions is also discussed.

AGM Paper #55

The Planning of the Avalanche Defence for the Trans Canada Highway at Rogers Pass

P. A. Schaerer, M.E.I.C.,
Snow & Ice Section, Division of Building Research, National Research Council, Ottawa.

The Rogers Pass section of the Trans Canada Highway is threatened by numerous avalanches which are mainly the result of the heavy amount of snowfall and the steep, long mountainsides. In 1953, at the same time when the highway route was first studied, an avalanche survey was organized to obtain the information required for the formulation of an avalanche defence plan, for the design of avalanche defence structures and for the future avalanche warning service.

This paper describes the observations that were made and how they were used for the formulation of an avalanche defence plan. The various possible defence methods are discussed and the defence chosen for Rogers Pass is outlined.

AGM Paper #57

A Research Viewpoint on Engineering Education

B. G. Ballard, M.E.I.C.
Vice-President Scientific and Director
Radio and Electrical Engineering Division,
National Research Council, Ottawa

Canada's engineers have served her well in the development of her primary industries. Some came from Europe and some from the United States, but Canadian universities very early initiated engineering training, and many of the men who contributed so much to country's growth were born and trained in Canada. The universities discharged their responsibilities well.

The pattern has ehanged in recent years. Canada emerged from colonial status and almost overnight became an industrial nation in a highly competitive world. The future demands men with new ideas, men who are imaginative enough and creative enough to make the best possible use of our resources. They must also have adequate training and encouragement to develop their creative talents, and these requirements clearly delineate the role of the university.

No longer can the universities be content only to impart to students the accumulated knowledge of the past. They must lead the way in creating new design techniques and new processes. They must look upon research not as an extra-curricular luxury to be financed by some benevolent outside organization, but rather as an essential element of university life. We need schools to impart knowledge of the past, but we need universities to develop knowledge of the future.

AGM Paper #58

The Hyraulics of the Pipeline Flow of Solid—Liquid Mixtures

G. W. Govier, M.E.I.C.,
Professor of Chemical Engineering, Dean of the Faculty of Engineering, University of Alberta, Edmonton;
M. E. Charles,
Research Engineer, Research Council of Alberta, Edmonton

Solids may be transported with liquids in pipelines, depending upon the particle size, density and concentration, either as non-settling or as settling mixtures. The conditions which determine in which manner a mixture will behave are discussed. Non-settling mixtures frequently behave as non-Newtonian fluids and at high concentration approach Bingham plastic behavior. The pressure drop, flow rate relationships for Bingham plastics and pseudo plastics are reviewed.

Settling mixtures cannot be treated as single phase systems except under conditions of high turbulence. Experimental pressure drop, flow rate data and the durand empirical correlation are reviewed. The semi-theoretical equations of Newton et al are discussed and compared with actual data.

AGM Paper #59

Force Variation During the Formation of Continuous Segmented Chips in Metal Cutting

R. Salman, JR.E.I.C.,
Research Assistant, Queen's University, Kingston
W. B. Rice, M.E.I.C.,
Associate Professor in Mechanical Engineering Queen's University, Kingston.
L. T. Russell,
Naval Research Establishment, Defence Research Board of Canada, Dartmouth, N.S.

A recent paper (published in the Engineering Journal) described the mechanism of formation of segmented continuous chips, and presented an explanation of chip-curl and cratering wear. Some speculation concerning the cutting force variation during the formation of an individual segment was involved. The paper describes the method of measuring the force variation and corelating it with the phase of segment formation in chips of 26S aluminum in which the segments were completely formed in .006 seconds. The results and the limitations of the method are presented. The research upon which this paper is based is supported (in part) by the Defence Research Board of Canada, under Grant DRB 9535-03.

"Canadian Design for Canadian Products"

Theme of the 75th

E.I.C.

Annual Meeting

Vancouver, B.C.

May 31, June 1-2

SUMMARIES OF PAPERS TO BE PRESENTED AT THE SYMPOSIUM ON AUTOMATIC CONTROL BY THE JOINT NATIONAL RESEARCH COUNCIL ASSOCIATE COMMITTEE ON AUTOMATIC CONTROL AND THE ENGINEERING INSTITUTE OF CANADA JUNE 1, 1961, IN VANCOUVER

Paper AC-1

The Optimization of the Performance of an Ore Bridge, An Analogue Computer Study

by J. A. Field, Department of Electrical Engineering, University of Toronto.

As with many other manually operated devices there is little information available concerning what the optimum performance of an ore bridge could be. This study of the optimum performance of the ore bridge yielded information that would be useful in determining the economic practicability of additional control equipment to improve performance, and would aid in future design of such bridges. An idealized bridge and a control circuit to replace the operator were simulated on an analogue computer and optimum conditions found by repeated trials. The equations of the idealized bridge are developed and the necessary computer approximations described.

Paper AC-2

The Determination of Linear Multivariable Models for Complex Processes

by R. J. Kavanagh, Department of Electrical Engineering, University of Toronto.

In order to design a control system for a process it is necessary to be able to describe the dynamic behaviour of the process in some way, e.g. by means of a transfer function. In many practical situations the use of special test inputs such as sine waves or steps to determine a transfer function is not suitable and the process is so complicated that a theoretical derivation of an appropriate process description is not feasible.

A method which is applicable to such situations and which is becoming widely studied is that of utilizing the statistical properties of the process inputs and outputs recorded while the process is in normal operation.

The paper develops the theory of this method for multivariable systems by first discussing the identification problem, which involves the determination of the transfer matrix of an active linear multivariable system by statistical analysis of the system inputs and outputs. It is shown that the exact solution is not applicable to practical processes and the paper then derives the transfer matrix for the optimum linear multivariable model in the minimum mean square error sense. The formulation of this model is identical to that of the optimum linear multivariable filter. The derivation given in the paper is original in that it is carried out in terms of matrix quantities thereby reducing the mathematical complexity. An interesting result is obtained concerning the correlation of the errors which result when the model is optimum.

The paper concludes with an assessment of the practicability of the method and a qualitative discussion of the various factors which govern the accuracy of the model transfer matrix. A bibliography listing papers relevant to the statistical method of estimating system dynamics is given in an Appendix.

Paper AC-3

Economic Performance Criteria for Optimizing Control Systems

by J. H. Milsum, Division of Mechanical Engineering, National Research Council, Ottawa.

The subject of economic performance criteria for optimization of control systems is considered after a brief review of conventional dynamic performance criteria, and the general concept of optimizing control. For economic optimization, the sum of operating costs is driven to a minimum value. These costs may be divided into "error penalty" costs and "power" costs which are functionally related to signals within the control loop, and which are "traded-off" against each other for a minimum. Examples illustrate the analogy of this method to that already used in engineering design and industrial management. Finally basic techniques are briefly reviewed for "hill-climbing" the performance criterion.

Paper AC-4

A Continuously Acting Adaptive Analog Computer for Determining the Impulse Response of Control Systems with Gaussian Signals.

by E. V. Bohn, Department of Electrical Engineering, University of British Columbia.

It is shown that the autocorrelation and cross-correlation functions of signals with a gaussian amplitude distribution can be determined from switched correlation functions. These are obtained by using the zero cross-overs of one signal to operate a gate which selects the positive or negative value of a second signal. A delay line for the zero cross-overs can be readily instrumented. Applications of this method to determine the impulse response of a feed-back control system are discussed. An analog computer is described which automatically adjusts itself to signal level and system bandwidth variations. Figures of merit and functionals of the error are easily determined at the output for adaptive control system optimization.

Paper AC-5

The Control System of an Automatic Stereo Mapping Machine

by J. M. Ham and G. L. Hobrough, Department of Electrical Engineering, University of Toronto and Hunting Associates Limited, Toronto, Ontario, respectively.

An automatic photogrammetric plotting instrument employing multiple-loop adaptive servos is described. The mechanical function of detecting and removing parallax from the stereo model is performed automatically by this instrument.

The detection of parallax between two images requires that corresponding points in the images be identified. In the Stereomat, a small area is scanned by a spot of light moving in a random pattern. Fluctuations in the light produced by the scanning spots crossing image boundaries are sensed by a separate photo-elcctric cell for each photograph. Signals from the two photo-electric cells are processed electronically to produce X and Y error voltages. The error voltages actuate servo motors which continuously adjust the geometry of the optical systems to reduce parallax to acceptably low values. The Y parallax nulling servo orients the projectors to correspond to the orientation of the serial cameras at the moment of exposure. The X parallax nulling servo effectively locates a reference point on the surface of the terrain in the servo model.

The magnitude and azimuth of terrain slope are computed by additional circuitry and steering signals are derived which enable the reference point to trace out constant height contours or paths of steepest descent. Both the size of the scanning pattern and the velocity of tracing are continuously optimized in response to image and terrain conditions.

Paper AC-6

Process Loop Optimization Through Valve Characterization Techniques

by G. L. d'Ombrain and S. M. Lyle, Department of Electrical Engineering, McGill University, Montreal, Que.

The performance of a linear process control system based on three cascaded first order lags controlled by a proportional-plus-integral controller and using both linear and exponential control elements is analysed and demonstrates the marked inferiority of the exponential valve for desired value system disturbances despite its beneficial effects for load value disturbances. An element which has two discrete gain values which are a function of its own output and of an incorporated dead space is then introduced into the forward loop between the controller and the control valve. It is shown that this arrangement gives improved results when based on the criterion of the minimum of the moment of the error squared for systems subjected to both load and desired value changes.

Paper AC-7

The Optimal Gain of Manually Controlled Machines.

by C. B. Gibbs, Defence Research Medical Laboratories, Toronto.

A spot of light on a CRT was controlled by a joy-stick, the operator's task being to effect uniform display movements with the highest possible speed, to a specified level of accuracy.

The thumb, hand and forearm were used in control and the extent of their movement was varied by altering the control gain. The speed of display movement was varied by introducing exponential lag between control and display. The effects of these variables were explored in positional and velocity control systems, and comparisons were based on the time taken for accurate display movements.

It was found that the optimal gain of the positional system depended on the lag; formulae were derived to express the relation. The optimal gain of the velocity system was independent of lag, and its value was computed.

In the positional system, control by the hand was superior to either thumb or forearm. With zero lag, increased gain (decreased limb movement) markedly reduced the accuracy of thumb control; there was much less deterioration with the longer limbs in these special conditions. Changes in gain had similar effects on all limbs in all the other experimental conditions, and in the velocity system.

It is concluded that rapid limb movements are continuously monitored and terminated by kineaesthetic feed-back from muscles and joints. Display movements in positional systems, however, must be terminated by visual cues, when exponential time lags are present. The same need arises in velocity systems with or without exponential delays, because of the phase lag between control and display movements.

The main theoretical issue is whether 'open-chain' or 'closed-loop' principles are used in controlling voluntary movements. The implications of this problem for current theories of learning and the transfer of skill are briefly discussed.

Paper AC-8

Relable Networks from Unreliable Components.

by Miss O. Boshko, G. S. Glinski, M.E.I.C., *and J. Therrien, Electrical Engineering Department, University of Ottawa.*

This paper is concerned with the study of the reliability of logical digital networks. It discusses how the reliability of such a network can be improved by properly interconnecting basically unreliable elements.

A given logical function can be represented by a suitable arrangement of components in a net. The theory of graphs can be used as a mathematical model for a study of the properties of such networks.

A summary of the work on logical nets is given with special emphasis on the work of von Neumann and Shannon, on the reliability of such nets. Although both come to the conclusion that a net can be made as reliable as desired by adding more elements, their methods differ in the redundancy required.

The introduction of the majority element greatly simplifies the structure of logical circuits. The work of McCulloch using these elements is discussed. He found that certain networks are "logically stable" under the effect of changes in the thresholds.

Experiments on logical nets are described. The first is a test on the "learning" ability of such network. An experiment on reliability is then described in which measurements are made of the changes in the "learning" properties of the network as some of its elements become defective.

Finally it is suggested that these studies should be extended to include pulse-rated asynchronous circuits, and should also be oriented toward the consideration of the proper balance between component and signal redundancy.

ANNUAL MEETING PREPRINTS

Preprints of all Annual General Meeting papers abstracted on the preceding pages will be available at the Meeting in Vancouver. They also can be obtained from The Engineering Institute of Canada, 2050 Mansfield St., Montreal 2, Que.

AUTOMATIC CONTROL PREPRINTS

Preprints of all papers to be presented at the Symposium on Automatic Control by the joint National Research Council Associate Committee on Automatic Control and The Engineering Institute of Canada also will be available both at the Meeting and from the E.I.C. The charge for these preprints will be announced at the Meeting and in the June issue of the Journal.

Canadian Developments

Studies in Air Pollution under way

An extensive research project has been put into operation in the fields of industrial hygiene and air pollution. This is part of a two-phase approach to the problems being taken by the Institute of Industrial Hygiene and Air Pollution of the University of Montreal.

The entire program is expected to take between seven and 10 years. Following the initial three-year phase the Institute will involve the provision of specialized personnel, laboratory space and equipment.

Assisting in the first phase were grants-in-aid given by the Department of National Health and Welfare, and grants from private sources.

At the University of Montreal a study of the pneumoconstriction effect of dust and on the pneumodilatation effect of certain aersols on the lungs is being undertaken by the Physiology Department. A grant to Dr. Hans Selye of the Institute of Experimental Medicine and Surgery of the University will assist his study of the mechanism of penetration of toxic substances through the skin.

These projects initiated by the Institute are considered extramural. A grant from the Department of National Health and Welfare will enable the Institute to study the insecticide problem in relation to health in the Province of Quebec. This is the Institute's first intramural project.

In the second phase research projects and teaching could be concentrated in the Institute where a congregation of specialists would permit a team approach to the many current industrial hygiene and air pollution problems requiring investigation. The consultants and an advisory committee would consider whether facilities existing in other University departments should be duplicated.

The Institute was established in May, 1960, and was approved by the Quebec Department of Health under a federal-provincial agreement.

Initially, a survey financed by the Department of National Health and Welfare was conducted in several countries where institutes devoted to the subject are operating. This survey followed extensive discussions between Dr. Kingsley Kay, Senior Scientific Consultant, Department of National Health and Welfare, and Dr. F. J. Tourangeau, Director of Industrial Hygiene, Quebec Department of Health.

The need for an institute in Montreal was indicated by the changing economic structure of Quebec. At the end of the Second World War, two-thirds of the province's population lived in rural areas. Now about two-thirds of the five million persons in Quebec live in urban areas.

Distinguished consultants from Europe and North America devoted their efforts in organizing the Institute's program.

The Institute staff now includes: Director Dr. Tourangeau who also is professor of Industrial Health and Air Pollution; Sarto Plamondon, Assistant Director who is Associate Professor of Industrial Hygiene; Dr. Kingsley Kay, Senior Consultant on a part-time honorary basis; and consultants in toxicology, physiology, physiological hygiene and industrial hygiene engineering. Other consultants will be secured in the fields of chemistry, physics, otology, ophthalmology and psychological hygiene.

The teaching program will be made subject of special study by organizational staff and consultants in collaboration with University authorities and appropriate professional organizations. It will be directed towards undergraduates and graduates in science, medicine, nursing, engineering and chemistry.

Self Sufficient Sewage Treatment Plant

The Iona Island Sewage Treatment Plant which is to be completed in late 1962 is designed to grow with the needs of Vancouver. Its peak flow will be 340 million gal. per day and will serve a population of 640,000. The plant will be a model of self-sufficient operation. Sludge gas produced from the plant's digestors will provide fuel for the engines that operate the plant. No more than 18 men will be needed for round-the-clock operation and maintenance.

The plant, for primary treatment of sewage, was designed to handle both sanitary and storm water flow particularly in wet weather peaks.

The operating cycle of the plant starts with the inflow of raw sewage through three 66 in. concrete siphons under the north arm of the Fraser River. The raw sewage is pre-chlorinated on entry to the plant and then goes to the pump building where screening and grinding takes place. Speed pumps lift the sewage to the grit chambers where the flow is slowed down so that coarse grit will drop out. This grit is carried away daily for use as on-site fill. From the grit channels the flow passes through five preaeration tanks. Air is blown through the flow to settle out the fine grit and aid in the sedimentation process. When the flow continues on through five sedimentation tanks it is maintained at a velocity low enough to get rid of organic material.

The two digestion tanks are the heart of the treatment process. They are 80 ft. in diameter, 35 ft. deep and each has a floating cover. Digestion is most effective when the sewage which has now become sludge is maintained at a temperature of 90° to 95°F. Circulation pumps constantly withdraw the sludge from the tanks and pump it through the adjoining sludge control building where it is heated, using waste heat from the engines which operate the plant.

The digesting process produces gas which makes possible the economical operation of the treatment plant. This gas, called sludge gas, is about 70% methane, and plays two roles in the plant operation. It is bubbled back through the digestors to assure intimate mixing of raw and digesting sludge. This improves the digestion process. Secondly, it is used to fire the main engines which generate power for the whole plant. This gas can be fed directly to the engines or compressed and stored for future use. Should there be any failure in the gas system, the engines automatically switch-over and would be operated on diesel fuel.

After a 30-day cycle in the digestion tanks the sludge is pumped to four sludge lagoons west of the Plant. The clarified effluent left enters a four-mile outfall channel which carries it out over Sturgeon Bank to mix with the tidal currents off the mouth of the Fraser River.

International News

Philippines Copper Plant

An integrated copper, zinc and ammonium sulphate plant to change ores into finished copper products is to be constructed in the Philippines at a cost of $23 million. Chemical leaching, gaseous reduction, and newly-developed rolling methods will turn low-grade ores into high quality copper powder without a melting step at any point in the process.

The capital cost of this installation to produce high purity copper should be 40% less than conventional smelting, refining and casting plants. The process to be used at Marinduque will make it possible to get high grade copper products from any starting material currently used by the copper industry. Complex ores such as copper zinc combinations can be handled more effectively than by conventional methods. Also, the capital cost of facilities to produce strip and tubing from copper powder will be at least 50% less than for conventional fabricating techniques starting from cake, ingot or billets.

The Export-Import Bank of Washington, D.C., has approved a $13 million loan to Marinduque Iron Mines Agents, Inc. for construction of the plant. This amount will be matched by Marinduque in pesos.

Jesus Cabarrus, president of Marinduque, said that the new plant will have important effects on future copper producing facilities and will produce immediate improvements in the economy of the Philippines. For the first time the new island republic will have an integrated copper industry capable of meeting all its copper requirements. Not only will the new plant produce approximately 14,000 tons per year of fabricated copper products, but it will also produce an estimated 100,000 tons per year of ammonium sulphate fertilizer. Fertilizer is badly needed in the Philippines for the production of sugar and rice. Zinc, at the rate of about 5,000 tons per year will be available either as zinc oxide or electrolytic zinc particularly for use in the galvanizing industry.

Output of this integrated copper-zinc-ammonium sulphate facility is estimated to yield, at current U.S. prices, an equivalent annual value of approximately $18.5 million for Marinduque. It could result, too, in a net annual saving of $10 million in foreign exchange for the Philippine economy.

Mr. Cabarrus feels that the establishment of this integrated primary industry would have other advantages for the Philippines. The new Marinduque plant will need 1,000 employees. Small manufacturing facilities to produce items such as air conditioning equipment, radiators, decorative metal products, weather stripping, hardware and electrical appliances would be established. A hydroelectric power plant program under way is aimed at increasing the living standard of the Philippines. The availability of domestic copper wire undoubtedly will be important to this program.

Every step or phase of the process has been proven in commercial operation in various North American installations. The ores from Marinduque mines have proved suitable to this type of operation.

Helicopter Completes Steel Tower

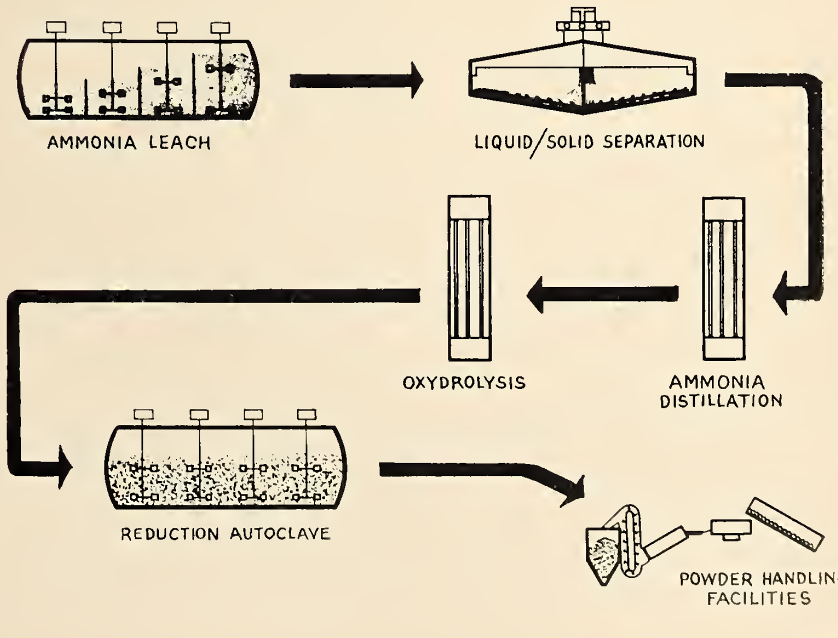
A steel transmission tower in Coos Bay, Oregon was completed by helicopter four days ahead of schedule.

A barge-mounted crane erected the lower 111 ft. of the 200 ft. tower on concrete footings. The remaining pre-built sections weighing between 500 and 1,200 lb. were laid out in order of assembly on the shore about 1,000 yd. from the tower. As the helicopter hovered low over the staging area, the ground team hooked each steel section to its cargo hook. Once above the tower, the helicopter hovered steadily with each steel section until signaled into position. When the assembly was bolted in place the pilot pressed the electrically controlled cargo hook release and flew back for another load.

Average time for each delivery round trip was under five minutes. Thirty structural assemblies plus insulators were delivered in this way.

The project, the first of two similar towers built to span 115,000 v. lines across ocean shipping channels in Coos Bay, is part of a four-mile powerline now under construction to serve a new paper mill.

This Simplified Diagram shows the major steps in the chemical process of producing pure copper powder from ores. With no melting steps anywhere in the process, the chemical method of refining offers great cost advantages from an equipment and operating standpoint.



Month to Month

Executive Committee

A meeting of the Executive Committee of Council was held in Montreal, April 8. President Dick was Chairman. Following are highlights of the meeting.

Financial Statement

F. L. Lawton, Chairman of the Finance Committee, presented the financial statements for February, 1961. He said the Finance Committee considered the statements to be satisfactory in the light of general economic conditions and that the Institute can be reasonably confident of its position. He noted that since the Institute's accounting system began operating on an accrual basis, the Finance Committee is able to maintain the closest possible supervision of financial operations.

Branch Officers Meeting

The General Secretary reported that the second of a series of meetings with regional groups of branch officers was held in Niagara Falls, March 24. This meeting was in line with an experimental policy of trying to utilize the General Secretary's travel time more effectively. The meeting was considered very successful and the branch officers were able to discuss matters which are not normally considered during more formal presidential visits.

Southern Ontario Conference

The General Secretary reported that the Third Southern Ontario Regional Conference, held in Niagara Falls March 25, had been very successful. Approximately 300 persons registered for the conference. A complete report will be available at a later date.

1962 Railroad Conference

It was reported that the Institute had informed the American Society of Mechanical Engineers that it was interested in becoming a co-sponsor of the ASME-AIEE Railroad Conference tentatively scheduled to be held in Toronto in April, 1962. This offer has been accepted.

Activities of Officers

President Dick reported that he had addressed the inaugural meeting of the Port Credit Branch March 24, the Third Southern Ontario Regional Conference March 25, and had visited the Sudbury Branch and Kirkland Lake region.

Vice-President Lawton said he was to visit Quebec City April 10 to address a joint meeting of the EIC and the AIEE.

Vice-President Cross said there is an excellent reaction from branches to visits from a Vice-President. He considered this practice well worth continuing. He reported on visits to the Chalk River, Orillia and Peterborough Branches, and student meetings at Hamilton and London. Before the season ends he plans to visit Cornwall, Sarnia and Kingston.

Public Relations

Following a discussion concerning the need of projecting the Institute's "image", and methods of accomplishing this, it was resolved that the President be empowered to appoint an ad hoc committee as soon as possible to study the proposed terms of reference of a Public Relations Committee. This ad hoc committee is to be requested to present its recommendations to Council at the Annual Meeting.

Relationship with A.P.E.O.

Following discussion concerning the Institute's relationship with the Association of Professional Engineers of Ontario it was decided that the E.I.C. publish a clear statement of policy regarding co-operation with A.P.E.O. This statement is to be published in the Journal, and distributed to Councillors and Branches in Ontario.

Career Development

The need for the Institute to investigate and improve its provision of vocational information was discussed. It was felt that a national E.I.C. Committee could provide valuable assistance to this end.

Following discussion it was resolved that a Committee be appointed to explore this field with a view to giving assistance to Branches and encouraging E.I.C. Branches in university centres to provide guidance to students. It was agreed that the Committee be known as the Committee on Career Development.

National Productivity Council

The General Secretary stated he had received comments from senior officers and members of the Institute concerning the fact that the Federal Government failed to appoint an engineer, primarily because of his engineering qualifications, to the National Productivity Council.

It was resolved that a letter be sent by the Institute to the Prime Minister expressing its regret and concern regarding the fact. The letter, addressed to Mr. Diefenbaker, follows:

Dear Sir:

National Productivity Council

The Engineering Institute of Canada notes with approval the principle of the Federal Government's constructive attitude toward the promotion of the efficient utilization of Canada's resources, manpower, and industrial efficiency; as expressed in the appointment of the National Productivity Council.

It is a matter of regret and concern to this Institute that the government apparently has failed to recognize the direct connection between all of the stated objectives of the National Productivity Council and the engineering profession in Canada.

'Productivity" implies the application of science and technology, and it is believed that the major concern of the Council will be engineering and technological problems, and their relationship to problems of labour management, and resources.

It is the opinion of The Engineering Institute of Canada that the membership of the National Productivity Council should include at least one appropriately qualified engineer, appointed primarily because of this qualification.

If future appointments are made to the Council, The Engineering Institute of Canada urges that an appropriately qualified engineer be appointed, in his capacity as an engineer.

Yours truly,
Garnet T. Page, M.E.I.C.
General Secretary

E.C.P.D.

The second term of Colonel W. S. Wilson as one of the E.I.C. representatives to the Engineer's Council for Professional Development expires next October. Colonel Wilson is not eligible for re-appointment. It was resolved that Mr. G. Demers be appointed to the E.C.P.D., replacing Colonel Wilson.

African Students

The General Secretary said McGill University students are required by the Faculty of Engineering to obtain six months of practical experience in Canada before a degree is granted them. A problem has been encountered with African students, many of whom are studying in Canada under Commonwealth aid sponsorship. Because they are not permanent residents of Canada, many companies do not offer them work as they are unlikely to be prospective permanent employees. McGill asked the Institute to assist the students in finding summer employment since this is a definite requirement if they are to obtain their degree. The Institute agreed to help these students in any way possible.

Technological Education

The Institute has been invited to be represented at the National Conference on Technological Training May 9-10, 1961, in Ottawa.

It was resolved that Dean D. M. Myers of the University of British Columbia represent the Institute at the Conference.

Striking Committee

On the recommendation of the President-elect it was resolved unanimously that Dr. K. F. Tupper be named Chairman of the Striking Committee for 1961.

UNESCO

The Institute has been appointed a Rotating Member of the Canadian National Committee for UNESCO for the period 1961-63. It was resolved that Dr. K. F. Tupper of Toronto be appointed E.I.C. representative, and the General Secretary be appointed E.I.C. alternate representative to the Canadian National Commission for UNESCO for this period.

Third Southern Ontario Regional Conference

Eight branches participated in the Regional Conference held at Niagara Falls, March 25. They were Border Cities, Hamilton, Kitchener-Waterloo, London, Niagara Falls, Oakville, Sarnia, and Toronto.

The keynote address was given by The Hon. Robert Winters, president, Rio Tinto Mining Co. of Canada. Mr. Winters outlined the challenge which engineers in Canada face today. He commented on the challenge to the technical and creative skills of the engineer which exist in our society. At the turn of the century, we had half a dozen or less branches of engineering which were recognized and broadly practised; now we have many times the number of acknowledged spheres of engineering endeavour. Mr. Winters concluded: "The engineer today, more than ever before, is meeting the challenge in making his training available in solving a wide spectrum of problems. The engineer plays his full role only when he accepts responsibility in these broader fields of administration and public service and when he is prepared even to run for public office."

The technical program included address by Alec G. Lester, M.E.I.C., Vice-President, Bell Telephone Company, in which he described, with the aid of a film, the use of satellites for intercontinental telephone calls. Rod Martin, Regional Manager, Western Division, International Underwater Contractors, gave a talk on "Underwater Engineering". Brian Palmer, Technical Services Representative, Dow Chemical of Canada, outlined the techniques employed in producing Polystyrene. R. Ross, Director of Engineering, O'Keefe Brewing Company gave an address on "Engineering as Training for Management". E. W. Hill, Utility Sales Manager, Canadian Westinghouse Co. Ltd. gave a talk entitled "Can Industry Generate Electric Power Economically?" W. C. Kimball, Assistant Chief Metallurgist, Algoma Steel Corporation, gave a review of the history and development of structural steels since 1920 entitled "A New Look at Structural Steels". Approximately 300 persons attended the meeting.

Shown at the highly-successful Third Southern Ontario Regional Conference are, from the left: Hon. Robert Winters, M.E.I.C., President, Rio Tinto Mining Company of Canada, Ltd.; Mr. R. Denham, Conference Chairman; President Dick.

Additional Report

The Report of the National Development Program Committee was not included in the 32-page Report of Council, Committees and Branches of the E.I.C. which appeared in the April issue of the Journal. Following is the report:

During the past year P.D.P. has served the needs of engineers in those centers where this movement has been organized, by providing non-technical programs to stimulate interest and understanding of the topics outside their chosen field of activity.

The effectiveness of the movement has been dependent on the receipt of reports from the Corresponding Members of each operating group.

Because of the national character of the Engineering Institute of Canada intercommunication has often been difficult to promote and maintain, however with the enthusiastic cooperation of the Corresponding Members the hope is cherished that the National Executive will continue to receive regular reports from the operating groups.

Saturday June 18, 1960 a Regional Conference was held at Hamilton when progress reports were received from Toronto, Sarnia, London, Brockville, Niagara Falls, Kitchener and Hamilton. The general concensus indicated that a high level of interest was being maintained in P.D. activities. In Western Canada enthusiastic groups are in operation at Vancouver, Kootenay, Calgary and Winnipeg. Inquiries have been received from other branches expressing their desire to organize P.D.P. groups, and in each case information has been disseminated by the National Committee to assist them.

The Hamilton group records the successful sponsorship of a course on Economics, as prepared by the Canadian Association of Adult Education. The feeling exists that this material can be used in the coming years with continued success. C.A.A.E. material covering several fields can be beneficially included in P.D.P. groups, especially in the smaller centers.

Non-technical training of engineers continues to be of utmost importance in developing citizens who can fulfill their responsibility in society.

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on February 25, 1961.

STUDENTS ADMITTED

University of Laval: R. Arcand, M. Arsenault, G. Beaulieu, H. Begin, A. Belanger, Y. Belanger, J. P. Bilodeau, L. A. Blouin, J. M. Boivin, H. Bonneau, A.

(Continued on page 132)

OFFICE OF THE PREMIER

PROVINCE OF BRITISH COLUMBIA

VICTORIA
1 9 6 1

April 7th

Mr. G. McK. Dick,
President,
Engineering Institute of Canada,
2050 Mansfield Street,
MONTREAL 2, QUEBEC.

Dear Mr. Dick:

Probably nowhere in Canada is the vital role of the professional engineer better appreciated than here in British Columbia, where we have seen in the years following World War II the greatest per-capita growth in the nation.

Development projects of international repute have marked almost every year of British Columbia's post-war history, and we are confident that the wonders of technological progress are just beginning for our province. One has only to consider, for example, the immense hydro-electric projects about to be undertaken on the Columbia and Peace Rivers to realize that the time-tested phrase, "Land of Opportunity", still has real meaning in British Columbia for all who believe that big dreams can be made big facts.

To the members of the Engineering Institute of Canada who join us, I know, in bringing these dreams to reality, I am accordingly most happy to extend the heartfelt welcome of the Government and people of British Columbia. We are confident that your 75th Annual Meeting opening May 31st in Vancouver will be an outstanding success, and we hope that you will take time from your deliberations to enjoy the hospitality which our province is eager to extend to you.

Most sincerely,

Premier

NEWLY ELECTED OFFICERS OF THE INSTITUTE

At the Annual Meeting, three vice-presidents and 34 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.

Francis Mott Cazalet, M.E.I.C. was elected vice-president of the Institute for Zone "A" — the Western Provinces.

Mr. Cazalet is Gas Sales Engineer with the B.C. Electric Company Limited. Since becoming a member of the Institute in 1945 Mr. Cazalet has been active at all levels. He has served as Vice-chairman, Chairman and past Chairman of the Branch, as well as holding the office of Councillor.

The Western Vice-President's non-professional activities include the Toastmaster Club of which he is Area Governor. He is president of the Vancouver Y.M.C.A. swim team and is a director of the Vancouver Y.M.C.A.

F. M. Cazalet, M.E.I.C.

P. E. Buss, M.E.I.C.

Paul E. Buss, M.E.I.C., elected Vice-President for Zone "B", the Province of Ontario, joined the Institute as an associate member in 1927, 12 years after he graduated from the University of Michigan.

Mr. Buss, whose home is in Thorold, Ont., brings to the Vice-Presidency a history of long service to the Institute's Niagara Peninsula Branch. He served several terms as Councillor, the first in 1937, and was a member of the Board of Management, Ontario Division, 1956-61. He was Branch Chairman for one year and Secretary for one year.

Vice-President Buss was a member of the Thorold Town Council for 10 years and president of the Thorold Board of Trade for five years. He has served as Chairman of his local Red Cross organization and has assisted in the activities of such organizations as the V.O.N.

Mr. Buss was born in Three Rivers, Michigan, and during World War I served as a sergeant with the United States Army Engineers in France. He then was with Provincial Paper Limited at the Company's Head office in Toronto, then as engineer on construction of the first sulphite plant at the head of the lakes at Port Arthur.

He later was on the engineering staff of Dominion Engineering Works, and for a number of years was plant engineer at the Thorold Division of Provincial Paper Ltd. During 1932-33, he and his two brothers carried on experiments in developing the new process for producing rock wool by the spinning method, since adopted in part by the entire industry. At present he is President of Spun Rock Wools Limited, Thorold.

Gerald N. Martin, M.E.I.C., Vice-President for Zone "C", Quebec, graduated from Ecole Polytechnique 27 years ago.

Mr. Martin joined the Institute as a Junior in 1937 and in 1944 became a Member. In the Montreal Branch, he served with the junior section and as a committee member. In 1952 he was chosen Vice-Chairman and the following year — became Chairman.

Vice-President Martin served as Councillor from 1954-56, during part of which time he was chairman of the Publications Committee. He was Institute Treasurer in 1958 and has served two periods on the Finance Committee. He was active in the work on the A.S.M.E.-E.I.C. International Council and the Institute's Committee on Technical Operations. He was a C.P.E.Q. Councillor 1958-60.

Two papers written by Mr. Martin concerning combustion and boilers resulted in two Phelps-Johnson prizes.

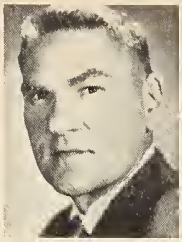
G. N. Martin, M.E.I.C.

T. A. Monti, M.E.I.C.

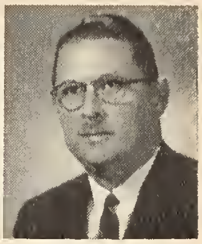
Thomas A. Monti, M.E.I.C. has been elected a Councillor representing Montreal Branch. Dr. Monti received his Civil Engineering degree in 1941 and 6 years later received his doctorate from University of Montreal. He was a member of the Montreal branch executive in 1950-51, was chairman of the branch's junior section and was president of the entertainment committee. He was vice-president of C.P.E.Q. in 1956 and was active in Corporation committee work. He is active in theatrical circles and with numerous charitable organizations. Prizes for papers written by Dr. Monti include the Ernest Marceau Prize, the Keifer Medal and the Duggan Medal.

Roger J. Harvey, M.E.I.C., was re-elected Councillor for Montreal. Mr. Harvey joined the Bell Telephone Company of Canada as an engineer in Montreal 15 years ago. He now is supervising engineer-Estimates and Design, Outside Plant Division, Engineering Department, Eastern Area. Mr. Harvey first became active in the Montreal Branch in 1949-50 when he served as Vice-Chairman of the Program Committee, then as Chairman of the Radio Communications Section. Subsequently he was Program Committee secretary, Secretary-Treasurer, ex-officio member of the Executive Council and Executive Committee member. In 1956 he became a member of the Admissions Committee.

Hugh Carey Brown, M.E.I.C. was elected Councillor for Ottawa. Mr. Brown graduated from McGill in 1926. He became active in Institute affairs following the war. He served as chairman of the Proceedings Committee of the Ottawa branch in 1956, was Treasurer in 1957-58, Vice-Chairman in 1959 and Chairman in 1960. He also was Chairman of the Joint Golf Committee in 1959. In 1960 Mr. Brown was Chairman of the Institute's Committee on Membership Procedures. He is a member of A.I.E.E. and the C.P.E.Q. During the war he was mentioned in dispatches when he was attached to the Signals Corps in Italy. Mr. Brown is a member of the Rideau Club and the Rivermead Golf Club.

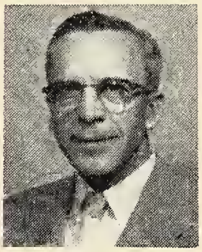


R. J. Harvey, M.E.I.C.

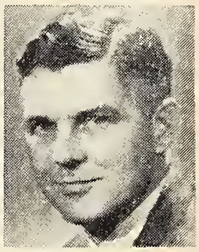


H. C. Brown, M.E.I.C.

Arthur M. Toye, M.E.I.C., elected Councillor for Toronto, is Bridge Engineer with the Ontario Department of Highways. Mr. Toye became a student member of the Institute while at University of Toronto, became a Junior in 1926 and a full Member in 1940. His activities with Toronto Branch include: member Branch Executive, 1957; Chairman Entertainment Committee, 1958; Branch Vice-Chairman and Chairman of the Papers and Meetings Committee, 1959; and Branch Chairman in 1960.



A. M. Toye, M.E.I.C.



C. Peter Jones, M.E.I.C.

C. Peter Jones M.E.I.C., elected Councillor for Vancouver is a partner in the consulting engineering firm of Read Jones Christoffersen. He received his B.A.Sc. degree from University of British Columbia in 1948, two years after he joined the Institute as a Student Member. He has served as Secretary, Vice-Chairman, and Chairman. He was Chairman of the Technical Papers sub-Committee of the Vancouver Committee for this year's Annual Meeting in Vancouver. He was also a member of the Institute's Committee on Membership. Active in local affairs, Mr. Jones was a member of the Board of School Trustees of North Vancouver, 1958-61 and served as Chairman last year. Other interests include skiing and swimming. He is a member of the Association of Professional Engineers of British Columbia.

L. C. Johnson, M.E.I.C., was chosen Councillor for Vancouver Island. Mr.

Johnson, Chief Bridge Design Engineer with the British Columbia Department of Highways graduated from U.B.C. in 1946. He served as a member of the Vaneouver Island Branch executive in 1957 and in 1958, was Vice-Chairman in 1959 and was Chairman in 1960.

L. C. Johnson, M.E.I.C.

J. Longworth, M.E.I.C.

Jack Longworth, M.E.I.C., Councillor for Edmonton, is an Associate Professor of Civil Engineering at University of Alberta and is a member of Consulting Structural Engineering, Kasten, Longworth and Associates Ltd. Mr. Longworth received his B.Sc. in Civil Engineering from the University of Alberta in 1945 and two years later received his M.Sc. degree from University of Illinois. He was an executive member of Edmonton Branch in 1957 and 1958, Young Engineers Committee Chairman, 1958, Branch Vice-Chairman and Chairman of the Program Committee in 1959. Mr. Longworth was elected Branch Chairman in 1960. He is member of Council of the Association of Professional Engineers of Alberta.

F. W. Catterall, M.E.I.C., Councillor for Saskatchewan, is Design Engineer with the Saskatoon firm of Underwood McLellan & Associates Ltd. Mr. Catterall was educated at the University of Saskatchewan where he joined the Institute as a Student Member in 1952. Four years later he became a full Member. He was Secretary of the Saskatoon Section 1959-61 and now is Chairman of that Section.

F. W. Catterall, M.E.I.C.

G. Flavell, M.E.I.C.

George Flavell, M.E.I.C., was elected Councillor for Winnipeg. Mr. Flavell, Sales Engineer, Apparatus Division of Canadian Westinghouse Co. Ltd. became a full Member of the Institute in 1956. In the Winnipeg Branch he has served as Papers Chairman and Vice-Chairman of the Electrical Section, and in 1958-59 as Chairman of the Electrical Section. He is a Councillor of the Association of Professional Engineers of Manitoba. He is a member of Toastmasters Skyliners. Other interests include photography and golf.

G. B. Starr, M.E.I.C., Councillor for Yukon branch is Territorial Engineer with the Yukon Territorial Government in Whitehorse. Mr. Starr graduated from the University of Manitoba in 1934 and before going to the Yukon was a member of the Vancouver Island, Vancouver, Central B.C., and Calgary Branches of the Institute. He was Chairman of the Yukon branch in 1959-60, and is Chairman of the Branch's Nominating Committee for 1961-62. He has been active in church, community, and professional affairs.

H. R. Hatfield, M.E.I.C., was re-elected Councillor for Central British Columbia. Mr. Hatfield graduated from U.B.C. in 1928 and two years later joined the Interior Contracting Company at Penticton. He worked with this company until 1958, by which time he had become President and Superintendent. He now is a consulting engineer. During World War II, Mr. Hatfield spent a year with the RCAF, and from 1941 until 1945 acted as Service and Works Engineer with the RCE at Petawawa, Barriefield and Chilliwack. Mr. Hatfield is a former Chairman of the Central British Columbia Branch.

Lloyd Williams, M.E.I.C., new Councillor for Kootenay, is Assistant Manager, Engineering Division, The Consolidated Mining and Smelting Company of Canada Limited at Trail. Mr. Williams has been an executive member of the Kootenay Branch for the past three years. He is a member of A.P.E.B.C. He is Reeve of the Municipality of Tadanac and is active in Chamber of Commerce affairs, and local sports activities. Mr. Williams has had several papers published on Cominco operations and practice.

L. Williams, M.E.I.C.

R. H. Wallace, M.E.I.C.

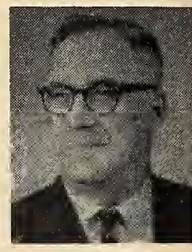
R. H. Wallaee, M.E.I.C., Councillor for Brockville, received his B.Sc. from McGill in 1926. He is Chief Engineer of the Canada Starch Co. Ltd. at Cardinal. Mr. Wallace has the distinction of serving as Chairman of both the Cornwall and Brockville Branches.

T. E. Flinn, M.E.I.C., Councillor for Belleville is an Operations Engineer with Ontario Hydro. Mr. Flinn was a member of the Branch executive 1953-58, served as Chairman of the Branch Professional Developments Committee 1954-56, and was Branch Chairman in 1958-59.

C. E. L. Hunt, JR.E.I.C., Councillor for Chalk River, is Loop Development Engineer for Atomic Energy of Canada Ltd., Mr. Hunt was Program Chairman of the Chalk River Branch 1958-59, and was Branch Chairman 1959-60.

S. D. Lash, M.E.I.C. was chosen Councillor for Kingston. Dr. Lash is Head of the Department of Civil Engineering at Queen's University. He reeeived his B.Sc. London in 1928, MSc. London 1929 and his Ph.D. from University of Birmingham in 1933. Dr. Lash was ehairman of the Kingston Branch in 1944, 1945. He is a member of the Bridge and Structural Sub-Committee of the Institute's Committee on Technical Operations. He is past Chairman of the City of Kingston Planning Board. Dr. Lash has had six papers published in the Engineering Journal and in 1941 was awarded the Gzowski Medal.

S. D. Lash, M.E.I.C.



D. B. McKillop, M.E.I.C.

D. B. MeKillop, M.E.I.C., who was re-elected Councillor for the Lakchead Branch is Area Engineer for the Canadian National Railways in Fort William. Mr. McKillop became a student member of the Institute in 1929, the year he graduated from Queen's University. He was Chairman of the Lakehead Branch in 1958 and was elected Councillor the following year. Mr. McKillop is a Commissioner of the Lakehead Harbour Commision, a member of the Fort William Library Board, and chairman of the Thunder Bay Field Naturalists.

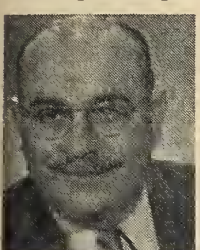
V. A. Ainsworth, M.E.I.C., Councillor for Newfoundland, is General Manager of Newfoundland Light and Power Co. Ltd., at St. John's. Mr. Ainsworth became a Member of the Institute 19 years ago.

A. S. Mitchell, M.E.I.C., re-elected Councillor for the Eastern Township, was born and educated in Montreal. He graduated from McGill University (Honours) Metallurgy, in 1938 and was awarded the A.S.M. Prize for Metallography and Thesis. Previous to joining The Union Screen Plate Company of Canada (Limited) Mr. Mitchell worked with International Nickel Company and Consolidated Mining & Smelting Company. Mr. Mitchell was plating engineer for Union Screen in 1941-42, General Superintendent in 1942-43, Works Manager, 1953-59, and was appointed Sales Manager in 1959. He has served as Treasurer of the Eastern Townships Branches of the E.I.C. and C.P.E.Q. and was elected member of Council for the town of Lennoxville.

S. B. Cassidy, M.E.I.C., was re-elected Councillor for Fredericton for a third successive term. Mr. Cassidy, a communications and electrical contractor, was born at Sussex, N.B. He received his B.Sc. degree from U.N.B. in 1933 and six years later earned his M.Sc. From 1933 until 1939 he was engaged in geophysical work with the New Brunswick Gas and Oil Field and was then appointed chief engineer with radio station C.F.N.B. In 1946 Mr. Cassidy entered his present business. Apart from his engineering work, Mr. Cassidy owns a restaurant, a hardware store and a service station. Last year Mr. Cassidy was appointed Chairman of the Institute's Committee on Membership.

J. F. Chantler, M.E.I.C., Councillor for Nipissing and Upper Ottawa, is Mill Manager for Canadian International Paper at Temiscaming, Que. Mr. Chantler was Branch Chairman in 1957-58.

Harry A. Gadd, M.E.I.C., re-elected Councillor for Port Hope, followed his engineering studies in England. This included 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 then by C.G.E. His activities include manufacturing, sales and engineering assignments. He now is manager, plastics engineering, C.G.E. plastics plant at Cobourg.



H. A. Gadd, M.E.I.C.

W. B. Ibbotson, M.E.I.C.

W. B. Ibbotson, M.E.I.C., Councillor for Sudbury, received his B.Sc. from the University of Manitoba in 1925. He is Master Mechanic of Reduction Plants for the International Nickel Company of Canada Ltd. at Copper Cliff. Mr. Ibbotson was Chairman of Sudbury Branch in 1958-59, and has served as Chairman of the Education Committee and the Papers and Publicity Committee. Active in community affairs, Mr. Ibbotson has served as member of the Copper Cliff Library Board, the High School Board, and the Technical School Advisory Committee of Sudbury.

Emil Bodmer, M.E.I.C., re-elected Councillor for Baie Comeau, is Maintenance Engineer for the Quebec North Shore Paper Company. He received his degree in Mechanical Engineering from the University at Burgdorf, Switzerland in 1944. He graduated with distinction, earning the highest marks of all 1944 graduates. Mr. Bodmer was a founder of the Baie Comeau Branch and has served as Branch Secretary, Chairman, and as a member of the Organization Committee. He is active in local church affairs.

R. W. Pryer, M.E.I.C., Councillor for North Shore Lower St. Lawrence is Soils Engineer with Quebec North Shore and Labrador Railway at Sept-Iles. He received his Bachelors degree from McGill in 1950 and his Master's from Purdue in 1958. He served as Branch Chairman in 1960-61.

J. U. Moreau, M.E.I.C.

J. U. Moreau, M.E.I.C., Councillor for the St. Maurice Valley, is a principal in the Trois-Rivieres Consulting Engineers firm of J. U. Moreau and Associates. He became a Student Member of the Institute in 1947, the year before he graduated from McGill. He was Chairman of the Junior Section of the St. Maurice branch in 1951-52, and was Branch Chairman in 1956-57. He is a member of the Club Richelieu in Trois Rivieres and is a past Director of the Trois Rivieres Chamber of Commerce.

J. W. Wilson, M.E.I.C., Councillor for Amherst, is Branch Manager of Armco Drainage and Metal Products of Canada Limited at Sackville, N.B. Educated at University of Toronto Mr. Wilson became a full member of the Institute in 1956. He was Chairman of the Amherst District Branch in 1958. Mr. Wilson was President of the Sackville Board of Trade in 1960-61, and President of the Sackville Rotary Club in 1958-59.

J. W. Wilson, M.E.I.C.

J. W. G. Scott, M.E.I.C.

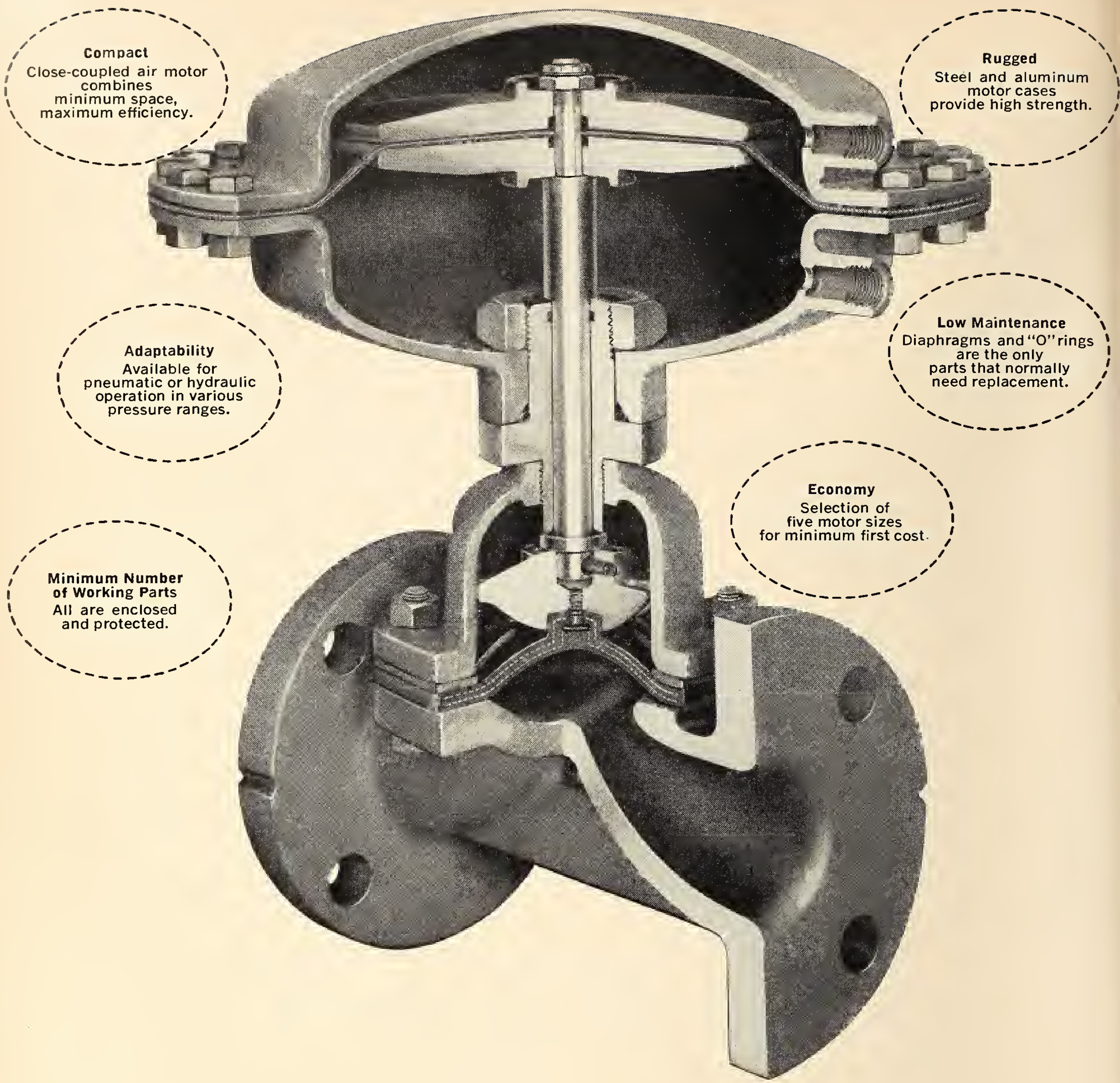
J. W. G. Scott, M.E.I.C., Councillor for Saint John, N.B., is employed by the Standard Dredging Co. Ltd., at Lancaster, N.B. He was educated at U.N.B. where he received his B.Sc. (Civil) in 1949. Mr. Scott served as Secretary-Treasurer of the Saint John Branch and was elected Chairman in 1959. He is a member of the A.P.E.N.B., of the Westfield Golf Club and of the Thistle Curling Club.

H. B. Carter, M.E.I.C., Councillor for Corner Brook, is Plant Engineer of Bowater's Newfoundland Pulp and Paper Mills, Ltd. A graduate of McGill, Mr. Carter served one term as Councillor and has been active in Branch activities. He is a past-President of the Association of Professional Engineers of Newfoundland and is Vice-Chairman of the Corner Brook Public School Board.

W. J. Phillips, M.E.I.C., Councillor for Halifax, is Electrical Engineer for the Nova Scotia Light and Power Company, Ltd. An N.S.T.C. graduate, Mr. Phillips joined the Institute as a Student Member in 1947. In Halifax Branch activities he served three years on the Professional Development Committee, one as Chairman, was a member of the executive for four years including one term as Vice-Chairman and another as Chairman. He is a member of the AP.E.N.S., and of the Bluenose Chapter of I.E.S. where he served one term as Chairman. Interests, besides his family, include photography, stamps, books and all sports.

J. R. Menard, M.E.I.C., re-elected Councillor for the Lower St. Lawrence, is a principal of the Rimouski Consulting Engineers firm of Menard and Marsan. He joined the Institute as a Student Member in 1942, the year before graduating from the University of Montreal. Mr. Menard was Secretary of the Lower St. Lawrence branch 1951-55 and was Chairman in 1956-57. He was National Director of the Junior Chamber of Commerce in 1954 and last year was

(continued on page 132)



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Personals

'. E. P. Duncan, M.E.I.C. (Glasgow '13), ›neral manager subway construction ith the Toronto Transit commission, as retired. Mr. Duncan, who has been ith the TTC for 40 years, will, howver, still be connected with the onstruction of the subway. He has een appointed general consultant on ıe construction of the University Ave. ıbway and will see the first phase ırough to operational stage in 1963. W. [. Patterson, M.E.I.C. (Queen's '35), is) succeed Mr. Duncan. Mr. Patterson as been the Commission's chief engieer for the past 12 years.

:harles W. Nash, M.E.I.C. (Wash. State :oll. '23), has been elected president of he B.C. Natural Resources Conference. Ir. Nash is director of load developıent.

. E. Cranswick, M.E.I.C. (Man. '29), has een elected vice president, wholesale livision, Canadian Westinghouse Comany. The division is engaged in the narketing of a broad range of light lectrical apparatus products to power ıtilities, contractors and institutional ustomers.

George L. Macpherson, M.E.I.C. (Toonto '20), has retired from the Board of Directors of Imperial Oil Limited. Mr. Macpherson became a director in 1954 and was formerly general manager of Imperial's manufacturing department.

J. M. Paquet, M.E.I.C. (Poly. '34), has opened his office as consulting engineer, mechanical and electrical in Quebec City. The office operates under the name of Paquet and Dutil, Consulting Engineers.

Joseph D. Dexter, M.E.I.C. (MeGill '32), has been appointed chief engineer, Bowaters Mersey Paper Company Limited. In 1941 Mr. Dexter was commissioned as an aeronautieal engineer in the R.C.A.F. Following the war he was appointed senior engineer with the company and in 1950 was appointed assistant chief engineer.

Dr. Arthur Porter, M.E.I.C. (Manchester '34), Dean of the College of Engineering at the University of Saskatchewan, has been appointed First Professor of Industrial Engineering at the University of Toronto. Dr. Porter was head of the research department at Ferranti Electrical Company in 1949 and returned to England in 1955 to become professor of Light Electrical Engineering at the Imperial College of Science and Technology, University of London. He joined the University of Saskatchewan in 1958 and was responsible for the introduction of engineering science courses for students of superior intelligence. He has directed a program of research at the University concerned with studies of the learning process in man and machines, the collaboration between engineering and medical scientists.

J. S. Waddington, M.E.I.C.

J. S. Waddington, M.E.I.C. (Man. '34), has been appointed a vice-president, Phillips Electrical Company Limited. In this position Mr. Waddington will be responsble for the operation of the Brockville, Montreal and Vancouver divisions and for overall technical coordination. G. H. Gallimore, M.E.I.C. (Man. '36), has been appointed manager of the Montreal Division. He will be responsible for the manufacture of telephone and power cables by the Company's Montreal plant. Mr. Gallimore joined Phillips in 1939 as sales engineer.

R. E. Tweeddale, M.E.I.C. (U.N.B. '35), has been named "Electrical Man of the Year" for Canada. A plaque representing the National award was presented to Mr. Tweeddale Jan. 24, following the Canadian Electric Association's National Convention luncheon. Each year the plaque is donated by the electrical publications of Hugh C. MacLean Company to the man who, in the opinion of a Committee of Editors, has made the most notable contribution to the progress of the electrical industry in Canada. Mr. Tweeddale was nominated as being responsible for the creation of the Maritime grid linking the electric utilities of New Brunswick and Nova Scotia into one power pool.

Prof. C. G. E. Downing, M.E.I.C. (Sask. '40) and Prof. F. H. Theakston, M.E.I.C., recently attended the International Technical Congress on Agricultural machinery in Paris. Prof. Downing, head of the Ontario Agricultural College department of engineering science, presented a paper at the Congress and Prof. Theakston, director of the Canadian Farm Building Plans Service Centre, studied developments and design of structures and equipment.

David Blair, M.E.I.C. (U.N.B. '46), has been appointed chief engineer, Modern Construction Limited. Mr. Blair formerly spent nearly 15 years with Canadian National Railways, the last six being spent as senior officer in the company's Atlantic Region.

Dr. W. C. Leith, M.E.I.C. (U.B.C. '48, McGill '60), has joined Hydronautics Inc., consultants in hydrodynamics at Rockville, Maryland, where he is specializing in cavitation damage of metals. For the past eight years he was mechanical research engineer with Dominion Engineering Works, Montreal.

B. I. Maduke, M.E.I.C. (Sask. '48, '52, Harvard '52), has been appointed manager of R. M. Hardy and Associates Ltd., Edmonton. Mr. Maduke has had wide and varied experience in the field of soil mechanics and foundation engineering in Quebec, Ontario, British Columbia, the Prairie Provinces and Northern areas.

Douglas H. Cohoon, M.E.I.C. (McGill '49) has been appointed Vice-President and Managing Director of Fry-Cadbury Limited, Montreal.

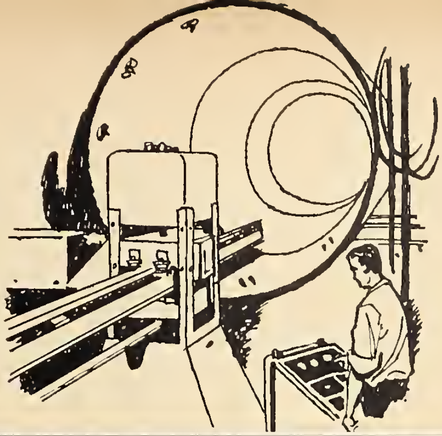
K. M. Mote, M.E.I.C. (Birmingham Central Tech. '49), has returned to Canada and is director and partner of F. and F. Tractor Equipment Limited. The company is at present serving the agricultural field but hopes shortly to cover the industrial field.

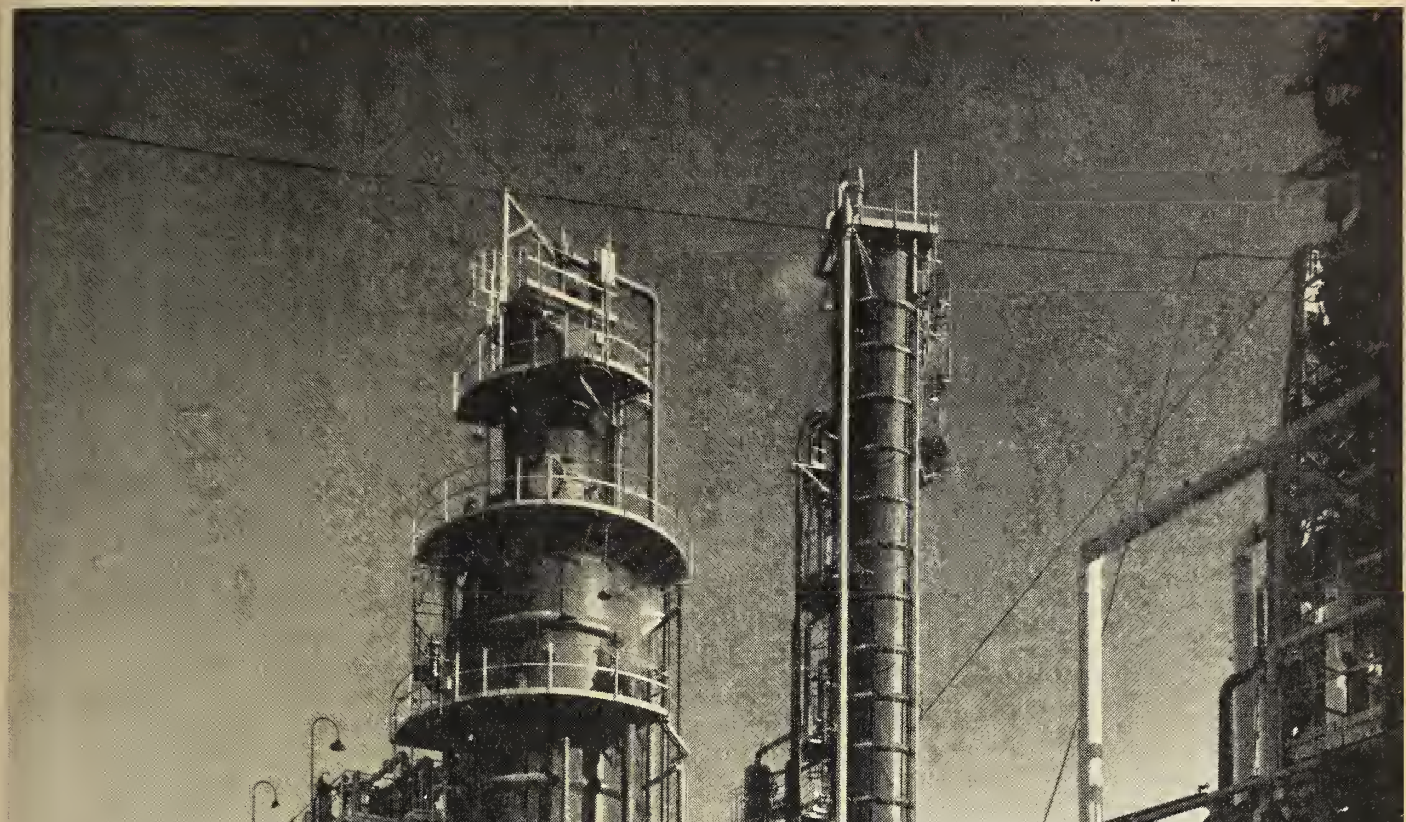
E. F. Holmgren, M.E.I.C. (Alta. '50), has been appointed manager of the Edmonton office of Materials Testing Laboratories Ltd. Mr. Holmgren has had wide experience in the field of concrete technology and concrete problems with ten years' experience in the field of ready mix concrete.

D. C. Cullingham, M.E.I.C. (Toronto '50), has a position with Parsons and Whittemore (France) in connection with the design of a sulphite disolving pulp

(Continued on page 94)

he Tough Ones...





Typical refinery towers. D.B. has a great deal of experience in the fabrication of vessels for the oil and chemical processing industry.

mill. Mr. Cullingham previously assisted in the start up of a pulp mill in Sitka, for the Alaska Lumber and Pulp Company.

Guy A. Hamel, M.E.I.C. (McGill '50), has been appointed technical services manager, Omark Industries Ltd., Guelph, Ont. Mr. Hamel will be in charge of the company's product service functions.

Robert Herdman, M.E.I.C., formerly Plant Engineer at Bowater's Newfoundland Pulp and Paper Mills Limited, has been transferred to Calhoun, Tennessee, where he will assume the position of Assistant to the Chief Engineer with Bowater's Engineering and Development Incorporated.

Jean-Louis Bourret, JR.E.I.C. (Poly. '52), has been elected president of the Quebec Concrete Products Association. Mr. Bourret is at present sales manager for Quebec Ready-Mix Inc. and is a director of the Association des Diplomes de Polytechnique.

E. H. Gilliatt, M.E.I.C. (N.S.T.C. '52), has been appointed assistant general superintendent, transportation, in charge of technical aspects, Great Lakes Region of the C.N.R. Mr. Gilliatt was formerly transportation engineer at Montreal headquarters.

W. Buryniuk, M.E.I.C.

Walter Buryniuk, M.E.I.C. (Sask. '53), is head of a consulting engineering firm in his name with his office in Port Arthur, Ont. Mr. Buryniuk previously worked as resident engineer with C. D. Howe Co. Limited and as assistant park engineer for the Civil Service of Canada in Banff.

R. Vanier, S.E.I.C. (Ecole Poly. '60), has been appointed Assistant City Engineer of City of Outremont.

G. H. Beuker, S.E.I.C. (Sask. '60), has been appointed lighting services supervisor, Saskatchewan Power Corporation, load development department. Mr. Beuker was formerly engineer in the electrical transmission design department.

Obituaries

Ira William Beverly, M.E.I.C. (McGill '18), electrical engineer, died March 5 at Winnipeg. Mr. Beverly was born in Kettle Falls, Washington, U.S.A., and received his education in Canada. He served as a pilot with the Royal Air Force in World War I. In 1926 he took up residence in Winnipeg where he later became Vice-President of Sangamo Company Limited. Mr. Beverly became an associate member in 1939 and became a life member in 1940.

H. H. Cantwell, M.E.I.C. (Union '07), a prominent figure in the pulp and paper industry, died Dec. 1. Mr. Cantwell came to Canada in 1916 and for more than 40 years served the pulp and paper industry in various executive positions. He joined the Institute in 1921 as an associate member and became a member in 1940. He was made a life member in 1957.

Frederick Harris-Lowe, M.E.I.C., died March 3, at St. Catharines, Ont. He was 59. Mr. Harris-Lowe was born in Kent, England and came to Canada in 1922. In 1941 he joined the Royal Canadian Engineers, and served for five years. He was employed by the Ontario Paper Company Limited in 1945, and later became manager of engineering. He held this position until the time of his death. Mr. Harris-Lowe became a member of the Institute in 1959.

Henning Jones Hermanson, M.E.I.C. (Sask. '25). Engineer for the Department of Highways, Province of Newfoundland, died Feb. 24 at St. John's, Nfld.

Mr. Hermanson was born Feb. 26, 1902, in the Parish of Hasjo, Province of Jamtland, Sweden. He received his B.A. and B.Sc. from the University of Saskatchewan.

Mr. Hermanson was employed as resident engineer with the Department of Highways in 1949. He supervised construction of various sections of the Trans Canada Highway between Gambo and Grand Falls, Nfld. He held the position of office engineer at the time of his death.

Mr. Hermanson was a registered engineer in the Province of Saskatchewan where he practiced engineering after his graduation. From 1923 until 1927 he was employed as resident engineer on various construction projects in that Province. From 1928 until 1930 he was a resident engineer on construction of Provincial highways, Province of Saskatchewan. He served as a district engineer for maintenance and constructio for the Saskatchewan Highway Depar ment from 1930 until 1945. Mr. Herman son then held the position of engine for the Campbell-Mannix Company Prince George, B.C. until that compan was dissolved in 1948. Mr. Hermanso then took charge of a reconnaissance su vey for the Department of Mines an Resources, Ottawa, in the Yukon territor between Whitehorse and Dawson City When this project was completed M Hermanson moved to Newfoundland an took a position with the Department o Highways.

Mr. Hermanson was a charter membe of the Association of Professional Engineers of Newfoundland and a membe of the Association of Professional Engineers of Saskatchewan. He joined the Engineering Institute of Canada as associate member in 1938 and became a full member in 1940.

Colonel Redford Henry Mulock, M.E.I.C., awarded the DSO and bar a Dunkirk, in World War I, died Jan. 23 He was 76. Colonel Mulock was a Commander of the Order of the British Empire and a Chevalier of the Legion of Honor. In 1921 he joined the Canadian Air Force as air commodore. He retired in 1924. Colonel Mulock joined the Institute in 1905 and became an associate member in 1912, he was awarded a life membership in 1954.

Walter Laidlaw Saunders, M.E.I.C., died March 5. He was born in Goderich, Ont., and studied engineering at the University of Toronto. He served as a lieutenant with the 6th Battalion of Canadian Railway Troops in France from 1917 until 1919. He was employed as assistant engineer on construction and maintenance with the Canadian Pacific Railway in Saskatchewan. In 1922 he joined the Department of Highways of Ontario and later became Ottawa division engineer. In 1949 he was transferred to Owen Sound, Ont. as division engineer. Mr. Saunders joined the Institute in 1910 as a student, became a junior in 1913, an associate member in 1920 and was awarded a life membership in 1960. EIC

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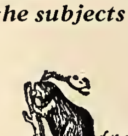

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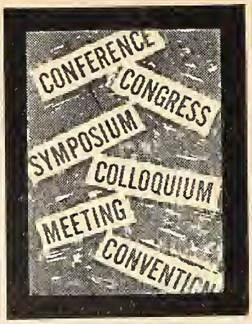
Other Societies



American Society of Mechanical Engineers

The ASME Aviation Conference was held at Los Angeles, March 13-15. Highlights of the meeting included a talk by C. J. Dayle, Thompson Ramo Wooldridge, Inc., about a miniature power plant that works on the same principle as a commercial generating station but is small enough to tuck into an orbiting satellite. Called "Sunflower I", the unit uses the heat of the sun instead of fuel and is designed to power the radios and other equipment in satellites. John W. Marshall, project engineer at Edwards Air Force Base, pointed out in his paper that helium production, centered around Amarillo, Texas, is not expected to meet demand this year. One way to conserve supplies, he contended, was to avoid losses in shipment by supercooling the helium to 452 degrees below zero F. where it becomes a liquid. Helium gas is now shipped in tanks under heavy pressure. D. B. Mackay, research specialist, North American Aviation, Inc. gave a paper and explored several possible refrigeration systems on the moon and discussed their relative advantages and disadvantages. Another speaker at the conference, Robert Z. Snyder, Aviation Medical Acceleration Laboratory, told aviation specialists of the tests performed on a human centrifuge to make sure pilots could control a new U.S. Navy aircraft even if the plane should slip into a spin.

American Society for Testing Materials

A three-day symposium on materials and electron device processing was held April 5-7, in Philadelphia. Subjects covered in the 35 papers included control of ultraclean device assembly areas, new techniques for the detection of trace contaminants, advanced device cleaning processes and reports on the effects of such cleaning on device performance. Also included were discussions of the characterization and control of gaseous and vacuum processing ambients, as well as safe handling practices and uses of beryllia ceramics.

Canadian Construction Association

The Association presented a brief on behalf of the construction industry of Canada to Prime Minister Diefenbaker and Federal Cabinet members March 21. C.C.A. President Arthur G. Sullivan headed the delegation.

The submission was based on the Statement of Policy and Resolutions passed at the C.C.A.'s 43rd Annual Meeting and endorsed by 59 affiliated construction organizations. Recommendations were made on the many facets of importance and concern to the industry including bidding and contract procedures, labour relations, apprenticeship, housing, taxes and tariffs and wintertime construction. The brief also outlined the Association's National Highways Policy and acquainted the Cabinet with its proposals designed to increase employment.

The Chemical Institute of Canada

The C.I.C. has established a committee to implement its program to certify suitably qualified chemical technicians. While the Institute is providing the machinery for dealing with certification procedures, it is hoped that ultimately

(Continued on page 98)

The Associations and Corporation

C. P. E. Q.

The 42nd Annual General Meeting of the Corporation of Professional Engineers was held at the Queen Elizabeth Hotel in Montreal, April 8.

During the meeting, A. J. Groleau, Vice-President of the Bell Telephone Company of Canada, was elected President of the Corporation, succeeding Arthur Piche of Quebec City.

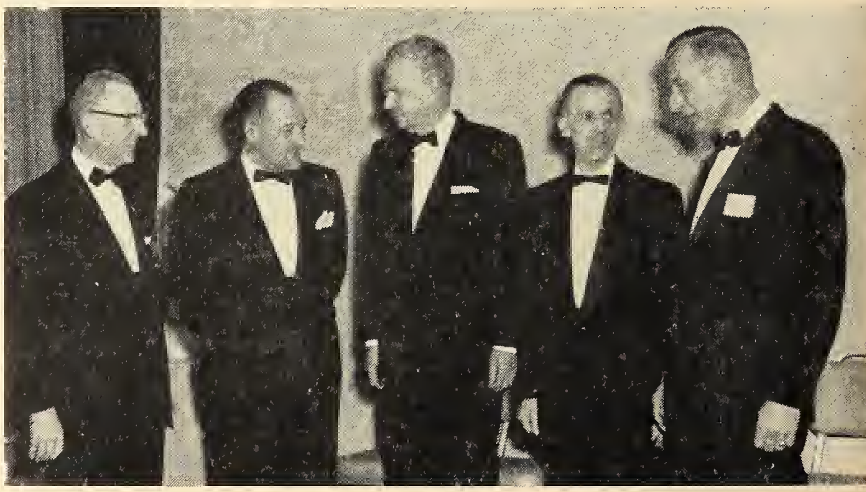
Gilles Sarault, consulting engineer of Quebec City, was elected Vice President, and H. J. Racey, consulting engineer of Montreal, was re-elected honorary Secretary-Treasurer of the Corporation.

R. A. Phillips of Montreal, Manager of Marketing for Canadian General Electric, was elected to Council. Mr. Phillips replaces W. J. Riley of Montreal who preceded Mr. Piche as Corporation President.

Prime Minister Diefenbaker, the guest speaker at the banquet, was presented with a certificate of honorary membership in the Corporation. This was only the third honorary membership awarded in the Corporation's history. The two others were the late Hon. C. D. Howe and the late Premier Maurice Duplessis.

Approximately 1,000 persons attended the banquet which followed the afternoon meeting which dealt with internal business.

Shown at the Annual Meeting of the C.P.E.Q. are, from the left: Dr. George McK. Dick, E.I.C. President; A. J. Groleau, C.P.E.Q. President-elect; Mr. Diefenbaker; Arthur Piche, C.P.E.Q. immediate past-President; L. C. Sentanee, A.P.E.O. President.



● OTHER SOCIETIES

the qualified technicians will assist in carrying on this program through an independent body.

Various governmental, industrial and educational groups have given warm support to this program which is designed to provide a method of uniformly assessing and grading the qualifications of technicians with widely diverse backgrounds. The Chairman of the committee is Dr. W. G. Hines.

Illuminating Engineering Society

The 17th Canadian Regional Conference is being held at the Queen Elizabeth Hotel, Montreal, May 14-16. The Society will focus on improvements and trends in office, home, school and industrial lighting techniques. The agenda will include papers dealing with "Municipal Lighting in Montreal", "Bridge Rail Lighting", "Economic Comparisons of Various Fluorescent Industrial Lighting Systems" and "Atmosphere Lighting in the New Vanguard Aircraft". The general chairman of the conference committee is J. P. Cristel, M.E.I.C., of the Shawinigan Water and Power Company.

The Institute of Radio Engineers

The Toronto Section held a meeting at the University of Toronto, April 3. Mr. G. W. Steck, Manager, Communications Product Sales, Westrex Corporation, New York, gave a talk "Command and Dispatch Consoles for Mobile and Point to Point Systems." Mr. Steck described the electrical and mechanical design and human engineering aspects of complex command and dispatch systems for single or multi-operator use in utility, police, fire or civil defence radio systems. At a meeting held April 2 L. Casciato, Traffic Research Corporation Limited, gave a talk entitled "Controlling Traffic in Metropolitan Toronto with an Electronic Computer".

Instrument Society of America

ISA is holding its first Canadian International Conference and Exhibit in Toronto June 5-8. Headquarters for the Conference June 5-8, will be the Royal York Hotel. The Exhibit, June 6-8, will be in the Queen Elizabeth Hall at Exhibition Park.

Twelve Conference sessions are planned with approximately 35 papers. Commencing Monday there will be a Management Day Program with two sessions planned on "Industrial Instrumentation — The Impact of Computers". Other sessions include Power Plant Instrumentation; Pulp and Paper; Underwater Instrumentation; Feedback Control Systems; Chemical and Petroleum; Analysis Instrumentation; Measurement and Control Data Handling and Computation. Over 100 exhibitors are expected. Featured will be a wide range of instrumentation, data handling and computation equipment.

Coming Events

- Annual Meeting, American Society of Tool and Manufacturing Engineers, New York, May 22-26.
- Annual Meeting, Canadian Society of Plant Physiologists, Ottawa, May 24-26.
- Annual General Meeting, Canadian Aeronautical Institute, Toronto, May 25-26.
- 75th Annual General and Professional Meeting, Engineering Institute of Canada, Vancouver, May 31-June 2.
- 11th Annual Meeting, Canadian Association of Geographers, Montreal, June 1-3.
- Summer Instrument Automation Conference and Exhibit, Instrument Society of America, Toronto, June 5-8.
- General Assembly, International Organization for Standardization, Helsinki, June 5-16.
- Summer Meeting of the Technical Section, Canadian Pulp and Paper Association, Saranac Lake, N.Y., June 7-9.
- Annual Meeting, Canadian Council of Professional Engineers, Edmonton, June 7-9.
- 16th Annual Congress, Canadian Association of Physicists, Montreal, June 7-10.
- Summer Annual Meeting, American Society of Mechanical Engineers, Los Angeles, June 11-15.
- Eighth International Nuclear Congress and Exhibition on Electronics and Atomic Energy, Rome, June 15-29.
- Annual Meeting, Canadian Electrical Association, Banff, Alta., June 26-28.
- Annual Meeting and Convention, Agricultural Institute of Canada, Regina, June 26-29. EIC

News of the Branches

Baie Comeau

G. W. Scott, M.E.I.C.,
Correspondent

At a meeting held Feb. 1 members heard an interesting talk on "Underwater Diving Operations". International Underwater Contractors Limited is the Canadian associate of the parent French oganization, Société Génerale de Travaux Maritimes et Fleveaux, or as it is better known, 'Sogetram'—the world's only international organization of professional frogmen. Representing International Underwater Contractors were F. Dreville, M.E.I.C., Montreal manager, and Tech. Diver Hervé Lallier.

Mr. Lallier briefly described the rigorous training and exacting requirements necessary in the make up of the professional frogman. The activities of the company were effectively illustrated by two color films entitled "White Island Lighthouse" and "Wreck Buster".

At a meeting held March 23, J. C. Dykes, M.E.I.C., Instrument Engineer, Dominion Tar and Chemical Company Ltd., gave a talk on "Instrumentation". In his address, illustrated by slides, Mr. Dykes described a typical flow process operation in the pulp and paper industry with a view to indicating the scope and responsibilities involved in the work of the instrumentation engineer towards establishing quantity and quality control. He also gave an outline of the prominent part the instrumentation engineer now has to play in establishing the design details in a new industrial plant particularly where the process is one involving continuous fluid flow. The extent to which instrumentation can be a major economic factor in plant work was shown by Mr. Dykes' observation that in the petrochemical industry instrumentation may amount to 12% of the total cost of the project.

Belleville

W. L. Canniff, JR.E.I.C.,
Correspondent

Topic of a March 13 address by E. J. Jones, Aerial Survey Mapping Branch, Dept. of Mines and Technical Surveys, was "Air Survey and Mapping Work".

With the exception of two areas, all of Canada has been aerially photographed for map work and topographic maps are available in many scales. The two areas are to be photographed during the next few years. Oceanography staff are being trained and the number of staff is being increased. The Polar Continental Shelf is being investigated to determine natural resources as well as all mapping survey data. Mr. Jones was introduced by T. J. McQuaid and was thanked by W. Benger.

Cape Breton

Lloyd E. Boutilier, M.E.I.C.,
Correspondent

Fifteen senior Mechanical Engineering students from Nova Scotia Technical College with Professor Ahern of the Mechanical Engineering Faculty were guests at the March 17 meeting. Purpose of their visit was a tour of the Sydney works of the Dominion Steel & Coal Corp., Ltd. During the few hours they spent there they viewed various operations and departments including the blast furnace, open hearth furnace, heavy mills, rod and bar mill, wire and nail departments and the coke plant. Several of the guides were Branch members employed by DOSCO.

In the evening the visitors were guests at a smoker attended by 40 members. They were welcomed by Rod Bradlev, Branch Chairman, who expressed the hope that future Mechanical Engineering classes would be able to tour the plant. Following a buffet supper the film "The Dosco Story" was shown. Harry Leonard, spokesman for the student visitors, expressed their thanks to the Branch members.

Corner Brook

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

"Instrument Engineering" was the title of a talk given by J. T. Dykes, M.E.I.C., at the March 2 meeting. Mr. Dykes introduced his subject by explaining the duties of an instrument engineer. He discussed instrument engineering in general, covering such subjects as circuitry and plant wide methods of indexing instrument components. The amount of instrumentation justified on a typical plant installation was thoroughly covered. The question and answer period was lively with questions centering on the relative merits of the various systems used to identify and index instrument components and systems.

Halifax

H. F. Peters, M.E.I.C.,
Correspondent

Graduating engineers from the Nova Scotia Technical College were guests of the Branch at a reception and dinner held at the Jubilee Boat Club, March 7. Seventy-two members and 127 students participated. Highlight of the evening was a panel discussion on the theme of "What Industry Expects from the Engineering Graduates". Leading the discussion were F. Dean, Dominion Structural Steel, M. J. Magman, Imperial Oil, A. R. Harrington, Nova Scotia Light and Power, and H. C. McGee, Canadian General Electric. The Panel pointed out that graduating students were presumed to have a good technical knowledge; what the graduate lacked was knowledge of how to adapt and sell his training, training in personnel management, a knowledge of financing and a knowledge of markets. A knowledge of all these matters is essential before the graduate can realize his full potential in business life. The necessity for continued study to keep abreast of current technical and other developments was emphasized.

Hamilton

P. J. McNally, M.E.I.C.,
Chairman

A meeting was held with the McMaster University engineering society Feb. 9 with Dr. W. W. Sawyer as principal speaker. Dr. Sawyer spoke of the erroneous tendency to teach and learn by note rather than by illustration and simple reasoning. He gave mathematical examples of the two methods. However, it was clearly indicated that the improved methods could be applied equally to all branches of learning. Edgar A. Cross gave an interesting history of the growth of engineering, particularly of engineering societies.

At the March 9 meeting, Mr. Marsh

of the Aluminum Company of Canada, spoke to members at the Argyll and Sutherland Highlander's Officers Mess. Mr. Marsh talked of some recently appreciated structural properties of aluminum. His talk was illustrated with slides showing many new and engineered uses of aluminum sheets and structural shapes.

Kingston

L. C. Miller, JR.E.I.C.,
Correspondent

An "Industrial Problems Night" was featured at the March 15 meeting. Thirty-eight members and guests heard problems discussed by A. K. Sneddan, Aluminum Company of Canada, H. W. Legere, Du Pont of Canada and R. O. Moore, Canadian Industries Limited. Respective topics of discussion were "Examination of the Conditions of Extrusion Press Tie Rods", "Fire Hazard Considerations in the Use of Flammable Heat Transfer Mediums", and "Determination of Cause of Low Flow in Raw Water Intake Line".

Lower St. Lawrence

Marcel Carrier, M.E.I.C.,
Correspondent

Roger J. Paquin, Managing-Director of Quebec Terminal Limited was guest speaker at a meeting held Jan. 23. His topic was problems of winter navigation. At the March 21 meeting, Leslie Orr, Chief Chemist for the Imperial Oil Refineries, gave a talk on petroliferous operations and products extracted from crude oil. An interesting film illustrated his talk on various stages of oil refining.

Newfoundland

A. O. Nemec, JR.E.I.C.,
Correspondent

The annual Memorial University of Newfoundland Engineering Student Speech Night was held March 27 at the auditorium of the Newfoundland Light and Power Company. This affair is conducted to award a $50 prize to the engineering student who gives the best speech as judged by the E.I.C. members in the audience. Three of the finalists of the University engineering seminar program were selected by the Engineering faculty to compete for the prize.

This year's winner was William W. Johnston, a second year engineering student who plans to take Civil Engineering at the University of Toronto. His speech, titled "A Metropolitan Dilemma" dealt with some of our local motor vehicle traffic problems as well as those faced by the major cities in Canada.

The runners-up were Leblan Davis who spoke on "The Decca Navigation System" and Rod Chafe whose talk was entitled "Exploration in Newfoundland for Peat Moss". Both are second year engineering students who plan to attend Nova Scotia Technical College after obtaining their engineering diplomas from Memorial.

The report of the nominating committee, presented at the conclusion of the meeting, was approved by the members.

Ottawa

M. Bozozuk, JR.E.I.C.,
Sec./Treas.

The Junior Section held their "Papers' Night", March 9. Forty engineers and students attended. The judges were Colonel W. A. Capelle, M.E.I.C., Department of National Defence, J. N. Pritchard, M.E.I.C., Waterworks Department of the City of Ottawa, and J. S. Watt, M.E.I.C., National Harbours Board.

Colonel Capelle summarized the papers presented and offered helpful criticisms to the speakers. G. B. Williams, M.E.I.C., Deputy Minister of the Department of Public Works, presented the prizes. First and second prize winners in the Junior Section were H. J. Thorburn and T. M. Dick, respectively. Of the students, G. Saunders and E. Edelson were awarded first and second prizes respectively.

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Sarnia

Joseph P. Zanyk, JR.E.I.C.,
Correspondent

At a joint meeting held with the Chemical Institute of Canada March 15, Dr. I. A. Johnson gave a talk on "Analog Computers". He dealt with the typical problems that are found in industry that can be solved using analog computers. Typical problems were discussed and a differential equation written for its solution. Dr. Johnson went on to outline how computers are programed. He concluded his talk by showing a short film.

Vancouver

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

Four technical meetings were held in March.

Dr. A. R. Anderson addressed the branch March 7. The subject of his talk was "Recent advances in Prestressed Concrete." Dr. Anderson is a co-founder of the Concrete Technology Corp. in Tacoma, Washington. This organization specializes in research technology, product development and the production of high strength concrete precast and prestressed structural members.

"Management Responsibility" was the subject of the speech given at the March 14 meeting. E. C. Roper who gave the talk is an Instructor at the Dept. of Commerce, U.B.C. He has a wide experience in management as he has been President of the Howe Sound Co., Manager of Britania Mining and Smelting Co. and is a past president of the Mining Association of B.C.

Two speakers, A. MacDougal and J. Carrigan, discussed "Cranberry Creek Hydro Electric Project, Revelstoke, B.C." at the March 21 meeting. This project, which has been recently completed is an excellent example of a small hydro electric facility specifically designed for local needs. The talks were illustrated with slides.

Heinz J. Heinrich came from Montreal especially to talk to the members on "Airline Maintenance in the Jet Age—An Economic Challenge for Technical Management". This address was the highlight of the March 28 meeting. Mr. Heinrich is Superintendent of Planning at Dorval for Trans-Canada Air Lines. He has been with this company for 17 years and has served as Chairman of International Air Transport Association of America, Production Planning Committees. Mr. Heinrich has spoken at various international management conferences and is the author of articles on Planning and Aviation. He is a Consultant to the aviation industry, The Royal Canadian Air Force, and the United States Air Force.

Winnipeg

P. M. Abel, JR.E.I.C.,
Correspondent

The annual Student Night was held March 16 at the Pembina Hotel, gave members the opportunity to the Student Section members from University of Manitoba. Chairman Dr. C. S. London.

Following dinner the program with presentation of Summer T Prizes of $10 and bronze me Dean A. E. Macdonald gave the i duction. Prof. W. F. Riddell pres James Cran, winner of the best Engineering thesis; Prof. J. P. C. Mc presented Garnet Ward, winner in Electric Department; Prof. R. E. C presented Rudy Kaethler, winner in Mechanical Department. Dean A. Macdonald then presented the A.S. book prizes and memberships to following: A. M. Lansdowne, J. A. C K. M. Postgate, W. H. Lehn and F Finlay.

H. J. "Paddy" Moorehead was g speaker at the March 20 dinner mee His talk, entitled "Design and Const tion of the Kariba Dam on the Zam River" was illustrated with slides. Dam was built for the Federation Southern Rhodesia, Northern Rhod and Nyasaland to help control Zambezi River which is subject to treme seasonal variations in flow.

Yukon

J. P. McGownan, M.E.I.C.,
Correspondent

The annual meeting was held in

(Continued on page 1

Whitehorse Inn March 29. Following dinner the business meeting was held. The chairman, J. H. Reeves, reviewed the financial situation and the work of the Branch during the past year. Future meetings and topics were discussed. Grant Starr, M.E.I.C., President of the Yukon Professional Engineers Association was a guest speaker. At the conclusion of the meeting the branch executive for the coming year was elected.

University of British Columbia

R. Parker, S.E.I.C.,
Correspondent

Weekly meetings, held Fridays, attract a regular attendance of about one third to a half of the 450 members. These meetings are usually devoted to films or speakers with a view to introducing the students to the many aspects of engineering. Topics have ranged from atomic energy in India to the imaginative uses of thin shell concrete in the construction of modern buildings.

The "Toastmasters" club, patterned after but not affiliated with the Toastmasters International, provides another interesting and rewarding hour. The annual EIC Students Night attracted more than 50 students. Other interests included field trips, debating squads, a technical journal subscription service, aiding the allocation of several scholarships, and recently, representation on the annual academic symposium.

University of Western Ontario

David Fader, S.E.I.C.,
Correspondent

A Student Night was held Feb. 28 by the London Branch. After the opening address by vice-president Cross, a panel of six prominent area engineers discussed their respective fields of engineering with 85 students and engineers present. Mr. Cross presented the E.I.C. Student Award to Gary Sutuer, president of the U.E.S.

V. A. McKillop, Manager of the P.U.C. and past E.I.C. president, spoke on the "Motivation of the Engineer" at the annual U.E.S.-E.I.C. Banquet, March 16. Mr. Baker, of A.S.T.M., awarded four students with A.S.T.M. awards, the first to be presented at any University in Ontario. U.E.S. honour and merit awards were also presented at the banquet.

L. C. Sentance, President of A.P.E.O. addressed a meeting held March 15 by the **BROCKVILLE BRANCH.** The **CORNWALL BRANCH** held a meeting March 23 when S. R. Cooper, M.E.I.C. gave an interesting talk on "Heat Transfer". A film, produced by Johns Manville was shown and a lively question and answer period followed. The March monthly meeting of the **ESTEVAN SECTION** was combined with a banquet and dance March 10. A short business meeting was conducted after dinner and Chairman Carlson gave a summary of the proceedings which took place at the Saskatchewan Branch's Annual Meeting, in February. **FREDERICTON** held a meeting March 20 when S. B. Cassidy, M.E.I.C. gave a talk on E.I.C. Membership. Two films featuring diving operations were shown to members of the **NORTH SHORE LOWER ST. LAWRENCE BRANCH** March 2. International Underwater Contractor showed the films. The **UNIVERSITY OF SASKATCHEWAN SECTION** elected their 1961 Executive March 17.

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.

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Engineers' Wives Associations

A Spring Bridge was planned for the last week in March by the **Moncton Association.** The **Calgary Club** toured the new Aquarium of the Calgary Brewing Company in February. The tour was followed by dinner. The members also took part in the entertainment for the E.I.C. Slide Rule Soiree. Wives accompanying their husbands to the Annual Meeting of the Saskatchewan Section, of the E.I.C., were guests of the **Saskatoon Club** February 25. A luncheon was held followed by a tour of the Mendel Art Gallery. Members of the **Nipissing and Upper Ottawa Association** were guests of **Temiskaming** members in February. The highlight of this joint meeting was a tour of the Canadian International pulp mill. The **Ottawa Association** which is holding its closing luncheon April 25 has formed a bowling league. Mrs. Holmes, President of the **Montreal Association** has spoken twice on the radio and appeared on television. Her topic was the Engineers' Wives Associations in Canada. The **Penticton Association** held a social evening in February. Membership of the **Winnipeg Association** is 262. The Annual Coffee Party was held in March and the Annual Meeting in April. The **Edmonton Club** entertained Mrs. G. McK. Dick at luncheon and dinner on April 13. The closing banquet was held April 20. In February members of the **Peterborough Auxiliary** went by bus to Toronto where, after luncheon, they toured the Art Gallery. In April the annual "Round-Up" Dance featuring western atmosphere and a midnight supper was held. The **Port Hope and Cobourg Association** held a Spring Tea in April.

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.

***INTRODUCTION TO CERAMICS.**

This book is a guide to ceramic materials and ceramic processes, but it does not discuss ceramic engineering as such. It stresses a unified view of ceramic technology, rather than the usual compartmentalization into metallurgy, ceramics and plastics technology. An introductory section gives historical developments and describes the current state of the art. Section two covers raw materials and forming processes, and the third section examines such characteristics of ceramic solids as structure, surfaces, interfaces and atomic mobility. Section four describes the microstructure of ceramics, including equilibrium and non-equilibrium phases, nucleation, crystal and grain growth, vitrification and specific structures such as those of refractories, glazes, clay products, cement and abrasives. The final section details the physical properties of ceramics, including thermal, optical, electrical and magnetic properties. (W. D. Kingery. New York, Wiley, 1960. 781p., $15.00.)

TRANSLATION FROM RUSSIAN FOR SCIENTISTS.

A brief introduction to the Russian language for the scientist wishing to read Russian scientific literature. The essential grammatical points are covered, and illustrated with examples of scientific terminology. The larger part of the book consists of passages for reading, taken from various Russian books and journals in the fields of physics, electrical engineering, chemistry and chemical engineering. A Russian-English vocabulary is included. (C. R. Buxton and H. S. Jackson. London, Blackie, 1960. 299p., 30/-.)

***THE ENCYCLOPEDIA OF SPECTROSCOPY.**

A compilation of brief review articles by authorities from industry, universities and governmental organizations in the U.S., Britain and Europe, dealing with twenty-three principal kinds of spectroscopy, and discussing for each method its history, theory, instrumentation, techniques, interpretations and applications. Each method is thoroughly but briefly discussed, well illustrated, and documented. Topics included – absorption, band, Beta-ray, emission, infrared, microwave, raman, solar and vacuum spectroscopy; flame and absorption photometry, fluorophotometry and phosphorimetry; and resonance, gamma-ray, infrared, neutron and emission spectrometry. (Ed. by G. L. Clark. New York, Reinhold, 1960. 787p., $25.00.)

***WELDED INTERSTATE HIGHWAY BRIDGES.**

Here are published the award winning designs of The James F. Lincoln Arc Welding Foundation's 4th (1958) bridge design competition, most by now built or started, representing a cross section of the best current practice in bridge construction for the Defense and Interstate Highway System. The introduction describes the award programs and gives the 1958 winners and summarizes their designs. The remaining chapters each take up one aspect of bridges—plate girders, arches, box girders, and bascule—with text, photographs, and reproductions of the drawings and specifications by the award winners. (Ed. by J. G. Clark. Cleveland, James F. Lincoln Arc Welding Foundation, 1960. 269p., $2.00.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 1050 Mansfield Street, Montreal.

***LOW-TEMPERATURE TECHNIQUES.**

This work of British authors is in tended to provide a source of up-to date information about the principle and practice of low-temperature tech niques, emphasizing the practical aspect Sources are not given, but readin recommendations reflect internationa publications. The book discusses th geographical and historical background the production and measurement of lov temperatures; low-temperature tech niques in the lab, the properties o materials at low temperatures, gas separ ation, and the storage, transport and use of liquefied gas, particularly in indus trial refrigeration. (F. Din and A. H Cockett. London, Newnes, 1960. 216p. 40/-.)

***FUNDAMENTALS OF AERODYNAMIC HEATING.**

This introduction to aerodynamic heating is based on senior-graduate level lectures given at the Virginia Polytechnic Institute, and constitutes a detailed development of the theoretical background of laminar and turbulent layers, and their relation to skin friction and heat transfer. The exposition begins with basic concepts and fundamental equations, and then discusses the laminar and the turbulent boundary layer, theoretical skin friction and heat transfer, and approximate methods for the solution of laminar boundary layers. The final chapters deal with low-density flow parameters, slip flow, free molecule flow, heat transfer and mass-transfer cooling in the stagnation region, and the calculation of skin temperature. Simple kinetic analyses of viscosity and heat conduction are given in appendices. (R. W. Truitt. Toronto, Ronald, 1960. 257p., $10.00.)

***HIGH-FREQUENCY MAGNETIC MATERIALS.**

In this book, a pioneer in the field attempts to clarify the behavior and manifestations of magnetic materials. Magnetic and ferromagnetic powders, and compressed powder cores are discussed, following the introductory chapter. Then the fundamentals of ferrites and some of their practical applications at high frequencies are covered, with ex-

tensive references to further sources of information. The remaining chapters deal with permeability, permeability tuning, losses, temperature effects, restivity, dielectric properties, ferroinductors, the ferromagnetic loop antenna, and special applications of magnetic materials. (W. J. Polydoroff. New York, Wiley, 1960. 220p., $9.00.)

MECHANICS FOR TEXTILE STUDENTS.

Reprinted from the 1954 edition, this study of mechanics is primarily intended for part-time students working in the textile field. Movement is considered in the first part, particularly the rotating, linear, reciprocating and oscillating movement of machine parts. The other two parts cover statics and force causing movement. Many examples are given in the text, the majority of which are taken from textile machines and processes. (W. A. Hanton. Toronto, Butterworth, 1960. 336p., $6.00.)

SCANDINAVIAN RESEARCH GUIDE.

A directory of institutions carrying out research in the fields of technology and science, in the four Scandinavian countries, and Iceland, published with the object of increasing co-operation amongst those engaged in research.

The first volume contains a list of research institutes and laboratories, classified by subject, and giving for each its address, affiliation with a university, government department, etc., the name of its head and number of staff, fields of research activities and publications. Volume two contains similar information on central research organizations, research carried out at the universities and institutes of technology, scientific societies and their publications, and scientific and technical libraries.

This is a very useful and well arranged directory. (Oslo, Scandinavian Council for Applied Research, 1960. 2 vols., $10.00.)

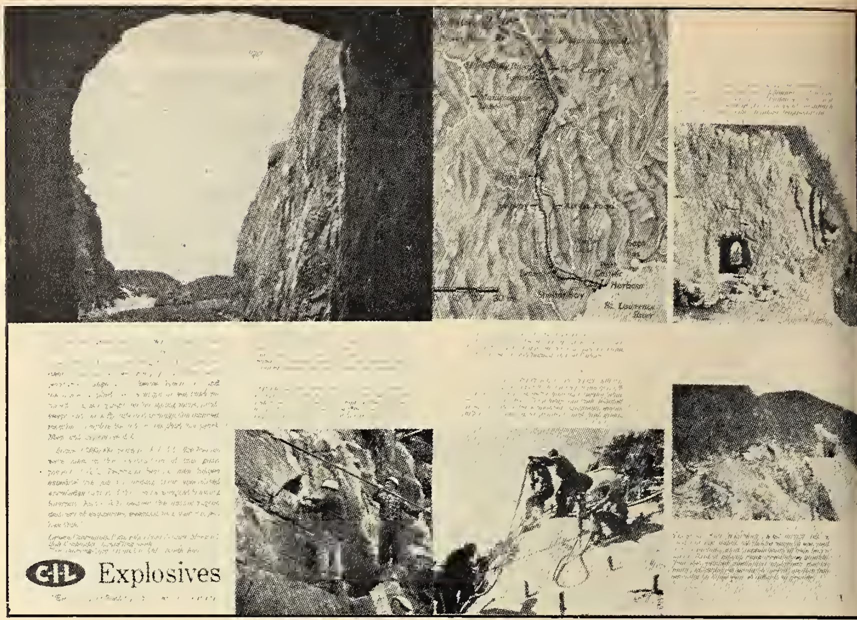
***THE SCIENTIST IN AMERICAN INDUSTRY.**

Based on two years' study of a large industrial research laboratory, this report describes and analyzes the problems encountered by the scientist employed therein. Its central theme is the need of entirely new principles of laboratory management oriented towards the "colleague authority" of the academic community rather than the "executive authority" characteristic of industrial enterprise. There are to be other studies of organizational environments as they affect scientific personnel. (Simon Marcson. Industrial Relations Section, Princeton University, 1960. 158p., $3.00.)

STANDARD METHODS FOR THE EXAMINATION OF WATER AND WASTEWATER, 11th. ed.

Many revisions have been made in this edition, and three new sections have been included covering procedures for the measurement of radioactivity in water and wastes; methods for the detection and isolation of iron and sulphur; bioassay methods for toxicity evaluation in streams, as affecting fish. Other methods cover the examination of natural and treated waters, both heavily and lightly polluted; the physical and chemical examination of industrial wastes; bacteriologic and biologic examination of water.

Both simple and complex control methods are included. Bibliographies are also included. This edition is prepared and published jointly by the American Public Health Association, the American Water Works Association, and the Water Pollution Control Federation. (New York, A.P.H.A., 1960. 626p., $10.00.)



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The Advertising Supervisor of CIL's Explosive Division is Mr. W. L. Hill. The advertising agency which prepared and placed the advertisement is the Toronto Office of Ronalds-Reynolds. Mr. H. O'Connor is the Account Executive.

THEORY AND PRACTICE OF CANADIAN ACCOUNTING.

Written both for students of accounting and businessmen, the purpose of this text is to present modern accounting principles, and the theoretical basis for Canadian accounting practices. The authors have adopted a functional approach, and analyze the relationships between purpose and method. The topics covered are accounting methods; income measurement, theory and practice; financial statements; limited companies; financial relations of parent and subsidiary companies; methods of control by management; budgets; accounting for special funds; valuation; taxation; bankruptcy and reorganization. Problems and questions for discussion are included. (W. G. Leonard and F. N. Beard. Toronto, McGraw-Hill, 1960. 442p., $7.75.)

THEORY AND PRACTICE OF VACUUM MELTING.

Reprinted from Metallurgical Reviews, this monograph is concerned with the vacuum melting of metals, that is the melting and resolidfying of a charge of solid metal under vacuum. The author discusses the thermodynamic equilibria and the kinetics involved; the principles of vacuum techniques, the vacuum induction melting process, furnace design, the electrical system, furnace practice, vacuum arc melting. A useful bibliography is included. (O. Winkler. Balzers, Liechtenstein, Balzers Aktiengesellschaft, 1960. 117p.)

WORKSHOP ENGINEERING PRACTICE.

The first two volumes in a series intended for students concerned with practice rather than theory. The first volume deals with fitting, and covers the tools used, saws, files, scrapers, cutting screw threads, measuring instruments, marking out, and the drilling machine. The second volume covers all aspects of lathe work, including tools, measuring instruments, marking out, turning, and tapers. Other volumes will cover sheet metal work, materials welding and foundry work. A series of filmstrips based on these books has been produced. (H. G. Rider. London, Iliffe, Toronto, British Book, 1960. $2.00 per vol.)

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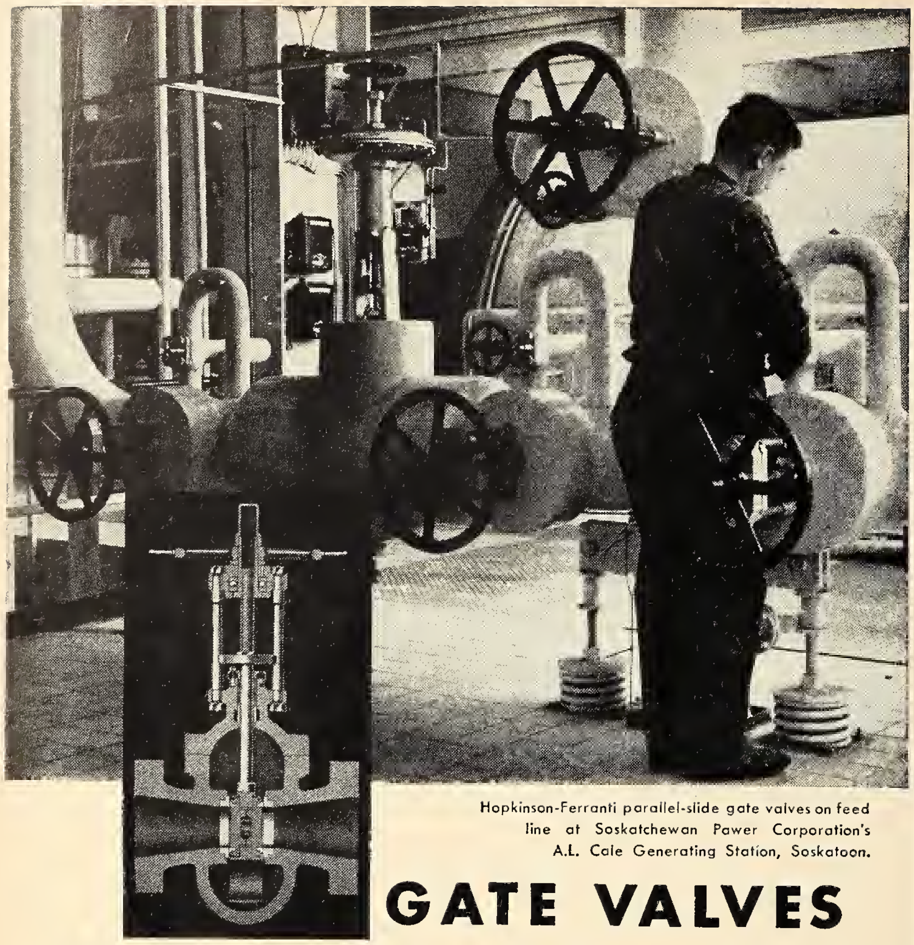


PROBLEMES DE THEORIE GENERALE DES OSCILLATIONS ET DE CHRONOMETRIE.

A book of worked problems, compiled primarily for students in the fields of chronometry and micro-mechanics, but of interest to all those concerned with the mechanieal measurement of time and of oscillations. The problems cover: astronomieal measurement of time; elementary theory of oscillation, theory of synchronization; pendulums; balancing wheels; etc. (J. Haag and R. Chaleat. Paris, Gauthier-Villars and Eyrolles, 1960. 412p., $8.00.)

DER STRASSENBAU, teil 2.

This second part of a German text on road planning and construction commenees with a chapter on retaining walls, drainage, bridges and tunnels. Succeeding ehapters cover various types of road markings, road signs, landscaping problems peculiar to city streets, the planning of construction, and various types of construction machinery. The first part, published three years ago, covered route location, road dimensions, foundations and materials. (Johannes Kastl. Leipzig, Teubner, 1960. 338p., 29 DM.)

HANDBOOK OF SUPERSONIC AERODYNAMICS. SECTION 18: SHOCK TUBES.

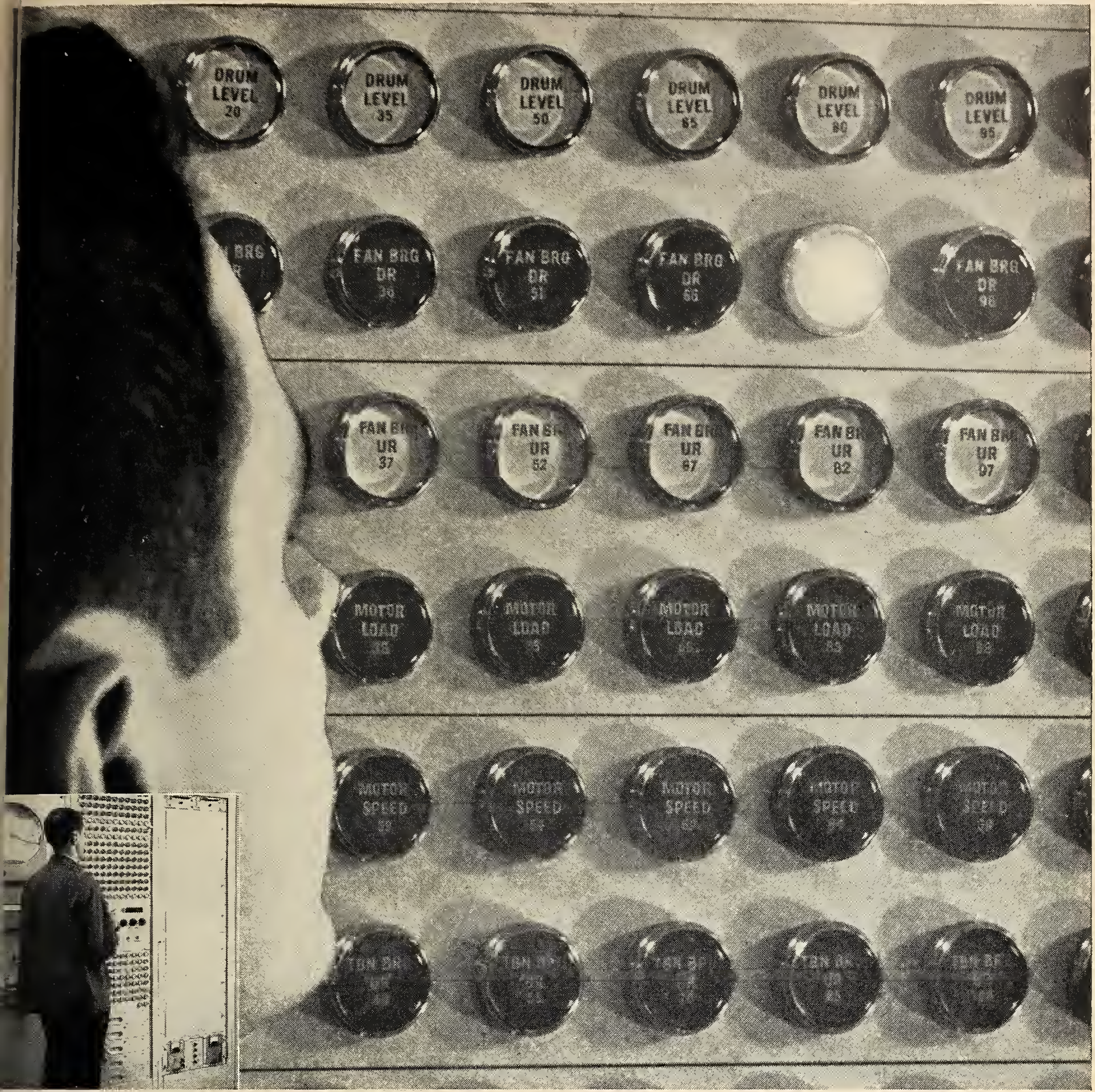
Prepared by The Johns Hopkins University under contraet with the U.S. Department of the Navy. The authors of this particular section are both at the Institute of Aerophysics of the University of Toronto. The text covers the theory and performance of simple shock tubes, and the production of strong shock waves, and shock tube applications, design and instrumentation. Much of the information is presented in tabular or graphical form, and extensive bibliographies are included. (I. I. Glass and J. G. Hall. Silver Springs, Md., Johns Hopkins Univ., 1959. 604p., $3.75. Sold by the U.S. Govt. Printing Office.)

THE PEOPLE'S POWER.

Published to celebrated its fiftieth anniversary, this fascinating history of Ontario Hydro describes its early struggles against political and other opposition, and outlines its growth through the twenties and troubled period of the thirties, and the rapid expansion during and since the last war, culminating with the completion of the St. Lawrence Seaway and Power Project in 1959. The importance of the men responsible for the growth of Ontario Hydro, from Sir Adam Beck on, is clearly shown by the author, who is well-known for his histories of other industries. (Merrill Denison. Toronto, McClelland and Stewart, 1960. 295p., $7.50.)

THE ELECTRO-EROSION MACHINING OF METALS.

Translated from the Russian, this book is based on work done by the author and his colleagues between 1950 and 1955, and is a description of the state of the technique, the technology and



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uses of electro-erosion machining in 1957, when the Russian edition appeared. The topics covered include electro-erosion machining methods, the generation of current pulses, automatic control, electrotechnological characteristics, and machine tools. Particular attention is paid to electro-pulse methods which have a wider field of application than electro-spark, and are more economical. (A. L. Livshits. Toronto, Butterworth, 1960. 115p., $7.75.)

REPAIRING TRANSISTOR RADIOS

Intended for the technician, this text explains the operation of transistor circuits and receivers, and outlines servicing procedures. After an introductory chapter on the transistor itself, succeeding chapters cover: the superheterodyne receiver; audio, power, i-f and r-f amplifiers; oscillators, converters and mixers; am and fm detector and agc circuits; portable receivers; and automobile radios. Two final chapters cover trouble-shooting techniques, and tools and test equipment. (S. Libes. New York, Rider, 1960. 159p., $3.50.)

***QUADRILINGUAL ENGINEERING DICTIONARY, rev. ed.**

The Ten Bosch "Quadrilingual Engineering Dictionary" will comprise four volumes — a main list of Dutch terms, giving the English, French, and German equivalents, and three supplemental lists, English-Dutch, French-Dutch, and German-Dutch. This first volume, which is the main list, is useful only in translating from Dutch into one of the other four languages, as there is no key list in English, French or German. There are no definitions included. (Ed. by E. L. Oberg. New York, W. S. Heinman, 1959. 692p., $12.00.)

DICTIONARY OF MECHANICAL ENGINEERING TERMS, 8th ed.

Now thoroughly revised, this dictionary, which is really a condensed encyclopedia, now consists of two parts, the second of which contains the general and traditional terms used in mechanical engineering. The first part, or appendix, includes terms which have come into use more recently, and these are drawn also from related fields such as electronics, computers, ultrasonics, atomic energy, etc. A most useful dictionary. (J. G. Horner, rev. bys. Abbey. New York, W. S. Heinman, 1960. 417p., $7.50.)

A SHORT HISTORY OF TECHNOLOGY.

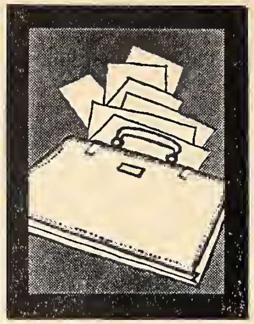
Although based in part on the five-volume History of Technology published three years ago, this volume is intended for the general reader as well as the student of technology, and it closely relates technological development to its historical background. New sources have been consulted, and some new illustrations included. The story is largely confined to developments in the ancient Near East, Western Europe and North America. The first part of the book covers ancient times to 1750, the start of the Industrial Revolution in Britain, and the second part takes the story to 1900. There is something of interest on every page of this volume, and references are included for further reading. (T. K. Derry and T. I. Williams. Toronto, Oxford, 1960. 782p., $7.75.)

***THE FERMI SURFACE.**

This volume contains the thirty-three papers presented at a conference on the Fermi surfaces of metals, held in Cooperstown, N.Y. in August 1960, sponsored by the Air Force Office of Scientific Research and the General Electric Company. Of the eight sections into which the papers have been organized, seven are topical, discussing the theory of the Fermi surface, the de Haas-van Alphen effect, galvanomagnetic effects, cyclotron resonance, the anomalous skin effect, the magnetoacoustic effect, transport properties and studies of alloys. The final section contains summaries of the theoretical and of the experimental considerations dealt with in the conference. Participating were representatives from the U.S., Canada, Great Britain, Spain, France and Japan, but there were no reports on Russian work in the field. (Ed. by W. A. Harrison and M. W. Webb, New York, Wiley, 1960. 356p., $10.00.)

(More Library Notes on page 137)

Business and Industrial Briefs



Appointments and Transfers

Chief geophysicist for the Aero Service Group is **Michael S. Reford.** Mr. Reford joined Canadian Aero Service Ltd. five years ago to direct survey planning and operations, and the interpretation of airborne geophysical data.

Professor James Urquhart MacEwan is retiring as head of the department of metallurgical engineering at McGill University. Recently he was awarded a platinum medal by The International Nickel Company of Canada Limited. The award, presented annually, is a mark of distinction and recognition for outstanding contributions to the mining and metallurgical industry of Canada..

RCA Victor Company, Ltd. has appointed **E. W. Miller** manager, technical products marketing for the Quebec area.

Peter C. Firing has been appointed plant manager of Canadian Titanium Pigments Limited at their plant at Varennes, Que. Mr. Firing is replacing **Harry A. Moon,** who is returning to the U.S.A. to take up duties with the National Lead Company.

The Moloney Electric Company of Canada Limited has appointed **R. H. Richmond** as Eastern Canada sales manager, succeeding the late **B. H. Johnston.** Mr. Richmond will have his headquarters in Montreal.

Arthur C. Rae has been appointed vice president and general manager of the North American Division, Atlas Steels Limited, Welland, Ont. In this capacity, Mr. Rae will be in charge of all operations and sales within the division.

Recent appointments at Canadian Locomotive Company include **Hector A. Dale** as assistant to vice-president — marketing, **Fred J. Benoit,** manager, Eastern Region — sales division, and **Lloyd A. Evans** as manager, Central Region — scale division.

In connection with the formation of Polymer Corporation (SAF), **G. H. Mearce,** manager, Special Projects for Polymer Engineering and Construction Division, is co-ordinating the design and construction of the plant near Strasbourg, for the French Company.

Recent appointments at Du Pont of Canada Limited include **C. J. Ransom** as technical service manager Montreal, **J. A. Walsh** as technical sales supervisor — Kingston, and **W. E. Bell** as resale products supervisor — Maitland.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A GUIDE TO DESIGN CRITERIA for Metal Compression Members has been published by the Column Research Council and is available from the E.I.C. The results of Column Research Council projects taken together with the results of many other investigations on the buckling strength of compression elements brought about a situation in which there is a vast amount of research information that is not applied in practice by the designer of columns or compression elements. This Guide presents both refined and simplified procedures of design calculation and assesses the limitations of the latter. In its introduction this 92-page book discusses the column strength problem, gives a historical sketch of Column Research Council, a summary of the Guide and mechanical properties of structural metals. Other chapters deal with centrally loaded columns, compression member details, laterally unsupported beams and beam-columns. There is a comprehensive index at the back of the book.

TRAVELLING WATER SCREENS are available from Jeffrey Manufacturing Company Limited, Montreal. This device for removing leaves, twigs, seaweed, fish, needle ice and similar solids from surface waters being reclaimed and prepared for further use, can be designed for handling large volumes of water with wide variations in water depth. The screen, usually installed in vertical position in the intake structure, consists of moving panels or baskets covered with wire mesh attached to two strands of 24 in. pitch steel thimble roller chain. It may run continuously or intermittently depending on plant requirements and may be furnished with manual, time or differential level control.

A TRANSISTOR TESTER claimed to be capable of measuring a.c. Beta with an accuracy of ± 5% has been introduced by the Hickok Electrical Instrument Company, Cleveland, and is being marketed by Stark Electronic Sales Co., Ajax, Ont. The instrument utilizes a method which neutralizes circuit impedance before tests are made. It is claimed that this neutralization nullifies the loading effects of external circuit impedance and, thereby, eliminates the inaccuracies inherent in other test methods. The instrument measures the following in-circuit parameters: a.c. Beta, I_c, transistor input resistance and base-emitter circuit impedance. It will also measure a.c. Beta, I_c and I_{cbo} out of circuit.

A HEAVY DUTY mixer for mixing or emulsifying dry, viscous or liquid materials has been manufactured by Soiltest Incorporated, Chicago, who are represented in Canada by Hoskin Scientific Company, Montreal. The apparatus consists of a steel platform, underneath which the electric motor is mounted and a steel frame which holds the reducing gear and mixing assembly. The mixing bowl is made of cast iron and attached to the platform by means of large wing nuts for easy removal. Stainless steel mixing bowls are also available at additional cost. The mixing bowl is removed by raising up the middle paddle and loosening the three wing nuts. It is supplied complete with motor.

AN AUTOMATIC TEMPERATURE and pressure relief valve series for hot water heaters and storage tanks has been announced by A. W. Cash Valve Mfg. Corp'n., Illinois. These type NFLX-6 relief valves feature a 6 in. thermostatic element. The valves are available in two pipe sizes, 90,000 B.t.u. per hr. in ¾ in. and 15,000 B.t.u. per hr. in ½ in. size. The valves are all bronze with stainless steel springs and silicone seat discs. EIC

● ELECTIONS & TRANSFERS

(continued from page 81)

Boucher, R. Bourget, J. Y. Bourgoin, V. Bourgoin, R. Brien, G. Bourridge, C. Cantin, J. G. Cantin, C. Cerantola, R. Charbonneau, R. Chasse, J. Chaumette, G. Chouinard, J. A. R. Chouinard, A. Cloutier, E. Cote, Y. G. Cote, R. Cote, M. Couture, G. Dagnault, A. Dali, M. Delagrave, P. Desaulniers, J. G. Dessureault, L. Dong, G. Doyon, J. Duchesne, R. Duchesne, G. H. Dufour, J. A. Dufresne, R. Fiset, F. Fluet, J. M. Gagnon, J. F. A. Galibois, J. A. G. Gravel, Y. Hamel, C. Hardy, R. Hardy, M. Hebert, R. Hudon, J. Huot, J. Lafrance, G. Langlois, G. Lavoie, A. Leclerc, R. Leclerc, B. Ling, C. Losier, R. Martel, M. Matte, A. Michaud, J. M. Miousse, G. Moisan, B. Morency, M. Morissette, A. Ouellet, Y. P. Page, J. M. Pageau, A. Paquet, J. P. Paquet, G. E. Paradis, G. Pelchat, P. Pelchat, G. Perrier, A. Pichette, J. Plante, R. Poudrier, A. Premont, C. Rae, C. Rainville, L. Richard, J. Rioux, D. Robitaille, C. Roux, J. A. C. Roy, G. Roy, J. G. Roy, M. Roy, C. Samson, C. Savoie, C. Simard, J. R. Tousignant, I. Tremblay, M. Tremblay, R. J. Tremblay, G. Trottier, G. J. Trudelle, D. Van Neste, J. P. Verreault, Y. Villeneuve.

University of British Columbia: G. C. Aalhus, C. J. B. Barratt, E. Brunner, G. D. Burkholder, D. Claus, N. E. Connacher, D. J. Connor, J. E. Cooper, K. R. Cretelli, J. B. Dalrymple, R. J. Davies, N. W. Dougan, R. G. Dunnet, J. Elduayen, D. Enjo, N. E. Erbacher, R. Freundlich, D. K. Friesen, E. Grande, D. H. Grant, O. W. Guggenheimer, R. A. Halliday, P. W. Herke, H. E. Hofer, B. L. Hollingshead, J. T. Hospedales, K. D. Hylkema, R. Jaakson, H. S. P. Jang, W. M. Johnson, P. J. Kidston, T. G. Kirkpartick, T. S. Kuan, C. Lee, R. D. Marra, H. McBride, P. J. Meehan, G. C. Nielsen, R. J. Nykwist, A. P. Olson, A. E. Peterson, P. Petijevich, P. A. Pincosy, R. W. Pledger, C. I. Pomeroy, A. M. Remedios, A. D. G. Robinson, R. G. Ross, J. M. Sharp, L. J. Strilchuk, F. H. Weniger, R. E. Woodland, P. W. Woolgar, S. K. S. Young.

University of New Brunswick: J. H. L. Addie, J. A. Anderson, L. E. Barchard, E. K. Bauckman, C. W. Baxter, E. J. Bednarski, A. C. Bene, L. Bosse, J. P. Burgess, R. A. Burpee, T. R. Buskard, K. L. Calhoun, W. S. Chan, W. M. Coffin, W. P. Cooper, T. G. Cotter, J. S. Csabai, J. C. Davidson, D. S. Dorcas, H. F. Doucet, E. L. Dow, A. C. Duffy, V. A. Dunfield, J. C. Dunlop, A. J. Efstathiou, A. R. Ferguson, A. A. Ferlatte, R. M. Fiset, C. T. Flynn, R. S. Harrison, E. F. Hill, P. R. Hill, N. Holmes, E. B. Irvine, J. Isaac, S. F. Jones, D. A. Knox, N. Kotoulas, E. H. Lane, W. L. Lawson, D. M. Lever, S. W. Libbey, D. W. MacDonald, G. R. MacDonald, M. V. MacFadyen, W. E. MacKenzie, J. M. MacPherson, A. A. Majzoub, G. Martin, J. A. McCarthy, F. J. McManus, W. A. Mersereau, G. A. Miller, R. J. Miller, P. C. Mitchell, J. D. Morrison, J. R. Mossman, W. M. Nason, L. R. O'Brien, C. W. Poirier, F. C. Risteen, F. C. Robinson, J. P. Roy, C. L. Russell, A. L. J. Salois, D. W. R. Sharpe, P. G. Sharpe, G. A. Shaw, W. C. Shortt, G. F. Smallwood, E. H. Smith, H. A. Stassen, A. L. Steeves, J. R. St. Germain, R. M. Stocker, C. K. Sullivan, H. A. Taylor, R. E. Thomas, B. A. Touchie, D. J. Tremblay, H. Walls, F. R. Wilson, D. L. Yee.

McGill University: A. G. Douglas, H. L. E. Haukkala.

The Ontario Agricultural College: D. J. Harman, M. J. M. Korsmit.

University of Toronto: G. M. Cornwall, C. C. Wong.

University of St. Joseph: R. A. MacLean, N. E. Pothier.

Queen's University: B. V. Brice.

University of Sherbrooke: R. Bernier.

Mount Allison University: R. V. Upham.

University of Idaho: P. B. Gattey.

University of North Dakota: T. W. Frith.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective February 25, 1961.

ALBERTA

Members: F. Fedor, F. J. Reintjes, N. E. Taylor, A. G. Warke.

Junior: J. C. Sprague.

Junior to Member: D. C. Jamieson, J. E. Savage, F. H. D. Moss.

Student to Junior: R. G. McCarthy.

SASKATCHEWAN

Members: D. J. Bester, C. Booy, S. M. Daniel, A. Holst, S. Ozsahin, D. H. A. Sellers.

Junior: W. Tomilin.

Junior to Member: R. H. Billings, A. M. Campbell, R. W. Culley, G. K. Weckman.

Student to Junior: C. A. Reed.

NEW BRUNSWICK

Member: P. J. Woods.
Junior to Member: R. G. Northrup, D. A. Slack.

NOVA SCOTIA

Junior to Member: G. B. Hill.

MANITOBA

Junior to Member: D. H. McLeod.

CORPORATION OF PROFESSIONAL ENGINEERS OF QUEBEC

Member: K. R. Gumennyi

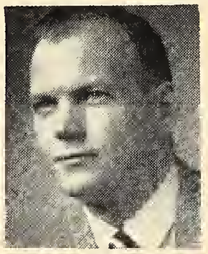
EIC

● COUNCILLORS

(continued from page 85)

chosen President of the Rimouski Board of Trade.

L. A. Coles, M.E.I.C., is the new Councillor for Prince Edward Island. A graduate of U.N.B., Mr. Coles is owner of the Summerside consulting engineers firm of Laurie A. Coles and Associates. Mr. Coles was P.E.I. Branch Vice-Chairman in 1957-58 and the following year was Chairman. He is a member of the Atlantic Provinces Economic Council and of the Masonic Lodge.



L. A. Coles, M.E.I.C.

D. M. Jenkins, M.E.I.C.

D. M. Jenkins, M.E.I.C., Councillor for London, is Chief Engineer, at General Motors Diesel Ltd. He graduated from the University of Toronto in 1949 and three years later became a full Member of the Institute. He was Chairman of the London Branch in 1955, and in 1959 was Chairman of the Professional Development Committee.

C. C. Louttit, M.E.I.C., Councillor for Saguenay, received a degree in electrical engineering from McGill in 1949. Mr. Louttit joined the Aluminum Company of Canada in Montreal in 1949, and the following year was sent to company's Shipshaw Development where he was responsible for electrical maintenance at the power house. Since then his responsibilities at Shipshaw have included electrical maintenance of generation and transmission facilities, except protective relays and system communications; maintenance of power metering, new power metering installations; work carried out in the transormer repair shop; and new sub-station installations.

● MORE BRIEFS

(continued from page 128)

the line provide capacities up to 775 g.p.m. and heads up to 300 ft. Interchangeability is claimed between all pumps as they all have overall lengths of 23 in. and couplings of 1⅛ in.

A HIGH AMPERAGE air cooled tungsten-inert-gas (Heliweld) holder is available from Air Reduction Canada Limited. The Airco H16-A holder is claimed to be the only air cooled holder on the market with 160 amp a.c. or d.c. continuous capacity. It has a 2⅞ in. head clearance and has an air-cooled construction. A variety of nozzle orifice sizes are available in 1¼ and 1⅝ in. lengths. Comprised of alumina these nozzles are thought to provide good thermal and mechanical shock resistance. Collet cap assemblies, collets and nozzles are interchangeable with those in the H35-B Heliweld holder, a water-cooled holder rated at 350 amp. d.c.

A GRINDING WHEEL which can be attached to all types of electric drilling machines has been introduced by Rawlplug Products (Canada) Limited. Suitable for resharpening masonry and glass drills, this 3 in. diameter wheel has been specially designed for Durium tipped drills and can be operated at speeds up to 1,200 r.p.m. It comes equipped with a ¼ in. diameter arbor to fit any portable machine of that size or larger.

THE SHELL OIL Company of Canada, Limited, has added the Universities of Manitoba and Saskatchewan to its post-graduate fellowship program for advanced study in science and engineering. The additions, applicable in 1961, Shell's 50th year in Canada, bring the number of Canadian universities involved to a total of ten. The fellowships, awarded annually, are each valued at a maximum of $2,300 including an unrestricted grant-in-aid to the university to help defray administration and teaching expenses entailed by the award.

A CONTRACT OF OVER A MILLION dollars worth of sanitary trunk and intercepter sewers and forcemains for the city of Fort William has been awarded to McNamara Construction Limited of Toronto. The contract involves the supply and installation of 24,500 ft. of pipe of varying sizes and structural, mechanical and electrical additions to the existing Brunswick St. Pumping Station.

CONSULTING SERVICES

TECHNICAL BULLETINS & PAMPHLETS RECEIVED

Space limitations do not enable us to record these in the Library Notes. A mimeographed list of the Bulletins and Pamphlets received during the last month is available free on request to the librarian.

LIBRARY NOTES

ontinued from page 116)

T'S THE LAW!

Based on a monthly column written y Judge Tomson over a period of years r "Progressive Architecture", this book ms to furnish to the architect, engineer, nd contractor a basic appreciation of me of the more important legal probms with which they may become inolved. It furnishes the answers to some pecific legal questions, contains a pecial section of standard legal forms, and discusses statutes regulating professional practice, organization and business problems, employment relations, rights and liabilities, and restrictions upon the use of property. There is also a useful index of cases cited throughout the text. This is a U.S. publication. (B. Tomson. Channel Press, Great Neck, New York, 1960. 436p., $7.50.)

STANDARDS RECEIVED

ASTM standards. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Textile materials (with related information). 31st ed., 1960. $9.75.

CSA standards. Canadian Standards Association, 235 Montreal Road, Ottawa 2.

B150.1—1961—Domestic gas ranges (free standing units). $3.50.
B150.2—1961—Domestic gas ranges (built-in domestic cooking units). $3.50.
C22.2, no. 117—1960—Construction and test of room air conditioners. $1.50.
C22.2, no. 122—1961—Construction and test of hand-held electrically-heated tools. $1.50.
D106—1961—Lighting for commercial vehicles. $2.75.
O118—1960—Western red cedar shingles, machine grooved shakes, and handsplit red cedar shakes. 75c.
O132.2—1960—Wood doors. $1.50.
Z7.1.4.6—1960—Threaded lens mounts for 16mm and 8mm motion-picture cameras. 25c.

INDEX TO ADVERTISERS

May 1961

PUBLICATION OFFICES: The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, Quebec, Canada.

Association of Consulting Engineers of Canada Incorporated

The following firms have principals who are members of this Association engaged as professional engineers in engineerng work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

ADVERTISING OFFICES

QUEBEC: J. E. Donovon, Monoger, Advertising Soles—D. W. Campbell, 2050 Mansfield Street, Montreal. Phone: VIctor 2-8121
ONTARIO: L. G. Barnum, Monoger, Advertising Sales, 24 King Street West, Suite 21, Toronto. Phone: EMpire 2-5058
EUROPE: H. A. Mockenzie, 4A Bloomsbury Square, London, W.C.1, England. Phone: HOlborn 3779
UNITED STATES: R. G. Melendy, 17 Mougus Avenue, Wellesley Hills 81, Moss. Phone: CEdar 5-6503.

EIC

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MEMBERSHIP

CCAB BNA

Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS


One call does it all!
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ELECTRICAL SUPPLIES
ELECTRICAL APPARATUS
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IN THIS ISSUE

Increasingly competitive situations in the field of export trade have forced many Canadian manufacturers to reconsider the relative merits of the Metric and the English systems of measurement. Four distinguished panelists, with enthusiastic assistance from a large audience, debated the merits of the two systems during the 1960 Annual General Meeting of the Institute which was held in Winnipeg. Chairman of the panel discussion was Gen. A. H. Young, Deputy Minister of the Federal Department of Public Works. The panelists were **D. S. Young, Dr. J. M. Thomson, G. L. d'Ombrain,** and **Dr. L. E. Howlett.** *The Yard or the Metre — Which?* is a transcript of the discussion. Seemingly conclusive arguments were presented for Canada—and all countries using English measure—to adopt the Metric Standard, and for English system countries to maintain their present systems.

A New Facility for Measuring Radiation Patterns of Model Shipborne Antennas describes the model shipborne antenna pattern range at the National Research Council. This range provides a conducting surface 200 ft. long by 70 ft. wide. Before the new facility to take pattern measurements in the vertical plane was added the range was limited to pattern measurements which could be taken in the horizontal plane. The paper describes the new equipment. While the co-authors of this paper are also co-workers, **J. Y. Wong** and **J. C. Barnes** arrived at the Radio and Electrical Engineering Division of the National Research Council by different routes. Dr. Wong was born in Manitoba and graduated from the University of Manitoba in 1948 with a B.Sc. degree in Electrical Engineering. His post-graduate work was done at the University of Illinois where he received an M.Sc. degree in 1949 and a Ph.D. degree in Electrical Engineering in 1952. It was in this year that he joined the National Research Council. Mr. Barnes received his M.A.Sc. degree in Mechanical Engineering from the University of Toronto after which he worked for five years at the Hydro Electric Power Commission of Ontario. Two years were spent in research and three in the Telephone Section of the Transmission Department. Mr. Barnes then spent two years with the Canadian Marconi Company in Montreal where he designed the grinding and lagging machinery for the crystal laboratory of the Canadian Marconi Company. He became associated with the National Research Council in 1942.

John Brandlmayr, M.E.I.C., author of *"An Evaluation of Plywoods and Plastics in Boat Construction"* has been interested in boat design since he was in high school. At that time he began to build boats for himself as well as for his friends. From this interest he developed a practice in the marine-design field. His designs for pleasure craft are well known in B.C. and he has wide experience in their design and construction. In his paper the author evaluates the use of plywoods and plastics in the construction of boats under 100 ft. in length and the use of other materials for the construction of hulls in larger craft. A comparison of the various materials and the result of a cost comparison study of 35 ft. sloops in wood and fibreglass are included. Fibreglass is becoming the dominant material for small power boats and sailboats up to 40 ft. in length.

Transport of Solids in Conduits Industrial Application Possibilities deals with research done on and the possibilities of use of this handling process. The authors hasten to point out that the transport of materials by hydraulic means is useful not only when this is the only method but also as a complementary means of transportation. All three authors, **E. Condolios, P. Couratin** and **E. Pariset,** M.E.I.C., have been associated with SOGREAH. In 1955 Mr. Condolios was named head of the special tests department of SOGREAH in Grenoble, France and has personally supervised all the studies reported in this paper. Mr. Couratin, who has been with the special tests department of SOGREAH since 1956 did many of the basic studies and model tests which have led to present working projects. Both men act as consultants to the LaSalle Hydraulics Laboratory, Montreal, on solids transport problems. Mr. Pariset, Director of the LaSalle Hydraulic Laboratory, holds degrees from Grenoble University in both hydraulic and electrical engineering.

The author of *Principles of Non-Linear Automatic Control* received his Ph.D. degree in Electrical Engineering from Manchester University in 1955, three years after receiving his B.Sc. degree in Engineering Physics at Queen's University. It is not surprising to note that **P. N. Nikiforuk's** doctoral work was done on non-linear control systems. Since 1955 Dr. Nikiforuk has held a variety of positions. He was associated with the Defence Research Board as a defence scientific service officer, Canadian Armament Research and Development Establishment near Quebec City; then spent two years as a systems engineer with Canadair Limited, Montreal. In 1959 he became an Assistant Professor in the Mechanical Engineering Department at the University of Saskatchewan, the post he holds at present. Dr. Nikiforuk in his paper gives a brief review of some of the more important principles of non-linear automatic control and defines non-linearity which he classifies according to static and dynamic effects. After a detailed look at phenomena arising from non-linearities the author discusses the simpler techniques for analizing non-linear control systems and, in conclusion, mentions recent developments in this field.

H. H. A. Davidson has been associated with the Pacific Naval Laboratory since its establishment in 1948. The author of *"Some Problems Encountered in Underwater Sound Propagation Research"* discusses the research done by the Pacific Naval Laboratory in marine physics to support the national defence program. Many problems have been encountered and overcome. When echo studies were done with triplane and spherical targets, the fluctuations of received signals over a wide area necessitated the development of special logarithmic amplifiers for reception. In long range studies, hydrophones and pre-amplifying units were used until the noise background was found a disturbing factor. Changes were made to reduce the noise to a minimum. Other problems, presenting formidable mechanical difficulties, are thoroughly discussed. Mr. Davidson, originally from Winnipeg, received most of his education in the Province of British Columbia. He received his B.A. and M.A.Sc. in electrical engineering from the University of British Columbia. After five years in radar research at the National Research Council he became associated with the Pacific Naval Laboratory.

COVER ILLUSTRATION

Wound nest subcoolers for 600 tons-per-day oxygen plant during fabrication. Each subcooler is 6 ft. in diameter and contains 652 copper tubes with a total length of 155,000 ft. (Photo courtesy Canadian Liquid Air Company, Limited)

Message from the President

MY FIRST WISH is to acknowledge the very high honour and trust which the Institute membership has conferred on me in selecting me for President for the ensuing year. I have been richly rewarded already through the many opportunities and associations which the Institute has made possible, and I look upon this honour as an enhanced opportunity to serve the Institute, and, through the Institute, to serve the members themselves.

But my aims must be much broader. It shall be my purpose to promote the service of the Institute not only to its members, but to all of Canada. The Canadian way of life has changed very markedly in the last few decades. Science and engineering have assumed an unprecedentedly important role, and we must accept the obligations which the new status imposes. We must provide leadership beyond a narrow engineering concept, and share with our sister professions responsibility for social development. In a few short years, engineering has grown from a relatively obscure profession to one which forms an important percentage of the entire professional structure. It is to the professions that the country looks for guidance and leadership. It is they who must furnish the new concepts to solve our problems and advance our society. We must merit public respect by an example of competence and integrity.

First of all, however, we must be competent in our own field, and it is here that the Institute offers the greatest opportunity. Our profession is developing so rapidly that most of us are confronted with problems unforeseen in our training period. The Institute must serve as a continuing university to foster our intellectual growth and equip us for the tasks ahead. One of the encouraging prospects is the quality and eagerness of the recent graduates. They are the equal of their contemporaries any place in the world. The senior members of the Institute have an obligation to these men to give them the benefit of their experience so that the younger engineers may assess problems of the future, fully equipped with a knowledge of the past.

The following year will be one of destiny for EIC. Important issues demand our attention, and Confederation is a matter of particular import. Whatever the result, the profession must advance.

B. G. Ballard.

BRISTOW GUY BALLARD, Hon. M.E.I.C.
President, 1961-62
The Engineering Institute of Canada

THE YARD OR THE METRE Which?

From a panel discussion held during the 1960 Annual General Meeting of the E.I.C. at Winnipeg, Man.

The relative merits of the English and the Metric systems of measurement are of great importance to Canada's export industry. Four distinguished panelists led an active debate on the question at the Institute's 1960 Meeting at Winnipeg.

THE FOLLOWING is a transcription of a panel discussion held at the 74th Annual Meeting of the Institute at Winnipeg. The opening remarks are those of **Dr. B. G. Ballard.**

The choice between the English and the Metric System of measurement presents a problem of increasing importance, and one which should occupy the attention of every member of the engineering profession. We have with us today a most competent panel to discuss the matter, and it is a pleasure to present them. The chairman is **General H. A. Young**, who needs no introduction to this session and who is Deputy Minister of the Federal Department of Public Works. Members of the panel are: **Mr. D. S. Young**, President of Powerlite Devices Ltd. in Toronto; **Dr. J. M. Thomson**, Chairman of the Board of Ferranti-Packard Electric Ltd.; **Professor G. L. d'Ombrain**, Head of the Electrical Engineering Department of McGill University; and **Dr. L. E. Howlett**, Director of the Division of Applied Physics at the National Research Council.

When the Committee first contemplated this panel they had intended to call the presiding officer a moderator, but somehow or other he became chairman. I have geed reason to believe that our panelists are not all of one mind on this subject, and it may develop that the first title would be more appropriate. I shall now turn the meeting over to General Young.

Chairman: Thank you very much Dr. Ballard. Gentlemen, this afternoon, we are about to have a discussion on metrology, its application, its economics and its practicality. The subject of the metric system in weights and measures is not only an interesting one, it is a far reaching one in this nuclear age when mathematics have become such a dominant part of the daily life of our country. I think it is most appropriate that this subject should be introduced by the Engineering Institute of Canada and I think the Engineering Institute of Canada can well take a lead in a discussion of this nature, notwithstanding its many ramifications.

The adoption of the metric system has gained favor in recent years throughout the world. It is now only in the major English-speaking countries that the system has not been adopted. As a subject for discussion, as you all know, it is not a new one. Some 10 years ago in the United Kingdom, the President of the Board of Trade issued instructions to a committee on weights and measures legislation. The direction was to review the existing weights and measures legislation and other legislation containing provisions affecting weights and measures and the administration thereof, and to make recommendations for bringing these two in line with present day requirements. After a year's study, the report of the Committee was published. They advocated the abolition of the Imperial system of measurement in favour of the complete adoption of the metric system and they proposed that this should take place over a period of 20 years. They also proposed the redefinition of the Imperial yard and pound in terms of the International metre and kilogram. They recommended the appointment of a Commission of units and standards of measure. The Committee recommended the adoption of the proposal but, in the intervening years, there has been considerable discussion.

Reference is sometimes made to errors which may arise through the new system. I was interested in reading recently a paper by an engineer in the United Kingdom who stressed this error factor. He quoted an example of a large medical company in the United Kingdom which is presently using the metric system. The company requested an order for 10 cubic centimetres of a rare medical compound. The order was delivered on a basis of metres rather than centimetres. We would all agree that this is not a good argument against the metric system. Mistakes can be made on our present system. You heard today about my being in the Arctic. At that time I lost my supply ship. The year previous, 1923, a trading company ordered 50 tons of coal but 150 were delivered. The error, of course, on our standard system was a beneficial one in that I was glad to take advantage of that extra coal.

The advantages of the system, I think most of us agree, are fairly obvious. On the other hand, you will hear from representatives of industry that many problems, particularly on the economic side will have an effect on costs. The ramifications, I think we will all agree, are great. We have to think in terms not only of nuts and bolts but larger machinery, of the liquid measurement we drink. We have to think of the land measurements and the survey of our country now based on the present system. One other aspect of course, I think, is the lack of accurate standardization between the English-speaking countries. The British length standard is the Imperial standard yard, a bronze bar established by an act of Parliament in 1878. This standard has been constructed as a replacement for an earlier standard which was destroyed by fire in 1834.

I mentioned the study in the U.K. of some 10 years ago. They recommended the introduction of the metric system and that the yard be defined as equal to 91.44 centimetres exactly, which gives us a 2.54 centimetre inch. They recommended further that efforts be made to encourage uniformity between the governments of the United Kingdom, United States and Canada. The situation in Canada is that, in 1951, the yard was established as a unit of length but based on the international metre. The legal ratio defines the yard as 0.9144 metres again equivalent to 2.4 centimetres inch. In the United States, there have been various Commissions and Committees who have been studying the problem. I have been made aware this morning of a new one that is presently working on this subject. Interest in the metric system has increased during the past few years and I think, therefore, it is opportune that today we are going to hear from four experts in the field who, I hope, will give you the arguments pro and con.

I am now going to have the discussion commence by asking Dr. John M. Thomson, who is Chairman of the Board of Ferranti-Packard Electric Ltd., to start the discussion.

Dr. Thomson: My first reaction on being asked to take part in this panel was to refuse but, on second thought, I realized that there might be few members who would be prepared to take up the cudgel in defenec of the yard. In the ensuing discussion the point of view of the average man in the street might not be presented, and in view of this I shall at least try to present his viewpoint.

The metric system as such is a decimal system and was based on certain dimensions of the earth which the scientists of that day thought they knew within very close tolerances. In other words, the metre was supposed to be 1/10,000,000 of the quadrant from the equator to the pole through Paris. Unfortunately, the dimensions on which this was based are not known accurately, and hence, as far as present day conditions are concerned, the metre is the distance between two lines on the standard rod at the standard temperature in Paris, whereas the yard is the distance between two lines on the standard rod kept in London. These distances are the basic standards, and temperature of course affects these measurements. Professor J. L. Synge of the Dublin Institute for Advanced Studies, and Professor B. A. Griffith of the University of Toronto, at the bottom of page 13 in their book "Principles of Mechanics" state as follows: "the f.p.s. units are arbitrary but the c.g.s. units are connected with natural measures; the centimetre is nearly 1/1,000,000,000 of the quadrant from the equator to the pole through Paris, and the gram is nearly the mass of a cubic centmetre of water at the temperature of greatest density. The second in each system is the same, namely, 1/86,164.09 of a sidereal day." You will note that they use the term "natural" and the second is given to a ratio containing seven significant figures of a sidereal day. In other words, the c.g.ss units are just as arbitrary as the f.p.s. units. The main advantage is that the c.g.s. units have certain relations between the cubic measure the litre, and the cubic metre, one litre being one cubic decimetre.

It is true, from the point of view of the scientist, the existence of two systems means that he has to remember the difference between the two systems, and if he forgets the proper conversion units he is in trouble. The engineer and, to a more limited extent, the draughtsman, have a similar problem. But, generally speaking, once they become familiar with a given system, they are not too concerned with the transfer of units to the metric system or the reverse unless they are reading a scientific work.

The average man in the street actually cares very little about the so-called complexities of the inch system as compared with the decimal ratios of the metric system because, in actual use, he has little reason to be concerned with these ratios. A man buying gasoline for his car orders so many gallons of gasoline, not so many cubic inches of gasoline and, in his mind's eye, based on his experience of this, he has some idea of what this means to him based on the mileage of his car and the cost per mile. The housewife buying a quart of maple syrup or a quart of vinegar has a good idea of the cubic content she is getting. She is not interested in the least in the amount of cubic inches or cubic centimetres that exist in the said quart. I quite agree that, if they had started off in the metric system, they would use the same technique as regards the litre. In other words, they would not be interested in the number of cubic centimetres in the litre but would be interested only in the amount of liquid they would get based on terms of their experience in using that measure.

Great play may be made of the fact of the ease and simplicity of the decimal system but I would like to point out that this system is not a natural system, it took centuries of education and development before it appeared. There is no question that, from the point of view of the scientist, the engineer and the accountant, it is the simpler system in that additions and subtractions of 10s instead of multiples of 8 or 12 is easier. However, from the point of view of the man who makes things in the factory or the field, and who has to divide a centimetre or an inch into parts of a centimetre or an inch, the decimal system is a very unnatural one. It is far easier to divide a rod into eight parts than into ten. In connection with this, of course, the preferred umbers are 2, 4, 8, 12 etc., and you have only to watch a man who has been used to dividing things into the ratios and multiples of two struggling with dimensions like 3, 7 or 5 to realze that, while the decimal system is an easier system, it is not a natural system and, therefore, for the man in the street, there is no demand to change our present inch or yard system to that of the decimal metric system and the corresponding measurements to the metric system.

In addition to all this, there is the economic problem. The yard has been used for generations in parts of the world which have been highly industrialized for a good many years. As a result of this there is a large amount of money tide up in the jigs, tools and fixtures that are now used in manufacturing on the North American continent and Great Britain. Based on ratios that have been worked out under manufacturing conditions in our plant, and applying them to the production in Canada, the cost of such a changeover would run between $500 million and $1 billion. The corresponding figure for the United States would be at least 10 times as great with a figure approaching this for Great Britain. Much money would be lost in making this changeover and, when we consider that the only people who would really benefit by such a changeover are the scientists and the engineers working in specialized fields, and that this money would have to be provided by the man in the street who is not interested in such a change, it does not seem logical for those countries now using the yard system to change over to the metric system as far as everyday use is concerned.

It is true that the spreading use of the metric system will raise problems of competition in the export market and that some Canadian manufacturers may be under a handicap in this field because they are now using the inch system. Recent articles in the newspapers would indicate that an attempt is being made to prove that the use of the inch system is handicapping the manufacturer in the export field. In selling any product either at home or abroad, there are four main factors:

1) The quality of the product, 2) The manufacturer's service facilities in the area in which the product will be used, 3) Delivery, 4) Price.

There are other factors as well but these four are the primary ones, and the most important one, particularly in the export field, is price. At the present time, the manufacturing cost, and therefore the selling price, of an article made in Canada is above the world price for the same article. As a result, the Canadian manufacturer is having quite a struggle to maintain the Canadian market, let alone extend his way into the export market. The primary factors are not affected by the inch or the metric system. We have only to refer to the price of Canadian wheat, butter and lumber as compared with world prices to make us realize that a change to the metric system would not lower the price of these products. In most cases, a change from the metric to the inch system concerns only the drawing office, the engineering department and the setting-up people in factories, who are very limited in number. In other words, the average workman uses a no-and-go gauge which is quite often marked with a number and not the dimensions, so that for some years to come the use of the metric system abroad should not be a handicap to the average manufacturer in Canada, certainly not such a handicap as to warrant the scrapping of all our measurement standards as well as our dies, jigs, tools etc. in order to make a change which will not benefit the man in the street who has to pay for it.

It seems to me that this whole problem of change from the yard to the metric system is based on making the whole world conform to one system which was developed as a supposedly natural system but which we now know to be as artificial as the yard itself, and that the whole pressure is being raised by a limited number of people who, by their training and mental capacity, should be the last people who should worry about having to work with two systems.

In closing, I want to emphasize that:

1) With the present level of Canadian prices, a changeover to the metric system will increase our cost but will not increase our ability to sell in the export market.
2) The man who has to pay the cost, that is, the ultimate customer in Canada and abroad, is not interested in changing over.
3) Therefore, why make the change until it is definitely to our advantage to do so?

Chairman: Thank you Dr. Thompson. Now, you have heard from the representative of the Electrical Industry, I would now like to call on Dr. G. L. d'Ombrain, Chairman and Professor of Electrical Engineering at McGill University.

Dr. d'Ombrain: When man developed from caves to building huts he required some measure of length; an early measure was the cubit or ell shown in Egyptian hieroglyphics as the elbow to the tip of the middle finger. A beautiful example of this is the Royal Cubit of Amenhotep I (1559-1539 BC) in the Louvre in Paris. This is subdivided and 2/3 cubit = 1 foot. Of even greater antiquity is the Northern Cubit closely associated with the Teutonic peoples and its history is traceable from 3000 BC to the 19th Century AD; it approximates 26.6 inches.

The foot as we now know it, can be attributed to Edward I in 1305 who defined 1 inch = 3 grain of barley dry and round and that 12 such inches should equal 1 foot. Subsequently, and at separate times, Henry VII, 1497, and Queen Elizabeth in 1588 confirmed and improved on the Edward I standard until we come to 1855 (when the current Imperial Stanard of gun metal was set up which was also the Canadian Standard until 1951). On January 1, 1959, representatives of Canada, U.K., U.S., Australia, New Zealand and S.A. agreed to define the inch = 2.54 cms. which substantiated the U.S. usage of this equivalence since 1933.

A long and glorious history; why bother to change such a hallowed measure? During the same period a serving-wench was used to warm the bed of the head of the household before retiring. Later she gave way to the introduction of the warming pan, later to be replaced by the electric blanket. We no doubt look back occasionally with longing to the serving-wench, but we could not seriously propound her reinstitution nor can we propound the continuance of the foot.

In 1791, when France was giving much thought to the reduction of heads, but before the Royal Head had been so treated, a Royal Commission was specifically charged "with the necessity of over-coming the confusion of the then existing multiplicity of standards". Four years later the Commission had set up the Metric System substantially in its present form. Adoption of the system was comparatively rapid so that in 1875, 21 delegates agreed to subscribe to the Bureau International de Poids et Mesures. In 1921, the Convention du Metre was amended to extend the coverage to electrical units which are entirely based on the metric system, and in 1927 to the photometric units.

As early as 1864, Great Britain gave optional legal adoption to the Metric System but has never put it into effect. Currently, the British Association is charged with the problem of investigating the possibility of its full introduction, and I cannot do better than quote Dr. Hughes, who heads this study: "We want to find out whether we can afford to make the change or whether we cannot afford not to make the change."

Chairman: Thank you Dr. d'Ombrain. We will now go back to the other side of the picture. I would like to call on Dudley Young, President of Powerlite Devices Ltd. of Toronto, to say his piece on this subject.

Mr. Young: I feel a little bit out of place here with my distinguished colleagues. I am just a poor industrialist and will attack the problem from that more or less practical standpoint. I would like to acknowledge help I received in researching this subject from Mr. H. N. Muller, Vice-President of Canadian Westinghouse and Mr. J. G. Little, General Manager of the Northern Electric Company Lachine Works.

Technical people like the metric system but feel that many of the advantages of the metric system are obtained in the English system where fractions of an inch are expressed in decimals and where dimensions up to several hundreds of inches are expressed in inches rather than in feet and inches.

J. R. Townsend, President of the American Standards Association, has expressed himself as follows:

"The recently announced agreement among the National Physical Laboratories of the United States, the United Kingdom, Canada, New Zealand, Australia and South Africa on a conversion factor between the international yard and the metre and the international pound and the kilogram makes a decision as to whether or not the US should adopt the metric system unnecessary.

"For linear dimensions, the agreed ratio becomes 25.4 mm equals 1 inch — a ratio which has been in existence for industrial purposes since the approval in 1933 of American Standard Inch-millimetre Conversion for Industrial Use, B48.1-1933. This standard provides convenient conversion tables which can be prepared by any competent organization.

"With an established conversion factor there is no problem in conversion between metric and inch units. The widespread use of the metric system in scientific calculations will undoubtedly continue, but with the use of decimal fractions of the inch and the established conversion factor there appears to be no practical necessity for adopting the metric system for linear dimensions."

Any advantages obtained by converting to metric system would be very heavily outweighed by the tremendous expense involved in converting to the metric system. These areas of expense would be as follows:

A complete retraining program of all employees would be involved. Experience in one British factory suggests that this could be done with present employees in perhaps a three month period, but the problem would last much longer than that due to the continual influx of new employees.

A major portion of measuring instruments would have to be either completely replaced or at least require considerable rebuilding. This would include micrometers, verniers, linear measurement devices, such as rulers, tape measures etc.; basic standards such as jo-blocks, pressure gauges, liquid flow metres, weighing devices, volume measuring devices, speed devices, and many types of basic standards. The cost of doing this would run into many millions of dollars and would have to be undertaken in a relatively short period unless we were prepared to try to live with two systems for a very appreciable length of time. H. S. Sizer, Director of Design, Machine Tool Division of Brown and Sharpe estimates the cost of replacing micrometers in the USA at $30 million. He estimates the cost of converting milling machines and grinders alone in the USA at $174 million.

On this facet of the problem G. W. Barlow, who heads the manufacturing operations of John Inglis Co. Ltd. has this to say:

"Whilst most engineers and scientists agree that the metre and the metric system is much easier to work, the fact is that all our engineering equipment is based on the yard. If there were to be a change from our system of measurement to the metric system of measurement, every single machine tool we own would be virtually useless. All our instruments, gauges, and so on would also become redundant. In a Company like ours, the real equipment involved would amount, this is just a guess, to some $4 million or $5 million. The returns obtained for such a mammoth capital expenditure would be so intangible that it would not be easily priced. I would imagine that the only people who would benefit from such a scheme would be the manufacturers of machine tools and equipment. Seriously, the project is just too big for Canada to consider at the present stage of industrial development."

Many types of machine tools such as turret lathes, engine lathes, jig borers, would require extensive changes of gears, lead screws, scales and other parts, after which many of them would not have the full accuracy required in manufacturing precision parts to metric dimensions. In some cases the replacement of the machine would be required rather than the rebuilding, and here again millions of dollars are involved.

Every drawing currently in use in industry using the English system would have to be changed over to metric dimensions. This might involve up to a half million drawings in a major electrical manufacturing company.

Every basic design table, design calculation, design specification, manufacturing specification, or other similar document would have to be changed, and these could be even more numerous than drawings.

A changeover of this type would involve not only going to metric dimensions but would sooner or later involve other metric standards such as threads. The changeover to such metric standards would require the building up of a rather large inventory of replacement parts for the English standard equipment before making the change to metric parts. We feel that the cost of building up such inventory could be exceedingly large and we do not consider that it would be feasible to continue manufacturing parts to both systems just in order to take care of our guarantee responsibility and our necessity of being able to supply replacement parts to customers on equipment that we have sold to them.

Before any change could be made preliminary supplies of all materials in sheet, rod, bar, tube, and other forms, would have to be made available in metric sizes. This would be quite a problem in itself.

The simplicity of the metric system does have advantages in the avoiding of certain kinds of errors. We feel however that the changeover period could be a very hazardous one from the standpoint of errors and this period could be of a number of years duration. It is felt that to a large degree the same freedom from error could result from the use of inches and decimals of inches for all dimensions requiring great accuracy.

It is felt that it would not be possible to change over the manufacturing industry by itself. The interrelationship with other parts of the economy would necessitate an almost complete change. For instance, the home builder now works on the basis of design modules which are in the English system and he would have to change over in order to be in step with the Appliance and Kitchen Equipment Manufacturer. All land surveys, marine charts, maps etc. would have to be revised. Commonly used devices such as weighing scales, gasoline pumps etc. would have to be recalibrated.

In conclusion, I feel I can do no better than quote the following remarks addressed to the American Standards Association by H. A. R. Binney, Director of the British Standards Institution:—

"There exist in the world today two primary systems of linear measurement, the inch system and the metric system. Neither in my view is likely to give place to the other within any foreseeable period and we should therefore accept that they both exist and possess equal status. If enthusiasts from both schools of thought would accept and work from this basis instead of prophesying that one half of the world will suddenly abandon one system of measurement in favour of the other, then we should all get along much faster."

Chairman: Thank you Mr. Young. I would now like to call on Dr. Howlett, Director of the Division of Applied Physics in the National Research Council.

Dr. Howlett: Whatever else we may be discussing this afternoon the core of the problem is not the relative merits and demerits from a scientific or a practical point of view of the metric and English systems. In fact it could be argued with validity that these questions are not relevant. It was long ago fully agreed by all intelligent persons, without emotional or other bias, that the metric system is a far more rational one. It is simpler and easier to use and for this reason less likely to cause mistakes. We in the English-speaking world have taken no action to adopt it—in large part because of a very natural but misguided attachment to our own historic measurement system. It is incontestable that this English system is archaic, illogical and complicated. In spite of these characteristics, however, we have been able to make it the most important in the world until recently by the weight of our superior industrial power and skill. While all was going well in this way there seemed to business leaders no sound reason for changing simply because of the intrinsic advantages of the metric system when, in doing so, a large financial cost would have to be faeed. The more indirect, but none the less tangible, economic advantages that would come from its adoption have never been allowed to outweigh the more direct and immediate economic cost of the ehange-over. However, today the situation has changed vastly and it is by no means clear that our past position can be maintained into the indefinite future. Economic factors are more likely to be operating in the reverse direction. There is evidence that the economic trend may have already been reversed. The rest of the world is becoming very powerful industrially and the English-speaking part, which alone uses the English system, must look forward to the time when it holds a minority position in respect of industrial power. If we could expect to always produce something better in performance or equivalent but very much cheaper than the metric countries it might be argued that self interest would force these countries to buy our products even if they were to a greater or lesser degree inconvenient to use within their measurement framework. This, however, would be a highly egotistic point of view and hardly likely to be justified by events.

The changing proportion of metric and English system users is a very serious problem which Canadians concerned with practical things seem slow to recognize. Management seems to look short-sightedly to the balance sheets of the present year and the next with a view to pleasing their current stockholders with no concern whatsoever as to the kind of catastrophe that may be in the making for their successors of their successors' successors, a decade or several decades in the future. Our method of corporate management seems to work against the serious consideration of long term problems such as are involved in this question. The 'bird in the hand' attitude is automatically favoured by the mechanism of our corporate system. At the same time can we really expect that in 30, or 40 or 50 years from now we are going to be trading without advantage in a world where our industrial power will be proportionately less by a considerable factor than that of the rest of the world that will be using the metric system? While we have been in the driver's seat from an industrial and trading standpoint we have been able to force the other fellow to make and buy equipment conforming to our English system. One of our panelists has already quoted from the remarks of an outstanding protagonist of the English system to the effect that people had better recognize that there are two systems in the world and that they both are here to stay — one alongside the other — and that is that. Such statements are a hangover from our prestige and stature in the past. It is, in fact, very audacious and highly optimistic to make such predictions for the future when the users of the metric system will be in such a great majority. It would certainly save us a lot of trouble if the opposition were prepared to take such a position, but on the basis of what we have done ourselves when the situation was the reverse it would seem to imply a very generous appraisal of the sporting characteristics of the human race.

Others are saying that the subject of our discussion is a storm in a teacup and that there is not the slightest indication of any disadvantage coming to our trading position as a result of continuing our use of the English system. This sort of statement brings into question the competence of Canadian business management, because such a light dismissal of the problem has certainly not been the attitude of businessmen generally in the United Kingdom and the United States. The United Kingdom has been deeply disturbed by the possible profit and loss implications of the present situation as it has been developing for some 10 or 15 years. The United States has come to share this disquietude in the last five or so years. One wonders why there is no problem for Canada — so interested in export — when business leaders of two of the greatest trading nations are very actively worried about the possibilities and are making a dispassionate, careful study of whether or not it is possible to avoid changing over to the metric system for strictly economic reasons.

One further point should perhaps be made. Today's conflict is not strictly speaking between the English system and the metric system developed at the time of the French Revolution. It is a conflict between the English system and the International System of Units adopted by the International Conference of Weights and Measures in 1954. This system provides internationally agreed units for length, mass, time, electric current, temperature and luminous intensity, which are the metre, kilogram, second, ampere, degree Kelvin and candela. Starting with these six units all necessary physical measurements may be made. It happens that the metric units of length and mass were the ones chosen to be incorporated into this International System. Fortunately, we of the English speaking world have not rejected the ampere, the unit of current, and established some curious unit of our own devising for electrical measurements. The electrical industry long ago realised it must utilise the acceptable International units, or work in a vacuum and suffer.

With these few remarks, inspired by those of our panelists who see no serious need for even studying widely and seriously a possible change in our measurement units, I will close on the suggestion that we should concentrate firmly on the real question that confronts us, namely, "Can we afford not to adopt the Metric System?". This question is too complex to make a definitive answer possible in our discussion, but we will hope that enough points will be brought out to show the need for a careful, systematic and dispassionate study of the question by Canadian business.

Chairman: Thank you Dr. Howlett. I hope at this time we may have some discussion between members of the panel. Dr. Thomson and Mr. Dudley Young have stressed the economics of this change and I wonder if Dr. d'Ombrain would like to say a word or perhaps question Dr. Thomson more specifically on the economic aspects involved that have been stressed so much by both people.

Dr. d'Ombrain: Yes Mr. Chairman, I would indeed. The argument appears to be that if you sell a good product and it's cheap enough, then it doesn't matter how it's made; whether the nuts are in the metric system, nobody is going to look inside to find this out and, even if they do, it doesn't matter. Now, I think that is most unrealistic. I think that, given all other things equal, people psychologically will prefer equipment which is made in a manner with which they are more normally familiar; that is the metric system. We are going to have to compete shortly in a world in which the labor position is very much to the favour of the nation to whom we shall sell rather than to ourselves. The suggestion that if we are going to convert to the metric system, this is going to increase our cost, hence, it's going to increase the cost of selling our material, therefore we are not going to sell it. No, this supposes that from now to an unforseeable eternity, we are going to remain on this British system. I would ask my opponents on the panel whether their opposition to this is an opposition of now or an opposition of forever.

Chairman: Dr. Thomson, would you like to answer that?

Dr. Thomson: Mr. Chairman, when you say forever, of course, nobody can foresee what will happen by this term forever. I think part of this misunderstanding that arises is merely a misunderstanding which, in fact, has no bearing on the subject. I will talk specifically of two things, one a very small article and the other a very large one which are made by our Parent Company in England who have been in the export market for over 50 years and who sell all over the world in and out of the metric system.

Take a large transformer for example. When a purchaser buys it, he is not concerned with the inside dimensions if he has an over-all drawing made in the inch system but converted to the metric system, and his weights are given in the metric system. He is not worried about the fact that the transformer as such was made in a factory where they use the yard—or rather the inch—rather than the metre. He is interested in whether he can get it cheaper, is it smaller, has it a certain minimum quality, whether the services are available to take care of any problems that might arise in the use of it, and whether the Company he is dealing with is a Company whose delivery means something; those are the things that determine whether you get the order or not. Therefore, to sell a transformer in a metric market, you're not concerned, nor are the metric people buying it concerned, with the fact that it's made in a factory using the inch system, because the purchaser has the critical dimensions that he has to use. If he wants to replace parts or to buy spare parts, he has to buy them from the original manufacturer because there is no such thing as interchangeability between manufacturers on a wide range of these products. Now, the transformer that we were talking of weighs anywhere from 100 to 200 tons.

Take the other extreme which our Company has had. In fact, it sells more on the market abroad than it sells on the English market. Here you are dealing with a small article weighing several pounds, less than 10 pounds. Certain accuracies have to be met and these are based on the use of the thing. In other words, it is measured in watts, volts and amps, not in inches and metres—or centimetres rather. Again, the parts of a meter made by one manufacturer are not interchangeable with the parts of a meter made by another manufacturer. It's true, that in Canada over the years we've got together to the point that the mounting dimensions of Canadian meters are interchangeable. In other words, you can take one Canadian meter out and put another one in the same place, but they are not physically the same thing at all and you could not interchange the parts. So these parts have to be made by the original manufacturer who, to give service, has to maintain parts over the years so that the meters can be repaired when brought in for recalibration. A meter is brought in every seven years in Canada for recalibration, but this varies of course all over the world. In any case, when new parts are required they have to be bought from the manufacturer, and these parts are given in the metric system in centimetres and there is no problem as far as selling these articles is concerned.

Now, I agree, this is past history. The Parent Company has done it almost from the begining but I can't say that they are going to do it 100 years from now, but certainly to date —and when I say to date it's been roughly three years since I was last in England—I have never once heard the question raised or the statement made that we lost that order because we would make the unit in inches and it was going into a metric system. When we lost the order, either our performance was not up to that of some of the others or our price was not the best price. Those are the things that decide in the commercial field, even in the export market, and actually the export market on a price basis is far sharper than the import market on a price basis. So all I can say is that, based on the experience of our Parent Company, we have never felt any handicap up to now by making things in the yard system and selling them in the metric system providing our quality, delivery, service and price are right.

Dr. d'Ombrain: May I come back on that Mr. Chairman? First, you have mentioned a meter. Now, I would take a very simple example of this. Take a small panel meter, let's say it has the terminals situated one and a half inches apart. The natural thing, if you are working in the inch system, is to choose some such simple dimension: 1 inch, 1½ inch, 1¼ inch, whatever it may be to do this. You send it abroad to the metric world and you tell them they must drill two holes which are 3.81 centimeters apart. Now, you can argue it is just as easy to drill something which is 3.81 centimeters apart as it is to drill something which is 4 centimeters apart. Well, I think that that is not so; I think that psychologically, people would far prefer, even in that simple example, to have dimensions which are both integral and familiar. I would also like to get a more direct answer from you as to the question of when this change is to be. I said, perhaps unfortunately, into eternity. Would you give me 20 years, would you give me 10 years, would you give me 30 years? Do you yourselves see that this will come about or do you consider that these two systems will in any foreseeable future co-exist?

Dr. Thomson: Again, I've got to go on the basis of past experience. As far as equipment like the house meter, the water meter, the fuse in the house, transformers, heavy electric machinery, steam turbines and that sort of thing is concerned, I don't think that the particular problem you raise has any bearing whatever because, usually, the dimensions have to be laid down and they are laid down from the drawing and there is always a tolerance in these dimensions, I mean from the point of view of the construction people, and I would say that should not be a serious problem, provided again that you are competitive in price. If you are not competitive in price, it does not matter what system you use.

Mr. Young: Could I add, Mr. Chairman, that the final question was ". . . Can we co-exist? . . ." I think we're co-existing today. We have both systems and we are co-existing today

Dr. Howlett: There is another factor which has not been raised in today's discussion. This is that there are two international organizations concerned with standards and specifications which have a bearing on trading and whose influence may well increase markedly. One is the International Conference of Legal Metrology, started a few years ago, which aspires to concern itself with specifications of all kinds of instruments used in legal metrology. This question, obviously, is of vital concern to foreign trade. The other organization is the International Standards Organization whose function is very well known to this audience. Both these organizations are numerically dominated by members of metric countries. Currently both organizations are prepared to have the two systems of measurement used in their standards and specifications. When however standards are set up in two dimensional systems having no simple ratio between them, and even if the two systems are maintained into the future for a certain time, it seems inevitable that the majority are ultimately going to demand that the convenient nominal dimensions occur in their system which has majority use. Just why they should be disposed to do otherwise, especially when industrial power has swung in their favour, seems rather unclear.

Mr. Thomson: Mr. Chairman, up to the present time the specifications by and large are not dimensional specifications. When it comes to the question of interchangeability, which is a different problem now but which is a problem tied in with what Dr. Howlett has raised, the only country at the present time that has done extensive work from the point of view of interchangeability of parts is Canada. For example, to give you the picture, some years ago—about 10 years ago now—as a result of pressure brought to bear by the authorities on the manufacturers, the Canadian manufacturers got together and agreed on an interchangeable transformer bushing. That didn't mean that the transformers had the same dimensions, it only meant that you could take a bushing for a transformer supplied by any manufacturer, and put it on another transformer made by another manufacturer. The bushings could look totally different, but certain critical dimensions were agreed on in order to arrive at that interchangeability. We have a number of specifications in which that has been done but, by and large, in any specifications that I have seen abroad, and I am including the States in this, they have shied away from that problem. That doesn't say that that problem may not come, but when it will come I don't know. In the case of this distribution transformer bushing standard, it took us between 30 and 40 years in Canada to arrive at the state we finally did, and that again is a totally different problem, and I quite agree that if standardization developed down to the point of making everything interchangeable then that would affect the picture, but to date there is very little of that being done outside of Canada.

Dr. Howlett: Dr. Thomson and I seem to be in agreement in at least one respect. He reports that he has done what I would like to see all Canadian industries do—i.e. he has examined the market for one of his products—transformers—and has decided it is sufficient for him to follow the electrical units of the International System of Units and that there is no need for him to employ the length and mass units of this system. This is an expert opinion based on his intimate knowledge of the current situation in a particular field and must be accepted as such. However, without in any way lessening the value of this opinion one may wonder at its validity for the indefinite future. Dimensional units of mechanical parts may not be important now but can one guarantee that this will always remain true?

Dr. Thomson: I used the transformer because it was the one thing that I could speak of from experience. But as far as I am concerned I see no difference between the transformer problem and that of motors, generators, turbines, water wheels and a host of other things that you can think of. And, to give you a little bit of the background of this sort of problem, after the war we had what we called the ABC screw threads. Great Britain, the States and Canada, that is the ABC—A for America, B for Britain and C for Canada—got together and agreed on a common screw thread which was interchangeable. The threads are not made exactly the same way but the dimensions are such that a screw made to this standard in Great Britain or the States or Canada is interchangeable between the three countries, and the nut is also interchangeable. Now, I say that is a simple problem, it only concerned a very limited field, but it concerned three countries who came up with this standard as a result of the problems that arose during World War II. At the present time, outside of the Armed Forces, that standard is in very little use, simply because of the cost of making an over-all change, so much so that everybody is sitting back waiting to see if the economic need will be great enough to warrant the changeover. We've got to keep in mind, and this is something we are liable to forget under present day conditions when we talk in billions and all the rest of it, that money is wasted changing from one product to another by deliberate scrapping of tools and so on that can still be used. In other words, when you scrap a tool that has useful life left in it, it's money that's wasted and it can never be returned. Now, obviously there is an economic problem: that if by scrapping that tool and making a new one, you will more than save the money that you lost when you scrapped the tool, then you are justified in doing it. Now, the minute we can say as a general thing — and perhaps some day this might come about—that the metre system is such that the cost of scrapping our tools and destroying all this wealth will be paid for by the export business that we will get, then this would be justified. But at the present time there is nothing in the immediately foreseeable picture that would indicate that scrapping all our tools and going over to the metric system, as far as Canada is concerned, is going to increase our export business to the point where it will pay for these tools and what have you that have been scrapped.

Chairman: I would like to ask Dr. Thomson a question leading from what has been said. Let us assume a decision was made by the Government today that effective Jan. 1, 1980, the metric system would be completely operative. My question is, with this 20 year period which industry would have to make the change, would the economic factors be as great as they have been indicated in our discussion?

Dr. Thomson: With our present price levels in Canada, we might as well face the fact that we have priced ourselves out of the world market and any such change would only be an additional cost put on top of our present high cost. I don't want to go into what I think is the reason for the high cost because the labor people would disagree with me and so on; but we must accept the basic fact that, as far as manufacturing is concerned (and you have only to look at the newspaper stories of the number of plants that have been closed and all the mergers that are taking place and one thing or another, all in an attempt to meet it) an economic condition has developed in Canada to the point that the Canadian price level is above the world price level, and there is no kidding on that one.

Dr. d'Ombrain: Well, this is a very pessimistic view. I hope it is not true. Surely, if this country is to be the Canada we all hope it to be, it has to grow industrially. Every year that it does grow industrially, you are going to add more and more machine tools, more and more equipment in this system which I suspect you yourself are beginning to think eventually will be replaced by another system. Now, you say that, well when the time comes, when the market, the slice of the cake is big enough, then we can afford to take this cake and the jam on the cake is going to enable us to pay for this change. But surely this can never economically be the case. We are always going to be getting worse in this direction, not better. The slice of the cake is not suddenly going to appear with a lot of jam on top for us. This slice is in fact going to go more and more to other people. We want this piece of cake now or as soon as we can get our hands on it. In a very short while, Russia will be one of the biggest competitors in the world markets and are we going to say then that we have never any hope of competing anywhere Russia competes? This is the sort of problem that is going to face us. Now, your argument seems to be one that says, well, we don't even sell now so what's the good of bothering about this?

Dr. Thomson: As long as we maintain the present standard of living in Canada, which carries with it the overall wage structure, and I am not referring primarily to the hourly paid, I'm referring to the whole wage structure throughout, as long as we maintain the present pattern of things, we will not be able to compete in the world markets against countries where the wage levels, and that applies right down even to the salaried people, are one-third, and in Japan even lower than that, of our levels, that's a far more serious problem than the problem of what we might save by changing over to the metric system; and the point is at the present time, with our price levels the way they are, anything that adds to that price is not going to help us in the world market.

Chairman: One question I would like to ask the panel. We have in Canada a number of companies which are subsidiaries to companies in the United States and the United Kingdom. In these circumstances, should Canada initiate the adoption of the metric system or would it be preferable to follow steps to be taken in the United States and the United Kingdom? Also, should we, in Canada, permit this change at the present time?

Dr. Howlett: There is another point which should receive serious consideration from Canadian industry and this is the following. Is it not possible that without a national changeover of the measurement system it might still be possible for certain Canadian industries to manufacture more advantageously certain articles for export in the metric system? It was brought to my attention recently that the Canadian pharmaceutical industry went over entirely to the metric system some years ago. One can safely assume that such an action was not based alone on the fact that the metric system is easier to use than the English system but that considerations of profit must also have had an important bearing on the decision.

Much has been made of the fact that, given equivalent quality, price is the principal consideration and that questions of units of measurement are very secondary and that, further, because Canadian costs are already high it is not possible from a practical point of view to increase them by the cost of changeover to a new system of measurement. The case of Japan should show clearly that this is a gross over simplification of a complicated problem. Certainly Japanese costs compare favourably with those of all other countries and with Canada in particular. It would seem unlikely that other countries' costs are going to shrink in the near future to match those of Japan and detract from her advantage in this respect. None the less, in spite of this cost advantage already held and likely to be held for some time, the Japanese converted entirely to the metric system as of last year. Presumably they expect to get an ultimate profit from this action which will cost them money, and presumably they have the courage to face all the growing pains of a changeover which has been so vividly described this afternoon. At the risk of another over simplification it seems that one can assume that the Japanese have decided it would be better in the long run in a metric world to be a low cost producer in the metric system rather than the English system.

Chairman: I think perhaps the panel have gone as far as they can in examining this matter of manufacturing for export in the metric market and I am sure there are many people in the audience here who could contribute to this discussion, people who are in other branches of industry than those represented by the panel.

Is there anyone in the audience who would like to say something about this or to ask questions from the panel?

Gentlemen, my name is **Tites.** I am a Group Captain in the R.C.A.F. I have appreciated what the panel has said. I can add something from personal experience. I was for three years in France as chief engineer for the construction of some 105 airfields and these were entirely designed and constructed in the metric system. I led a team of seven engineers, military engineers, of six nationalities, only one of whom had ever used the metric system before and I was surprised, as they were, to find the changeover from our thinking in the feet and inches to the metric system came with surprising rapidity and ease. This went right down to international contractors who found that they, in their turn, had little difficulty in conversion.

Not because I have anything great to contribute in this but, arising out of something that has just been said, I too have had experience in France during the first misunderstanding, it became my job to purchase certain areas of land and, before going out to meet the farmers concerned and their legal advisors, I carefully looked up the difference between hectares and acres and metres and yards and so on and went out to meet them and I found that not one of them knew what a hectare was or had ever heard of it. They used a different article or a system. They could not relate it to the hectare and of course they couldn't relate it in any sense to the acre which I didn't expect. I merely point out that, even in France, which first introduced this system, in my experience, it is not universally used.

N. N. Muller, Canadian Westinghouse. Mr. Young has already told you that I and people on our staff gave him some of his information so I think you know which side of the panel I have to argue for today. I wanted to make two points. Dr. Thomson has already touched on one of them. We try to engage actively in foreign trade in our company. A very minuscule portion of that foreign trade which we are successful in getting the contracts is with English system countries. It's virtually all with, nearly all, with metric system companies and we have found no difficulty whatsoever. For those people, we are glad to make drawings in the metric system. Then, it's no problem for an intelligent draughtsman so to do or for a professional engineer so to instruct the draughtsman. The other point, and perhaps more important at this point and time, is this: that, when Mr. Young contacted me and I got some members of our staff whose opinions I greatly respect gathered in my office to discuss this, preparatory to giving him a reply of our opinions on his side of the panel of course, this led us a little farther and we began to put down some round figures of what we thought it might cost if it was required that in some and reasonable period of time, not 20 years but more than one year, we were required by Government action to go over completely as a large manufacturer in Canada to the metric system and, before we got more than halfway through our analysis of what various of the things would cost in the way of converting several hundreds of thousands of drawings and many of them from microfilm, from specific information which is now on punch cards and ready to program computers with it, from the machine tool difficulties and so on, we soon got to the point where we saw that the continuing the analysis was crazy because the company would be broke.

My name is **Baracos.** I am with the Civil Engineering Department of the University of Manitoba. I would like to ask the two gentlemen, Mr. Young and Dr. Thomson. They have related to us the experiences that they have had, one with the electrical industry where really their product is sold in the metric system so that when one buys transformers, he buys something that is graded in kilowatts and the voltage is as stated and this is an internationally understood unit. The spacing of where the bolts come is rather immaterial because, even in this country or in Europe where there is free competition, if a manufacturer feels that his product will gain a little more of the market by tracing the bolt holes 2½" or 2.1367 and this will give him a distinct advantage in selling his product, I am sure he will, and it's immaterial whether that distance is measured in units or inches or centimeters provided it gives him that position of being able to hold, we might say, a captured market. I would like to ask these gentlemen if this is not really the case?

Dr. Thomson: Mr. Chairman, there doesn't seem to be an understanding that you can take the dimensions of any machine that you are going to send abroad and convert those dimensions into the metric system, so that a man who is familiar with the metric system would have no difficulty in reading the drawings. But, that's a very minor thing from changing all your tools and what have you so that you have made the equipment using the metre system in the factory instead of the yard. In other words, horsepower can be converted to the corresponding measurement in the metric system and can be put on the nameplate but that's a very minor operation compared to changing all your tooling on which you would make that machine. In other words, the machine as it goes out could be so marked and so dimensioned that a man familiar with the metric system would read it in the metric system and that's all he is interested in when he comes to mount this thing on a platform and use it.

Mr. Chairman, gentlemen, my name is **Aikers.** I am a lowly contractor. It seems to me that I have to get up here and show my ignorance by stating something which seems to be self-evident. This doesn't seem to be a debate as to the merits of the metric system and the English system. It seems to me that both sides have granted that the metric system is the best before they start to argue and, it's just a question, as far as I can see whether we can afford the cost of changing over. Now, I don't think that the cost of changing over is so terrible. I don't think that's the problem. I think the problem is to educate all our people, all our children from the time they start into a new system so that, when we do change over we are thinking in that system. I think it's a problem of changing in the schools, we can start that with our engineers. We know the metric systems here. I know, when I went to university, we knew about it, we were told what we had to multiply by and occasionally we got a problem but we never were sat down definitely to work in the metric system and I think, much more important than money, is the fact that we would have to re-educate our people to this system. Now, if we should do it, if it is an advantage, probably we should start doing so. As far as money is concerned, there isn't a complete change-over advance in manufaeturing or in contracting or in anything else which brings complete changes over a period of 10 to 15 years. I would venture to say that most of these machine tools and so on have an obsolescence of probably 15 or 20 years, they are going to be replaced anyway so it might be quite possible to replace them with tools which would have both measurements on them if that was desirable and we might then start training our people into using both systems. I don't think that anybody can contemplate changing directly but the point that surprises me is that there is no argument as to the value of our English system at all, it's just assumed that it has no value that the only thing is can we live with it? In other words, we are debating the problem of can we afford to change over or can we not afford to change over, and I think that's the only thing that's come out of the meeting so far.

Dr. d'Ombrain: I would heartily support the remarks of the last speaker. The great ease of use of the decimal system relieves the user of mensuration of a great deal of unnecessary effort which he can therefore use to more profitable purpose. How much do we now remember of our rods, poles and perches, and how much time we spent on acquiring this knowledge? On the scientific side in a university training particularly in electrical engineering, there is now a universal adoption of the M.K.S. system whose introduction was fiercely contested some years ago. It is now widely agreed that this system has given to students a much clearer insight into the principles of the system of units.

However, adoption of this most desirable system in the schools does presuppose that there is to be a change over in our legal weights and measures so that a child can purchase a kilo of potatoes!

Dr. Thomson: Well, it comes back to the same basic pattern that we have two systems that have been established and, in the early days, the highly industrialized areas were the ones that were established on the yard system. It's quite true that quite a number of the other countries, India for example, faced this problem. When India started to look into it, they found they had in existence some 300 to 500 systems of weights and measures in use in various parts of India and therefore they had to come up with a system which they hoped would be accepted all over the country. Now, I am not living in India but I know something of human nature and my guess is that it will be another 50 years before all the old systems die out. The new system, the metric system, will be used in formal documents, but the people as people buying and selling will be using their old measurements but giving them in terms of the equivalent metre system. They won't be using the equivalent, they are calling it by its old name, but the supplier will be supplying it in terms of the metric system. After all, you have seen the same pattern in Quebec today, they don't use the acre, they use the arpent — and try and get that word out of their language. I think you will find the same thing in France. My guess is that today the country people of France use some of the old names to describe their acreage, not the new names under the metric system whatever they are. I don't know them so I can't tell you what they are, but the equivalent of an acre in the metric system to my guess is what the country people in France are using.

I would say offhand that the manufacturers of machine tools in Canada are practically zero, but the point is well taken. If we were making machine tools in Canada, there is no reason why we could not make them to the metric measures for selling to the metric countries.

The operation of cutting the thread, whether it's in the metric system or the inch system, is still the same. The only thing is, it's the old problem of giving gauges and measuring devices to a man in the metre system and then turning around the next day and giving them to him in the yard system. Then, there is the old problem of always collecting the instruments before you start the next project or you find half way through that some mechanic got hold of the yard system measurements and applied them to the metric, and vice versa, and then, of course, you're in trouble. That's the problem with trying to operate the two systems side by side. This error problem will occur, and the question is can you always pick up all the tools and make sure that the mechanics have used the right measuring devices?

My name is **Henry Spencer.** I am with the Alberta Research Council. Sweden has never changed its laws to permit driving on the right-hand side of the road even though all cars manufactured there have the conventional left-hand drive. Danger and inconvenience are caused, but the public has defected efforts to change the laws through a plebiscite because taxes would rise. It costs money to change standards.

Speaking of money, the English system seems as awkward to us as does the yard to those in metric countries. If England changed to a dollar system, the time now lost in conversion of pounds, shillings and pence during calculation would benefit the country's economy measurably.

Utilization of a standard metric system has the economic advantage of speeding up calculations, particularly in this age of computers.

Dr. Thomson: For certain types of computers you have to go to the binary system. So, whether you have to convert inches and feet into the binary system or centimetres into the binary system, you still have that problem; so I feel that we all realize that, as our development grows, we are going to have all kinds of systems that are going to be in use by a limited amount of the population, and I don't feel that we should go into this special field and say that, for instance, because the physicists and the electrical engineer are working using the rational system we should also do so. As far as I am concerned, the physicists have spent a lot of time trying to bury that simple little figure π, and as long as we use spheres and cubes somewhere along the line we are going to have that figure π come up. We may bury him by putting him in a constant, but he is there just the same.

Mr. Chairman, my name is **Kees Vogel.** I am with the City of Winnipeg. I immigrated to Canada three years ago from Holland and therefore of course I am in favour of the metric system. Now, on the part of changing over, I think there are a few points that might be worth while mentioning. There is the point of education. Don't start only with children. I am thinking of changing over for adults at the same time. You don't have to throw your tools away, Dr. Thomson, because if you start in time and spread it gradually, I think people after some time of training are able to convert into the metric system. It's just like my little boy. At home, we speak Dutch to him, and with his friends on the street he speaks English. But, he'll get into the period when he has to understand both well, and will be able to, and it will be the same in the industrial aspect of training people in the use of the metric system. Another thing is that Canadian industry has to grow, and that requires manpower. I have no figures at hand, I don't know how many immigrants will be involved in this requirement, but one thing in favour of these immigrants when they come from European countries, except the United Kingdom in this case, they are trained in the metric system, and Canada might take advantage of that. Thank you.

Chairman: Any more questions? I think we will all agree we have had an interesting afternoon and there seems little for me to say in summing up. We have had the various factors presented on one side where there is a strong feeling that the adoption of the metric system would have many advantages. On the other hand, there is the economics involved in effecting a change. Perhaps the answer will come in a gradual transition and over the years we may get more towards using the metric system. This could be the case where new tools are required or where new industries are commencing operations. I am sure you all wish to join me in extending our sincere thanks to the four members of the panel who spent considerable time in preparation for this discussion today and who have contributed to the success of the afternoon. Thank you very much.

Dr. Ballard: Gentlemen, General Young has thanked everyone except himself and I think it would be inappropriate for this meeting to close without our sincere gratitude to not only the four other members of the panel but to General Young for the magnificient manner in which he has handled the discussion today.

Fig. 1. 60 ft. boom in elevated position.

A NEW FACILITY FOR MEASURING RADIATION PATTERNS OF MODEL SHIPBORNE ANTENNAS

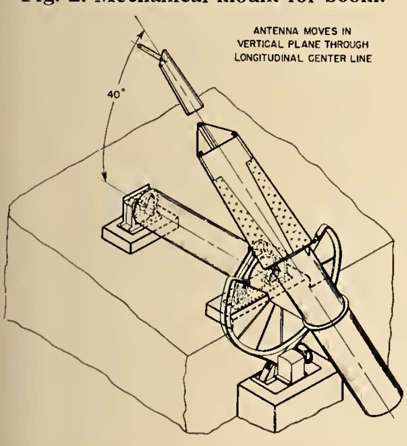
J. Y. Wong and J. C. Barnes,
Radio and Electrical Engineering Division,
National Research Council, Ottawa

IN AN earlier paper[1], the authors described the design and construction of a model shipborne antenna pattern range. The range is used primarily in the development of high frequency (2-30 mc/s) antennas for the Royal Canadian Navy. Although the range has proved to be extremely valuable, its use was limited to pattern measurements in only the horizontal plane. A knowledge of the pattern in the elevation plane is also desirable and in many cases essential. For long range communication it is desirable to concentrate the radiated energy between grazing angles of about 5° to 30° above the horizon. Signals radiated overhead are wasted and lost insofar as effective communications is concerned. In view of the above requirements, facilities to measure elevation patterns have been added recently.

Description of Mechanism and Boom

Our basic model range provides an aluminized surface 200 ft. long and 70 ft. wide on which a turntable, 20 ft. in diameter, is located about 140 ft. from the illuminating antenna. The model ship under test is placed on the turntable and rotated so that the effect on the radiation pattern of the ship's superstructure, adjacent antennas and other objects may be determined. The mechanism for measuring elevation patterns consists essentially of a 60 ft. long boom which sweeps an illuminating antenna in a 35 ft. arc over the centre of the turntable. A photograph of the boom in an elevated position is shown in Fig. 1.

Fig. 2. Mechanical mount for boom.



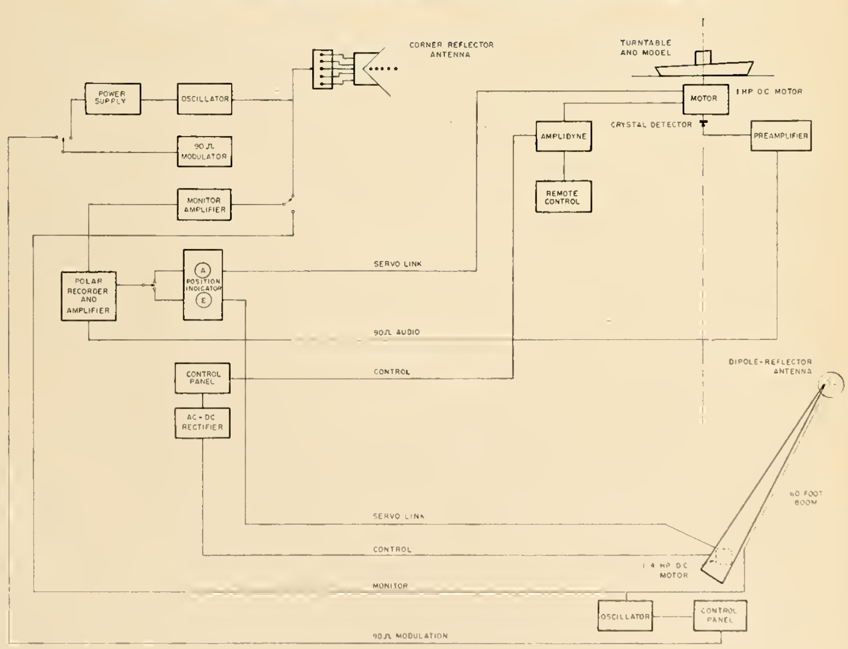
A concrete base was constructed for the drive mechanism shown in Fig. 2. A horizontal shaft 6 ft. long by 18 in. in diameter is supported at one end by a self-aligning roller bearing fitted to a 2 in. diameter stub extension of the main shaft; the other end is supported on three ball-bearing rollers. To this shaft is welded, at an angle of 40°, a 2 ft. diameter tube having provision at one end for attachment of the boom, and at the other end for attachment of the counterweight. A 6 ft. diameter disc sector is fastened rigidly to the horizontal shaft and a standard double roller chain is wrapped around the periphery over two suitably located idlers and around a sprocket on the output shaft of a motor-driven gearbox. This device eliminates the necessity for machining a 6 ft. diameter gear.

The boom itself is a tapered equilateral triangle, 60 ft. long, 6 in. per side at the small end and 30 in. per side at the large end. It is constructed of first grade B.C. fir. Three tapered stringers form the corners of the triangle, and fir plywood forms the sides. All joints are glued and screwed. During a static test in which the boom was supported at one end only, it sagged 4¼ in. in the 60 ft. length.

Attachment of the boom to its steel support presented a problem which was solved by fastening a steel angle piece 5 ft. long to each corner of the triangle. Approximately 180 fasteners (¼ in. screws and bolts) were used in all. The load was then transferred from these corner pieces to the steel frame by means of three 1¼ in. high-tensile steel cap screws.

The final problem was that of making a suitable counterweight. The container is a 2 ft. diameter, 6 ft. long steel can made of ¼ in. boiler plate which in itself weighs 670 lb. The weighting materials consist of 700 lb.

Fig. 3. Diagram showing essential layout of pattern range.



of lead, 1800 lb. of cast iron, and cement to fill in the spaces. When the counterweight was installed it was possible to lift the small end of the boom with one finger. The total moving mass was almost two tons.

Instrumentation

The boom is driven by a ¼ h.p. D.C. motor which is belt-coupled to a pulley on the gear box. A shunt-wound motor is used because of its constant speed — load characteristics. Power for the motor is supplied from a full-wave silicon-diode bridge rectifier. The motor speed and direction of rotation are controlled by varying the armature voltage and polarity, respectively.

Attached to the main 18 in. diameter shaft are two limit switches. In a nearly horizontal position of the boom, the limit switch is actuated, opening the armature circuit and thereby stopping the motor. This safety feature is built into the facility in order to prevent damage to the boom and the surface of the range. Cables carrying power to the motor are located in a steel conduit buried along the side of the range. Another conduit carries all the signal leads and cables.

Two small selsyns mounted on a base-plate are geared to the stub extension of the main shaft. One selsyn is used as part of the position indicating system. A dial indicator permits the operator in the control hut to set the boom at any desired elevation angle. The second selsyn provides information for the pattern recorder.

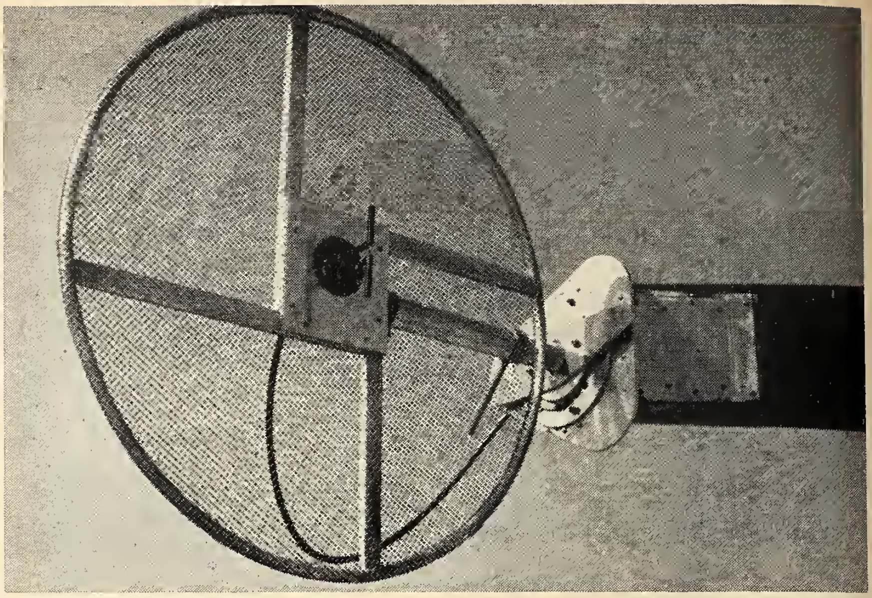
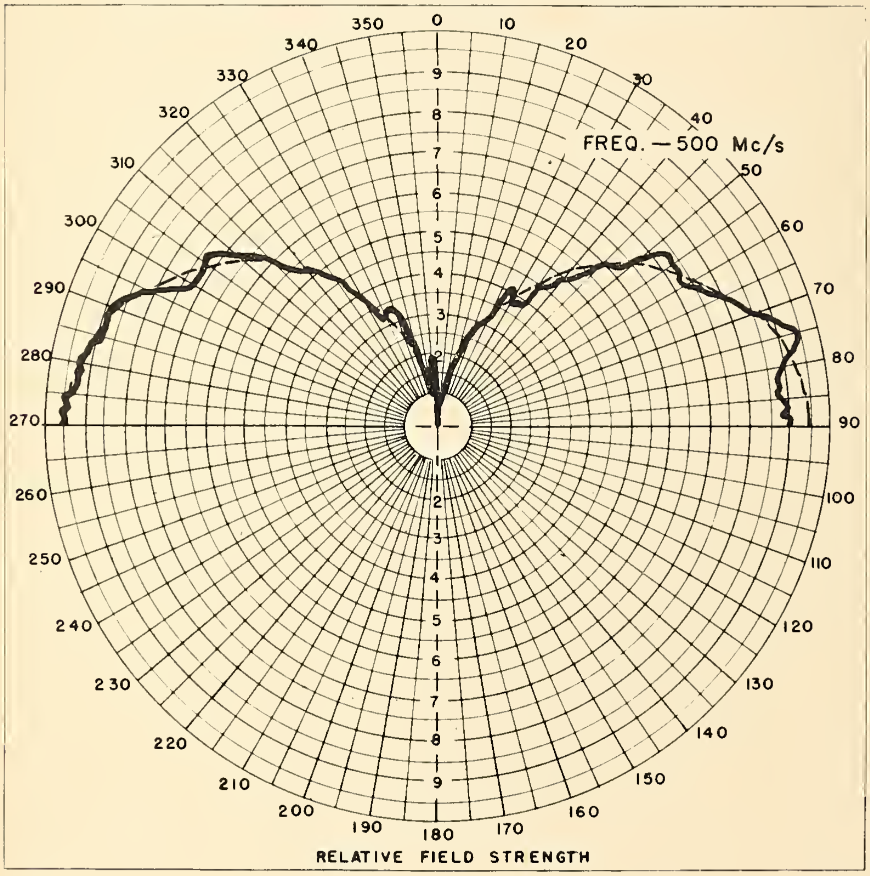


Fig. 4. Reflector and dipole antenna.

A diagram showing the essential layout of the pattern range is given in Fig. 3. The controls for operating the boom and the associated equipment for measuring patterns are located in the control hut. To eliminate a long run of coaxial cable (about 200 ft. from the signal source to the illuminating antenna), the source is located at the base of the boom instead of the hut. The attenuation in this length of cable could be as much as 18 decibels.

The illuminating antenna consists of a half-wave dipole backed by a reflector. The reflector is constructed of ¼ in. aluminum hardware-cloth stretched over a circular form. Two different reflectors and five dipoles are used to cover the band of frequencies from 96 mc/s to 1440 mc/s. A photograph of an antenna attached to the end of the boom is shown in Fig. 4.

Fig. 5. Vertical pattern of quarter-wave monopole antenna.



To determine the amount of boom deflection with height, a transit was used to measure the actual elevation angle. This angle was compared with the angle read on the dial indicator and it was found the maximum deviation was about 1°. This value occurred for a boom height corresponding to about 30°.

Before the boom was used to measure any patterns of the model ship, measurements were carried out on a quarter-wave monopole antenna mounted on the centre of the turntable. These measurements were conducted in order to determine whether or not the overall system was functioning satisfactorily. A measured radiation pattern is illustrated in Fig. 5; the calculated pattern is shown as a dotted curve and it can be seen the agreement is very good.

Radiation pattern measurements of the aircraft carrier model, HMCS "Bonaventure", are currently being carried out employing the new facilities.

Reference

1. J. Y. Wong and J. C. Barnes, "Design and Construction of a Pattern Range for Testing High Frequency Shipborne Antennas", Trans. E.I.C., Vol. 2, No. 1, January 1958.

AN EVALUATION OF PLYWOODS AND PLASTICS IN BOAT CONSTRUCTION

John Brandlmayr, M.E.I.C.,
President, John Brandlmayr Ltd., Vancouver.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

VESSELS under 100 ft. in length are considered in this paper since this is the size range in which plywoods and plastics have gained acceptance for hull construction.

Acceptance is basically a function of economics with a time factor to demonstrate or prove the favorable economics of a new material. With a durable product such as a boat hull where a useful life will range from 20 to 50 years, a new material is likely to be received with reservations until it has been demonstrated in service for a significant length of time. Reservations are justified since there are a great many conflicting requirements in a boat hull material.

Physical test results including strength and weathering are necessary when evaluating a new material but care must be taken to see that material as actually produced for a hull is tested and consideration of the effect of fabrication methods must not be overlooked. Test results have been discredited in the eyes of boat owners since the values given have in many cases not been representative of the material as incorporated into a hull.

Solid Wood

Construction techniques for hulls built of solid wood have been developed over many centuries and are based on joining wood members together to produce a strong, watertight structure. In fastening these members into a unit various interlocking and friction joints are used together with wooden dowels and tree nails or metallic fastenings in the form of drifts, bolts, nails and screws. Some relatively recent solid wood hulls utilize glued plank construction and laminated components are now common but basic modern practice is simply well fitted members and metal fastenings.

The strength and stiffness of wood varies with the moisture content and this moisture content is usually high below the waterline. 30% moisture content in service is a reasonable average while most of the wood going into the construction ranges between 10% and 15% during the process of construction. Fig. 1 shows the variation of the flexural and compressive strengths of Douglas fir with moisture content. At fibre saturation, representing about 30% moisture, flexural strength is less than half the value at low moisture contents and compressive strength suffers even more.

Actually the great limiting factor in a solid wood hull is the joint efficiency and secondarily the basic grain property of the wood. Laminated members, double and triple planking are steps toward the improvement of joint efficiency and a reduction in grain effect.

Despite these limitations the techniques used in the construction of solid wood hulls are so well developed and successful that this type continues to be favorably received in lengths ranging from 20 ft. to 100 ft. However, indications are that solid wood will continue to lose ground to other materials.

Metal Hulls

Metal hulls of practical interest are either steel or aluminum alloy. There is about one century of experience with small steel hulls and slightly less time with aluminum alloy hulls.

Fabrication techniques have to some extent been developed or at least guided by knowledge gained with other products made of the same materials. The industrial use of steel for process industries, structures and vehicles and the accumulation of welding knowledge in other fields has doubtless aided in the advance of steel hull construction and in particular has made possible the economical production of small steel vessels. Except for fast craft where light weight is important, steel is strongly in the picture for all sizes of vessels and completely dominant over 100 ft. In the case of fast or otherwise light boats some are being produced in steel but their share of this market does not appear to show a significant change.

Aluminum alloy hull construction has been very much influenced by the aircraft industry and by other aluminum consuming industries.

Aluminum alloy is accepted as a contender in all sizes of hulls and very desirable where a high strength to weight ratio is important. In the overall picture for hulls under 100 ft. aluminum is not showing a significant change in its share of the market. Innovation in marine applications of aluminum are constantly being produced and publicized and the material has become firmly established for some types of craft under 16 ft. Larger commercial and pleasure boat hulls are currently being built by many different builders and future indications for the material are favorable.

Plywoods and Plastic

In the case of plywood and plastic hulls very little useful knowledge has been obtainable from other than boat applications.

Acceptable plywood has been available for about 30 years but has been greatly improved during this period. Acceptable reinforced plastics have been available since about 1945 and great improvements in the material have been made in the intervening period.

Satisfactory construction techniques for both of these materials have only recently been adopted and the purpose here is to evaluate what can be currently achieved with the best present practice.

Plywood Hulls

Plywood defined: The term plywood as used herein refers to sheets made up of laminations of wood with the grain orientation alternating at right angles to the orientation in adjacent layers. Readily available commercial sheets are of ¼, ⅜, ½, ⅝ and ¾ inch thickness and can be obtained in up to 5 ft. width and 60 ft. length. The grain in the outer plies runs parallel to the length of the sheet in all cases. ¼ in. plywood is usually made up of three plies, ⅜ in. of three or five plies and ½ in., ⅝ in. and ¾ in. of five plies. Plywood is initially made in sheets 8 or 10 ft. long. To produce longer sheets, scarfs are machined for an accurate fit of adjacent sheets and a hot cured glued joint is made. These scarfed joints have been found reliable and economical to the point that wherever the application permits, full length sheets are used rather than joining shorter sheets on the hull.

To be suitable for marine use the bonding agent between the plies must be a durable, "waterproof" glue. Phenol formaldahyde, which is polymerized in a hot press at a high temperature and pressure is acceptable and is general among plywood manufacturers.

The most widely used plywood species in North America are the true mahoganies, the Philippine mahoganies, Douglas fir and, to a lesser extent, other hardwoods. Except for surface finishes, which will be dealt with later, there is no significant difference in the structural application and function of mahogany compared to Douglas fir plywood. Some other hardwoods differ sufficiently that they should be given special consideration but the basic application remains the same.

Flat sheet plywood made in large volume by highly mechanized plywood plants accounts for all but a very small portion of plywood hull construction. Molded plywood which is actually built of veneers laid up on a form to produce the hull shape is used to a limited extent. The resulting hull is structurally very efficient but relatively high labor costs and the limitation to round bilge hulls are among the factors that confine the use of molded plywood to a relatively small and diminishing field.

Sheet Plywood: The function of the skin of a hull is to resist the direct water pressure and the overall hull torsion and bending. This requires a measure of multidirectional strength and watertightness which is achieved in conventional solid wood hulls by laying planks with the edges tightly in contact and holding the planks together with frames at right angles. The planks are fastened to the frames with screws or nails to produce in effect a strong, watertight sheet with an adequate balance of strength in all directions. However, the metal fastenings are inefficient, rarely developing over 50% of the strength of the solid wood members and the solid wood is subject to splitting. Plywood provides such a watertight sheet of equivalent strength with a weight saving of 20% to 40% due to the efficient joining by glue of the plies making up the plywood.

Structural Arrangements and Hull Forms: Plywood sheets can be stiffened and joined on a hull form adapted to the material to produce a structure of a very high strength to weight ratio, and form limitations have not proved to be serious.

Unsatisfactory experience with plywood boats is most frequently traceable to faulty joint design. A cruiser hull is a structure subject to an infinite variety of loading conditions the most serious being the repeated buffetting of waves which send rippling deflections through the length of the hull. Where the plywood is continuous there is usually no problem since it absorbs energy and dampens the deflection quickly and in this respect wood is quieter than plastic or metal and less susceptible to fatigue. There may be ample strength at joints but it has been found that this repeated deflection tends to pry joints open, breaking the bond of seam compound and starting a leak. It was felt that this could be avoided by minimizing the deflection at the joints.

In 1952 the writer designed a hull section which has been used on all boats built by Spencer Boats Ltd. since that date with minor refinements, and it is typified in the cross section of the Spencer 32. The hulls are built upside down using a sawn member at the sheer and sawn frames spaced about 3 ft. on centre. Laminated fir stems are used. Only the chine log is of oak for its superior screw holding properties but all of the battens and the keelson are of Douglas fir. Battens and chine logs are laid on the outside of the frames and the battens nearest the joint at keelson and chine are spaced to give a plywood end span ½ of the intermediate span. A non-hardening seam compound is used at the joints since it is impractical to make the joint accurate and close it quickly as required for hard setting glues. Screws provide the fastening. Full length sheets of plywood are applied on the topsides then trimmed flush with the chine logs whereupon the bottom full length sheets are applied and butted at the centerline.

Side panels are applied before the bottom panels since the width of the chine log gives ample bearing for the sides and the sides when bevelled flush adds to the bearing provided for the bottom panels on the thickness of the chine logs. There is also the advantage of continuity of the bottom surface.

While plywood is a relatively stiff material and is most easily bent into single developable surfaces, it is possible to depart slightly from the conical forms. There is certainly no need for a boxy appearance and an experienced designer who understands his material can produce a form with concave flare forward in a power boat. He can also produce convex curves in a sailboat hull. Extreme curves are not practical since they would induce excessive initial stresses. When great flare forward is required it can be accomplished with double diagonal plywood planking. Since the forward topside area is not highly stressed there is no loss of needed strength.

A detail is shown on the cruiser cross section Fig. 2 in the form of a wave deflecting shim fastened to the bottom at the chine. This triangular strip extends from the stern over ¾ of the boat length and tends to improve the efficiency at planing speeds. The shim must be of kiln dried Douglas fir and it is encased in reinforced plastic with the hull. An oak spray strip is fastened outside the plastic cover as is the keel or skeg.

In the case of planing hulls, a double purpose is served by the spray strip. Firstly it serves to deflect spray down and out, away from the hull by means of its lower horizontal surface. This reduces resistance and tends to make a dry running boat. Secondly it serves as a replaceable bumper and seems to be at the point which is most frequently in contact with floating debris. After a few seasons of use the spray strip may be sufficiently scarred to warrant replacement and this is readily done.

The sailboat cross section Fig. 3 illustrates the difference between it and the power boat although both follow the same construction procedure. A wide fir chine log is used on the sailboat and a filler of kiln dried fir about 5 in. wide is used between the topside and bottom plywood. This filler and the plywood are sanded into a round bilge that has the appearance and characteristics of a conventional round bilge sailing hull.

Protective Coverings: Protective coverings for weathering and abrasion are necessary over the outer surfaces of fir and mahogany plywood hulls. Some of the other hardwoods not commonly used in North America are claimed to have such a hard surface that further protection is not needed.

Surface durability required is dependent on the service. A car top boat that is handled gently, stored under cover and only has occasional use demands no more than a fir ply surface with possibly a groundwood overlay and proper painting. A 15 ft. runabout used for water-skiing, carried on a trailer and stored out of the water will have adequate life if the material is fir with groundwood overlay and paint or a harder wood. In this case the ability to withstand weathering and light impact is greatly improved if the hull is sheathed in a glass fibre reinforced plastic. Usually a polyester plastic is used or at greater expense, epoxy.

Larger craft, cruisers, fishing vessels and those intended for more rigorous service require fibreglass sheathing. Unsheathed, the life of such plywood hulls is generally limited by weathering and abrasion to an unacceptably short period.

The surface of fir plywood presents a flat grain and has a bearing yield strength in the order of 500 p.s.i. compared to figures of 17,000 p.s.i. for fibreglass reinforced polyesters.

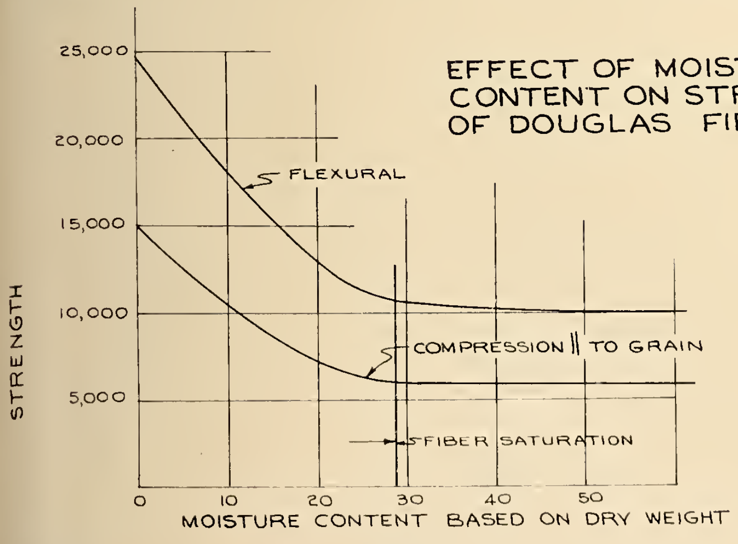
Fibreglass reinforced sheathing over dry fir plywood hulls with well supported and fastened joints using single thicknesses of cloth or woven roving has been amply proved in service over the past eight years. Proper procedures and rigid joints between the plywood sheets are essential to obtaining a successful covering.

Useful Life: Du Cane in his book "High Speed Small Craft" mentions a plywood power launch built in 1898 which at his time of writing, 1950, was still sound. This boat the "Consuta", an umpire's launch, was built using plywood sewn together with copper wire.

Other examples of long plywood life as well as some of short life can be found. Indications are that the probable life of well built plywood hulls is equal to that of well built hulls of solid wood, metal or plastic.

General: The strength to weight advantage of plywood structures over metal fastened solid wood structures has been clearly demonstrated in the case of aircraft and in applications for hydroplanes where only plywoods and high strength alloys are used. It seems probable that plywood will largely replace solid wood for the construction of custom built boats or where relatively small numbers of one design are required. Strip planked hulls, in which narrow strips are glued and edge nailed together provide an intermediate construction between solid wood and plywood.

Figure 1. The Effect of Moisture Content on the Flexural and Compressive Strengths of Douglas Fir.



Plastic Hulls

Material: Many types and combinations of plastics have been used for hulls. The currently dominant plastic hull in all sizes is built of polyester resin reinforced with glass strands but even within these limits there are infinite variations of both the plastic and reinforcement. It is evident that

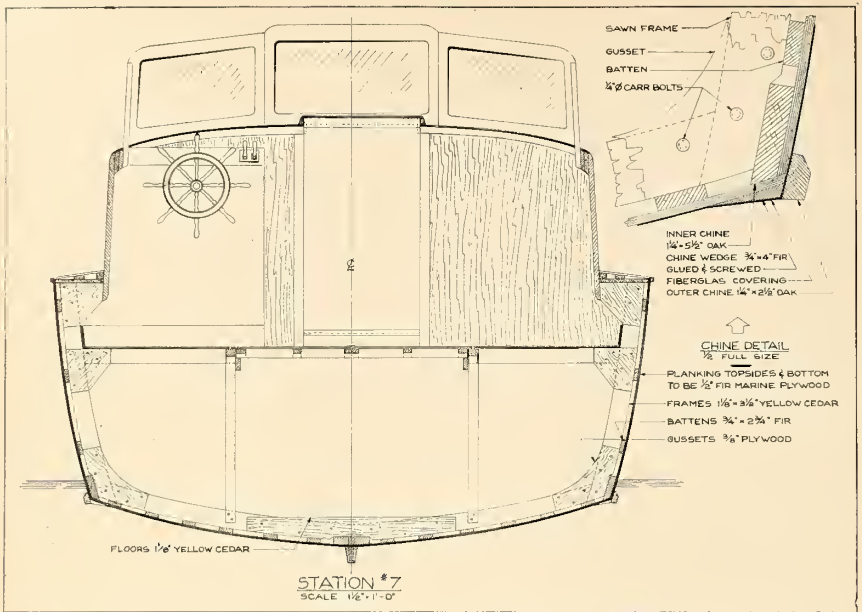


Figure 2. Typical Construction Section of a 32 ft. Plywood Power Cruiser. This shows the spacing of longitudinal support for the plywood planking and the emphasis on support along the edges.

painstaking development and quality control are unusually important with this material. It is equally evident that great differences in the success of reinforced plastic structures can be expected.

The physical properties of fibreglass reinforced polyesters are dealt with in some detail in Reference 2. However, even the most complete accumulation and analysis of test results must be regarded with caution in the process of application to the design of hulls.

Glass strands in themselves are extremely strong with tensile strengths claimed to range up to 400,000 p.s.i. Their modulus of elasticity is 10.5 x 10^6 p.s.i.

Polyester resins on the other hand have tensile strengths in the order of 9000 p.s.i., compressive strengths of 17,000 p.s.i. and moduli of elasticity from 500,000 to 700,000 p.s.i. Values mentioned for these individual raw materials should not be considered of any significance especially after the raw materials have been joined in a laminate. The selection of the proper resin is vital and cannot be done on the basis of lowest price or highest strength. Other properties to do with the way the resin acts with the glass reinforcement to produce a suitable structure are of primary importance and affect both the initial strength of a hull and its durability.

These two very different materials are combined by flowing the polyester in liquid state around the glass fibres and then curing the polyester into a solid thereby binding the two together to form a material with a new set of properties. This is actually a composite material.

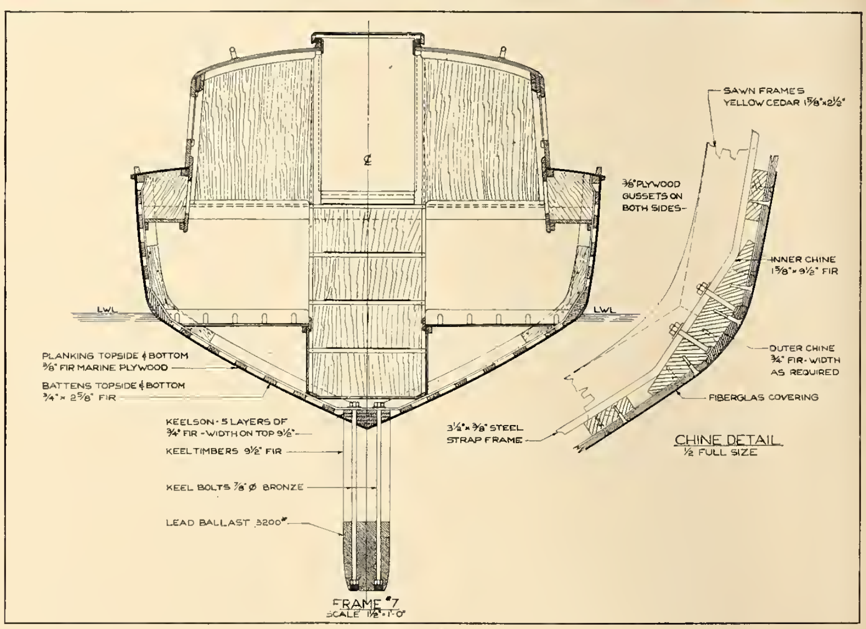
Current practice produces hulls which with contact or hand lay up have a glass content of 30% by weight and a specific weight of 100 lb. per cu. ft. The flexural strength is about 20,000 p.s.i. and varies directly with the glass content. A 100% increase is possible under special conditions. Compressive and bearing strength are 17,000 p.s.i. and are somewhat affected by glass content but these values will not usually vary more than 40% from the figure mentioned.

A figure of 1.7 x 10^6 can be assigned for modulus of elasticity but this varies greatly with glass content, direction of reinforcement and type of reinforcement and it is possible to have values range from .8 to 2.5 in a hull. A thermal K factor of 3.6 B.t.u./in./ft.^{2}/°F/hour is representative.

This material has in effect a straight line stress-strain curve with no definite yield point and in this respect is entirely different from wood or the various metals, which, while they do not all exhibit a yield point, at least have a distinct change in the slope of the stress-strain curve between the proportional limit and ultimate stress. A comparison of stress-strain curves for wood steel and fibreglass is shown in Fig. 4. The characteristic of the stress-strain curve must be borne in mind throughout the design of a reinforced plastic structure and any analogy with steel or wood must be tempered by this consideration. Progressive cracking beginning at the corners of hulls and industrial liquid storage tanks is often traceable to the stress-strain relationship of the material.

The values mentioned apply to the wet condition comparable to a hull immersed in water. Dry, the material may have a strength 30% higher (as illustrated on the water immersion curve Fig. 6). Since water affects the glass more than the resin, laminates with a higher glass content suffer an even greater loss of strength when subjected to prolonged immersion. Sizes and finishes have been developed to give high wet strength. With their use and by limiting the glass content a material is produced

Figure 3. Typical Construction Section of a 31 ft. Plywood Sailboat. A rounded form is achieved by convex curves in the plywood and a rounded chine log.



that has lower dry strength but has a strength reduction of only 20 to 25% when wet while other laminates lose much more strength. Gasoline and oil have less effect than water and all these liquids can be carried in fibreglass tanks. The relative humidity at the time a laminate is built also affects its strength.

Weathering is similar to immersion in its effect on strength. In weathering, exposure to the sun initially promotes further curing and a corresponding increase in strength results during the first three months and then the material gradually settles to a long term strength some 2/3 of the highest value. This is shown on a weathering curve Fig. 5.

Except for damage at points of stress concentration the impact strength of glass hulls is excellent when compared to hulls of other materials. Quantitative values are lacking and in fact a really significant test short of full scale loading is not known.

The fatigue limit of fibreglass polyester laminates has been stated at 20 to 30% of their ultimate strengths with further reductions required for weathering, water immersion and elevated temperatures. Fatigue characteristics are good and present no problem in hull design where excessive deflections and excessive stress concentrations do not exist.

Type and orientation of fibreglass reinforcement determines the directional strength relationships of the resulting laminate. Strength varies depending upon the angle of the load to the various reinforcing layers. It is possible to substantially balance the strength in all directions or to build for greater strength in some desirable direction.

Molding: Contact molding is generally used for all but the smallest boats. In contact molding a female mold is generally used and the hull is built inside this mold. The contact surface of the mold has a glossy finish which is imparted to the outer surface of each hull molded therein. Molding proceeds with the application of a parting agent, then a gel coat containing the desired color followed by lay-ups of fibreglass cloth, mat, woven roving, chopped strands in the selected combinations and distributions over the area.

It is not intended to discuss the techniques employed except as necessary to evaluate the results being achieved. In this connection mention should be made of the shrinkage of polyester resins during curing and the need to remove entrained air bubbles from the resin and completely "wet" the fibreglass reinforcement.

Polyesters are thermo-setting plastics which shrink during their cure by 4 to 8% by volume. Due to the addition of fillers this shrinkage is reduced but is still sufficient to cause warping of surfaces adjacent to corners or sharp changes in direction. The exothermal curing and shrinkage must always be considered in planning large moldings or moldings with relatively abrupt changes in shape. Very little shrinkage occurs parallel to the placement of the reinforcing fibreglass.

In all contact molding it is necessary at some stage to make the resin completely penetrate around the glass or wet the glass and also to remove any entrained air bubbles. The air is "rolled out" and this procedure is easy over flat or gently curved surfaces, but requires more time at corners or sharp changes in direction. The shorter the radius of the corner the more difficult it is to do good molding.

Hull Forms and Cost: Fibreglass gives greater latitude of hull form than any other material. It is most effectively used for rounded forms such as sailboat hulls where long gentle curves exist with few flat areas or hard corners. With such a form, molding costs are at a minimum while the shape contributes to rigidity and thereby strength. This form of hull due to its shape is the most expensive

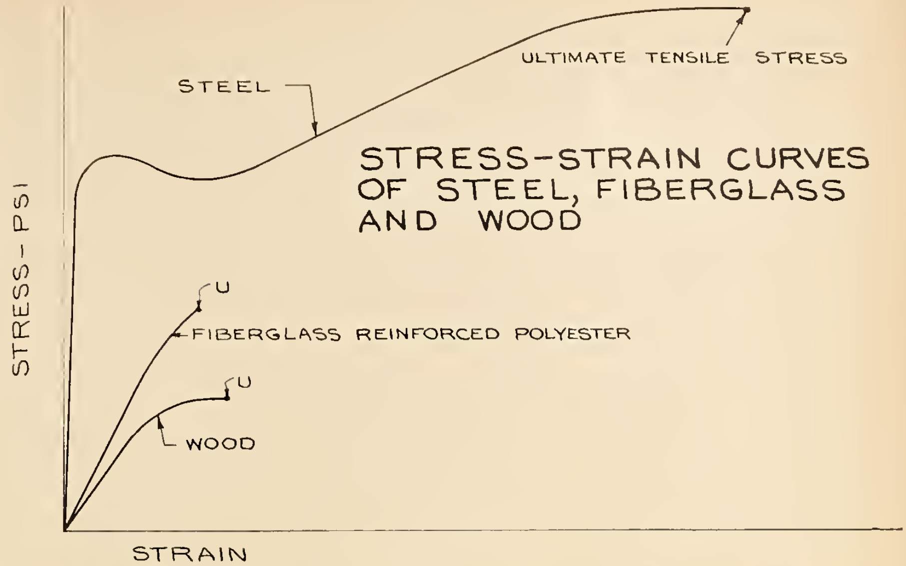


Figure 4. Stress-strain Curves of Steel, Fibreglass Reinforced Polyester and Wood.

Figure 5. The Effect of Weathering on Flexural Strength of Fibreglass Reinforced Polyester Hulls.

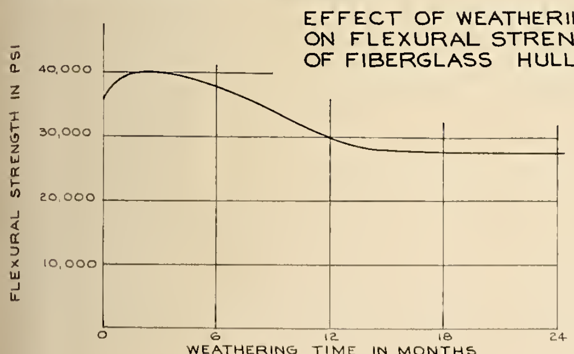
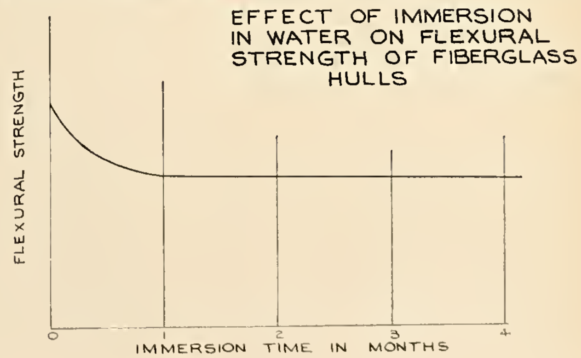


Figure 6. The Effect of Immersion in Water on Flexural Strength of Fibreglass Reinforced Polyester.



to build when using other materials including solid wood, plywood or metals and a plastic hull of this type is now generally cheaper than the equivalent in other materials. As a consequence, fibreglass is rapidly gaining in this field and is shortly expected to completely dominate this field up to hulls of 60 ft. in length, except for limited custom construction.

The hull lines (Fig. 7) of a fibreglass sloop 35 ft. overall length, 25 ft. waterline length, 9 ft. 6 in. beam and 5 ft. 3 in. draft illustrate the type of form that benefits most from reinforced plastic construction. A cost study, Fig. 8, of the 35 ft. sloop compares in graphical form the new 35 ft. fibreglass sloop with a hypothetical 35 ft. wood sloop identical except as to material. While these values are based on one company's costs they are representative of cost relationships presently existing throughout North America.

In making this cost study it was found that there was very little overall difference between the costs of solid wood construction and plastic sheathed plywood construction so that no distinction between these types was warranted. The cost picture of wood compared to fibreglass is however quite distinct.

The three chief cost factors affected by the material of construction are:

1. Cost of design, lofting, permanent jigs and molds;

2. Maintenance of jigs and molds;

3. Material, labor and overhead costs involved in construction.

Items 1 and 2 are low for a wooden vessel and high for a fibreglass boat due to the cost of a mold. Item 3 is lower for a molded glass hull because of the greatly reduced labor time involved. Material costs are slightly higher for fibreglass than for wood.

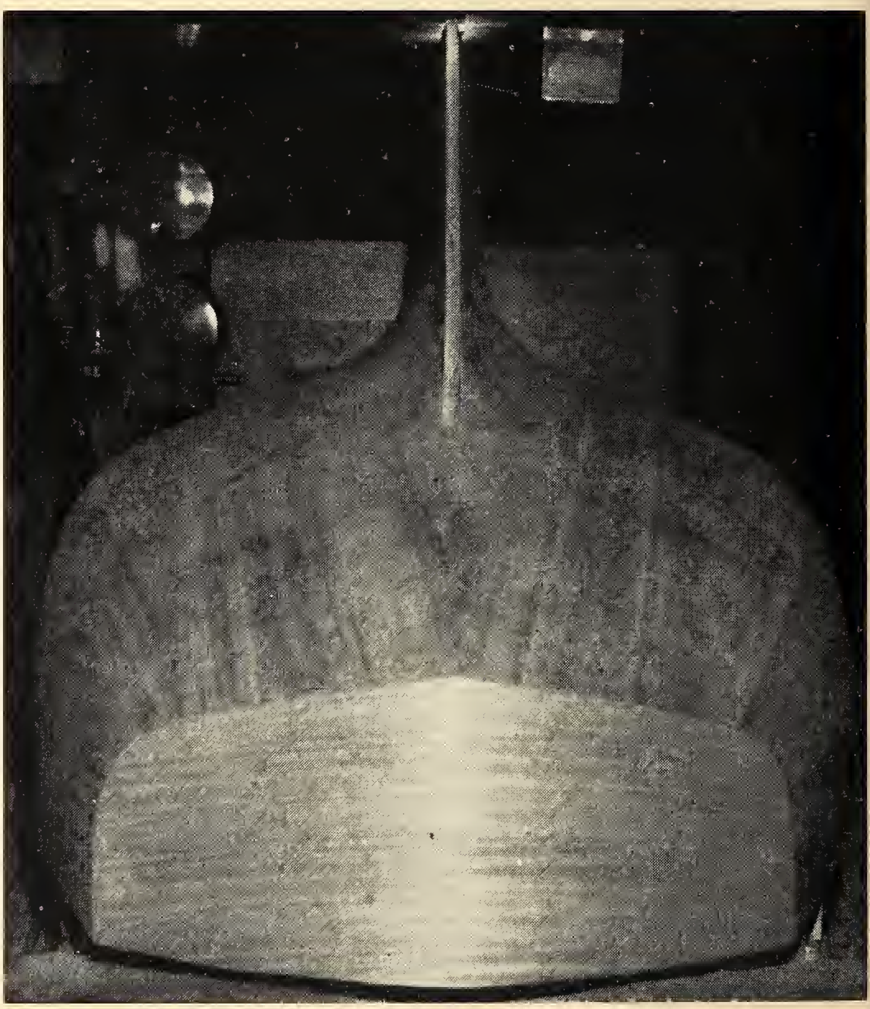
These differences are illustrated in the form of increment costs, unit costs and summation costs. Increment costs begin with the cost of the first boat and show the additional cost of each succeeding boat. Unit costs are the average cost per unit for each total number of boats built. Summation costs represent the total sum spent after completing a given number of boats.

Increment costs show an interesting pattern with the greatest difference existing between the first and second boats whether of glass or wood. The second glass vessel costs some 40% of the first whereas the second wood vessel costs about 70% of the first. Unit costs averaged over all boats built do not drop as rapidly and for wood boats of this size quantity production (more than five units) reduces costs to about 75% of single or custom building. This relationship is reflected in pricing in that stock boats are offered for the same or 5% less than similar custom built boats but stock boats must carry advertising and sales costs in the order of 20 to 25%. Unit costs of glass boats in this example are higher than for wood boats if fewer than six units are built. After the sixth unit the glass boats are cheaper and in this case the curves level out with the glass sloops about 10% below the costs in wood when built in quantities over 10. It should be mentioned that the maintenance and amortization of molds for fibreglass vessels are important portions of the total cost.

Fast powerboat hull forms involve relatively flat surfaces over the after 2/3 of the bottom and also over this area of the topsides. For best hydrodynamics a hard chine must be used with spray strips at or near the chine. Such a form requires more care and consequently expense in molding both to ensure soundness at the corners and to avoid warping. These flat areas must be made sufficiently rigid by means of closely spaced stiffeners, frames or bulkheads. Since fibreglass has an effective modulus of elasticity of about 1.7 x 10^6 which is in the same order as wood but the effective strength is such as to require only about 1/3 the thickness of fibreglass compared with wood it is evident that deflections should be considered. Excessive rippling (panting) and overall deflection of the bottoms of power boats has affected both performance and structural life of improperly designed craft and in many cases further stiffening members were added after a short period of use. The selection of the type of stiffener and its placement is also influenced by the fact that fibreglass exhibits no definite yield point and care must be taken to avoid stress concentrations since they could quickly result in local failure.

Conversely solid woods, plywoods and metals are all adaptable to flat surfaced hulls with joints at more or less right angles. The cost picture appears to favor these other materials

Figure 7. Stern View of Hull Plug. The flowing curves of this 35 ft. sailboat are readily molded in plastic.



and at present except for small hulls under 20 ft. fibreglass power boats are slightly more expensive than their counterparts in wood, plywood and metal.

Hull Size: Little if any uniformity of lay-up of the hull shell is discernible. Many variations are in current and apparently successful use.

In the case of hulls of small size and ranging up to 40 ft. it is usual to find the strength almost solely in the skin by the use of thick lay-ups, strong types of reinforcement such as woven roving and cloth and by incorporating surface shapes that stiffen the structure such as ridges or corrugated effects. Where emphasis is on developing strength and stiffness in the skin a minimum of supplementary stiffeners are used. A hull without internal stiffeners has the advantages of more internal space, a smooth unbroken inner surface and a reduction in the possibility of stress concentrations especially in the case of local impact. It may also cost less to manufacture.

Over 30 ft. in length and in the case of most power boat hulls it is difficult to obtain sufficient rigidity without using a properly proportioned pattern of bulkheads and longitudinal and transverse stiffeners. The larger boats tend to use a thinner skin which is in some cases built up of mat with little or no cloth or woven roving. This skin acts as a continuous curved or flat plate spanning between supports.

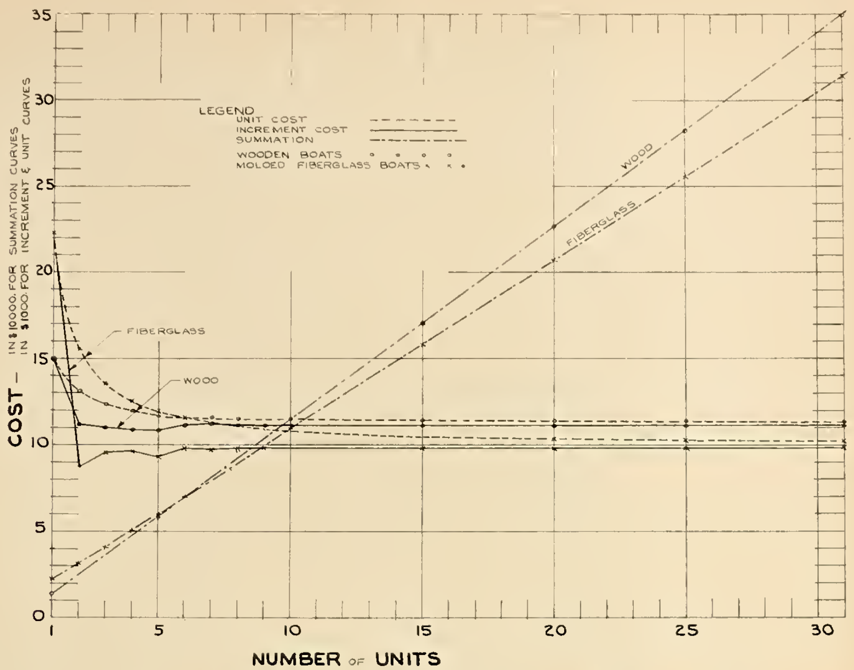


Figure 8. Cost Comparison of Wood and Plastic Sloops. This study compares the cost of complete 35 ft. sloops having fibreglass hulls with equivalent wood hulls.

Further Aims

Costs: There is a constant search for a reduction in both material and labor costs going into hull construction. In addition to direct costs there are related costs to do with inside and outside surface finishes, equipment attachment, built in items, storeability and others.

It is unlikely that hull shapes will be found that, due to their form, are cheaper than the best current designs but there is a significant cost factor in the selection of hull form which can easily amount to 10%. The chief gains must come from methods of construction using cheaper or less material and less labor time.

Improvement in Performance: Certain minimum physical requirements exist which must be met. While meeting these requirements any possible reduction in total weight will in effect improve performance as measured by speed or load carrying capacity.

Most pleasure boats and many of the small commercial craft are high speed vessels designed to plane and are very sensitive to weight. A material or method that offers the possibility of a reduction in overall weight receives serious consideration.

It is the weight in service rather than the weight at launching that determines performance. Since wooden hulls absorb water amounting to 5% to 15% of their launching weight, they must initially be correspondingly lighter than metal or plastic hulls which absorb or accumulate virtually no water.

Maintenance: The maintenance of hull surfaces is a problem, the importance of which is inversely proportional to the size and continuity of service of a vessel.

A large hard-working tug built of heavy steel plate has some hull surface maintenance cost but it does not bulk large compared with other costs. However, a 20 ft. varnished wood runabout which is continuously in the water and used only on week-ends requires a boat house or complete cover to minimize the considerable cost of surface maintenance. On this type of hull neglect of the surface results in fairly rapid deterioration of the major structure.

Low maintenance as exemplified by fibreglass surfaces is desired by most purchasers of pleasure boats. Under conditions of pleasure boat service fibreglass requires no attention for several years and a suitable plastic paint applied every five years will ordinarily maintain acceptable standards of protection and appearance. Both hulls built of solid fibreglass and those sheathed with fibreglass are in this category.

Useful Life: All currently used hull materials result in hulls that have an adequate useful life in the order of 25 to 50 years or longer. During this period obsolescence or the other hazards of service nearly always call for the scrapping of a hull.

Some materials do present a greater likelihood of deterioration than others and where favorable characteristics exist their acceptance will be enhanced by improving their probable span of life.

Acknowledgment

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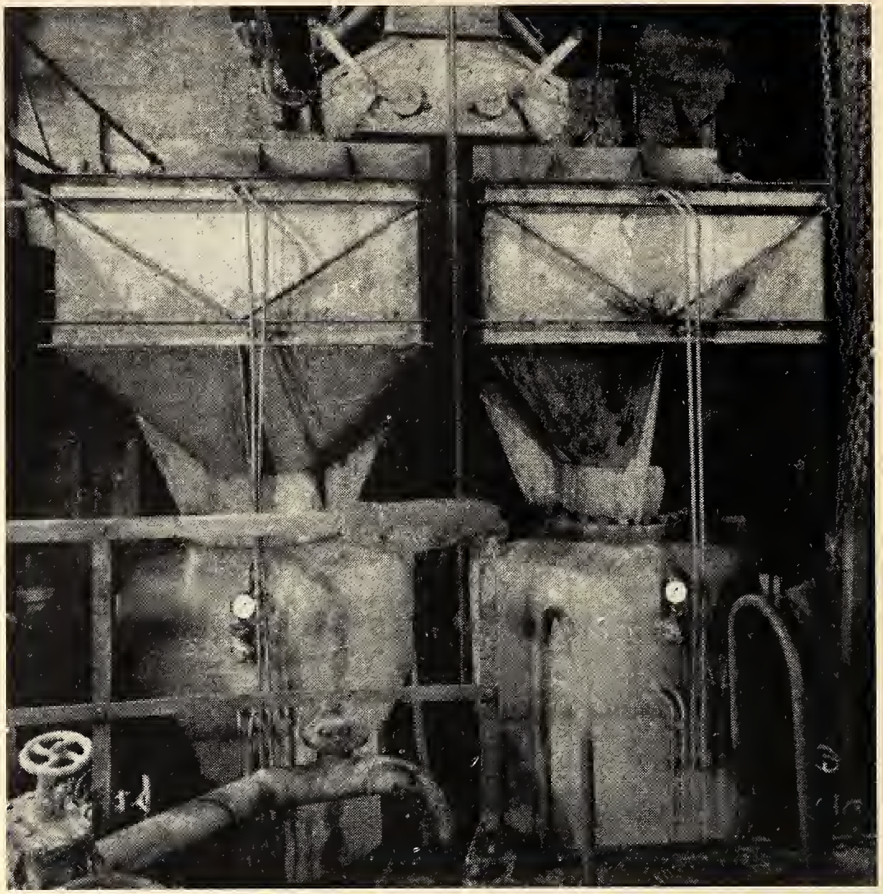


Locking Chamber Arrangement which introduces coal at the bottom of the St Etienne (France) mine circuit.

Transportation of Solids in Conduits Industrial Application Possibilities

E. Condolios,
Head of Industrial Hydraulic Section — SOGREAH

P. Couratin,
Engineer — SOGREAH

E. Pariset, M.E.I.C.
Lasalle Hydraulic Laboratory Director

BEGINNING from a purely empirical approach, hydraulic transport over the past few decades has improved in technique as the result of systematic research. It has been developed especially in the mining industry, and other industries using fluid treatment of material. It was in fact the technical necessities which imposed this process rather than a determined desire to use hydraulic transport.

Recent applications of this handling process illustrate the possibilities far better than publication of laboratory experiments. Some mining projects, which had been shelved because of the prohibitive cost of the installation of traditional means of transport, are being studied again with good hope of arriving at an economical solution.

Hydraulic transport, however, should not be considered only when conventional means fail or present difficulties, but as a means in parallel with the others each time the problem is the movement of powdered or granular materials. The investment necessary for a hydraulic transport system are nearly always much less, if the classical means do not already exist (roads, railways). Operation costs will always be very low for finely ground material, and generally higher than competitive means if the product has a larger granulometry. Abrasive characteristics can, however, modify completely the former case.

The present expansion of the mining industry in Canada should increase the use of this handling process which is already used in uranium mines.

The aim of this article is to outline the studies done by the Sogreah-LaSalle Hydraulic Laboratory group, and installations built in this field by the firm Neyrpic.

THEORETICAL AND EXPERIMENTAL STUDIES

At the International Hydraulic Convention in Minnesota, 1953, R. Durand presented the principle results of studies carried out in the laboratories of the Sogreah in Grenoble (France). We shall outline only briefly here the laws he exposed in that report.

Possible Transport Regimes for Different Types of Mixtures

Horizontal and Inclined Conduits: We will note firstly that, in mixing the material with the water necessary for transport, we obtain different mixtures which are functions of the physical characteristics and the concentration of the material added.

Two mixture types are generally found; mixtures which we will call homogeneous if the added material is very fine, and heterogeneous mixtures, if the material is large—dimensions larger than a few tenths of a millimeter. This classification, although very schematic, will allow us to describe the different transport regimes observed in the two cases. However, we must note that the problem becomes particularly complicated when a mixture exhibits characteristics of both cases at the same time.

Homogeneous Mixtures

Homogeneous mixtures form a solution in which the grains alter the viscosity of the water; they present plastic properties. In the state of near-repose, the mixture behaves like a solid and the grains cannot settle out. A definite internal shear stress must be attained before flow can take place. As long as the laminar regime lasts, the flow occurs with a variable apparent viscosity as a function of the velocity. In turbulent regime, the mixture behaves as a Newtonian fluid.

Transport of these plastic pastes is possible in laminar regime as well as turbulent regime, if the matter being transported is very fine; less than about five microns (colloidal clays, for example, bentonite).

If the matter to be transported comes from a grinder, for example, a bar grinder, and contains particles which might attain one to two tenths of a millimeter, with however a noticeable proportion of fines less than 50 microns, a turbulent regime should be adopted. If a laminar regime were used, sedimentation would ultimately take place forming continuously and progressively a concentrated solid deposit on the conduit bottom. Such deposits have been found in pipelines transporting raw cement paste, drilling muds etc.

Heterogeneous Mixtures

In heterogeneous mixtures, the grains do not modify the viscosity of the transporting liquid. They move in the flow following two means:

in suspension, if the grains are fine and the flow viscosity is high;

by saltation, if the grains are large, or if the velocity is low.

During the experiments which were carried out, three classes of material were noted according to their sizes:

1) materials of less than 0.2 mm. diameter are transported nearly always in suspension;

2) materials larger than 2 mm. diameter are transported by saltation;

3) material between these two diameters may be transported either by saltation or in suspension depending on the flow velocity.

These methods of transport characterising the grain movements are then superimposed on the hydraulic regimes in the pipeline, which may be of two types as well;

1) The transport regime without deposit; in effect a forced regime. No grains can settle in the pipe, but rather they all advance with the flow, lagging more or less depending on their size. The liquid discharge being sufficient, the flow commands the movement of the grains;

2) The transport regime with a deposit is a state of equilibrium between the flow and the material. The liquid discharge is insufficient, hence the mean velocity in the pipe is less than the velocity limiting the formation of a deposit. The material is deposited and forms a uniform layer on the bottom, such that the flow velocity in the remaining pipe cross-section becomes this limiting velocity. The materials create the equilibrium conditions necessary for their transport;

STABILITY CONDITIONS FOR DIFFERENT TYPES OF HYDRAULIC HANDLING INSTALLATIONS

— Fig N° 1 —

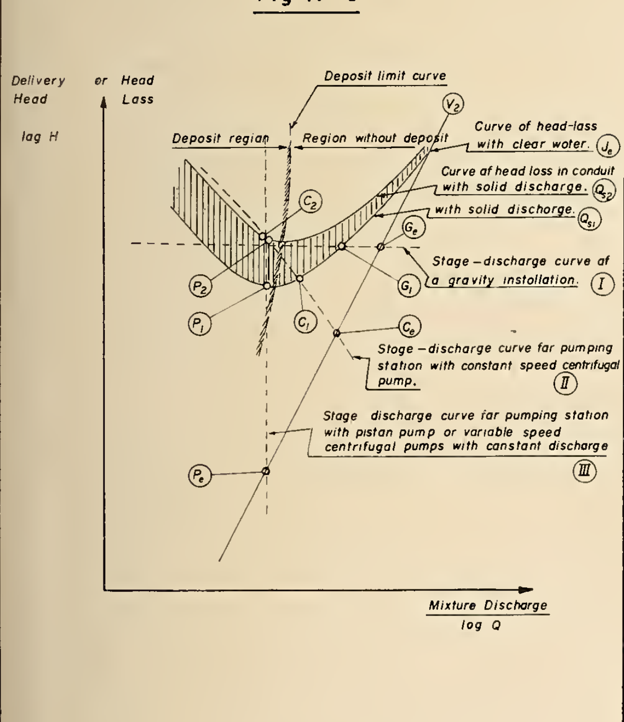
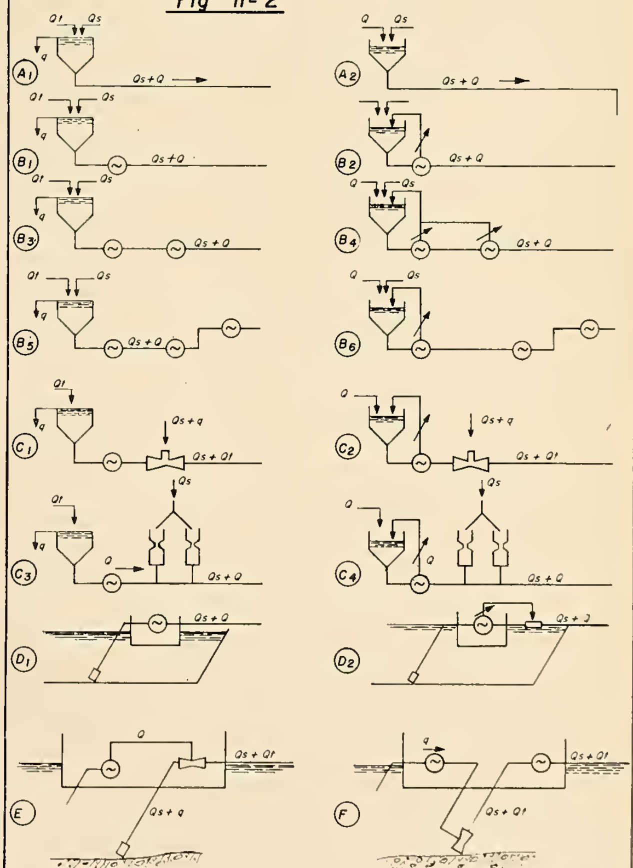


Fig nº 2



there is an auto-regulation of the conduit diameter by modifying the cross-section of flow.

If the pumping station characteristics are not correctly selected, these regimes may be unstable and can initiate the complete obstruction of the pipeline.

Knowledge of the limiting velocity characterising the change from one regime to the other is very important as it corresponds to the economic operating point. This allows the correct choice of the conduit diameter.

Power Necessary for Horizontal Transport

The diversity of materials and transport regimes described above leads to the supposition that the necessary energy gradient, hence total energy input per unit pound transported, is different for each case:

1) it decreases with the concentration of materials introduced into the flow.

2) it is very sensitive to any variation in dimension of the material. It is a maximum and independent of grain size if this is larger than 2 mm. It decreases rapidly with the mean dimension of the materials and the granulometric spread, reaching a minimum when transporting in paste form.

3) it is a function of the apparent density of the materials in the transporting liquid.

A few figures will help clarify the ideas expressed above. In order to economically transport by means of a pipeline 100 tons/hour of materials of equal density, such as gravel, sand, cement paste, it may be estimated that:

to transport gravel larger than 2 mm. diameter, provision must be made for power of about 6 hp. per ton mile.

for sand with a mean diameter of 0.4 mm., and included between 0.15 mm and 0.7 mm, the power necessary would be about 2.2 hp. per ton mile.

the power required would be only 0.12 hp. per ton mile for raw cement paste with a mean diameter of the order of 40 to 50 microns, and included between two and 100 microns.

These few figures allow a better understanding of the interest in studying this type of installation carefully, to obtain the best possible returns with a stable industrial operation and no risk of obstruction.

Vertical Conduits: The transport problem is much simpler in vertical than in horizontal conduits. It is sufficient to adopt a transport velocity equal to at least twice the limiting falling velocity of the solids in the water.

INDUSTRIAL DEVELOPMENT STUDIES

Apart from the laws of head losses and deposition velocities, a certain number of utilization conditions must be studied to assure the correct operation of the installations. We shall treat these problems succinctly.

Safety of Functioning: The safety of functioning can be absolute if the operation conditions are perfectly known. Two causes could initiate transport interruptions in this type of installation:

1) jamming
2) instability of the flow regime.

Jamming Conditions

To have absolute safety of operation, it is necessary that the conduit diameter be equal to or greater than three times the diameter of the largest grains. If the percentage of large grains is small, a conduit diameter of a minimum of twice these grains' diameter might be used.

On the other hand, if the materials are moved by means of a pump, the maximum allowable diameter of grains would be one half of the smallest canal dimension in the pump.

In industrial applications a suitably chosen intake screen must be provided to eliminate these risks. This screen mesh can be proportionately larger as the tonnage to be transported increases.

Stability Conditions

The stability conditions are fixed by a comparison of the characteristic stage-discharge curves of the pumping station, and the pipeline discharge-headloss curves. (Fig. 1).

The practical stability condition for the operating point is the following: for decreasing discharges, the characteristic curve of the pumping station must be such that the pressure furnished is always greater than that required for the conduit. The larger the algebraic angle between the two characteristic curves, the greater will be the stability around the operating point. It will therefore be possible to handle safely accidental variations of operation conditions, for example, an accidental increase in concentration.

For a given horizontal conduit transporting a mean solid discharge of granular particles which fluctuates during operation, we have shown on Fig. 1 the two extreme operation curves corresponding to solid discharges Qs_1 and Qs_2. The cross-hatched area between the two curves corresponds to the operational zone of the conduit. These curves are cut by a shaded line V_L which indicates the appearance of the deposit regime. If the operating point is to the left of this curve, transport occurs with a deposit in the conduit; if it is to the right, the transport regime has no deposit. The curve Je traces the conduit head losses for clear water.

We have superimposed on the same graph the operating curves of three different solid transport cases:

curve I shows the stage-discharge law of gravity installation delivering from a constant head bassin;

curve II gives the characteristics of a pumping station with centrifugal pumps driven by constant speed electric motors;

curve III shows the characteristics of a pumping station equipped with either piston pumps or centrifugal pumps driven at variable speeds to give a constant discharge.

We see on the graph that curve No. 1 crosses curves Je and Qs_1 at the points Ge and G_1, but does not cross curve Qs_2. For the minimum solid discharge Qs_1, the process will be stable. However, if the solid discharge approaches the maximum, Qs_2, the conduit which originally was functioning in regime without a deposit, would begin to deposit material and finally become blocked along its entire length. As a result of the shape of the operation curves of the conduit, this type of installation cannot work with a deposit regime.

Let us now examine the case of an installation operating through constant speed centrifugal pumps: curve II crosses curves Je and Qs_1 at points Ce and C_1; it crosses curve Qs_2 at point C_2 as well.

The operating points Ce and C_1 are very stable, as the algebraic angles between curves Qs_1, Je and II, are large. Operating point C_2 is just stable, since the algebraic angle between the curves II and Qs_2 is small, therefore the least increase in solid discharge over Qs_2 would initiate the total obstruction of the conduit. Nevertheless, this pumping station allows operation in regime without deposit, point C_1, and with a deposit in the conduit, point C_2.

The next comparison is curve III characterising the operation of a pumping station equipped with either piston pumps or centrifugal variable speed pumps which are regulated to deliver a constant discharge. In this case, this curve cuts cleanly each of the curves, Je, Qs_1, and Qs_2: safety of operation is complete. Dependent on the delivery discharge chosen, the conduit can operate indifferently with or without a deposit.

Starting and Stopping of Installations — Water Hammer

Starting and stopping an installation equipped with only one pump delivering into a horizontal or slightly inclined conduit presents only minor difficulties. It is however recommended that starting and stopping be carried out using clean water or at least lightly charged water, and that the pump speed be progressively increased or decreased to avoid water hammer. Starting successive pumping stations is more delicate and should be done following a predetermined order.

Installations with vertical or steeply inclined rising delivery cannot be stopped with material in the conduit because of the risk of jamming. Means of emptying must be provided in case of a sudden shut-down.

In certain cases, the installations should be equipped with anti-water hammer devices, which must function without fail even in the presence of the solid materials.

Conception of Installations: Up to now, we have spoken of the problems concerning the general conditions of transporting materials in a conduit: we shall now approach the problem of the general conception and possible schemes depending on the use required of the installation.

Fig. 2 shows typical diagrams of different conceptions:

—type A are gravity installations.

—type B installations are equipped with pumping stations, the material passing through the pumps.

—type C installations are equipped with pumping stations, but the material does not pass through the pumps.

—those of type D allow underwater pick-up with passage of the material through the pumps.

—those of type E are the same as above, but the material does not pass through the pumps.

—type F installations allow pick up from great depths underwater.

Gravity Installations — Type A

These installations have the lowest operating costs. They may be of either constant head, type A_1, or constant discharge, type A_2.

With a constant head, if the conduit diameter is correctly selected, wear in the pipeline is small; no air may enter, so water hammer and corrosion are eliminated. There is a risk of obstruction if the diameter is wrongly adapted or the solid discharge too variable. It is currently used for the evacuation of solids from decanting basins or from washing and classing apparatus.

With a constant discharge, the stability is perfect if the head necessary for transport is always less than that available. Used currently for filling mines, soot evacuation from thermal powerstations etc. Possibilities of wear in vertical wells, the entry of air could initiate water hammer and corrosion.

Pumping Station Installations Equipped With Sludge or Solids Pumps

These are the classical installations for hydraulic operations over all distances.

Installation B_1 is the type currently used for transportation inside a factory where it often advantageously replaces classical handling means if the circuit is complex. It allows interconnection of two or more appliances on a production line. A constant speed centrifugal pump is used, and the discharge regulation is done by a constant level reservoir.

Installation B_2 allows the same uses as the preceding one. In this case, the pump may be centrifugal, membrane or piston type for use with pulp or mud. It can be driven by electric or combustion motors, the discharge regulation being controlled by the pump speed.

Installation B_3 is identical to B_1, but includes two or more pumps grouped in the same pumping station. It provides delivery over medium distances.

B_4 installations have an advantage over B_3; their increased stability due to their regulating system.

Installations B_5 and B_6 are conceived for transport over long distances. Several pumping stations can be installed, each including one or several pumps with either fixed speed or regulation. It is necessary to make a thorough economic study of this type of installation, especially if the materials are granular.

In any case, the choice of pumps and conduits should take into account the dimensions and abrasiveness of the material, as well as the chemical characteristics of the transporting water.

Installations with Pumping Stations Equipped with Clear Water Pumps

For certain particular cases, the installations may be studied in such a way as to introduce the materials after the pumps. The pumps then can be of standard design as it moves only water; it can be of single or multiple stage centrifugal, piston or membrane type.

If the material is fine and must be transported over short distances, injectors allowing its introduction into the circuit (diagrams C_1 and C_2) can be used. The consumption of energy is slightly greater than diagrams B_1 and B_2, whereas the maintenance can be diminished. This arrangement is used in ancillary circuits for drilling mud, evacuation of mineral mill tailings etc. . . .

If the material has larger dimensions, is of a cumbersome form or very abrasive; if the transport distance is long or vertical, it is better to consider introducing the material by a chamber system. This system may be single or double depending upon the transport method; continuous or dis-continuous. Diagrams C_3 and C_4 show this type of installation, with or without regulation.

Investment for this type of installation is higher than for type B, but its operation in certain cases offers numerous arvantages.

This type of installation is presently

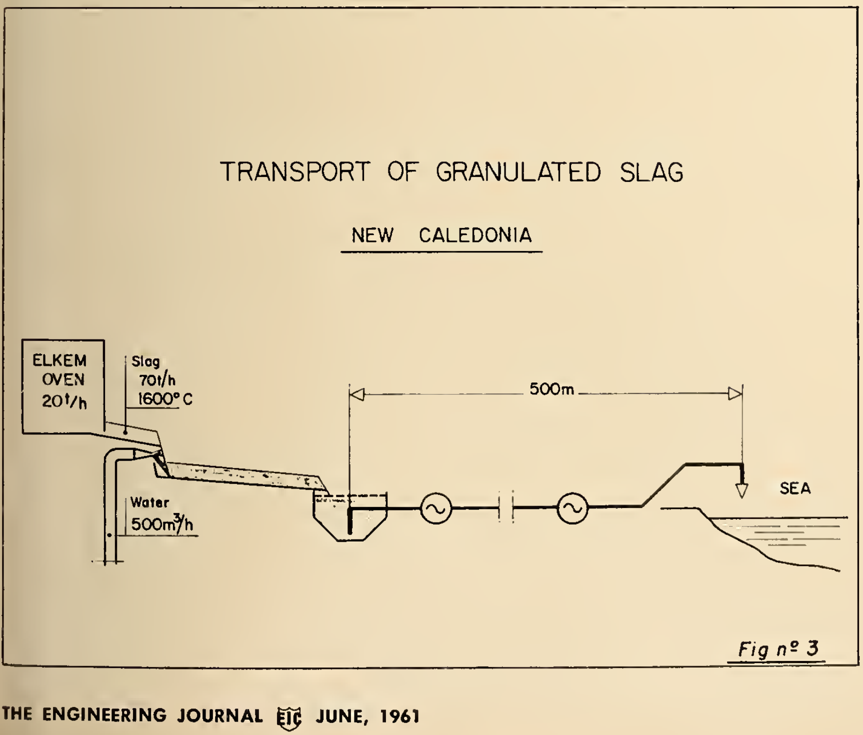


Fig nº 3

used to lift coal or ore in mines, and to transport manufactured articles.

Suction, Dredging and Filling Installations: These are used for problems of dredging in rivers, lakes, at sea, to by-pass littoral drift, or in dam reservoirs. They can also be used for the suction of materials from decanting basins. The pumping station is usually mobile, installed on a floating pontoon, a mobile dredge, a ship, or on a land-bound rig, such as a truck, on rails or over-head crane. They allow suction of materials only within reach of their installation.

Diagrams D and D_2 show this type of installation with transport pumps allowing suction of material from depths of 30 to 35 ft, and delivery to chosen deposit points.

Type E installations permit suction at the bottom by an ejector without the material's passing through the pumps. Type F in turn provides suction by the ejector to considerable depths, and transport by pump.

These diagrams indicate the large diversity of conception of the handling installations from which must be selected and adapted the correct solution to each particular problem.

RECENT INDUSTRIAL APPLICATIONS

Among the many recent applications, we will cite a few for which we have acted as consultants.

Soot Evacuation from Kincardine Steam Power Station (Great Britain) 1958.

This installation was built following a hydraulic study in the Sogreah laboratories in Grenoble.

Its characteristics are:

Tonnage	110 tons/hour
Liquid Discharge	62,500 IGPH
Transport Distance	3 miles
Material transported	soot and cinders
Granulometry	0-50 mm.
Power necessary for operation	120 hp.

Evacuation of Granulated Slag from Electric Furnous (New Caledonia) — 1958.

This installation was designed by Sogreah and constructed by Neyrpic.

PROBLEM DATA: Discharge into the sea of scoria from four ELKEM ovens starting at 200 metres, prolonged progressively to 600 meters; for each oven, slag pours every two hours, 70 metric tons/hour, 1600°C.

GRANULATION: A jet of sea water of 500 m³/hr, cuts the nappe of the incandescent slag causing explosion into grains of 2 to 50 mm., plus clinkers which are eliminated on a screen (Fig 3).

HYDRAULIC TRANSPORT:

1) water and slag fall into the "granulation basin"

2) pick-up by a suction head at the bottom of the basin—solids pumps delivery conduit 200 mm. diameter.

3) progressive lengthening of the conduit for dumping into the sea. Maximum range with one pump, 300m, with two pumps in series, 600 m.

4) power; 125 hp. for 300 m.

Nota

The transport concentration is low since the hydraulic transport must evacuate all the water necessary for granulation (8 to 10 litres/kg).

Pipeline Transport of Uranium Ore in Forez (France) 1959.

This installation was designed by Sogreah and built by Neyrpic.

PROBLEM DATA:

1) Transport of ore from the preparation mill to the chemical factory (production of uranium nitrate).

2) Distance, 600 meters plus geometric elevation of 45 meters.

3) Tonnage: 25 metric tons/hour of dry ore.

ORE CHARACTERISTICS:

1) All granulometry ground to 0-500 microns

2) Nature: ground quartz plus 0.3% uranium, plus clay. Extremely abrasive.

HYDRAULIC CHARACTERISTICS: (Fig. 4)

1) Grinder outlet—concentration too low for economical transport (200 g/litre)—therefore a concentrator.

2) Transport at 720 g/litre in a conduit 90 mm. diameter.

3) Two pumps in series, one with fixed speed, the other with variable speed adaptable to the extraction discharge of the concentrator.

4) Total power: 30 hp.

Pipeline Transport of Radioactive Containers at Marcoule (France)

This original installation evacuates the radioactive containers from the exit of the Marcoule reactors. They are introduced by a stop-cock chamber in the pipeline. The transport speeds were determined as a function of the shape and weight of the containers:

Container weight	:	14 to 18 kg.
Container length	:	1.30 meters
Transport distance	:	120 meters

Transport of Powder in Sticks (France) 1958

This development also was built following a hydraulic study by Sogreah.

It includes 10 transport installations distributed at various stages along the manufacturing of the product:

Volume	:	600 kg./hour per installation
Liquid discharge	:	23 m³/hour
Transport distance		variable from 60 to 240 meters
Geometric rise	:	+6 meters
Nature of material	:	gun-powder
Granulometrie	:	cylinders 4 to 7 mm. diameter, 9 to 20 mm. long.
Power required	:	5 hp.

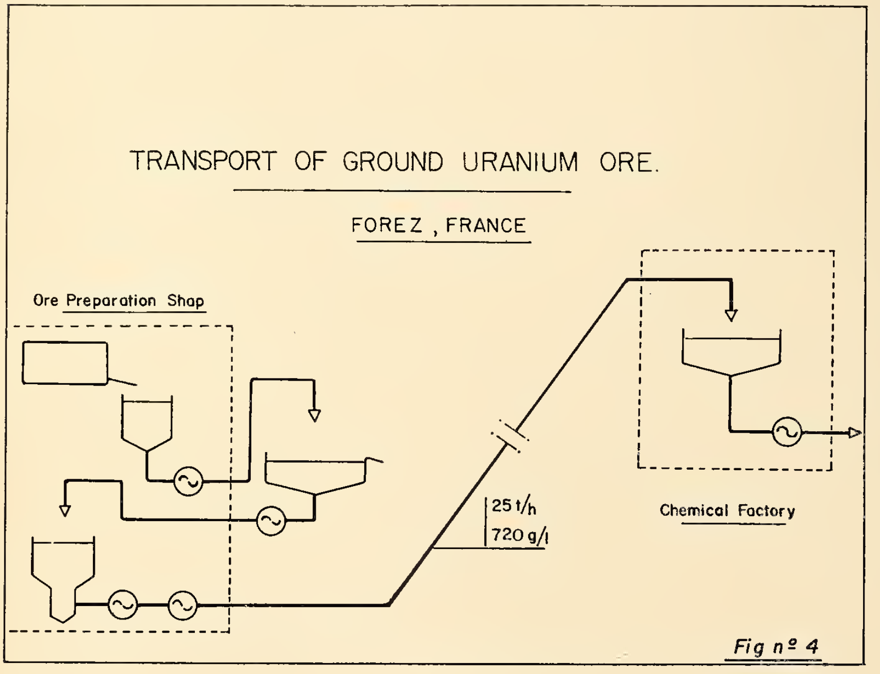


Fig nº 4

Hydraulic Lift of Coal — St. Etienne (France) 1959

This installation was designed by Sogreah and built by Neyrpic. Its general characteristics are:

Volume	:	50 metric tons/hour
Liquide discharge	:	230 m^3/hour
Height of lift	:	180 meters
Nature of material	:	rough coal (coal, middlings, schists)
Granulometry	:	0-80 mm.
Power required	:	70 hp.

The originality of this hydraulic transport rests in the fact that the pump used is a low pressure machine installed above ground. A pipeline conducts the water delivered by the pump to the bottom of the mine where the coal is introduced. A second pipeline brings up the coal-water mixture. The coal is added at the bottom under a pressure of 20 kg./cm^2, by means of a specially designed pressure locking chamber. (Figs. 5 and title page.)

As a result of the interest shown in this procedure, a present study is considering an installation which would lift 100 tons of coal per hour from a 1000 meter depth.

Hydraulic Transport of Phosphates (Senegal) — 1960

Working of phosphate deposits in Senegal requires the removal of 15 meters of sand overburden. The operation site moves on a non-stabilized sand deposit. Fortunately, the ground water table is at the same level as the phosphate which allows working with a dragline from a floating barge. The phosphate is transported hydraulically from this barge to the treatment plant:

Tonnage transported	:	350 metric tons/hour
Distance	:	2300 meters
Total lift	:	30 meters
Pipeline diameter	:	300 mm.
Granulometry	:	0-3 mm.
Number of pumps	:	three
Power consumed	:	900 hp.

This installation is working in an operation which has not yet reached its equilibrium regime. The power plant could be reduced considerably if the admitted granulometry is conserved.

Transport of Ground Limestone to Supply a Cement Plant (Australia).

An important study was carried out by Sogreah in Grenoble concerning the pipeline transport of ground limestone to the cement plant. Due to outside financial questions, the installation was never undertaken.

Characteristics of the Proposed Installation

Tonnage transported	:	50 metric tons/hour
Distance	:	103 km.
Elevation change	:	
1st section		+ 150 meters
2nd section		—615 meters (gravity operation)
Granulometry	:	ground to 200 microns
Pump type	:	piston pumps
Power consumed	:	200 hp.

The three figures, 50 tons/hour—103 kms—200 hp.—are extremely eloquent and give an idea of the advantage sometimes offered by hydraulic transport over the competetive processes.

ECONOMIC POINT OF VIEW

No formal rule can be given characterising the costs of hydraulic transport as compared to classic methods. Each case is special. If for example the feed pumping station can be located in the product preparation shop, the personnel of the shop could check the operation periodically. On the other hand, if the pumping station is separate, a man would probably be required to assure its correct functioning. Elsewhere, the question of wear in the pumps and pipeline by certain products can become a determining factor of the operating cost. Thus two products of the same granulometry can have very different operating costs.

We will examine, however, the principal points which constitute the operating costs of transport:

amortization of equipment
energy
upkeep
labor

The first point varies depending on the length of amortizing period chosen. The investment in turn diminishes:

1) with the mean diameter of the material to be transported due to the reduction of power required;

2) with the concentration of material;

3) with an increase of tonnage.

The unit power supply is essentially a function of the physical characteristics of the transported material:

1) it diminishes noticeably if the mean diameter and density decrease, becoming very small when the material is transported as pulp;

2) it decreases also if the concentration in the pipeline or the tonnage transported is increased.

With reference to power figures given elsewhere in this paper, and for a price of five mills per kw./hour, the energy item may be included between:

-0.031 cents per ton-mile for cement paste

-2.12 cents per ton-mile for gravel

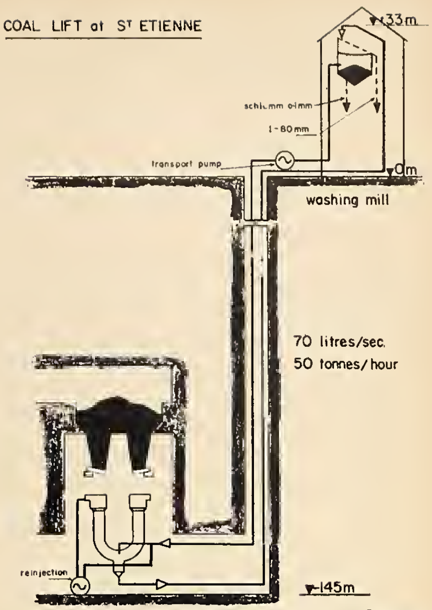


Fig nº 5

The principal expenses for maintenance arise from the wear in the pumps and pipelines. These depend essentially on the dimensions and abrasiveness of the material, and decrease with the tonnage transported. They can be less than 0.03 cents per ton-mile for cement paste, and can exceed 4 cents per ton-mile for gravel.

The labor item for surveillance of the installations is generally small. It depends essentially on the tonnage transported, length of pipeline and the local operation conditions.

These considerations allow us to draw the following conclusions:

1) transport of very fine products, in pulp form, over all distances is very economical. Its operating cost can be as little as 0.3 cents per ton-mile.

2) for transport of powdered products of mean dimensions, such as fine to medium sands, the operating costs are comparable with those of classical handling processes, and sometimes slightly less.

3) for transport of larger materials, the operating cost is generally high; the maximum can reach 30 cents per ton-mile. Even in this case, however, this handling process may be chosen where it eliminates very costly intermediate transfers or operations.

We can cite a definite operating cost figure for an installation moving ore of 0 to 0.5 mm. granulometry at a rate of 25 tons/hour; this plant has been running more than a year. The operating cost including power, upkeep and labour is 2.5 cents per ton-mile. This ore is very abrasive. EIC

Principles of Non-Linear Automatic Control

P. N. Nikiforuk

Assistant Professor
Mechanical Engineering Department
University of Saskatchewan, Saskatoon

MOST PHYSICAL phenomena can be represented accurately only by non-linear differential equations.[1,2,3,4,5] This is an unfortunate fact for it tends to increase the complexity of many engineering problems, especially those presently besetting the control engineers. Perhaps no other branch of engineering is as concerned with the problem of non-linearity as that of control engineering, for present day feedback control systems have to be exceptionally versatile and accurate devices. Engineers working in this field are continuously faced with the practical limitations of the many elements which make up a complete control system. Thus, one need only mention dead-zone, saturation, backlash, hysteresis, coulomb and static friction as typical examples of practical limitations which no end of engineering can eliminate. Lack of suitable design techniques, and the false concept that all non-linearities degrade system performance, limited until very recently the art of control engineering to the linear domain. Non-linearity within a control system was considered to be a most undesirable feature, and much effort was devoted to the deliberate and systematic linearization of all system elements. Failure in this attempt often resulted in the system being confined to that region of operation which was considered to be most linear, even when this occurred at the expense of reduced capability.

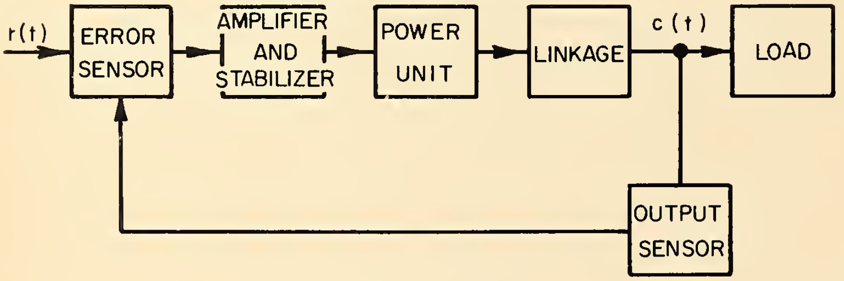
Gradually, it became apparent that this was a most uneconomical practice, if not impossible, and in attempting to utilize fully the capabilities of automatic control systems it was found that certain systems gave rise to phenomena[6,7,8] which could not be explained by linear theory. This led to the introduction of technique for the analysis [9,10,11,12] of non-linear control systems and to a finer appreciation of the problem of inherent non-linearities. Even more important, it led to the successful development of automatic control systems deliberately incorporating non-linearities to improve system response.[13,14,15] Much effort is now being devoted, therefore, to the latter and also to the development of a cogent body of non-linear theory.

Much of the theory and many of the methods presently used to effect the analysis and synthesis of non-linear control systems originated in the domains of non-linear mechanics and non-linear electric circuits. Non-linear problems were first encountered in the latter two domains a long time ago and consequently much theory and many methods of solution were already highly developed at the advent of control engineering. It was logical, therefore, for the control engineers to borrow as much as possible from these two domains. In fact, there is still a vast quantity of theory and numerous powerful methods which have not been applied to control engineering problems. This is largely due to the fact that control engineering problems tend to be complicated by feedback and much work remains to be done in the field of non-linear feedback control.

Definition of Non-Linearity

Non-linearity is defined only in a negative sense ; that is, by what it is not. A linear element or system is one which may be represented by a linear differential equation (or system of equations) with constant coefficients. A system which may be represented by differential equations in which at least one of the coefficients is a function of time, is known as a linear system with variable coefficients. Any system which cannot be represented by linear differential equations with or without variable coefficients is known as a non-linear system. Consequently, for a non-linear system the principle of superposition* is not valid : there is no proportionality between cause and effect. This implies, therefore, that in the study of non-linear control systems the simultaneous signal level and operating range of all inputs must be specified in order to define system performance.

Fig. 1. A Typical Control System.



Classification of Non-Linearity

By Static Characteristics: According to this classification[16] there are two types of non-linearity : incidental (parasitic) non-linearity and intentional non-linearity. An incidental non-linearity is inherent to the control system and is the result of imperfections in an otherwise linear system. Neglecting this non-linearity often does not compromise initial analysis and preliminary design. However, in high performance systems this type of non-linearity often results in unsatisfactory, or even unstable, operation and must be taken into consideration.

An intentional non-linearity is one which is necessary to the basic operation of a control system. A relay-controlled servomechanism is an excellent example of a system which incorporates an intentional non-linearity and which is essential to the operation of the system. This type of non-linearity must be included in any system analysis and synthesis.

By Dynamic Effect: Non-linearity, when classified according to dynamic effect,[16] is also of two types: slowly varying non-linearity and rapidly varying non-linearity. A slowly varying non-linearity is one which causes system characteristics to change slowly with respect to the response time of the system. A non-linearity of this type is very frequently related to the variation of an independent parameter outside the control system. A typical example is the variation of aircraft control-surface effectiveness with dynamic pressure.

A rapidly varying non-linearity is one which changes system characteristics at an appreciable rate relative to the response time of the system and is usually a function of the dependent variable. Typical examples are dead-zone, saturation and backlash.

Typical Non-Linearities

The prime purpose of any control

* The principle of superposition states that if $y_1(t)$ is the response to an input $x_1(t)$ and $y_2(t)$ is the response to $x_2(t)$, then the response to the combined input $x_1(t) + x_2(t)$ is $y_1(t) + y_2(t)$.

ystem, as can be seen from Fig. 1, is to ave the controlled variable $c(t)$ reproduce the reference input $r(t)$ at all imes. Just how accurately this takes lace can be established by relating (t) to $r(t)$. For linear systems this oses no problem since the two quanities can be related by linear differential quations or transfer functions, which re derived from the expressions relatng the response of each element within he control system to the element's own articular excitation signal. Normally he latter expressions are quite simple. However, if non-linearity is involved, hese expressions become very comlicated and may even defy analytical lefinition. Consequently, it has become tandard practice to define the response of a non-linear element by a graphical lisplay of the type shown in Fig. 2.

The non-linear element is shown in lock diagram in Fig. 2(a). Its response (t) to an excitation signal $i(t)$ is shown n Fig. 2(b) and is called the "inpututput characteristic". For an amplitude dependent non-linearity the amplitude I of $i(t)$ is plotted along the horizontal axis and the amplitude E of $e(t)$ along the vertical axis. Thus, f a single-valued linear relationship xists between $e(t)$ and $i(t)$ a single line of appropriate slope is used to represent this situation. If a two-valued relationship exists, two lines are used. Arrows re also used to denote which set of values of $e(t)$ is valid for increasing mplitudes of $i(t)$ and which set is valid for decreasing amplitudes of $i(t)$. Frequency sensitive non-linearities are defined in a similar manner. Since the atter are encountered much less frequently in control engineering, only mplitude sensitive non-linearities are treated in the following paragraphs.

Common Incidental Non-Linearities

DEAD-ZONE : All physical elements, whether they are electronic, electromechanical, hydraulic, or pneumatic devices, have a threshold below which input signals cannot be detected and which cannot be completely eliminated. This can be a serious problem, for it seriously degrades system resolution especially when the amplifier gain must be limited to maintain stability. Many factors contribute to the existence of this non-linearity. Thermionic noise establishes a threshold below which electronic equipment cannot detect signals. Electric motors possess a deadzone because of coulomb, or static friction and slot effects. Coulomb friction in mechanical systems, as for example in hydraulic and pneumatic valves, causes dead-zone as does a minimum current input requirement to solenoids and relays.

The input-output characteristics of an element having a dead-zone nonlinearity which is symmetrical for positive and negative valves of the excitation signal amplitude is shown in Fig. 3 (a) as an idealized straight line approximation.

SATURATION : Proportionality of output-vs-input never holds in practice for large values of excitation signal amplitude. It is found that for increasing values of input amplitude the proportionality between output-vs-input decreases until a stage is reached where the output remains constant and independent of input. This phenomenon is called saturation (or limiting) and is characteristic of all physical systems. An idealized straight line approximation of the actual characteristic is shown in Fig. 3(b).

Perhaps the most common form of saturation is that which occurs in electronic equipment and which is due to the limitations imposed by the supply voltages. An excellent example is that of amplifier voltage saturation. Magnetic saturation occurs in practically all electro-mechanical devices and causes the magnetic flux to be less at high excitation currents, or voltages, than is indicated by the normally used straight line relationship. Since in most electro-mechanical devices torque is proportional to flux, saturation causes less than theoretical torque. In servo motors this results in a droop in the stall torque-control voltage curves and also in the developed torque-speed curves. Saturation also occurs in hydraulic and pneumatic equipment. For example, flow rate through hydraulic transfer valves is proportional to spool displacement. Maximum spool travel establishes, therefore, maximum flow rate for a given supply pressure.

Saturation can also be the result of indirect mechanical design limitations. For example, the maximum acceleration of high performance missiles at low altitudes is frequently established by the airframe structure and not by the manoeuvre capabilities. Again in some applications motor speed must be limited due to the mechanical design limitations of the rotor. This type of limitation requires the control system to be so designed that saturation occurs deliberately at a predetermined signal level.

BACKLASH : Backlash is a residual effect and is most difficult to predict and control. It arises from a number of sources : manufacturing tolerances, assembly inaccuracies, looseness of assemblies due to wear, ambient temperature change, etc. It is a most undesirable feature and frequently acts as the limiting factor on the performance which can be achieved with a power servomechanism.

For an excitation signal with a large amplitude backlash is quickly taken up and has very little effect upon performance. However, for a low-level signal having an amplitude which approaches the magnitude of the backlash, the backlash tends to disconnect the load from the motor during signal reversal. This causes the load to lag further behind the motor than would occur with a linear system. In addition, because the motor is disconnected from the load, it accelerates faster than normal in the backlash zone. The motor position tends to lead the normal response. The presence of friction will also affect the system response, the response for viscous friction damping differing from the response for coulomb friction damping. As a result of this complex effect on system performance, backlash cannot be represented accurately in most cases by a simple nonlinear characteristic. However, for many types of instrument servos where there is little coasting by the load, it can be approximated by the straight-line two-valued characteristic shown in Fig. 3(c).

HYSTERESIS : Hysteresis occurs whenever the magnitude of the control signal necessary to initiate a corrective process is greater than that value to which the signal must be reduced to cause correction to cease. Among servomechanisms components there are two main causes of hysteresis : magnetic effects and mechanical effects. Magnetic hysteresis is peculiar to ferromagnetic materials and is responsible for hysteresis effects in motors, rotating amplifiers, clutches, solenoids and relays. Mechanical hysteresis, which is perhaps less well known, is chiefly due to the lag in the deformation of an elastic material during removal of previously applied loads. It is responsible for the hysteresis effects which occur wherever spring action takes place, as for example in relays, solenoids and mechanical linkages. A typical straight line approximation of a typical hysteresis characteristic is shown in

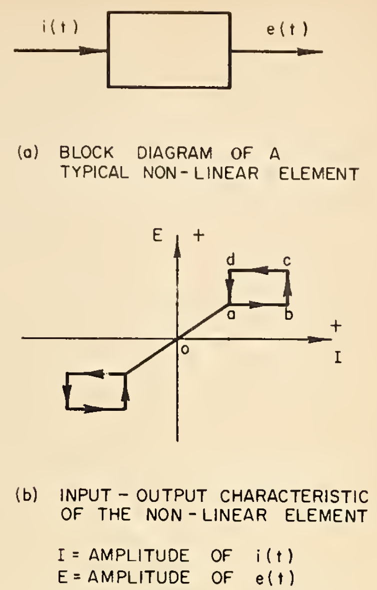


Fig. 2. Characterization of a Non-Linear Element.

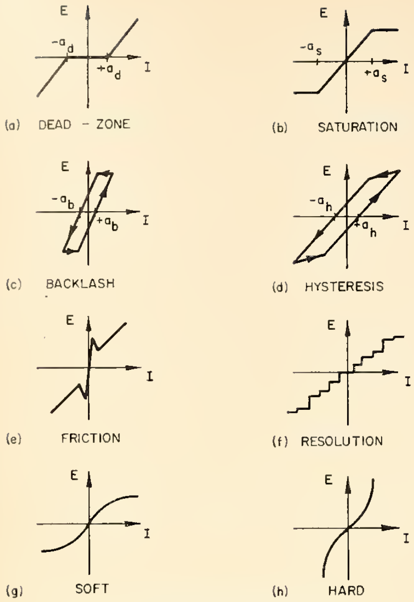


Fig. 3. Typical Input-Output Characteristics.

Fig. 3(d).

FRICTION: Frictional torque is actually due to a combination of loads caused by coulomb (dry) friction, static friction (stiction) and viscous friction. Coulomb friction is independent of the magnitude of velocity and always opposes it. Static friction opposes motion also, but decreases to zero whenever motion sets in. Viscous friction, as is well known, is directly proportional to output velocity and always opposes it.

It is difficult to separate the three effects in many practical situations and in these cases the characteristic which must be considered is of the form shown in Fig. 3(e).

RESOLUTION: Many transducers utilize potentiometers which are wire-wound. If contact resistance is negligible, the wire-wound potentiometer in which the wiper contacts the winding at discrete points has a stepwise variation of voltage. If the wiper is near the center of the potentiometer, these steps represent approximately equal variations in output voltage. However, when the wiper is near the end of the potentiometer, the steps caused by contacting two wires simultaneously are unevenly displaced. This stepwise variation in output voltage sets a lower limit on the resolution that can be obtained and must be taken into consideration in the design of precision servomechanisms. A typical input-output characteristic is shown in Fig. 3(f).

CURVATURE: Many control components have characteristics which display a lack of proportionality between output amplitude and input amplitude for all values of the latter. This occurs in some electronic amplifiers due to non-linear tube characteristics. It also occurs in hydraulic and pneumatic systems where flow is controlled by a valve setting. Occasionally, as for example in some electro-mechanical devices, the effects of saturation are more accurately described by a curvature characteristic than that shown in Fig. 3(b).

The two types of curvature effects encountered in practice are those in which the rate of change of the output with respect to the input is decreasing, and those in which it is increasing. The former are termed "soft" (or "soft-spring") characteristics while the latter are termed "hard" (or "hard-spring") characteristics. These two characteristics are shown in Figs. 3(g) and 3(h).

COMBINED CHARACTERISTICS: It frequently happens that an element within a control system has a characteristic which can be described accurately only by a combination of several types of non-linearities. Very often this is due to the way in which the element is used. For example, under normal steady-state conditions the control system error is small and the input to the preamplifier has an amplitude which is approximately at threshold level. Under transient conditions the system error is large and the input to the preamplifier has an amplitude which is sufficiently large to cause saturation. Under such conditions both threshold and saturation must be taken into consideration and this is accomplished by combining the two characteristics into one.

In electro-mechanical devices it is not unusual to encounter a situation in which an element is subjected to both hysteresis and saturation effects. Again, the two original characteristics must be combined to form a new characteristic which displays hysteresis effects at low-levels of input signal and saturation effects at high-levels of input signal.

Common Intentional Non-Linearities

Although an almost infinite variety of intentional non-linear characteristics can be incorporated into a control system, the number actually used is small. One of the best known of the intentional non-linearities is that of the relay whose characteristic is shown in Fig. 4. The characteristic shown in this figure is typical of relays found in practice and includes a dead-zone and a hysteresis effect. The dead-zone is due to friction and restoring spring force while the hysteresis is due to both magnetic and mechanical effects.

Frequently used intentional non-linearities also include such characteristics as dead-zone, saturation and curvature. Dead-zone compensation[18] is often used to eliminate backlash oscillations which are of small amplitude. Saturation is used to limit the maximum amplitude of the fine error signal in a coarse-fine change-over system to eliminate spurious zeros.[18] It is also used to limit integrator voltage output in systems employing integral control to prevent excessive over-shoot during transient conditions. In addition, saturation is used whenever system motion must be confined to certain limits to prevent structural failure.

Curvature is used in many ways. One of its most worthwhile applications is in those systems which are frequently subjected to transient inputs.[13,14] By proper design it is possible to produce a non-linear system which is superior in response to its linear counterpart. It is also used to compensate for slowly-varying non-linearities which are related to the variation of an independent parameter outside the control system.

Non-Linear Phenomena

Many unusual and interesting phenomena[6,7,8] occur in non-linear control systems which have no counterpart in linear systems. There is no cogent body of theory which can handle the analysis of these systems and at present it is impossible to predict system response to a given input knowing its response to some other input. In some cases performances completely deteriorate between a step response and a sinusoidal response. It is because of this that control engineers must be thoroughly aware of the peculiar characteristics which can be exhibited by non-linear control systems in order that intelligent design be carried out.

JUMP RESONANCE: Jump resonance occurs in lightly damped control systems which are excited sinusoidally and which have non-linear restoring forces. This phenomenon is characterized by discontinuous variations in the amplitude and phase of the controlled variable as either the frequency or the amplitude of the reference input is varied smoothly and continuously. These discontinuous variations in the output are accompanied by a bending, or skewing, of the resonance curve as is shown in Fig. 5.

Theoretically, when the amplitude of the controlled variable is plotted as a function of the reference frequency, the resonance bends to the left for soft characteristics and to the right for hard characteristics. In practice, the three-valued function shown by full line in Fig. 5 does not exist, and the output amplitude varies discontinuously in the manner shown by the dashed lines. The frequency at which this discontinuity occurs depends upon whether the frequency of the reference input is increasing or decreasing. It is also a function of the reference signal amplitude and the type of non-linearity encountered. This phenomena is well known and is described in detail in references 7 and 11.

LIMIT CYCLES OSCILLATIONS: Limit cycle oscillations[3,7] are oscillations of fixed amplitude and period and occur in unstable or conditionally stable non-linear systems. They can vary from oscillations which are almost simple harmonic to oscillations which are highly non-linear and which are of the relaxation type. They arise from a wide variety of conditions. Conditionally stable non-linear systems are almost bound to display this characteristic. Under proper conditions system imperfections (incidental non-linearities) and intentional non-linearities can equally well cause limit cycle oscillations.

Existence of this type of oscillation requires that system stability be defined in terms of acceptable magnitude of oscillation. For example, it is very probable that a low level limit cycle oscillation may be quite acceptable in many applications. Conversely, it may be highly detrimental to the performance of a precision position control system.

HARMONIC GENERATION : Non-linear elements are excellent harmonic generators. The application of a sinusoidal excitation signal to a non-linear element can result either in the generation of only odd harmonics of the excitation signal, or in the generation of both odd and even harmonics. These harmonics are frequently not noticed in practice because an automatic control system is analogus to a low pass filter and attenuates the harmonics much more severely than the fundamental component. Thus, if a power amplifier saturates in an electro-mechanical control system, the effect of the motor following the amplifier is to attenuate the third harmonic at least three times as much as the fundamental. Higher harmonics are attenuated even more greatly. Consequently, the controlled variable $c(t)$ often appears sinusoidal even though severe non-linear action takes place within the control loop.

SUBHARMONIC GENERATION : Control systems occasionally oscillate at a frequency which is an integral submultiple of the reference signal frequency.[7,17] Oscillations of this type occur most frequently in lightly damped systems having non-linear restoring forces or non-linear energy delays and which are sinusoidally excited. Transition from harmonic to subharmonic oscillation can be quite sudden, but once established, the subharmonic oscillation is usually quite stable.

The subharmonic which is most easily obtained experimentally has a frequency which is one third that of the driving frequency. Lower orders are more difficult to obtain. No general rules are yet available for evaluating the necessary conditions for occurrence, although it has been found experimentally that appropriate initial conditions must exist within the system.

FREQUENCY ENTRAINMENT : It is well-known that if an excitation signal of frequency ω is applied to a system oscillating at a frequency ω_0, the phenomenon of beats occurs. Linear theory predicts that as the difference between the two frequencies decreases to zero, the beat frequency decreases to zero also. This is not the case with most non-linear systems. It is found instead that within a certain band of frequencies the system frequency becomes synchronous with, or entrained by, the external frequency ω. This phenomenon occurs in a discontinuous manner and is called frequency entrainment.[5,7] The band of frequency in which entrainment occurs is called the zone of entrainment.

ASYNCHRONOUS EXCITATION AND QUENCHING : Asynchronous excitation exists whenever it is possible to start a control system oscillating at a frequency ω_1 by exciting it at some different frequency ω_2. The frequency at which the system is set into oscillation can be either higher or lower than the excitation frequency. If it is possible to stop a system oscillating at one frequency by exciting it at some different frequency, asynchronous quenching exists. Again, the frequency at which the system oscillates can be either higher or lower than the excitation frequency.

SOFT AND HARD OSCILLATIONS : A control system is said to have soft oscillations if it is unstable for reference inputs of very small amplitude, but becomes stable when the amplitude of the input exceeds a certain minimum value. This kind of oscillation is self-starting so long as there is any arbitrarily small disturbance within the system. If the system is stable for reference inputs of small amplitude, but becomes unstable when the amplitude of the reference input exceeds a certain value, the system is said to have hard oscillations. This type of oscillation requires an initial disturbance exceeding some minimum value for instability to occur.

Methods of Analysis

The principle of superposition is not applicable to non-linear systems and consequently there is no general overall unifying theory available for the analysis and synthesis of non-linear control systems. This is a serious limitation for in linear systems this principle allows a complicated solution to be built up as a linear sum of simpler solutions. Thus, if a system is linear this principle allows a complicated periodic reference input to be expressed as a series of harmonic components. The individual components of the controlled variable corresponding to each harmonic of the input are calculated and the system output is evaluated by means of a linear summation of the simpler solutions.

The procedures for analysing non-

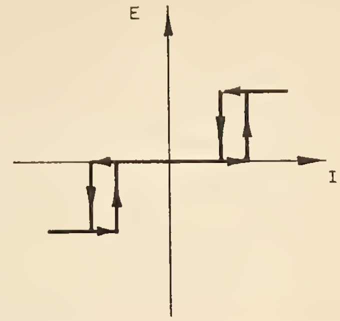


Fig. 4. The Relay Characteristic.

linear systems are cumbersome and difficult. Only in a very few cases can exact solutions in terms of known functions be found, and usually these appear not to apply to typical control system problems. If the amount of non-linearity is not too large, or if the equation describing the system is of a special type, analytical methods are available for obtaining approximate solutions. These methods enable the solution to be obtained in algebraic form without inserting specific values for the numerical constants. Once the solution is obtained, numerical values can be inserted and the effects of variations in these values explored. Unfortunately, these methods can be applied at present only to the most rudimentary of control systems.

If the non-linearity is severe analytical methods are not normally sufficient and solutions must be obtained by numerical or graphical methods. These methods require that specific numerical values for the parameters of the equation and for the initial conditions of the variables be used in the solution of the problem. Any solution obtained in this manner applies for only one particular set of conditions and the entire process must be repeated if a solution is required for some different set of values.

A brief survey of a number of well established techniques of analysis for non-linear control systems is given in the following sections of this paper.

Numerical Methods: Many methods are available at present for solving differential equations numerically. Although these methods differ in the manner in which the solution is attained and the information used, the technique is basically the same. It is a step-by-step process and gives the solution as a table of corresponding values of the independent and dependent variables. Definite numerical values of all initial conditions and parameters must be specified, and the solution obtained applies only for the conditions and parameters used.

The basic problem of the simpler methods is the solution of the first-order equation

$$\dot{c} = f(c, t) \qquad (1)$$

subject to the initial conditions that at $t = t_0$, $c = c_0$. In addition, it is generally required that $f(c, t)$ be continuous and single-valued and that the derivatives exist.

The numerical solution of this equation is built up as shown in Table I. In this technique the independent variable is assigned incremental changes, usually of constant value, and successive values of the dependent variable are found. To carry out the solution, the information which is available at any step m must be used to evaluate the dependent variable at the next step $m+1$. The procedures available for carrying out this extrapolation from one step in the solution to the following step are many: Taylor's series expansion and Euler's method are only two of a large number.

These methods are directly applicable to first-order differential equations. Equations of order higher than the first can be solved in a similar manner by first reducing them to a set of simultaneous first-order equations. A brief description of the two methods mentioned is given in the following paragraphs to indicate the procedure used.

TAYLOR'S SERIES EXPANSION:

To evaluate the function at some interval $m+1$, c is first expanded in a Taylor series as follows:

$$c_{m+1} = c_m + \dot{c}\,\Big|_{t=t_0+m\Delta T} \Delta T + \tfrac{1}{2}\ddot{c}\,\Big|_{t=t_0+m\Delta T} \Delta T^2 + \tfrac{1}{6}\dddot{c}\,\Big|_{t=t_0+m\Delta T} \Delta T^3 + \ldots \qquad (2)$$

All derivatives at the m^{th} step are evaluated and the increment ΔT, which has been selected previously, is substituted into the equation and the value of c_{m+1} calculated. To calculate the value of c_{m+2}, the above procedure must be repeated.

EULER'S METHOD:

If the increment ΔT is made small enough, the first two terms of the Taylor's series provide reasonable accuracy. However, the accuracy of the solution can be improved without increased complexity by the following technique. The value of c_{m+1} is evaluated as described in the preceding section using the first three terms of equation (2) and the value of c_{m-1} is also evaluated by using the first three terms of equation (2) but substituting $-\Delta T$ for ΔT. The value of c_{m-1} is subtracted from that for c_{m+1} and the result is

$$c_{m+1} = c_{m-1} + 2\dot{c}\,\Big|_{t=m\,t_0+m\Delta T} \Delta T \qquad (3)$$

This equation is more accurate than that which would be obtained using only the first two terms of Taylor's series. The reason for this is that equation (3) was derived by dropping all terms of order ΔT^3 and higher, whereas in the other method all terms of order T^2 and higher were dropped. Since ΔT is small, ΔT^3 is much smaller than ΔT^2 and, consequently, Euler's method is normally much more accurate.

Analytical Methods: There is considerable advantage in finding an analytical solution to a problem for once this solution is obtained it can be explored over a wide range of conditions. Solution by analytical means requires that all relations describing the physical system be expressed in analytical form. All empirical relations resulting from experimental measurement must be expressed in the form of equations relating the variables concerned. Since the analytical expressions must be kept simple, it follows that approximations must be made in the definition of the empirical relations. In addition, the techniques used in arriving at a solution frequently involve approximations. The consequence of these approximations is that exact analytical solutions are never obtained, although the accuracy may be exceptionally high.

A number of methods exist for deriving approximate analytical solutions. While details of the various methods differ, most are rather similar and follow the steps outlined in the following sections.

PERTURBATION METHOD:

This is one of the most widely used techniques for deriving approximate analytical solutions. It is based on the assumption that for small deviations (perturbations) in the variables about some average value of the variables the system is linear and that normal techniques of analysis can be applied. This method is useful only when the non-linearities associated with the system are not severe, or when operation is restricted to a small range of parameters.

The perturbation method requires he derivation of a linearized expression for the non-linear function in the form of a power series. There are several ways of accomplishing this. It is possible, for example, to obtain a linearized expression for a non-linear function of one or more variables by means of a Taylor's series expansion about the operating point. As a first approximation all second order and higher derivations are neglected.

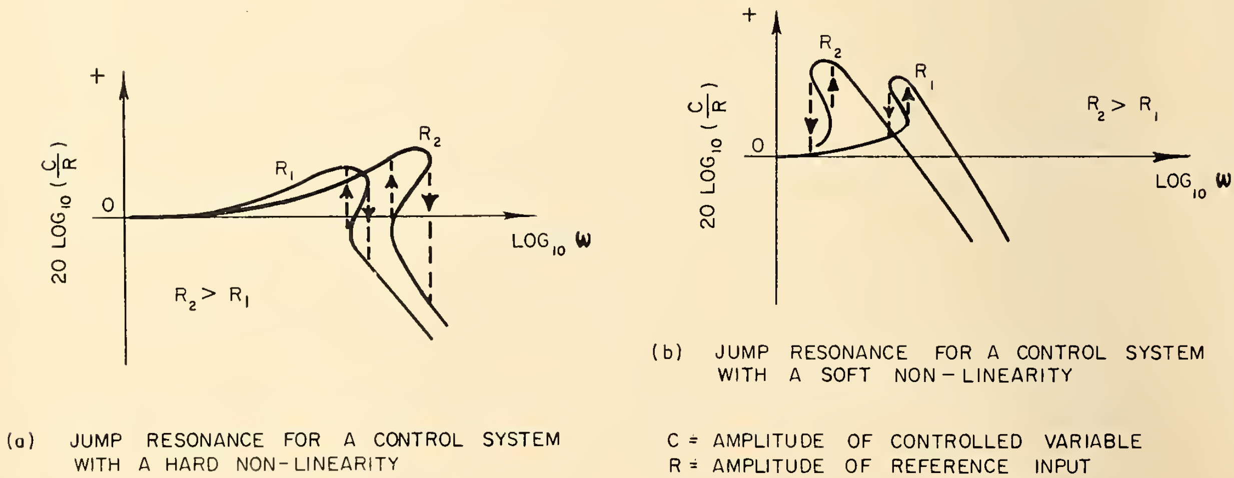
The usefulness of this technique may be seen from the following example which is concerned with the linearization of the expression relating flow rate through a hydraulic valve to the orifice area and hydraulic pressure. It is found experimentally that for hydraulic valves

$$q = C_d A \sqrt{P} \qquad (4)$$

Where q = flow rate, the dependent variable
C_d = flow coefficient, a constant
A = orifice area, an independent variable
P = hydraulic pressure, an independent variable

An approximate linear expression for the dependent variable q is obtained by expanding equation (4) in a Taylor's

Fig. 5. The Jump Resonance Phenomenon.



series for a function of two variables and neglecting all second order and higher terms. The result is

$$q_{\text{lin}} = C_d A\sqrt{P} + \frac{C_d A \Delta P}{2\sqrt{P}} + C_d\sqrt{P}\,\Delta A \qquad (5)$$

In this equation A and P are steady-state and are denoted by the subscript s indicating that for analysis purposes A_s and P_s are considered to be constants. The deviations ΔP and ΔA are replaced by the perturbation variables P_t and A_t respectively. Equation (5) becomes, therefore,

$$q_{\text{lin}} = C_d A_s\sqrt{P_s} + \left(\frac{C_d A_s}{2\sqrt{P_s}}\right)P_t + (C_d\sqrt{P_s})A_t \qquad (6)$$

In this equation q_{lin} is a function only of the two perturbation variables P_t and A_t and normal techniques of analysis may now be employed.

There are, of course, alternate ways of evaluating q_{lin}. However, once linearization is accomplished the result is identical to equation (6).

The perturbation method has a number of limitations which are worth noting. It is limited to small deviations from the operating point, and to non-linearities that are not severe. In addition, it is valid only if the derivative of the function exists. Under other conditions the inherent errors in the approximation may be considerable. Finally, it has limited usefulness when the operating point is zero. Indeterminate or inaccurate solutions may result, for under these conditions second and higher order terms may not be negligible.

PIECEWISE LINEARIZATION:

Many non-linear control systems are linear within well-defined regions of operation. At the boundaries of these regions are discontinuities which make the overall operation non-linear. A good example of such a system is one subjected to sharp saturation. In this system there are three regions of linear operation: a region of saturation for negative signals, a region of saturation for positive signals, and a region in which there is no saturation.

For such systems linear differential equations can be set up for each region of operation. These equations are then solved for each region of operation taking into consideration the initial and boundary conditions which exist at each cross-over point. Thus, for a control system which has a preamplifier that saturates at an error signal level of $\pm V_c$, the equations of motion for the three regions of operation are of the form

$$\ddot{c} + a\dot{c} = bV_c \quad \text{for} \quad E \geq V_c$$
$$\ddot{c} + a\dot{c} = -bV_c \quad \text{for} \quad E \leq V_c$$

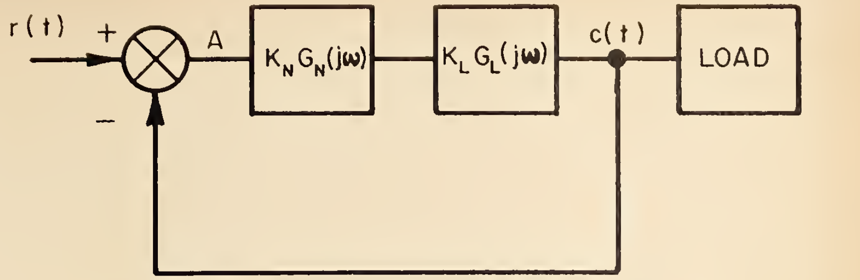


Fig. 6. Characterization of a Non-Linear Control System.

and

$$\ddot{c} + a\dot{c} = b(r - c) \quad \text{for} \quad -V_c < E < V_c \qquad (7)$$

where

$\ddot{c}$ = acceleration of the controlled variable
E = error signal amplitude
$\dot{c}$ = velocity of the controlled variable
$\pm V_c$ = preamplifier saturation level
a, b = system constants

This technique is essentially a step-by-step solution and its application is generally limited to obtaining the transient performance of heavily damped systems. Although the order of the system is not limited, the types of non-linearities which can be handled are restricted.

Graphical Methods: When solutions of high accuracy are not required, or when control systems are subjected to severe non-linear action, it is often possible to arrive at satisfactory solutions using graphical techniques. A number of techniques are available. The two which are most commonly used are the phase-plane and the describing function.

Both methods are relatively simple to use and are especially useful as exploratory tools in initial analysis and synthesis. To a certain extent the accuracy is dependent on the way the construction is made and increases as the size of the figure increases. It also depends upon the approximations made in arriving at the construction data. The greatest advantage of the graphical method is that it gives qualitative information quickly and without much work.

THE PHASE PLANE:

The phase plane is concerned with the graphical solutions of second-order autonomous equations which are of the form

$$\ddot{c} + f_1(c, \dot{c})\dot{c} + f_2(c, \dot{c})c = 0 \qquad (8)$$

Since the independent variable t appears only in the derivatives, equations of this type can be reduced to first-order by introducing the new variable $v = \dot{c}$. Since $\ddot{c} = v\,dv/dc$, equation (8) becomes

$$v\frac{dv}{dc} + f_1(c, v)dv + f_2(c, v)c = 0 \qquad (9)$$

This is a first-order equation with c the independent variable.

The phase plane is a plot of v as a function of c for various values of initial conditions. It has, therefore, the coordinates of velocity (usually the ordinate) and position (usually the abscissa) of the system. Solutions of differential equations consequently appear as loci (phase trajectories) on the plane. A series of solutions, or phase trajectories, is referred to as a phase portrait.

Phase trajectories may be constructed either analytically or graphically. Analytical solutions are not common because the original characteristic equation is usually of such a form that integration by analytic means is not possible. Of course, there are cases where this is possible as, for example, in the analysis of an ideal relay servo whose operation can be described by

$$\left.\begin{aligned} \ddot{c} + a\dot{c} &= -A \quad \text{for } E > 0 \\ \text{and} \qquad & \\ \ddot{c} + a\dot{c} &= +A \quad \text{for } E < 0 \end{aligned}\right\} \qquad (10)$$

Substitution of $v = \dot{c}$ into equations (10) and separation of the variables leads to integrals which can be evaluated easily and the resulting functions plotted on the phase plane for different constants of integration.

When the original equations of motion are of such a nature that analytical integration is impossible, graphical methods of solution must be used. A number of methods exist for obtaining a direct plot of v versus c. One of the most useful methods is that of isoclines (lines of constant slope on the phase plane).

In general, equation (8) can be reduced to the form

$$\frac{dv}{dc} = \frac{F_1(c, v)}{F_2(c, v)} \qquad (11)$$

where dv/dc is the slope of the phase trajectory. By setting dv/dc equal to some numerical constant, the locus of a constant slope on the phase plane can be obtained. If this procedure is repeated for a large number of values of dv/dc, the entire phase plane will be covered by isoclines. Having found the isoclines, a phase trajectory may be drawn by starting at some point in the plane on an isocline defined by the initial conditions and then proceeding to the next isocline along a straight line which is the average of the slopes corresponding to the two isoclines.

Occasionally the original equation of motion is of the form

$$\ddot{c} + g(c, \dot{c}) = 0 \qquad (12)$$

where the function g is not separable into the two functions f_1 and f_2 of equation (8). This type of equation may be handled by a technique which is an extension of an earlier method first proposed by Lienard.[18] According to this technique equation (12) is reduced to the form

$$\frac{d}{dc} = \frac{-h(c + ur)}{v} \qquad (13)$$

where $h(c + ur)$ need be known only graphically.

A trajectory is constructed by starting at the required point in the phase plane and finding a gradient at this point. This is drawn as a short line. A second point is chosen at the tip of the short line and a second gradient is obtained. Thus, the entire phase trajectory is again constructed of small segments. The method of finding a gradient at a specific point is somewhat detailed and the interested reader is referred to reference 18.

The phase plane technique is limited to second order systems with impulse, step or ramp inputs. Although the limitation on the order of the system is severe, it is possible to approximate many practical systems by second-order differential equations, especially during preliminary analysis and synthesis. Methods have also been developed for extending the phase plane technique to higher order systems. These extensions are not widely used due to their complexity since an nth order system would require a phase trajectory plot to be made in n dimensional space.

THE DESCRIBING FUNCTION:

It is an experimental fact that in most control systems which are excited sinusoidally the controlled variable $c(t)$ is also sinusoidal even though severe non-linear action takes place within the loop. This is a result of the low-pass filter characteristics of these systems. The describing function technique is based on this experimental fact and assumes that if the input to a non-linear element is a sinusoidal signal, only the fundamental component of the output of this element contributes to the control system error signal.

The describing function is defined as the ratio of the amplitude of the fundamental component of the output of a non-linear element to the amplitude of the sinusoidal input to the non-linear element. If there is a phase shift of the output fundamental relative to the input, this phase shift is included with the describing function. The describing function is normally dependent only on the amplitude of the signal at the input to the non-linearity, but occasionally it is also dependent on the frequency of this signal. The manner in which this technique is applied is readily apparent from Fig. 6. In this figure the linear and non-linear elements have been separated into units having frequency response functions $K_LG_L(j\omega)$ and $K_NG_N(j\omega)$ respectively. For purposes of frequency response analysis $K_NG_N(j\omega)$ is replaced by the describing function $K_DG_D(j\omega)$. Hence, for the system shown the closed loop frequency response function is

$$\frac{c}{r}(j\omega) = \frac{K_DG_D(j\omega)K_LG_L(j\omega)}{1 + K_DG_D(j\omega)K_LG_L(j\omega)} \qquad (14)$$

The describing function technique was first used to study the stability of non-linear control systems. The approach is almost self-evident from equation (14). For a minimum phase network instability occurs when the characteristic equation of the control system is equal to zero, or

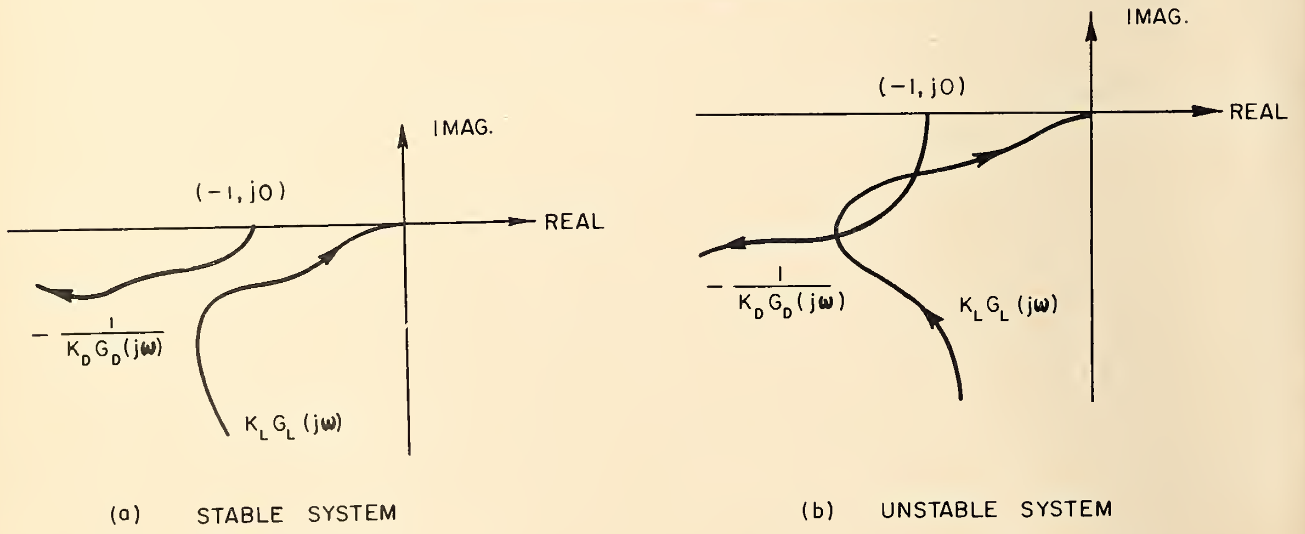
$$K_LG_L(j\omega) = \frac{-1}{K_DG_D(I, j\omega)}$$

The $(-1, j0)$ point of the Nyquist diagram for linear systems becomes therefore the plot of the negative reciprocal of the describing function for non-linear control systems. Typical Nyquist plots for stable and unstable non-linear control systems are shown in Fig. 7.

The manner in which the describing function is used to evaluate the frequency response of a non-linear control system is not immediately evident from equation (14). Several graphical techniques have been developed for this purpose.[9,11,14,16] Although they vary in detail, they are all based on the principle of breaking the loop at some point between two elements and relating the signals on each side of the break point. Thus, if the non-linear control system shown in Fig. 6 has its loop broken at the point A and a sinusoidal signal of known amplitude and frequency is applied to the non-linear element, the amplitude and phase of the controlled variable can be evaluated from the known characteristics of $K_DG_D(j\omega)$ and $K_NG_N(j\omega)$. By graphically relating the reference input to the error signal and controlled variable it is possible to evaluate the amplitude and phase of the reference input which satisfy the conditions chosen. By proceeding in this manner it is possible to build up the frequency response of a large class of non-linear control systems.

The chief advantage of the describing function is that it may be applied to control systems of order higher than the

Fig. 7. Nyquist Plots for Non-Linear Control Systems.



second. In fact, for most systems accuracy of analysis increases with increasing order. This is due to the increased attenuation of harmonics in high-order systems. It does have, however, a number of limitations. It is limited to systems with no time dependent non-linearities. If there is more than one non-linearity in the system, the non-linearities must be separated by adequate filtering. Otherwise, a single equivalent describing function must be found, which in general is not equal to the product of the individual describing functions. Finally, only sinusoidal inputs may be considered, or sinusoidal inputs contaminated by noise.

Other Methods

A large number of other methods are also available for the analysis of non-linear control systems. These methods are less widely used and in a short paper it is simply impossible to list and to explain all of them. In fact, it is impossible to do even the former. Some of these methods are recent developments. Others date back to non-linear mechanics and non-linear electric circuits. The majority give the response for a particular input or set of initial conditions, but a few give an over-all view of system behaviour.

Analytical techniques for the solution of non-linear differential equations are not limited to the perturbation method and piecewise linearization. Other useful methods are reversion, variation of parameters and averaging based on residuals (Galerkin's method and Ritz's method).[21] Reversion is similar to perturbation in that the effects of non-linearity are accounted for by the addition of small correction terms. When the solution is an oscillation whose amplitude and phase change with time, it is better to use the variation of parameters method since less work is required. This method is based on the fact that the particular integral of a linear equation can be written as the product of one or more parts of the complementary function and one or more functions of the independent variable. In general, the non-linear differential equation is reduced to a set of simultaneous first-order equations and the solution is found by first removing the non-linear terms and considering only the linear terms. The Galerkin and Ritz methods are applicable to oscillatory and non-oscillatory systems and require the assumption of an approximate solution. The residual is found by substituting the assumed solution into the differential equation and the parameters are so adjusted as to minimize some property of this residue.

Graphical techniques include methods in addition to those mentioned previously. Phase plane solutions may be obtained by means of the delta method,[3] which is somewhat similar to the isocline method, but is much faster. The describing function can be used to determine the response of non-linear control systems subjected to random inputs and to sinusoidal inputs contaminated by noise.[12] Step-by-step methods combining numerical and graphical techniques have also been used.[19] In these methods numerical techniques are used to evaluate the responses of linear elements and graphical constructions for the non-linear elements.

Finally, recent publications[20] have shown the development of a mathematical theory for the analysis and synthesis of non-linear control systems. This work emphasizes the statistical approach and makes use of orthogonal networks and the statistical transform theorem.

TABLE 1.

Tabulation of Numerical Solutions

n	t	c
0	t_0	c_0
1	$t_0 + \Delta T$	c_1
2	$t_0 + 2\Delta T$	c_2
3	$t_0 + 3\Delta T$	c_3
—	—	—
—	—	—
—	—	—

Conclusions

A number of non-linear automatic control system principles have been reviewed in this paper. In particular, common system non-linearities, typical non-linear phenomena and reasonably well established methods of analysis have been discussed. This presentation is far from complete and it could be argued that important aspects of this field have been omitted. This was not done unintentionally since it was the purpose of this paper to review only the better established principles of non-linear control. A broader coverage of the field would have resulted in only a more superficial treatment and this would have merely subtracted from the value of the paper.

Although many hundreds of papers have been published on non-linear control systems, very little is known about this field and much pure and applied research remains to be done. In particular, only the phase plane and describing function are useful for both analysis and synthesis. They complement each other and furnish answers to many of the performance questions which concern control system engineering, but are far from being entirely satisfactory. Other methods are even less satisfactory for they merely reveal general features of system behaviour after exhaustive investigation and are better adopted to analysis than synthesis. There is, above all, a need for a cogent body of theory for the analysis and synthesis of non-linear control systems.

Acknowledgement

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SOME PROBLEMS ENCOUNTERED IN UNDERWATER SOUND RESEARCH

H. H. A. Davidson, Pacific Naval Laboratory of the Defence Research Board of Canada, Esquimalt, B.C.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THE Pacific Naval Laboratory was established by the Defence Research Board in 1948 to do research in marine physics in support of the National Defence program. Early work was devoted entirely to sound propagation studies, beginning with measurements of echoes from artificial targets such as triplanes and spheres.

The triplanes used were assembled with octagonal planes 6 ft. in width, containing many layers of wire screen sandwiched between copper sheets and enclosed in a steel frame. The purpose of the screen was to enclose air while maintaining resistance to collapse under hydrostatic pressure. The air was necessary to create an impedance mismatch—a discontinuity in transmission characteristics which would produce a reflection of incident sound. When three of these panels were assembled orthogonally and suitably braced with wire struts, the whole assembly became a vulnerable and unwieldy device to handle on a ship, and even more so in water.

The spherical target used was even more cumbersome. It consisted of a double concentric steel sphere 11 ft. in diameter, weighing five tons when empty. The internal plumbing was arranged so that buoyancy could be adjusted by suitably flooding the inner sphere, leaving a surrounding shell of air to produce the reflections.

To avoid unwanted reflection from surface buoys supporting the targets, the triplanes were often suspended on spacer lines strung between buoys, and a series of these would be held taut by anchor clumps at the ends of the lines. The spherical target was anchored, and supported itself by its positive buoyancy.

There were mechanical problems in laying a target line of this type in various configurations. One disturbing characteristic of the spherical target, usually known as the eight-ball, resulted from the peculiar plumbing arrangements, which required the air to be submitted to the hydrostatic pressure corresponding to its depth, which might be 200 or 300 ft. Upon retrieving the target, as the pressure was reduced the air expanded forcing out water and increasing buoyancy. This process was regenerative, with the result that the target would accelerate all the way to the surface and practically leap out of the water. Since the exact location of the target was never known, the captain was always relieved to see it appear on the surface.

All this work was carried out in inshore waters, and particularly in one channel which had been found to have uniquely uniform sound transmission characteristics as a result of extremely uniform temperature from surface to bottom. As in all such channels, tidal currents presented many difficulties to the ships' crews in laying targets, particularly when manoeuvring space was limited.

On one occasion, during a joint experimental operation in conjunction with the U.S. Naval Electronics Laboratory of San Diego, we were operating with a 300 ft. submarine as a target, and it was an enlightening experience for all concerned. To assist the surface ships in keeping track of the submarine, we 'suspended' the submarine from two large mooring buoys fore and aft while it submerged to a depth of several hundred feet. Tidal currents required that it manoeuvre into position frequently, and there was evident astonishment among the transient fishing boats, who often found it necessary to detour by our operation, to be passed by two large mooring buoys proceeding up the channel against the tide. If they saw the submarine surface, they were even more impressed.

The general plan of operation was to use standard RCN ships fitted with Asdic as the sound sources, recording echoes from the various targets as the ship attacked on various courses. An additional smaller ship was anchored at the target line with one or more hydrophones down to monitor the sound field as viewed at the target. This provided necessary information for the target evaluations.

As mentioned earlier, tidal currents caused much inconvenience in many ways, one of which was the streaming of hydrophones. In our innocence at first we assumed that there would be no problem in determining the depth and position of hydrophones hung 300 ft. below the ship, by measuring the amount of wire out. It quickly became apparent that the wire was entering the water at an appreciable trailing angle, and the hydrophone depth and position were unknown quantities. Elaborate formulae for catenaries were devised, based on the wire angle and some arbitrary assumptions about wire drag, but very little confidence was placed in them. Additional weight below the hydrophone acted in the right direction, but was only a palliative measure.

It was necessary to hang the hydrophone from a strain wire parallel to the electric wire, and we soon found that it was imperative to tie the two wires together securely at intervals of 20 ft. If this was not done, the electric wire coiled itself around the strain wire and slid down into an enormous tangle. This problem was to confront us for years to come. Eventually we did devise and build a mechanical monster resembling a cable-making machine which was capable of wrapping a tight spiral of cord around the bundle of wires as they were lowered, and of removing the cord as they were raised, but occasionally the wires would invent new ways to thwart the machine.

Depth determination of hydrophones became sufficiently urgent that some effort was put into developing a depth meter capable of measurement and recording to within 1 ft. in 400. Since then further work has resulted in much simplified devices producing frequency modulated signals and requiring only one conductor for operation.

As experiments progressed, it became desirable to operate a sound source at depth, and we converted a harbor defence Asdic unit to our purposes. This added another burden to the unfortunate ships' crews, because the unit weighed a little over one ton, and in the process of lifting it from the deck over the side in rough weather it assumed the capabilities of a demolition ball. In fact, handling had to be restricted to relatively fair weather. There were occasions when we were trapped by sudden deterioration in the weather while the unit was submerged, and grave difficulties were experienced in getting it aboard without damage to the ship.

The troubles were exaggerated by occasional malfunctioning of the winches, which were required to have extremely smooth control but sometimes preferred to operate in step functions with alarming consequences.

To turn to some of the electrical problems, we began in a most primitive fashion with practically no equipment. Initial records of sound fields were taken by visual observation of pulses on an oscilloscope without benefit of a long-persistence screen.

One of the main characteristics of these signals was their extreme variability, amounting to changes of one hundred times or more between successive pulses sometimes. This was later discovered to be the result of interfering propagation paths creating Lloyd mirror patterns as in the optical case.

Our problem was to record these pulses manually while changing attenuator settings and reading from the oscilloscope. The physical strain was sufficient inducement to inspire development of a system of photographic recording of both pulse and attenuator readings, which were still required to be adjusted manually by observation on a monitoring oscilloscope.

The next stage in labor saving, which came somewhat later, was the development of logarithimic amplifiers having instantaneous response to pulses. These amplifiers accepted input signals varying in amplitude by 1000 times, and compressed then to output variations of ten times, suitable for direct photographic recording. No such amplifiers were available commercially at the time (1950) so two different types were produced by us and used successfully for several years.

Hydrophones in the beginning were principally magnetostrictive types, and fairly rugged in construction. As the work progressed it became necessary to have arrays of six or more hydrophones mounted on odd shaped spars to maintain certain geometrical relationships between the hydrophones. These spars with their attendant multiplicity of cables added much to the difficulties of handling the gear at sea.

As emphasis in the research changed from higher to lower frequencies, we changed to barium titanate hydrophones when they became available, and since some of these were very small and of high impedance, preamplifiers were required to be mounted with the hydrophones on the spar arrays. Power had to be transmitted from the ship to operate the preamplifiers because operating periods were too long for batteries, and transistors were not yet in a practical state of development. Some ingenuity was required to operate the whole system with a minimum number of conductors, to supply power, to transmit signals up, and to carry calibrating signals down.

Much experience was acquired in the construction of water-tight joints of all kinds, and these evolved gradually from home-made types relying on brute force for a seal, through commercial types having the same principle, to more effective and simpler 0-ring types which are used almost universally now. In the course of events there was considerable experience with the effect of salt water on electronics and the necessary immediate treatment of immersion in fresh water, followed by prolonged cooking over radiators. We were always amazed at how well the amplifiers survived a number of such cycles of treatment. For the deepest work, oil-filled units were used, with a diaphragm or bellows to take care of temperature changes.

With increasing demands for greater sensitivity, considerable work was necessary in developing preamplifiers having the lowest possible inherent electrical noise levels. As transistors became available the further problem arose of matching high impedance hydrophones to essentially low impedance transistors while maintaining the lowest possible noise level.

Because of low frequencies too, the sound sources become much more difficult to produce. After an unfortunate experience with a commercially developed barium titanate unit in which the maximum power lobes appeared ninety degrees removed from the intended pattern, we made one of our own operating on the electrodynamic principle which was fairly successful.

The electronics required to drive these sources is comparable to a small broadcast station, and consequently is susceptible to the adverse operating conditions on board ship, but breakdowns have been kept to a reasonable minimum. The high voltage supplies and filter condenser banks constitute an additional occupational hazard for personnel trouble - shooting behind electronic racks during rough weather.

The next development in the efforts to reduce background noise and increase sensitivity to small signals was the construction of a buoyed hydrophone array with radio telemetering to the ship over a distance of a mile or so. This permitted the hydrophones to be removed from the vicinity of the noises unavoidably produced by the ships auxiliary machinery and by wave action on the hull. The buoy used was a fibre glass skiff, 12 ft. long, decked over completely and having two hatches for access to the battery-operated electronics.

Although only two hydrophone channels were employed, the telemetering system evolved into a considerable degree of complication, partly in order to allow for expansion into more information channels. Two radio frequency links were used between ship and buoy. One frequency modulated link operating at 230 mc/s carried the data in FM form multiplexed on sub-carriers of the FM transmitter, thus constituting an FM-FM system. The other link, at 2.6 mc/s amplitude modulated, carried the control information in the form of audio tones. Twenty-one possible combinations of the five tones used were employed to carry out such functions as turning on the FM transmitter, selecting one of eight attenuator settings for each hydrophone amplifier channel, turning on or off the calibrating oscillators, or navigating lights. Power was supplied by a bank of eight automobile batteries to operate the electronics which was all transistorized with the exception of the VHF transmitter.

The telemetering operations were conducted in the open sea off the Continental Shelf, and weather conditions increased the difficulties of launching the buoy, with its trailing hydrophone cables. A system which was used with moderate success employed a heavy canvas ramp trailed behind the ship. The buoy was skidded down the ramp and later hauled up the same way, but not without some difficulty in retrieving all the lines.

The antennae on the skiff were vertical dipoles, and on the ship a helix was used on the 230 mc channel because of its insensitivity to polarization angle, which necessarily varied a great deal as the skiff rolled. Another whip antenna on the ship carried the low frequency control channel.

Several years ago we began experiments in propagation and ambient noise measurement under the ice in the Canadian Arctic Archipelago. Here the requirements of very low power consumption, light weight and portability combined with wide temperature tolerances have been met by new transistorized amplifier designs. The mechanical problems of access to the water required design of power operated ice auger equipment, hand-held at first and later installed on the tractors used for hauling the sled-mounted instrument huts. Tents provided sleeping quarters, and an Eskimo with dog team assisted in hauling supplies and provided local knowledge for travel offshore on the ice. Explosive charges dropped through holes provided the sound sources. One of the most difficult aspects of the operations was accurate navigation and plotting of propagation ranges, with no geographical reference points to work from, and over featureless terrain consisting of broken ice which prohibited travel in straight lines. EIC

Discussion

BACKWATER COMPUTATIONS FOR THE ST. LAWRENCE POWER PROJECT

Part A—Hydraulic Engineering Aspects of Computations

H. M. McFarlane,
Hydraulic Design Engineer, Ontario Hydro, Toronto

The Engineering Journal, February 1960, page 55.

Discussion by P. S. Quan

It is true, as Mr. T. R. Anand and Mr. H. M. McFarlane agreed (p. 81, Dec. 1960, the Engineering Journal), that the interpolation equation

$$h_{f_2} = \left[\frac{2n_2}{n_1/h_{f_1}^{1/2} + n_3/h_{f_3}^{1/2}}\right]^2 \qquad (1)$$

is correct only if

$$A_2R_2^{2/3} = \tfrac{1}{2}\,[A_1R_1^{2/3} + A_3R_3^{2/3}] \qquad (2)$$

In practice, this condition may not be met, and to reduce error, h_{f_1} and h_{f_3} from the original computations may be selected to be sufficiently small. For a river channel with a broad width, the change of n value would not appreciably affect its top width, and the following relation may hold:

$$\frac{A_1R_1^{2/3} + A_3R_3^{2/3}}{A_2R_2^{2/3}} = \frac{d_1^{5/3} + (d_1 + \Delta d_3)^{5/3}}{(d_1 + \Delta d_2)^{5/3}} \qquad (3)$$

in which d_1, $d_1 + \Delta d_2$, and $d_1 + \Delta d_3$ represent the mean depths of the channel section for n_1, n_2, and n_3, respectively. If h_{f_1} and h_{f_3} are selected such that $\Delta d_3/d_1$ and $\Delta d_2/d_1$ are negligible, then the value of

$$\frac{A_1R_1^{2/3} + A_3R_3^{2/3}}{A_2R_2^{2/3}}$$

approaches two.

That, as Mr. McFarlane pointed out, the computed profile practically coincided with the interpolated profile between the power dam and Morrisburg but diverged from Morrisburg to Chimney Point, would be partly attributed by the fact that $\Delta d_2/d_1$ and $\Delta d_3/d_1$ were negligibly small near the power dam, but became larger further upstream. However, the interpolation had been guided by the principle mentioned above, the divergence between two profiles was practically very small.

Following the relation shown in (3) but neglecting the terms of higher order, another equation may be obtained and used for interpolations without the restriction shown by (2). The equation is

$$\left[\frac{n_3}{n_1}\left(\frac{h_{f_1}}{h_{f_3}}\right)^{1/2} - 1\right]h_{f_2}^{3/2} - h_{f_3}\left[\frac{n_3}{n_1}\left(\frac{h_{f_1}}{h_{f_3}}\right)^{3/2} - 1\right]h_{f_2}^{1/2} - \frac{n_2}{n_1}(h_{f_1})^{1/2}(h_{f_3} - h_{f_1}) = 0 \qquad (4)$$

The writer computed a reach of river, some 15,300 feet in length, by the standard step method for five different n values, and to interpolate by equation (4) the losses for three of them. The comparative results are as shown in table (1).

Table (1)

n	*Total losses (including minor losses) by standard step method*	*Total losses by eq. (4)*
*0.050	*2.879′	
*0.020	*0.662′	
0.044	2,331′	2.39′
0.035	1.590′	1.69′
0.025	0.921′	0.97′

*Value used for interpolation.

Although equation (4) could be applied to higher losses than equation (1), the latter was adopted for the St. Lawrence interpolation because of its simplicity.

Equations (1) and (4) were derived based on friction losses only. However, it is easy to separate the friction losses from the total losses for interpolations, and by adding the average minor losses originally computed to the interpolated loss thus found, the total losses are obtained. For the same above example, the results are as shown in Table (2).

From the results listed in Tables (1) and (2), it can be seen that the use of the gross total losses for interpolation is justified.

By these interpolation equations, a loss for any n value may be found if the other two losses are known. It follows that the n value for the required interpolated loss is not necessary to be bracketed by the other two.

In hydraulic engineering, it is often required to determine the roughness of a river channel. Usually, by the standard step method, it requires a number of repetitions of trial and error at a correct n value. The use of an interpolation equation would reduce some of the tedious work, for only the losses based on two assumed roughnesses are needed for computation.

Table (2)

	By standard step method			*By interpolation*	
n	*Total losses*	*Minor losses*	*Friction loss*	*Friction loss*	*Total losses*
*0.050	2.879′	0.219′	*2.660′		
*0.020	0.662′	0.225′	*0.437′		
0.044	2.331′			2.06′	2.28′
0.035	1.590′			1.32′	1.54′
0.025	0.921′			0.68′	0.90′

*Value used for interpolation.

BENEFIT COST ANALYSIS OF THE GREATER WINNIPEG FLOODWAY

Carson Templeton, M.E.I.C.
Consulting Engineer, Winnipeg

The Engineering Journal, February, 1961, page 46

Discussion by R. H. Clark

The Red River Basin Investigation,

(Continued on page 106)

Canadian Developments

MUSKEG RESEARCH

The seventh annual Conference on Muskeg Research held recently at McMaster University, took on an international aspect this year. Papers on research done in Great Britain and in Japan were presented to the 130 American and Canadian engineers who attended the Conference.

The paper presented by Dr. I. Miyakawa, of the Hokkaido Development Bureau described some aspects of research and development of roads over organic terrain in Japan. According to Dr. Miyakawa there is much similarity between the terrain in parts of Canada and that of Hokkaido, the northern main island of Japan.

J. R. Lake of Scotland presented a paper dealing with British investigations on the problem of constructing roads over peat in Northern Scotland. Mr. Lake is with the Scottish Station of the British Road Research Laboratory.

The Canadian papers dealt with engineering problems regarding muskeg or muskeg research. As there are approximately 500,000 sq. mi. of muskeg in Canada, muskeg is a factor the engineer must take into consideration in many projects. Of special interest was a paper by Major J. L. Charles of Winnipeg on the organic terrain factor in northern railway construction. The author, who drew on his many years of experience in railway construction, dealt particularly with the construction of the Hudson Bay Railway and the importance of muskeg in that project.

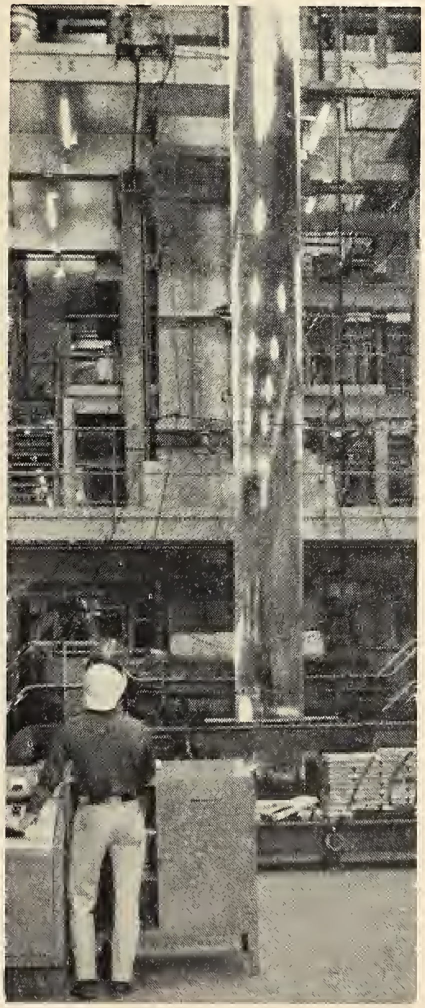
An unusual aspect of the practical applications of muskeg research was dealt with in papers covering the Peaee River area in Alberta where muskeg was a real problem in the exploitation of petroleum. Another unusual aspect was presented in a paper by J. V. Healy in which he described the progress made in Newfoundland in reclaiming muskeg for agricultural purposes. Newfoundland, which has so little agricultural soil, is already using reclaimed muskeg for crop production. The way in which it is being used has important implications for the future of agriculture there.

Ivan MacFarlane of the National Research Council reviewed the corrosive effects of the water in or run-off from muskeg on concrete and metal structures. This is a new problem which has arisen because of the development of the Canadian North.

Dr. N. W. Radforth presented the first general map showing the location of muskeg in Canada. This was prepared by the Defence Research Board.

One half day was spent at the famous Copetown Bog near Hamilton where the delegates were shown field demonstrations of sampling techniques and muskeg identification by Dr. Radforth and some of his assistants. Dr. Radforth, Chairman of the Department of Biology of McMaster University, was general chairman of the conference. This conference was directly sponsored by the Muskeg Subcommittee of the Associate Committee on Soil and Snow Mechanics of the National Research Council of Canada. Research work on muskeg was started at McMaster University more than 10 years ago.

Zinc Coated Steel Rising from the Pot



"CENTURY 21"

Canada will be well represented in the "Century 21" Exhibition to be held in Seattle, Wash., next year from April 21 until October 21. The theme of this exhibition is "Man and Science in the Space Age."

A variety of exhibits have been chosen to fill the 11,900 sq. ft. of space allotted to Canada in the Commerce and Industry Pavillion. Trans Canada Air Lines will show its electronic ticketing system which will be introduced next year. The Canadian satellite, developed to examine the upper reaches of the ionosphere, will graphically illustrate the mysteries of outer space. One of the many Canadian contributions to the use of atomic energy for peaceful purposes, the "Theratron" cancer machine, will be on display. The "Theratron", developed by Atomic Energy of Canada Limited, is now in use throughout the world. Canada is also well known for aerial photography and the preparation of maps and interesting material in these fields will be exhibited. Another area of Canadian development that will be stressed is the scientific activity in and the many things which have been achieved in the Canadian North.

NEW GALVANIZING UNIT

"Made in Canada" was the theme of the construction project for the building which houses Stelco's new Sendzimir Continuous Galvanizing Line. This 1700 ft. building is believed to be the largest ever built in Canada using a rigid frame design. All steel used in this project was fabricated in Canada. (See illustration on this page.)

The Sendzimir Continuous Galvanizing Line takes cold rolled steel coils and anneals them. The oxide formed during this process is completely reduced and the steel, now a strip, enters a pot of molten zinc following which it is cooled and chemically treated to make it especially resistant to abnormal atmospheric conditions. EIC

International News

SHELL STRUCTURE COMPETITION

The International Association for Shell Structures has announced a papers competition open only to students attending universities, colleges or other educational institutions.

Papers submitted should refer to shells or three-dimensional, continuous or discontinuous structures whose thickness is small compared with its two other dimensions, and in which the forces acting along the middle plane are fundamental.

Submissions should be received at the Secretariat of the International Association for Shell Structures before Feb. 28, 1962 and should be marked with a code name. The name of the author, or authors, and a certificate issued from the school attended by the author should be submitted in a separate, sealed envelope. The certificate should state the author's educational status.

First and second prizes are, respectively, $200 and $100.

The Association will have the right to publish the prize papers. The authors will be awarded a Diploma of Honour by the Association.

Evaluation of the papers submitted, and the adjudication of the prizes will be done by the Executive Council of the International Association for Shell Structures considering the scientific, constructive, economic and aesthetic aspects, and the educational status of the student.

The Executive Council may divide the prize money, total it, or declare the contest void if it is considered opportune.

Further information regarding the competition or the Association itself, is obtainable at: The Secretariat, International Association for Shell Structures, Alfonso XII, Madrid 7.

REQUEST FOR PAPERS

The Sixth World Petroleum Congress will be held at Frankfurt am Main, Germany, June 19-26, 1963. The Canadian National Committee has been requested by the Organizing Committee for the Congress to submit a list of papers which might be presented by representatives from Canada.

Technical sessions will cover:

Geophysics and Geology
Drilling and Production
Processing and Refining of Oil and Gas
Base Stocks from Petroleum and Natural Gas for the Chemical Industry
Composition, Analysis and Testing
Utilization of Petroleum Products
Engineering, including Materials and Transportation
Operations Research, Statistics and Education

The members of the............are requested to consider the preparation and presentation of a paper which will have technical merit and provide an interesting basis for the discussion period.

The title and summary outlining the scope and content of the paper should be forwarded to F. P. Irwin, 111 St. Clair Ave., West, Toronto 7, Ont., for consideration by the Canadian Committee.

The membership is:

C. E. Carson, Chairman; R. J. W. Douglas, Geological Survey of Canada; D. L. Flock, Department of Petroleum Engineering, University of Alberta; G. W. Govier, Engineering Institute of Canada; A. W. Hutchinson, Chemical Institute of Canada; N. W. Martinson, Alberta Society of Petroleum Geologists; D. C. Skeels, Canadian Society of Exploration Geophysicists; J. C. Sproule, Canadian Institute of Mining and Metallurgy; F. P. Irwin, Secretary.

PRINCE PHILIP

Addressing the Institutions of Civil, Mechanical, and Electrical Engineers recently in London, Prince Philip, Hon. M.E.I.C., presented his views on how engineers could help develop the Commonwealth.

The wealth of a nation depends on the efficient organization of its resources, both natural and industrial, as well as human, Prince Philip said, and in this the engineer has a chief responsibility.

Referring to agriculture, Prince Philip said 44% of the Commonwealth land area now is not under cultivation. Some of this land cannot be developed.

"This leaves about 30% as potentially cultivable and gives some idea of the scope for bringing deserts, equatorial forests and tropical grasslands into production, and the tremendous contribution which engineering can make to agriculture."

In the field of energy, ". . . the engineer has almost unlimited scope, and the solution of this energy problem demands more than skill and intelligence. It demands the services of far-sighted engineering administrators to exploit every indigenous source of energy and to plan the most economic form of energy production from other sources."

Speaking of engineering training in the Commonwealth, Prince Philip said the problem of higher education and technical training could not be solved once and for all. But he added:

"Every country in the Commonwealth should look forward to progressive development, which means that plans for education must look ahead to the needs of the next generation.

"Clearly the contribution engineers can make to the development of the Commonwealth depends," Prince Philip said in summing up, "to a large extent upon the organization of the engineering profession, both nationally and inter-Commonwealth."

NORA RESEARCH AGREEMENT FINALIZED

The trilateral agreement between the United States, Norway and the International Atomic Energy Agency has been recently concluded in Vienna. Norway and the United States will both contribute materially to a research project which aims at obtaining precise and widely applicable reactor physics data on cores with mixed and variable lattices moderated by light or heavy water or a mixture of both. Norway is supplying two of the cores to be used as well as its critical assembly NORA. One of the cores consists of natural uranium and the other of slightly enriched uranium. The United States will supply a third fuel core which has been enriched to 3% in the radioisotope U-235. It was originally used in development work for the nuclear merchant ship "Savannah" and contains 42 kilograms of U-235.

Sterling Cole, Director General of I.A.E.A. stated that this agreement opens up a new avenue for the Agency as direct participation in a long-term research project in the field of reactor physics is of prime interest in nuclear energy development.

Representatives of the United States, Norway and the International Atomic Energy Agency were present in Vienna when the documents were signed. This project marks the first occasion in which special nuclear material has been leased through the Agency to a member state. EIC

Month to Month

Northern Ontario Conference

The Northern Ontario Regional Conference, sponsored by the Nipissing and Upper Ottawa Branch of the Institute attracted more than 100 engineers. Theme of the highly-successful meeting, held May 6 at North Bay, was "An Engineering Approach to Northern Development."

Col. C. E. Reynolds, chairman of the Ontario Northland Transportation Commission, outlined at one of the technical sessions, the advantages of a harbor at Moosonee, Ont., on James Bay.

"As the shortest route to the centre of the greatest population density and industrial activity a harbor at Moosonee would open up 4,000 miles of shore line along Hudson and James Bays which now are completely cut off," Col. Reynolds said. "It is my firm conviction that when Moosonee is established as an ocean port, Northeastern Ontario will have an additional 100,000 inhabitants."

Col. Reynolds said that at Moosonee, unlike Churchill, permafrost is unknown and the surrounding country is well timbered and offers an excellent site for a city of 15,000 people. Recent tests made of the bay bottoms showed no material for at least 35 feet below low tide that could not be removed successfully by a suction dredge.

Dredging operations to remove an estimated 28 million cubic yards of material to create a new harbor and a channel to deep water for ocean-going vessels would cost about $8,250,000 Col. Reynolds said.

W. Keith Buck, chief of the mineral resources division of the Department of Mines and Technical Surveys, said the only producing mine in the Hudson Bay area is north of Churchill. It contains copper, nickel, gold and small amounts of iron.

"A prime consideration in a study of economics of developing mining properties in the Hudson Bay area is the availability of markets," Mr. Buck said.

"In the case of copper and nickel, it is very probable that the existing Canadian smelters could absorb any production in this area. In the case of zinc, however, due to the present smelter and refinery at Flin Flon, Man., the only alternative would be to ship the material to the east coast of the United States or to Europe for treatment."

Brig. A. B. Connelly, M.E.I.C., said the major problem encountered by engineers attempting the construction of settlements in the far north is the presence of permafrost.

"The thickness varies from about 18 inches at Hay River to about 1,300 feet in the Elizabeth Islands," said Brig. Connelly, who at one time was chief engineer on the Alaska Highway.

"The building of the defence installations throughout northern Canada gave immense impetus to the study of northern construction methods," he said.

William A. Young, Affiliate E.I.C., general manager of the Canadian Johns-Manville plant at North Bay, was chairman of the session which ended with a banquet and dance. An attractive program for the ladies also was held.

MEMBERS WITH NO ADDRESS

The following members' mail has been returned to headquarters. As a result, their names have been removed from the Institute membership list, but would be readily reinstated if a current address were forthcoming. Information regarding them should be sent to: **Records Department, The Engineering Institute of Canada, 2050 Mansfield Street, Montreal.**

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E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on April 8, 1961.

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Chairman, Dean H. G. Conn, Queen's University, Kingston, Ont.
Secretary, A. C. Davidson, 106 Bideford Street, Downsview, Ont.

Preprints of papers presented at the Institute's Annual General Meeting in Vancouver, May 31, June 1 and 2, are available at Institute Headquarters, 2050 Mansfield Street, Montreal 2, Quebec, at 50 cents per copy.

* *

Preprints of papers presented at the Joint N.R.C.-E.I.C. Symposium on Automatic Control are available at E.I.C. Headquarters at a price of 25 cents per copy.

(Continued from page 82)

man, Port Hope; F. M. Corbett, Arvida; G. P. Cote, Sherbrooke; R. E. G. Cox, Montreal; M. E. Cyr, Newcastle; H. D. Daigle, Montreal; G. Damecour, Quebec; W. W. Davis, Ottawa; A. V. Delcloo, Saint John; L. A. Deschamps, Montreal; D. K. Dickey, London; E. R. Dinsmore, Hamilton; W. G. Dolman, Fort William; F. W. Donaldson, Montreal; J. Dorval, Montreal; R. M. Dunton, Montreal; M. C. Edwards, Hamilton; G. J. Ennis, Montreal; G. K. Escott, Toronto; L. J. Feinman, Montreal; L. J. Findlay, Hamilton; J. O. Flower, Hawkesbury; G. E. French, Kingston; H. D. F. Frith, Vancouver; J. S. C. Frost, Vancouver; E. R. Ganong, Toronto; T. L. Gibson, Montreal; R. D. Gillett, Sherbrooke; H. E. Gladish, Ottawa; G. J. Glencross, Montreal; G. L. Gooding, Toronto; J. D. Goss, Moncton; E. W. Hall, Kingston; H. B. Hall, Toronto; J. D. Harvie, Montreal; E. P. Hewer, London; D. R. Hickey, Montreal; L. A. J. Imbeau, Montreal; G. W. Ince, Vancouver; S. M. Istvanffy, Kingston; E. T. Jackalin, Montreal; L. D. A. Jackson, Montreal; R. E. Jess, Bedford; C. C. Johnson, Ottawa; J. M. Kennedy, Ottawa; J. C. Kirkup, Fort William; D. S. S. Knickle, Deep River; W. Kruchowski, Montreal; W. M. Kruse, Galt; C. J. A. Labrecque, Iles Laval; J. J. Lafleche, Montreal; K. C. Langtry, London; J. V. Lavigne, Montreal; J. A. Lemelin, Montreal; M. M. Levene, Kitchener; H. H. Lochhead, Montreal; A. R. Love, British Guiana; G. P. Luke, Jasper; L. J. Lukys, Montreal; W. R. Lymburner, Victoria; V. C. MacDonald, Ottawa; J. H. MacDougall, Antigonish; A. W. Malmberg, Riverside; T. Matsui, Montreal; J. D. McCrea, Moncton; A. W. McIntyre, Pembroke; G. N. McLellan, Sarnia; J. G. Melvin, Chalk River; G. P. Milton, Bathurst; I. A. Mohammed, Trinidad; R. G. Montrose, Toronto; W. D. Moore, Montreal; R. G. Moorman, Belleville; J. B. Moriarty, Cardinal; A. D. Murphy, Montreal; E. Olynek, Winnipeg; H. Orlando, London; W. Ostvik, Toronto; R. Page, Seattle; J. P. Paradis, Beauharnois; C. M. Paul, St. Catharines; L. Pease, Toronto; V. S. Pendakur, Vancouver; A. L. Perley, St. John's, Nfld.; K. P. Pfrimmer, Waterbury, Conn.; L. A. Phillips, Montreal; H. J. Pile, Toronto; J. A. Pollock, Port Hope; K. S. Preston, Toronto; J. F. Probert, Sarnia; H. L. Purdy, Moncton; G. W. T. Richardson, Welland; D. A. Ridewood, Ottawa; J. G. Ripley, Toronto; S. M. Roberts, Hamilton; E. Rohatynski, Trail; J. E. Sackville, Saskatoon; L. S. Salsbury, Three Rivers; R. E. Schock, Toronto; J. E. Seary, Halifax; A. R. Semmler, London; J. M. Simon, Port Arthur; A. S. Simonsen, Port Arthur; H. D. Smith, Port Credit; T. C. Smith, Three Rivers; H. L. Snyder, Toronto; C. V. Steinberg, Windsor; R. A. E. Stenberg, Vancouver; A. L. Sutton, Toronto; P. Tassie, Vernon; R. S. Thibodeau, Montreal; M. P. M. Thomas, Montreal; J. T. F. Thorpe, Toronto; C. R. Tod, Brantford; R. B. Todd, Montreal; W. J. Tough, Toronto; R. K. Vail, Isle Maligne; I. J. Vogwill, Bombay, India; J. W. Wale, Montreal; R. C. Wannop, Kelowna; J. R. Warren, Montreal; R. C. White, Winnipeg; J. F. Whitehead, Hamilton; B. A. Wightman, Ottawa; G. S. Williams, Montreal; D. B. Williamson, Cobourg; C. L. Willcox, Peterborough; J. W. Withrow, St. Catharines; W. J. Wood, Port Alice.

Student to Junior: S. Campanelli, Montreal; J. M. Chittick, Montreal; N. Isyumov, Ottawa; J. Mar, Montreal.

STUDENTS ADMITTED

Nova Scotia Technical College: P. M. P. Aucoin, T. J. Brideau, J. F. Ciavarella, J. E. Davis, C. Deziel, D. G. Evely, E. J. Flinn, R. M. Fraser, R. F. Gibson, A. G. Goussis, H. T. Joseph, P. Kontaras, V. A. Landry, D. W. MacAulay, H. A. MacDonald, K. M. MacLanders, G. T. McDonald, P. J. McDonald, A. B. Melanson, J. A. Morris, T. W. Mullane, S. T. J. Nugent, S. M. O'Regan, G. H. C. Paterson, C. A. Penny, J. W. Ross, J. K. S. Wong.

Saint Francis Xavier University: L. C. Alfonso, A. Bastien, D. B. Baker, J. W. Baxter, M. R. Beauclair, G. H. Cameron, D. J. Collins, R. R. Cyr, J. P. Didyk, G. R. Doucet, J. C. Ferron, T. F. Garey, M. W. Hagar, G. A. Lahey, J. C. R. Lavallee, J. A. MacDonald, J. C. McGrath, W. G. McLean, J. T. Nadeau, C. T. Smyth, J. G. Thibaudeau, B. L. Wadey, W. N. Walsh, D. K. M. Wong.

Memorial University: M. G. Andrews, H. W. Barnes, G. R. Bartlett, L. J. Butler, P. M. Clarke, J. J. Finn, L. D. Fudge, H. M. Grant, G. Greenland, R. H. Hunter, D. A. J. Knight, S. W. Mouland, P. M. Murray, R. W. Myers, R. D. Newbrook, F. D. Noel, A. Noseworthy, R. A. Parsons, W. W. Pinhorn, J. T. Schwartz, R. H. Taylor.

Sir George Williams University: D. D. Allen, A. Arbour, T. A. Ball, M. Charbonneau, A. Jipa, J. K. Koszutski, D. W. MacDonald, O. Podymow, Y. W. Qunital, F. V. Rolling Jr., J. Szentes, R. E. Wyman.

Queen's University: J. Conradi, J. E. Dawson, P. M. Gallop, I. S. Geczy, C. J. Howse, M. W. Keenan, P. P. Kronberg, J. H. Palmason, N. H. Price.

Mount Allison University: M. S. Chan, T. M. Drummond, A. C. Gullon, D. Leong, A. D. Tupper, D. R. Wagner, S. E. Wamboldt, A. C. Zwicker.

McMaster University: W. G. Booth, J. Dubbeldam, J. K. Hardy, G. E. Menzies, R. Shiomi, G. G. Teather, P. R. Wabersich, D. M. Wellard.

University of Waterloo: H. R. Etherington, B. A. Fransen, G. Fung, D. L. Kilner, D. Low, G. A. Rife, J. J. G. Yaciuk.

University St. Joseph: L. P. Gagnon, P. A. Hebert, C. J. Lacasse, J. E. LeBlanc, L. Theriault, F. Vienneau.

University of Toronto: R. J. Fleming, G. Kato, W. A. Kemper, A. K. Kingdon, J. Leppik, R. B. Stevenson.

Ontario Agricultural College: A. E. Bailey, N. R. Gill, J. D. A. Long, B. H. Tolton.

McGill University: B. W. Bussy, B. Esar, T. C. Jessop.

University of Alberta: B. I. Bryson, W. S. Ingham, G. C. Kingsep.

Royal Military College: R. R. Leroux, J. A. P. Rouillard, D. H. Smith.

University of Western Ontario: G. R. Farrow, T. B. Kozyra, R. A. Warner.

Acadia University: R. B. Hamilton, D. B. MacAdams.

Loyola College: E. Baudry, J. B. McCran.

Dalhousie University: D. W. Shatford.

University of British Columbia: M. Ternan.

St. Mary's University: S. N. Macharia.

Student of Corporation of Professional Engineers of Quebec: W. E. Schimek.

University of Western Ontario: P. C. Maurice, B.E.Sc., 1960.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective April 8, 1961.

ALBERTA

Members: E. L. Fowler, A. Hanson, D. R. Low, R. W. Peddie.

Junior to Member: F. W. Beairsto, J. W. D. Berry, G. F. Bishop, M. M. Brown, H. T. Greaves, J. Kaye, J. E. Lyle.

SASKATCHEWAN

Members: C. F. Agar, L. S. Beck, V. E. Campbell, B. L. Fisher, E. D. Hoffman, D. F. Hughes, J. A. Rupf, G. A. Smith, K. Stenbraaten, N. Visman, G. C. Zoerb.

Junior: R. B. Baranowski.

Junior to Member: N. J. Antaya, P. J. Bonser, B. M. Cameron, H. G. Gilchrist, J. N. Keen, R. B. Kroeker, G. A. Ledingham, K. Lukawitsky, J. W. McGuffin, D. J. Nevill, E. M. Pashniak, B. W. Petschulat.

Student to Junior: E. A. Anderson, W. J. Harder, R. C. Landine, W. C. Lee, P. Machibroda, R. W. Nordquist, J. O. Ochitwa, G. K. Revon, C. J. Runolfson, S. S. Strilchuk.

Students: R. Chez, E. F. Derkach, C. L. Korall, W. H. Martynes, J. Omelchuk.

NOVA SCOTIA

Member: C. J. Fear.

NEW BRUNSWICK

Members: W. Lenco, C. H. Robart.

MANITOBA

Junior to Member: J. E. Wachowich.

Personals


Dr. R. E. Heartz, M.E.I.C.


G. R. Rinfret, M.E.I.C.


J. A. Thomas, M.E.I.C.


R. E. Grout, M.E.I.C.


F. F. Fulton, M.E.I.C.


J. R. Crerar, M.E.I.C.

Dr. R. E. Heartz, M.E.I.C. (McGill '17), is one of the four executives whose recent promotion has been announced by the Shawinigan Engineering Company Limited. Mr. Heartz, president of Shawinigan since 1951, has been appointed Chairman of the Board. Succeeding Mr. Heartz, is **G. R. Rinfret**, M.E.I.C., previously vice-president, Engineering. **J. A. Thomas**, M.E.I.C., formerly chief engineer, Civil Division, has been appointed vice-president. He replaces **R. E. Grout**, M.E.I.C., who now is vice-president, Engineering Division.

Dr. Donald Charles Rose, M.E.I.C. (Queen's '23), associate director of the Division of Pure Physics, National Research Council, has been awarded a 1961 Gold Medal by the Professional Institute of the Public Service of Canada for pure and applied science. His recent achievements in the co-ordination of Canada's contribution to the International Geophysical Year, and his observations in the field of cosmic rays, were particularly commended by the award.

Charles-E. Tourigny, M.E.I.C. (Poly '24), formerly president and general manager of Home Laundry Inc. has returned to private practice. His newly opened consulting engineering firm will specialize in the planning and design of laundry installations for hospitals, schools, hotels and other large institutions, as well as advice on operational techniques.

Robert A. Emerson, M.E.I.C. (Manitoba 30), vice-president and member of the Executive Committee of the Board of Directors of the Canadian Pacific Railway Company has been elected a director of The Consolidated Mining and Smelting Company of Canada Limited.

Nicholas Th. Roehrberg, M.E.I.C. (Lille, France '34), has been elected member of the Public Relations Committee of the Professional Engineers Corporation of the Province of Quebec.

Dr. George William Holbrook, M.E.I.C. (London, Eng. '38), has been appointed president of the Nova Scotia Technical College. Lieutenant-Colonel Holbrook, formerly chairman of the Engineering Division, Royal Military College, will assume his new post in May.

Fraser F. Fulton, O.B.E., M.E.I.C., (McGill '28), has been appointed vice-president, Industrial and Public Relations Division, of Northern Electric Company Limited. Mr. Fulton was formerly vice-president and general manager of the Telephone Contract Division.

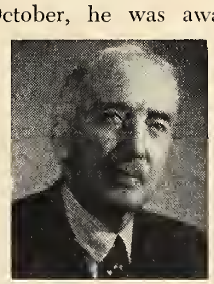
J. R. Crerar, M.E.I.C. (Toronto '30), formerly manager of engineering, has been appointed vice-president of manufacturing at H. J. Heinz Company of Canada Ltd.

Obituaries

Dr. Arthur Surveyer, M.E.I.C., (Poly '02), President of the Engineering Institute of Canada in 1924-25, died April 17. He was 82. Dr. Surveyer, an engineer for 59 years, founded his own consulting firm half a century ago. He began his career in 1904 as engineer on the Georgian Bay ship canal project and later worked as a project engineer in the construction of grain elevators at Port Arthur and Montreal.

He held engineering degrees from Canadian, American and European universities as well as a Bachelor of Arts degree from Laval University. In later years, he figured prominently in arrangements for the establishment of a separate university in Montreal.

Last October, he was awarded the Archambault Medal by the French-Canadian Association for the advancement of science.

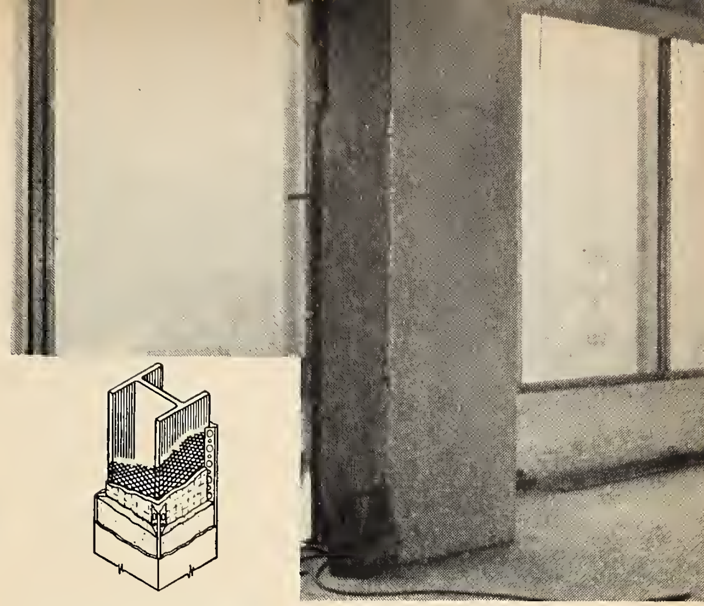

Dr. A. Surveyer, M.E.I.C.

A founding member of the Canadian Institute of International Affairs, Dr. Surveyer served on several Federal Government commissions, including the Royal Commission on National Development in the Arts, Letters and Sciences in 1949. He was a member of the National Planning Committee from 1949 until 1954; the National Research Council from 1917 to 1924 and from 1942 until 1948 and served on the Canadian Advisory Committee on Reconstruction in 1943.

In 1931-32, Dr. Surveyer was chairman of the Chignecto Canal Commission and in 1936 he represented Canada at the International Power Congress in Washington. He was a member of the board of engineers, Lachine Section, of the St. Lawrence Seaway and of the board of engineers for the Strait of Canso Commission in 1948-49.

For many years an active member of the Canadian Chamber of Commerce, he served on the Executive Committee. He was a member of the Montreal Board of Trade, the Canadian Council of the International Chamber of Commerce and from 1919 until 1955 he was a member of the Corporation Ecole Polytechnique de Montreal.

Dr. Surveyer joined the Institute as a student member in 1899, became an associate member in 1907, a member in 1912 and a life member in 1947. In 1953 he was presented with an honorary membership in recognition of his outstanding record. EIC



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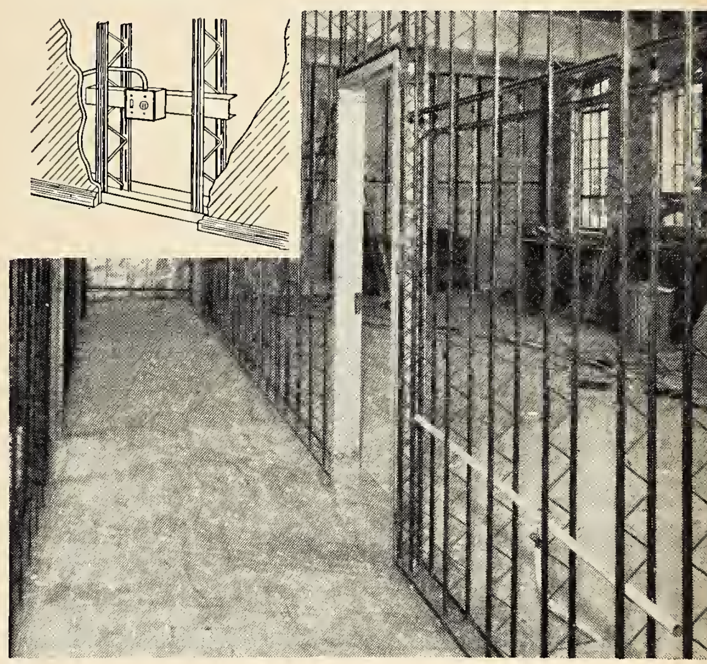

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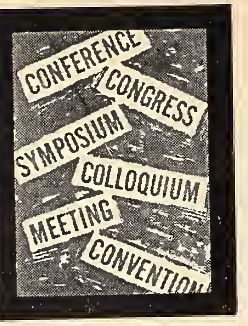
Other Societies



Instrument Society of America

A comprehensive program is to be featured June 6-8 at the International Instrument-Automation Conference & Exhibit sponsored by the Society. Approximately 150 instrument manufacturers will display all types of equipment in the Exhibit site, the Queen Elizabeth Building, Exhibition Park, Toronto.

Subjects to be covered at the conference include: operating experience with digital computers and data loggers; analog computer analysis of process control systems; training needs imposed by systems engineering, nuclear and conventional power plant instrumentation and safety aspects of electronic instruments. Papers will be presented by speakers from both the United States and Canada.

Canadian Institute of Steel Construction, Inc.

The Institute held its 31st Annual General Meeting May 12 and 13 at the Seigniory Club, Montebello, Que. Delegates and guests from all parts of Canada attended.

The Institute of Physics and the Physical Society

The first Presidential address was given to the recently amalgamated groups May 2 in London by Sir John Cockcroft.

He referred to recent and probable developments in solid state physics and discussed the new demands for physicists caused by the wide interest in atomic energy. Besides the studies which can lead to the prediction of radiation damage, physicists are engaged in plasma-physics research.

Space research, he felt, would outstrip nuclear physics both in glamour and cost in the two major powers. An interesting fact, he noted, was that the advent of rockets with their prestige and military uses had brought the long neglected field of astronomy back into the limelight.

The President stressed the need for international co-operation in providing the expensive but necessary equipment so important for fundamental research in physics.

Membership in the newly amalgamated Society is about 10,000.

International Institute of Welding

Russell A. Dunn was Canada's chief delegate to the Institute's world congress held in New York. Mr. Dunn, chairman of the Canadian Council since 1957, has been chief delegate to the Institute's governing council since then.

Twenty-eight nations are members of the Institute which endorsed a full scale research program in welding and its allied fields at the recent world congress.

The Royal Architectural Institute of Canada

An Honorary Fellowship in the College of Fellows of the RAIC has been conferred upon His Excellency Major-General Georges P. Vanier, Governor General of Canada, at a special ceremony held at Government House. Approximately one-eighth of the 2300 architects registered in Canada are Fellows of the RAIC College of Fellows.

Two additional Honorary Fellowships were awarded at the 1961 Convention of the Institute. One was awarded to Philip Will of Chicago, President of the American Institute of Architects and the other went to Stewart Bates, President of the Central Mortgage and Housing Corporation.

The American Institute of Mining, Metallurgical, and Petroleum Engineers

Robert W. Shearman of Darien, Conn. was the delegate chosen to represent the AIME at the First Latin American Iron and Steel Congress held recently in Sao Paolo, Brazil. Mr. Shearman is Secretary of the Metallurgical Society, one of the constituent organizations of the Institute.

The British Institute of Radio Engineers

"Radio Techniques and Space Research" is the theme of the Institute's convention to be held July 5-8. The convention will be the first of its kind to be held in Great Britain. The decision to hold the Convention was influenced by the value of discussion of satellite communications to those associated with the European Space Launcher Club. In addition to the discussion on communications, research projects and radio sessions on Satellite Engineering and astronomy will be discussed.

A full day each will be devoted to Communication Satellites. Other important papers will deal with satellite launching and the actual satellites themselves. Papers on research projects concerned with the determination of the properties of outer space have been scheduled. Another topic of wide interest is the possibility of using artificial earth satellites as relay stations for communicating between widely separated points on earth.

There will be about 50 papers read at the Convention which will be held at Oxford University.

Coming Events

- Annual Meeting, American Association of Cost Engineers, Boston, June 21-23.
- Annual Meeting and Convention, Agricultural Institute of Canada, Regina, June 26-29.
- Canadian Society of Agricultural Engineering, Regina, June 26-29.
- Annual Meeting, Canadian Soil Science Society, Regina, Sask., June 26-29.
- 69th Annual Meeting, American Society for Engineering Education, Lexington, Ken., June 26-30.
- Second Joint Automatic Control Conference, ISA, AICHE, AIEE, ASME, IRE, Boulder, Colo., June 28-30.
- 27th Annual Meeting, The National Society of Professional Engineers, Seattle, Wash., July 4-7.
- International Symposium on Macromolecular Chemistry, International Union of Pure and Applied Chemistry, Montreal, July 27-Aug. 1. EIC

The Associations and Corporation

Quebec

President of the Corporation of Professional Engineers of Quebec for the 1961-62 year is Arnold J. Groleau, P. Eng., M.E.I.C. Mr. Groleau graduated from McGill University in 1925 with a degree of Bachelor of Science in Electrical Engineering. Since graduation he has been with the Bell Telephone Company in a variety of positions. His most recent appointment with that company was vice-president and general manager, Toll Area, on May 1, 1960. In 1954 Mr. Groleau was appointed chairman of the Trans-Canada Telephone System, and in that position he played an active role in the conversion of Canada from the old manual to the new direct dial system. As a member of the C.P.E.Q. he has been active on many committees. He is an enthusiastic golfer and philatelist.

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Baie Comeau

G. W. Scott, M.E.I.C.
Correspondent

Many members were present to hear D. M. Saunders, M.E.I.C., Technical Service Manager, Canadian Industries Limited, give a talk entitled "Recent Contributions to the Explosives Industry". Most of his remarks concerned the development work done by his company since the end of World War II. Many improvements have been made in explosives which have brought about greater safety and accuracy in all forms of demolition work. The various ranges of short period caps, detonator relays, and igniter cords now in use were enumerated and their applications to specific operations discussed. Particular reference was made to their use in conjunction with "Exactex" cartridges for precision demolition where high accuracy of rock cleavage with a minimum of overbreak is required.

The film "Blasting a New Niagara" illustrated several of the operations described by Mr. Saunders. This film was produced by C.I.L. with the co-operation of Ontario Hydro. The project shown was the tunnel and canal excavation work associated with the supply of water to Sir Adam Beck Generating Station No. 2 at Niagara Falls. Water flowing at the rate of 15 million gal. per min. had to be diverted and conveyed under the city in twin parallel tunnels. Graphically illustrated was the high accuracy of the precision blasting of the new canal for the rock sides did not require further treatment or surfacing after the original explosive cutting had been completed. Protection of adjacent underwater installations from the effect of blast by using the "air curtain" method was shown. In the final stages of the Niagara Falls project an 11,000 cu. yd. plug situated only a few feet away from the power station intake was removed by a single blast, the effect of which was neutralized by an intervening air curtain.

The speaker showed a series of 35 mm. slides giving details of laboratory testing equipment currently in use in laboratories devoted to research on explosives. An active discussion period followed the address. Mr. Saunders was introduced by S. J. Simons, Branch Chairman and a vote of thanks was proposed by E. Gauthier.

Brockville

A. N. Campbell, M.E.I.C.
Correspondent

Approximately 60 members and guests attended the April 23 meeting which was devoted to a talk by Dr. C. A. Vendendries, General Manager, Brockville Chemicals Limited. The speaker was introduced by T. Reade and thanked by W. Simmons.

Dr. Vandendries gave a capsule history of the evolution of fertilizers and a detailed account of the progress in Nitrogen Chemistry in the past 60 years. Slides were used to illustrate the processes and chemical formulae.

Colored slides were used when the speaker discussed the new plant under construction. He discussed the processes that will be used as well as the economics of the design and operation of the plant. The talk was coneluded with a general discussion of fertilizers and other nitrogen compounds, types, world markets, the economics of this business, and future trends. He gave a short history of the market development and outlined Canada's place in the world picture.

Cape Breton

L. R. Boutilier, M.E.I.C.
Correspondent

An unusually large group heard Dr. J. F. Elliott, Associate Professor, Metallurgy, at the Massachusetts Institute of Technology speak on his trip to Russia at the branch meeting, April 21.

Dr. Elliott, who toured Russia three years ago, described the general attitude of the Russian people. He found Russian technicians willing to discuss scientific and technical developments though reluctant to discuss politics. They were devoted to their work, he said, and seemed to have little regard for personal comforts. Comforts such as clothing and housing seem to have little importance to the Russians he met. The quality of the rails is poor, and the Russian people have communication difficulties. Though the Russians have good blast furnaces and open hearth practices their rolling mill practices are inferior. Their main sources of news communication are radio and television and the speaker said they valued quality in these types of equipment.

M. R. Campbell introduced the speaker who was thanked by John Campbell.

Central B.C.

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

Ten members of the Central B.C. Branch were guests of the Kootenay Branch April 7 and 8. The main purpose of the visit was a tour of the Consolidated Mining and Smelting Company plant at Trail and Warfield.

A dinner meeting was held at the Crown Point Hotel in Trail April 7. Two talks preceded the plant tour. Frank Gaunu, development engineer, Cominco, spoke on "The Metallurgical Processes of the Consolidated Mining and Smelting Company at Trail". Later Al Brookes, superintendent of Warfield Storage, described the chemical and fertilizer operations at Warfield. Both talks were illustrated with slides and gave the visitors a good idea of what they would see.

The following morning the visitors, including Central B.C. Branch members, their wives and guests toured the lead-zinc smelter and the other related metallurgical operations located at Trail. Their hosts acted as guides.

After lunch in the cafeteria of the Consolidated Mining and Smelting Company the party heard a talk by R. Bailey, administrative assistant, on the history of the Company. The afternoon was devoted to a tour of COMINCO's chemical and fertilizer operations at Warfield with members of the Kootenay Branch acting as guides.

Cornwall

John M. Ferguson, M.E.I.C.
Correspondent

Members attending the April 27 meeting heard two speakers. Edgar A. Cross, M.E.I.C., Ontario Vice President of the E.I.C., gave a talk entitled "History of Engineering Societies". Art Williams, whose talk was entitled "The New High Level Bridge Over the North Channel of the St. Lawrence at Cornwall", is with H. H. L. Pratley, Bridge Consultants. Mr. Williams discussed the planning and steel erection of the new bridge. He made special reference to the elaborate safety precautions taken when the span over Second St., a very heavily travelled thoroughfare, was erected.

During the Easter holidays the Student Guidance Committee of the branch organized a series of visits to local industries for Grade 12 and 13 students who are interested in a career in engineering. Local E.I.C. members served as guides and covered the Electrical, Mechanical, Chemical and Civil Branches of Engineering.

Also during this period the branches of the E.I.C. and C.I.C. co-sponsored the annual "Sojourn in Science" for local students. This activity consists of two lectures on scientific subjects, one being given by a Cornwall scientist and the other by someone from out of town. The purpose is to demonstrate to students that subjects such as chemistry, physics and biology can be both interesting and entertaining. This year Dr. W. G. Bornin, Research and Technical Manager, T.C.F. Canada Ltd. spoke on "Chemistry". Dr. Oliver Heroux, of the National Research Council, Ottawa gave a talk entitled "Do Animals Freeze in Cold Weather". Both lectures were heavily illustrated and very well attended by local students.

Edmonton

Bill Rutherford, M.E.I.C.
Correspondent

The Branch held its annual general meeting at the Seven Seas Restaurant April 13. The retiring Chairman of the Branch, Jack Longworth, introduced the President of the Engineering Institute of Canada, Dr. George McK. Dick of Sherbrooke, who addressed the Branch membership in particular on the affairs of the Institute during the past year. Dr. Dick reported on progress being made towards confederation.

In a question period afterwards Dr. Dick answered many questions ranging from the problems of confederation, ably assisted by Graham Dale, to the problem of making arrangements for tours by persons eminent in engineering and allied sciences to the E.I.C. Branches throughout Canada.

In the business part of the meeting the retiring Chairman introduced the new Chairman of the Branch for 1961-62, Adam Sandilands. The following members were elected to the Branch Executive:

Ron Dalby, Ron Phillips, Bill Rutherford, Dave Usher and D. L. McDonald.

These executive members are in addition to:

Hal Morrison, Ken MacMillan and Vic McCune.

The new Vice-Chairman, Brian Ellis was elected in absentia. The retiring Secretary-Treasurer, George Hodge handed over his duties to Don Smith.

A meeting of the Branch Executive was held April 26 and the following points of interest are set out below:

Secretary-Treasurer Smith reported that the financial position of the Branch was healthy and a considerable surplus was available. Proposals will be considered to ascertain whether some grant should be made to a library, scholarship or other worthy cause. The Program Committee was set up with Brian Ellis, Chairman, and Members R. Dalby, Dave Usher and Hal Morrison.

The Publicity Committee was set up under the Chairmanship of Bill Rutherford, assisted by Hal Morrison. The Branch will be represented at the annual meeting of the Engineering Institute of Canada in Vancouver by Counsellors Jack Longworth and S. Sinclair.

The E.I.C. Picnic will be held in Victoria Park June 21 and Vic McCune, who ably dealt with the arrangements last year, will do so again this year. The program survey request by last year's Branch Executive has now been received with a 38% return on membership. Mr. Dalby and Mr. Usher are tabulating the results and will report the results to the executive.

On the recommendation of S. Sinclair, a special dinner meeting of the Edmonton Branch was held at the Seven Seas Restaurant May 1. Guest speaker C. F. Ripley of Vancouver, introduced by Dr. R. M. Hardy, spoke on "Glimpses of Civil Engineering in Japan." Mr. Ripley, a graduate of the Universities of Alberta and Harvard was a Canadian delegate to the International Commission on Large Dams in Tokyo, Japan in the fall of 1960. During this visit he took the opportunity of visiting major civil engineering works throughout the country. In addition he showed some slides of Japan which were greatly appreciated by the members. He drew attention to the different conditions in Japan and their effect on the basic philosophy of design, construction and operation of engineering works as compared with Canadian practice.

Highlights of his talk included:

The volume of civil engineering construction in Japan is considerably greater than that in North America and the Western Hemisphere. This is probably due to the fact that Japan has a very large population density and must make use of every possible natural resource available.

Construction projects which would be uneconomical in Canada are, for this reason, common in Japan.

Mr. Ripley drew attention to severe climatic and topographical conditions in Japan which have had an effect on design, construction and operation of their engineering works as follows:

(a) The incidence of earthquakes is probably the highest in the world and all structures must be designed to withstand the forces induced by such natural phenomena.

(b) Typhoons and tidal waves from the Pacific Ocean bring great devastation to the country and induce very high wind and wave forces and soil erosion. A considerable amount of ancillary works are needed on all projects affected by these two natural phenomena.

(c) Because of the high population density the value of arable land for agriculture is very important and all construction projects must include extra works, sometimes of a very expensive nature, to conserve agricultural land in a number of cases make arrangements to resettle farmers who have been displaced as a result of the construction work.

(d) Because of the mountainous terrain the Japanese people have developed tunnelling to a fine art and in fact where we would normally build roads, the Japanese appear to have selected tunnelling instead. Furthermore some of the protective works to prevent soil erosion are in our eyes fantastically expensive.

(e) Masonry walls are constructed on the face of excavation cuts and Mr. Ripley said that these were not even included in the construction cost of the job, being done as a matter of course. A philosophy which many engineers would like to see here.

Mr. Ripley's speech was received with acclamation by the membership. It is thought that other branches could, with advantage and enjoyment, ask Mr. Ripley to address them.

The membership was pleased to make a presentation to George Hodge, who for the past year has been a popular and efficient Secretary-Treasurer of the Branch.

Estevan

O. P. Lesiuk, M.E.I.C.
Correspondent

President Dick was the guest speaker at the April 17 meeting. In his address entitled "The Canadian Engineer—His Responsibilities and Opportunities" he touched briefly on the history of the E.I.C., and the tremendous amount of work already accomplished by engineers in Canada. Engineers must try at all times to keep up with the developments in their field of engineering.

The branch gave Dr. Dick a tour of local industries and he was flown over the oilfields.

A Career Day was held at the Estevan Collegiate Institute March 29. A panel of local engineers headed by Jim Stephenson answered queries by the high school students regarding opportunities in industry for future engineers. Considerable interest was shown by the students.

London

Eric T. Skelton, M.E.I.C.
Correspondent

Three films highlighted the talk given by D. H. Perkins at the March 7 meeting which was a Technical Session concerning culverts. Nineteen members of the Branch attended as well as 16 from the Ontario Department of Highways. Art Gator introduced the speaker who was thanked by Harry Orlando of the Department of Highways.

The April 18 meeting featured an informal and informative talk by J. H. Waghorne whose subject was "Where Does the Technician Fit Into the Picture?" Mr. Waghorne is Chairman of the Technician's accrediting Committee of the A.P.E.O. The meeting was held with the local chapter of A.P.E.O. and 150 attended.

Moose Jaw

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

President and Mrs. Dick were guests of honor at the April 18 meeting. Sixty members and their ladies heard President Dick's address entitled "The Role of the Canadian Engineer". He described the role of the engineer in the early development of Canada and the contributions made by Canadian engineers to the national economy during and after the world wars. Turning to the engineer's status in Canada today, the speaker said it was different from that of the past. Today the Canadian Engineer must work hard and use all his ingenuity to turn Canada's natural resources into products that will sell in a highly competitive world market.

President and Mrs. Dick were welcomed to Moose Jaw by the mayor, the Hon. O. Fysh, and were taken on a tour of the city before being honoured at a banquet. Speeches and entertainment formed the balance of the meeting. Mr. T. L. Salmon introduced President Dick who was thanked by M. Shelby. Maurice Pardoe of the Saskatoon branch gave a short speech.

Nipissing and Upper Ottawa

W. A. Adams, M.E.I.C.
Correspondent

"Modern Trends in Steel Construction" was the topic of a talk given by Donald K. Turner at the April 12 meeting. Mr. Turner is regional engineer for Ontario of the Canadian Institute of Steel Construction. This is a national organization representing the structural steel and plate fabricating industries for the purpose of promoting the scientific and economical use of structural steel.

He gave a short history of construction before steel was used and followed the use of steel in building construction from the first buildings on this continent through the most modern methods used today. Steel with new specifications and new alloys is constantly being developed to be more durable and useful in more fields. The long costly hours spent on research in plastic design can now save builders up to 25%. Tomorrow it should be in everyday use. Mr. Turner presented a film entitled "Men, Steel and Earthquakes". It illustrated how a building with a properly designed framework could withstand severe earth tremors.

Oakville

J. W. Kirk, M.E.I.C.
Correspondent

"Winter Construction in Russia" was the title of the talk given by D. G. McKee, President of Perini Construction Ltd. at the April 6 meeting. Mr. McKee, who toured Russia in 1958 showed a 60 minute film made by the Russians to illustrate his subject. The use of electric heat when concrete is poured in sub-zero weather is wide spread. Much construction done in winter consists of putting up prefabricated buildings. For example, most apartment buildings now going up are prefabricated.

Mr. Alford of the De Havilland Aircraft Co. of Canada Ltd. gave a talk entitled "Design of STOL" short take-off landing gear) at the May 4 meeting. The speaker gave a comprehensive lecture on the engineering of "STOL". He showed movies and slides of the "Caribou" aircraft.

Ottawa

Frank C. Woodruff, JR.E.I.C.
Correspondent

Eric Thrift, General Manager of the National Capital Commission, addressed the April 20 meeting. In his talk, entitled "Railway Relocation Plans for Ottawa" he stated that Ottawa may be unique among cities in North America because the relocation of its railway facilities will make possible the redevelopment of large downtown areas. When Union Station alone is relocated 22 acres in the heart of Ottawa will be open to new development. But, besides opening up new possibilities this would also pose many problems, he said. An example of this is the construction of the western part of the Queensway along the old CNR line. Mr. Thrift said that the removal of the CPR yards at Nepean Bay would make further development of the Ottawa River Parkway possible. The speaker, who used a large map to illustrate his talk, cited many problems of industrial relocation to coincide with railway plans. It is hoped, he said, that the project will be completed by 1965.

Peterborough

R. C. Johnston, JR.E.I.C.
Correspondent

A. E. Berry, General Manager, Ontario Water Resources Commission addressed the April 20 meeting. "Water Resources and the Engineer" was the topic of his talk. Dr. Berry first established the importance of water resources in our present economy. He related this to industry by stressing the importance of water supplies in the choice of new locations. The importance of water resources to municipalities is graphically illustrated by the growing prices communities must pay for adequate water supplies. The speaker devoted the remainder of his talk to water pollution, its causes, and what the engineer can do in protecting natural sources of pure water by assuring adequate treatment of industrial wastes.

A second meeting was held when the branch was honoured by a visit from President George McK. Dick, who outlined activities being carried out on a national and international scale. He devoted part of his talk to emphasizing the need of creating a national image of the professional engineer and the need for engineers to recognize the benefits to be obtained from associations with other engineers.

E. A. Cross, Vice-President of the E.I.C. for Ontario was an honoured guest at both meetings and on both occasions he addressed the meetings briefly.

Approximately 100 people attended

e May 9 meeting which was a joint eeting of the local branch and the anadian General Electric Company's .M.C. group, Peterborough. Engineers om Lakefield, Lindsay and Cobourg tended.

The meeting consisted of two parts. he first was an address by A.P.E.O. resident Sentance who dealt with the stablishment of local A.P.E.O. Chapters, the formation of a new national ngineering society, and the A.P.E.O. ouncil's view on compulsory bargaining.

Following the address by Mr. Sentance here was a discussion on the details f chapter organization, the separate oles of the Chapters and E.I.C. ranches and the opportunities for co-operation between the two groups. An nterim executive was presented to the neeting and the motion moved and passed that the executive take office, be esponsible for drawing up a constitution to be ratified by Council and presented to the area members along with a ballot for acceptance or rejection.

Port Credit

At a meeting March 24 the branch received its charter from President Dick. Members and their ladies were invited as well as members from the Hamilton, Kitchener, Niagara Peninsula, Oakville and Toronto branches. Dr. Dick, also the guest speaker, gave an address entitled "The Future of Canadian Engineering". He was introduced by W. L. Hutchison, and thanked by T. H. Rosborough.

Saguenay

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

J. J. Gagnon, Manager, Industrial Relations Division, the Aluminum Company of Canada Limited, addressed a joint meeting of the E.I.C. and C.P.E.Q. April 21. Speaking on personnel administration the speaker maintained that the ultimate objective is this field is to have each person who directs the work of others become a good personnel administrator. This applies to many groups of professional people, the engineer, the accountant and the chemist, for example. The speaker went on to cover the essential elements of personnel administration, the responsibility of the personnel administrator, the necessity for collective bargaining and unions, labor relations and human relations as applied to a large company.

Saint John, N.B.

G. A. Phinney, JR.E.I.C.
Correspondent

Fifty members were present on March 21 to hear M. F. Rodman give a talk on his experience in Pakistan while working on the Warsak Dam, built under the Colombo Plan. He discussed the technical problems encountered in building this project and illustrated his words with slides. The problem of organizing a work force in a country lacking trained personnel was considered. The point that received the greatest attention, however was the adjustments engineers and personnel from a western culture had to make to an eastern culture. Though the engineer is there to fill a technical position he is in fact the local ambassador of good will. This fact highlighted the engineer's need of a liberal education. Though the Canadians who worked on the project were technically equipped for their job they were not prepared for many of the social problems encountered. He wondered if Canadians going to work abroad might benefit from a training program to help prepare them for life in other lands. A question period followed Mr. Rodman's talk.

P. W. Hastings, branch chairman, outlined the program for the balance of year.

John D. Cunningham, Assistant General Manager of the New Brunswick Telephone Company, discussed "The Evaluation of Management Resources" at the April 10 meeting. This talk was one in a series on professional development, a concern of the branch.

Mr. Cunningham said that as the workings of a business or company become more complex the need for well qualified supervisors is a serious problem facing management. A company must assist in the training and development of its management personnel. In a company, such as the one with which Mr. Cunningham is associated, an employee is rated on his work performance, by his supervisor during an annual appraisal and finally by a group which reviews his work and decides whether he is ready to advance. Though many firms use psychological tests to evaluate the potential of an employee, Mr. Cunningham felt that supervisors and fellow workers could better evaluate his qualifications for a management position. He urged the engineer to avoid becoming complacent and to strive to improve himself if he wanted to rise to the top of his company. Following a controversial discussion, Phil Hastings, branch chairman, thanked the speaker.

Sarnia

Joseph P. Zanyk, JR.E.I.C.
Correspondent

The March 15 meeting was a joint meeting of the CIC and EIC branches. Members of both institutes heard Dr. I. A. Johnson's address on Analog Computers. Dr. Johnson, an Associate Professor of Chemical Engineering at the University of Toronto, dealt with typical industrial problems that can be solved using analog computers. After writing the differential equations needed to solve these problems, the speaker outlined the programming of an analog computer. At the conclusion of the talk, a film made by Dr. Johnson was shown. It illustrated the actual solutions to a number of problems as done by an analog computer.

Brian G. Shellon, Publisher and General Manager of the Sarnia Observer, was the featured speaker at the April 26 meeting. His address was entitled "Functions of a Newspaper in the Community". After a brief history of printing, and of the Sarnia Observer, Mr. Shellon described the purpose of the newspaper in the community. The newspaper's responsibility to its readers is to report the news as it happens and to make sure the coverage is as wide and as factual as possible. The newspaper editorial is the only place to properly take sides on an issue, to criticize or to comment. Mr. Shellon was introduced by Harold Page and thanked by Frank Dyer. R. Young gave a brief report on the recent Regional Conference held at Niagara Falls. The branch was well represented at this conference.

Vancouver

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

The Section Program concluded in April with the following speakers and talks:

Civil Structural Section:

"Ocean Cruising Under Sail" by G. Palmer, Manager for John Brandlmayr Ltd., Consulting Engineers and Naval Architects.

Management Section:

"Municipal Taxation and Financing of Capital Works" by B. McCafferty, Municipal Treasurer, The Corporation of the District of Burnaby.

Natural Resources Development Section:

"Economics of Resource Development" by Ian Mahood, B.C.R.F., Assistant to the President, Council of the Forest Industries of British Columbia.

Mechanical Section:

"Feasibility Studies for the Canadian Nuclear Power Reactor Program and some of the Design Problems Considered" by Norman Williams, M.E.I.C.

The Annual Meeting of the Vancouver Branch was held April 19. Guest speaker was Ralph C. Pybus, Chairman of the Greater Vancouver Industrial Development Commission who chose as his topic "The Industrial Development Commission".

Members of the executive for 1961-62 are: Chairman, C. H. White; Vice-Chairman, D. R. Bakewell; Secretary, T. C. Covello; Treasurer, L. A. Broddy.

Executive members elected for a two year term are H. R. Brownell, P. S. Jagger, A. A. Kay, C. F. Ripley, and H. R. Wright. Two members are on the executive as they were elected to a two year term at the last Annual Meeting. They are S. W. Faliszewski and A. W. Greenius. Ex-officio members are: Past Chairman, J. H. Swerdfeger; Past Secretary, R. Clough, all Technical Section chairmen, and the two Councillors of the Vancouver branch.

Vancouver Island

W. Tivy, M.E.I.C.
Correspondent

Harry Hunter, meteorologist for the Water Rights Branch of the British Columbia Government gave a speech entitled "Snow Surveys and their Use in Forecasting Stream Flows" at the March 22 meeting. According to the speaker between 75% and 85% of the flow of B.C. rivers comes from snow melt. Therefore the volume of water released to streams during spring and summer can be predicted by measuring the depth and water content of mountain snows before melting starts. Knowledge of this runoff is important to planning groups in fields such as flood control, hydro-electric power and irrigation. Readings at the 109 snow courses, which have been established throughout the Province, are taken Feb. 1, Mar. 1 and April 1. Most measuring stations are at high elevations and can be reached by ski, snowshoe, plane or helicopter. A film, showing how a two man snow-survey team obtains a set of readings and how the results are used, followed the talk.

Winnipeg

A. C. Warrender, M.E.I.C.
Correspondent, Electrical Section

At a meeting held March 2, C. Gillespie, Supervising Engineer, Radio Relay Systems, Manitoba Telephone Systems, gave a talk entitled "Scatter Systems in Northern Manitoba". The speaker gave a brief description of Tropospheric Scatter and the two more common forms of communication, "Line of Sight" and "Diffraction". He pointed out that scatter is well suited to Northern Manitoba where towns are widely separated and traffic is not heavy. The present Manitoba Telephone System link between Cranberry Portage and Thompson which consists of a diffraction system between Cranberry Portage and Snow Lake and a scatter hop from Snow Lake to Thompson was discussed in detail. In conclusion, the speaker indicated that the scatter system would be replaced by a Line of Sight system as traffic grows heavier. The scatter equipment would be then moved north to accommodate our own expanding frontier, he said.

The Electrical Section held a smorgasbord and dance April 28 which was attended by 160 members and guests.

At the Annual Meeting the Executive for the 1961-62 year was elected. The members are: A. S. Williams, Past Chairman; D. C. Bryden, Chairman; T. L. Woodhall, Vice-Chairman; D. E. Haig, Executive Member; T. J. Erskine, Executive Member; R. M. Fraser, Secretary Treasurer; A. C. Warrender, Papers Chairman; P. Brett, Reporter.

M. Mindess, M.E.I.C.
Correspondent, Civil Section

"Cement Treatment of Soils" was the title of the talk given by E. J. Buss, Sales Engineer, Canada Cement Company, Toronto, at the April 13 meeting. The speaker dealt mainly with the method of cement stabilization of soils for road subases or base courses and he referred to other applications, such as lining irrigation ditches and reservoirs. Various methods of applying cement, proper compaction techniques and the importance of a proper curing membrane (usually an asphalt emulsion) were discussed. The laboratory test program was also explained in great detail. All phases of the talk were illustrated with slides. Following a film, a question and answer period was held.

W. A. Johnson, chairman of the meeting, announced that the Executive Committee of the branch hopes to give impetus this fall to a professional development program. This would include not only engineering subjects, but also commerce and the humanities. This program was discussed with President Dick on his recent visit to Winnipeg.

May 3 was the date of the inaugural meeting of the Joint Winnipeg Soil Mechanics — E.I.C. Soils Group. Thirty-four people attended. Prof. Mindess, chairman of the meeting, described the operation of other groups in Montreal, Ottawa, Toronto and Vancouver and indicated some of the activities which are planned. J. J. Hamilton, Research Officer, National Research Council, addressed the group briefly and stated that the N.R.C. Division of Building Research would co-operate fully with the new group. Prof. A. Barracos presented a paper entitled "Winnipeg — Foundations and Building Codes" which dealt with the limitations in the existing ones, the proposed new national code and his own suggestions for further research and field testing required to improve the foundations sections of these codes.

Assumption University of Windsor

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

At a meeting held April 11 the results of the elections for the 1961-62 executive were announced. They are as follows: Chairman: John Lindsay, Vice-Chairman: Richard Findlay, Secretary: Ron Burns, Treasurer: Ken Long, Chemical Representative: Ludwig Khoubessarion, Civil Representative: Mike Prince, Electrical Representative; Lorn Grale, Mechanical Representative: Joe Skoropinski.

Through I.A.E.S.T.E. John Lindsay, Bruce Jacques, Dave Peach and Hubert Arnowitz have arranged positions in England, Wales and Germany.

Ken Long will represent the student chapter at the student conference at the Annual General Meeting in Vancouver while Garry Dunlop will represent the Undergraduate Engineering Society there.

Carleton University

Robert F. Alexander, S.E.I.C.
Correspondent

A. B. Hunt, executive vice-president of the Northern Electric Company's Ottawa Research and Development Laboratories, gave a talk entitled "An Explosion in Technology" at the March 24 meeting. He discussed the effects of technological advancement in the previous century. Cited were examples in technical production. Mr. Hunt discussed the large number of technical publications now available. John Buchan, a member of Carleton's first graduating class introduced the speaker who was thanked by George Saunders, a third year Engineering student.

Steins were presented to the graduating class by Dr. John Ruptash, Director of the School of Engineering on behalf of the Engineering Society.

* * *

Approximately 100 members of the **HALIFAX BRANCH** toured television station CJCH April 19. Fifty couples attended the Ladies Night Dance of the **KITCHENER BRANCH** April 14. "Power for Carol" was the title of an address given to the **NORTH SHORE LOWER ST. LAWRENCE BRANCH** at a recent meeting. The speaker outlined the development of the power site at Twin Falls, Labrador. He was introduced and thanked by Bob Prior. The annual dance of the **NEWFOUNDLAND BRANCH** was held April 18. A highlight of the evening was a comedy staged by the Engineers' Wives Club. April 20 was the Annual Career Panel Discussion Night for the **NIAGARA PENINSULA BRANCH.** A panel of four engineers discussed three questions of interest to the Grade 13 members who attended. The **UNIVERSITY OF MANITOBA BRANCH** elected its executive at a noon hour meeting March 16. Ray Roscoe, Chairman for the coming year and Bill Fisher, a delegate from the Engineering Society will represent the University of Manitoba at the Annual General Meeting. EIC

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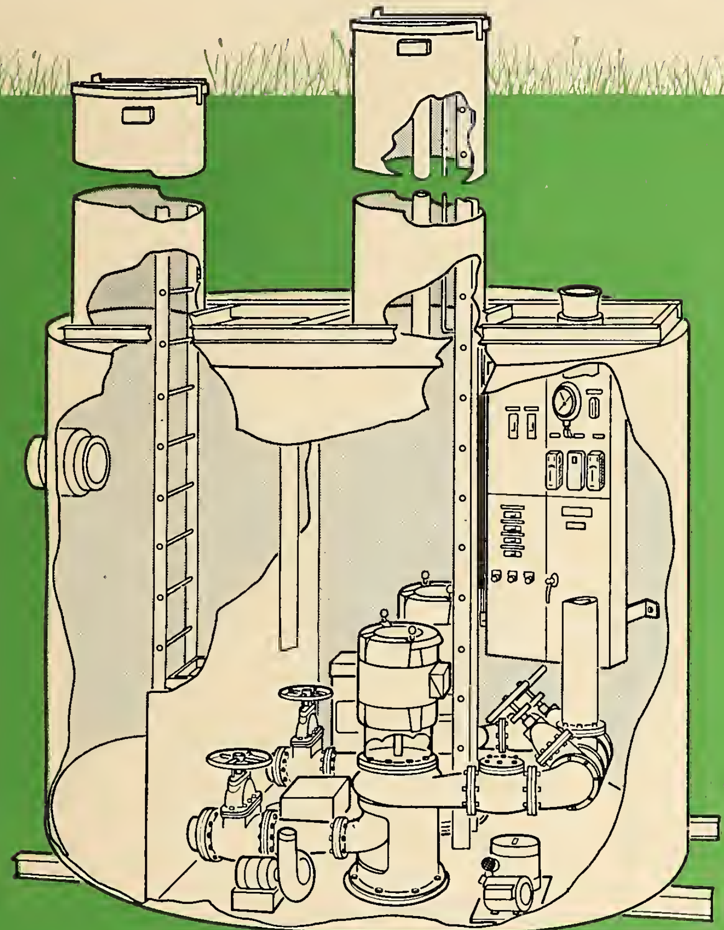

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• DISCUSSION

(Continued from page 78)

set up by the Government of Canada in 1950, was instructed to "report on measures for the reduction of the flood hazard in the Greater Winnipeg area". A comprehensive engineering report was prepared on the nature and causes of periodic flooding on the Red and Assiniboine Rivers and preliminary plans for a number of flood control schemes were set out. For the Assiniboine River, the proposals were based on results of a parallel study of a rather broader scope carried out by the Prairie Farm Rehabilitation Administration of the federal Department of Agriculture. The report of the Red River Basin Investigation, presented in October 1953, did not include a study of economic benefits.

In December 1956, the Province of Manitoba set up the Royal Commission on Flood Cost-Benefit to determine whether the economic benefits of various flood control works designed to reduce or prevent flooding in the Red and the Assiniboine River basins would justify the costs of these projects.

In his paper, Mr. Templeton has provided a brief background of the history of flooding in the Greater Winnipeg area and has reviewed the essential features and effects of the various flood protection projects considered. Although the paper is directed to a benefit-cost analysis of the Greater Winnipeg floodway, the author has presented some of the main features of the technique used in this particular case without discussing some of the more important principles and assumptions in a benefit-cost study, except to state:

> "A benefit-cost analysis is the comparison of the dollar benefits which a project would produce for each and every year of the life of the project versus the dollar costs per year of the project. If everything is brought down to an average annual benefit versus an average annual cost, there is no problem in determining whether the project is economically feasible".

However, the analysis is not as simple as this statement would indicate.

One of the major problems in such an analysis is the determination of benefits. Primary benefits of flood control may be measured by taking into account: (i) the value to be derived from reduction or prevention of flood damage, based on the estimate cost of replacing or rehabilitating damaged property; (ii) reduction or elimination of costs of emergency measures such as flood fighting and flood relief; and (iii) increased net incomes resulting from more profitable land uses in the protected area. A distinction should be made, however, between benefits arising from damage prevention and those resulting from changes in land use, to avoid double counting in the analysis.

Secondary benefits may arise from other activities, such as the processing of products and services which are directly affected by floods. Such benefits are represented by the difference in net income of these activities with and without the project. The estimate of net income without the project should make allowance for other measures which would be undertaken to avoid losses in these activities. Computed on this basis, secondary benefits of flood control projects will generally be very small in comparison to primary benefits.

Consideration of intangible benefits of flood control is of great importance. Such factors as loss of life, and impairment of health, are not amenable to monetary evaluation yet they are crucial considerations in flood control programmes.

A project is considered to be economically feasible if it meets the following requirements: (i) the benefits of the project exceed its costs; (ii) each separable segment or purpose provides benefits at least equal to its costs; (iii) the scale of development is such as to provide the maximum net benefits; (iv) there is no more economical means of accomplishing the same purpose.

To meet these requirements it is necessary to make a number of basic assumptions in the analysis: (i) a comprehensive public viewpoint is assumed, so that the analysis should include consideration of all beneficial and adverse effects which occur within the project's zone of influence; and (ii) a monetary basis of valuation is assumed in order to permit expression of the various effects of the project in common terms. Generally, a market value can be attached to most project effects. In addition to such "tangible effects" there are "intangible" or "extra-market values" such as improvement of health, saving of life, etc., which must be considered if a comprehensive public viewpoint is assumed in the analysis.

The usefulness of the report of the Royal Commission on Flood Cost-Benefit, on which the author has based his paper, is not confined to evaluating the economic aspects of flood protection schemes for the Red River basin. Other agencies will be able to benefit from the experience of the Commission and may add refinements to the techniques which it has used. The Commission is to be highly commended in its use of the incremental benefit-cost analysis which is geared to project formulation rather than towards project justification.

Although the rule that benefits exceed costs is a necessary condition, it is not sufficient reason for undertaking projects nor does a benefit-cost ratio equal to or greater than 1:1 necessarily justify development. Investment in projects should proceed to the point where net benefits are at a maximum. Beyond that point further investment cannot be justified on purely economic grounds. In other words, developments should be formulated and evaluated in such a way that the excess of benefits over costs is maximized rather than that the largest possible benefit-cost ratio is achieved.

In Fig. 11, there is shown the benefit-cost ratio of the three recommended projects, separately and in combination. These projects together would provide protection to the Greater Winnipeg area from a flood flow of 169,000 c.f.s. In his comments, the author states that the Commission attempted unsuccessully to determine what degrees of flood protection had been provided for other cities. In matters such as these, there can be no single criterion defining the degree of protection to be provided to an urban area. However, it would be interesting to learn whether or not the recommended projects constitute the economic limit of flood protection to the Greater Winnipeg area.

Benefits of the flood protection measures considered by the Royal Commission on Flood Cost-Benefit are represented by the property damages and losses of income which the projects prevent.

Property damages were estimated from records of the Red River Valley Board and the Manitoba Flood Relief Fund, supplemented by data gathered by the Commission. Property damages are direct losses which, in general, are readily identfiable and measurable. According to the proportions shown in Fig. 9, property damages constitute from 60-70% of the total losses which would result from a major flood in the Greater Winnipeg area.

Loss of income also results from major floods through a reduction in output and a reduction in payments to factors employed in economic activities both within and beyond the flooded area. According to Fig. 9, the estimates of loss of income which would be caused by three major floods range from 25-30% of the total estimated losses. In making estimates of such income losses, however, it is important to ensure that the loss can, in fact, be attributed to the flood and is not offset elsewhere in the economy. Within the flooded area there will be certain losses of income which can be directly attributed to the flood. These losses include loss of wages and salaries of workers who are unable to secure alternative employment, and loss of income to other factors of production which are unemployed as a result of the flood. Such losses constitute a genuine loss of national income. Their elimination can therefore be regarded as benefits accruing to flood protection measures. Some losses of income in the local area, however, may be offset by gains in other sectors of the economy. Where such offsets occur they should be deducted from the estimates of income losses. For example, not all persons who are displaced from their normal occupations will remain idle. Some will be employed in alternative activities either within the flooded area (for example, in flood fighting and rehabilitation), or outside the flooded area. Similarly, reduced production in the flooded area may call into use idle capacity elsewhere in the economy. Again, while individuals incur the costs of evacuation and extra costs of transportation, certain transportation concerns may profit thereby; the extra income they derive should be regarded as an offset to these costs. Because the Royal Commission confined its attention to the local area and because it does not identify primary and secondary effects, it is possible that from a national standpoint the estimates of income losses furnished by the Royal Commission may be overstated.

Benefit-cost analysis is only one of several criteria which may be used in the evaluation of projects. Policy makers may decide for or against a development on the basis of several factors; the benefit-cost ratio should be one of these but other, less tangible benefits or detriments to the users and to society at large also will have to be carefully considered. As a result, it may be that a development having a favourable ratio of benefits over costs may be rejected or one having an unfavourable ratio accepted. In either case the decision may be quite justifiable on the basis of factors which cannot be included in the ratio.

There is a need to develop standard principles and procedures governing benefit-cost analysis and I understand that an effort is now being made to define such principles and procedures which can be used by different groups and agencies throughout Canada. This is one of the matters which will receive careful consideraiton at the forthcoming National Conference on "Resources for Tomorrow".

Discussion by W. D. Hurst, M.E.I.C.

Having been closely exposed to the Winnipeg flood for some 8 to 10 sleepless weeks in 1950, it is now a pleasure, looking back on those perilous days, to know that careful documentation of remedial measures have been undertaken by both the Red River Investigating Commission, and the Royal Commission on Flood Cost Benefit, 1958.

When the Royal Commission on Flood Cost Benefit made its report, the Commission stated that it "had made a careful study of the cost and feasibility of a flood insurance programme and concluded that

(1) A self-sustaining flood insurance plan is not practical or feasible either on a governmental basis or by the insurance industry;

(2) That an assistance fund should be established and should be supported by federal, provincial and municipal governments in the same proportion as now applies in disaster relief throughout Canada and that for the upper Red River Valley such a fund would require:

(a) A capital sum of $16 million on 4% interest.

(b) Annual payments of $75,000 per annum.

I believe that there was in this community a great deal of public opinion following the flood of 1950 that an insurance program should be set up. This follows public opinion elsewhere where such measures have been suggested. The Insurance Executives Association of New York, reporting on the problem of floods and flood damage, said in 1952: "Even though flood has been one of the oldest threats historically confronting human endeavours, the insurance business has not been able to devise a method of providing specific flood insurance coverage on a basis acceptable to the public and at the same time according to sound insurance principles." It was noted by the insurance executives that except for policies covering bridges, tunnels and fixed property of a kindred nature virtually all these present forms of insurance which include flood coverage have one thing in common, that is to say, they cover property mobile in character which presumably has a chance of being moved out of danger when flood threatens.

In order to establish the validity of the opinions held, the Insurance

Executives Association retained the firm of Parson, Brinckerhoff, Hall and Macdonald, Engineers of New York City to prepare a technical report on this subject. The results of the studies made by this firm of engineers in 1952 showed that specific flood insurance would be prohibitive in cost except possibly in cases of businesses in high tax brackets which could use the cost of flood insurance as deduction for tax purposes. Cost estimates of the average annual physical damages to property in the United States due to flood varied between 110 million to 466 million dollars per year. The catastrophe potential of such an undertaking would be so great as to threaten the solvency of the entire property insurance business and it seemed doubtful that the aggregate net free assets of all insurers would be adequate to withstand the constant the constant drain of the recurrent catastrophe losses that would be inherent in flood insurance.

The Executive concluded that "to the experienced insurance mind the flood peril presents the same source of unpredictable widespread devastation and destruction that we associate with modern war damage, and the same considerations which prompted the business of insurance to refrain from assuming liability for war damage to property on land during the second World War also to floods.

The Executives felt that "because of the virtual certainty of the loss, its catastrophic nature, and the impossibility of making this line of insurance self-supporting due to the refusal of the public to purchase such insurance at the rates which would have to be charged to pay annual losses, insurance companies generally could not prudently engage in this field of underwriting."

The question of government insurance was then examined and the Executives believed that for the same reasons that private underwriters cannot undertake to provide specific flood indemnity by means of insurance measures it follows that the government likewise could not undertake to provide specific flood indemnity and that there is no reason to believe that the Government would encounter fewer obstacles to such an undertaking than would private insurers.

I have again raised this question of flood insurance because it seems to die a slow death and Mr. Templeton did not happen to note in his paper that the Royal Commission on Flood Cost Benefits, to whom he acted as Consultant, did in fact give this problem very careful consideration and that their conclusions are in line with the conclusions quoted above made by the Insurance Executives Association.

The Royal Commission examined the work that had been done in Canada and in the United States with respect to the methods of determination of flood cost-benefit ratios. Most of the work has been carried out in the United States by the U.S. Army Corps of Engineers and I understand that the conclusions in general arrived at by the Corps of Engineers were those employed by the Royal Commission on Flood Cost Benefit. I think it should be said that we owe a great debt to the U.S. Army Corps of Engineers for pioneer work in this field.

The determination of average annual benefits and of average annual costs is, of course, the key to the problem. Edgar E. E. Foster* defines what the United States Corps of Engineers regard as flood losses and benefits. He concludes that loss may be defined as those losses arising from the following exigencies:

1. Any destruction or damage caused by a flood to the existing real or personal property of the community.

2. Loss of earnings — or loss of services.

3. Increased expense of usual operations.

4. Diminution of capital value of real estate.

5. Expenditures caused by the flood emergency or the threat of flood.

The method of computing the flood loss is in accordance with mathematical expectancy reduced to an annual basis as expressed by the formula

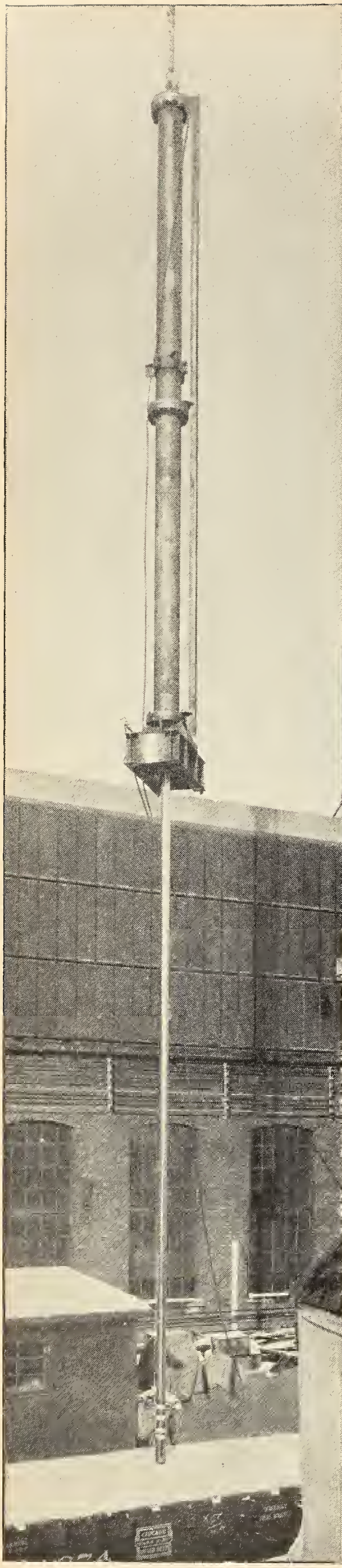
$$A = p \times D$$

where A is the annual flood loss, p the probable number of floods per annum, and D the total damage caused by the flood.

The equation, of course, is the well known mathematical expectancy of payment or cost of a chance event.

The Royal Commission on Flood Cost Benefit has apparently followed this method for they have prepared frequency damage curves and have totalled the damages from all causes as shown in figure 18 in Mr. Templeton's paper. They have employed the principle, also accepted elsewhere, that incremental damages result immediately upon the flooding of each floor level and they have ingeniously worked out the damage in percent of

* Foster Edgar E., Evaluation of Flood Losses & Benefits. Trans. Am. Soc. C.E. Vol 107, 1942 pages 871-894.



market value, not only for incremental damages by floor levels but by the depth of flooding above each level.

I would be interested to know if the 5 categories of flood losses taken, referred to by Mr. Foster were taken into account by the Royal Commission. I believe the Commission was wise in not taking into account intangibles, and particularly so due to the fact that a case could be so easily made for remedial measures without bringing into the calculations matters that could do nothing but raise controversy. I wonder also if the Royal Commission made any estimates of probable loss of life in future floods and if so what monetary allowance were made in respect thereof?

The second step, of course, to be taken is a calculation of the cost of the remedial measures to be taken. It would be presumptuous on my part to criticize the unit costs for the various classes of work as were developed by the Commission. These were developed after intensive study and I believe can be regarded as being as substantially correct as engineers are able to make them.

Mr. Templeton does illustrate, however, an important point and that is the necessity of having the most accurate costs possible. To illustrate this he has pointed out that the difference of one cent per cubic yard in the cost of common excavation means a total difference in the cost of the job of One Million Dollars. It will be seen, therefore, how much care must be taken in the development of realistic costs.

Dividing the benefits by the cost gives the ratio which in the case of the Greater Winnipeg Floodway is a very satisfactory ratio indeed.

The benefit-cost study method provides a most useful tool in engineering economic studies and has wide application for the method is not at all confined to the solution of flood problems and it can be most usefully employed by the engineer in comparing the annual costs and benefits accruing from the proposed construction of many engineering projects. By this method one may also make economic comparisons of one project against another or others.

Author's reply

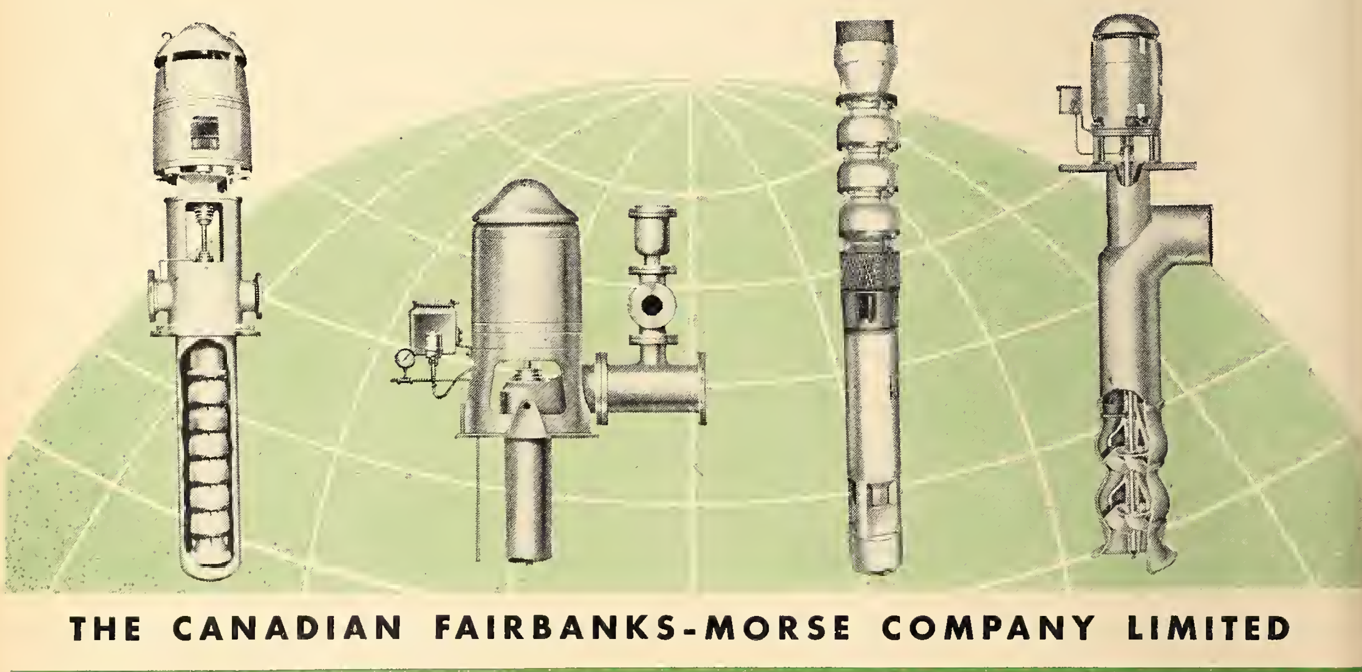
Mr. Clarke is quite right when he states that the Commission used the incremental benefit-cost ratio to determine how large a floodway should be. This means that if, by increasing the size of a floodway, the benefits attributable to the increased size are greater than the costs of the increased size, then the larger size is justified. If the incremental benefit-cost ratio is less than 1, then the increased size is not justified.

As an example, a 60,000 c.f.s. floodway, acting in combination with other projects, had a benefit-cost ratio of 2.7. An 80,000 c.f.s. floodway had a benefit-cost ratio of 2.4. However, the incremental benefit-cost ratio, in increasing the size from 60,000 to 80,000 was only 0.8. Therefore, the 80,000 c.f.s. floodway was not economically justified, even though the benefit-cost ratio of the combination was 2.4.

The incremental method is not universally accepted, but in my opinion, was the correct method to use in this case.

Mr. Hurst asked if the five categories of flood losses referred to by Mr. Foster were taken into account in this study. Number 4 — "Diminution of capital value of real estate" was not taken into account because this was considered an "intangible".

Mr. Hurst's comments on Flood Insurance are well taken. To be an economic type of insurance, it would have to be nation-wide because an insurance fund for a local area, or even a province, might well be exhausted in a single flood. National coverage would probably have to be subsidized by the government to make it acceptable to people living on high ground. Governmental subsidy would probably encourage the settlement of areas likely to be flooded. EIC



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.

SURVEY OF MINES, 1961.

The 35th annual edition of this basic reference book on Canadian mining includes, in addition to its usual features, 28 pages of maps showing holdings in the main Canadian mineral areas. The Survey contains all the information required by anyone interested in investing in a Canadian mining company. (Toronto, Financial Post, 1960. 366p., $4.00.)

*SEMICONDUCTOR ABSTRACTS, VOLUME VI, 1958.

This annual compilation of abstracts of literature on semiconducting and luminescent materials and their applications is a cooperative effort of the Battelle Memorial Institute, the Electrochemical Society, and the Air Force Office of Scientific Research. It covers material published up to the end of 1958, including some references to much earlier publications not previously abstracted. The subject index is more complete than in preceding volumes. (Ed. by J. J. Bulloff and C. S. Peet. New York, Wiley, 1961. 528p., $14.00.)

*FUEL CELLS; POWER FOR THE FUTURE.

This is a technical and economic analysis of developments and opportunities in electrochemical fuel cells. Five engineering and four liberal arts graduates formed the research group which prepared this report at the Harvard University Graduate school of Business Administration. The report is composed of a description of the fuel cell, its electrochemical processes, limitations, advantages, and criteria for evaluation; examination of conventional fuels, reserves, and consumption rates; and performance and economic analysis of present and expected fuel cells, with their use in mechanical and electrical power applications. (D. R. Adams and others. Cambridge, Fuel Cell Research Associates, 1960. 160p., $18.75.)

*IMPACT.

Based on the author's lectures at the University of California, this book summarizes the more important contributions to the theory of impact. Intended as a reference source or advanced text in applied mechanics, and some areas of applied mathematics and physics, it requires knowledge of partial differential equations, operational calculus, and elasticity. The first chapter describes the nature of physical impact and gives a brief history of the study of impact phenomena. Chapters 2-5 discuss the dynamics of impact, employing mathematical analyses in the process. Lack of space prevents inclusion of complete derivation of some of the analytic relations, but extensive references are given to pertinent sources. Chapter six contains the results of experiments designed to substantiate various theories of impact, and the final chapter describes the behavior of materials under conditions of dynamic loading. (Werner Goldsmith. Toronto, Macmillan, 1960. 379p., $15.25.)

*INTERNATIONAL CONFERENCE ON NUCLEAR STRUCTURE, PROCEEDINGS.

Nearly 500 scientists from all over the world attended the conference held in Kingston, Ontario, in August-September, 1960. Three hundred research contributions were received at Conference headquarters. Just five weeks after the Conference this volume was published, containing 127 of the papers received, and a list with abstracts of all of the contributions. The topics covered by the published papers include the physical foundations of nuclear models, properties of nuclear matter, nuclear reaction mechanisms, properties and statistics of nuclear levels, and fission. (Ed. by D. A. Bromley and E. W. Vogt. Toronto, University Press, 1960. 990p., $16.75.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*ULTRASONICS AND ITS INDUSTRIAL APPLICATIONS.

This is a translation of a Moscow State Press publication of 1958. After a brief review of the development of ultrasonic technology, the propagation, generation, and absorption of ultrasonic oscillations is described in detail. The remainder of the book deals with specific ultrasonic techniques — in flaw detection, investigation of the microstructure of metals, physical-chemical analysis, machining hard and brittle materials, aluminum soldering and plating, and cleaning operations. The final chapter discusses the metallurgical effects of ultrasonic processing, and the utilization of these effects in improving the structure of a metal. (O. L. Babikov. New York, Consultants Bureau, 1960. 224p., $9.75.)

*PROGRESS IN DIELECTRICS, VOLUME 1.

Intended for technologists in the many diversified areas utilizing dielectrics, this volume is the first of a planned series of annual reviews in the field. In electrical engineering the behavior of insulating materials under a wide range of operating conditions, electrochemical deterioration, and tests for insulation are of interest. The first articles deal with dielectric breakdown and insulating properties of solid, liquid, and gaseous dielectrics, and directional breakdown effects in crystals. Subsequent papers treat ferroelectricity, non-oxide ceramics, and the theory of electro-phoretic deposition of insulation. (Ed. by J. B. Birks. London, Heywood, New York, Wiley, 1959. 312p., $11.00.)

*PROGRESS IN DIELECTRICS, VOLUME 2.

The main theme of this volume is dielectric properties in weak electric fields. An introductory survey is given in a paper presenting the theory of dielectric polarization and absorption. Next a

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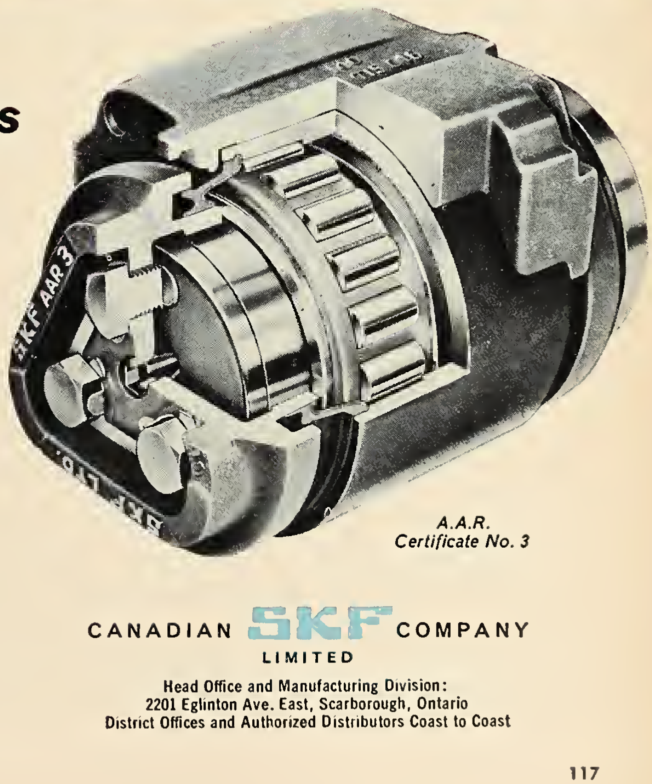

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TECHNICAL BULLETINS & PAMPHLETS RECEIVED

Space limitations do not enable us to record these in the Library Notes. A mimeographed list of the Bulletins and Pamphlets received during the last month is available free on request to the librarian.

detailed review and comparison of the dielectric properties of polymeric systems is presented, followed by a discussion of the present state of knowledge of the physico-chemical effects of radiation on high polymers. Then two papers discuss inorganic dielectric materials, one, the dielectric properties of glass, and the other, high-permittivity ceramics. The final paper reviews artificial dielectrics, arrays of conducting and non-conducting elements for use where conventional dielectrics are unsuitable. (Ed. by J. B. Birks. London, Heywood, New York, Wiley, 1960. 225p., $9.50.)

PRACTICAL NUCLEONICS.

Sub-titled "A course of experiments in nuclear physics", this text for advanced students contains forty-nine experiments concerned with nuclear physics, radioactivity, and the detection and measurement of nuclear radiations. The experiments are grouped by subject into chapters, each of which contains an introductory section describing the topic of the chapter. The subjects covered include health hazards, physical constants, electroscope experiments, geiger counting, and neutron counting. (F. J. Pearson and R. R. Osborne. London, Spon, 1960. 208p., 37/6.)

HYPERSTATIC STRUCTURES: vol. 2. WORKED EXAMPLES . . .

The first volume of this work, reviewed in our May 1960 issue, covered the theory of hyperstatic, or statically indeterminate, structures. his second volume contains worked examples, and problems to be worked, to enable the student to apply the theorems explained in volume 1, and in general follows the order of the first volume. (J. A. L. Matheson and others. Toronto, Butterworth, 1960. 282p., $11.00.)

INDUSTRIAL MANAGEMENT GUIDE BOOK SERIES.

A series of fourteen guide books to be issued by this publisher on various topics which have not previously been extensively covered. The books can be used in company training programmes, and each includes basic principles which can be adapted to any company. The authors are both on the staff of the Management Institute in New York.

The volumes received so far deal with Applied industrial psychology; Human relations in industry; A Guide for maintenance supervisors; Preventive maintenance; Work simplification. (B. T. Lewis and W. W. Pearson. New York, Rider, 1960-61. Each vol. less than 100 pages, cost $1.25 to $1.50 each.)

MANUFACTURING PROCESSES IN CANADA.

A description of manufacturing processes in some seventeen industries in Canada, ranging from aluminum, through brewing, detergents, textiles and tobacco to wire and cable. Each industry is described by someone connected with it, and for each are given details on obtaining and preparing raw materials, in-plant processing, packing and shipping. Flow charts, illustrations and diagrams are used to advantage. (Ed. by K. C. Livingston and T. C. Graham. Toronto, University Press, 1960. 304 p., $10.50.)

NATIONAL DIRECTORY OF THE CANADIAN PULP AND PAPER INDUSTRIES, 1960-61.

Thoroughly revised from the latest government and company reports available, the Directory contains statistical information on the various sections of the industry in Canada. Detailed information on location, personnel, equipment, production, etc., is given for the

(Continued on page 129)

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FACULTY OF AGRICULTURE UNIVERSITY OF ALBERTA — Applications invited for position of Assistant Professor in the Department of Agricultural Engineering, University of Alberta, at a starting salary of $7,500 per annum with excellent prospects for advancement. Duties to commence September 1st, 1961. Initially, duties will include undergraduate teaching and participation in Operations Research activities and their application to practical agricultural problems. Candidates should have training in Operations Research techniques and should be familiar with modern computational methods. Preference will be given to candidates with an advanced Industrial Engineering degree, or equivalent, who possess a farm background.

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• LIBRARY NOTES

various pulp, paper and paper board mills in Canada. Other sections include classified listings of pulp and paper manufacturers; and of manufacturers of converted paper products, and information on various organizations connected with the industry. As always, the Directory is an essential for anyone connected with the industry. (Ed. by J. N. Stephenson. Gardenvale, National Business, 1960. 534p., $7.00.)

LANDSLIDES AND RELATED PHENOMENA.

A reprint of the 1938 edition, which has long been out-of-print, and which is still a valuable reference on landslides, although much work has been done on them in the intervening years. The book covers the significance and types of mass movement, slow and rapid flowage, the various types of landslide, and subsidence and its causes. It is unfortunate that advantage of the reprinting could not have been taken to bring the useful bibliography up-to-date. (C. F. Stewart Sharpe. Peterson, N.J., Pageant Books, 1960. 137p., $5.00.)

PRODUCTION OF WIDE STEEL STRIP.

The report of a symposium on this subject held in London in May 1960, at which papers were given covering present practices in Europe and the United States.

Two papers discuss the future requirements of the tinplate and automotive industries, and the remaining fourteen papers cover: steelmaking for wide strip; hot rolling of wide strip; cold rolling and heat-treatment of wide strip; coatings on wide strip. The discussions which followed the papers are also included. (London, Iron and Steel Institute, 1960. 187p., £3.5.)

CONCRETE MATERIALS AND PRACTICE, 3rd. ed.

Revised to include the latest advances in technique, the object of this British book is to give a broad outline of the science of concrete making. After a chapter on the properties of concrete, the materials and techniques of concrete making are covered, including preparation and joints, placing, compaction and curing. There are also chapters on prestressed and precast concrete, road construction, piles, lightweight concrete, and quality control, inspection and testing. Reference throughout is to British Standards, and a useful bibliography is included. (L. J. Murdock. Toronto, Macmillan, 1960. 392 p., $8.50.)

BUILDING WITH STEEL.

Based on courses given by the author, this text covers both the design and erection of steel buildings. Under Design are considered beam and column design, riveted, bolted and welded connections, trusses, plate girders and rigid frames. Two chapters deal with detailing drawings for riveting, bolting and welding.

The chapters on erection cover shop practice, methods of fastening, erection procedure, and the use of steel prefabricated components, such as curtain walls, doors and windows. The author has given the text continuity by studying the framework of one multi-storey building throughout. (D. A. Halperin. Chicago, American Technical Society, Toronto, General, 1960. 254p., $6.00.)

PHOTOGRAMMETRY: BASIC PRINCIPLES AND GENERAL SURVEY.

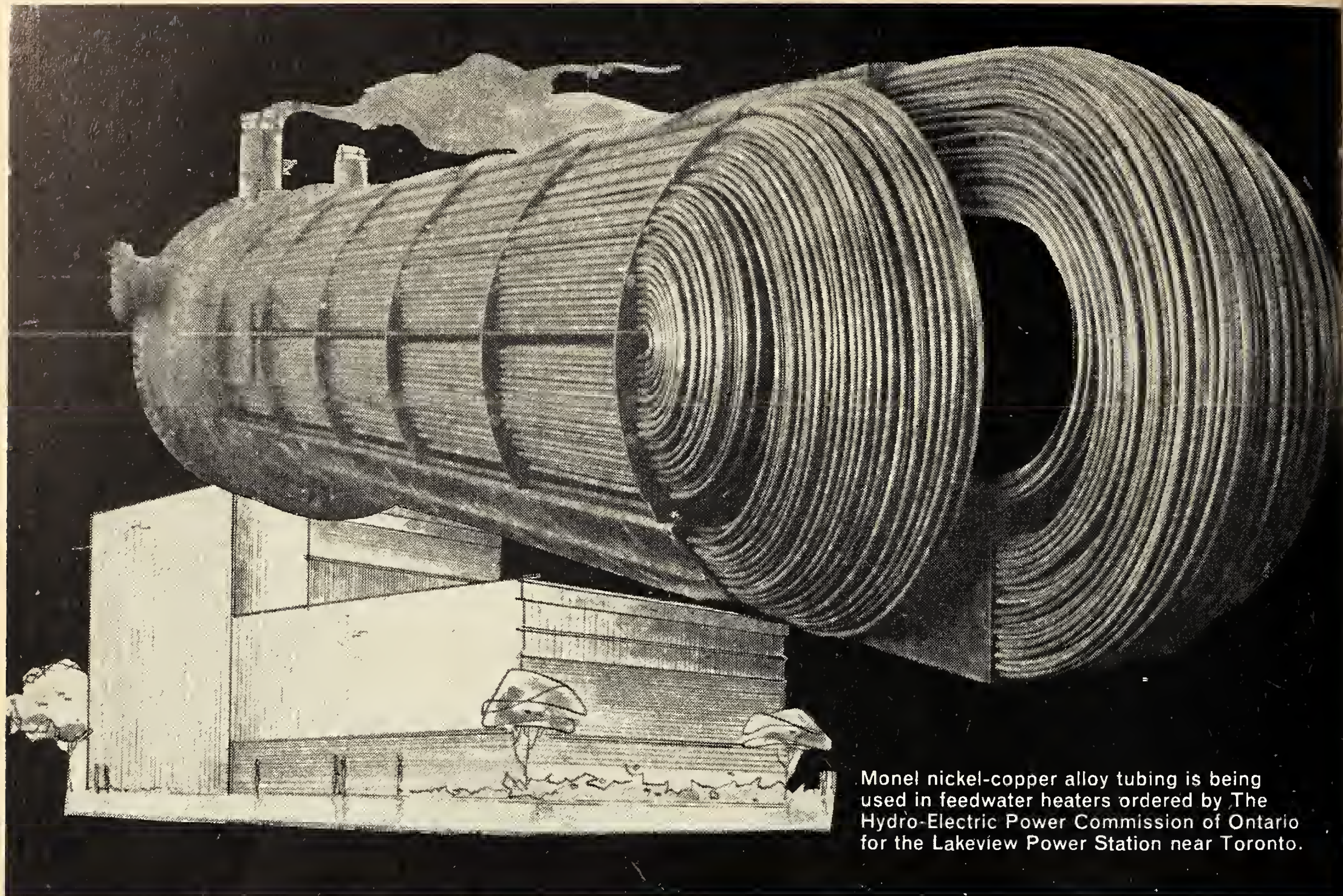
In an introductory chapter, the author discusses the fundamentals of optics, photography, the survey camera and stereoscopic vision as applied to photogrammetry, as well as the geometry of central projection. Other chapters cover terrestrial and aerial photogrammetry, and their applications. Appendices give theoretical studies of the geometry of photogrammetry and of the theory of errors. The author is at the Royal Institute of Technology, Stockholm. (Bertil Hallert. Toronto, McGraw, 1960. 340p., $11.00.)

***BRITISH ELECTRICAL POWER CONVENTION, PROCEEDINGS, TWELFTH, 1960.**

The four papers, with discussions, published here are keynoted by the theme of the Convention: "Electricity—the New Horizon", and emphasize future developments. The topics discussed are: electrical supply sources and activities in England and Wales; electricity in industry, both as a power source and in manufacturing control, and relevant to the products manufactured; the export of electrical products, from power station equipment to household appliances; domestic uses of electricity. The volume also contains Convention statistics, such as Council and committee personnel, membership, and the report of the Annual General Meeting, and a bibliography of papers presented at all eleven Conventions, from 1949 to date. (Published 1960 by the Convention, London. 356p., price not given.)

BIBLIOGRAPHY ON AIRPORT LITERATURE.

A compilation of over 2,000 references, covering the years 1938 to 1959, classified under 26 subjects, and arranged chronologically within each category. The topics covered include: legislation and legal aspects; location; design; soil mechanics; drainage; pavements; lighting; hangars; terminal buildings; control towers; military airfields; arctic airfields; jet airports; heliports; construction unit prices. (Shu-t'ien Li. New York, A.S.C.E., 1960. 170p., $8.00.)



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For further information about Monel and Inconel in heat exchanger applications, write for the Inco booklet "How to Select Tubing for Modern Feedwater Heaters."

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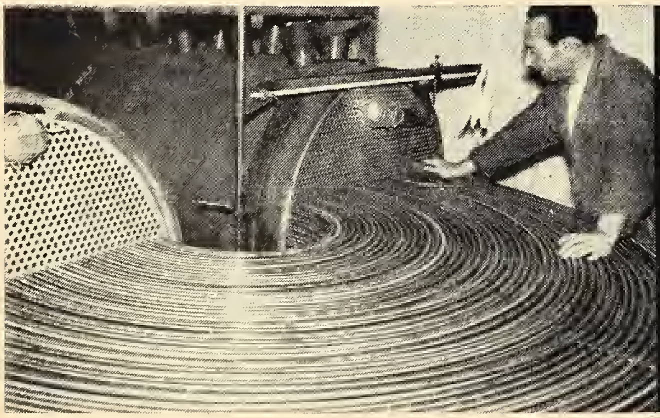

Inconel nickel-chromium alloy tubing being fitted to heat exchanger for Canada's first commercial pressurized-water reactor NPD-2, fabricated by Babcock-Wilcox and Goldie-McCulloch Limited for the Canadian General Electric Co. Ltd.

THE INTERNATIONAL NICKEL COMPANY OF CANADA, LIMITED

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• LIBRARY NOTES

°SPACELIGHT TECHNOLOGY.
(PROCEEDINGS OF THE FIRST COMMONWEALTH SPACEFLIGHT SYMPOSIUM, 1959)

Many of the eighteen papers in this volume represent the first published results of original research; together, the papers are intended to foreshadow and encourage a technological program of aerospace development among British Commonwealth countries. The papers have been arranged into nine topical sections. The first section discusses Commonwealth activities in interplanetary exploration, with two papers concentrating on University participation and Canadian facilities. Section two deals with launching of space vehicles, discussing solid propellant rockets, nuclear thermal fission rockets, the Woomera tracking and launching station, and a spaceflight program based on Blue Streak. The three papers of section four are concerned with aero/space vehicles and re-entry, and the remaining five sections deal with propulsion systems; cabin-conditioning equipment for manned satellites; instrumentation of unmanned satellites; tracking, communication (Jodrell Bank), and navigation; and minimum propulsion for soft moon landing of instruments. (Ed. by K. W. Gatland. London, Academic, 1960. 365p., 75/-.)

POWER FROM WATER.

A non-technical account of the history of water power development, and of the growth of hydro-electric power in Great Britain. The first chapters cover the early uses of water power, water wheels and the first hydro plants. Various types of hydro-electric schemes are discussed, and developments in different areas of Great Britain described, as are advances in design and construction in the last few years. Additional chapters cover fish passes, tidal barrages, and the use of pumped storage. There are many illustrations. The authors are authorities in the field, Mr. Brown being well-known for his definitive work on hydro-electric engineering issued three years ago. (T. A. L. Paton and J. G. Brown. London, Hill, 1960. 210p., 25/-.)

°TRANSFORMERS AND GENERATORS FOR POWER SYSTEMS.

A British translation of the original French text. Both transient and steady-state conditions are studied. In addition to chapters dealing with and developing the fundamentals, there are survey chapters giving general treatment to practical aspects of special problems. The volume is divided into two books. Book 1 discusses the transformer, covering electromagnetic theory, windings, insulation, losses, voltage regulation and phase connection, with survey chapters on abnormal conditions, special types of transformers and transformer construction, technical literature, and the particular interests of the specification and the operating engineer. Book 2 deals with the synchronous machine under similar relevant headings. (R. Langlois-Berthelot. London, Macdonald, 1960. 541p., 65/-.)

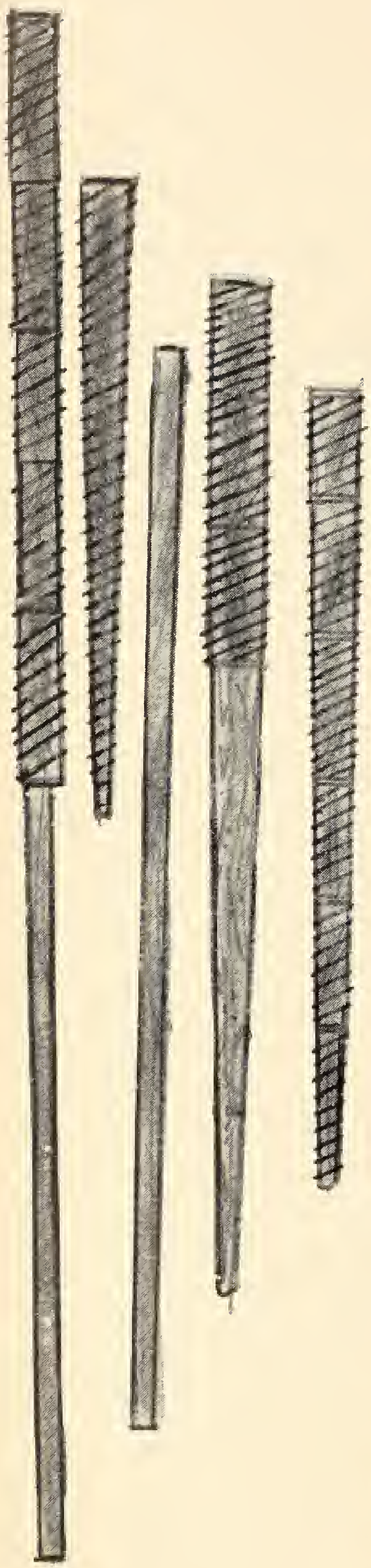
NUCLEAR PROPULSION.

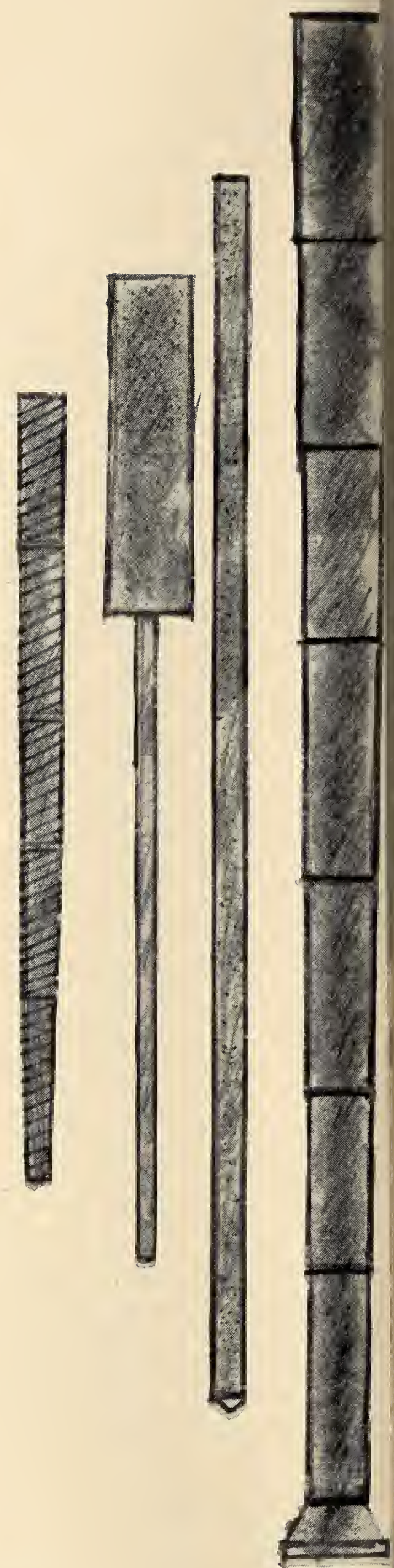
For some reason, the editor of this text has provided no introduction to it, but it appears to have been written, by men active in the field, for engineers interested in methods of nuclear propulsion. It covers basic nuclear reactions and reactor physics; the applications of nuclear power to jet and rocket propulsion; nuclear-powered closed-cycle gas turbine; problems connected with the use of nuclear reactors; nuclear propulsion used in vessels, aircraft, and rockets. A final chapter discusses life in a sealed cabin. (Ed. by M. W. Thring. Toronto, Butterworth, 1960. 300p., $9.50.)

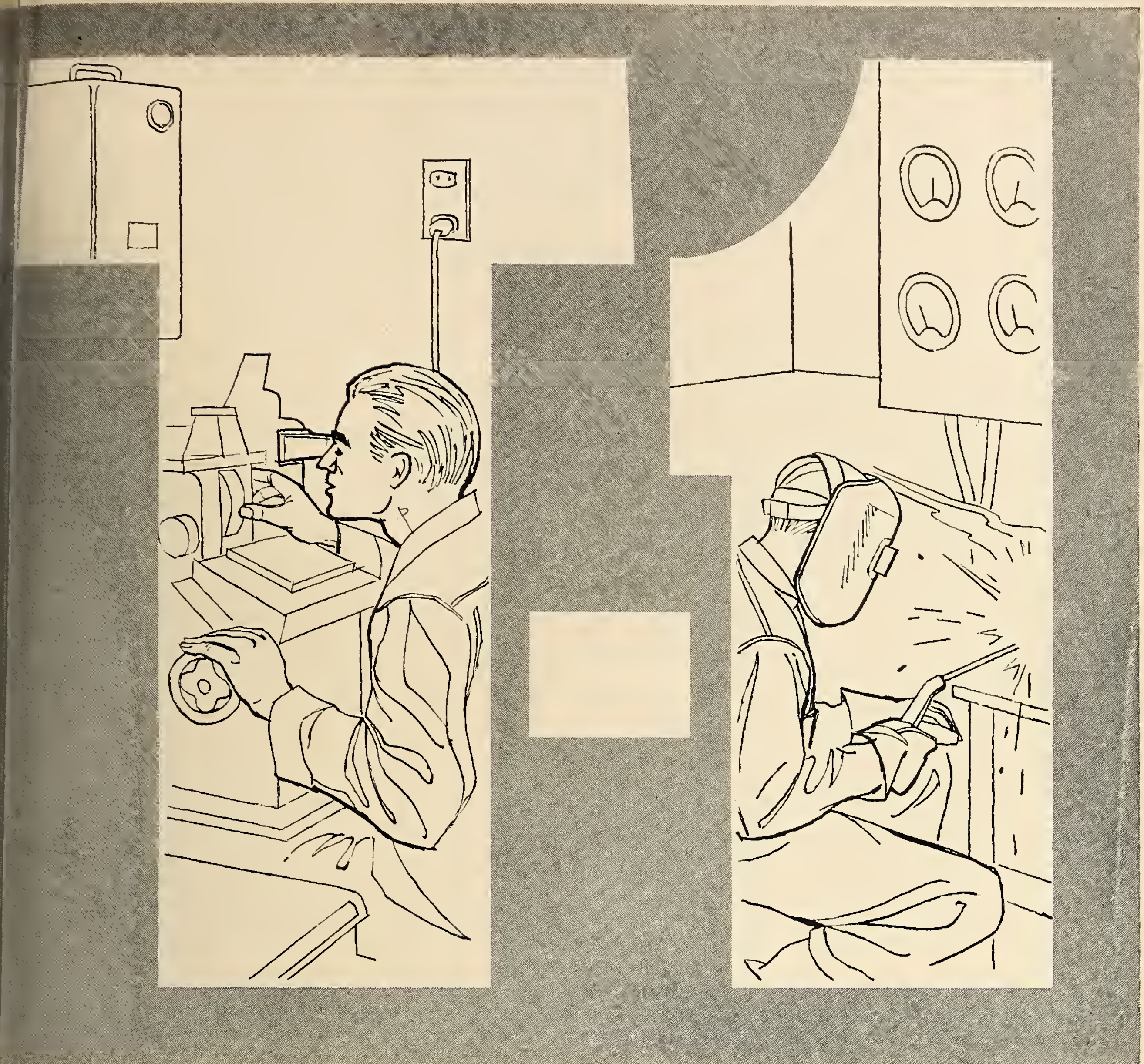
BASICS OF ANALOG COMPUTERS.

Another of the Rider "pictured-texts", this volume presents a basic introduction to analogue computers, in which the first four chapters cover the principles and techniques of analogue computers, and the mathematical concepts involved. The next four chapters deal with general purpose analogue computers and their operation, while the final chapters discuss the actual use of the computers, and their applications. (T. D. Truitt and A. E. Rogers. New York, Rider, 1960. 400p., $12.50.)

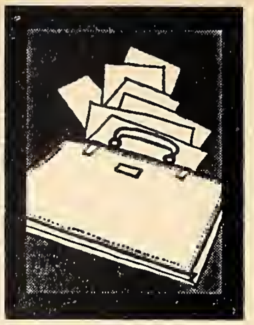
(More Library Notes on page 145)







Business and Industrial Briefs



Appointments and Transfers

Alexis Quenneville is in charge of production of the Sept Isles, Quebec, plant of Canadian Industries Limited which recently resumed production of blasting agents.

The appointment of **L. G. Lumbers** as president of Canada Wire and Cable Company Limited has been announced. Mr. Lumbers succeeds **O. W. Titus** who has been named vice-chairman of the Board of Directors.

Carl Ingimundson has been appointed Manager of Ontario Hydro's East Central Region. He was previously executive assistant to the general manager.

The Hydro-Electric Power Commission of Ontario has announced the resignation of **James S. Duncan**, who held the position of Chairman of Ontario Hydro. His successor is **W. Ross Strike** who has been with the Commission since 1944.

The Electric Storage Battery Company (Canada) Limited has announced the election of **D. C. Brownell** as president. Mr. Brownell, formerly vice-president, succeeds J. E. Eells who has retired.

Delmar K. Brundage, vice-president — general sales manager, Jenkins Bros., Limited, was elected a member of the Board of Directors at the Annual Meeting of the shareholders.

The appointment of **Rear-Admiral John Birch Caldwell** to the Board of Directors of Canadian Arsenals Limited has been announced.

H. E. C. de Chassiron, managing director of D. Napier & Son Ltd., London, England, has become president of D. Napier & Son (Canada) Limited. **L. A. Sanson**, executive vice-president, is the Company's top executive in Canada. Operating headquarters are in Montreal.

The president of the Master Builders Company Limited, Stephen W. Benedict, has announced the appointment of **Andre Grenier** as manager of their Montreal office.

The appointment of **John J. Sales** as general manager of Morse Chain of Canada, Limited, Simcoe, Ontario, has been announced.

J. Donald Greensward, president of Canadian Allis-Chalmers Limited, recently announced the appointment of **J. C. Slingsby** as general manager of the St. Thomas Works.

The appointment of **Thomas J. H. Tatnall** to the position of chief engineer of Richards-Wilcox Canadian Limited, London, Ontario, has been announced by John J. Judge, president.

Dr. J. M. Harrison, Director of the Geological Survey of Canada, has been elected first president of the newly formed International Union of Geological Sciences. Dr. Harrison had assisted in the organization of the new Union and his election was announced after the organizational meeting in Paris.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A PORTABLE ROTARY screw compressor using the rotary screw principle has been introduced by Atlas Copco Canada Ltd., Montreal. Available in two sizes, 620 c.f.m. and 365 c.f.m., the "Twin-Air" can be powered by a choice of liquid-cooled General Motors or Rolls-Royce diesel engines or Deutz air-cooled engines. The two-stage, rotary screw principle is claimed to provide a surge-free supply of air, eliminating metal-on-metal contact between rotors and rotor housing. The unit is mounted on a rigid frame, equipped with fully independent four-wheel torsion-bar suspension and automotive-type steering.

A JOINT STATEMENT was issued recently by the Dominion Bridge Company Limited, John Thompson Water Tube Boilers Ltd. of Wolverhampton, England, and John Thompson-Leonard Ltd. of London, Ont., announcing that the Dominion Bridge Company will manufacture under license a wide range of John Thompson-designed steam generating units. These units will be of the types used for thermal power stations, large industrial plants and waste heat recovery.

AN ILLUSTRATED catalog describing a line of semi-automatic machines for low production deburring, buffing and polishing operations is available from Acme Manufacturing Company, Detroit. Also included in the catalog are 12 special semi-automatic polishing and buffing machines designed for specific application requirements such as: reflector and bowl shaped parts, electric fry skillets, stainless steel sinks, die cast handles, bowling balls, bicycle rims, round and square tubing and shafts and rolls.

AN EIGHT-PAGE catalog has been published by Rapistan Canada Ltd. on its wheel and live roller APC conveyors. Photographs and diagrams illustrate principles and features of the conveyors that are claimed to permit accumulation on powered horizontal conveyor with no pressure build-up. Product information on the two types include specifications on length, width, height, belt speed, load capacities and other details of construction and operational features.

A DRY-BULK truck-trailer using a pneumatic unloading system has been introduced by Highway Trailers of Canada Ltd., Toronto. The 'Highway-Interconsult' has been designed for the movement of cargo ranging from chemicals and flour to cement and sand. It combines spherical vessels, a pneumatic discharge system and power auxiliaries in a lightweight monocoque-type trailer of semi-wheel and four-wheel designs, depending on load capacities required. The spherical, all welded vessels are made in 300, 340 and 400 cu. ft. sizes. The pneumatic system is composed of a V-4 gasoline industrial engine which drives a two-cylinder single-acting, single-stage air-cooled compressor.

A PUBLICATION has been released by Thermo Electric (Canada) Ltd., Brampton, Ont., on their thermo electronic multi-point controller — an instrument for automatic, two-position control of up to 10 industrial processes; three position control of five processes; constant control of a single process; manual balance indication of exact process conditions at each point controlled and monitoring facilities for controlled points or others. Detailed information is given on the various applications of the bridge or potentiometer circuits, installation and operation.

PURCHASE OF ALL ASSETS of Associated Quarries and Construction Limited, Toronto, by St. Lawrence Cement Co., has been announced jointly by executives of both companies. This purchase follows the awarding of a $2 million engineering contract to the St. Lawrence Cement Co. for a large single project cement plant at Albany.

CONSULTING SERVICES

Beaver Bill says:

Starting work on a new project? Write and ask the library at headquarters for a list of books and magazine articles on the subject. But be sure and give them all the details you can, so they don't give you a lot of irrelevant information.

LIBRARY NOTES

RINCIPLES OF FLUID MECHANICS.

A text for a first course in fluid echanics, based on a background of hermodynamics, proceeding from a eneral discussion of unsteady, compressible, three-dimensional flow to the less eneral: one-dimensional, steady, incompressible, and ideal. The applications f the principles of fluid mechanics in he motion of rockets and satellites, in urbomachinery and jet engines are discussed. Final chapters cover dimensional nalysis, the incompressible flow of a on-ideal fluid, and an introduction to oundary-layer theory. (R. A. Kenyon. New York, Ronald, 1960. 216p., $7.00.)

TIME SERIES ANALYSIS.

A description of statistical methods used in the treatment of time series, and the mathematical theory on which they are based. The emphasis is on the spectral theory of stationary time series. The methods are illustrated by numerical examples taken from various fields. A bibliography is included. This is a volume in Methuen's monograph series. (E. J. Hannan. Toronto, Ryerson, 1960. 152p., $4.25.)

PHOTONS AND ELECTRONS, 2nd. ed.

One of Methuen's Monographs on Physieal Subjects, intended for the student and general physics reader, and giving an account of the interactions between radiation and electrons, and the problems involved. Some of the topics covered include the photo-electric and Compton effects, reciprocal processes, positive electrons, and cosmic-ray phenomena. A final chapter covers developments in the last ten years. (K. H. Spring. Toronto. Ryerson, 1960. 133p., $2.25.)

USING CENTRIFUGAL PUMPS.

This book deals with the centrifugal pump from the user's point of view and more particularly from that of the operating and maintenance staff responsible for the efficient running and daily care of pumps, and their emergency repair or installation. Fundamental principles are dealt with, pump characteristics explained, and numerous examples given of methods of correctly choosing type and capacity for both permanent and emergency needs. (E. Allen. Toronto, Oxford, 1960. 246p., $4.50.) EIC

EIC CERTIFICATE OF ADVERTISING MERIT

Winner of the Monthly Award for the best advertisement in the March, 1961 issue of The Engineering Journal, was Caterpillar Tractor Company, with a striking 4-page, 4-colour insert which appeared on pages 33, 34, 35 and 36. Headed, "Big! Powerful!", the insert introduces the new "Cat" 630 and 631 with a number of colourful, explanatory illustrations and plenty of hard-hitting, factual, reason-why copy.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

The Advertising Manager of Caterpillar Tractor Company is Mr. C. M. Adams who is located at the Company's Head Office in Peoria, Ill. The advertisement was prepared and placed by N. W. Ayer & Son Inc. of Philadelphia — Account Executive A. Kennedy Manns. EIC

INDEX TO ADVERTISERS

JUNE 1961

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The following firms have principals who are members of this Association engaged as professional engineers in engineering work independent of salaried employment or sales promotion.

The revenue derived from the sale of advertising space assists the Institute in publishing THE ENGINEERING JOURNAL on a regular monthly basis. Listed above are the names of the Companies and individuals whose advertisements appear in this issue.

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ONTARIO: L. G. Barnum, Manager, Advertising Sales, 24 King Street West, Suite 21, Toronto. Phone: EMpire 2-5058
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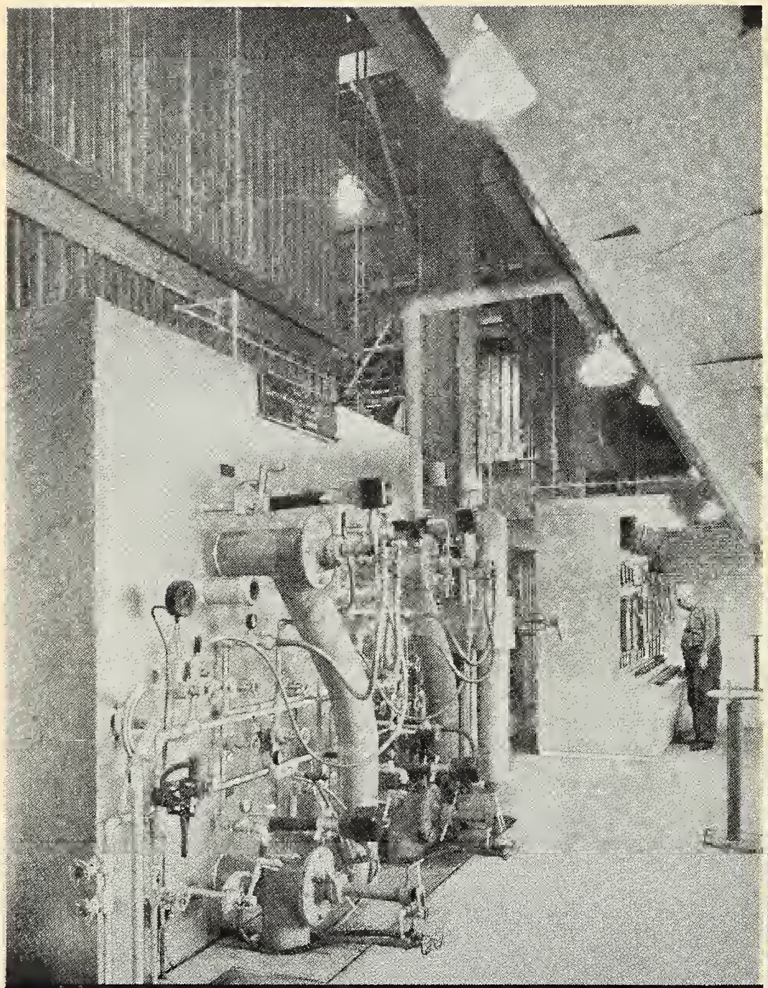
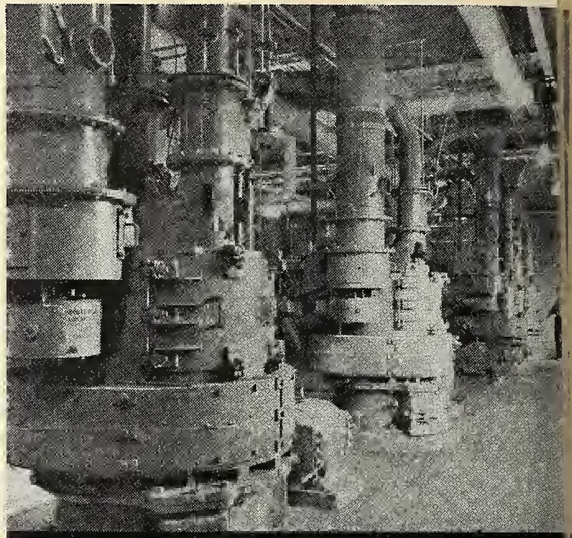
B&W ADDS STEAM TO UNIVERSITY OF TORONTO EXPANSION



Two, 2-drum B&W Stirling Boilers, in service



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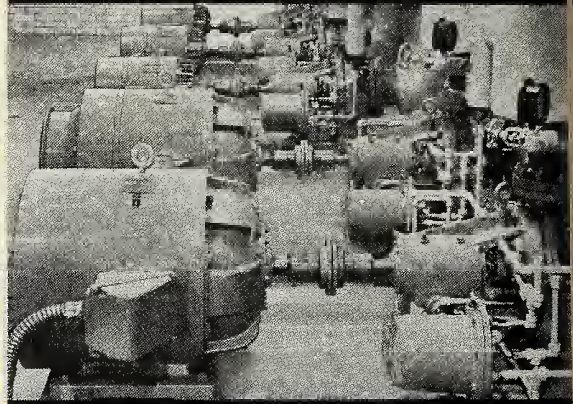


B&W 4/6 SJ Pumps, capacity 890 U.S.G.P.M.

When the University of Toronto planned for a major expansion, one problem stood out... how to provide economical heat for 100 major buildings, spread over 400 acres.

The problem was solved by H. G. Acres & Company Limited, Consulting Engineers, with a high-temperature, hot-water system utilizing 2 B&W Stirling Boilers equipped with B&W Pulverizers. Each boiler has a capacity of 125,000 lbs. of steam per hour. These units are equipped with sootblowers, dust collectors, steam coil air heaters, flues, ducts and coal scales. In addition, B&' Type S Pumps circulate hot water in the U of T heati system.

Here indeed, is a B&W installation capable of su plying ample steam to economically and reliably heat expanded University.

For information about steam generation phone or wri the nearest B&W office. There's a B&W representati qualified to discuss steam for heat, processing or powe

STEAM FOR POWER B&W STEAM FOR PROCESS

BABCOCK-WILCOX and GOLDIE-McCULLOCH LIMITED, GALT, ONTARIO MONTREAL • TORONTO • CALGARY • VANCOUVE

IN THIS ISSUE

Gerrit Hardenburg, author of *The Port Mann Bridge Superstructure*, was born in Holland where he received all of his education. In 1954 he graduated from the Technological University in Delft with a degree in Civil Engineering. During that time, from 1951 to 1954, he was Assistant to the Professor in Applied Mechanics there. After graduation he worked for three years as a design engineer with a firm specializing in bridge and steel fabrication. He came to Canada in 1957 and has been associated since then with C.B.A. Engineering Ltd., Vancouver, where he is senior structural engineer. The Port Mann bridge, under construction to span the Fraser River, will be an important link in the Trans-Canada Highway section between Vancouver and the Frazer Valley. The article deals with factors present which governed the design of this bridge. Functionally, the structure had to have a main span of 1200 ft. and be wide enough to accommodate a four-lane roadway and two 5-ft. sidewalks. Poor soil at the location of the bridge site ruled out any design which would transmit heavy horizontal loads to the foundations. The author describes what design was considered the most economical and discusses in detail the design, construction and the materials used in the Port Mann bridge superstructure.

G. B. Walker, Research Professor at the University of British Columbia, came from Queen Mary College, London, to assume the post he now holds. There he had been in charge of a laboratory engaged in research on high energy electron accelerators and microwave tubes sponsored by the A.E.R.E. and the British Admiralty. "Five members of the research group in London also came to Vancouver and some tons of microwave gear was shipped so that an entire working laboratory was transferred some 6000 miles." the author of *New Uses for Ceramic Materials in Microwave Tubes* writes. The paper discusses present uses of low-loss ceramic materials in microwave tubes and goes on to possible applications of recently developed ceramic materials. Ceramics offer solutions to some factors governing the design and construction of these tubes. The author presents some possible future uses of ceramic slow-wave structures and discusses current research in this field. Born in Scotland, Professor Walker graduated with an M.A. degree from Glasgow University in 1940 and received his Ph.D. degree from London University in 1950. He began his career in research upon graduation from Glasgow University when he joined the research staff of Mullard Radio Valve Co. Ltd. where he remained for six years. In 1947 he became a Turner and Newall Research Fellow, Imperial College. In 1950 he joined the staff of the University of Sheffield where he held a post as lecturer for two years. Then he accepted the post at Queen Mary College where he not only lectured but was in charge of the laboratory which was transferred to U.B.C. in 1959. The research he and his group is presently engaged in is being supported by the Defence Research Board and the National Research Council.

The author of *Rearward Communications in BMEWS* discusses this subject with authority as he has been associated with the communication aspects of the Ballistic Missile Early Warning System at various stages. **Leo J. Hammerschmid**, M.E.I.C., received his education in Montreal, graduating in 1946 from McGill with a B.Eng. degree in Electrical Engineering. His career with the Bell Telephone Company of Canada began before graduation and since that time he has held a number of engineering posts. He worked on the engineering co-ordination of the Trans-Canada Microwave Radio Relay System and the BMEWS facilities through Newfoundland and the Maritime Provinces. The transmission assessment of U.S. and Canadian SAGE external circuits and the equipment engineering of the BMEWS facilities through Bell territory in Labrador and Quebec have been among his responsibilities. At present he is Terminal Equipment Engineer in the Toll Area Engineering Department. The author begins the paper with a brief description of the BMEWS system including the three Forward Detection Sites at Thule, Greenland; Clear, Alaska; and Fylingdales Moor in Yorkshire, England. Following a discussion of the part Canadian communications companies are playing in the development of this system the missile detection process is described. Considered in detail is the Rearward Communication System. The objectives of this system are outlined and the special functions of the component systems are studied at length.

A hazard to transportation in the exposed waters on west coast of Vancouver Island and Queen Charlotte Island is the movement of logs. **T. A. McLaren**, M.E.I.C., author of *Side-Tipping Log Barges,* discusses the latest development for handling these logs. The side tipping log barge is a very efficient vessel which is capable of being loaded and unloaded with a minimum of labor and can be towed with a minimum of difficulty. While the barge itself is new, the principle of side tipping is not. "The side tipping barge is designed with a series of water ballast tanks on one side of the vessel, so arranged as to be flooded by the opening of sluicing valves. The admission of water to the tanks lists the barge to such a degree that the deckload slides off." Mr. MeLaren was born in Montrose, Scotland in 1919. In 1941 he received a degree in Mechanical Engineering from the University of British Columbia. Upon graduation he became associated with West Coast Shipbuilders Ltd. as a naval architeet and in 1946 was named shipyard manager. He joined Allied Builders Ltd. in 1949 and is now President and Managing Director. He is also a principle in the firm of McLaren and Sons, Consulting Engineers and Naval Architects, which he and his father founded in 1945.

COVER ILLUSTRATION

Two types of welding are being done on this two-can section of steel tunnel liner at the South Saskatchewan River Dam. Inside the 20 ft. diameter section a tractor welder performs its task, while on top of the section, a boom-type welder joins the outside seam. (Photo courtesy P.F.R.A.)

DESIGN OF THE SUPERSTRUCTURE OF THE PORT MANN BRIDGE

G. Hardenberg,
Senior Structural Engineer,
C.B.A. Engineering Ltd., Vancouver, B.C.

Very unfavorable soil conditions at the Port Mann Bridge site ruled out designs which would transmit appreciable horizontal loads to the foundations. Studies showed the most economical design would be one incorporating an orthotropic steel deck.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THE Port Mann Bridge, now under construction over the Fraser River, is about four miles upstream from New Westminster and forms a link in the Trans Canada Highway which runs from the new Second Narrows Bridge through Vancouver and Burnaby into the Fraser Valley. (Fig. 1)

The bridge itself is a stiffened tied arch with a main span of 1200 ft. flanked by side spans of 360 ft. which together form a continuous structure 1920 ft. long. The north approach structure from bridge to abutment has three spans of 225 ft., six spans of 175 ft. and 12 spans of 125 ft. while on the south approach there are, in the direction of the south abutment, three spans of 225 ft. and six spans of 175 ft. (Fig. 2)

The design is based on partly riveted and partly welded shop assembly. All field connections (with one exception, which will be mentioned later) are high strength bolted.

The basic requirements leading to the adopted design were:

1. Provision of a four-lane roadway with sidewalks, having a total width between fences of 64 ft. divided into a median strip of 2 ft., two inner lanes of 12 ft., two outer lanes of 14 ft. and two sidewalks of 5 ft. including the fences;

2. A main span of 1200 ft. with a vertical clearance under this span of approximately 146 ft. above high water.

This fairly large span was deemed necessary in view of shipping requirements since it is expected that in the future ocean-going vessels will make use of the river up to and beyond the location of the bridge. This factor therefore established the vertical clearance as equal to that of the existing Patullo Bridge at New Westminster. The length of span is further warranted by the poor soil conditions which are of such a nature that the construction of piers, especially in the river, is relatively very expensive.

The 1200 ft. main span also avoids the necessity of building piers in the main river channel where the depths reach 50 ft. at low water;

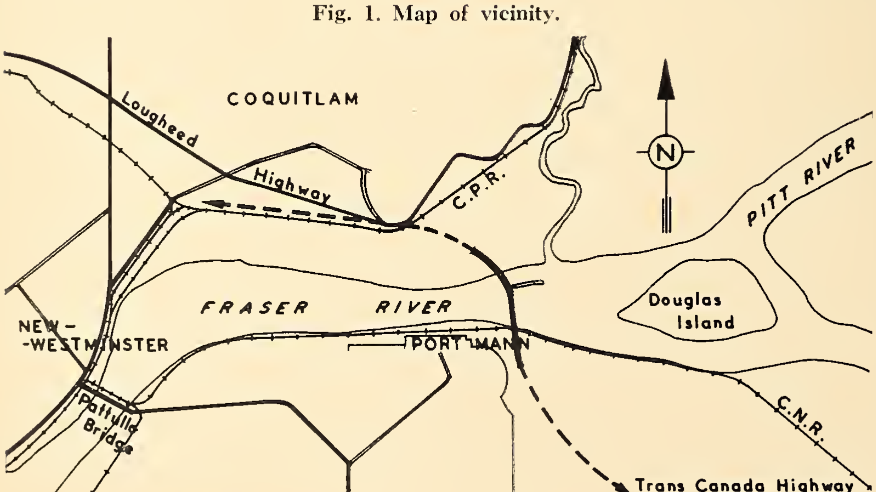
3. The road alignment is based on a safe speed of 60 m.p.h.;

4. Maximum gradient on approaches of 3% to avoid undue slowing of heavy trucks.

Alignment of the Roadway

The total main structure length of 1920 ft. is less than the theoretically required length of vertical curve between the 3% gradients of north and south approaches, necessary to provide a safe sighting distance over the crown of the roadway at the centre of the main span. Rather than provide a curve over this required minimum only, and have the outer parts of the main structure on a straight 3% slope, it was felt that the whole appearance would be improved if the curve was extended over the full 1920 ft. A continuous parabola over this length would provide a drop in elevation of 14.4 ft. between the centre of the main span and the end of the side spans. In order to economize on the length of the approaches, a curve was chosen which consists of two parabolas, one, extending each way from the crown of the road over a length of 400 ft. with a change in gradient from 0 to 2%, followed by a flatter parabola over the remaining 560 ft. providing a further change from 2% to 3% and giving a total drop in elevation of 18 ft. Towards the north abutment the gradient remains constant at 3%, while the south approach reverses its gradient from 3% descending from the main span to an upward slope of 4½% at the north abutment, the reverse gradient being required to suit the alignment of the highway beyond the bridge. Although this latter gradient is in excess of the maximum of 3% considered allowable to avoid slowing down heavy transport it will only affect traffic leaving the bridge and even then, only over a very short distance. Any slowdown will be noticeable only after the traffic has le the bridge where an extra lane f slow traffic can easily be provide The horizontal alignment shows a S-curve with the main structu straight between the curved a proaches. The degree of curvatu provided is 1.7°, while the superel vation of the roadway is 4%.

Fig. 1. Map of vicinity.



The Main Structure

The existing soil conditions at th bridge site are extremely poor (som of the pile foundations extend abo 200 ft. below ground level) and it wa quite evident from the outset that an design which transmitted appreciab horizontal reactions to the founda tions would lead to extremely cost pier structures if, indeed, the desig of piers capable to sustain such load was practicable. This thus ruled out suspension bridge or stiff arch.

Recent developments in the desig of large steel bridges have shown th advantage obtainable by introducin a stiffened steel deck, generally know as orthotropic deck, in place of th conventional concrete deck. Althoug not economic if considered as a de structure alone, the orthotropic dec does offer the advantage of its ligh weight, a factor of prime importanc for a long span bridge where th greater part of the load carrying capa city is required to support the dea load of the bridge itself. Further more, it has been found that an ortho tropic plate designed with sufficien stiffness to perform satisfactorily as roadway, retains a reserve in strengt which enables the deck to be used a a part of the main girders.

Naturally this limits the number o bridge types in which such a dec can be incorporated, to those in whic one of the flanges or chords of th main girders follows the line of th roadway. Stiff arches and all trusse which do not have a chord coinciding with the elevation of the roadway ar therefore ruled out. The only remain ing possibilities are then a deck truss a through truss with straight botton chord, a plate girder, a self anchored suspension bridge, or a stiffened tied arch.

Although the deck truss is definitely the most attractive of all trusses from the point of view of appearance it has however, the disadvantage that the depth of the truss at mid span, all other things being equal, requires a higher elevation of the roadway than can be obtained with a through type structure. This of course affects the length of the approaches, which in the case of the Port Mann Bridge is particularly critical on the north side.

The through truss, plate girder or

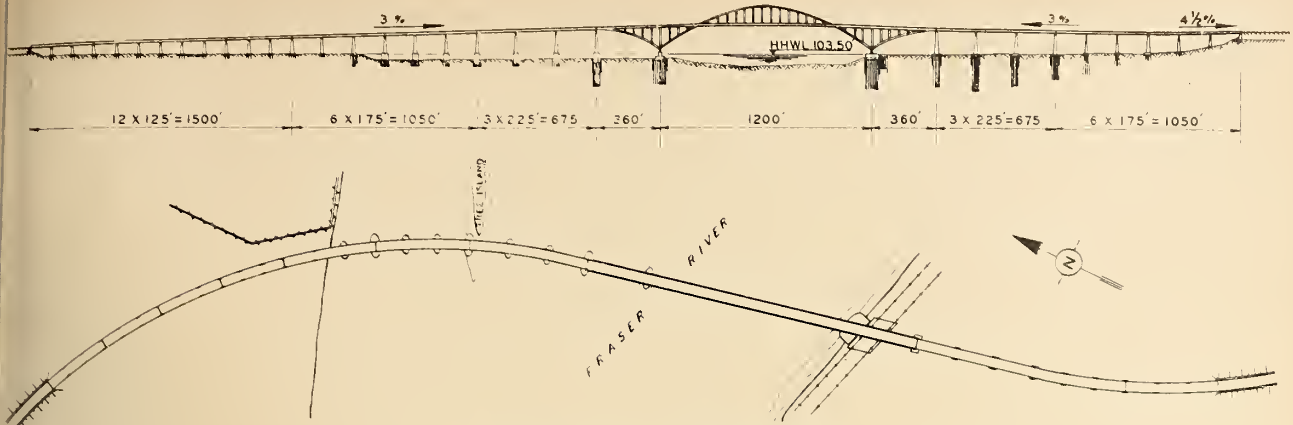


Fig. 2. General plan and elevation.

elf anchored suspension bridge all equire high piers or towers to overome the required clearance. The deign which was finally adopted, a tiffened tied arch, turns this restricion to an advantage and makes use of this clearance in having the arch ome down to the main piers just bove high water. The total height of his arch is approximately 230 ft., a eight which cannot readily be obained with a structure in which the main girders are located above the elevation of the roadway over their entire length.

Comparative studies confirmed that a stiffened tied arch as chosen, incorporating an orthotropic deck offered substantial savings in weight compared with any of the other types investigated. The total weight of the main structure is approximately 11,800 tons, including paving, sidewalks.

In this structure the arch is of a relative slender construction and designed only to sustain compressive forces. Two box-shaped stiffening girders not only counteract the arch thrust but also absorb the ending moments caused by the live load in the same manner as in a self anchored suspension bridge. The orthotropic plate acts, in addition to its function as bridge deck, as the top flange of these stiffening girders.

While the length of the main span is determined by considerations largely independent of the design of the superstructure, the length of the side spans is governed by the following factors:

1. A short side span produces a large uplift on the anchor piers and tends to increase the cost of the bridge per lineal foot;

2. A long side span destroys the harmonious balance of the arch layout;

3. Moreover, the southern side span must clear the right-of-way of the C.N.R. The minimum length of side span for this purpose would be about 300 ft.

After several trials the side spans were finally established at 360 ft.

Because of the continuity of the structure only one of the four bearings under each main girder is a fixed bearing and this is located at the north main pier, the foundation conditions here being more suitable for any longitudinal horizontal reactions. The south main pier and the two anchor piers show roller bearings.

Analysis of the Main Structure for Vertical Loads

The main structure consists of two 1920 ft. long continuous stiffening girders extending over a main span of 1200 ft. and two side spans of 360 ft. each. The panel length is 50 ft. except for two 60 ft. panels at the end of each side span. The stiffening girders are supported by an arch following a catenary corresponding with the dead load distribution of the bridge, thus eliminating any bending moments under dead load conditions alone: the arehes are in pure compression and the stiffening girders in pure tension, except, of course, for local bending of the individual members between panel points. To obtain this condition all members are fabricated shorter or longer than the desired dead load geometry to an extent corresponding to their expected elastic dead load elongation or shortening.

The analysis for live load is somewhat more complicated. If not only the stiffening girders but also all arch members, hangers and columns are considered as stiff members with rigid connections, then the structure would have to be analyzed with 107 redundancies. However, by neglecting the stiffness of the hangers and columns and considering them to be pin-connected to the arch and girder, the redundancies decrease to 46.

By further neglecting the stiffness of the arches and considering them also pin-connected at each panel point, the redundancy is reduced to five times.

Since the ratio of inertias of hangers, columns, arches and stiffening girders is about .006 : .03 : 1 : 12.5 respectively it is clear that only the stiffness of the girders has any great influence on the distribution of forces in the structure and that this overshadows the stiffness effect from the other members. It was decided therefore that an analysis of the bridge with five redundants would be fully justified and the redundancies chosen were, the three horizontal components of the arch force in the two arch parts below the deck and the centre arch above the deck and the two bending moments above the main piers in the continuous stiffening girder.

In addition to the deformation of the structure produced by moments in the girders, the analysis accounted for the elongation and shortening of girders and arches due to their axial forces, but neglected such deformation in the hangers and columns; the influence of the latter being negligible as is also the case in suspension bridges.

The stiffened tied arch being a closed system where, contrary to stiff arches and true suspension bridges, the arch thrust is carried through the stiffening girders, the effect of the system deformation in the distribution of forces (deflection theory) is very small and need not be investigated.

Although the analysis of a structure with five redundancies is practicable by manual means, it was decided to make use of an electronic computer for this purpose thereby eliminating a great deal of tedious and monotonous calculation and providing the means of an easy recalculation after revising the sections of the members, a process often necessary with statically indeterminate structures. Since it was necessary to have an idea of the size of the various bridge members for preliminary and comparative estimating the bridge was first analyzed by manual means using a constant moment of inertia for the stiffening girders and neglecting the effect of elastic deformation due to axial forces. The results of this analysis enabled tentative sections for the main members to be established and further provided useful information for the determination of the scale factors in the computer program, which was subsequently written.

The results of a first run with the computer were used to determine the sections more accurately. The differences with the preliminary sections were large enough to warrant a second run through the computer after which no further changes were necessary. The influence lines for the redundants are shown in Fig. 3.

In addition to influence lines for shear forces ad moments in the stiffening girder and for the arch thrust in the three parts of the arch, the program was so arranged as to provide influence lines for angular displacements and deflections of the stiffening girder, for stresses in the top and bottom of the stiffening girder and for horizontal displacements at the supports. The same data were provided for various temperature conditions. It was found however, that the temperature stresses were not governing after taking into account the usual allowance for stress increases, whenever loading combinations including temperature effect are considered.

Neglecting the influence of rigid end connections of arch panels, hangers and columns tend to overestimate the stresses in the stiffening girders while at the same time secondary stresses may develop in the rest of the structure too large to be ignored; secondary stresses being defined as the difference in stress between the actual structure with rigid joints and the system used for the analysis with pin-connected arch panels, hangers and columns.

These stresses are of particular importance in the design of the hangers and columns and were computed on the basis of a column with given axial load, end rotations and end displacements, all calculated from the influence lines as supplied by the computer. The calculation of the corresponding end moments and resulting stress is then a simple matter.

The influence of the axial load on the magnitude of these moments is quite substantial and the calculated end moments in the hangers are as much as 30% greater when the tension force is taken into account, than when this force is neglected. Similarly the end moments in the columns are considerably smaller when the influence of the compression force is included in the analysis.

In the governing case the secondary stress in the hanger is about 140 of the primary stress indicating that hanger calculated on the basis of th primary tension force alone would b grossly underdesigned.

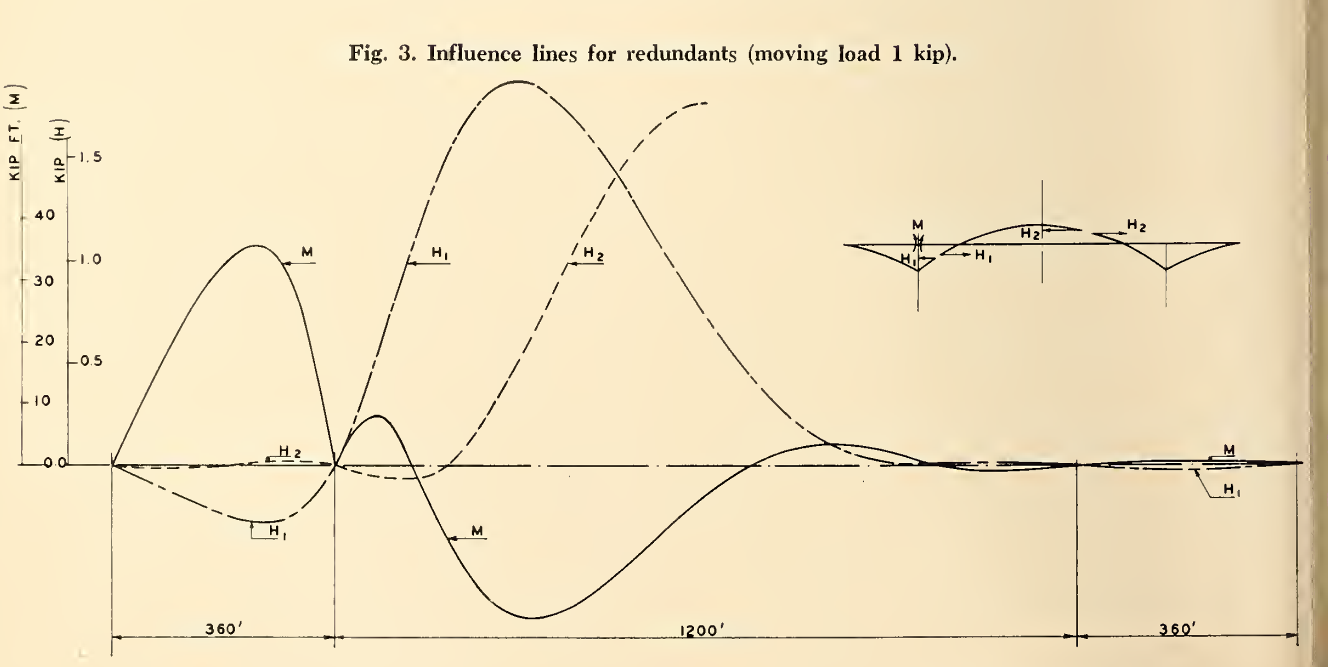
In the columns the secondar stresses are of the same ratio in term of primary stress but of lesser im portance, the initial stress being lo in view of the slenderness of th column.

The secondary stresses in th arches were determined by assumin that the arches must at all times fo low the deformations of the stiffenin girders, neglecting the influence o relative horizontal displacements be tween arch and girder, as well as th elongation of the hangers or columns Thus the deflection curve of th arches being known the secondar moments and stresses can be calcu lated. Although this method is ad mittedly approximate it was con sidered sufficiently accurate on th basis of a comparison of this metho with more accurate, but mor laborious methods for a stiffened arc bridge having a less complicated lay out than the Port Mann Bridge. Th differences between these method were not large enough to justify th extra work involved. Furthermore the actual magnitude of the second ary stresses is relatively small an stays within the allowance which i usually made for such stresses.

Analysis for Horizontal Loads

The bridge, considered as a hori zontal girder carrying the lateral load (wind load or earthquake), consists o two interacting systems.

Fig. 3. Influence lines for redundants (moving load 1 kip).



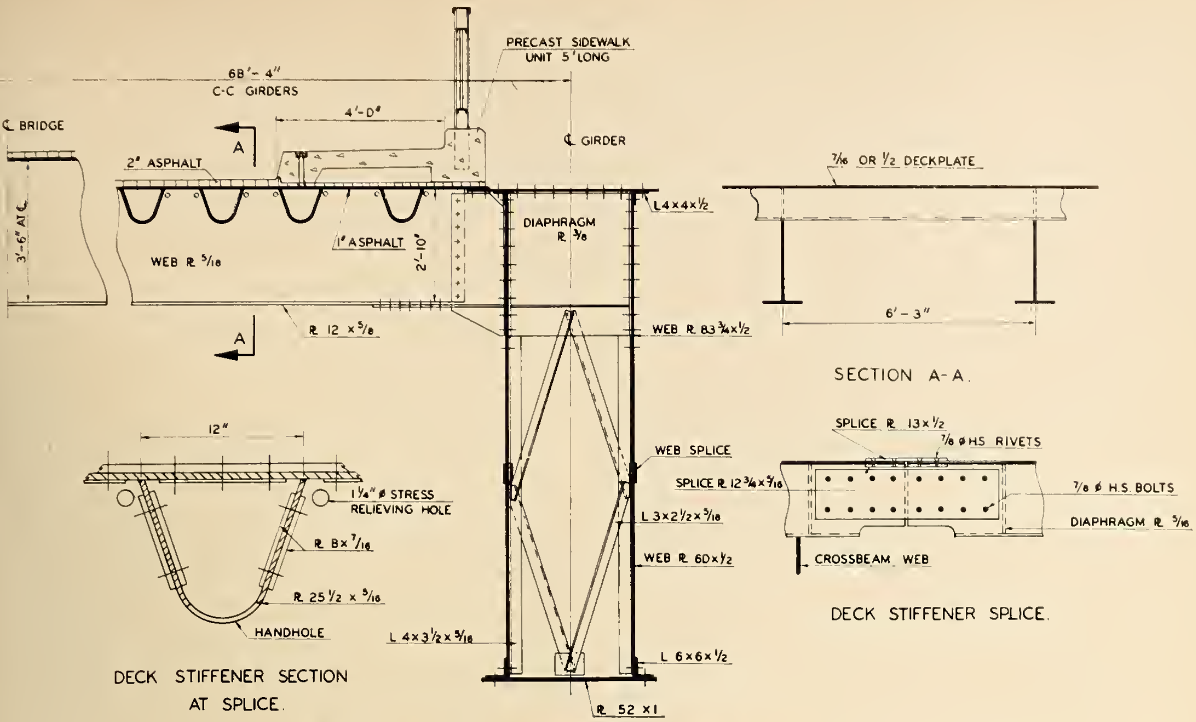


Fig. 4. Details of deck and stiffening girders.

Firstly, the two stiffening girders connected by the steel deck act as a horizontal plate girder, supported at the two anchor piers and elastically supported by the sway frames over the main piers.

Secondly, the arch ribs with their lateral bracing act as a continuous horizontal, curved truss supported at the four piers. The support at the north pier acts as a clamping support since the two fixed bearings at this pier prevent rotation of the wind truss in a horizontal plane.

The two systems are coupled where the arches meet the stiffening girders. Here deflections and rotations of the two systems must be equal.

Finally, the two systems are elastically coupled at the two traffic portals where specially reinforced hangers together with a strut between the arches form two vertical frames.

The interaction due to the lateral stiffness of the remaining hangers and the columns is negligible because of the slender nature of these members.

The horizontal wind system thus considered is 13 times redundant and as such much more complicated than the system used for the analysis of vertical loads.

Although windload is not necessarily uniformly distributed along the structure the wind certainly will be present over the full length and will not, as can happen with the live load, appear only over any given part of the bridge.

Consequently, no influence lines for windloads were deemed necessary and only three cases were considered: wind on the centre part of the bridge over a length of 800 ft. and wind on the remaining 560 ft. on either side of this part.

For each bracing member, arch panel or stiffening girder section, the governing combination of these three cases was taken and subsequently used for the design of these members.

Despite the need to handle 13 redundants it was found unnecessary to use the electronic computer in this case since they had to be calculated for three cases only. Furthermore the problem of solving 13 equations with 13 unknowns was avoided since it was possible to break down the system into various parts which yielded no more than four unknowns at any one time.

Taking into consideration the usual increase in allowable stresses for loading combinations in which wind load occurs it was found that generally windload conditions were not governing except of course in bracing members.

Construction Details

The Steel Deck: The type of construction used consists of a flat steel plate having a minimum thickness of 7/16 in. and a maximum of ½ in. in the heavier stressed sections of the deck.

This plate is supported longitudinally by box stiffeners, 12 in. wide and approximately 10 in. deep, spaced at 2 ft. c.t.c. and cold formed from 5/16 in. plate.

Transversely, the deck is supported by cross beams, spaced at 6 ft. 3 in. c.t.c. The cross beam flange is 12 x ⅝ in. and the web is 5/16 in. thick with a depth in the centre of 3 ft. 6 in. tapered down towards the end to 2 ft. 10 in. to provide the necessary transverse slope for the roadway.

The deck plate and stiffeners are designed in low alloy steel, the cross beams in medium grade steel.

The deck will be fabricated in all-welded units, each unit having a width equal to the width of the deck between stiffening girders and a length of approximately 25 ft. in the direction of the bridge axis.

The field splice between the deck plate and the top flange plate of the stiffening girders is a high strength bolted lap splice; the transverse splices between the individual deck panels being designed with high strength rivets with a countersunk head at the top of the splice. Since the deck plate will be covered by only a 2 in. layer of bituminous paving it is important to maintain a smooth surface and avoid as far as possible protuberances above the top of the plate. Although the thickness of the splice (½ in.) can still be tolerated, the asphalt cover above the head of a high strength bolt would become too thin, hence the use of countersunk rivets in this case.

For the analysis of the deck structures the deckplate is considered as acting as a top flange for both longitudinal and transverse stiffening members. It can be shown that it is permissible to take the full width of the plate between members as effective for this purpose, thereby giving the box stiffeners a top flange of 24 in. and the cross beams one of 75 in. wide. This system of stiffeners and cross beams acts as a grid which — due to the great number of members (31 stiffeners across the deck) — cannot be analyzed by the usual methods for grids. The inertia of the individual stiffeners is therefore divided by their spacing and an equivalent stiffness per lineal foot obtained. The actual construction is thus replaced by a plate having an inertia, in the transverse direction, equal to that of the deck plate proper and longitudinally corresponding to the equivalent inertia of plate plus stiffeners. This plate is supported by the cross beams which are too flexible to be considered as rigid supports; hence for the calculation of moments in the deck, allowance must be made for the cross beam deflection under live load. At the same time this flexibility causes the load to be spread over a great number of cross beams so that in the Port Mann design only about 25% of a load placed on any cross beam is carried by the beam itself, the remainder being spread to the adjacent cross beams. The connection between cross beam and stiffening girder is designed as a rigid joint. The stiffening girders, being of box section, have a high torsional rigidity and therefore produce a clamping effect on the cross beam ends, an effect which was taken into account in the calculations of the cross beam moments.

The governing load for the deck structure is produced by the standard design trucks. Four trucks, one in each lane and each truck with three axles, giving a total of 24 individual wheelloads grouped in three rows of eight wheels, produce the heaviest loading on one cross beam. While analyzing the loads on the cross beams one row of eight wheels is replaced by an equivalent line load, the difference between eight concentrated loads and a corresponding uniformly distributed load being negligible. Once the loads on the cross beams are known it is a relatively simple matter to calculate the moments in the longitudinal stiffeners. Since the distance between the wheels in a row is a multiple of the stiffener spacing, a correction must be made to the moments resulting from the substituted line loading.

There is a relieving effect on the cross beams due to their flexibility, however, this causes at the same time the moments in the stiffeners to be considerably greater than for a corresponding continuous beam on rigid supports. Proceeding from the centre of the deck towards the edges, the deflection of the cross beams decreases and gradually approaches the situation by which the stiffeners are indeed rigidly supported. As a result the maximum moment in the edge stiffeners is only about 75% of that in the centre stiffener. For the sake of uniformity it was decided, however, to give all stiffeners the same cross section. The costs of a welded steel deck are relatively high and it is of importance to maintain as much uniformity as possible in the fabrication. The advantage of this was considered greater than the saving of steel which would have resulted from a variation in the stiffener cross section.

In addition to the stresses in the deck plate acting in its function as top flange for the floor beams and stiffeners the stresses in the plate itself, spanning from stiffener to stiffener under a direct wheelload, were investigated.

For this purpose the plate is considered as a rigid slab continuous over the stiffener webs. The clamping effect exerted by these webs on the plate, due to the torsional rigidity of the box stiffeners, has been taken into account. The minimum plate thickness, however, is not so much governed by the stresses but rather by the stiffness required to provide an adequate base for the bituminous paving. Earlier attempts in orthotropic plate construction displayed failures of the paving traced to excessive deflection of the deck plate. Experience has shown that the plate deflection should be limited to about 1/300 of the plate span, which is equal to the distance between stiffener webs, in this case 12 in. The deflections are further determined by the intensity of the wheelload which in turn is dependent upon the tire pressure.

The design wheelload of 20,000 lb. was assumed to have a contact area of 25 x 6 in., corresponding to a tire pressure of 133 p.s.i. This pressure is high compared with the values given for most truck tires and a certain margin of safety is therefore incorporated.

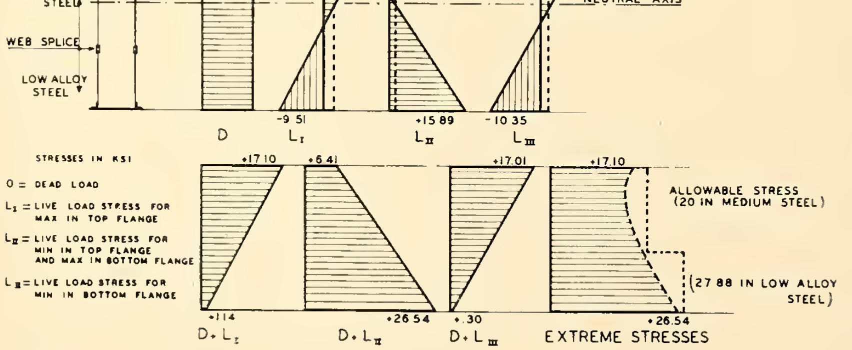
With a span of 12 in. and pressure of 133 lb. the minimum plate thickness works out at about .4 in. and as a practical minimum for construction 7/16 in. was chosen.

Finally the deckplate in its capacity as top flange for the stiffening girders, is subject to axial stress parallel to the bridge axis. It has been shown by analysis and strain measurements in actual bridges that, provided the ratio of length to width of the deck is sufficiently large, the complete cross section of the deck plate plus longitudinal stiffeners can be taken as effective for main girder action.

The various stresses in the deck plate, resulting from its multiple function as roadway slab, top flange for floor members and part of the stiffening girders were finally combined in accordance with the Hencky-von Mises failure theory.

In addition to the stresses from vertical loads the plate carries shears and moments produced by wind

Fig. 5. Typical stresses in stiffening girder section.



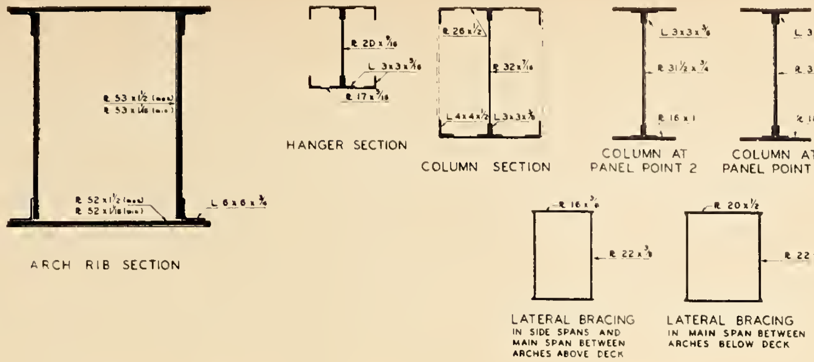


Fig. 6. Cross sections of arch ribs, verticals and bracing members.

ction on the deck as a horizontal irder. These stresses were found to e of no consequence and did not nfluence the design.

The Stiffening Girders (Fig. 4): he stiffening girders are of box secon consisting of two webs, normally ½ in. plate, spaced 3 ft. apart and ith a depth of 12 ft. The bottom ange has as minimum section a 2 x 1 in. plate, with a second 1 in. late for local reinforcing. The top ange has a minimum section of 57 ½ in., with one or two ¾ in. cover lates over part of its length.

As mentioned above, the whole ross section of the deck has been ssumed as acting together with the op flange of the stiffening girder.

This combined girder section is symmetrical having its neutral axis bout 3 ft. from the top. As a result he bending moment stresses in the bottom flange of the stiffening girder re roughly three times as high as hose in the top flange. Due to the presence of the arch thrust stress which is of course, uniformly distributed over the girder section, and to the reversal in sign of the bending moments, the difference between the extreme stresses in the top and bottom is reduced. The difference is still large enough, however, to make it possible to design the lower part of the girder in low alloy steel and the top part in medium steel thus using the materials to their best advantage. The change over from low alloy to medium steel is accomplished at the longitudinal web splice located about 5 ft. from the bottom of the girder. (Fig. 5)

When comparing this 12 ft. deep asymmetrical girder with a conventional symmetrical girder and using the same allowable stresses, it is clear that the latter requires a depth of twice the distance from the neutral axis to the bottom flange, in this case about 18 ft. in order to have the same inertia. The stiffness of the bridge is therefore relatively high in spite of its slender appearance. Indeed the maximum calculated deflection under live load is 1.04 ft.—small for a bridge of this size and less than the ordinarily allowed maximum of 1/800 of the span length.

The girders are provided with stiffening diaphragms spaced in line with the deck floor beams; these at the same time make the rigid floor beam end connection referred to previously, effective.

The tension stresses from arch thrust sufficiently counteract moment compression stresses so as to eliminate the need of longitudinal buckling stiffeners, although the ratio of depth to thickness of the girder web is 288. During erection and depending on the method to be followed, buckling stiffeners may be required if the girder moments exceed a certain value before the thrust tension is present.

With the exception of some welding in the diaphragms, the stiffening girders are all riveted.

Arch Ribs (Fig. 6): The arch ribs consist of riveted box members, built up from plates and angles with outstanding legs. The distance back to back of the angles is constant over the whole length of the arch, i.e. 38 in. horizontally and 53.5 in. vertically. The two web plates have a depth of 53 in. and the flange plates are 52 in. wide. All the main material of the arches is low alloy steel.

Following customary practice the ends of the arch panels are faced and the splices designed on the assumption that 50% of the load will be transmitted in contact bearing.

The size of the box is determined by the desire to keep the slenderness ratio of the arch panels as low as possible to avoid too big a reduction in allowable compression stress.

The allowable stresses are also related to the minimum guaranteed yield point of the material, which in the standard specification for low alloy steel (ASTM A 242), shows a drop from 46,000 p.s.i. to 42,000 p.s.i. for plate exceeding 1½ in. in thickness. The size of the arch cross section has therefore been designed so that the maximum plate thickness does not exceed 1½ in. at the same time avoiding the use of more than one plate thickness thus eliminating the necessity of stitch riveting.

Although this requirement can always be met, the width of the plates may become so large that local buckling of the individual plates has to be prevented by the use of relatively costly longitudinal stiffeners.

However, the great height of the arch (230 ft.) corresponding to a ratio of span to height of only 5.2 and the relatively low dead load of the bridge produce arch forces low enough that stiffening is not necessary for the given sections.

In accordance with the criteria given above, the maximum plate thickness of the arches is 1½ in. The minimum of 1-1/16 in., occurs in the top part of the central arch, where the forces are the smallest.

The stability of a stiffened tied arch against buckling in its own plane is usually only investigated locally between panel points, buckling of the arch as a whole being ruled out because of the stabilizing influence of the stiffening girders. This concept is the result of an approximate analysis which does not take into account second order effects produced by the elastic deformation of the system. It has been proven, particularly in the case of stiffened arches of large dimensions, that these secondary effects, for which the elongation of the hangers can no longer be neglected, can become of such importance that the equivalent slenderness ratio of the whole arch becomes larger than that over one panel length, thus governing the design.

The Port Mann arch being unusually large for a bridge of this type required that this problem was investigated. Contrary to what has been found in existing bridges with a smaller span, the results in this case showed that panel buckling is still the governing factor. This can be explained by the fact that the hangers, assembled from plates and angles have a cross section which is many times that of the cable hangers often used in the design of stiffened arches, and where the magnitude of the hanger elongations is of much greater influence on the overall stability.

Hangers and Columns: Both hangers and columns are I-sections built up from medium grade angles and plates and are of riveted construction. To ensure sufficient stiffness over the weak axis the flange ends are reinforced with angles.

All hangers except the shortest one at the traffic portal have the same cross section. The depth of the I-section (1 ft. 9 in.) has been kept to a minimum in order to maintain the light appearance of the superstructure where it emerges above the deck level. The end connecting gusset plates have been kept in line with the webs of arches and stiffening girders and to simplify these details (distance between gussets 2 ft. 11 in.) the hanger ends are tapered to overcome the difference between the two dimensions.

For the column members below the deck the appearance is less important and their depth has therefore been established to suit the distance between the end gusset plates.

The rigid end connection of the columns to arch ribs and stiffening girders has been taken into account in the analysis. In particular the girders, with an inertia about 500 times that of the columns and in tension as ties for the arches, exert a considerable clamping effect. For this reason the equivalent length for the determination of the slenderness ratio has been established at 0.85 of the column system length.

To ensure the stability of the column flanges against torsional buckling the outer angles are connected at regular intervals with batten plates.

Due to the presence of the web the column section differs from ordinary built-up columns consisting of two separate sections, connected by bracing or batten plates. The necessary amount and size of the batten plates is therefore less in this case, a problem which was investigated by means of an analysis especially derived for this purpose. For the sake of uniformity all columns, have the same cross section, except the two shortest in the side span. For these shortest side span columns the regular cross section would have been unsuitable in view of the secondary stresses. To overcome this the sections in these two cases have been designed with a considerably smaller moment of inertia over the weak axis thus reducing the secondary end moments. This reduction in inertia compared with the regular column section is possible because of the shorter length of these members which gives a corresponding reduction in slenderness.

Lateral Bracing: In addition to the bracing action of the steel deck two sway frames over the main piers and diagonal bracing between the arch insure lateral stability and strength.

The bracing layout shows crossin diagonals connected to the arches the panel points without lateral mem bers. This provides a slender an pleasing appearance and at the sam time reduces secondary stresse caused by arch rib shortening to minimum.

Only at the traffic portals whe the distance between the arch ri is rigidly maintained by the port cross-strut could such stresses develo to any great extent. Because roughl 80% of the total arch compressio is generated by the dead load th problem has largely been overcom by specifying that the diagonal en connections in the vicinity of the stru shall not be permanently bolted u until the bridge carries its ow weight. The remaining rib shortenin effect (from the live load) is to small to influence the design of th bracing members.

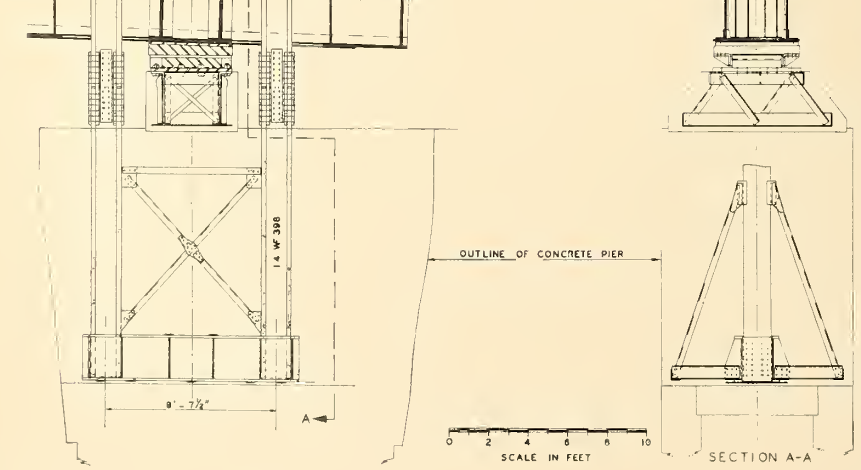
Apart from the interruption at th traffic portals, no diagonal bracing i provided over a short distance alon the ribs just below the stiffening gir ders to accommodate the passage o a travelling service gallery. Here similar to the traffic portals, the lat eral shear forces are carried throug stiff portals and a cross strut betwee the arches is provided for this pur pose.

The bracing diagonals are designe as welded rectangular box sections the depth of which is constan throughout the bridge at about 2 in. This depth was largely determine by the desire to keep the dead loa bending stresses in the bracing belov a reasonable value and to provide suf ficient rigidity against possible vibra tions.

The depth of the bracing is abou half that of the arch ribs and in thi respect the design deviates from tra ditional practice where to ensure sta bility, bracing members are made equal to the full depth of the chor members. Such a full depth membe can only be made economical by de signing the web in the form of lat tices or batten plates and these would be out of place with the otherwis neat and simple lines of the super structure.

It was decided therefore to design the bracing members to have a minimum possible depth and this necessitated an investigation of the arch stability against torsional buckling. The result of this analysis showed that, due to the large torsional resistance of the closed arch box members, lateral buckling over one panel length remained governing.

Fig. 7. Tie-down arrangement at anchor piers.



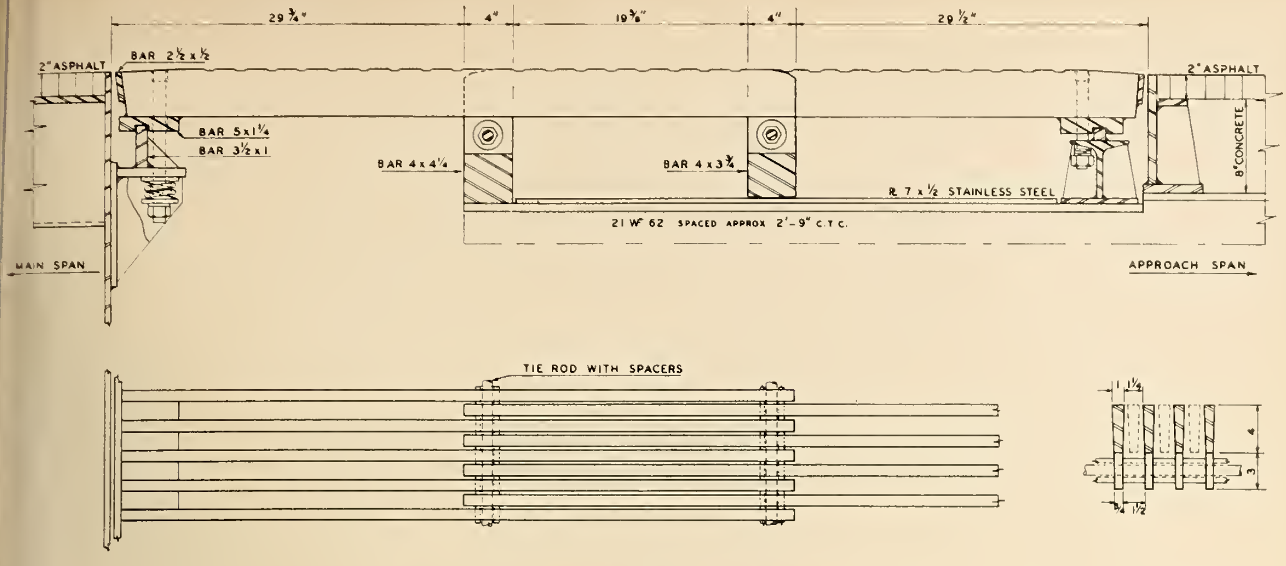


Fig. 8. Expansion joint at south anchor pier.

Bearings: While the bearings on the two main piers do not show any special features other than that the roller bearing on the south main pier had to be designed for a total expansion range of approximately 25 in. (temperature 12 in., live load 13 in.), the tiedown arrangement on the two anchor piers is of somewhat unusual conception. (Fig. 7)

The total range of expansion at the south anchor pier is approximately 15 in. for temperature effects and 7 in. resulting from live load deformations. In place of the conventional tiedown with eyebars, the negative reactions are taken by an inverted roller bearing, in which the roller pushes upwards against the top beam of a rigid frame anchored in the concrete pier. This construction eliminates any vertical movement, however small, which accompanies the horizontal displacements of an eyebar anchorage and also provides an easy arrangement for jacking. The whole of the tiedown frame is placed within the stiffening girder box section. A separate sliding bearing under each girder is provided to carry the downward reactions which can occur under extreme load combinations. These bearings at the same time act as a wind anchor.

Expansion Joints (Fig. 8): Of the two expansion joints at the anchor piers, the one at the south anchor pier has to accommodate the greater range of expansion. In addition to the deformations of the main structure, the expansion of the adjacent approach span has also to be overcome. The total necessary range of expansion was computed to be approximately 3 ft., though the design of the joint includes an extra allowance to cover possible misalignment of the superstructure and other uncertainties. The joints are of the finger type of construction and in view of the unusual length of the joint, special attention has been given to prevent squirming of the fingers. This has been achieved by providing a lug below the end of each finger by means of which they can be clamped together with a tierod and spacers after assembly of the two halves.

Maintenance: The interior dimensions of all box members, except small welded boxes which are hermetically sealed, are large enough to make them accessible, consequently no hand holes are necessary. Access is provided by manholes in the arch ribs and stiffening girders at panel length intervals. For inspection of those bridge parts below the elevation of the roadway a catwalk along the arch ribs is provided. Full maintenance is facilitated by a self-propelled travelling service gallery suspended from tracks bolted to the deck floor beams.

This gallery consists of an upper platform with a suspended lower gallery which can move laterally to provide access to the bottom and outside areas of the stiffening girders. The lower gallery in turn is equipped with cages which can be lowered for maintenance of all lower parts of the bridge.

Finally the bridge is equipped with a 2 in. diameter water line and a compressed air line.

Paving and Sidewalks: The 2 in. layer of bituminous paving is of special composition to insure watertightness and proper adherence to the steel deck and is placed over the full width of the deck, including the sidewalks.

Experience with existing orthotropic decks has shown that it is not advisable to interrupt the asphalt at the curbs due to the danger of water seepage through the joints which results in corrosion of the deck plate. Since the asphalt under the sidewalks acts only as protection to the steel, the thickness is reduced here to one inch.

The sidewalks themselves are of 5 ft. long precast lightweight concrete units which will be connected to the deckplate with stud welded anchor bolts. Fences and lampposts are anchored in the sidewalks.

Materials: The design of the main structure makes use of five different grades of structural steel.

The riveted members are designed in A7 steel wherever a medium grade is required, i.e. all vertical members, sway frames, riveted bracing members, the upper parts of the stiffening girders and of course all minor parts such as diaphragms and stiffeners even though a certain amount of welding may have been used in their design.

Low alloy riveted members (all main material of arch ribs and lower part of stiffening girders) are designed in A 242 steel. For the welded box members in the lateral bracing A 373 steel will be used.

All of these grades mentioned above are commonly used in bridge design but special attention was given, however, to the specifications for the steel in the orthotropic deck.

The deckplate is a highly stressed member showing a marked biaxial stress pattern, subject to impact from the direct wheelloads and with welds running along both directions of the plate. In addition the plate forms an integral part of the stiffening girders and any failure would not only affect the deck structure but also impair the safety of the bridge as a whole so that it is clear that every precaution must be taken to prevent the possibility of brittle fracture. Apart from proper design and fabrication procedures this can be achieved by specifying a steel having excellent notch ductile properties, generally measured by Charpy impact tests. However, it is known that a steel which shows excellent notch toughness before fabrication can be subject to considerable embrittlement after aging by cold working or in zones adjacent to welds. Therefore it is also advisable to check the impact values after an appropriate aging test, and the results should not differ more than a specified degree from the tests in the original condition.

As a result of these considerations the specifications for the deck steel (low alloy for the plate and longitudinal stiffeners, medium grade for the cross beams) provide for impact testing in addition to the standard A 242 and A 373 specifications. The complete specification for the deck steel is given in an appendix to this paper.

The Approach Spans: The superstructure of the approaches consists of an 8 in. thick concrete slab supported by three main girders and four stringers, the latter being supported by cross beams. The main girders are designed as welded plate members in composite action with the concrete slab and are continuous over three spans, the composite action being assured by welded stud shear connectors.

The individual span lengths selected as being the most suitable were 3 x 225, 3 x 175 and 3 x 125 ft., the whole approach structure being composed of a series of these units. A detailed study was made of the costs of seven different combinations of these spans, based on estimates for superstructure, bents, pilecaps and piles separately. While the 225 ft. spans are longer than usual in this type of construction the foundation conditions indicate that these spans are economically warranted. Architectural considerations require further that the ratio of length of span to height of pier shall not be too small.

The 125 ft. and 175 ft. spans were found to be most economical when designed as plate girders, though for the 225 ft. spans trusses might have been slightly more advantageous. However, the plate girders are aesthetically much superior when taken in consideration with the continuous line formed by the girders of the adjacent 175 ft. spans on one side and the stiffening girders of the main span on the other.

As an alternative to the composite plate girder design a solution with an orthotropic deck was investigated for the 225 ft. spans. The fabrication costs for the curved north approach were estimated to be too high to justify its use.

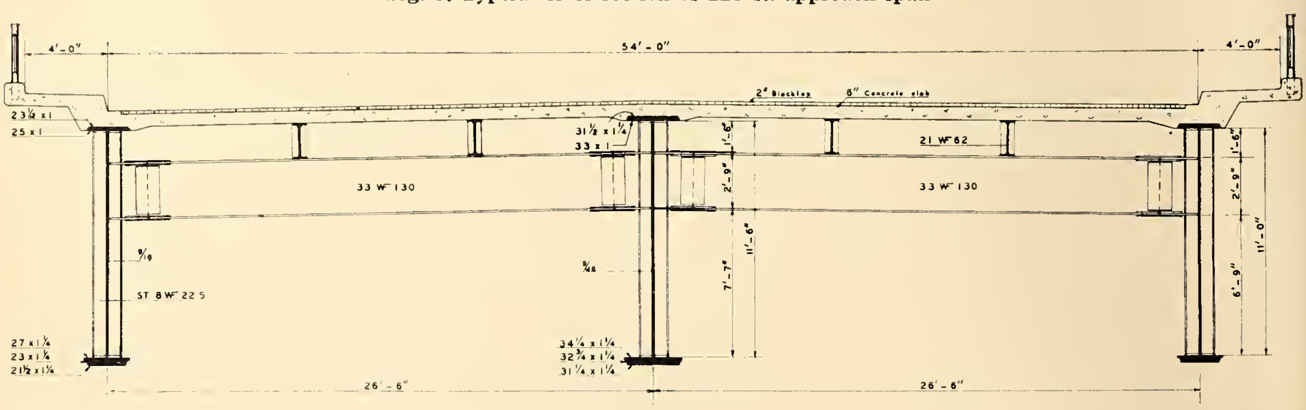
In the vicinity of the intermediate supports of a three span continuous unit the negative moments will generate tensile stresses in the concrete slab. To overcome these the girders are erected with a superelevation at the intermediate supports, varying from 40 in. for the 225 ft. spans to 22 in. for the 125 ft. spans. After pouring and hardening of the deck the girders are lowered to their final elevation thus introducing compression stresses in the concrete. Due to shrinkage and creep a large percentage of this prestressing is lost again in the course of time, with the result that under the design live load tension stresses will cause the concrete to crack. However, the remaining effective prestressing is still sufficiently large to prevent open cracks under dead load and ordinary live load conditions.

The occurrence of cracks under live load necessitates that the girders be designed in such a way that the negative moments on the intermediate supports can be carried by the steel girders alone. This could be prevented by prestressing the concrete separately with prestressing cables or bars. However, it was found that the extra costs involved in such a measure could not be offset by the ensuing savings in the steel girders.

The steel girders which vary in depth from approximately 6 ft. for the 125 ft. spans to 8.5 and 11.5 ft. respectively for the 175 ft. and 225 ft. spans have a web thickness ranging from 7/16 in. to 11/16 in. and have their flanges built up from one to three plates of maximum 1¼ in. thickness. This solution was preferred to using one heavy flange plate with a thickness of up to three or four inches. Welding of such heavy plates to the thin webs presents certain difficulties and the weldability of heavy plates is generally less than that of thinner plates. A typical cross section is shown in Fig. 9.

The floor system consists of cross beams, spaced at approximately 18 ft. c.t.c. and stringers spaced at approximately 9 ft. Both cross beams and stringers are—with a few exceptions—wide flange beams. Except for a temporary lateral wind bracing to be used during erection and removed subsequently, no wind bracing is

Fig. 9. Typical cross section of 225 ft. approach span



›vided. The lateral forces on the rmanent structure are transmitted ough the concrete slab and lateral bility of the main girder bottom nges, wherever they are in comession, is safeguarded by vertical ffeners forming rigid frames toher with the cross beams which e provided with stiff end connecons to eliminate the need of a lower eral bracing.

The whole approach spans are degned in medium grade steel with 373 quality for the welded girders id A 7 for the floor material.

All field connections are designed ith high strength bolts.

cknowledgements:

C.B.A. Engineering Ltd., Consultig Engineers, of Vancouver, B.C. ere retained by the Government of British Columbia for the design and upervision of the construction of the Port Mann Bridge. The program for he electronic computer was prepared y R. F. Hooley, B.A.Sc., M.Sc., Ph.D., Assistant Professor of Civil Engineering, University of British Columbia. Assistance in the preparaion of some of the Contract Drawings was provided by Choukalos, Woodburn, Hooley and McKenzie, Consulting Engineers, of Vancouver, while the mechanical design of the travelling service gallery was carried out by Robert McLellan & Co. Ltd., Consulting Engineers, of North Vancouver.

APPENDIX "A"

Design Loads and Stresses

DEAD LOAD:

Main Structure	*Tons*	
Structural Steel		
A 7	1,660	
A 373	380	
A 242	3,490	
A 373 (modified)	1,020	
A 242 (modified)	1,960	
		Tons
	8,510	8,510
Bearings and anchorages		285
Expansion joints		50
Drains, air line, water line		40
Catwalks, ladders, platforms		25
Bolts and rivets		410
Tram beams		50
2-24″ Watermains		600
Asphalt paving, concrete, sidewalks, fences		1,880
		11,850
Approach Structure		
6–225 ft. spans	*Tons*	
Structural Steel		
A 7	480	
A 373	1,760	
Bearings	110	
Concrete deck, asphalt paving, drains, airline, waterline, fences	5,460	
		Tons
	7,810	7,810
12–175 ft. spans	*Tons*	
Structural steel		
A 7	730	
A 373	2,050	
Bearings	160	
Concrete deck, etc.	8,480	
	11,420	11,420
6–225 ft. spans	*Tons*	
Structural steel		
A 7	500	
A 373	1,110	
Bearings	100	
Concrete deck, etc.	6,050	
	7,760	7,760
		26,990
Expansion joints		80
Shear connectors and high strength bolts		170
		27,240

LIVE LOAD:

(a) Lane loading 800 lb./ft. plus a single force of 22.5 kips (on the main span the single force has been omitted).

(b) Truck loading H25–S20 i.e. 3 axle loads of 5, 20 and 20 tons respectively; one truck per lane.

(c) Sidewalk loading 33 lb./ft.

Impact and reduction for multiple lane loading in accordance with A.A.S.H.O. specification.

LATERAL WIND LOAD:

On Main Span: on each arch rib and vertical member 50 p.s.f. On two stiffening girders combined 50 p.s.f. On live load 200 p.s.f.

On Approach Spans: on three girders combined 75 p.s.f.

Vertical Wind Load: 8 p.s.f. acting upwards or downwards. For overturning effect: in accordance with A.A.S.H.O. specifications.

Longitudinal Forces: in accordance with A.A.S.H.O. specifications.

Earthquake: a force acting in any direction equal to 10% of the dead load of the superstructure.

Basic Allowable Stresses:

Tension, Medium Steel (A 7, A 373): 20,000 p.s.i.

Low alloy steel (A 242):

$$\frac{\text{Min. Guar. Yield Point}}{33{,}000} \times 20{,}000 \text{ p.s.i.}$$

Compression:

Medium steel: 20,000 − 70 l/r p.s.i.

Low alloy steel

$$\frac{\text{Min. yield}}{33{,}000} \times 20{,}000 - 100\, l/r \text{ p.s.i.}$$

In either case no more than

$$\frac{\pi^2 \times 29{,}000{,}000}{2.5\,(l/r)^2} \text{ p.s.i.}$$

Where l = length of member with pin-connected ends or equivalent length for members with other than pinned end-connections.

Secondary stresses in excess of 4000 p.s.i. (for tension members) or 3000 p.s.i. (for compression members) are treated as primary stress.

Shear in high-strength bolts: 15,000 p.s.i.

Allowable stress increases for loading combinations in accordance with A.A.S.H.O. specifications.

Maximum allowable stress in deck plate for all stresses combined according to Hencky-von Mises: 38,000 p.s.i.

APPENDIX "B"

Specifications for Low Alloy Steel for the Deck Plate and the Longitudinal Deck Box Stiffeners of the Main Span

This steel shall conform to the requirements of A.S.T.M. Specifications A 242–55 with the following additional requirements:

(a) The steel shall be semi or fully killed and normalized.

(b) The steel shall be free of laminations.

(c) Max. carbon content 0.20% (ladle analysis), 0.24% (check analysis)

Max. P content 0.05% (ladle analysis), 0.063% (check analysis)

(d) Impact requirements:

(i) Type of test: Charpy test with keyhole or U-notch conform to A.S.T.M. Specifications A370–54T.

(ii) The test bars shall be taken transverse to the final direction of rolling. The base of the notch shall be taken perpendicular to the plate surface.

(iii) Temperature of testing 0° (+32° F.)

(iv) Minimum required impact values:

In the delivered condition:

average of 3 bars:	22 ft. lbs.
minimum of 1 bar	11 ft. lbs.

In the strain aged condition:

average of 3 bars	14 ft. lbs.
minimum of 1 bar:	7 ft. lbs.

The strain aging is performed by cold working (upsetting) 10% the sample from which the test bars are made, followed by heating at 250° C. (480° F.) during 30 minutes.

(v) For material under 1/2 inch, sub-size impact test specimens shall be used in accordance with A.S.T.M. Specification A370–54T. The minimum required impact values are reduced proportionally to the thickness of the sub-size specimen.

Structural Carbon Steel for Webs and Flanges of the Deck Cross Beams

This steel shall conform to the requirements of A.S.T.M. Specifications A373–58T with the same additional requirements as specified for the deck plate and longitudinal deck box stiffeners.

Note: The impact test bars for the steel, from which the flanges of the cross beams are fabricated, may be taken along the final direction of rolling of the material. EIC

NEW USES FOR CERAMIC MATERIALS IN MICROWAVE TUBES

G. B. Walker,

Research Professor, Department of Electrical Engineering, The University of British Columbia

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THE PURPOSE of this paper is to indicate some of the ways in which low loss ceramics may be employed in U.H.F. electron tubes and other microwave devices. At the outset it is important to stress that the applications envisaged are still no more than proposals and must remain so until adequate evidence on reliability has been obtained from comprehensive laboratory tests.

The subject is a challenging one. On one hand, there are theoretical advantages, which are well understood and which offer yet farther avenues for speculation. On the other hand there is a lack of information on practical matters and an entirely new technology has to be developed.

Perhaps the most surprising feature is the very wide range of microwave devices for which ceramic techniques can be considered. Two only are discussed here, namely an electron linear accelerator and a millimetre wave travelling wave tube, design studies on which are at present being carried out at the University of British Columbia.

General Considerations

During recent years research in the field of microwave tubes has mainly been concentrated on the problems associated with very high frequency operation, that is at frequencies above 1 K Mc/s or at wavelengths in the centimetre and millimetre region. There are a number of reasons for this; in communication systems a greater number of information channels can be accommodated with ample bandwidth, high definition short range Radar becomes more feasible and in the case of electron linear accelerators, the electron energy which can be obtained from a given driving power level increases with the frequency of the driving source. Apart from these, and other advantages of immediate practical application, there is also the need to explore the region of the frequency spectrum between say 1 mm. and 0.1 mm. wavelength, a region which is beyond the capacity of infra red sources, at the short wave end and is at about the limit for conventional microwave tubes at the long wave end.

Looked at from a historical point of view, progress in electron tubes has been a gradual development of devices to operate at higher and higher frequencies. At frequencies below, say, a few megacycles per second electron transit times are negligible in comparison with the period of oscillation and the size of the tube is unimportant. The transit time limitation in conventional grided tubes was partly overcome by decreasing the length of path of the electrons. In this way it has been possible to extend the upper frequency limit to about 3 K Mc/s, but there is little prospect that inter-electrode spacings can be reduced further. New principles were evolved which very largely removed the transit time limitation, notably in the Klystron, Magnetron and Travelling Wave Tube, amplification and oscillation now taking place by a direct interaction between electrons and electromagnetic waves. In the tubes mentioned, the electromagnetic fields require to be confined in a structure certain dimensions of which must of necessity be less than a wavelength in size and so again, there is a practical limitation, the limit being reached at millimetre wavelengths. To go beyond to still shorter wavelengths requires a completely new approach and various suggestions have been made, using for example, the radiation from accelerated electrons (the undulator principle), the Cerenkov effect and radiations from excited states in solids.

The use of ceramics, to be described, relate to improvements in tubes at centimetre and millimetre wavelengths and stem from the following considerations:

(a) The electromagnetic power absorption in metals increases as the square root of the frequency and hence, tubes become inherently less efficient as the frequency increases. Ceramics normally show some increase in power absorption with frequency but this is relatively small in comparison with metal loss;

(b) A greater degree of freedom in design is possible with ceramics than with metals, dielectric constant being an additional variable. In certain cases frequency characteristics may be produced which are unobtainable in all metal structures;

(c) In general, machining tolerances are less critical. This can be extremely important in the case of very small structures;

(d) The power handling capacity is greater due to the fact that the component parts of the tube can be larger.

Reduction of power absorption

As is well known, at microwave frequencies currents in metal parts are confined to the surface and penetrate only to a minute depth known as the skin depth, of the order of 10^{-4} cm. The power absorbed depends upon the effective electrical resistance presented by the metal and hence is proportional to the resistivity of the material and also to the skin depth (the latter diminishing as the frequency increases). Surface roughness causes an increased absorption by increasing the length of the paths of the surface currents and unless precautions are taken to maintain clean and near perfect surfaces, the power absorption may be considerably greater than the expected value. Except by operating at temperatures approaching absolute zero, there is no prospect that metals can inherently be improved and a new approach to the problem of confining electromagnetic energy in small enclosures is required. It may be pointed out that as the size of the enclosure diminishes, the ratio of volume to surface area also diminishes and hence power absorption into the enclosing walls increases in importance.

To understand the advantages to be gained by dielectrics it is informative to approach the question of power absorption in walls from a different viewpoint. To obtain a small absorption it is necessary that the wall should act as a good reflector of electromagnetic waves. In the case of a plane wall on which a simple plane wave is incident in the direction of the normal, the question of reflection can be analysed from impedance concepts. The condition for a good reflection is that the characteristic impedance at the wall is either

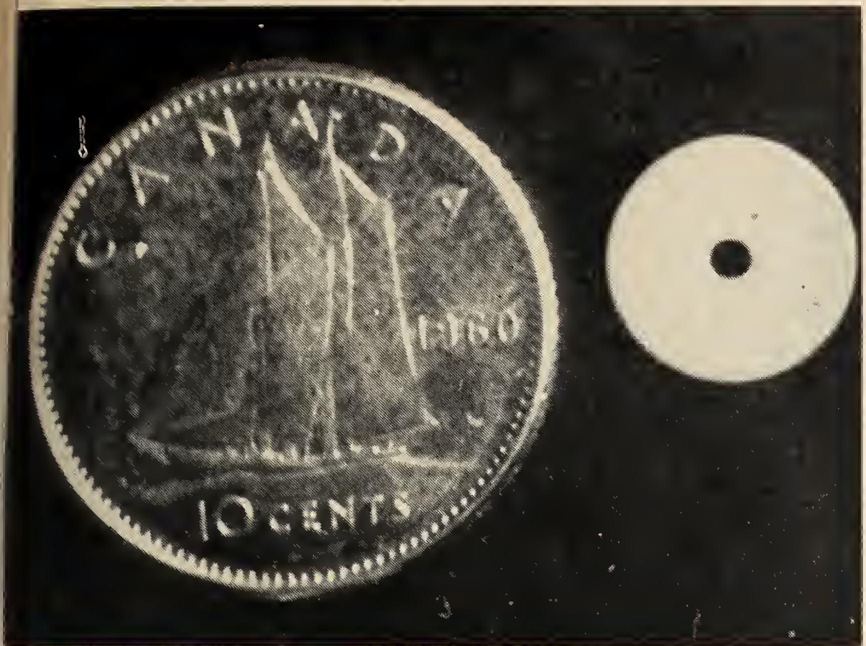


Fig. 1.

very low or very high in comparison with the characteristic impedance of the region in which the wave approaches the wall, (i.e. short circuit or open circuit reflection). It has been shown[1] that by placing a sheet of dielectric one quarter wavelength thick at a distance of one quarter of an air wavelength from the wall, the impedance appearing at the outer edge of the sheet can be written

$$Z = \frac{1}{\epsilon} Z_M + \frac{30\pi^2 \tan\delta}{\sqrt{\epsilon}}$$

where Z_M is the characteristic impedance of the metal wall, ϵ is the relative permittivity (dielectric constant) and tan δ the loss tangent of the dielectric. By using the combination of a high ϵ and low tan δ it is possible to make Z less than Z_M and therbey achieve a better reflection.

The important factor in deciding the quality of a dielectric for this purpose is tan $\delta/\sqrt{\epsilon}$. Using a titania ceramic ($\epsilon = 100$, tan $\delta = 0.0002$), a reduction in loss by a factor of 2 has been measured at 3 K Mks. This factor increases roughly as the square root of the frequency and hence a considerably higher improvement is to be obtained at millimetre wavelengths. By using a few dielectric layers the metal wall can be dispensed with entirely.

This principle also applies at curved walls as in waveguides and resonant cavities. Due to difficulties in fabrication it is doubtful if it could be used successfully for the long distance transmission of microwave power, the most obvious uses being in aerial design, high Q resonant cavities and microwave components such as tubes and filters.

Further research in these areas has taken second place to studies into the properties of dielectric slow-wave structures, the basic principles of which will now be described.

Slow-wave structures

The basic principle underlying the operation of a travelling wave tube and electron linear accelerator is an interaction between electromagnetic waves and an electron beam. If the phase velocity of the wave is equal to the velocity of an electron, the electron travels in a constant electric field. Electrons which move in an accelerating field gain kinetic energy, this energy being extracted from the wave, whereas electrons which move in a retarding field lose kinetic energy and hence add to the intensity of the wave. In both a linear accelerator and travelling wave tube the electron beam is formed into bunches of electrons separated by one wavelength, the significant difference being the position of the bunches in relation to the wave.

The major design problem is to construct a structure through which a wave can propagate with the requisite phase velocity. The structure is known as a slow-wave structure since the phase velocity of the wave must be less than the velocity of light in free space. In the case of a high energy electron accelerator the required wave velocity approaches very closely to the velocity of light.

It is a general property of waveguides, or hollow metal tubes, that the phase velocity of the waves which can be propagated is always greater than the velocity of light. There are, however, a number of ways in which the wave velocity can be reduced, the most common being (a) to load the waveguide with thin metal disks, or (b) to replace the waveguide by a coil of wire wound in the form of a helix.

In the helix structure the wave may be described as travelling along the wire of the helix with the veloeity of light. Its progress in the direction of the axis of the helix is therefore slower and can be regulated by adjusting the pitch of the helix. This type of slow-wave structure is very suitable for travelling wave tubes in which the electron gun voltage is low, of the order of a few KV. There are limitations on power handling eapacity and operating frequency, the wire diameter and the coil diameter becoming exceedingly small for millimetre wavelengths. Some conception of the problems involved in the use of a helix for a millimetre wave tube may be obtained from the structure reported by McDowell, Danielson and Reed.[2] This tube is a half-watt C.W. travelling wave amplifier for the 5-6 mm. band the helix being wound from a 2 x 4 mil molybdenum tape, the pitch being 110 turns per in. and helix diameter 15 mils. With a beam current of 3 ma and a gun voltage of 7 kv. a gain of about 30 db was obtained from a helix length of 4 in. The limiting factor is the extremely small size of the helix, serious heating being caused by electron bombardment in addition to absorption of power from the electromagnetic fields.

The metal disk loaded waveguide is more suitable for high power operation and is exclusively used in electron linear accelerators and high-power travelling wave tubes. The wave pattern, due to multiple reflections within the structure, is rather more complicated, but the salient features may be understood as follows.

The waveguide, containing disks at regular intervals, has propagation characteristics which are common to all periodically loaded systems. There is a cut-off frequency below which no propagation will occur, as is also true of an empty waveguide, but unlike the empty guide propagation can only take place in a succession of frequency bands. In this respect, the structure resembles a band-pass filter.

In a propagating region, or pass band, the wave pattern can be analysed into a system of space harmonics, each of which is a simple harmonic wave of the same time periodicity. The phase velocities of the space harmonics differ by discrete amounts, the complete set including backward as well as forward waves.

The structure is designed so that one space harmonic has the same velocity as the electron beam, all other space harmonics having no coupling action.

One limitation of this structure is that it is strongly dispersive, that is, the velocity of the space harmonics varies strongly with frequency.

Dielectric slow-wave structures

Since the velocity of an electromagnetic wave is inversely proportional to the square root of the dielectric constant of the medium through which it propagates, it is immediately obvious that dielectrics are inherently suitable for the production of slow waves.

The simplest application for accelerators or travelling wave tubes is to fill a length of waveguide, of circular section, with a dielectric having an axial hole to permit the passage of an electron beam. An accelerator structure of this type was investigated by Flescher and Cohn,[3] using quartz as the dielectric. It did not prove successful for two main reasons. (1) Breakdown occurred at the surface of the quartz, probably due to electron bombardment, and (2) the structure proved to be more lossy than an all metal structure, power absorption taking place in the dielectric and, due to the presence of the dielectric, the power absorption in the containing metal waveguide was increased.

A very significant advance was made by Shersby Harvie[4] who showed that if the dielectric tube is made of an anisotropic material the dielectric constant being greater in the radial than the axial direction, a remarkable improvement in losses results. The required anisotropy can be obtained by laminating the dielectric, i.e. forming the dielectric tube from a system of closely spaced disks. Not only is the power absorption in the dielectric material reduced but the power absorption in the metal wall is also diminished and the efficiency of the structure can be made considerably higher than is obtainable by any other known means. The possibilities of this type of structure have not yet been fully explored and it will not be discussed further in this paper.

An alternative type of dielectric slow-wave structure which is at present under investigation consists of a metal waveguide loaded with a series of dielectric disks, the spacing between disks being an appreciable fraction of the wavelength. This is clearly a periodic structure and must therefore have pass and stop bands. It can be shown, however, that a much greater freedom in design is possible than with metal loading disks. A most significant point is that in an all metal structure the slowing down of the wave is achieved by having partial resonances in the region between disks. With dielectric disk loading the slowing of the wave is an inherent property of the dielectric and it is even possible to choose a frequency at which the disks are transparent to the wave, i.e. no reflections occur in the system. This property is made use of in the accelerator structure to be described, and will be discussed in a later section.

In regard to travelling wave tube applications an important feature of the dielectric slow-wave structure is that the phase velocity is less frequency dependent than in a metal disk loaded guide, which enables the tube to operate over a somewhat greater bandwidth. A second feature is that in the helix and metal disk loaded structure the longitudinal electric intensity of the wave is a minimum along the axis of the tube this field reduction becoming more marked for slow waves and hence low electron gun voltages. Using disks of high dielectric constant it is possible to reduce this effect, the wave in the region between disks having maximum electric intensity on the axis. To put the matter otherwise, in order to obtain a high coupling between a wave and an electron beam it is necessary that the electrons should be present in the part of the wave carrying the greatest amount of energy. In helix structures the energy is concentrated in the neighbourhood of the helix, in metal disk loaded structures the axial field is weak and in the case of a solid dielectric cylinder, power is transferred through the dielectric rather than along an axial hole.

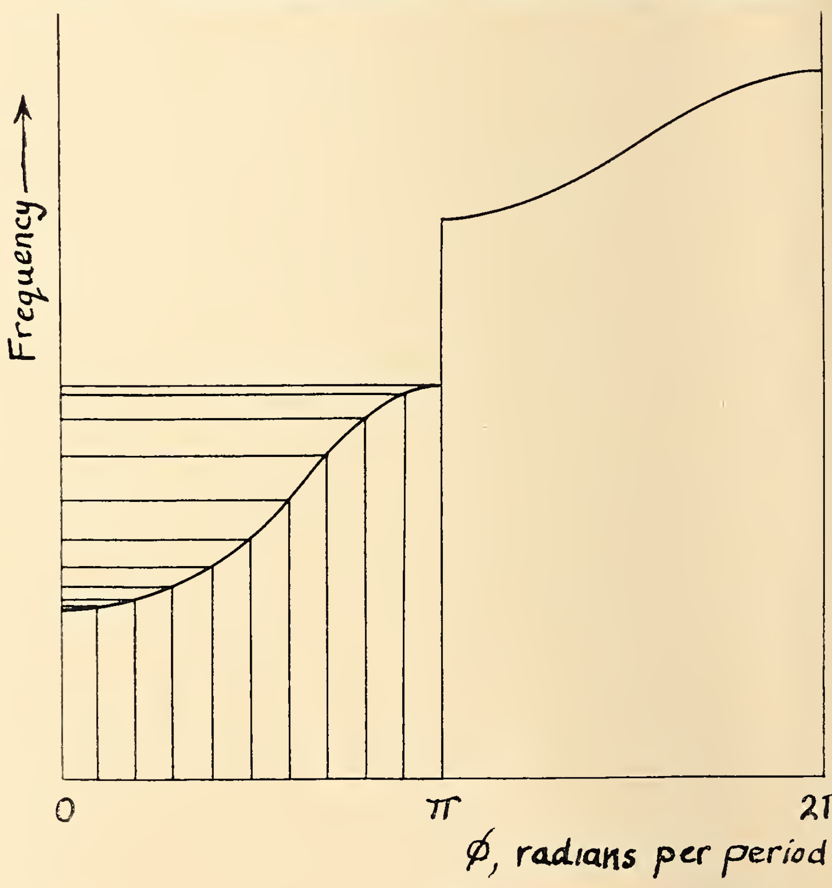
Description of proposed 8 mm. T.W.T.

Design studies have been carried out at U.B.C. on a forward wave t.w.t. to act as an amplifier at a wavelength of 8 mm. The component parts are now being assembled to meet the following specification.

The slow-wave structure is a copper tube containing 100 disks of a titania ceramic of dielectric constant 93. The disks, illustrated in Fig. 1, are of outer diameter 0.322 in. and have a central hole of diameter 0.050 in. to permit the passage of the electron beam. A disk thickness of 0.007 in. has been chosen and in the structure, the disks are placed .010 in. apart, the total length of the slow-wave structure being 1¾ in. Despite their small size the disks are surprisingly robust and can withstand large compressive forces.

To assemble the disk-loaded waveguide, the disks are first mounted on a mandrel and spaced with plastic spacers. Having aligned the system, the disks and spacers being held together under slight pressure,

Fig. 2. Typical Dispersion Curve for a Periodically Loaded Waveguide.



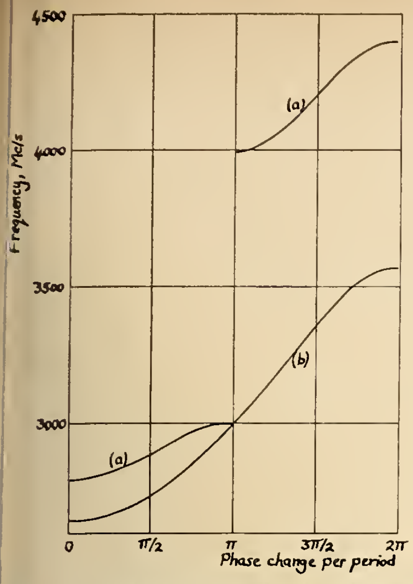


Fig. 3. Dispersion Curves for Matched and Unmatched Disk loading. (a) With Unmatched disks; (b) With matched disks.

the whole is inserted in a well-annealed copper tube having an axial cut. By the application of external pressure on the tube, the disks are firmly held in position. The axial cut is necessary to assist the evacuation of the tube. It has little effect on wave propagation since wall currents flow parallel to the cut.

An electron gun of the convergent type is being designed to give a beam current of 10-14 ma at a voltage of 11 kv. With this beam the calculated gain of the tube should be about 9 db. As a first experiment with a tube of this type the policy has been to endeavour to obtain the maximum amount of information on the uncertain factors rather than aim at an optimum design. A structure of twice or three times the length would be required to obtain a useful figure of gain but the additional cost would add little to the value of the experiment.

Probably the most important question is whether the disks will suffer damage from stray electron bombardment. Tests under D.C. conditions have been favourable both in regard to surface charging and electrical breakdown but experience under actual working conditions is essential.

The loss tangent of the ceramic being small (about 0.0002) no noticeable heating can be caused by the electromagnetic fields, even at C.W. power levels of the order of watts. The hole size in the disks being 50 mils (c.f. 15 mils for a helix tube) it should be possible to avoid bombardment by stray electrons to an extent sufficient to cause a marked rise in temperature. The beam diameter it is hoped to achieve is 10 mils, using an axial magnetic field to constrain the beam.

A dielectric loaded electron accelerator

Experiments are also in progress on a new type of electron linear accelerator employing dielectric loading. Before describing this device it may not be out of place to review some of the current approaches to accelerator design.

The maximum length of an accelerating structure is limited by phase considerations. Slow-wave structures being dispersive, a small change in driving frequency must result in a change in wave velocity, causing the electrons to fall out of phase with the wave after a certain distance has been travelled. Temperature changes may also affect the phase velocity and it has been found impractical to operate with an electron-wave interaction region greater than about 10 ft. To obtain higher energies a number of such structures, each driven by a separate power source, are placed in cascade.

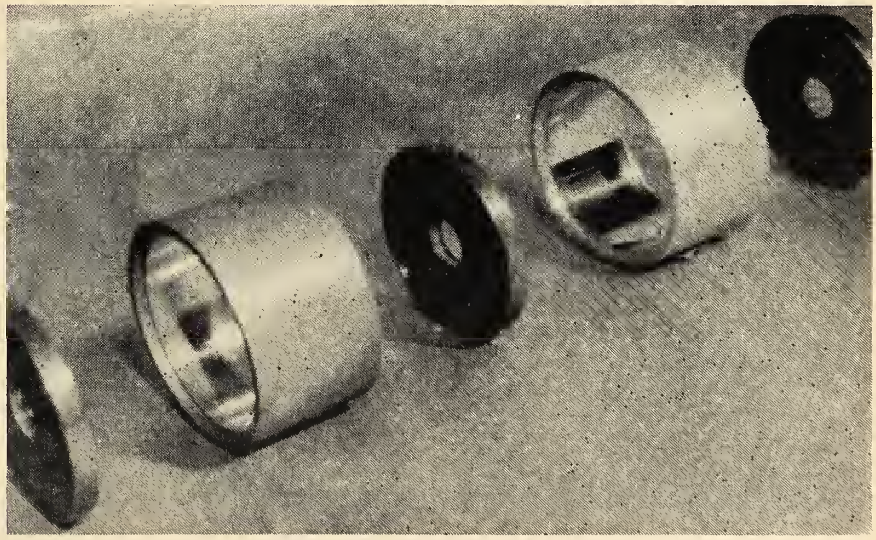
For a given power source the problem is to make the best use of the available electromagnetic energy in a structure of limited length. There are three approaches, one which is common in England, is to extract electromagnetic energy from the end of the structure and feed it back into the input. In this way a higher electromagnetic intensity can be built up which is limited by losses in the slow-wave structure and in the feed-back loop. A second approach, favoured in America, is to design the slow-wave structure so that the group velocity, i.e. the velocity of propagation of energy along the structure, is low. An appreciable fraction of the operating time of the machine is thus taken in filling the structure with electromagnetic energy and as a result a high stored energy is achieved. The third approach is to run the structure as a resonant system.

In the latter case, the backward wave in the structure does not couple with the electron beam except in the unique condition that the phase change in the wave in passing from one loading disk to the next is π. This is known as π-mode operation, the loading disks being one half wavelength apart.

The coupling efficiency in a π-mode resonator is approximately twice that obtained in any other mode and it is obviously desirable to operate in this way.[5] One serious difficulty with an all metal structure is that the frequency separation between the π-mode and the neighbouring resonant mode is very small and it is difficult to ensure that unwanted modes are not excited. This point is illustrated in Fig. 2. The heavy lines show part of a typical dispersion curve. A stop-band occurs at the frequency corresponding to a π-phase change per section and the vertical lines show the frequencies at which other resonances can occur in a structure containing 10 loading elements. By using dielectric disks it is possible to remove the stop-band in the dispersion curve, the requirement being that the disks are transparent or "matched" at the π-mode frequency (Fig. 3.)

This principle is employed in the dielectric loaded accelerator at present undergoing tests at the University of British Columbia. The machine consists of two main resonant cavities each 50 cm. long loaded with ten dielectric disks of titania ceramic. A copper ring is shrunk on to each disk and the disks are held at a distance of 5 cm. apart by means of spacer tubes as illustrated in Fig. 4. The assembled tube is enclosed in a vacuum jacket, shown in Fig. 5 and microwave power is fed from a 2

Fig. 4.



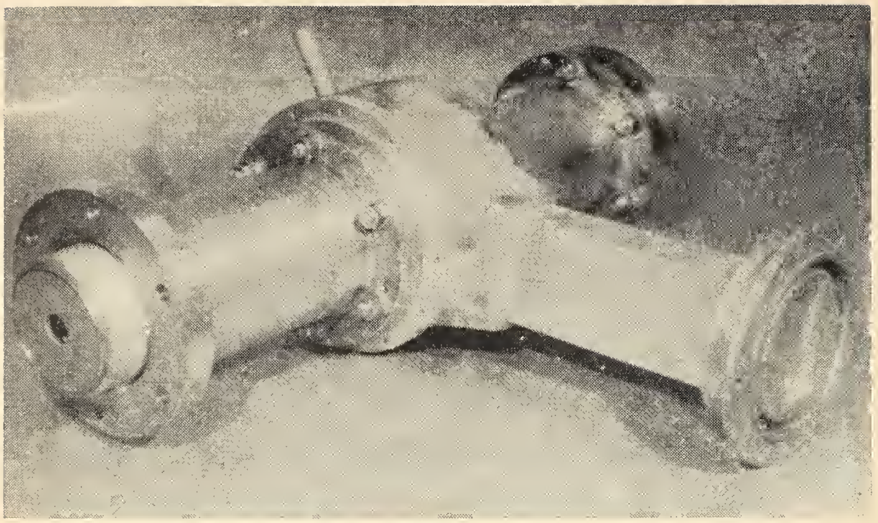


Fig. 5.

Mw. magnetron to the centre of each cavity.

An electron beam produced by a low voltage, tungsten cathode gun is passed through a pre-accelerating cavity to obtain an injection energy of about 200 kv. Electrons of this energy are then passed into the main accelerator and obtain a further gain in kinetic energy of about 10 Mev. In the final accelerator, linear velocities are approximately equal to the velocity of light and gain in kinetic energy takes the form of an increase in mass. For this reason, no variation in phase velocity is necessary and the dielectric disk spacing is kept uniform throughout.

This type of structure is probably the simplest and most efficient that has so far been designed and may have applications in medicine and high energy physics. There are also industrial applications in the treatment of polymers, food processing, etc. where a source of high intensity X-rays is required.

Suitable ceramic materials

For tube applications of ceramics it is desirable that the material should have a combination of a high dielectric constant and low-loss tangent. In addition, it should be mechanically strong and able to withstand high temperatures in vacuo.

The most promising material is a ceramic formed by sintering powdered titanium dioxide with a flux. A dielectric constant up to 100 can be obtained and it is possible to adjust the constituents to achieve any desired value in the range 1-100. Other ceramics of interest are formed from magnesium titanate, aluminum oxide and berylium oxide, with dielectric constants respectively, in the region of 14, 9 and 5. For most purposes higher dielectric constants are desirable but there are compensating advantages, e.g. berylia has a high thermal conductivity and low coefficient of expansion. In the main there is a tendency for the loss tangent to be high in materials of high dielectric constant and as far as is known the ratio $\tan \delta/\sqrt{\epsilon}$, which is a useful measure of quality, has a lower value for titania than any other material.

For the applications envisaged, namely slow-wave structures and impedance transformation, ferrites offer an alternative since in addition to an increased dielectric constant, they also have a high permeability which may be controlled by the application of a magnetic field. Unfortunately the loss tangent in known ferrites is considerably higher than in the ceramics mentioned above and consequently high electrical efficiency cannot be obtained.

Assessment of feasibility

The use of ceramics in commercial tubes must depend upon the question of reliability, a matter which is always difficult to assess accurately by laboratory experiments alone.

Machining to adequate tolerances and the mechanical construction of tube structures presents no special difficulties. More knowledge is required on the bonding of ceramics to metal, particularly when a vacuum tight joint is desired. For many purposes, however, a simple press contact is sufficient and it has been found that no additional losses are introduced even with a poor contact.

The most important practical considerations have to do with the behaviour of ceramics under electron bombardment. Reliable evidence is difficult to obtain since a large number of interrelated factors are involved and the question is the subject of considerable study throughout the world. There are a variety of ways in which a ceramic disk can become unserviceable, e.g. by the formation of static electric charges on the surface which may cause the tube to fail due to the production of unwanted DC fields. Static charges may also cause an electrical breakdown, or discharge, to occur over the surface of the ceramic or throughout its volume. Electron bombardment may cause sudden heating resulting in a fracture of the material by rapid expansion.

The relative importance of these various factors is very different in a high-energy accelerator and in a comparatively low power t.w.t. In the former, the most important consideration is electrical breakdown across the surface of the disks occasioned by intense microwave electric fields. Titania ceramic suffers from a serious disadvantage in that any arcing or sparking at the surface in vacuo causes a reduction to a lower titanium oxide, which is conducting. It has been found that by applying a lead borate glaze to the surface of the disks this difficulty is removed and test cavities have been successfully operated at field strengths of the order of 3 x 10^5 v./cm.[6] This field intensity compares favourably with the level at which commercial accelerators operate. The field intensities in t.w.t. applications are considerably lower and no problems are anticipated on this account. For millimetre tubes the problem of confining the electron beam is the major problem and some bombardment of the disks is unavoidable. Such bombardment is by comparatively low energy electrons, less than 10 kv., and tests so far give encouraging results.

Acknowledgements

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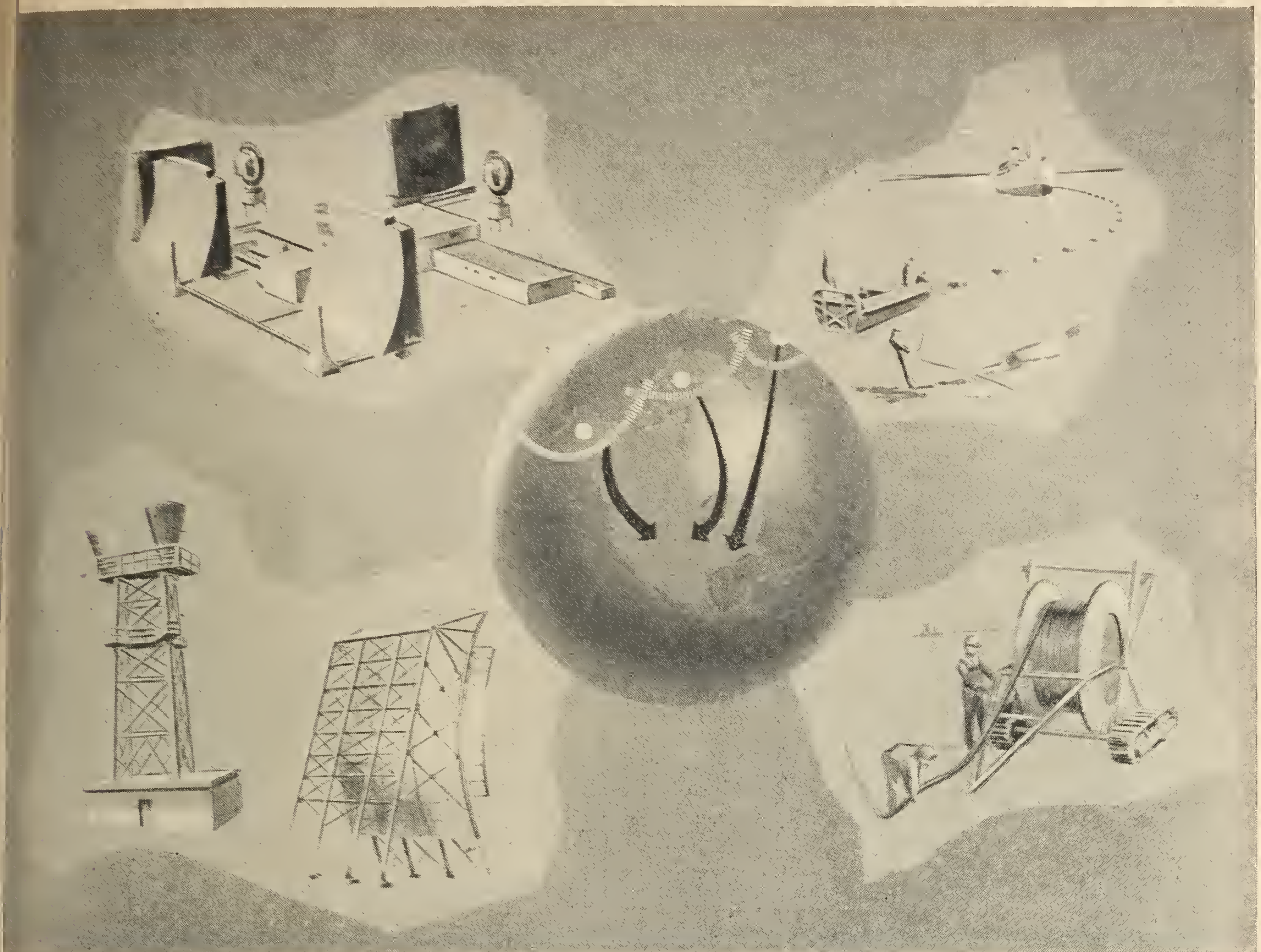

Rearward Communications for BMEWS

Leo J. Hammerschmid, M.E.I.C.,
Terminal Equipment Engineer, Toll Area,
The Bell Telephone Company of Canada, Montreal

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AN ADEQUATE defence of the United States, Canada and the United Kingdom against surprise air attack is vital to everyone. A guarantee that the probability of retaliation in kind is high enough, depends to a large degree on our being able to detect and identify ICBM's and IRBM's shortly after launching from anywhere within the Eurasian land mass. In this paper I will limit my discussions to the ICBM threat on the U.S. and southern Canada.

The Ballistic Missile Early Warning System will give approximately a 15 minute warning of an ICBM attack. It is designed to give the North American Air Defence Command, the Strategic Air Command, and Civil Defence agencies the "breathing space" necesary to take defensive and retaliatory measures in the event of an enemy missile attack on the North American continent across the north polar regions. BMEWS supplements aircraft detection systems such as SAGE, the DEW Line, and the Mid-Canada Line, and is regarded as one of the deterrents against war.

BMEWS is a long-range, ultra-high-speed radar warning system. It consists of three forward detection sites, an operational control centre and a communications system between each of the forward sites and the control centre. The layout is shown in Fig. 1.

The three forward radar sites are located at Thule, Greenland; Clear, Alaska; and Fylingdales Moor in Yorkshire, England. These sites are equipped with powerful radars and complex computers. Their purpose is to detect and evaluate possible ICBM attacks on the U.S. and Southern Canada, and ICBM and IRBM attacks on the United Kingdom.

A central computer and display facility is installed at the control centre at NORAD headquarters in Colorado Springs, U.S.A. It is here that all information ultimately is assimilated and presented for evaluation. In the event of an attack, defensive and retaliatory actions are initiated at the Control Centre.

A rearward communications system is therefore required between each forward site and the Control Centre. Each communication system is designed to convey information rapidly and accurately between the Detection Sites and the Display Facility.

Overall direction for the establishment of BMEWS is invested in the USAF BMEWS Program Office at Hanscom Field, Bedford, Mass. RCA, as weapon system contractor for the BMEWS Program is charged with the technical direction of the forward sites, the BMEWS Central Computer and Display Facility and the SAC Display Facility. The Western Electric Company has a separate prime contract for the Rearward Communications Systems from each of the three forward sites to Colorado Springs. The communication facilities which make up the rearward communications system are owned and operated by various communications agencies in three countries as follows:

Fig. 1. BMEWS Layout.

Canada

- Alberta Government Telephones
- The Bell Telephone Company of Canada
- Canadian National Telegraphs
- The Canadian Overseas Telecommunications Corporation
- The Eastern Telephone and Telegraph Co.
- The Maritime Telegraph and Telephone Co.
- The New Brunswick Telephone Co.
- Quebec Telephone

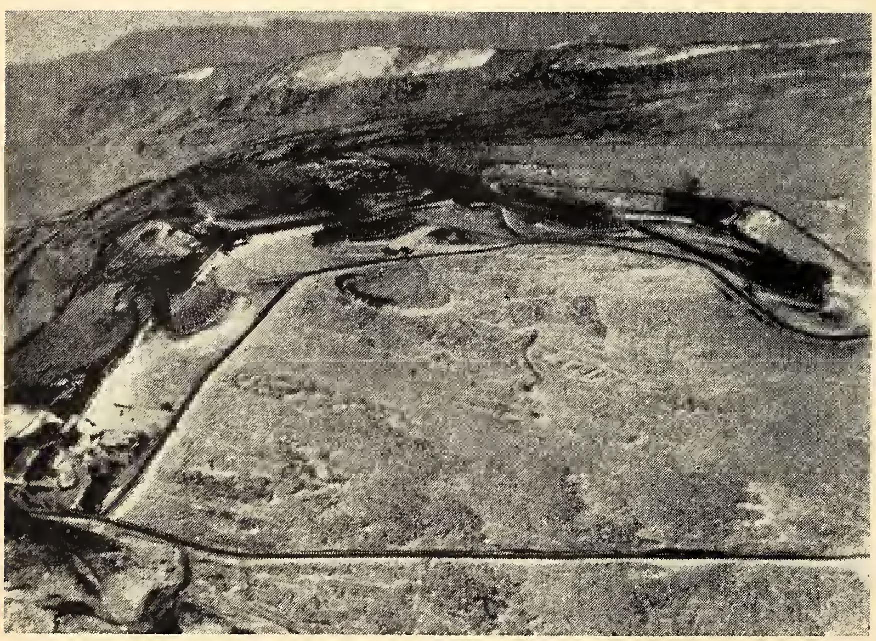
United Kingdom

- British Post Office
- Royal Air Force

United States

- U.S.A.F.
- Army Signal Corps
- American Telephone and Telegraph Co.
- The Mountain States Telephone and Telegraph Co.
- The Pacific Telephone and Telegraph Co.

Fig. 2. Aerial View of Thule Site.



Each forward detection site consists of high powered radars, plus support buildings. Fig. 2 shows an aerial view of the installation at Thule. In addition to the radars, each site contains a missile impact prediction computer, checkout, switching and monitoring equipment, and the terminal of the communications link to the control office in the United States.

The surveillance radars designed for use at Thule and Clear, consist of four torus-shaped antennae reflectors, 165 ft. high and 400 ft. wide at Thule and three at Clear. Each antenna weighs 1500 tons, is constructed of special nickel-chrome steel, and is designed not to deviate more than ± 2.2 in. under 6 in. ice loading and winds of 185 m.p.h. Associated with each antenna reflector are two high speed scanner switches, an array of 88 feed horns, and the associated transmitter equipment.

Missile detection with these fixed surveillance radars is accomplished as follows:

Narrow beams of RF energy are made to scan across the face of the ınt reflector antennas, producing ı-shaped areas of radiation extend-g out from the reflectors. Two such ınning actions are actually going ı simultaneously, one above the her, forming an upper and lower n. Scanning is performed by switch-g the RF energy from one feed ırn to another in rapid succession. ıch feed horn, in turn, passes its ıergy to one of a row of fixed an-ınas which aims its energy against ıe reflectors.

When a missile passes through the ıwer fan, radar pulses will be re-ected from it, and be detected by ınsitive receivers. From these radar choes, the position and velocity of a ıissile 3000 miles away can be deter-ıined. Seconds later, as the missile asses through the upper fan, radar choes will again be picked up, and osition and velocity co-ordinates gain measured. The missile's trajec-ory can be calculated since the ballis-ic missile will be in free flight (that s, in the unpowered phase of its tra-ectory) as it passes through the radar ans. From the missile's trajectory, he Missile Impact Prediction Com-puter at the detection site can pre-lict the impact area, the impact time, ınd the area of launch. This informa-ion is then transmitted back to NORAD headquarters for evaluation ınd action.

The BMEWS installation at Fyling-dales Moor, England, will be differ-ent in concept and equipment from those in Greenland and Alaska. The British station will use three dual purpose tracking radars, featuring 84 ft. diam. parabolic antennas mounted on 50 ft. pedestals, and protected from the weather by a 140 ft. diam. radome.

This type of tracking radar can both detect an enemy ballistic missile at 3000 mile range, and, once the target has been detected, "lock on" to the missile. Radio echo information is then fed to the Missile Impact Prediction Computor, and the mis-sile's speed, direction, and impact area is calculated. This information is then transmitted over the rearward communications link to NORAD headquarters.

The communications links from the forward sites are capable of deliver-ing information practically instan-taneously, and with the highest relia-bility and accuracy.

Basic Objectives of RCS

The basic objectives of the Rear-ward Communications System are fidelity, reliability, and speed.

The objective of fidelity, is met through the use of a new data system especially developed for BMEWS. In addition, new equipment and tech-niques are used to reduce noise and distortion below levels formerly con-sidered acceptable.

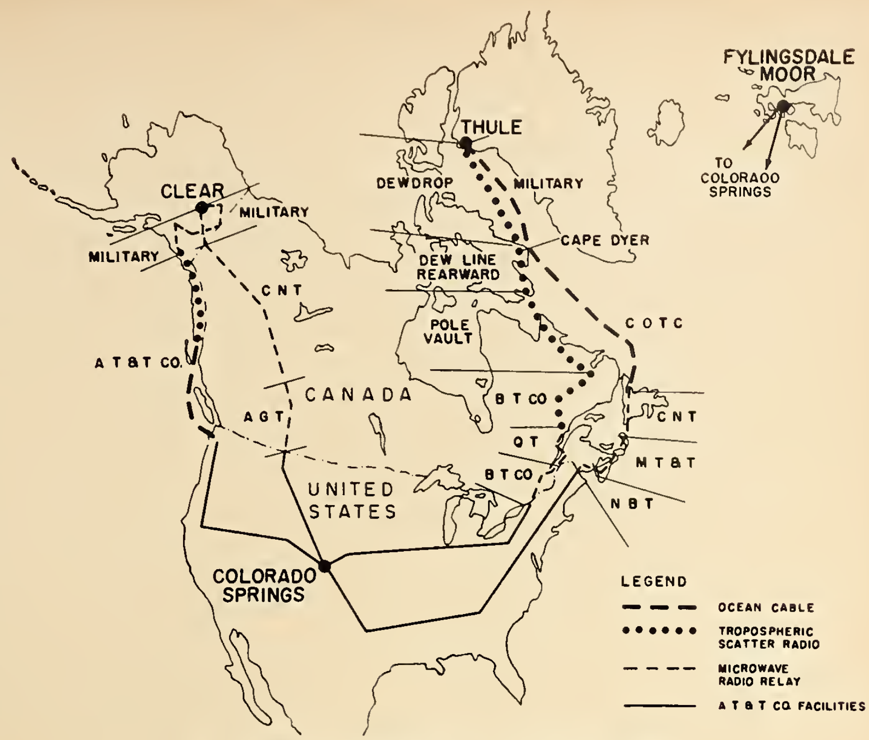


Fig. 3. Rearward Routes from Thule and Clear.

To achieve the desired reliability, a number of steps are taken. First, two geographically separate routes are used between each detection site and the NORAD Combat Operations Centre. Second, different types of transmission facilities are used in the comparable sections of alternate routes (e.g. microwave radio relay vs. cable carrier, and tropo-scatter vs. submarine cable). Third, BMEWS voice and teletypewriter circuits, nor-mally used for operational control are used to baek up the data cireuits. Fourth, standby circuits are provided for prompt use in case of failure. Finally, a carefully worked out oper-ating plan divides each route into sub-control sections to enable fast co-ordinated operation and maintenance.

Speed of transmission is an inherent characteristic of the system. With 18,000 m.p.h. missiles, the RCS must be capable of almost instantaneous transmission in order to allow some useful time when the message is re-ceived.

To meet the stringent reliability and performance requirements, sub-stantial advances in concept and de-sign were made. Major items designed especially for the rearward communi-cations system include a novel high speed data transmission system, a spe-cial circuit status reporting system and new tropo-scatter radio equip-ment. The overall bandwidths for the scatter systems used vary from 1 mc to 10 mc, depending on the number of voice channels required. Quad-ruple diversity and parametric receiv-ing converters are employed. Trans-mitters have been redesigned to re-duce distortion, and waveguide runs and components have been modified with resultant lower voltage standing wave ratios than obtained in previous installations.

Rearward Routes

In choosing the communication routes, fairly simple rules were fol-lowed. Where feasible, commercial routes were adapted or built. Where suitable commercial circuits were not available, new plant was provided for military ownership.

Beeause of reliability requirements, two geographically separate routes are used between each detection site and Colorado Springs. These are shown on Fig. 3.

One route from Thule utilizes ocean cables via Cape Dyer to New-foundland, a total distance of almost 2000 miles. All but 700 miles of this was placed especially for BMEWS by the Canadian Overseas Telecom-munications Corporation. The route between the cable terminating station and the U.S. border was coordinated by the Bell Telephone Company as prime contraetor to Western Electric. Provisioning companies in this section include the Canadian National Tele-graphs who provide 270 miles of STC radio relay equipped with ATE multi-plex equipment. From Nova Scotia to New Brunswick the route is over new

British GEC microwave and multiplex equipment provided by the Maritime Telegraph and Telephone Company and the New Brunswick Telephone Company. The latter company then provides the route over existing TD-2 facilities to the U.S. border, from where, the BMEWS circuits are carried over TD-2 and coaxial cable facilities to Colorado Springs. A data repeater is provided by Canadian National Telegraphs in Newfoundland, and Repeater/Monitors are provided by AT&T Long Lines at other sites on the route.

The second Thule route utilizes the Dewdrop tropospheric scatter system from Thule to Cape Dyer. This system covers the 700 mile distance in one hop. DEW Rearward, a primary tropospheric communications link from the Eastern end of the DEW Line, and a portion of the Pole Vault tropospheric system, connect Cape Dyer with Labrador. Between Labrador and the U.S. border, the Bell Telephone Company with Quebec Telephone provides over 1000 miles of the 4800 mile route. The first link in this route is over tropospheric scatter, and the balance to the U.S. border is over TD-2 radio and K2 cable carrier facilities. The U.S. portion of this route to Colorado Springs is over TD-2 radio and coaxial cable facilities. Data repeaters are provided on this route by The Bell Telephone Company of Canada and by AT&T Long Lines. Bell Telephone also provides a Data Monitor.

Fig. 3 also shows the two geographically separate routes from Clear, Alaska. Only one of these routes involves Canadian facilities. From Clear, to the Alaska-Canadian border, USAF owned, TD-2 radio relay carries the BMEWS circuits. Through Canada, the first link is provided by Canadian National Telegraphs over RCA MM600 microwave equipped with Telefunken transistorized multiplex equipment. Alberta Government Telephones, as subcontractor to CNT, then provides service to the U.S. border over TD-2 microwave facilities. The route is completed to Colorado Springs by AT&T Long Lines, using TD-2 microwave. A Data Repeater point is provided by Alberta Government Telephones and a data monitor is provided in the U.S.

The second Clear route bypasses Canada. It extends through Alaska over troposcatter and radio relay systems to the coast, and from there to the U.S. via Ocean Cable. TD-2 radio relay and coaxial cable systems extend the route to Colorado Springs. Data repeaters and one data monitor are provided on this route.

Information on routes from the third BMEWS site at Fylingdales Moor, England, is classified.

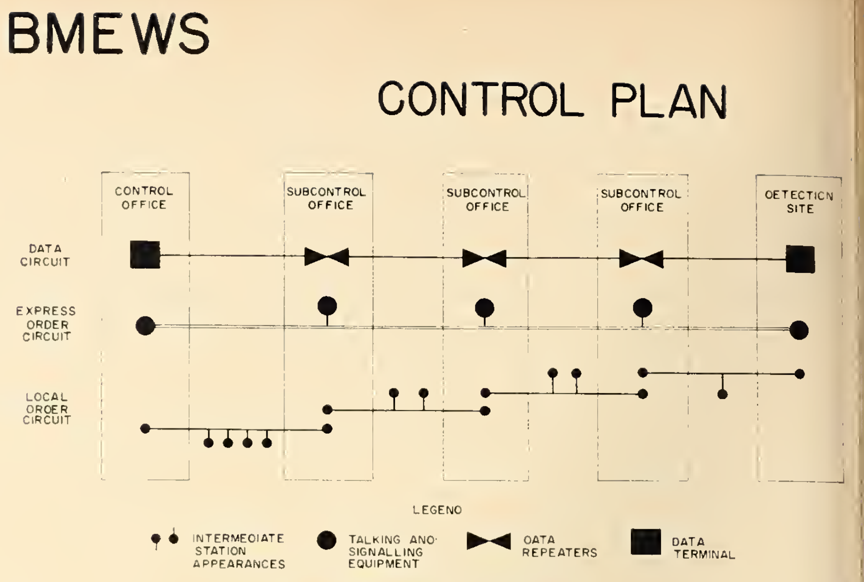
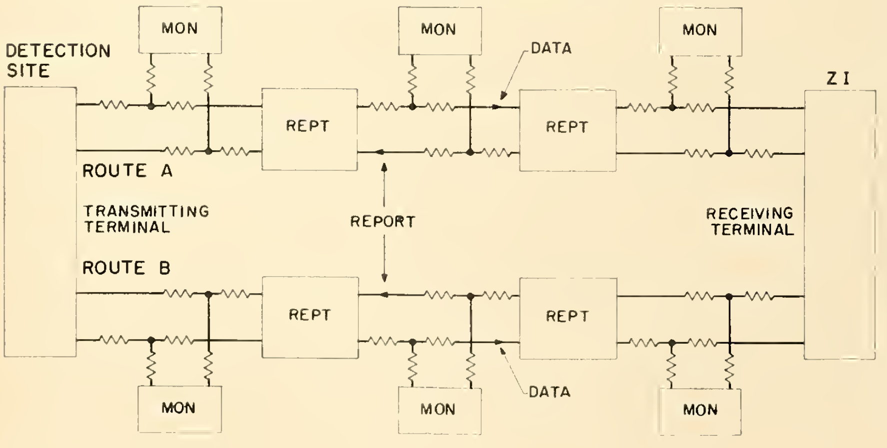


Fig. 4. Route Control Plan.

Fig. 5. Data System Schematic.



Route Organization and Control

Successful operation of a system which involves inter-company, inter-agency, and inter-country co-ordination, requires first, an organized plan of operation to be followed by all operating companies; and second, a unified control plan whereby one agency co-ordinates the efforts of all.

A control concept is created by the establishment of one control office and a number of subcontrol offices for each route. The control plan is shown schematically in Fig. 4. The control office for each route is Colorado Springs, and is responsible for overall operation of the RCS. This overall operation not only includes service restoration control, but also operational responsibilities such as service reports, release of facilities for routine maintenance and service analysis.

Subcontrol offices are established at intermediate points along each route. They are responsible for the operation and maintenance of service in their designated sections. They are subordinate in authority only to the Control Office and are responsible for sectionalizing troubles within the subcontrol section, co-ordinating operations between the Control Office and the operating companies, etc. These offices are also either data repeater or data monitor locations. They are located approximately 1000 miles apart, and are administered by the operating company at the particular location. A special route express order circuit from Control office to Detection Site, with appearances at each sub-control office, provides the control office ready access to each subcontrol office and the Detection Site. Local order circuits are used between each sub-control office and its sub-

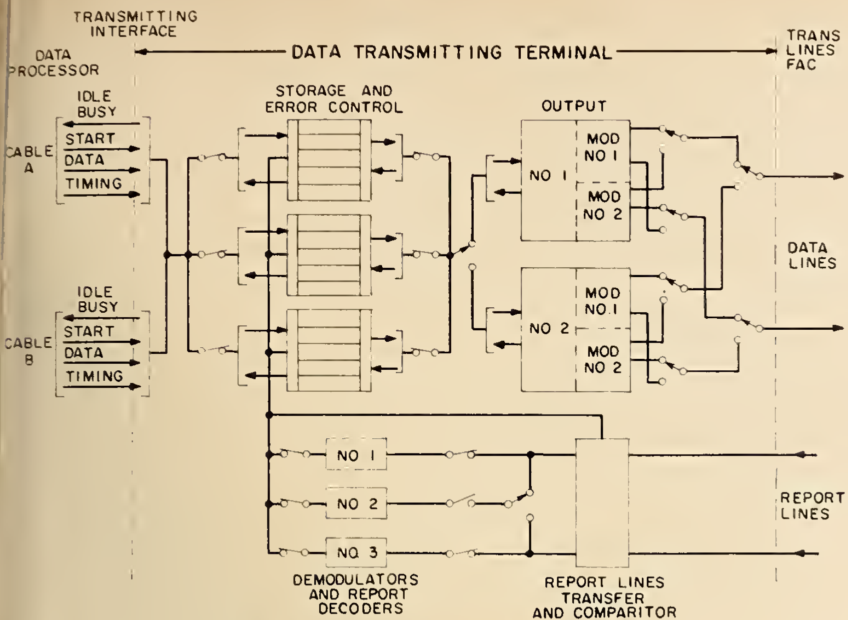


Fig. 6. Data Transmitting Terminal.

ordinate facility maintenance organizations.

RCS Circuit Package

Each route from Thule and Clear of the RCS consists of a "circuit package" of six circuits. These are:

1 Data channel (Regular, N-S)
1 Data channel (Standby, N-S)
1 Voice channel (Regular)
1 Voice channel (Standby)
1 Teletypewriter channel
1 Express Order Circuit (XOC)

Since there are two routes from each site, there are twelve BMEWS circuits linking each Detection Site with the Control Office. The data terminals are linked via two working and two "hot" standby data circuits (one each per route). The telephone terminals are linked via two geographically separate working voice circuits, and the teletypewriter terminals are linked via two geographically separate working teletype circuits. In addition, two standby circuits, suitable for either voice, data, or teletype transmission, are available, one per route.

On each route, the "circuit package" is accessible only at the Control Office, at each Sub-Control office, and at the Detection Site. The circuits appear at Test and Patch Boards at each of these locations, and they are treated for line-up and maintenance purposes as circuit units between these points.

Circuit Objectives

The overall objectives for a data circuit between the Detection Site and the Control Office are defined as follows:

(1) Deviation from 1000 cycle gain

Frequency	*Deviation*
350 cycles	—12.0 to +3.0db
500 cycles	— 6.0 to +3.0db
1000 cycles	0db
1300 to 2400 cycles	— 3.0 to +3.0db
2600 to 3050 cycles	— 4.0 to +3.0db

(2) Envelope Delay Distortion
Per Route .... Max. 500 microseconds
Per Repeater Section .... Max. 80 microseconds

(3) Absolute Delay
Per Route (Round Trip) .... Max. 150 milliseconds
Differential between Routes .... Max. 120 milliseconds

(4) Transmission Variation .... ±3db

(5) Noise (3A NMS)
45 dbRN (Average)C Msg. Wtg.
56 dbRN (Maximum)C Msg. Wtg.

The voice channel requirements over a 6000 mile route should allow message grade two-way transmission, two-way inband signalling, and long distance quality 97% of the time.

Teletypewriter channels should allow two-way full duplex, start-stop operation, at a speed of not less than 60 words per minute. Frequency-shift carrier telegraph terminals are used.

Data Transmission System

To support the reliability, accuracy and rapid trouble clearing required for the transmission of data signals over a 6000 mile rearward communications route, a new data system was designed by Bell Telephone Laboratories especially for BMEWS. The requirement for this data system is to accept from the RCA transmitting interface at a Detection Site, a 63 bit data message and deliver it almost instantaneously, accurately, and unchanged to the RCA's receiving interface at the Control Office 6000 miles away.

Basically, the BMEWS Data System, shown schematically in Fig. 5, consists of two, geographically separated, four-wire circuits between a data transmitter and a data receiver, with intermediate, regenerative data repeaters and data monitors. Data messages are transmitted in one direction of each four-wire circuit, and message received reports are transmitted in the opposite direction.

Data Transmitting Terminal

A schematic of the data transmitting terminal is shown in Fig. 6. Upon receiving a 63 bit message from the RCA data processor, the message is converted to DC pulses, checked for interface parity, and read into storage elements in the Storage and Error Control (SEC) groups. Three such groups are employed. Each group in turn contains five storage units. As a message is read into SEC, a Store-Address signal is generated. The message and its Store-Address, is then stored simultaneously in corresponding storage units in each group.

Just prior to a message being released from store, a Ready-Start signal is generated and fed into the Output group. This is followed by the released Store-Address and the 63 bit data message, and an 18 bit Triple Interleaved Parity code is generated as the message is read out of store.

When the message is read out of SEC, a bit by bit comparison of the three messages is made in the Output group, and since at least two of the three should agree, the majority values are selected and transmitted forward. As the message is read out of store, it is also read back into the same store via a feed back arrangement for possible retransmission.

Modulators in the Output group

convert the DC signals into line signals, and identical translation of the message are applied to the dual transmission line facilities.

Data Repeater/Monitor

The data signal is checked for error at approximately 1000 mile points along each route. In addition, the signal is regenerated at every other such point. This results in two types of intermediate data check points; data repeaters and data monitors.

At a data repeater, shown schematically in Fig. 7, the Ready-Start signal which precedes each message is used by the demodulator to prepare its internal circuits for the data message which follows. The output of the demodulator consists of a series of DC pulses which are passed into the delay register to afford time for the generation of a new Ready-Start signal. The regenerated message is then fed to the modulator which in turn produces new line signals. A simple parity check is made of a message format, and if errors are detected, an alarm is generated.

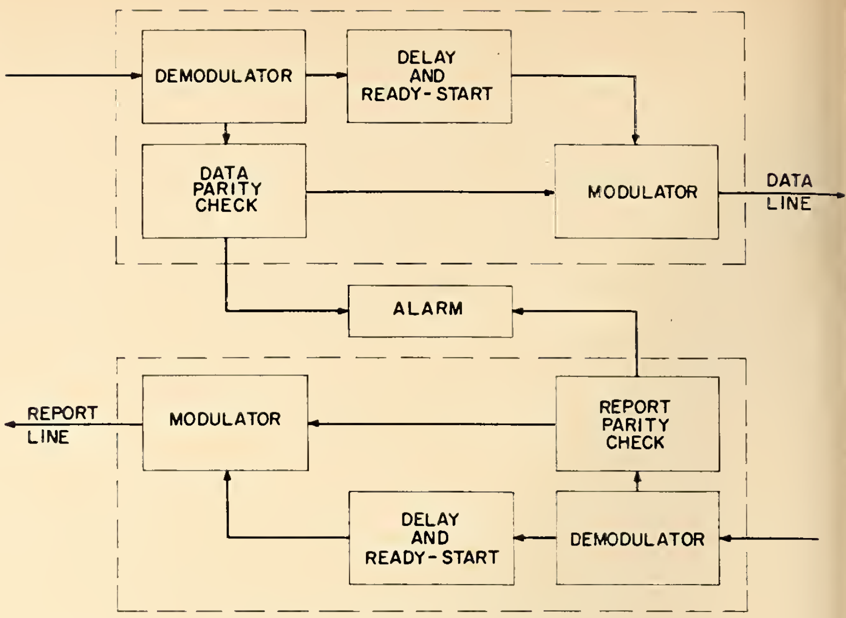


Fig. 7. Data Regenerative Repeater.

At a data monitor, shown schematically in Fig. 8, the demodulator is bridged so that the channel being monitored is not disturbed. Again, the line signals are converted to DC pulses in the demodulator, a simple parity check is made, and an alarm is generated if errors are detected.

It should be noted that monitoring, i.e. a parity check, is made in both the repeater and monitor arrangements. Also a repeater is a series device from which a new data signal is generated, whereas a monitor is a shunt device with the original data signal going by undisturbed.

In actual practice, a monitor can readily be converted to a repeater by the addition of four plug-in units.

Data Receiving Terminal

In the data receiving terminal, shown schematically in Fig. 9, the incoming dual data circuits are each terminated in a receiving group consisting of a demodulator and storage and error control equipment. The storage component consists of three stores. A third receiving group is alternately bridged onto each of the incoming data lines, and the output of this receiver is compared with that of the other two receivers.

In each receiving group, the Ready-Start signal preceding each message is used by the demodulator to prepare its internal circuitry to accept the message which follows. The demodulator converts the line messages to DC pulses, and reads them into one of the three storage units of the Receiving group. As the message is read into storage, the Triple Interleaved Parity code is reconstructed and compared to the original Triple Interleaved Parity code associated with the message. In addition, the 63 bit data message is checked for Interface Parity errors. If errors are detected the message in this receiving group is rejected.

If the parity checks are correct for either or both of the Receiving Groups accepting the same message, a valid copy is read out of storage through the Report and Read Out Control unit and passed to the signal converters. The transmitter Storage-Address of this message, and the Triple Interleaved check result for each transmission path, are passed on to the Report Encoder, and back to the transmitting location over the Report Lines.

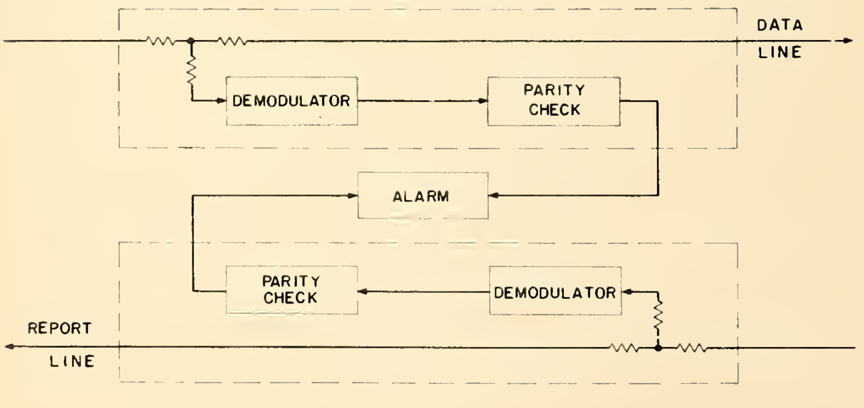
The signal converters change the DC pulses of the 63 bit data message back into a signal suitable for transmission to the Receiving Data Processor.

Report Lines

The report lines use the other two wires of each four-wire data circuit. For each data message that arrives at the data receiving terminal over one or both data transmission links, identical copies of a Report message are generated and transmitted to the transmitting terminal over both report lines. The report message consists of the Store-Address plus two status bits, followed by the Report Message. The status bits show, by mark or space, whether the message received at the Receiving Terminal was good or bad on line A or line B.

If the received message was bad, then the transmitter is advised to send again. If the received message was good, then the transmitter is advised to dump the stored message from storage units identified by the

Fig. 8. Data Monitor.



torage Address, and accept a new .CA message. This is done by interreting the Report Message.

The report is transmitted seven mes, and is voted upon on a five out f seven basis.

)ata Signal Format

The Data received across the interace is in the form of groups of bits r dipulses, which are known as "mesages". Each message is 63 bits in ength. Each 63 bit message contains ine sections, each of which contains ix information bits followed by one parity bit. This 63 bit message is nown as the Data Processor's Signal Format, and is shown as part of Fig. 0. "Odd" parity is used by RCA in he data messages delivered across he interface. This means that if the umber of marks in the six bit group s odd, the seventh bit is a space; if even, then the seventh bit is a mark.

Triple Interleaved Parity

To verify the accuracy of transmission of each 63 bit message over the rearward communication system, a triple interleaved parity scheme is used for error detection. Since a single parity check will not detect multiple errors involving even numbers of bits, it alone is not suitable for checking messages that have been transmitted over a 6000 mile circuit. Three simple interlaced parity systems used simultaneously are used instead.

In the Triple Interleaved Parity scheme shown in Fig. 11, three moduli are used; numbers 5, 6 and 7.

Modulus 5 numbers the 63 message bits from 0 to 4 repetitively. The marks in each bit numbered 0 are counted, and if the total is odd, the first parity tag bit for modulus 5 is a space. If the total is even, then the first parity tag bit is a mark. The marks of each bit numbered 1 are counted next, and the second parity tag bit becomes a space or a mark, depending on whether this total is odd or even. The bits numbered 2, 3 and 4 are checked in the same way, and corresponding parity tag bits are generated. This results in a total of 5 parity tag bits for modulus 5.

Modulus 6 then numbers the same 63 message bits from 0 to 5 repetitively, and each numbered bit is again checked for odd or even parity.

This results in six Parity Tag bits for modulus 6. These are added in sequence after the modulus 5 parity tag bits.

Modulus 7 numbers the same message from 0 to 6 repetitively, and a modulus 7 Parity Tag is generated, resulting in a total Interleaved Parity tag of 18 bits.

It is important that the module lengths be relatively prime in order to avoid repetition of the three digit designations of each bit. For the same reason it is necessary that the message length be less than the product of the three module lengths.

A Triple Interleaved Parity tag is generated and added to each 63 bit message as it is being stored. This parity tag is then transmitted with the message over the data circuit. When the message and transmitted parity tag are received, a new Triple Interleaved Parity tag is generated at the receiver for the 63 bit message. This parity tag is then compared with the transmitted parity tag, and if they are the same the message is considered correct.

For comparison, two errors are indicated in the message shown in Fig. 13. The parity tag generated at the receiver differs from the transmitted parity tag. Four discrepancies exist between the old and new parity tags.

If simple interlaced parity had been used, the errors would have gone by undetected, since two mark bits were added in the "1" position, keeping the total an odd number.

Operating Modes

To meet the twin objective of optimum message delivery rate and system reliability under all conditions,

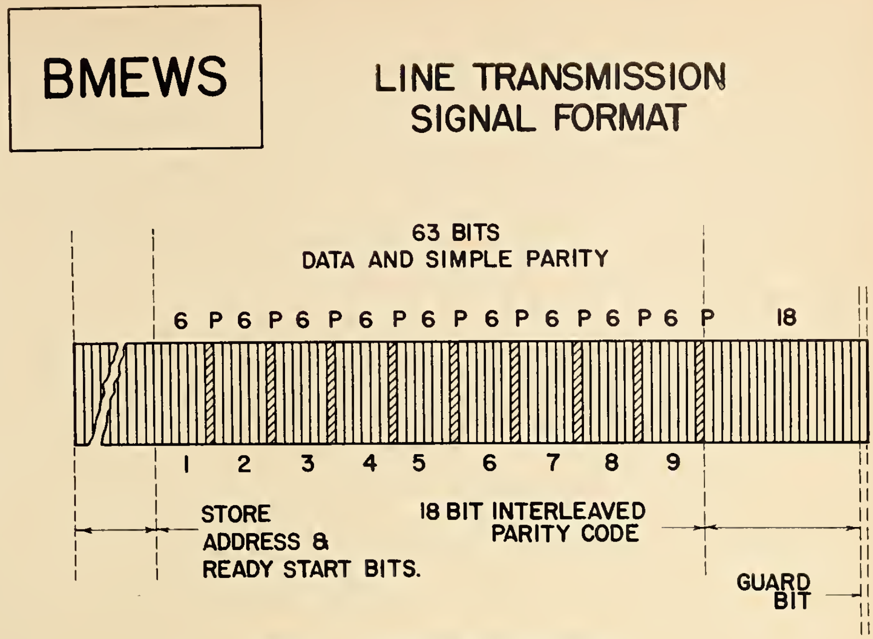
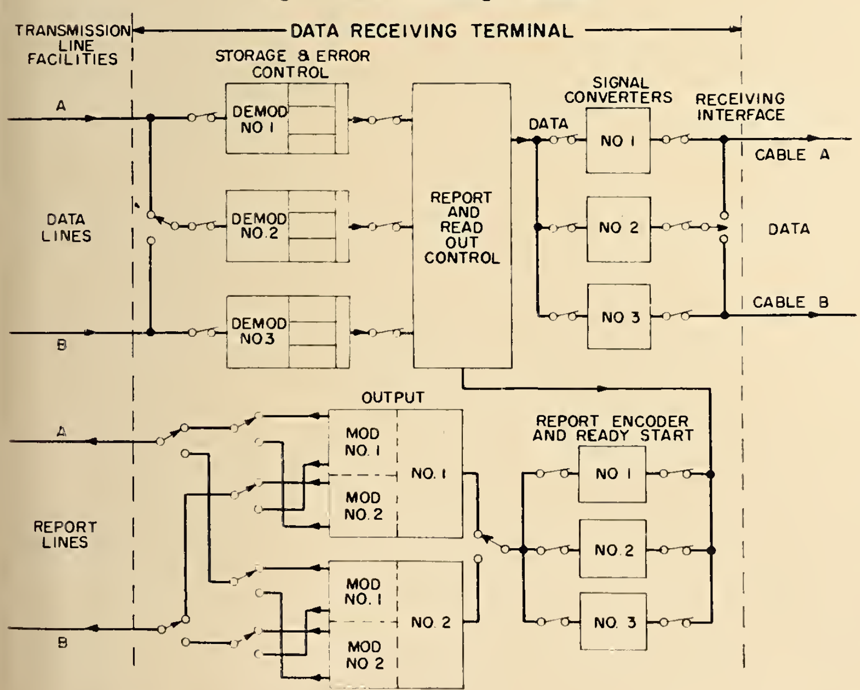


Fig. 10. Data Line Signal Format.

Fig. 9. Data Receiving Terminal.



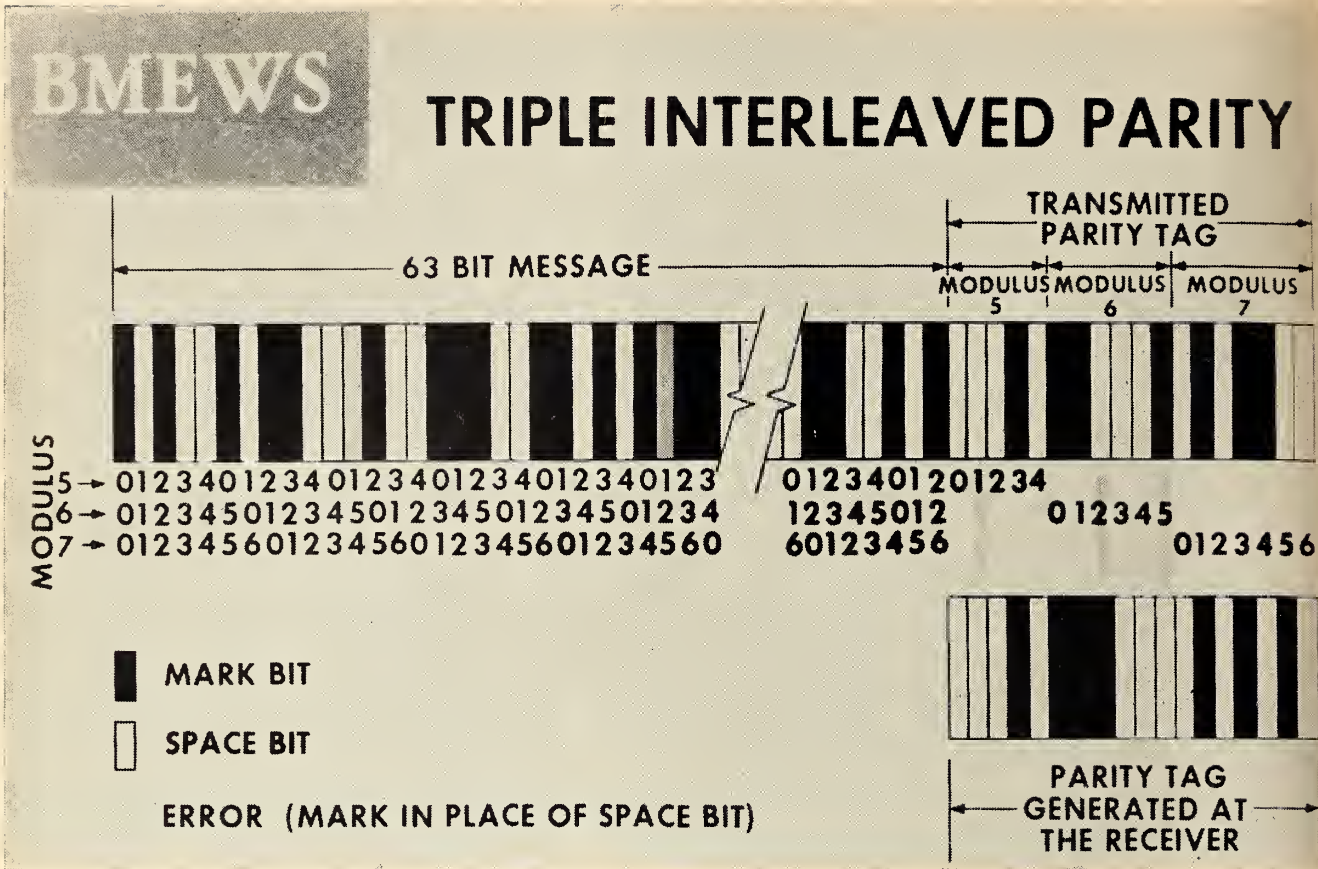


Fig. 11. Triple Interleaved Parity.

the data transmission system is capable of operating in three modes: normal; impaired data circuit; and impaired report line conditions.

Mode 1—Normal Operating Condition: The transmission system normally operates in this mode. Only messages which are free of detected transmission errors are delivered to the data processor.

Mode 2—Impaired Data Circuit: This mode of operation is used if the delivery rate of correct messages drops below an acceptable limit. In this mode, correct messages are delivered in the usual manner, and messages containing detected transmission errors are also delivered but with an indication that an error exists.

Mode 3—Impaired Report Line: Under this condition, each message is transmitted twice.

Automatic Status Reporting System

A status reporting system has been provided as part of the Rearward Communications System to automatically furnish performance information on an in-service basis of the data terminals, intermediate repeater/monitors, and voice and teletypewriter channels.

The voice and teletype channel monitors are located at the Detection Sites and at Colorado Springs. Their function is to alert maintenance personnel when these circuits become submarginal.

The information derived from the status reporting system is displayed at the BMEWS Monitoring Console in the form of lamp alarms geographically arranged to represent the control and sub-control stations of each route of the Rearward Communications System.

A display facility similar to that provided at the console is also provided at the test and patch board at the rearward site to allow observation and evaluation of the overall performance of the data system. Any trend which, if continued, could result in substandard performance, can therefore be detected.

Lamp alarms are also provided at the data repeater and monitor points, as well as at the detection sites, to monitor data circuit and equipment performance and call malfunctions to the attention of local maintenance personnel.

Generally, three gradations of data service are used. Green lamp alarms are displayed when the data system or equivalent is operating normally. A "Marginal" operating condition is indicated by an amber lamp alarm, and an "Inoperative" condition is indicated by a red lamp alarm.

Summary

The BMEWS Rearward Communications System is more reliable than previous systems of similar length and complexity. New developments have been required in fields of data transmission, tropospheric scatter radio, and communications status reporting equipment.

Five of the 13 agencies participating in the development, transportation, or contracting of the Rearward Communications system are Canadian. In addition, eight Canadian agencies own and operate communications plant representing some 10,000 route miles, or one-third of the total BMEWS route mileage.

The Rearward Communications System represents one of the most extensive communications projects ever undertaken. Its engineering and implementation would not have been possible without the close co-operation of all participants.

In addition to providing the circuits necessary for BMEWS, the Rearward Communications System also provides circuits for other users. For this reason, and because these circuits might not otherwise have been provided, the System further reduces the remoteness of the "far" north, and provides additional facilities for world wide communications.

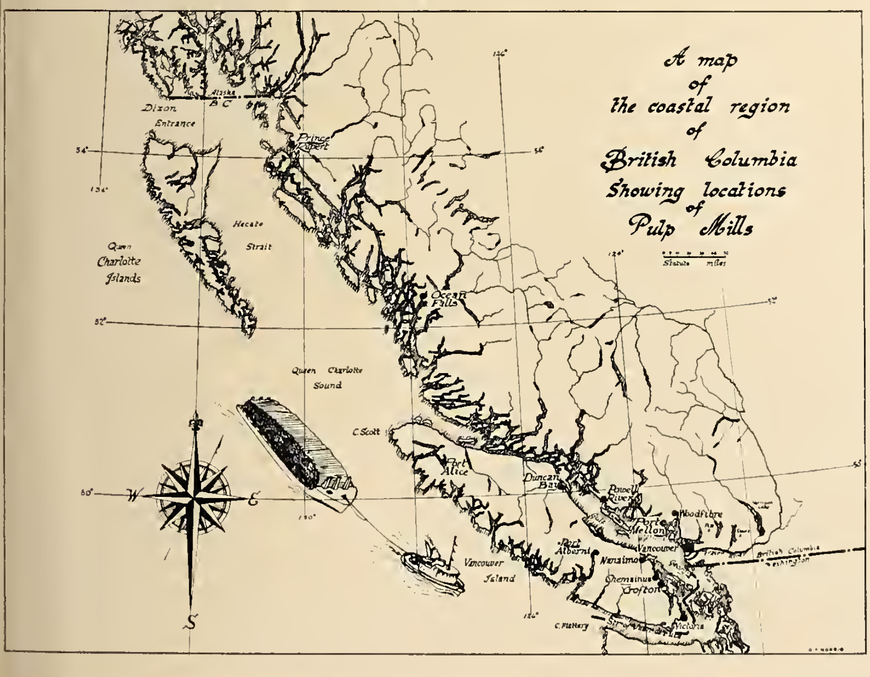
SIDE TIPPING LOG BARGES

T. A. McLaren, M.E.I.C.,
President and Managing Director
Allied Builders Ltd., Vancouver

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

FORESTRY is the major business of British Columbia producing by far the greatest part of the total wealth of the province. When the secondary industries providing ancillary services are considered, it is quite obvious that this province is entirely dependent on the health of this industry for economic survival.

Fig. 1.



Logging areas can be roughly divided as follows:

(a) The coast area which with moderate summer and mild winter temperatures together with a heavy rainfall produces Douglas fir, cedar, spruce and hemlock. These trees, particularly in the primary forest, attain huge sizes. The main forest industry with sawmills, plywood, pulp and paper mills, is located on the coast.

(b) The interior area which with much more extremes in temperature and considerably less rainfall, is more predominantly a pine and spruce forest with more normal sized trees. Logging in the interior, except for one pulp mill recently opened, is limited to production of sawn lumber.

Fig. 1 is an outline map of the British Columbia coast showing the location of the main sawmills, plywood and pulp and paper mills. It will be noted that, although one or two mills are located on the Northern coast, the bulk of the "manufacturing" is located within a radius of one hundred miles of Vancouver, i.e. in the populated part of the province. Logs are almost invariably moved by water from the logging camps southward to the mills.

Log Transportation—Sheltered Waters

A study of Fig. 1 shows a coast line deeply indented with deep fjord-like inlets and studded with islands. With the exception of one or two exposed areas, there are sheltered waters extending from Puget Sound to Alaska. Logging areas are never far from salt water—a fortunate situation.

Sheltered waters permit the towing of logs in flat rafts or booms. The raft used in coastal waters differs from the conventional bag-boom common to the lakes and rivers of Eastern Canada in that it is rectangular in plan, bounded laterally by a series of logs known as boom sticks and transversely with other logs known as swifters.

The logs float within bounds of the boom sticks and underneath the swifters, producing a boom which is satisfactory for coastal towing. The flat boom, however, has definite limitations and cannot be towed in excess of one-and-a-half knots nor can it be towed in rough water without danger of breaking up.

One of the problems in log towing is the time lost through tows being weather bound, often for as long as two or three weeks at a time. The flat raft, however, does provide economical transportation. The number of rafts towed by any particular tug depends on the power of the vessel. However, a simple rule of thumb is

Fig. 2.

to allow 300 b.h.p. per million feet log measure.

Log Transportation—Open Waters

Referring again to Fig. 1, it will be noted that certain areas of the coast line are outside the limits of sheltered waters, viz. the Queen Charlotte Islands and West Coast of Vancouver Island. Transporting logs over these exposed waters has always presented difficulties. The following are some of the methods by which these problems have been met.

DAVIS RAFT: The flat boom raft is incapable of withstanding a seaway. The Davis raft was developed for log towing in exposed waters both in British Columbia and along the Oregon-California coast line.

The Davis raft is essentially a large cigar-shaped bundle of logs containing over 1 million ft. log measure. Logs are tied together with circumferential lashings, and, by staggering the butts of adjacent logs within th bundle, some degree of longitudina stiffness is obtained.

Not withstanding these attempts a rigidity, the Davis raft is incapable o standing any extended period of heavy weather. The limitations of the Davi raft may be summarized as follows

(a) The raft has to be built lo by log in large cribs and the whole raft adequately lashed securely to gether. Thus the construction of a Davis raft involves a high labor cost

(a) The heavy Davis raft is sluggish and difficult to tow, speeds o two knots being about the maximum obtainable;

(c) The raft is only relatively sea-worthy, and time is lost through being weather bound;

(d) Breaking up the Davis raft involves releasing the lashings, a dangerous time consuming job.

The popularity of Davis rafts has declined and they are seldom built today.

LOG BARGES: (1) *Open Barges*: In addition to the Davis raft, it has been the practice in the past to use old iron and steel sailing ship hulls as log barges.

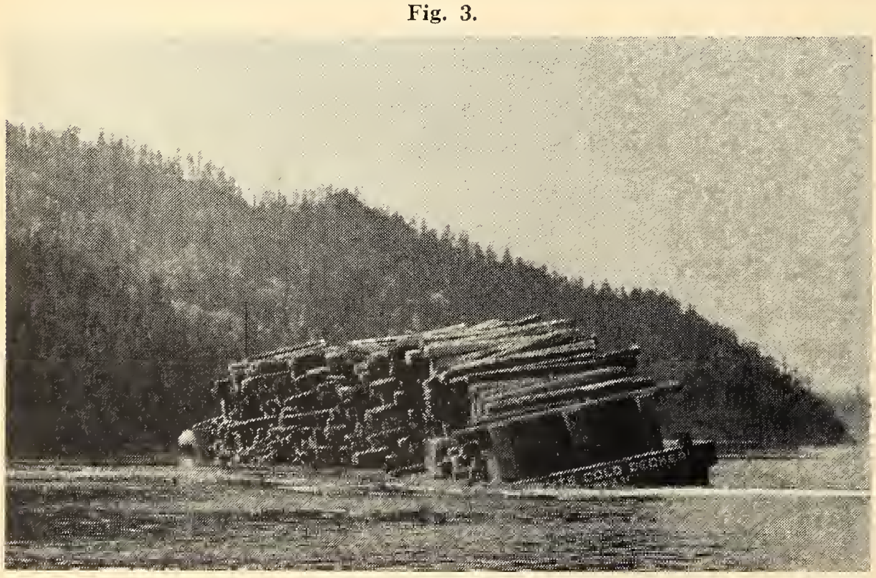
The conversion of the hull was very simple, consisting merely of tearing out the decks and bulkheads and leaving a hollow shell. In the course of gutting out the vessel, a great deal of the longitudinal transverse strength was lost. However, the conversion did provide an inexpensive log carrier, capable of speeds of five to six knots.

The disadvantages to the sailing ship conversion are as follows:

(a) Logs have to be stowed carefully within the hull of the vessel in order to get reasonable stowage;

(b) At sea the vessel is somewhat unseaworthy, due to the absence of a weathertight deck;

Fig. 3.



(c) On arrival at the destination, he logs have to be individually unoaded;

(d) Sailing ship hulls when owed as barges are very difficult to teer and it is usual practice to leave he rudder and steering gear intact nd to carry a crew of two or three nen to steer the hulk.

(2) *Decked Barges:* At the end of he Second World War, work was uspended on the construction of a number of Transport Ferries (LST's) being built in the Vancouver shipyards for the Admiralty. Two of these essels under partial construction were purchased by one company and completed as log barges. Another company purchased two U.S. Navy LST's and converted these units into log barges.

In making the conversion, high hollow bulwarks were fitted on the port and starboard sides so that the midship section of the log barge resembled a floating dock.

The barges carried logs, loaded longitudinally on the deck between these heavy bulwarks, and held down by lashing cables. These units, however, did not prove to be too successful and all four vessels have subsequently been transferred to other services.

(3) *Side Tipping Log Barges:* It will be seen from the foregoing, that a vessel with optimum efficiency for log transportation must satisfy the following requirements:

(a) Capable of being loaded quickly with a minimum of labor;

(b) Capable of being towed at reasonable speed, and able to withstand at least a moderate seaway;

(c) Capable of being discharged quickly with a minimum of labor.

The side tipping log barge has proved to be the best solution to date in meeting the above conditions.

The principle of side tipping is not new. Side tipping barges have been used for spoil removal, etc. in connection with dredging operations. The side tipping barge is designed with a series of water ballast tanks on one side of the vessel, so arranged as to be flooded by the opening of sluicing valves. The admission of water to the tanks lists the barge to such a degree that the deckload slides off.

The decision to make a practical log barge incorporating this principle was undertaken by the late Floyd Kurtz, who, in consultation with a naval architect, produced the designs for the two log barges "POWELL NO. I" and "POWELL NO. II".

Other log barges have been built, and a number of shallow draft tankers purchased in Venezuela have been converted into side tipping log barges.

Fig. 4.

Fig. 5.

Log Conversion Factors
(Forestry Branch)
(Dept. of Northern Affairs and National Resources

Species	*Top Diam. (in.)*	*Wt./ cu.ft.(lbs)*	*Cu.ft./ M.ft.B.M.*	*Wt./ M.ft.B.M.*
Douglas Fir (32′ 0″ logs)	10″ and under	47	270	12,700
	11″ to 18″	44	196	8,600
	19″ and over	43	166	7,150
Western Hemlock (32′ 0″ logs)	10″ and under	52	264	13,700
	11″ to 18″	49	190	9,300
	19″ and over	47	166	7,800
Western Red Cedar (32′ 0″ logs)....	10″ and under	35	320	11,200
	11″ to 18″	32	200	6,400
	19″ and over	31	166	5,100
Sitka Spruce (32′ 0″ logs)	All logs	34	166	5,650
Yellow Cedar (32′ 0″ logs)	10″ and under	41	320	13,100
	11″ to 18″	39	200	7,800
	19″ and over	37	166	6,150
Lodgepole Pine (16′ 0″ logs)	10″ and under	45	240	10,800
	11″ and over	43	190	8,200
Western Larch (16′ 0″ logs)........	15″ and over	56	175	9,800
Yellow Pine (16′ 0″ logs)	15″ and over	51	166	8,450
Western White Pine (16′ 0″ logs)	15″ and over	40	166	6,650
Western White Spruce (16′ 0″ logs)	9″ and under	39	250	9,750
	10″ to 16″	38	175	6,650
	17″ and over	37	156	5,750

Operation

Fig. 2 shows a log barge carrying a typical deckload. It is in this condition that the vessel proceeds to sea. It will be noted that the logs are loaded transversely and that there are no restraining lashings whatsoever.

The loaded barge can be towed at speeds up to 6½ knots, the light barge towed at speeds up to 8 knots in fair weather. The speed of course is governed to some extent by the power of the tug. In order that the tug can handle the vessel safely in heavy weather, a good margin of towing power is essential. The larger barges, i.e. those 300 ft. and over, require a tug in excess of 1200 hp. The smaller barges, i.e. 200 ft., etc., can be handled by a 600 hp. tug.

On arrival at the destination, the sluicing valves are opened and the tipping tanks allowed to flood, thus listing the vessel as shown in Fig. 3.

As the tipping tanks fill, the vessel continues to list until eventually the deck cargo dislodges and slides overboard. Immediately, the barge is relieved of its deckload and literally jumps up in the water to a light ship condition. See Fig. 4.

Design & Construction—Side Tipping Log Barges

Barge Capacity: When construction of a log barge is considered, the owners specify the desired capacity of the vessel in terms of feet log scale (i.e. a barge of one million feet log scale, etc.)

It is then the designers problem to provide a barge that will accommodate the desired scale of logs. In doing this, a conversion must be made from log scale measurement to deadweight tonnage, usually considered in long tons (2,240 pounds).

Fig. 5 shows the weights of various logs per M feet log scale. The extreme variations in these weights should be noted. Log cargoes may consist of selected logs conforming very closely to the above-mentioned table, or alternatively, the logs may consist of "Camp Run", i.e. logs of varying species and diameters. Considerable judgment must therefore be exercised in designing the vessel and likewise care must be taken in loading the vessel.

Stability: After the capacity of the vessel has been calculated adequate stability must be provided. Stability must be controlled within the following limits:

(a) The vessel must have adequate stability and freeboard so as to ensure safe passage even in heavy weather.

(b) The stability and freeboard must not exceed the capacity of the tipping tanks to list the vessel and dislodge the cargo.

The following factors must be considered in making stability calculations:

(a) Weight and centre of gravity of the deck cargo.

(b) The metacentric height (GM) of the loaded vessel.

(c) The range of stability of the loaded vessel.

The difficulties in determining accurately the weight and centre of gravity of the deck cargo have been discussed heretofore. The metacentric height can be determined from the Hydrostatic Curves prepared by the designer or shipbuilder.

The Hydrostatic Curves for the log barge "ISLAND PINE" are shown on Fig. 6. The Curve KM is the height from the keel to the metacentre. KG is the centre of gravity of the combined light ship and deckload. The metacentric height (GM) is simply expressed as follows:

$$GM = KM - KG$$

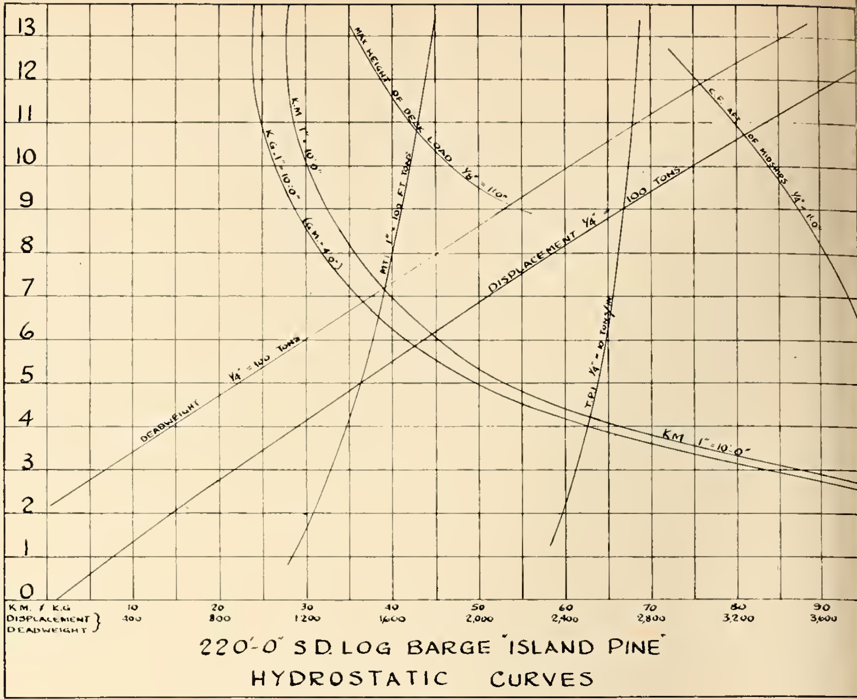


Fig. 6.

As a result of experience with the behaviour of existing log barges, insurance underwriters and other interested parties now recommend a minimum GM of 4 ft. for the average log barge.

In the case of the "ISLAND PINE", the recommended load draft is 11 ft. At this draft the vessel can carry 2,735 tons and a maximum deckload of 30 ft. and still maintain a GM of 4 ft.

In addition to initial stability, proper consideration must be given to the range of stability. Initial stability is the ability of the vessel to recover to an upright position under small degrees of list. Range of stability involves large angles of heel.

To illustrate this point, stability curves are shown on Fig. 7(a) and 7(b). These curves plot the righting moment against the angle of heel, the righting moment being a product of the righting lever and the displacement of the vessel and is the total moment tending to right the barge at any given angle of inclination.

Fig. 7(a) shows the range of stability of the vessel loaded to an 11 ft. draft with a GM of 4 ft. Fig. 7(b) shows the range of stability of the vessel loaded to an 8 ft. draft with a GM of 14 ft. The moment to upset the vessel under the second condition is greater than the moment imposed by filling the tipping tanks. Thus the vessel cannot unload.

It is usual practice to assign the

Fig. 7(a)

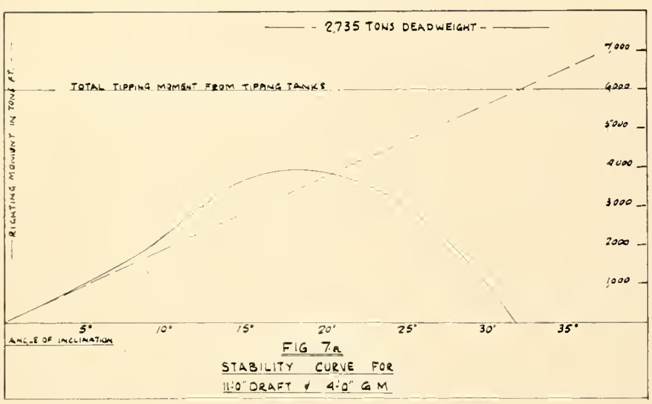
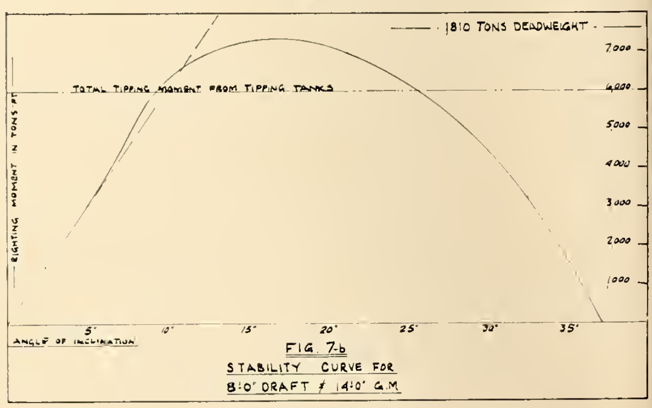


Fig. 7(b)



d lines on log barges to limit load-. With the variation in weights of s, it will be apparent that loading vessel down to a load line is not only criterion. It is quite possible t if the logs were all of light ight and with the vessel loaded her load line, the centre of gravity the cargo would be too high and iously imperil the stability of the ssel. On the other hand, if exces-ely heavy logs were loaded, the ssel could be loaded to her load e and the centre of gravity of the rgo would be so low that difficulty ight be encountered in dumping.

Unfortunately, these vessels are aded by loggers—not by naval arch-ects, and it is very difficult to give mple instructions which will ade-uately cover all conditions of load-g. A simple method of checking ability, however, is to incline the arge slightly and time the period of complete roll. The period of roll a function of the metacentric eight (GM). If the designer will urnish the loading crew with maxi-num and minimum permissible period f roll, there should be little difficulty n loading the barge within accept-ble limits of stability.

Strength: The basis of strength cal-ulations on a sea-going vessel is to onsider the ship as a box girder, lternately supported by a wave mid-hips, producing a hogging load, and by waves at the extreme ends, pro-ducing a sagging load.

For sea-going vessels of ordinary construction, Lloyd's and other Class-fication Societies have published Rules governing the scantlings of the vessel. The scantling Rules are usually based on the length and depth of the vessel. The L/D ratio of an ordinary vessel usually lies within the limits of 10 to 13.5.

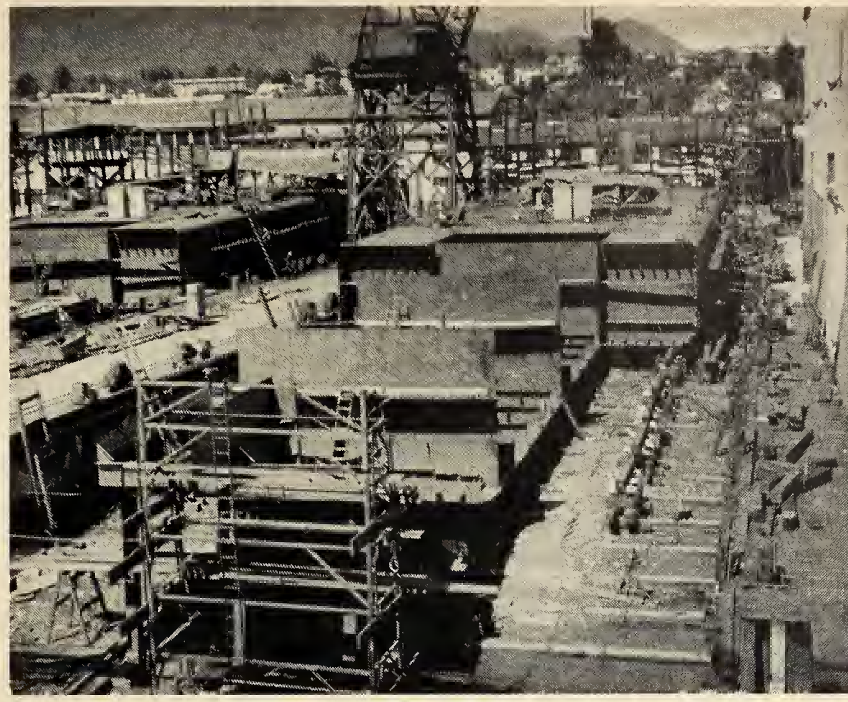


Fig. 8.

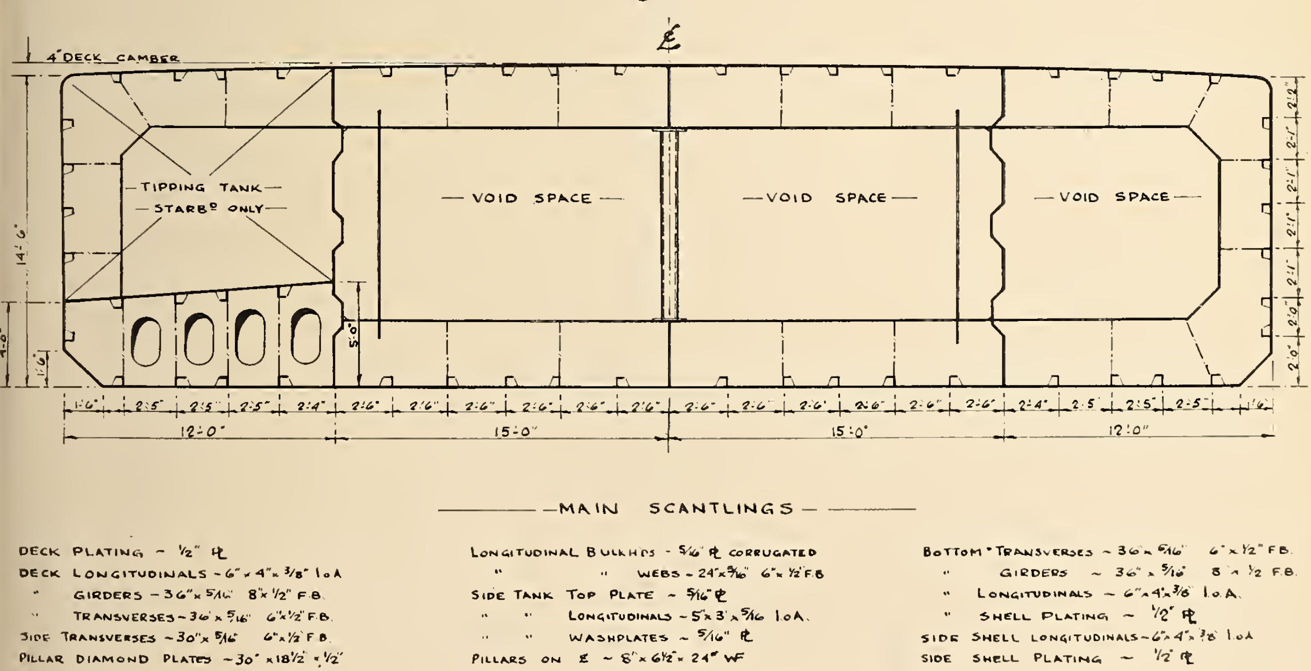
To maintain adequate stability, it is necessary to build log barges with somewhat less depth than that of the ordinary sea-going vessel. It will be noted by the summary on Fig. 11 that the L/D ratio on existing log barges varies from 15.75 to 20.6.

To give adequate strength to such a slender vessel, a larger cross-sectional area of steel is required in both the bottom and deck plating than would be the case of a normal vessel,

It has been the practice to build log barges on the longitudinal framing system, see Fig. 9. The total sectional area of the longitudinal framing is combined with the total sectional area of the deck or bottom plating in order to determine the sectional modulus of the vessel.

Since the log barge carries its entire deadweight on the deck, ample pillaring and girdering of the deck structure is imperative. Since the framing is usually longitudinal, the deck is supported by transverse webs at about 10 ft. centres in conjunction with longitudinal bulkheads and girders and extremely heavy pillaring. The deck plating is subject to

Fig. 9.



the impact from logs being dropped thereon. However, since it is necessary to have heavy deck plating for the overall strength of the vessel, no extra precautions are taken against impact loading on the deck.

A notable feature of the log barges are the heavy box section log posts fitted at the fore and aft ends. These posts retain the logs from rolling in the fore and aft direction. They are of extremely heavy construction and well tied into the deck and bottom structure of the vessel.

Fig. 8 shows two log barges under construction and generally illustrates the construction of these vessels.

Tipping Tanks and Sluice Valves: As described heretofore, the vessel is tipped by admitting water into the tipping tanks. Fig. 9 shows Midship Section of the log barge "ISLAND PINE". It will be noted that the tipping tank which is fitted on the starboard side of the vessel has a bottom approximately 5 ft. above the keel.

With such an arrangement, the tipping tank can be flooded when the vessel is loaded, but after dumping the load, the vessel rises to its light draft and the tipping tank drains back automatically through the sluicing valve. This self-bailing arrangement has been installed on all the new log barges. In the case of the tanker conversions, however, tanks are pumped out through the original tanker piping system.

The arrangement of sluicing valves varies from vessel to vessel. However, the flooding system must be as foolproof as possible. In the waters where these barges operate, there is a great deal of debris, bark, etc. On at least one occasion, a sluicing valve has been held slightly open by a small chip under the valve seat. During the loading of the barge, the leakage was not immediately apparent. However, in the course of time, the tipping tank filled up sufficiently to dislodge and lose the whole load while at sea.

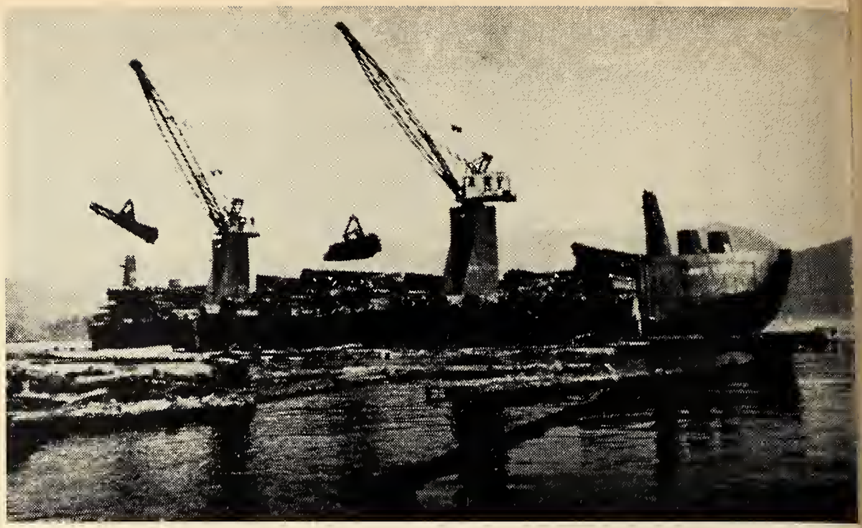


Fig. 10.

To overcome this difficulty, it is desirable to fit two valves on each sluicing line so that both valves must be opened before the tipping tanks will flood.

Self-Loading Log Barge: A further development is the self-loading side tipping log barge. A prototype, the "FOREST PRINCE", has recently been completed. Fig. 10.

This barge is peculiar in that two Diesel driven cranes are mounted on pedestals on the starboard side of the barge. The cranes each have a capacity of 35 tons at a radius of 40 ft. or of 10 tons at a maximum outreach of 65 ft.

This vessel is particularly suitable for loading at small logging camps that are not equipped with shore loading facilities. The "FOREST PRINCE" can unload by side tipping or by selective unloading with her deck cranes. Thus, selective off-loading, though presumably much more time consuming and costly than side tipping, might have an advantage where the log cargo has to be delivered to two or more destinations.

The self-loading facilities increase the capital cost of the vessel. Whether or not the self-loading side tipping log barge will prove more economical and adaptable than its non-loading counterpart remains to be seen.

Conclusion

This paper has briefly outlined the development of the side tipping log barge. At the present time, the use of the log barges is generally confined to the movement of logs on exposed waters where no other satisfactory means of transport has proved satisfactory.

Although the cost of transporting logs by barge is higher than towing by flat raft, there is considerable saving in the time involved, particularly in winter months when flat rafts so often are weather bound for extended periods, inceasing demurrage costs.

It is probable that future economic conditions will favour the log barge even for the transportation of logs in sheltered waters, particularly where the movement of selected high-priced timber is concerned.

Fig. 11

Side Dumping Log Barges in Service on B.C. Coast

Name of Vessel	*Year*	*Dimensions* L x B x D x d	*Dead Weight*	*L/D Ratio*
		NEW CONSTRUCTION		
Powell No. 1	1954	337′ 7″ x 63′ 1″ x 19′ 6″ x 14′ 3″	6360	17.25
Powell No. 2	1954	337′ 3″ x 63′ 1″ x 19′ 6″ x 14′ 3″	6360	17.25
Straits Cold Decker	1957	280′ 0″ x 60′ 0″ x 16′ 6″ x 12′ 0″	4028	17.00
Straits Water Skidder	1957	280′ 0″ x 60′ 0″ x 16′ 6″ x 12′ 0″	4028	17.00
Crown Zellerbach No. 5	1957	280′ 0″ x 60′ 0″ x 16′ 6″ x 12′ 0″	4028	17.00
Crown Zellerbach No. 6	1957	280′ 0″ x 60′ 0″ x 16′ 6″ x 12′ 0″	4028	17.00
Island Pine	1959	220′ 0″ x 54′ 0″ x 14′ 6″ x 11′ 0″	2735	15.75
Forest Prince	1960	305′ 0″ x 60′ 0″ x 17′ 0″ x 12′ 0″	4380	17.95
V.T. No. 65	1959	200′ 0″ x 52′ 0″ x 14′ 6″ x 11′ 0″	2450	13.80
		CONVERSIONS		
Island Cypress	1929	330′ 0″ x 55′ 0″ x 16′ 0″ x 11′ 0″	4100	20.60
Island Fir	1925	305′ 0″ x 50′ 0″ x 15′ 0″ x 10′ 6″	3780	20.40
Island Hemlock	1924	305′ 0″ x 50′ 0″ x 15′ 0″ x 10′ 6″	3780	20.40
Island Spruce	1924	305′ 0″ x 50′ 0″ x 15′ 0″ x 10′ 6″	3780	20.40
Island Balsam	1929	330′ 0″ x 55′ 0″ x 16′ 0″ x 11′ 0″	4100	20.60
Island Maple	1929	330′ 0″ x 55′ 0″ x 16′ 0″ x 11′ 0″	4100	20.60

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The author wishes to acknowledge with thanks assistance given by the following firms and individuals.

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Island Tug & Barge Ltd.
Kingcome Navigation Co. Ltd.
Straits Towing Ltd.
Yarrows Limited

Discussion

'ANDARD ALUMINUM
'BSTATION STRUCTURES
R. McMullan and J. H. Myers,
mes R. Kearney Corporation,
Canada Limited, Guelph.
'ie Engineering Journal, October, 1960
iscussion by A. B. Dove

The paper was most interesting, ıt I fear that some of the points ıentioned in that paper could tend to ıislead the readers in evaluating aluıinum sections in comparison with ıose normally specified for structural se in steel.

The statement has been made "The luminum alloys normally specified ɔr structural use, compared with teel, have ultimate tensile strengths anging from 63% to 100%. Howver, the tensile yield strengths vary rom 66% to 140% of the yield trength of steel". This latter statenent is quite at variance with my nowledge of aluminum alloyed maerials, and I am wondering whether he authors would be prepared to xhibit further information regarding he physical properties of these alloys. f any of them have 140% of the rield strength of steels specified for structural use, they must be unusual alloys which have not yet been advertised widely by the producers. Even the old A.S.T.M. Specification A-242 for low alloy structural steel requires a tensile strength of 70,000 p.s.i. *minimum* and a yield strength of 50,000 p.s.i. up to ¾" thickness, and most of the members would fall into such category. Were the aluminum to have 140% of such yield strength, we should be expecting a value of 70,000 p.s.i. There is only one case in the normal alloys with which I am familiar where such a strength can be obtained, and that is in the alloy 75-ST in the Alcan group, and this strength is expected with an accompanying ultimate of 78,000 p.s.i. in smallest dimensions up to 0.249". The alloy, however, depends upon heat treatment to achieve these strength values.

It would be natural to wonder whether the authors had ever considered the use of some of the newer steels, for example, Strenlite or Stelcoloy which meet A.S.T.M. Specifications A-242, A-374, A-375 and A-195. Stelcoloy also meets S.A.E. 950 for high strength low alloy steels. With these steels the high strength to weight ratio permits weight reductions of as much as 25%. While the usual tensile strength for Stelcoloy is 70,000 p.s.i. *minimum*, values 20,000 p.s.i higher can be reached in Strenlite.

The authors have also stated "The coefficient of linear expansion is approximately twice that of steel, while the modulus of elasticity is three times". I believe that they meant to state that "the modulus of elasticity is *one-third*". Since the modulus of elasticity for aluminum is only one-third that of steel, the stress-strain curve for aluminum would be tilted to the right with respect to the curve for steel, indicating much greater elongation for equivalent loadings compared to steel; with the greater coefficient of linear expansion, the combined efect could hardly produce lesser deflections in aluminum.

On the subject of welding aluminum, it is interesting to note that the authors have stressed the particular care that must be taken in the welding of aluminum and the fact that it is not a readily field-welded material. I agree that welders must be specially trained and that the cleanliness of joints is much more important than with steel in order to maintain high-quality welds. The authors have mentioned that the alloys are tempered. Indeed, this is the only way in which they could achieve the physical properties which they desire to obtain. This implies the inclusion of copper and zinc alloying and the possibility of precipitation of the alloying elements from solid solution as the paper mentioned. Unfortunately, however, the weld-affected zone will have a tensile strength of just a little more than one-half the unaffected zone, and the use of the bulb mentioned in the article becomes an absolute necessity in increasing the area of the section, but it will not account for the immediately adjacent section which has lost the effect of tempering. I wonder whether we can be sure of the exact conditions under which the precipitation took place and whether the strength in the joint is always exactly reproducible.

One other thought should be presented at this point concerning the corrosion resistance of the weld-affected area, since it may now become susceptible to selective grain boundary attack or intergranular corrosion. The depleted zone is definitely anodic to the aluminum-copper solid solution of the main body of the grain and also to be precipitated particles of copper aluminide ($CuAl_2$).[1] Consequently, the depleted zone corrodes out, giving an intergranular form of attack. The extent to which the area may become susceptible will be a function of the temperature of the surrounding area, the contact of the structural member with other metals, and the welding technique used. These factors are not so important with the lower tensile aluminum alloys which are not in the heat treated condition.

Steel sections in high tensile materials can be pre-fabricated just as readily as non-ferrous metal sections. Indeed, one could say that steel sections can be more readily welded, and that there are more welders capable of welding steel than there are with the specialized knowledge of metallic inert gas welding. The correct electrodes are available from many sources, and many of these high tensile steels can be joined without preheating techniques. The advent of the new columbium type steels, too, has brought about a revolution in welding, whereby steels having relatively high yield points can be field-welded by operators with normal experience.

Aluminum, it must be admitted, does have excellent corrosion resistance in some alloys, but consideration must be given to the necessity of high corrosion resistance with re-

(1) "Corrosion Handbook", Uhlig, 1955, page 54.

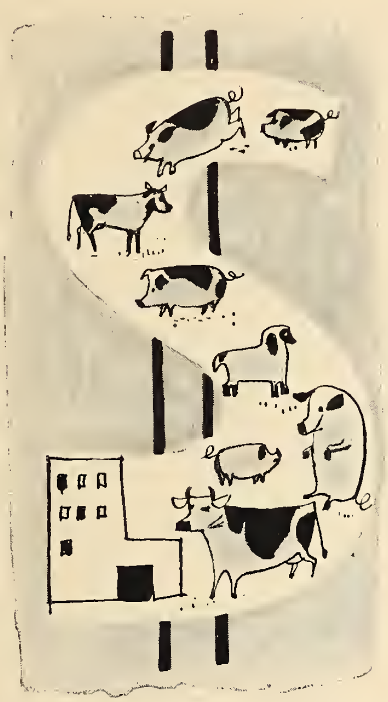
spect to the area in which the ma-terial will be exposed. Many area do not have the requirement for highly resistant base metal. Rural ou-door areas may have rates of co-rosion of zinc coatings as low as 0.0 oz. per square foot per year, whi marine areas have rates in the ord of 0.07 oz. per square foot per yea Under such conditions, the life o a 2 oz. per square foot coating woul be 33 and 29 years respectively. I industrial areas the corrosion rat could vary from 0.1 to the very hig rate of 0.4 oz. per square foot pe year, giving life values of 20 years t as low as 5 years with a 2 oz. coating In the light of these figures, it woul appear unnecessary to base considera-tions of the structural material substation erections on more expen-ive metals purely from the standpoin of the life of the structure.

One other point of which users fre-quently lose sight is that zinc coating in the presence of a larger body o aluminum might act anodically to th extent that the zinc protects the alu-minum. In such cases, the zinc coat-ing will be attacked and the alu-minum will appear to have outlasted the zinc coating. In cases where th area of zinc coating is high compared to the aluminum, the reverse could be true. Zinc coated pole-line hard-ware with zinc coated structural would appear to be a natural com-bination.

Bolting materials are available in high strength steels, regardless of th material of construction used. It would be well, however, to consider the ad-vantages of the use of insulating ma-terials at junction points. The authors have mentioned that galvanized steel may not be drilled without exposure of the bare steel. The insertion of a rubberized or vinyl coating washer could eliminate this objection.

The paper appears to assume that aluminum alloy structures do not dis-colour. Aluminum may be treated by anodizing, but this would hardly pro-vide the finish the user desires in the field.

The writer respectfully submits that consideration could be given to the newer low price, high strength alloy steels which have advantages in strength, yield point, modulus of elas-ticity and lightness, for such construc-tions as substations. The use of such steels can be standardized to the extent that field construction may be reduced to the minimum effort. The greater majority of requirements could then be filled by the more economical steel structure, without the use of the higher price, lower strength aluminum alloys. EIC



Canadian Developments

WIP South Saskatchewan River Damsite

Welding is now an important facet of the work in progress at the South Saskatchewan River damsite. Steel liners for three of the five tunnels to be driven through the west abutment of the dam are being welded on location.

Initially, steel plate 8 ft. wide, 30 ft. long and between ¾ and 1⅛ in. thick, is rolled into a semi-circle. The sections are then shipped to the damsite. Ten sections form a 40 ft. unit of tunnel liner. As these units are made up they are stockpiled and will be installed when the tunnels are completed.

Because of their cumbersome size the sections are difficult to handle and weld. Two semi-circular plates are set on edge and tack welded together to form a "can". Two more sections are added and welded both along the horizontal and verticle seams so that the can is 16 ft. deep. Two assembly lines are in operation; one making two-can units and the other making three-can units. (24 ft. deep). One of each of these is put together to form the finished five-can unit.

When the two and three-can units are put together the sections are laid on their sides to facilitate handling. A tilting jig, one of the pieces of apparatus specially designed for this project, is used in this operation. As the unit rotates slowly a tractor welder rolls around and welds the longitudinal seams from the inside. Boom type welders, mounted on carriages, are used to weld the outside seams allowing the welder to operate from the top of the rotating unit.

The welded seams are checked in off hours by a radiographer using a gamma ray camera. Six or seven X-rays are taken for each 40 ft. unit. As this is done while the welders are not there the radiation hazard is kept to a minimum. Sections that have been approved are set to the stockpile area.

The tunnels which these steel sections will line will have an inside diameter of 20 ft. and the walls will be reinforced concrete 2½ ft. thick.

New Lab for Ontario Hydro

The extension to the Ontario Hydro Research Laboratory is due to be completed in August. It will provide room and the facilities for 360 people to work on a variety of projects. Research on equipment and the testing of it for use in the production of electricity will be done there. Projects in the advancement of nuclear power will also be undertaken, and the laboratory will be used for new research in electrical, structural and mechanical materials.

The laboratory extension is an H-shaped building. The exterior, on a steel superstructure, is concrete block back-up with brick facing, hermetically sealed aluminum windows, and insulated aluminum panels with pre-cast concrete exposed aggregate panels. The second floor will be poured suspended concrete while precast concrete autoclaved cellular slabs have been specified for the remainder. The roof will be flat.

Research on E.H.F. (extra high voltage) in which Ontario Hydro is regarded as the world's leading authority, will continue in this new laboratory extension. The Commission is engaged in the development of E.H.F. with A.C. which is considered an important factor in the transfer of power in the Canadian north. According to report, research in E.H.V. with D.C. is being undertaken in the U.S.S.R.

Tower-Antenna Under Construction

A tower and antenna "package" for the communications field has been developed. The "package" includes: parabolic reflectors, made by a new vacuum forming process which insures a high degree of surface contour accuracy, a range of guyed towers, which can rigidly support heavy installations at great heights, as well as a failure warning system for the obstruction lighting.

The Manitoba Telephone System is using one of these tower-antennas ne[ar] Elie, Man. to form the main link [in] the System's heavy route relay betwe[en] Winnipeg and Portage la Prairie. T[he] microwave tower at Elie will have tw[o] 10 ft. diameter parabolic reflecto[rs] mounted on the platform which is [...] ft. square. Designed to support fo[ur] cornucopia antennae, the tower wi[ll] support a dead weight of more tha[n] 12,000 lb. at a height of 330 ft. Th[e] guyed structure, it is felt, will do th[e] same job at lower cost than an equiva[-]lent free standing tower.

These package tower antennas we[re] developed by Bristol Aero-Industri[es] Ltd., Winnipeg, as one of the Com[-]pany's projects in the communication[s] field.

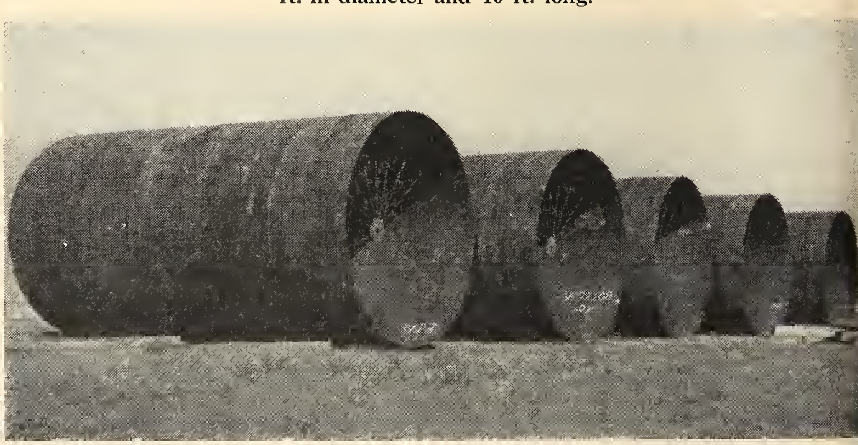
Bras d'Or Bridge Near Completion

At a special ceremony the steelwor[k] for the Bras d'Or Bridge was recentl[y] completed. The Hon. G. I. Smith[,] Minister of Highways for Nova Scotia[,] gave the signal for the last piece o[f] steelwork, joining the east and wes[t] sides of the main tied-arch truss spa[n] to be set into place.

The bridge, another link in the Tran[s-]Canada Highway, provides a 120 ft. clear[-]ance for ships in the waters of Big Bra[s] d'Or in Cape Breton Island. A two[-]lane highway crossing, it is located nea[r] the Cabot Trail and about halfway be[-]tween Ross Ferry and the town of Bi[g] Bras d'Or. Total length is 2450 ft. o[f] which the main span is a 1200 ft. tied[-]arch truss. A 200 ft. causeway is bein[g] constructed on the west side.

The crossing will be opened to traf[-]fic this September. EIC

The completed sections of tunnel liner, constructed specifically for the South Saskatchewan River Dam are stockpiled. Completed they weigh up to 60 tons and are 20 ft. in diameter and 40 ft. long.



International News

Lab Expansion at Northwestern

Both faculty and facilities of the Gas Dynamics Laboratory of Northwestern's Technological Institute are being greatly increased. The facilities will be more than doubled and five new faculty members will be added to staff. The object of this program is to make the laboratory open to more graduate students than can use it at present. Formerly a part of the mechanical engineering department, the laboratory now becomes an independent inter-disciplinary one open to graduate students and faculty from all engineering and science departments.

Graduates of this laboratory have become research-development engineers who go on to posts in teaching and research, government and industry and the applications of plasma and mhd.

Among the research facilities of the Gas Dynamics Laboratory are a hyperthermal plasma jet (which gives temperature of 40°F.) and an electromagnetic shock tube (which develops Mach numbers up to 80). Research projects there feature the applications of "plasma" (termed the fourth state of matter along with solid, liquid and gas) and mhd (magnetohydrodynamics). While hot electrically charged gas (plasma) is used daily in electric arc lamps and fluorescent lights, it has more dramatic applications in fuel for space travel, in the "fireball" of an atomic explosion, or the glow around the sheath of a returning ICBM.

New developments in propulsion systems have changed the emphasis in the search for fuels. Formerly the laboratory concerned itself with research on chemically-fueled engines both jets and chemical rockets. One of the results of research has been the switch to electrical space engines and electrical power generation, both of which use plasma and mhd. schemes.

Basically, the laboratory concerns itself with the dynamics and applications of liquids, gases and plasmas. Liquids and gases used in everyday life are studied for the insight they give the research worker into problems in underwater ballistics and aerodynamics.

M.I.T. Summer Course on Cohesive Soils

"Shear Strength Behaviour of Cohesive Soils" is the title of a two week summer course to be held at the Massachusetts Institute of Technology from Aug. 28-Sept. 8. Of special interest to engineers, educators and others in soil research, the program is designed to provide a comprehensive understanding of the latest developments in strength behaviour of cohesive soils and the principles which are the key to using this new knowledge in actual practice and further research.

The course will be given in two parts. The first, to be given primarily by the staff of the M.I.T. Soil Engineering Division, will be a lecture course designed to present current knowledge in five main areas dealing primarily with saturated cohesive soils: generalized shear strength behaviour; the measurement of shear strength; the general principles used to explain and predict strength behaviour; observed deviations from these general principles; and the mechanics involved in using shear strength in stability analyses.

The second part of the course will be concerned with selected controversial topics on which a considerable amount of research is currently being done. Specially invited guests will present papers during this part of the program.

Supplementing the lecture will be discussion periods, a tour of the Soil Engineering Laboratory at M.I.T., an opportunity to participate in triaxial testing and a review of the research program currently in progress at M.I.T.

This is the last in a series of special summer courses being given by M.I.T. during 1961 which is the Centennial year of this Institute.

Research Results Reported by Cornell

Professor Sydney Davis of the Technion, Haifa, Israel, who has been a visiting professor in the civil engineering department of Cornell for the past two years has devised a formula making possible the unification of various calibrations of the Parshall Flume.

A device for measuring the flow of water in irrigation canals and other open channels, the Parshall Flume must conform to rigid dimensional requirements before accurate flow measurements can be obtained. Previously each new size had to be calibrated as it was produced, a procedure costing hundreds of dollars.

Thanks to Prof. Davis' work any flume can now be measured and the discharge flow accurately determined without expensive experimental calibration. The Parshall Flume is used in most of the countries where irrigation for agricultural purposes is common.

Curriculum Changes Studied at UCLA

With the help of a grant from the Ford Foundation, the faculty of the College of Engineering has undertaken a five year program with three main objectives:

1) To critically analyze and, if necessary, make changes in the undergraduate curriculum;

2) To analyze and modify the graduate research program;

3) To develop a graduate program based on the discipline of design.

The whole status of engineering education and its environment will be minutely scrutinized so that the engineering student, upon graduation, will have the knowledge to meet the demands of his profession.

The faculty was asked, prior to the establishment of the unified undergraduate curriculum in engineering, to analyze everything being taught in every course. Material being taught in two courses could be eliminated from one, and anything that had been neglected could be introduced.

After a thorough inventory of material taught in engineering and related courses the faculty was prepared to design an engineering education to meet the demands of a world that is rapidly changing both technologically and socially.

The "Discipline of Design" could and should play a greater role in the education of the engineer members of the faculty feel. Design has been described as a decision-making process which creates systems to optimize the value of resources.

This vital discipline should be the keynote throughout the seven year educational period from freshman to Ph.D. level. The present dilemma in engineering education is that the increasing stress on science courses during undergraduate study and in math and physical sciences during post graduate studies has been at the expense of studies in design.

Future demands, it is felt, will not be for engineers with narrow specialties, but for the engineer with a broad background who can apply basic principles to a variety of problems. The faculty feels that increasing the emphasis on design in the engineering curriculum will make the curriculum useful to future engineering graduates. EIC

Month to Month

J F M
A M J
J A S
O N D

April Meeting of Council

Council of the Institute met at the University Club, Montreal, April 22, 1961. President Dick was Chairman. The following highlights are taken from the minutes of the meeting.

Branch Operations

The first meeting of the Committee on Branch Operations, held in Montreal April 21, was well attended by members who contributed very useful discussions, it was reported by CBO Chairman F. L. Lawton. The Committee had studied the analysis of returns to the questionnaire which was mailed by the CBO to Branches Dec. 20, 1960. The report on the results of this analysis, together with recommendations, was approved by the Committee for presentation to Council.

Council adopted these 18 recommendations, and requested that the Committee be asked to make further studies and recommendations regarding the methods of implementation of these recommendations.

Mr. Lawton drew attention to the percentages of Branch meeting attendance, an analysis of which was contained in the report. It is evident that for all groups, general meetings were more frequently held and were better attended than technical meetings. The larger the Branch the more general and technical meetings were held, but there is a lower percentage attendance at each meeting in comparison with smaller Branches. There is an inverse correlation between the size of the Branch and the average attendance at its meetings. It would appear that the smaller Branches are doing a far better job than the larger Branches, if the criterion of a good job is a greater percentage of membership attending meetings.

Further discussions and recommendations were made, after which it was resolved that the Committee on Branch Operations and the Committee on Membership be Standing Committees of the Institute, subject to ratification of the necessary By-Law changes by the membership, and that the Committee on By-Laws be instructed to prepare the necessary changes.

Confederation

The final report of the Engineers' Confederation Commission to the Council of the E.I.C. and the C.C.P.E. which was distributed to members of Council just prior to the meeting, was received. Council approved the text of a press release, as follows:

> An important occasion in the professional life of Canada's more than forty thousand engineers occurred recently when the report of the Engineers' Confederation Commission was completed. This report was received by the Council of the Engineering Institute of Canada at its meeting in Montreal today.
>
> During the summer of 1959 it was mutually agreed by the Canadian Council of Professional Engineers and the Engineering Institute of Canada that a jointly appointed Engineers' Confederation Commission be set up to study and report on a procedure for a possible confederation between the two bodies.
>
> The completion of this report is the result of two years of intensive work by the Commission which was composed of John H. Fox, Toronto, as Chairman, J. E. Leo Roy, Montreal, as Vice-Chairman and twenty-five senior members of the profession representing all parts of Canada.
>
> This report will be presented officially to the membership of the Engineering Institute of Canada at the Institute's Annual General and Professional Meeting to be held in Vancouver, B.C., on May 31 and June 1 and 2.
>
> Garnet T. Page
> General Secretary

1960 Student Conference

C. G. Southmayd reported on resolutions considered at the 1960 Student Conference in Winnipeg. The Committee examined these eight resolutions on behalf of Council, and requested that Council endorse seven of them. One resolution dealt with IAESTE. As Council now is discussing the Institute's continued participation in IASTE, it was not asked to endorse this resolution.

Adult Education

The Institute has been invited by the Canadian Association for Adult Education and l'Institut Canadien d'Education des Adultes, the two organizations convening the National Conference on Adult Education, to join in support of this activity to name a delegate to it. The cost to the Institute of participation will be $35. Council resolved that the Institute take part in the Conference and that the Ottawa Branch be asked to recommend to Council the name of a suitable delegate to represent the Institute.

Publications Policies

R. A. Phillips, Chairman of the Publications Committee, said his Committee firmly believes there should be a clarification of purpose of EIC publications so their role might be pursued more vigorously. Mr. Phillips said that replies to the President's questionnaire indicated a wide range of opinions concerning the Journal. The Committee feels that the Institute's objectives are quite clear, and that it should be possible to establish just as clearly a set of objectives for the Institute's publications.

The Committee, in attempting to define objectives, found that confusion existed because its statements were combining both objectives and policies. It was therefore decided to segregate the objectives from the policies, and to compile two statements; the objectives to be fairly stable over a period of time, whereas the policies should be laid down to cover all matters on which the staff currently requires guidance. The policies would require frequent modification as changing circumstances indicate.

Council approved the positive approach to the situation and the Committee's statements of policy and objectives.

Slides Investigation

Dr. Dick said the matter of investigation of river slides in the Winnipeg area had been discussed during a recent Presidential visit. He had been assured the project would be kept clear of all political implications. Council approved the Winnipeg Branch project and asked that the Chairman of the Civil Division of CTO be kept fully informed.

Officers' Activities

Dr. Dick reported that he had just returned from Presidential visits to Branches in mid-western Canada and that prior to attending the Annual Meeting in Vancouver he would visit Branches in British Columbia.

Vice-President Lawton reported he visited the Quebec Branch and had ac-

ve discussion with the Branch Execu-
ve concerning the problems with which
e Branch is faced.

The General Secretary reported that
e plans to attend an organizational
eeting of the proposed new EIC
ranch in Whitby, Ont., early in May;
at he will also attend the Regional
onference of the Institute in North
ay and the Annual Meeting of the
ouncil of Engineering Society Secreta-
es in New York City.

Ionours and Awards Committee

The General Secretary summarized
he report of the Honours and Awards
Committee which had been appointed to
ecommend rules and procedures in con-
ection with the award of Institute
onours and awards.

International Agreement

The General Secretary reported that the Institution of Civil Engineers (U.K.) as prepared a form of conditions of contract (international) for works of civil engineering construction, with forms of tender and agreement. The Institution has suggested that the Institute review this document.

After discussion it was resolved that E. R. Davis, Toronto, be invited to review this proposed contract form on behalf of the Institute.

Centenary Council

After discussion it was resolved that the Ottawa Branch be asked to recommend to Council the name of an EIC representative to the Canadian Centenary Council, bearing in mind the Institute's proposal that a museum of science and technology be founded as part of Canada's Centenary celebrations.

It was subsequently recommended that the Institute's representative be Brig. A. B. Connelly.

Honours and Awards, 1960

Council empowered the President to receive and approve the results of ballots from the scrutineers and inform the recipients of Honorary Memberships, 1961, and the Julian C. Smith Medal, 1960. Ballots for the Honorary Memberships and the Medal were to close May 1, 1961. This action was to be taken on behalf of Council and without further reference to Council. Council also approved other Medals and Prizes.

NRC Associate Committee

The General Secretary reported that at the request of the Canadian National Commission for UNESCO, the National Research Council is establishing an Associate Committee on the Natural Sciences Program of UNESCO. The National Research Council has indicated it would be pleased if the Institute would nominate a member to serve on this Committee for a two-year term.

After discussion it was resolved that the Ottawa Branch be invited to make a recommendation regarding a suitable member to represent the Institute on the NRC Associate Committee.

Executive Committee

It was suggsted that in view of the vital importance of the Committee on Branch Operations, and the Committee on Membership, the chairmen of these Committtees shall be members of the Executive Committee of Council. After discussion it was resolved that these Chairmen be ex-officio members of the Executive Committee.

New Councillors

J. E. Dykeman was elected Councillor representing the Border Cities Branch, to take office at the 1961 Annual General Meeting.

F. R. Denham was elected Councillor representing the Niagara Peninsula Branch to take office at the Annual Meeting and to complete the remainder of Mr. Buss' term of office, until June, 1962.

Ratified was the appointment of *A. J. Groleau* as the representative of the Corporation of Professional Engineers of Quebec to the EIC Council.

Two New Councillors Elected

F. Ronald Denham, M.E.I.C., has been elected a Councillor representing the Niagara Peninsula Branch following the election of Paul E. Buss as Vice-President for Zone "B". Dr. Denham received his B.Sc degree in 1951 and his Ph.D. degree in 1953, both from the University of Durham. A staff consultant with Stevenson & Kellogg Ltd., he joined the Institute in 1954. He has been an active member of the Niagara Peninsula Branch. In 1958, he became Secretary, the following year Vice-Chairman, and in 1960 he was elected Chairman. He was also Chairman of the Southern Ontario Regional Conference of the EIC held in March of this year. Dr. Denham is a member of the Rotary Club and a Graduate Member of the Institution of Mechanical Engineers.

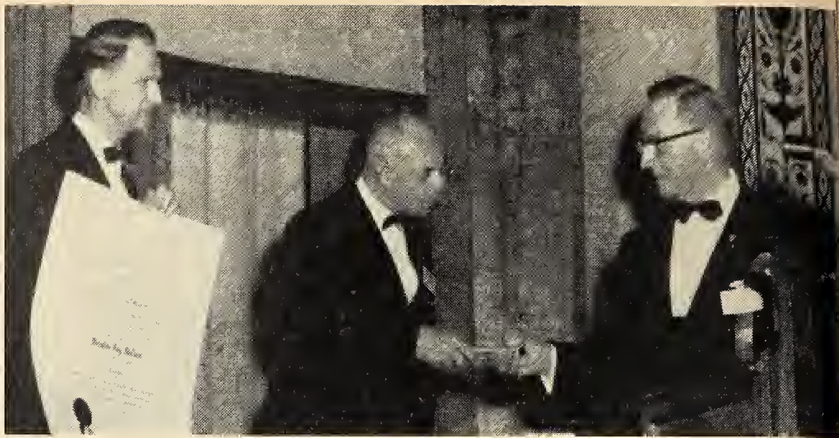
F. R. Denham
M.E.I.C.

D. S. Moyer
M.E.I.C.

David Stanley Moyer, M.E.I.C., elected Councillor for the newly formed Port Credit Branch, is Manager of Manufacturing Engineering, Electronic Tube Section, Canadian General Electric Co. Ltd. Mr. Moyer joined the Institute in 1948 as a student, and in 1958 became a full member. He was an active member of the Toronto Branch; in 1945 he was elected Assistant Secretary-Treasurer of the Branch for a two year term. In 1956 he was elected Secretary-Treasurer for a two year term. He was Director of the Professional Development Program of the Branch 1955-56.

ANNUAL GENERAL MEETING

Pictures shown on these two pages were taken at the Institute's Annual General Meeting in Vancouver. The presentations are described fully on the following pages.



C. H. White, Dr. Ballard and Dr. Dick

General McNaughton and Dr. Dick

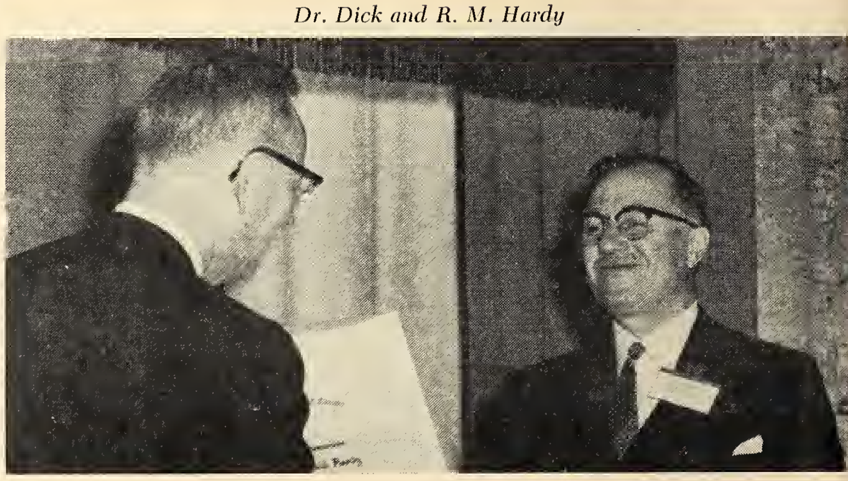
Dr. Dick (sitting) and Dr. J. B. Stirling

H. R. Sills and Dr. Dick

Dr. Dick and K. F. Tupper

R. J. Beaumont and Dr. Dick

Dr. Dick and R. M. Hardy



John A. Hall and Dr. Dick

H. R. Sills and Dr. Dick

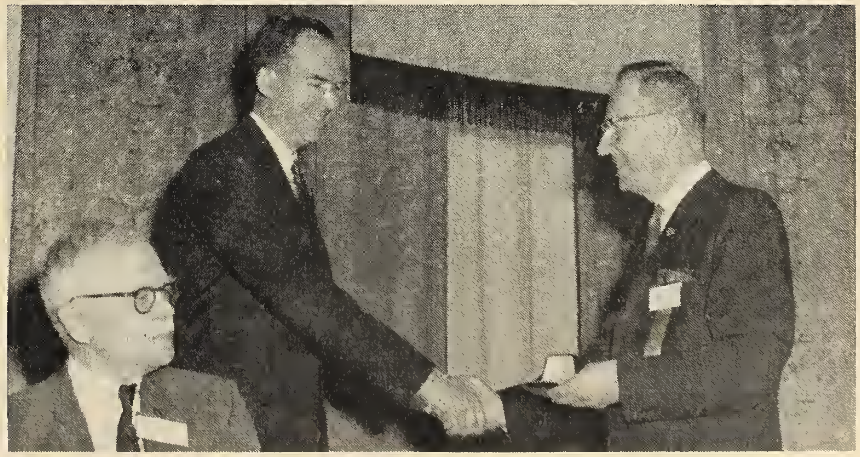
L. M. Hovey and Dr. Dick

S. D. Lash and Dr. Dick

Dr. Dick and R. H. Wilkins

Dr. Dick and R. N. Boyd

General McNaughton (sitting), J. B. Bryce and Dr. Dick



Annual General Meeting

An outstanding technical program, coupled with imaginative social activities and the Institute's business sessions, contributed to a highly successful 75th Annual General and Professional Meeting of the Institute in Vancouver, May 31—June 2.

Even Vancouver's weather, which has a reputation for fickleness in late Spring, co-operated, and the 879 persons registered enjoyed bracing, sunny days.

Theme

Theme of the meeting, "Canadian Designs for Canadian Products", was amplified by President-elect Dr. B. G. Ballard of Ottawa at a press reception.

Dr. Ballard said that Canadians are living in a world of reflections of foreign designs. To Canadian willingness to make goods in patterns which others have developed he ascribed much of Canada's difficulties in both export and domestic markets, and much of her unemployment.

"Sweden has been able to market in Canada and the United States a distinctively Swedish motor car. Switzerland appears to be able to command world markets, not only in those fields in which she is traditionally adapted, but also in heavy engineering. Japan has invaded the U.S. market very successfully and her success with optical goods and electronic equipment is particularly notable."

Dr. Ballard said the mass production, annual style change methods of American production isn't the answer for Canada.

Canadians themselves gave an example of this in their automobile purchases. They were large buyers of one overseas car (the Volkswagen) in the low-priced field, and of the Jaguar in the high-priced field, neither of which went in for style change.

Canada, he said, hasn't followed up her wartime development when she showed she "possessed the physical resources and the creative ability to develop, design and manufacture products of a very sophisticated design".

The failure, however, was not true of all industries. "One aircraft manufacturer, for example, (de Havilland) has marketed planes developed primarily for the Canadian north (the Beaver, Otter and Caribou) which found extensive foreign markets as well. Some electronic firms have captured U.S. markets, not so much in the consumer product field as in custom-built equipment. Developments from Canadian laboratories have found favor in many foreign markets."

Dr. Ballard said industry should give its research and development groups scope for speculative work. "Canadian industries sometimes so prescribe their research departments that they are virtually impotent."

Honorary Memberships

Five distinguished Canadians were presented with Honorary Memberships in the Institute during the Honours and Awards Luncheon June 1. Citations were read and the certificates were presented by Dr. Dick.

Honored were: Robert John Beaumont, Honorary Chairman and Consultant, The Shawinigan Water & Power Company, Montreal, whose citation was read by E. D. Gray-Donald, Montreal; Albert Edward Berry, General Manager and Chief Engineer, The Ontario Water Resources Commission, Toronto, whose citation was read by E.I.C. Vice-President Cross; Robert MacDonald Hardy, consulting Engineer and formerly Dean of the Faculty of Engineering at University of Alberta, Edmonton, whose citation was read by Professor S. R. Sinclair of Edmonton; Hubert Ryerson Sills, Design Engineer, Waterwheel Generators, Canadian General Electric Company, Peterborough, Ont., whose citation was read by Mr. Cross; Kenneth Franklin Tupper, President, Ewbank & Partners (Canada) Ltd., Toronto, whose citation was read by Paul B. Dilworth of Toronto.

Medals and Prizes

Also presented during the Awards Luncheon were medals and prizes to outstanding Canadian engineers and authors of engineering papers.

Following are the awards and their recipients:

The Sir John Kennedy Medal (1960) to Mr. Sills "as a recognition of outstanding merit in the engineering profession and of noteworthy contribution to the science of engineering";

The Julian C. Smith Medal (1960) "for achievement in the development of Canada" to Arthur Duperron, formerly Chairman and General Manager, the Montreal Transportation Commission;

The Gzowski Medal (1960) to Carson Howard Templeton "for the best paper of the medal year on a civil engineering subject". His paper was Benefit Cost Analysis of the Greater Winnipeg Floodway;

The Leonard Medal, open to members of the EIC and the Canadian Institute of Mining and Metallurgy, and awarded for the best paper on a mining subject to John A. Hall, M.C.I.M.M., Mine Superintendent, Gaspe Copper Mines Limited, Murdochville, Que. Mr. Hall's paper was Trackless Mining at Gaspe Copper;

The Plummer Medal, awarded for the best paper on chemical and metallurgical subjects, was won by Robert Norman Boyd and Vladimir Joseph Bakanowski for their paper Electronic Computation in the Chemical Industry. Mr. Boyd is Supervising Engineer — Design Services, DuPont of Canada Limited, Montreal. Mr. Bakanowski is Principal Computation Engineer, DuPont, Montreal.

The Duggan Medal and Prize "for the best paper dealing with the use of metals for structural and mechanical purposes" was won by Stanley Dale Lash and Brian B. Hope, co-authors of Structural Behaviour of Highway Bridge Decks. Mr. Lash is Head, Department of Civil Engineering, Queen's University, Kingston, Ont. Mr. Hope is a Research Assistant at Queen's.

The R. R. Ross Medal for the be[st] paper on an electrical engineering sub[ject] was won by Lindsay Mansur Hove[y], Assistant to the General Manager [–] Planning, the Manitoba Hydro-Electri[c] Board, Winnipeg. Mr. Hovey's winnin[g] paper was Optimum Adjustment [of] Governors in Hydro Generating Station[s].

The Robert W. Angus Medal for th[e] best paper on a mechanical engineerin[g] subject was won by John Bemiste[r] Bryce, Hydraulic Engineer, Hydr[o-]Electric Power Commission of Ontari[o], Toronto. Mr. Bryce's paper was Head Loss Coefficients for Niagara Wate[r] Supply Tunnels.

The John B. Galbraith Prize, a Junio[r] Prize, was won by Roger Hugh Wilkin[s] of Belleville, Ont., for his paper, Sewag[e] Treatment Plant for the City of Belle[-]ville.

General McNaughton Honoured

General The Honourable Andre[w] George Latta McNaughton, Hon[.] M.E.I.C., was honoured by the Institut[e] during the closing banquet. An inscribe[d] silver tray was presented. The inscrip[-]tion read, in part: "Presented to Genera[l] . . . McNaughton . . . Engineer, Soldier[,] Scientist, Diplomat, Humanist, by hi[s] friends of the Engineering Institute o[f] Canada as a token of deep appreciatio[n] of the great services rendered to Canad[a] and to the Engineering Profession i[n] Peace and War, June 2nd, 1961."

A citation which dealt sincerely wit[h] General McNaughton's outstandin[g] career was read by Dr. John Bertram Stirling, Hon. M.E.I.C., Chancellor of Queen's University and President of A.G.M. Cape, Montreal, and a past president of the E.I.C.

The career of General McNaughton "makes one of the most amazing stories in the history of this country," Dr. Stirling said. "It is in truth the story of two or three careers crowded into one — indeed, what he has accomplished since reaching the conventional age of retirement is far and beyond what the majority of us accomplish in life's normal span".

Technical Program

Fifty-nine technical papers were presented during 21 sessions. Quality of the material was high and the enthusiastic response to its presentation was a credit to the thorough planning and hard work of the local committee. Discussion, the gauge of a technical meeting's success, was spirited in most instances. Several sessions drew overflow attendance, and late-comers had to be turned away.

In addition to the Institute's technical program a Symposium on Automatic Control was held. The Symposium, sponsored by the Joint National Research Council Committee on Automatic Control and the Institute, consisted of eight papers in two sessions. In addition there was a panel discussion on Automatic Control and Economic Survival.

Social Program

The Vancouver Committee, which obviously had gone to some pains to order erfect weather, provided an excellent ocial program for the visitors. The omen enjoyed tours, teas and sightseeing. For all the visitors, a highlight as an evening cruise aboard the eamer Princess Patricia. More than 500 ersons, including Muriel, took part. ther activities included a visit to the raser River model at University of ritish Columbia and tours of plants. everal receptions were held at the lotel Vancouver, again with the ubiquious Muriel as hostess.

Other Activities

A highly successful students conference, under the leadership of C. G. outhmayd of Montreal, was held in onjunction with the meeting.

Many Branches were represented at a ell-attended and profitable meeting of he Committee on Branch Operations. Committee Vice-Chairman Jim Rettie f Winnipeg served as Chairman of the eeting.

Local Committee

The splendid job this group did cannot be over emphasized. Particular congratulations are extended to the following persons and their assistants; Chairnan, Dean D. M. Myers; Vice-Chairnan, Professor W. G. Heslop; Chairman Vancouver Branch, C. H. White; Secreary, F. M. Cazalet; Publicity, A. D. Cronk; Budget and Finance, D. D. Bakewell; Technical Papers, C. P. Jones; Hotel Arrangements, J. T. Turner; Registration, R. F. Binnie; Reception and nformation, C. F. Ripley; Ladies, P. N. Bland; Plant Visits and Transportation, Ian Hamilton; Communication and Projection, G. M. Ellis; Muriel's Room and Entertainment, W. K. Gwyer; Annual Dinner and Dance, H. R. Wright; Ladies' Convener, Mrs. C. D. Bailey; Ladies' Co-Convener, Mrs. K. E. Patrick.

Annual Meeting of Council

The highlight of the first part of the Annual Meeting of Council was the formation of a new Branch of the Institute at Whitby, Ont. The formation of this Branch is in line with a policy of providing more convenient Institute facilities for members in the Greater Toronto area.

It was decided that the Institute will participate as a co-sponsor in the ASME-AIEE Railroad Division Conference in Toronto, April 10-11, 1962.

Council expressed pleasure in the appointment of C. G. Kingsmill as Chairman of the 1962 Annual General Meeting which will be held in the Queen Elizabeth Hotel, Montreal.

In response to an invitation from the Minister of Northern Affairs and Natural Resources, Council decided that the Institute should be represented at the Resources For Tomorrow Conference which will be held in Montreal, Oct. 23-28, 1961.

The feature of the second part of the meeting was the official presentation of the final report of the Engineers Confederation Commission by Chairman Fox and Vice-Chairman Roy. They reviewed the report in some detail and amplified and explained its contents to Council members.

It was resolved that the Executive Committee of Council be charged with the responsibility of advising Council, no later than November 1, 1961, on the method of presentation of the final reports of the Engineers Confederation Commission to the membership of the E.I.C. The Executive Committee is empowered to express any views that it may have in favour of or contrary to the contents of the report, and to transmit to Council any legal opinions regarding the contents of the report that may be obtained.

Heard was a most interesting report by L. A. Wright, Chairman of the Life Members Committee, convening a memorial to the late C. D. Howe. Among the proposals were: the preparation of a biography; the establishment of a lectureship; the establishment of a memorial library.

The Life Members decided against the first two proposals as a biography has been prepared, and because it was felt that a lectureship would be difficult to perpetuate. The Committee, therefore, decided to investigate further the possibility of establishing a memorial library which would take the form of donations of books each year to engineering libraries throughout the country.

The first meeting of the new Council, June 1, was devoted primarily to the appointment of officers and committees to enable Council to discharge its responsibilities.

The President assured Council that he will take action to get the views of every Council member regarding the Confederation report, and that the Executive Committee would proceed with its responsibilities in this matter with all due dispatch.

Annual General Meeting

Minutes of the Annual General Meeting, and lists of all officers will be published in subsequent issues of the Journal. EIC

Delegates and guests enjoying a luncheon at the Annual General Meeting

Personals

…nes Buekland Mawdsley, M.E.I.C. (Mc-…ll '21), professor and head of the …ology Department at the University of …skatchewan, and director of the Insti-…te of Northern Studies, has been ap-…inted president of the Canadian Insti-…te of Mining and Metallurgy.

…lph C. Pybus, M.E.I.C. (Manitoba '22), …s been elected chairman of the Greater …ncouver Metropolitan Industrial De-…lopment Commission. He retired re-…ntly as president of the Common-…ealth Construction Company.

…nest Arthur Ford, M.E.I.C. (Man. '27), …as elected president of the Canadian …stitute of Steel Construction, Inc. at … annual meeting in Montebello, Que. …r. Ford succeeds G. Eric Ellsworth.

… A. Cairns, M.E.I.C. (Alta. '36), has …en appointed superintendent, Chem-…als and Fertilizers Division of The …onsolidated Mining and Smelting Com-…any of Canada Limited, at Warfield, …C. He succeeds A. M. Chesser who …as retired.

…erald B. Williams, M.E.I.C. (Manitoba …5), was the successful candidate among …0 applicants in a Civil Service compe-…tion to fill the position of an Assistant …eputy Minister (Technical), in the …ederal Department of Public Works.

His new position, announced by the …Ion. David J. Walker, Minister of Public …Vorks, was created to facilitate the …andling of the Department's technical …esponsibilities in the architectural and …ngineering fields.

G. B. Williams
M.E.I.C.

R. R. Noyes
M.E.I.C.

…R. R. Noyes, M.E.I.C. (Toronto '36), has …een appointed assistant general manager …nd secretary, Stanley Works of Canada …imited. Mr. Noyes, who was also elected …o the Company's Board of Directors, …as had a number of years experience in …eating, plumbing, air conditioning and …marketing.

W. P. Nesbitt, M.E.I.C. (Queen's '35), general manager of Fine Papers, Howard Smith Paper Mills Limited, has been elected a director of Alliance Paper Mills Limited and Don Valley Paper Co., Limited.

J. E. Piekering, M.E.I.C. (Sask. '46), has been appointed manager, Pump and Turbine Division for Babcock-Wilcox and Goldie-McCulloch Limited, Galt, Ont. He was previously manager of the Company's Eastern Branch in Montreal.

J. E. Piekering
M.E.I.C.

W. P. O'Malley
M.E.I.C.

W. P. O'Malley, M.E.I.C. (Laval '49), has recently been appointed to the permanent staff of the Corporation of Professional Engineers of Quebec as Specialized Services Officer.

Jaeques Souey, M.E.I.C. (Ecole Poly. '48), formerly project engineer with C. D. Howe Co. Ltd., Montreal, has been appointed assistant chief engineer, Research and Development Division for Sicard, Inc.

G. E. J. Blaikloek, M.E.I.C. (Toronto '51), has been appointed executive assistant to the vice-president, The Foundation Company of Canada Limited.

George F. Johnston, M.E.I.C., previously supervisor of Electrical Construction at Canadian Johns-Manville, Asbestos, Que., has been appointed national service manager, Scale Division, Canadian Fairbanks-Morse Company Limited, Sherbrooke, Que.

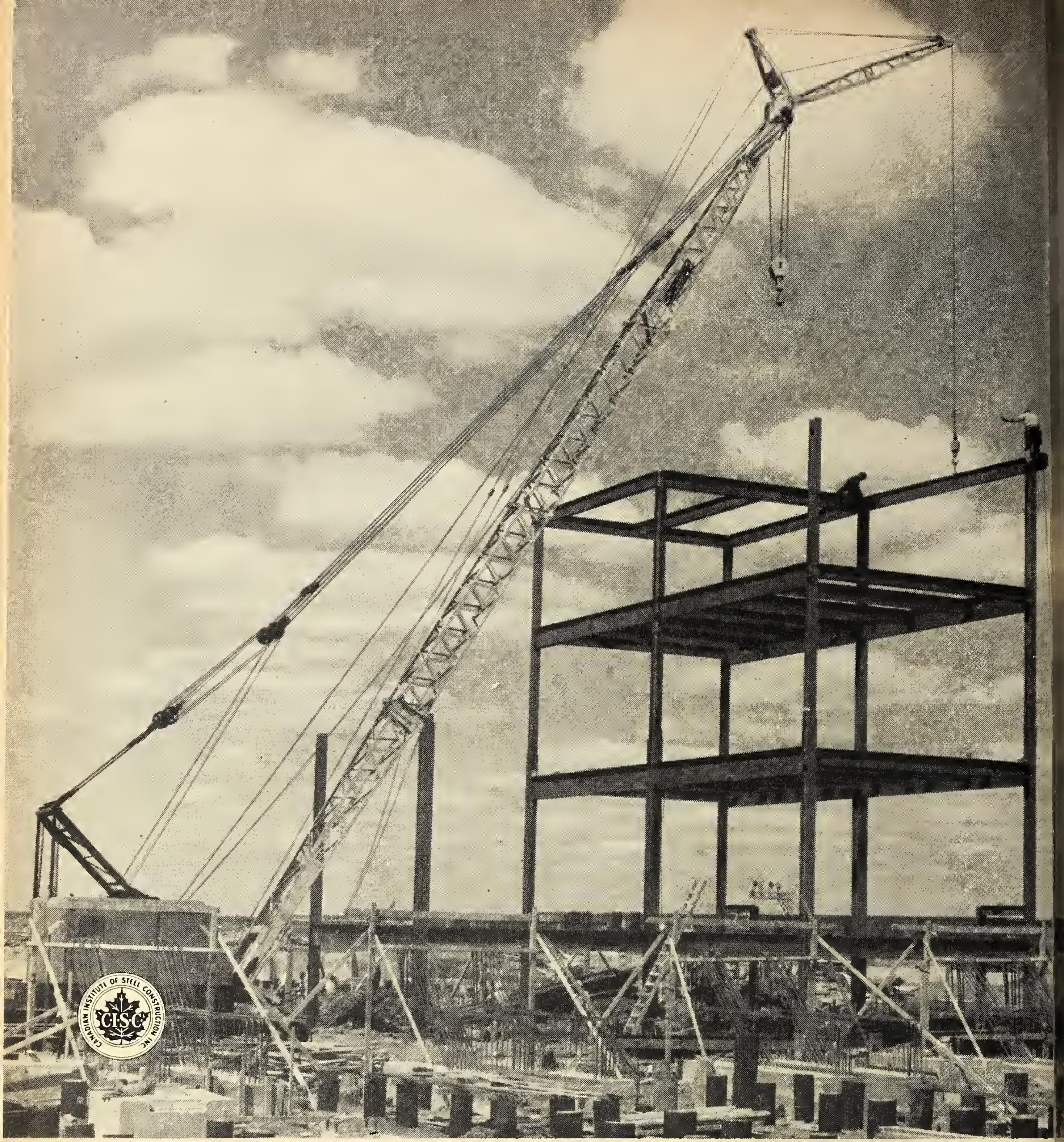
David John MeLeish, JR. E.I.C. (Toronto '59), has been appointed assistant development engineer by the Canadian Institute of Steel Construction, Inc. Mr. McLeish will be mainly concerned with technical improvement in the uses of structural steels and will act as consultant to architects, engineers and contractors on the uses of structural steels in construction.

Obituaries

Albert Coleman Garner, M.E.I.C., civil engineer, died May 11, 1961. He was 83. Col. Garner was born in England, educated in Canada and joined the Saskatchewan Government as a student engineer in 1902. In 1912, after two years of private practice, he returned to the Saskatchewan Government to organize the Surveys Branch, Land Titles Office. He held the post of chief surveyor until his retirement in 1943. Col. Garner was active in various Veteran's Organizations and during the Boer War served as a Special Scout, Lord Strathacona's Horse. In World War I he was a Lt. Colonel of the C.A.S.C. He joined the Institute as a student in 1904, became an associate member in 1908, a member in 1916 and was awarded a life membership in 1938.

Wilfred Almon Hare, M.E.I.C. (Toronto '99), engineer and inventor, died July 6, 1960. Mr. Hare invented the first hang-up furnace and designed several types of furnace stokers. A man with a wide variety of interests, he was past-president of the Windsor Centre of the Royal Astronomical Society, and a member of the Windsor Educational Council. Mr. Hare became a life member in 1954.

Herman J. Mutz, M.E.I.C., (Missouri '21), mining engineer, died April 6, at Guatemala City. He was 64. Mr. Mutz, assistant manager of the International Nickel Company, was known throughout the world for his work in mining technology and development, particularly in underground mining methods. Mr. Mutz joined International Nickel in 1929 as consulting engineer on installation of the fill system at Frood Mine, Ont. Originally an expert on square set stoping, he was named superintendent at Frood in 1931, general superintendent in 1935, manager of mines in 1954 and assistant general manager of the Ontario Division of International Nickel in 1959. Mr. Mutz became a member of the Institute in 1958.


CANADIAN INSTITUTE OF STEEL CONSTRUCTION INC.
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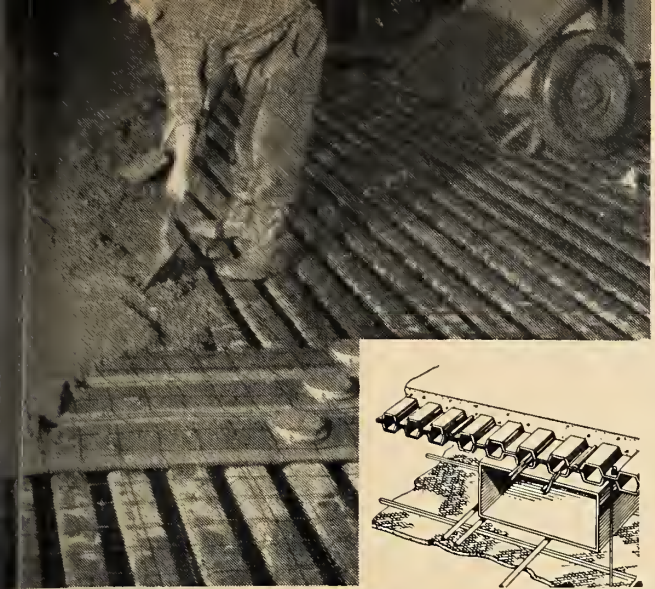
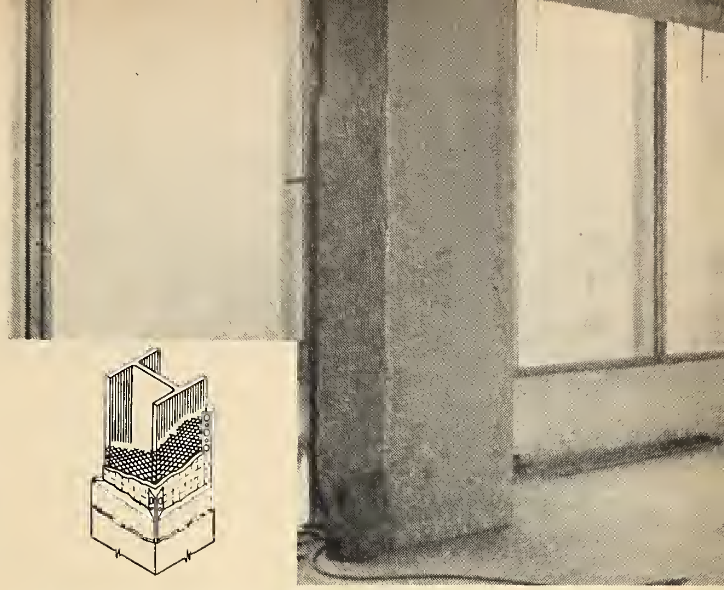


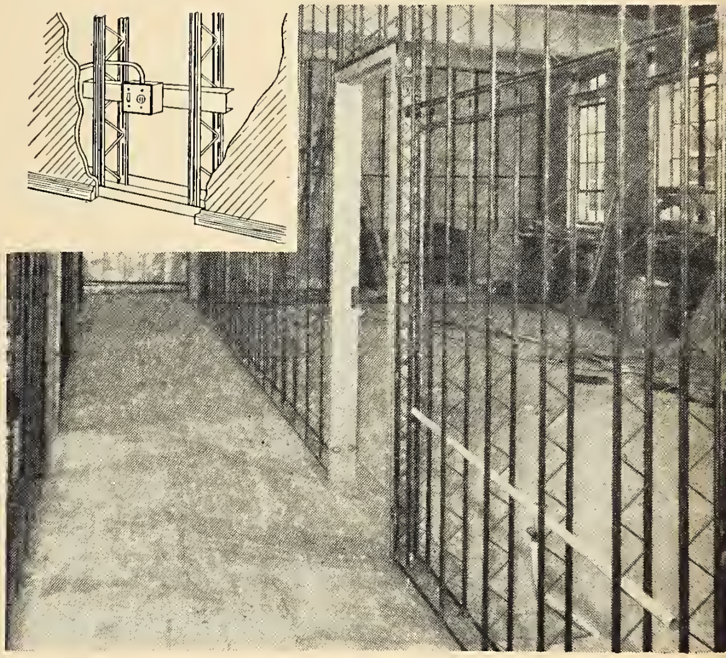


...gauge steel cellular floor is covered with thin layer of ...te. Material is available in several shapes and sizes ...it span and service requirements. Cellular floors can ...le built-in air conditioning duct, and raceways for ...cal services, etc.

Vertical columns are fireproofed and finished with gypsum plaster over self furring metal lath. Recesses between column webs provide excellent ducts for service pipes.

...ral fibre, in this case asbestos, is sprayed on steel to ...le light weight fireproofing. Material also provides ...ble acoustical characteristics.

DB Litebilt open web steel stud sections provide one of the most efficient methods of building light weight low cost partitions. The material is available in four stock sizes of various lengths.



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If you are planning construction, consider carefully the merits of steel. Dominion Bridge have engineers, fabrication and erection facilities in most of the major cities. Their experience and the quality of their performance have no equal in Canada.

70

Structural Division **DOMINION BRIDGE**

FIFTEEN PLANTS COAST-TO-COAST

Other Societies

Canadian Nuclear Association

"Forward with the Atom" was the theme of the first annual meeting and conference of the Assocition which was held in Toronto May 16-17. The conference attracted scientists, businessmen, mining executives, educators and government officials. Delegates from Canada, the United States and Europe were present.

Represented at the conference were the Canadian uranium mining industry, major manufacturers of electrical generating equipment and of industrial isotopes and medical equipment, major power producers such as Ontario Hydro, government agencies and crown corporations, including Atomic Energy of Canada Limited, and specialists in banking, finance, engineering, science and research.

Canada has concerned herself with the peaceful uses of the atom and is known all over the world for her leadership in certain applications. As the peaceful uses of nuclear power have rapidly widened in scope and have become an important part of the Canadian economy, the main task of the delegates was to co-ordinate information and to study ways in which these horizons could be broadened even further.

The Canadian nuclear power program was reviewed in detail by J. Lorne Gray, President, Atomic Energy of Canada Limited. Mr. Gray indicated that AECL looks forward to the time when Canada will have a commercially operated program.

Mr. Gray went on to outline the major nuclear projects now underway in Canada.

Of prime importance to AECL is NPD (Nuclear Power Development), the 20,000 kw. station now under construction. Too small to produce electric power at a competitive cost, the successful operation of this power station will be graphic proof of the soundness of the design. Experiments are scheduled to start this fall. The reactor itself should be critical late this year. It will demonstrate many of the technical aspects of the particular design and will give an example of the performance of full scale reactors of this type in providing fuel.

The AECL in co-operation with the Hydro-Electric Power Commission of Ontario is building a 200,000 kw. nuclear plant, the Douglas Point Nuclear Generating Station, an operation similar to, but considerably larger than NPD.

The plans for a 30,000 to 40,000 kw. (thermal) organically cooled, heavy water moderated experimental reactor is under study by the directors of AECL. Organic materials will be used as the coolant for the OCDRE reactor rather than heavy water. This system promises higher temperature at lower pressure and cost of material. The higher overall efficiency combined with a low pressure system means that the capital cost per kilowatt should be lower. This type of plant may prove to be more economical in smaller sizes (50,000 to 150,000 kw.) than a straight heavy water plant. There is a very active development program at Chalk River concerned with the use of organic material.

Canadian reactor types have been compared at Chalk River with those being developed in other countries. So far, nothing has been found that seriously competes with CANDU, Mr. Gray said. The CANDU reactor at the Douglas Point Project is the main item in Canada's applied program.

Much research has been done on fuel for nuclear reactors. Canada's natural uranium high-burn-up system is economical in that the only use made of the uranium is as fuel for the reactor, while in other systems plutonium is formed along with other fission products.

At the conclusion of his address, Mr. Gray mentioned that the Canadian nuclear program is mainly financed by the government and directed by AECL. At this point it is felt that research and

(Continued on page 89)

The Associations and Corporation

A.P.E.O.

The Association has officially accredited the Faculty of Engineering, McMaster University. Notification was received prior to commencement exercises. Courses taken by engineering students who graduated this year were accredited as well as McMaster's curriculum in chemical engineering, electrical engineering, mechanical engineering and engineering physics. Twenty five students graduated this year from the Faculty of Engineering of McMaster University. In 1962 the first graduating class in metallurgical engineering will receive their diplomas, and the following year will see the first graduates in civil engineering.

"Professional recognition for our first graduates is gratifying to the University, to our faculty and our students alike". Dean J. W. Hodgins of McMaster's Engineering Faculty said "Accreditation at this time means that our first graduates can now proceed toward full professional status in the minimum specified time".

The Ontario Professional Engineers Foundation for Education has announced a scholarship to McMaster University valued at $500. This is an entrance scholarship to be awarded to a Grade 13 student enrolling in electrical, chemical, mechanical engineering or in engineering physics.

The Foundation will award a $250 scholarship to an undergraduate enrolled in an accredited engineering course, the candidate to be selected by the University.

The gold Medal of the Association will be awarded annually to the graduating engineering student with the highest standing in an accredited course in the Faculty of Engineering.

Dr. Hodgins, expressed his appreciation for recognition by the engineering profession as well as the encouragement demonstrated by the scholarship support.

Dr. F. A. Demarco, M.E.I.C., Principal, Essex College Assumption University of Windsor and Dean, Faculty of Applied Science, has announced that the Association has given recognition to their engineering courses. All courses in Chemical, Civil, Electrical and Mechanical Engineering have been recognised for the purpose of registering graduates in these courses as professional engineers. The Metallurgy option in Engineering Physics was also accepted. Other options, depending upon student choice, will be considered on their own merits with the individual student in mind.

evelopment by private companies could ·ell be done in Canada. The Canadian eveloped high burn-up natural urani- m system is considered the best to date. :s simplicity along with other advan- ıgeous conditions has caused some con- ıderable foreign interest and can lead) more work in this field for Canadian onsulting engineers, manufacturers and uppliers of uranium.

'he Chemical Institute of Canada

The 44th Conference and Exhibition f the Institute, to be held in Montreal ıug. 3-5, immediately precedes the 18th nternational Congress of Pure and Ap- lied Chemistry. This Congress will also ıe held in Montreal from Aug. 6-12. ıore than 60 chemical displays will be ın view and delegates to the CIC confer- ence, because of the congress which fol- ows, will have extra time in which to iew them.

The combined conferences of the two ırganizations are expected to attract nore than 8,000 delegates expressing nterests in many related fields. Com- ıanies from Canada, the United States ınd England will display a variety of xhibits covering a wide range of prod- ıcts, equipment, instruments and serv- ces.

Coming Events

International Symposium on Macromolecular Chemistry, International Union of Pure and Applied Chemistry, Montreal, July 27-Aug. 1.

44th Annual Conference and Exhibition, Chemical Institute of Canada, Montreal, Aug. 3-5.

Hydraulics Division, American Society of Civil Engineers, Urbana, Ill., Aug. 16-18.

Western Electronic Show and Convention, Institute of Radio Engineers, San Francisco, Aug. 22-25.

Biennial Gas Dynamics Symposium, American Rocket Society, Evanston, Ill., Aug. 23-25.

Fifth International Conference on Coordination Chemistry, International Union of Pure and Applied Chemistry, The Chemical Society, Detroit, Aug. 27-Sept. 1.

Electric Power Seminar including sessions on Prospects and Problems of Nuclear Power, United National Economic Commission for Latin America; International Atomic Energy Agency, Mexico City, July 31-Aug. 12. EIC

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

Address all information to: *The Engineering Journal*, Editorial, 2050 Mansfield Street, Montreal 2, Que.

News of the Branches

Border Cities

V. Corin, JR.E.I.C.
Correspondent

Thirty-two members and guests went to Ann Arbor, Michigan on May 17 to tour the Hoover Ball Bearing Company's manufacturing facilities. Guides for the occasion were the Company's operating managers. All facets of the manufacture, quality control and assembly of ball bearings were shown and explained to the group. The tour was followed by a question and answer period.

Brockville

A. N. Campbell, M.E.I.C.
Correspondent

Dr. F. C. Jelen was the featured speaker at the May 16th meeting. Dr. Jelen, an engineer formerly with Allied Chemical and now with the American Economic Federation, is concerned with matters of economic importance to the engineer. In his address "What Price Inflation?" the speaker dealt with its effects on individuals and corporations. He termed overhead, depreciation and plant replacement "hidden inflationary results." The cost of replacing plants and equipment during a period of inflation (while the laws of depreciation still apply) has its effects on industrial development the speaker said. Slides were used to illustrate the talk. Dr. Jelen was introduced by J. M. Woods and thanked by D. Ashenden.

Work is proceeding on a student Science Fair in the district. It will be under the joint sponsorship of the C.I.C. and E.I.C. and will be held in Feb. 1962.

Estevan

O. P. Lesiuk, M.E.I.C.
Correspondent

"Results of Fracturing with the Single-Plane Entry Technique in the Steelman and Pembina Oilfields" was the title of a talk given at the May 24 meeting by H. J. Strain, Area Engineer for the British American Oil Company Limited.

Hamilton

P. J. McNally, M.E.I.C.
Chairman

Report of Branch activities 1960-61:

The February meeting held jointly with the McMaster Engineering Society was outstanding, as were social functions such as the Engineer's Wives Christmas Party and the Engineer's Ball. All were well attended, and members had the opportunity to meet Pres. and Mrs. Dick informally at the Engineer's Ball.

The civil section held meetings last fall and one this May.

Herb Hohn looked into the feasibility of publishing a joint engineering society monthly in the area. He has found a printer who would even handle the advertising. All that is needed is "an engineer with a little printer's ink in his blood".

Industrial Relations was the subject covered by the technical section this year.

The Professional Development Program completed its first decade this year with a high and interested enrollment.

The councilling program at McMaster and several high schools was continued. A prize was awarded to the McMaster Engineering student with the highest Christmas marks. The executive discussed establishing a loan fund for McMaster engineering students which will be administered by Dr. Hodgins and the Dean of Men. The loan fund will be self-perpetuating.

The Branch actively participated in the Third Southern Ontario Regional Conference in Niagara Falls. Executive meeting quarters, two speakers and several chairmen were provided by the Branch.

Kitchener

A. R. Lefeuvre, M.E.I.C.
Correspondent

"Plastic Design of Steel Structures" was the title of the talk given by Dr. D. T. Wright at the May 18 meeting. Dr. Wright, Dean of Engineering at the University of Waterloo, Ont., presented an illustrated lecture on the principles of plastic design. Tables of research and theoretical values were used to indicate the superiority of plastic design theory in predicting failure. Dr. Wright cited several typical examples of the application of plastic design. His talk ended with pictures of early applications of plastic design in air raid shelters built during World II.

Thirty members went to Hamilton, June 3 to inspect the Dominion Foundry & Steel Corporation's operation there. The tour was climaxed with dinner at the Hamilton Yacht Club, where Branch members were the guests of DOFASCO.

Montreal

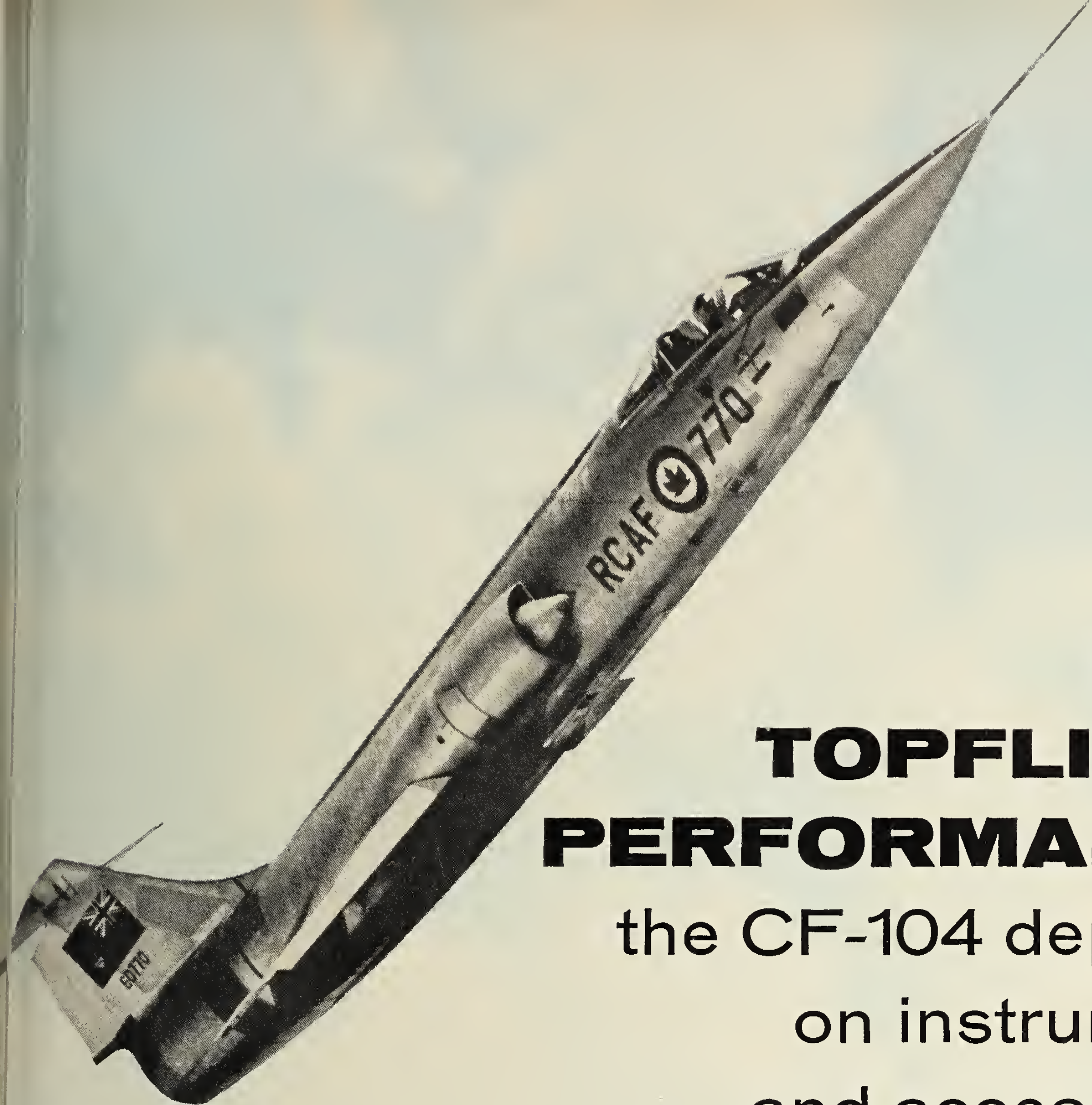
J. Robert Sabourin, M.E.I.C.
Correspondent

A further step towards the possible formation of a social club for the Branch will be undertaken shortly. Two members of the Branch executive together with the Chairman of the Junior Section will meet with one retired manager of the Montreal Engineer's Club to discuss the problems involved in organizing a club of this nature.

Le possibilité de sub-diviser le territoire qui comprend les quelques 4800 membres de l'E.I.C. présentement desservis par le Chapître de Montréal, a été soulevé en plusieurs occasions au cours des dernières séances du comité exécutif. Le but, il semble, serait de créer de nouveaux chapîtres, englobant moins de territoire, et dont les lieux de réunions seraient situés de façon à obtenir une participation plus active de la part de certains membres résidents de banlieues et éloignés du centre actuel de 2050 Mansfield. En une occasion, il a suggéré qu'un sondage d'opinion soit effectué auprès des membres pour déterminer si le project pourrait obtenir le support et l'apporbation de la majorité. Le comité de conduite et coordination a été chargé de poursuivre l'étude de ce project.

Junior Section

The Professional Development Program sponsored by the Junior Section of the Branch during the winter of 1960-61 was again successful. The objective of the program is to help young engineers acquire more knowledge of business and administration policy and management function. Four courses were conducted for about 50 members. Two courses were added to the usual curriculum of Principles of Management and Public Speaking. They were Non-Engineering Business and Industrial Personnel Problems, both of which were given by the case study method. Speakers, outstanding in their respective fields, were secured for the various topics. They were well received and the informal discussion period following the lecture was considered of great value. A similar program is plan-


RCAF
770

ned for the coming season. If enough interest is shown, the program will be in both English and French.

Newfoundland

Anthony O. Nemec, S.E.I.C.
Correspondent

The final meeting of the 1960-61 season was held May 17. Thirty members attended. Following the reading of the Chairman's report the members discussed what they could do to promote engineering as a profession. The emphasis was on attracting the high school student by working with career guidance programs in the Province. The meeting was turned over to Roy Myers, Vice Chairman for next year who represented the incoming executive. A film on Newfoundland completed the meeting.

Niagara Peninsula

Gordon G. Jacox, JR.E.I.C.
Correspondent

Dr. Marcus Long, Professor of Philosophy at the University of Toronto was the featured speaker at the annual Ladies Night. In his talk entitled "Ends and Dead Ends in the 20th Century" Dr. Long surveyed Canada's position in the 20th century, in relation both to her neighbors and to the countries in Asia and Africa. This was followed by a critical analysis of the Canadian national character and its effects on Canada and her place in the world.

F. R. Denham, outgoing chairman, turned the meeting over to V. J. O'Reilly, chairman for 1961-62 and the newly elected officers were introduced.

A highlight of this meeting, at which 58 were present, was the presentation of a Life Membership Certificate to Mr. V. C. Jones, M.E.I.C., F. R. Denham made the presentation.

Ottawa

Arthur G. Sullivan, President, Canadian Construction Association addressed the Branch at the May 18 meeting. Mr. Sullivan outlined the position of construction industry this year. Construction employs more workers off-site than on site he said. This makes the construction industry "a good barometer of our country's wealth". The Canadian Construction Association has undertaken a program to investigate the ways to solve some of the problem of surplus capacity which in turn would increase employment.

The engineer who does make decisions on construction contracts can, of course, help the C.C.A. achieve its goal. What can the engineer do? The speaker listed three main areas in which the engineer could be of assistance. First, he can provide more information and make his drawings and specifications as clear as possible. Second he can cooperate with the tender and contract procedures approved jointly by the engineering profession and the construction industry. Third, he can assume greater responsibility for his work, which may mean that more confidence must be shown the engineer from other sources.. Mr. Sullivan concluded his talk by pointing out the outstanding engineering achievements (outstanding in the eyes of the world) in Canada.

St. Maurice Valley

Jack I. Butcher, JR.E.I.C.

The Annual Meeting of the Branch was held May 25 in Shawinigan. Committee reports were presented by the chairmen. Branch membership now stands at 236; including 83 M.E.I.C., 100 junior members and 53 student members.

Nine general meetings were held during the year and one of these was held jointly with the A.I.E.E. Last October a mixed dinner meeting was held when Pres. and Mrs. Dick visited. And in March E. C. Luke, membership services manager, attended a special meeting devoted to a discussion of Institute affairs which was highly interesting and informative to the members.

The principle members of the executive for the coming year are:

Chairman J. S. Whyte
1st Vice-Chairman T. B. Lounsbury
2nd Vice-Chairman W. W. Ingram

At the conclusion of the business, Paul Cadrin of the Metalite Company Ltd. gave a talk entitled "The Need of

Salesmanship to Engineers". The speaker pointed out the ways salesmanship enters into the daily activities of the engineer, professional as well as private. He emphasized the need of the engineer to sell his ideas and the lamentable lack of training most have for this important task.

Vancouver Island

R. W. Lockie, JR.E.I.C.
Correspondent

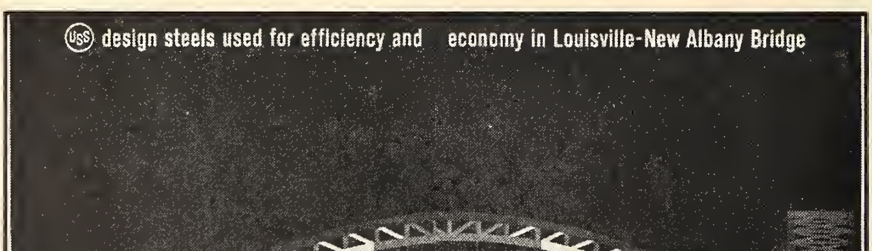
Dr. W. H. Gaddes, Professor of Psychology, Victoria College, spoke on Industrial Psychology at the May 24 meeting. The speaker dealt with the new advances in techniques used. The main part of his talk was concerned with the inability of a psychologist to predict behavior patterns in individuals. Methods used to evaluate jobs and candidates for new positions were explained. This meeting was held jointly with the A.P.E.B.C. President Dick attended the meeting.

On May 25 Pres. and Mrs. Dick were guests of honour at a dinner meeting. Dr. Dick spoke of the challenges presented to Canadian engineers in the complex modern world. He stressed that Canadians must keep informed of scientific and engineering accomplishments if Canada is to keep pace technically. He stressed the need for expanding secondary industry and our domestic markets and pointed out that Canadian engineers have the ability and responsibility to lead in the development of Canada.

Dr. Dick presented a Certificate of Life Membership to Major-General C. R. S. Stein. The Branch Chairman made a surprise presentation to Commander P. F. Fairfull, retiring Councillor of the Institute.

Over 100 members of the **LONDON BRANCH** toured the Northern Electric Company's telephone manufacturing plant May 16. The **NIPISSING AND UPPER OTTAWA BRANCH** held their Annual Meeting May 17. Following the election of the executive for the coming year two films were shown. Forty three members and guests of the **OTTAWA BRANCH** went on the Annual Spring Field Trip to view the new T.C.A. maintenance facilities at Dorval Airport. The May 16 meeting of the **SARNIA BRANCH** was held at the Sarnia Golf Club. Three films, produced by the International Nickel Company of Canada Ltd. entitled "Corrosion in Action" were shown. Charles Ripley, M.E.I.C. was the speaker at the April 28 meeting of the **SASKATOON SECTION.** His topic was some aspects of Civil Engineering in Japan. His talk was illustrated with slides. Dave Sellick, Engineer, Production Research, Iron Ore Co. of Canada, Schefferville, P.Q. gave a talk entitled "Basic Research Applied to Blasting Cherty Iron Metallic Formation" at the March meeting of the **SEVEN ISLANDS BRANCH.** EIC

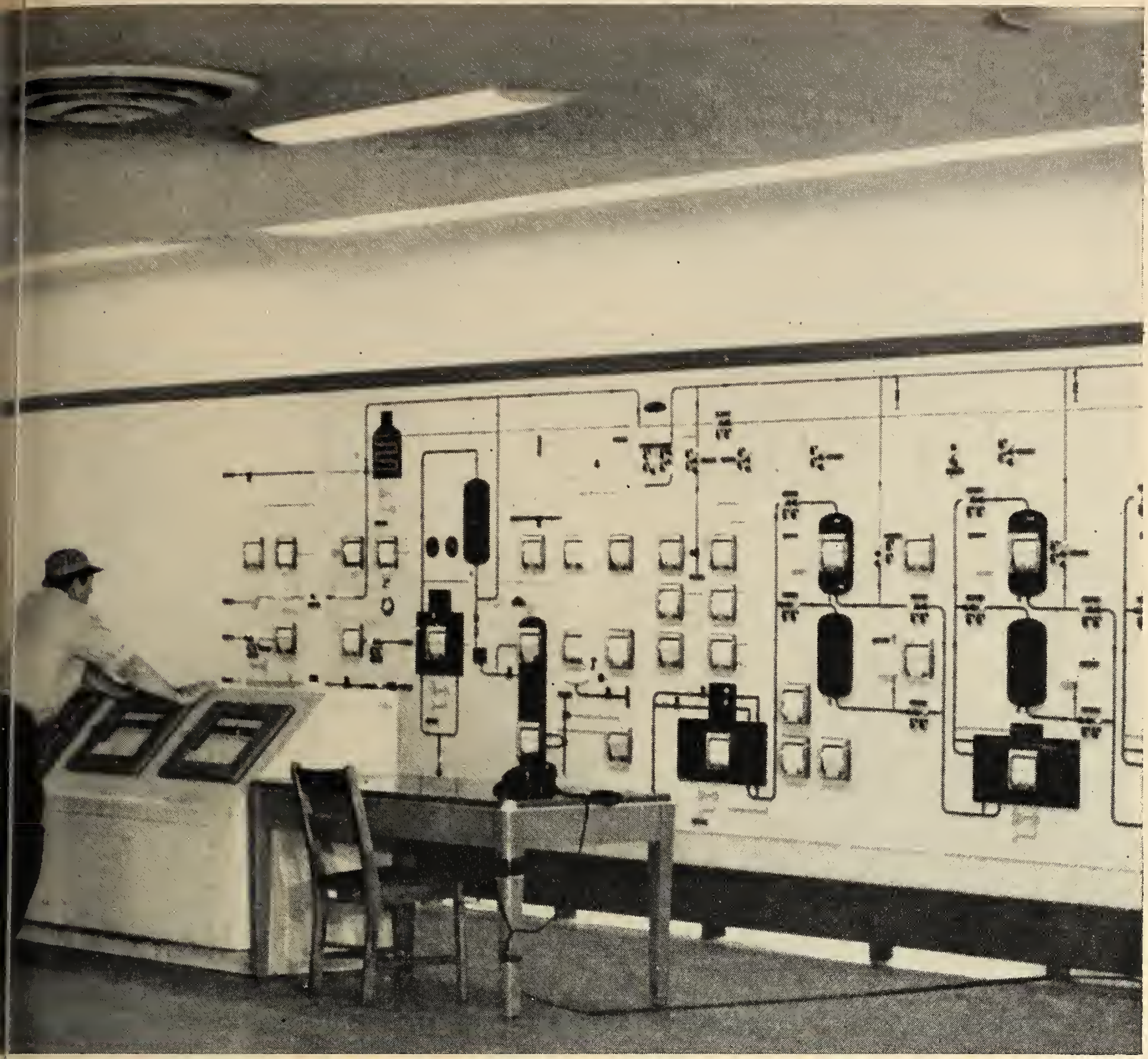
E.I.C. CERTIFICATE OF ADVERTISING MERIT



For the second time (also Aug. '59) United States Steel Export Co. advertising in THE ENGINEERING JOURNAL has won the Monthly Advertising Award of the Institute. The winning advertisement, appearing in April, was a 2-colour, double-page spread headed, "USS design steels used for efficiency and economy in Louisville-New Albany Bridge".

The illustration, occupying over half the spread, is a sketch of one span of the bridge, showing just where, by the use of gray, red and white, the designers used 3 types of steel "to provide the desired strength at the least weight and lowest cost." Copy gives facts and figures regarding qualities of USS steels for bridge design.

As usual, the winner was selected on the basis of accuracy, information and attraction by a 50-reader jury selected from a cross-section of The Journal's mailing list. The advertisement was prepared by Batten, Barton, Durstine & Osborn Inc., Pittsburgh; C. R. Sigelman, Account Executive. EIC



Over 200 Foxboro Consotrol instruments are used to operate the 30,000 bpd Pointe-aux-Trembles Petrofina Refinery. The full graphic panel in the control room is an outstanding example of colour-coding.

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eumatic Consotrol instrumentation

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.

MECHANICS OF SOLIDS AND FLUIDS.

Intended as an undergraduate text, this volume develops the equations of motion of elastic solids and Newtonian fluids. It contains a detailed treatment of vectors and of Cartesian tensors. Also covered are stress and strain in a continuous medium, deformation and flow, the equations of elastic solids and fluid mechanics, and problems in linear elasticity and fluid statics and dynamics. The author has not covered plastic and visco-elastic solids, non-Newtonian fluids and non-linear elasticity. (R. R. Long. Englewood Cliffs, N.J., Prentice-Hall, 1961. 156 p., $9.00.)

GEOLOGICAL NOMENCLATURE.

Compiled under the auspices of the Royal Geological and Mining Society of the Netherlands, this quadrilingual dictionary lists over 5000 English geological terms, and their equivalents in Dutch, French and German. The terms, which are numbered, are arranged in ten broad subject divisions, geomorphology, sedimentology, etc. For each a definition is given in English, and the corresponding terms in the other three languages. (Ed. by A. A. G. Schieferdecker. Holland, Noorduijn, New York, Heinman, 1959. 523p., $18.00.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 1 p.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

THEORY OF MACHINES, 3rd. ed.

This text for undergraduates has been revised to include additional material on gyroscopic motion, velocity and acceleration diagrams, toothed gearing, epicyclic trains, inertia forces in mechanisms and vibrations. The topics covered include mechanisms; valves; friction; belt, rope and chain drives; brakes; cams; governors, etc. The diagrams are all drawn to scale. A bibliography for further reading is included. (Thomas Bevan. Toronto, Longmans, 1956. 621p., $6.00.)

REINFORCED CONCRETE, new ed.

Re-written and enlarged by John Faber and Frank Mead, this new edition is designed for both practising engineers and students, and provides up-to-date information on the theory and practice of reinforced concrete design. The composition and properties of reinforced concrete are discussed, followed by a chapter covering the elements of reinforced concrete design. The design of beams, slabs and columns is treated separately. Other useful topics covered are spread foundations, retaining walls, piling, bunkers and silos, shell-concrete roofs, tanks, water towers, tall industrial chimneys and roads. A final chapter deals with prestressed concrete. Useful bibliographies are included in each chapter. (Oscar Faber. London, Spon, 1961. 532p., 75/-.)

*THE TESTING OF ELECTRICAL MACHINES.

This book covers not only the actual techniques of testing, but also the purposes of the tests, the subsequent treatment of the data obtained, and the principles underlying the actions of the standard classes of machines concerned. Single-phase and three-phase commutator machines are not included. British testing practice and British Standard Specifications are referred to only. (L. H. A. Carr. London, Macdonald, 1960. 299p., 50/-.)

THE THEORY AND DESIGN OF INDUCTANCE COILS, 2nd. ed.

Completely revised, this second edition has been enlarged to include information on the electromagnetic field theory. The rationalized m-k-s system of units has also been used. The book explains the theory on which the design of inductance coils is based, and shows how it can be simplified by the use of approximations. Among the topics covered are: equivalent circuits; air-cored coils; cores with laminated iron cores; coils with dust-cores; self-capacitance; harmonic distortion. A bibliography is included. (V. G. Welsby. London, Macdonald, 1960. 232p., 30/-.)

*TECHNICAL WRITING.

A handbook written by an engineer with a long and varied experience in technical writing, this book sets forth rules, formulas, techniques and ideas in technical writing which will help the engineer select those elements of his material which he wishes to communicate, and to organize and present them in a manner which will reach his readers at the level of their understanding. The author first defines "technical writing", and "writing level", and then gives examples of the five levels he sets up — from the operator's or non-technical level, to the advanced engineering or scientific level of reader understanding. Then the selection of the appropriate words, and letter and mathematical symbols is discussed, followed by descriptions of illustrations and the preparation of manuscripts. The book is completed by five glossaries of terms used in writing about such special topics as computers, automation, electricity, electronics, guided missiles, radio and radar navigation, space technology and transistors. (Joseph Racker. Englewood Cliffs, Prentice-Hall, 1960. 234p., $6.95.)

*INTRODUCTION TO THE STATISTICAL DYNAMICS OF AUTOMATIC CONTROL SYSTEMS.

This version of a translation of the original 1952 Russian work, edited to remove errors of terminology and of style, constitutes a self-contained exposition of the principles of the analysis of linear systems, the statistics of random signals, and the theory of linear prediction and filtering. It does not contain discussion of specialized contributions to the theory of filtering and prediction made since 1952. (V. V. Solodovnikov. New York, Dover, 1960. 307p., $2.25.)

ELEMENTS DE PHYSIQUE NUCLEAIRE.

An introduction to nuclear physics, with the emphasis placed on the results of experiments rather than on theoretical proofs. The topics covered include: the growth of nuclear research; structure of the atom; nucleii; radio-activity; neutrons; nuclear reactions and nuclear fission; and thermonuclear reactions. (Daniel Blanc and Georges Ambrosino. Paris, Masson, 1960. 238p., 30 n. fr.)

PERCAGE ALESAGE POINTAGE TARAUDAGE MECANIQUE.

A study of cutting tools and of tools for drilling, boring, screw cutting and threading. In general, the author has described the most characteristic machine tools, and in each case discusses their use in ordinary production, and in the performance of special work. Many diagrams and photographs are included, as well as a brief bibliography. (Louis Compain. Paris, Eyrolles, 1960. 320p., 41.60 n. fr.)

SOLUTIONS NUMERIQUES DES EQUATIONS ALGEBRIQUES.

Intended particularly for those working with electronic computers, this text is concerned with equations of the type F(x)=0. The author has worked out all the formulae used, and points out the merits and defects of each method used. Numerous exercises are included. The author is the head of the Department of Applied Mathematics at the University of Toulouse, where he and his colleagues have worked out the methods of calculation described on an IBM 650. (Emile Durand. Paris, Masson, 1960. 327p., 65 n. fr.)

TECHNICAL BULLETINS & PAMPHLETS RECEIVED

Space limitations do not enable us to record these in the Library Notes. A mimeographed list of the Bulletins and Pamphlets received during the last month is available free on request to the librarian.

ORGANISATION TECHNIQUE DE L'ENTREPRISE INDUSTRIELLE.

Written by a group of experts, the aim of this volume is to present the basic theories of industrial organization, and of subjects connected with it.

Among the topics covered are decision-making, and the offices responsible, stock control, time study, work simplification, personnel, salaries, quality and cost control, budgets, research, equipment, and accident prevention.

This is a useful and interesting book, giving as it does the French ideas on industrial organization which often differ from the American. (Ed. by Louis Pehuet. Paris, Eyrolles, 1960. 852p., 92.75 n. fr.)

*STRUCTURAL CONCRETE.

This volume surveys the whole field of structural concrete, dealing with materials, design, and construction. Two of the chapters present short summaries on two topics treated at length in the author's previous book, "Prestressed Concrete" (1952), and "Precast Concrete" (1955). The first part of this present work deals with the properties, mix design, quality control, placing, compaction, curing, and other treatments of concrete. Part two deals with design, making frequent references to the Codes of Practice for reinforced concrete of the U.S., Great Britain, France, Germany and other countries. Subjects such as shell construction and factory-made concrete products, not covered extensively in the Codes, are stressed, the author basing his treatment on current accepted practice in Great Britain and abroad and his own experiences. Part three deals with the design and construction of all kinds of concrete structures, from foundations to dams, presenting fundamental analyses of loading and operating conditions, structural analyses, design techniques and illustrative examples. (Kurt Billig. Toronto, Macmillan, 1960. 1020p., $14.25.)

ELIMINATING MAN-MADE INTERFERENCE.

A practical book on noise and interference problems, intended primarily for the technician concerned with radio and t.v. reception. The book covers the various types of noise, noise filter design, the location of interference, and noise problems in automobile radios, two-way mobile radio systems, aircraft and marine radios. Many illustrations of equipment and diagrams of circuits, etc., are included. (Jack Darr, Indianapolis, Sams, 1960. 160p., $2.95.)

*APPLIED RADIATION AND RADIOISOTOPE TEST METHODS.

The eleven papers published in this volume examine the applications of methods involving radioisotopes to established industrial test methods, with the ultimate goal of adoption of these methods as routine test procedures. The test areas involved include diesel locomotive ring wear, grain boundary segregation, soil density and moisture content, hydrocarbon-sulfur analysis, magnesium oxide content in Portland cement, mixing uniformity, metal film thickness, permeability of organic sheet materials, and uniformity of coated fabrics. (Philadelphia, American Society for Testing Materials, 1960. 112p., $3.75 (s.t.p. no. 268)

THE DETERMINATION OF GASES IN METALS.

The report of a symposium organized by the Society for Analytical Chemistry, the Iron and Steel Institute and the Institute of Metals. The papers were concerned primarily with the gases oxygen, hydrogen and nitrogen, and with iron and a very few non-ferrous metals. The methods of determination discussed included vacuum fusion; semi-micro vacuum-fusion; carrier-gas; activation analysis; emission spectrometry and isotope dilution. Discussions of the papers, and bibliographies, are also included. (London, Iron and Steel Institute, 1960. 308p., £3.3.0.)

MINE VENTILATION.

Written by a team at the Post Graduate School of Mining of the University of Sheffield, this is both a text for students and a reference book for mining engineers.

The opening chapters cover the theory of flow of fluids, pressure determination and the determination of air velocity and volume. The nature of mine atmosphere and dust is considered next, and the thermo-dynamics of mine ventilation. Several chapters cover the theory of mine fans, and the various types of fans used. The final chapters discuss the planning and estimation of ventilation networks. Many diagrams and nomograms are included, as well as useful bibliographies. (Ed. by A. Roberts. London, Cleaver-Hume, 1960. 363p., 72/-.)

APPLIED STEEL WELDING METALLURGY.

This volume is an enlargement of the Swedish edition published in 1953, an was based originally on work on ferrou arc welding done by the Welding Sec tion of the Royal Swedish Institute o Technology. Introductory chapters cove the fundamentals of physical metallurg and basic principles of welding. Othe chapters cover the weldability of con structional and tool steels, hardfacing corrosion in welded joints, operating tem peratures for arc-welding and defect in arc-welds, and welding cast iron Numerous illustrations are included. (T M. Noren and C. Pfeiffer. Montreal ESAB Arc Rods. 196p.)

*HEATING, VENTILATING, AIRCONDITIONIN GUIDE, 1960, VOLUME 38.

The Technical Data section of th 1960 "Guide" is the largest yet, due t the inclusion of new material on thermo-dynamics, sound control, restaurant ho water requirements, sizing storage tanks coils and heaters, fundamentals, detec-tion and control of odor, residential ai conditioning, and many other topics, as well as condensed and revised materia from the previous edition. The Catalog Section, as before, contains indexes to manufacturers, and to equipment, as well as manufacturers' catalog data (New York, American Society of Heat-ing, Refrigerating and Air-Conditioning Engineers, 1960. 468p., $12.00.)

:NDUCTION HEATING.

This book describes procedures for the esign of coils, power systems, and enerating equipment for applications in nduction heating. Economy and techni- il conditions are both fully considered. Descriptions of such typical processes as w-frequency through-heating, localized etal joining at higher frequencies, and ccurate surface hardening are given, long with the coil and systems designs or these applications. The methods and ata were collected from work performed y divisions of Westinghouse Electric, nd of General Electric and Redifon td., of England. (P. G. Simpson. oronto, McGraw-Hill, 1960. 295p., 13.25.)

. W. LANCHESTER: A LIFE OF AN NGINEER.

A biography of an outstanding British ngineer of this century, whose working ife spanned the period from the coming f the automobile and the early days of nanned flight to the beginning of the ra of rocket flight. As Sir Harry Ricardo aid of him, he was ". . . the very rare ombination of a great scientist, a great ngineer, a mathematician, an inventor nd a true artist in mechanical de- ign. . ." His many achievements in, and contributions to, aeronautical science and automotive engineering are described, as are the difficulties he encountered. He was awarded both the Ewing Medal of the Institution of Civil Engineers, and the James Watt Medal, and his name will long be remembered for the Lan- chester car, and the many papers he has contributed to engineering literature. (P. W. Kingsford. Toronto, Macmillan, 1960. 246p., $6.25.)

X-RAY MICROSCOPY.

One of the Cambridge Monographs on physics, this volume is the first compre- hensive account of the use of X-rays for microscopical investigation, the authors having been leaders in the development of this field. The technique is used for the examination of plant and animal tissues and living organisms, for non- destructive microanalysis in metallurgy, for detecting segregations and inclusions in metals, and for inspecting welds and castings. The book is divided into three parts, covering the principles of X-ray microscopy, their practical use for quali- tative microradiography and quantitative microanalysis, and their applications in different fields. A very long bibliography is included. (V. E. Cosslett and W. C. Nixon. Toronto, Macmillan, 1960. 406p., $13.50.)

*CONCRETE AND SOIL-CEMENT ROADS.

This is a summary of British advances in the design and construction of con- crete roads, and of concrete, lean con- crete and soil-cement bases for asphalt coverings, together with experience with these forms of construction in other countries. It also includes details of special methods, such as prestressed con- crete, and of roads for special purposes, such as concrete farm roads, and gives information about concrete curbs and the maintenance and repair of concrete roads. (W. P. Andrews. London, Con- tractors Record, 1960. 157p., 30/-.)

*CLASSICAL MECHANICS, 2ND. ED.

This book describes "classical mecha- nics" — the theory of the motion of particles under conditions in which Heisenberg's uncertainty principle has essentially no effect on the motion, and therefore may be neglected. It is the mechanics of Newton, Lagrange, Hamil- ton, and Einstein. The book is intended to show the underlying assumptions and the boundaries beyond which its un- critical extension is dangerous, and to smooth the transition to quantum and relativistic mechanics. This second edi- tion includes new material and revisions, particularly in applications to such prob- lems as the theory of space-charge limited currents, atmospheric drag, rocket motions, transfer functions, the motion of meteoric dust, dissipative sys- tems, spin motion, rotating coordinate systems, noncentral forces, the inverted pendulum, and the motion of particles in high energy accelerators. (H. C. Corben and Philip Stehle. New York, Wiley, 1960. 389p., $12.00.)

*ALTERNATING-CURRENT CIRCUITS, 4TH. ED.

The numerous changes and additions in this edition of a standard college text are designed to make introduction of the subject more understandable to students. An introductory chapter on network concepts has been added, and material on complex frequency and poles and zeros included as preparation for suceed- ing advanced courses. The book adopts the term "phasor" for a time-varying quantity which is handled by vector methods, and the change from vector to phasor diagram is made in chapter 4. Knowledge of differentiation and integra- tion is required. (R. M. Kerchner and G. F. Corcoran. New York, Wiley, 1960. 602p., $8.75.)

*PRESTRESSED CONCRETE, 4TH ED.

A free translation of M. Guyon's "Béton Précontraint" appeared in 1953. This present two volume set, the work of the 1953 editor, translators, and pub- lishers, consists of the 1953 English v. 1 with a 15-page supplement of revisions, and the first English version of v. 2. Worked examples and test results have been recast using British dimensions. Volume one is concerned only with statically determinate straight beams, dealing in part 1 with such general con- siderations as prestressing methods and materials, friction between cable and duct, fire resistance, bond phenomena, and anchorage stresses, and in part 2 with elastic design of simply supported beams. Volume two deals with elastic analysis and testing of statically in- determinate structural systems such as beams and assemblies of beams arches, portal frames and multi-storied framed structures — and certain types of slabs. (Y. Guyon. New York, Wiley, 1960. 2 volumes. $33.00.)

*STEEL CASTINGS HANDBOOK, 3rd. ed.

An extensive revision of a handbook intended for the purchaser of steel castings, and the design and materials engineer and student. Its nineteen chapters discuss steel castings from the standpoints of advantages in mechanical structures and assemblies, industrial applications, purchasing, design, patterns for casting, tolerances, normal variations in properties, physical values, welding, heat treatment, machinability, manufacture, and particular types. In this latter category, carbon steel and low-alloy grades, and cast steels for special applications resistant to wear, low and high temperatures, heat, and corrosion are described. The final chapter surveys the past, present and future of steel castings, and a glossary of foundry terms, and engineering tables complete the volume. (Ed. by C. W. Briggs. Cleveland, Steel Founders Society of America, 1960. 670p., $5.50.)

*ELECTRONICS AND NUCLEONICS DICTIONARY.

An illustrated dictionary giving definitions, abbreviations, and synonyms for over 13,000 terms used in television, radio, medical, industrial, space and military electronics, avionics, radar and nuclear science and engineering. Actually a second edition of "Electronics Dictionary" (1945), it bears little resemblance to its predecessor, showing vast changes in meanings of the old terms, addition of many new terms, and interlocking of the terminologies of nucleonics and electronics. It consistently adheres to common usage and standardization by engineering organizations in controversial cases, so that it becomes, in effect, a style guide also. (N. M. Cooke and John Markus. Toronto, McGraw-Hill, 1960. 543p., $13.75.)

*OIL HYDRAULIC POWER AND ITS INDUSTRIAL APPLICATIONS, 2nd. ed.

The fundamental concepts of fluid mechanics and fluid theory are covered briefly but thoroughly in the opening chapters, followed by application of these concepts to oil under pressure in the generation, utilization, transmission, control and applications of oil hydraulic power. Fully revised and incorporating such recommendations as the Joint Industry Conference Standards, this edition also contains new material, in such fields as synthetic hydraulic fluids, pump control, noise and vibration in pumps, and servomechanisms and valves. (Walter Ernst. Toronto, McGraw-Hill, 1960. 467p., $14.50.)

*ELECTRICAL NOISE.

A series of 5 articles written in 1956 for "Electronics" magazine has been expanded by inclusion of basic facts about the measurement of electrical noise, and the design of circuits in which noise effects are minimized. A development of the theory of noise, based primarily on the response of tuned circuits, and derivation of the properties of the noise sources, is presented without involving complicated mathematics. A succeeding chapter introduces the more advanced mathematical concepts of the theory of noise, and leads into the final chapter, which explores the intricate relationships of signal and noise in various types of communication systems. (W. R. Bennett. Toronto, McGraw-Hill, 1960. 280p., $11.50.)

THE DESIGN OF CYLINDRICAL SHELL ROOFS, 2nd. ed.

The popularity of cylindrical shells has increased greatly in the last few years, and this edition has been revised to include latest knowledge and design techniques.

Four new chapters have been added, the first describing the preparation of programmes for solving shell problems by computer. The second describes the use of models for shell design. The third chapter outlines the use of strain energy methods, and the fourth considers the choice of building materials.

This volume presents the principles of the design of cylindrical shells, and the mathematics involved, and contains worked examples to illustrate the problems encountered in designing. (J. E. Gibson. London, Spon, 1961. 272p., 52/6.)

THE BIOLOGY OF POLLUTED WATERS

With the increased interest being shown in water pollution, it is useful to receive this British book outlining the biological problems connected with polluted rivers and lakes. The book comnences with an outline of the biology of unpolluted inland waters, followed by an account of the different types of pollutants, and their chemical and physical effects. A separate chapter is devoted to the pollution of lakes. A bibliography of almost 300 references is included, and this volume will prove most valuable for all those interested in the study of water pollution. (H. B. N. Hynes. Liverpool, University Press, 1960. 202p., 25/-.)

PULP AND PAPER: CHEMISTRY AND CHEMICAL TECHNOLOGY, 2nd. ed. VOL 1: PULPING AND BLEACHING, VOL. 2: PAPERMAKING.

A thorough revision of the 1952 edition, presenting the technical side of papermaking from a fundamental viewpoint. The revision has been necessitated by the rapid advances in the industry over the last ten years.

The first volume discusses cellulose and hemicellulose; lignin; pulpwood; pulping; and bleaching. The second volume covers fibre preparation; fibre bonding; sheet formation; water usage and disposal in the industry; microbiology; beater and wet-end additives; filling and loading; internal and surface sizing; wet strength; and colouring. Useful bibliographies are included in each chapter.

A third volume will deal with paper testing and converting. (J. P. Casey. New York, Interscience, 1960. vol. 1, 580p., $19.50: vol. 2, 568p., $25.00.)

°PRECISION MEASUREMENT AND GAGING TECHNIQUES.

The primary purpose of this book is to acquaint the technical and engineering student with up-to-date instruments, methods and techniques used in inspection and gaging. The author discusses screw, unified and American National Taper threads from the standpoint of accuracy checks, and describes ramp and fixed gages, precision gage blocks, and pneumatic gaging. Other topics covered include mechanical and electronic comparators, optical measuring instruments, measurements with light waves, evaluation of surface roughness, hardness testing, torque wrenches and the use of the slide rule. (William Grohe. New York, Chemical Publishing Co., 1960. 222p., $7.50.)

°CREATIVE ENGINEERING DESIGN.

This book whimsically draws on an intriguing variety of sources, from "Machine Design" to the "Saturday Evening Post", and "Alice in Wonderland" for quotations and cartoons to support the sound suggestions and techniques presented. The aim of the book is to develop in the reader a capacity to design. The author makes a keen analysis of the particular challenge to imagination and creativity which distinguishes design problems from other engineering problems, and, effectively pointing out why some designs are not creative, he describes the particular traits of the creative design engineer and his techniques. The various steps in the process of creative design are carefully presented, from recognition and definition of the problem to evaluation and presentation of the solution. Somewhat of a "popularization", with an unusual format, this book offers a stimulating and refreshing viewpoint. (H. R. Buhl. Ames, Iowa, Iowa State University Press, 1961. 195p., $4.95.)

STANDARDS RECEIVED.

ASTM standards. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Cement (with related information). 15th ed., 1960. $4.00.

Gypsum products and plaster aggregates, with related standards. 2nd ed., 1960. $2.75.

Soaps and other detergents. 9th ed., 1960.

1960 supplement to book of ASTM standards, including tentatives. 10v.

CSA standards. Canadian Standards Association, 235 Montreal Road, Ottawa 2.

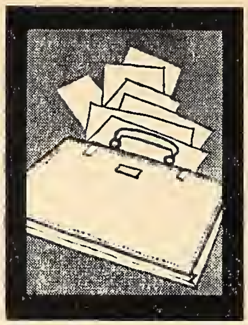
C22.2, no. 114 — 1961 — Construction and test of X-ray equipment. $2.25.

0112.6 — 1961 — Phenol, melamine, and resorcinol base adhesives (high-temperature curing). $1.00.

0121 — 1961 — Douglas fir plywood. 75c.

0151 — 1961 — Western softwood plywood. 75c. EIC

Business and Industrial Briefs



Appointments and Transfers

Five staff changes at the Varennes, Quebec, plant of Canadian Titanium have been announced. **W. R. Phillips,** formerly production superintendent is now plant manager. **R. Seguin,** previously production supervisor is staff assistant to plant manager. **G. T. Smyth** replaces Mr. Phillips as production superintendent. **M. Schuller** who was maintenance and construction supervisor is now plant engineer, and **J. Gibson** is now process superintendent.

James R. Beard will be president of the British Electrical and Allied Industries Research Association for the year 1961-1962, it was announced recently. Mr. Beard has presented many papers on electricity generation, transmission and distribution and is known internationally for his work in the electrical field.

Charles W. Nash of Victoria has been elected president of the B. C. Natural Resources Conference. Mr. Nash is director of Load Development for the B.C. Power Commission.

The appointment of **H. J. Bernat,** P.Eng., as chief engineer has been announced by the Henry J. Kaiser Company (Canada) Ltd.

The Shawinigan Water and Power Company has announced the election of **Senator Paul-Henri Bouffard** to the Board of Directors.

Ernest Wall has been appointed Manager of Planning and Development, Aviation Electric Limited.

At a recent meeting the directors of Canadian Johns-Manville Co. Limited elected **Karl V. Lindell** chairman of the board and **A. G. W. Sinclair** president. Both men will retain their present responsibilities. Mr. Lindell is in charge of the Company's asbestos operations and Mr. Sinclair is general manager of the Canadian Products Division.

Maurice Conklin, P.Eng., has been appointed technical account executive by the public relations firm of Burson-Marsteller Associates (Canada) Ltd.

William Ronald Atkins, a research associate with RCA Victor Company, Ltd., Montreal, has been awarded a $7000. David Sarnoff Fellowship for post-graduate studies leading to a Ph.D. in engineering for the 1961-62 year. He will study at Imperial College, the University of London, England.

Roger Gariépy was recently appointed president of Val Royal Building Materials Ltd.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

MAGNETIC LIQUID LEVEL GAUGES, available from Peacock Brothers Limited, Montreal, are now on the market in four models. These feature a unique safety device which assures protection when dealing with toxic gases, problem liquids or corrosion. The dangers inherent in glass have been eliminated as the measuring device is inside a stainless steel or other non-magnetic chamber. Magnetic gauges will take a wide range of pressures and temperatures and are available with electric alarms.

A FOUR-IN-ONE mig welding torch featuring an in-line design has been announced by the Linde Gases Division of Union Carbide Canada Limited. All service lines enter the torch through the rear of the barrel so they can be supported on the welder's shoulder for balanced torch operation. This 500 amp. ST-5 torch can be used for all four types of mig welding and with all "Sigmatic" mig welding machines.

A SERIES of heavy industrial arc welders for a.c. manual and automatic production welding operations has been placed on the market by Air Reduction Canada Limited. These employ a transformer with a movable coil design and are claimed to be among the simplest, most rugged and least expensive industrial arc welders available. More efficient welding is made possible by eliminating magnetic arc blow and permitting the use of larger electrodes and higher heat values. These arc welders come in 300 and 500 amp. sizes and have a 60% duty cycle rating and are in the MCM-AC Bumblebee "S" Series.

CELL-U-FORM is an insulation material to protect newly poured concrete. Marketed by Webster and Sons Limited, Montreal, Cell-U-Form is claimed to hold the initial heat of the concrete mixture and to control the heat generated during hydration. For slab work and the protection of horizontal plates Cell-U-Mat provides the same protection as Cell-U-Form. Both can be successfully used and re-used under adverse weather conditions.

A FOUR PAGE BULLETIN distributed by Canadian Blower & Forge Company Limited, Kitchener, Ont., facilitates the selection of H Sky-Vent Roof Ventilators. These units, specifically designed for Canadian weather conditions, have been used in many types of installations. The bulletin outlines ratings and dimensions of the ventilators for easy reference.

ALL 318 ELIGIBLE STUDENTS from the winter term of the University of Waterloo's co-operative engineering course have obtained employment with Canadian industry. They will remain at their industrial jobs until the end of June when they will return to the Waterloo campus for another three-month academic term.

A CONTRACT for Ontario Hydro's biggest earth-moving job since the St. Lawrence power project has been awarded to Perini Limited of Toronto. The firm will build a five-mile earth dike at Ontario Hydro's Little Long power development, 42 miles north of Kapuskasing on the Mattagami River. Perini's bid of approximately $4 million was the lowest tender.

AN ALL-ELECTRIC telemetering system of new design offering cycles of two seconds and less has been announced for industrial applications by the Foxboro Company, Foxboro, Mass. The standard two-second cycle provides high scanning speed and more sensitivity to rapidly fluctuating measurements.

(More Briefs on page 110)

tion and maintenance. Married, Canadian Citizen. Seeks responsible position where engineering may be combined with administrative ability. Prefer foreign duty as several years spent on foreign work. File No. 6320-W

PRODUCTION ENGINEER, M.E.I.C., P.-Eng., Full apprenticeship Toolmaking and Design. Work study and value analysis. Experienced and energetic Manager for all phases of small to medium manufacture. Domestic appliances, automotive, telecommunications. Seeks permanent, responsible and challenging position with progressive company. File No. 6321-W.

CIVIL ENGINEER, Jr.E.I.C., P. Eng. Ont. Jr. A.C.I., B.Sc. (Civil) Manitoba, 1954. Age 35. Single. Experience: 2½ years highway construction and design, 1½ years municipal construction supervision and design, 3 years of reinforced concrete and steel design. Seek employment in structural design in Southern Ontario. Located in South Western Ontario. File No. 6324-W.

AIR CONDITIONING DESIGN ENGINEER, M.E.I.C., P. Eng., Toronto 1949, married, age 35. Experienced in design and pricing from simple package systems to large zoned perimeter systems. Practical experience in balancing and trouble-shooting air side, water side and refrigeration cycle. Desire design position in Toronto area. File No. 6325-W.

STUDENT S.E.I.C., with Mechanical Technician diploma and presently completing 2nd year mechanical engineering course at Sir George Williams' University evening classes, experienced in mechanical and sheet metal draughting die design, seeks permanent position as mechanical draughtsman or any other position related to mechanical engineering work. Present location Montreal area. File No. 6326-W.

CIVIL ENGINEER, Jr.E.I.C., P.Eng. (Que.) B.Sc., U.N.B. 1958, M.C.E. (Structures) R.P.I. 1961. Age 25, single, fluently bilingual. Experience includes two years design and construction supervision on highways and railroads. Desires position in Structural Field as Field Engineer or Designer. Located Eastern Canada, but willing to relocate. File No. 6327-W.

ELECTRICAL ENGINEER, P. Eng., M.E.I.C., Married, Age 35 with 14 years' experience in Electrical Utilities in construction, maintenance and operation of Transmission and Distribution facilities. Last 5 years largely administrative. Desire a position. Available for management position with an excellent future. Present location Southern Ontario. File No. 5916-W.

ELECTRICAL-MECHANICAL ENGINEER, P.Eng., M.E.I.C., B.S., London 1952. Age 41 with eight years' experience in the electrical and mechanical aspects of the design, construction, contract administration, operation, and maintenance of large hydro electric stations, seeks responsibility for the contract administration of a hydro project with consulting engineers or utility, at home or abroad. Located Central Canada File No. 6033-W.

PROFESSIONAL ENGINEER, M.E.I.C., P. Eng. (Ontario) B.A.Sc. (Civil) Toronto, 1954. Age 29, married no children. Experience: 2 years' municipal field work and 5 years in pulp & paper industry (plant maintenance, design, layout and construction). Seeks responsible position in industrial field. Location preferred Southern Ontario. Located Central Canada. File No. 6128-W.

CIVIL ENGINEER, TORONTO 1951. Experience since graduation includes work on many heavy construction projects: highway, railway and hydro. Married, young family. Seeks change of employment preferably in Montreal area. File No. 6130-W.

CIVIL ENGINEER, B.Sc., 1947 (London). Civil Engineering Diploma, A.M.I.C.E., P.Eng. Married, 33, Canadian citizen. Have design, materials, construction and administrative experience in highways, airfields and marine fields in Canada (9 years), Europe and Africa. Seeks new opportunities, preferably with consultants or large company. Willing to travel, home or overseas. Present location Central Canada. File No. 6146-W.

GRADUATE MECHANICAL-CIVIL ENGINEER, P.Eng., M.E.I.C., U.N.B., age 36, with six years experience in design, construction and project work for Chemical Plants, Petro-Chemical Plant, Building Products Plants. Presently employed as Assistant Project Manager on $12,000,000.00 Chemical Plant nearing completion in Southern Ontario. Seeks more responsible position to utilize experience, administrative capabilities and training to their fullest. Montreal or Toronto area preferred. File No. 6201-W.

CERAMIC ENGINEER, P.Eng., M.E.I.C., B.E., Sask. 1951. Age 33. Single. Ten years experience in research, development and plant process engineering in the heavy clay products and whiteware electrical porcelain fields. Seeks challenging position with growing firm in Western Provinces. Complete resume on request. Presently located in Prairie Province. 6288-W.

CIVIL ENGINEER: Jr.E.I.C., P.Eng., age 31, married, thoroughly bilingual. Six years' experience in Municipal Engineering. Presently Deputy City Engineer for an Ontario City of 30,000. Desires position in a larger city or with a consulting firm in the same field. Will locate anywhere in Canada or abroad. Full resume on request. Available on two weeks' notice. File No. 6312-W.

ELECTRICAL ENGINEER, B.A.Sc. 1959, Jr.E.I.C., P.Eng., Post-Graduate studies in Automatic Control & Electronic Analog Computation & Simulation: D.I.C.E.E. Imperial College 1960 London, Post-Graduate studies in Business Administration: D.B.A. 1961 London School of Economics, Age 26, Bilingual, Officer R.C.E.M.E., Single, Desires responsible position in Electrical Engineering where opportunities to use his qualifications, exist. Willing to travel, Quebec & Ontario preferred. File No. 6313-W.

CIVIL ENGINEER, M.E.I.C McGill 1950, P. Eng., age 35, married, bilingual. Five years' experience in general construction and consulting work, five years' experience in municipal design, supervision and administration. Desires responsible position with consulting engineering firm or other administrative, technical or municipal concerns. Available upon one month notice to present employer. File No. 6314-W.

MECHANICAL ENGINEER, M.Sc., P. Eng., Jr.E.I.C. 3½ years in industrial engineering which included installing wage incentive systems, plant layout and material handling, 2½ years in machine design and experimental stress analysis. Preferred location: Western Canada. File No. 6315-W.

MECHANICAL ENGINEER, B.Sc. M.E. 51, age 32. Family, 10 years of design experience including truck transportation, mobile equipment hydraulics, steel fabrication, production tooling and pulpwood logging fields. Desires responsible design, development, application or service position where present experience would be applicable. File No. 6319-W.

ELECTRICAL ENGINEER, P. Eng., Jr.-E.I.C. B.Sc., in E.E., age 29, eight years' experience in design of power systems, industrial control, distribution, construcmore challenging and remunerative position in any field (except sales), anywhere in Canada. Presently located in Atlantic Province. File No. 6328-W.

ENERGY - EXPERIENCE - CAPITAL. Professional Engineer M.E.I.C. wishes to invest administrative and technical skills in manufacturing, plant engineering and maintenance, product design and development in small established and growing business, preferably electrical-mechanical or allied lines, where present owners wish to gradually withdraw capital or where additional management and capital required for expansion. Presently located in Maritime Province. File No. 6330-W.

GRADUATE UNIVERSITY OF DELHI (INDIA) 1950, M.E.I.C. Married 2 children. Experience includes 3 years in electrical and mechanical shop in India (centrifugal pumps). Four years oil exploration in Western Canada. Presently engaged with large Oil Company in Production Department. Located Prairie Province. File No. 6331-W.

MECHANICAL ENGINEER, Jr.E.I.C., P.-Eng., B.Sc. in Mechanical with 15 years maintenance and 10 years engineering experience in plant engineering and production supervisory work, including plant layouts, estimating, scheduling, preventive maintenance, budgetory control, construction, etc., in the chemical and food packaging industry. Staff of 250 Professional Engineers technicians and tradesmen. File No. 6332-W.

MECHANICAL ENGINEER, M.E.I.C. P.Eng., B.Eng. 1950. Seven years design, layout and construction experience in plant facilities including steam, water, air, heating and process. Three years consulting office design and layout of air conditioning and slant equipment with one year as resident engineer. Prefer Montreal and vicinity, present location. File No. 6335-W.

MECHANICAL ENGINEER, Jr.E.I.C. B.E., University of Saskatchewan 1960 Single. Age 24. Employed since graduation in Sales Division of an Agricultural Machine Co. Also some experience in construction supervision. Desires responsible position combining technical and administrative duties. Present location Prairie Province. Will relocate. File No. 6336-W.

MORE BRIEFS

INTRODUCTION OF A new portable compressor capable of delivering 1200 cu. ft. of compressed air per minute has been announced by Canadian Ingersoll-Rand. The new compressor, which weighs 1000 lb. less than the company's 900 cu. ft. vane-type models, uses highly efficient rotors for compression. The unit is powered by a new compact GM engine.

CONCRETE made entirely from basic slags from the blast furnace may be a commercial possibility, according to the Ontario Research Foundation. The Foundation says such concrete would use pulverized slag as the cementing material and various sizes of slag as the fine and coarse aggregates. No sand or gravel would be needed.

A 48-PAGE PUBLICATION, MBR-P-3, of the Master Builders Company, Ltd., features 25 reports on major dams built in the United States, Japan, Canada and South America using Pozzolith's role as a concrete improving admixture in proving durability, strength and economy. Pozzolith provided more plastic mixes, greater strengths and complete control of setting time and air content in maintaining the strict low water content specifications for such specialized construction.

COMPLETE DATA on the insulation of piping, fittings and heating equipment for service in temperatures up to 1625° F. is contained in a 24-page catalogue entitled Specifications for Thermal Insulation. The booklet, recently released by Atlas Asbestos Company Limited, is addressed to consulting and plant engineers, specification writers and contractors. It describes and illustrates application methods and finishes, and tables which provide material specifications for varying conditions and recommended thicknesses.

A NEW, high accuracy portable Kelvin bridge is now available in Canada from Canadian Research Institute, Don Mills, Ont. The Model LB-14 is a self-contained bridge for measurement of resistors from one ten millionth of an ohm to 10.1 ohms, with an accuracy from 0.1 to 0.3% for all values above 0.0001 ohms. A built-in battery and high sensitive reggedized galvanometer gives true portability for all but unusual circumstances. Provision for use with external battery and galvanometer has been made.

FLUID-FLO, a new dryer for processing granular solids with a minimum of product loss or degradation, is discussed in a 6-page folder No. 2909, published by Link-Belt Limited, Toronto. The new unit, low in maintenance, can be applied in coal, chemical, rock, sand and many other industries that have granular solids processing needs and can be modified for use in cooling or roasting operations.

THE SEARCH for an improved structural grade steel has resulted in a new specification recently issued by the Struetural Steel Committee of the Canadian Standards Association. This new specification CSA G 40.8 offers structural designers and steel fabricators a group of structural steels with increased resistance to brittle fracture, improved weldability and higher yield strength over CSA 40.4 and G 40.5. Canadian designers now have a series of steels having graded steps of notch toughness, allowing them to use the most economical steel for a particular application.

(More Briefs on page 115)

Consulting Services

• MORE BRIEFS

THE DAVIS GASTESTER, a new instrument for measuring true gases zero to 100%, is a portable, battery-operated instrument developed to provide fast simplified detection and measurement of true gases, such as manufactured or natural gas. The Gastester is useful in pinpointing gas leaks in underground mains and services, as well as for checking the progress of intensity of a known gas leak and for measuring the explosibility of confined gas-air mixtures.

REGULAR MEETINGS of both the Society of Plastics Engineers and the Society of the Plastics Industry will be held during The Plastic Show of Canada, scheduled for Oct. 17-19 in the Canadian National Exhibition's Automotive Building. This will be the first exhibit for Canada's $300 million plastics industry and a four-hour evening showing is planned to enable the public to learn what developments in the use of plastics by the consumer lie in the future.

THE MODEL 550 Power Crane and Shovel built by Dominion Engineering Works Limited is described in a bulletin issued recently by the company. The Dominion 550 is a 2½ cu. yd. machine built for heavy duty service as a shovel, dragline, crane, clamshell or pullshovel. It features a balanced design with the accent on precision reliability and simple machinery layout.

THE ANNUAL REPORT of Canadian Industries Limited, issued recently, shows a net income in 1960 of $6,575,000 compared with $6,246,000 the previous year. Consolidated financial highlights show earnings a common share of 74 cents last year compared with 70 cents in 1959. Dividends remained at 50 cents a common share.

A NEW EDITION of the National Building Code has been published by the National Research Council through its Associate Committee on the National Building Code. Copies are available at the $4 cost price in either bound or loose-leaf form through the Secretary, Assoeiate Committee on the National Building Code, c/o National Research Council, Ottawa. A French edition of this publication is being prepared.

EXTENSION OF ITS product line to include a broad range of iron vane AC volt meters, ammeters and mill-ammeters has been announced by the Precision Components Division of Honeywell Controls. The AC meters are available in the following ranges: volt meters, one to 800 volts; ammeters, one to 800 amperes; milli-ammeters, 10 to 800 milliamperes.

A BOUND VOLUME containing the collected issues of the Creosote Information Bulletin for 1958-60, has been issued by the Dominion Tar & Chemical Company, Limited. The volume deals with a wide range of topics including the development and related technology of wood preservation through creosoting.

Journal Readers

Have you changed your address recently? If so, please notify the Circulation Department at EIC Headquarters

INDEX TO ADVERTISERS

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The Engineering Index
The Applied Science and Technology Index

CONTENTS

IN THIS ISSUE

The three authors of *The NAE Five-Foot Supersonic Wind Tunnel* bring a wealth of experience to bear on their subject. **K. F. Tupper**, M.E.I.C., worked from 1929 to 1944 at the National Research Council, where, among other activities, he was engaged in the design and operation of research facilities and the supervision of aircraft structural research. **P. B. Dilworth**, M.E.I.C., spent four years (1939-43) at the National Research Council where he too worked on the design of research facilities as well as equipment for testing and further research on aircraft power plants and later on experimental programs. In his present capacity as president, Dilworth, Secord, Meagher and Associates, Limited, which he founded, he directed technical work on the NAE high speed wind tunnel project. **L. A. Jenkins**, M.E.I.C., as a project engineer was engaged in the design of control systems and the electrical aspects of the wind tunnel project. As resident project engineer at the site his responsibilities have included the co-ordination and supervision of construction and the actual erection of this project. Now in the final stages of construction at Uplands, Ottawa, the new tunnel is considered the latest and "probably the most versatile" large wind tunnel of this type in North America. Its operating speed range is from Mach 0.2 to 4.5 at stagnation pressures from 1.8 to 13.7 atmospheres. Because of the amount of heat generated, and the wide range of operating speeds and air densities the new high speed wind tunnels are based on the principles of intermittent operation and are "driven by high pressure compressed air". In this paper the authors have described the new wind tunnel facility and technical problems resulting from its design are discussed.

J. C. Clapham, author of *The Need for Research in Planning Mechanization*, received a Bachelor's degree from Cambridge, and a Master's degree from London, England. From 1947 until 1951 he was a statistician at the Shoe Research Association, Kettering, England. There he worked on foot measurement surveys and shoe fitting trials; the object was to determine the best shoe size intervals. Then he became a Section Leader in the Operating Research Group of the National Coal Board. He made studies of underground hauling costs and assessed the adequacy of underground communications systems in use. From 1957-58 he was a Senior Research Associate at Dunlap and Associates, Stamford, Conn. His projects included; the optimum distribution of a mass-circulation periodical amongst wholesalers and retailers; studies of automobile accidents in the armed forces and the development of a mining plan for phosphate strip mining. At present he is head of the Operating Research Section, B.C. Research Council, where his activities have included the location of a milk distribution plant, manpower requirements of a lumber-sorting chain and the use of manpower manufacturing facilities. In his paper, the author explains how operating research can be used to overcome the mechanization problems faced by industry today. The author discusses methods of selecting mechanization projects, the limitations of these methods and how operating research can effectively explore, evaluate and guide industry. The author concludes that since so many mechanization problems are fundamental, research in this complex field could well be supported by industry.

The Hydraulics of the Pipeline Flow of Solid-Liquid Mixtures covers the complete field of transporting solids with liquids in pipelines. They may be carried in this manner either as settling or non-settling mixtures. Conditions which determine the behaviour of a given mixture are discussed. The behaviour of non-settling mixtures at high concentration can be similar to that of a Bingham plastic. The flow rate for the Bingham plastics as well as pseudo plastics are reviewed in relation to pressure drop. Settling mixtures are quite different. Only under conditions of great turbulence can they be treated in a single phase operation. Pressure drop and flow rate data are discussed and the durand empirical correlation reviewed. Semi theoretical equations are compared with actual data. **Dr. G. W. Govier**, M.E.I.C., is Dean of the Faculty of Engineering of the University of Alberta and Professor of Chemical Engineering there. Born in Alberta, Dr. Govier received his secondary education in Vancouver and attended the University of British Columbia where he received a B.A. Sc. in Chemical Engineering in 1939, the University of Alberta where he obtained an M.Sc. degree in Physical Chemistry in 1945 and the University of Michigan where he was awarded an Sc.D in Chemical Engineering in 1949. **M. E. Charles**, co-author of this paper is a Research Engineer with the Research Council of Alberta. His B.Sc. degree in Chemical Engineering was obtained at the University of London in 1957 and he received his M.Sc. degree in Chemical Engineering at the University of Alberta in 1959. His research experience is in single and multi-phase fluid flow.

The advances in map making in Canada can be ascribed in part to the electronic systems now in use. In a paper entitled *Electronic Aids in Canadian Mapping*, the author, **J. T. Henderson**, M.E.I.C., describes and evaluates them. "Conspicuous successes have been achieved in the case of distance measurements, as illustrated by the use made of Shoran, tellurometer and geodimeter". Other specialized equipment used by the hydrographer and the photogrammetrist is mentioned by the author so that a complete picture of these aids is presented to the reader. Dr. Henderson obtained his B.Sc. degree from McGill in 1927, his M.Sc. degree from that university in the following year and his Ph.D. from London in 1932. He has been a member of the N.R.C. staff since 1933 where he has worked in a variety of capacites. He joined as head of the Radio Section in the Division of Physics and, prior to World War II, worked on cathode ray direction finders. Following introductory visits to radar establishments in Great Britain he started the research and development of radar at N.R.C. in 1939. He was associated with the establishment of Research Enterprises, Toronto. From 1947-49 the author was connected with the N.R.C. group which worked on Shoran. Since 1949 Dr. Henderson has been head of the Electricity and Mechanics Section, Division of Applied Physics at the National Research Council.

COVER ILLUSTRATION

A view of the upper and lower attachments before the installation of flexible plates in the supersonic nozzle of the N.A.E. five-foot supersonic wind tunnel. (Photo by Malak)


when service ends
with the sale... you're on your own!

pressure unit. The high pressure unit consists of three uncooled centrifugal stages followed by an aftercooler.

The compressor is intended to run continuously during periods of tunnel operation. Furthermore, to achieve maximum moisture separation from the compression cycle the discharge pressure is maintained constant at full storage pressure (300 p.s.i.g.) during the pump-up period. This is achieved by provision of a back pressure valve in the discharge line to the storage vessels. The compressor is provided with intake throttling and by-pass to atmosphere so that power consumption under idling conditions may be minimized.

While the peak power requirements for a blowdown tunnel are relatively small, the energy consumption entailed in pumping is large and constitutes a major item of operating expense. High operating efficiency is therefore an important consideration and was stressed in the compressor plant specification and tender evaluation.

Because of the very low static temperatures which exist in the working section under high speed conditions, it is necessary to remove moisture which would otherwise form small ice crystals and disturb the flow pattern. A limit of 0.0002 lb. of water per pound of air is therefore specified. The residue of moisture in the air following compression and aftercooling is removed in a silica gel drier, consisting of two units one of which is regenerated while the other is operating. Following the drier is a filter to remove particles down to five microns in size.

Air is stored at 300 p.s.i.g. in three series-connected cylinders each 11.5 ft. diam. and 157 ft. long, providing a total volume of 50,000 cu. ft. These cylinders are housed in a heated building because if the stored air were to fall to a temperature corresponding to Ottawa winter weather, then the static temperature in the high speed flow would be so low that liquifaction of the air would occur. The discharge end of the air storage vessels is closed with a butterfly type valve operated by an electric actuator mechanism.

As air is discharged from storage to the tunnel during a run, the remaining air drops in temperature because of its nearly isentropic expansion. In the absence of means for controlling this factor, the temperature of the air supplied to the tunnel would fall nearly 200°F between the start and end of a tunnel run, thereby greatly complicating the problem of obtaining satisfactory aerodynamic test data. To minimize this effect a thermal matrix consisting of a 90 ft. long assembly of steel tubes occupies the end of the storage vessel next to the discharge. The metal in the matrix weighs some 210 tons and its heat capacity is sufficient to reduce to about 12°F the temperature drop during blowdown. The thermodynamic design study for this matrix is described in a paper by Billington.[4]

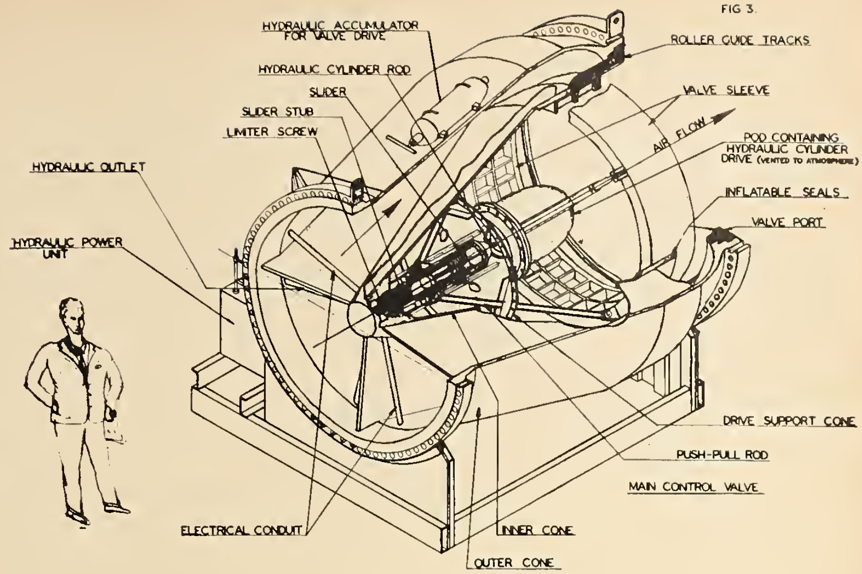


FIG 3.

Control Valve

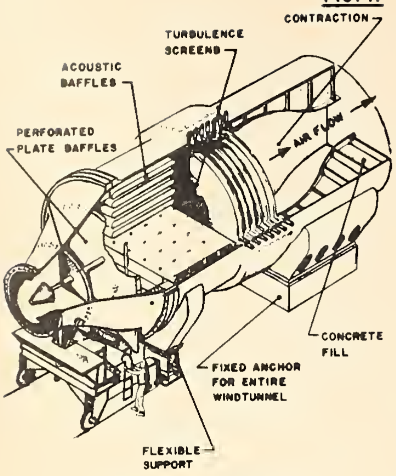
The function of the control valve is to maintain a constant rate of airflow during a tunnel run in face of a steadily falling upstream pressure as the storage vessels are exhausted. To satisfy the specification requirement it must maintain stagnation pressure in the settling chamber constant within ±½%. In addition this valve must provide very rapid opening and closure characteristics with a safeguard against inadvertent over-pressuring of the tunnel. Rapid opening is essential to the successful and economic starting of the tunnel, i.e. to ensure the development of full supersonic flow and to minimize loss of stored air during starts. Rapid closure is necesary to reduce buffeting of the model during the period of flow instability which occurs during shutdown. Tunnel overpressuring could result under certain circumstances if the valve port should open too wide and too long during the initial period of blowdown when the storage pressure is high. Such a situation conceivably could arise from a valve control system failure.

Consideration was first given to scaling up the model control valve used in the initial phase of operation of the 1/12 scale pilot model tunnel. It soon became evident however that this course of action was impractical in that the mass of the moving parts and pressure balance characteristics of the resultant full-scale valve would fail to achieve the required degree of sensitivity and response. It was also recognized that the design of the valve and the related servo control system would have to be closely integrated if the exacting specification requirements were to be met.

Accordingly, the design of a full-scale valve was evolved with what were considered to be satisfactory aerodynamic characteristics over the full range of port openings and having minimum mass of moving parts. A 1/12 scale model of this valve was designed and built for testing in the pilot tunnel. Concurrently, work was initiated by the N.A.E. on the design and development of the servo control system — employing the pilot tunnel with the new model valve for experimental verification and refinement.

The valve design which resulted from this program is illustrated in Fig. 3. It is of the cylindrical sleeve type. The sleeve is a 72 in. diam. light alloy ring driven by an hydraulic actuator and has a 14.6 in. stroke. Velocity and position transducers connected to the sleeve mechanism provide feedback signals to the valve servo control system. The valve is capable of opening or closing in 0.25 sec. A screw driven safety stop is provided which limits valve opening in relation to storage pressure and Mach number setting. This safety stop gradually recedes as the storage pressure falls, thereby permitting progressively increased port opening with falling storage pressure but preventing overpressurization in the event of any system failure tending to drive the valve open.

FIG. 4.



SETTLING CHAMBER

Settling Chamber with Fixed Contraction

Initially the settling chamber was intended to serve two purposes only —viz. to reduce to an acceptable minimum aerodynamic turbulence generated by the control valve and to house the initial fixed geometry portion of the contraction fairing. Subsequently, however, the question of aerodynamic noise became a matter of concern from the standpoint of possible adverse effects on the flow properties in the tunnel. Acoustic measurements conducted in the pilot tunnel confirmed that noise pressure levels were indeed high, i.e. peak levels of about 160 db in the 5000-6000 c.p.s. frequency range.[3] This indicated that in the full scale tunnel equally high noise levels could be anticipated at frequencies approximately 1/12 those in the pilot tunnel.

In consequence, the settling chamber design was modified by an increase in length and the addition of acoustic absorption baffles designed to provide peak noise attenuation of about 50 db. at frequencies in the 300/600 c.p.s. octave band.

The final configuration evolved is shown in Fig. 4. It will be seen that the settling chamber is structurally a cylindrical pressure vessel with a conical inlet section and a flat plate downstream bulkhead upon which is supported the upstream end of the supersonic nozzle.

At inlet to the cone is a cruciform plate structure whose function is to stop rotation of flow generated by the control valve. A conical centre body and coarse plate baffles serve to effect a measure of flow uniformity at entry to the acoustic baffle grid. The 8 in. thick panels which comprise this grid consist essentially of parallel perforated steel sheet plate boxes filled with fibreglass wool to a density of 6 lb./ft.^{3} They are supported along their edges in channel shaped slots. Since these baffles are not expected to last indefinitely, provision has been made for their removal and replacement by detaching the settling chamber inlet cone at the large diameter flanged joint to the main chamber. The cone can thereupon be retracted upstream while resting upon a wheeled truck mounted on rails.

Following the acoustic baffle section is a series of seven wire mesh screens for turbulence control. These screens (0.032 in. wire diameter, 11 mesh and spaced 15 in. apart) are supported on spring mounts which keep the screens taut and equally spaced yet permit them to bulge with increasing airflow thereby limiting the peak level of tensile stress in the screen wire.

The fixed geometry contraction fairing at the downstream end of the settling chamber serves to initiate acceleration of the flow and to transform the channel from circular to rectangular. Since the shape of the contraction fairing does not lend itself to support of the pressure loads and gradient to which it is subjected, the space between the fairing plates and the settling chamber outer shell is filled with a low shrink concrete grout which transmits the pressure forces on the fairing to the outer shell of the settling chamber.

The settling chamber is supported from the main concrete substructure through a reinforced concrete plinth and an upstream flexure plate column. In addition to supporting the settling chamber and a significant share of the weight of the control valve and

SUPERSONIC NOZZLE
LONGITUDINAL SECTION

FIG. 5A.

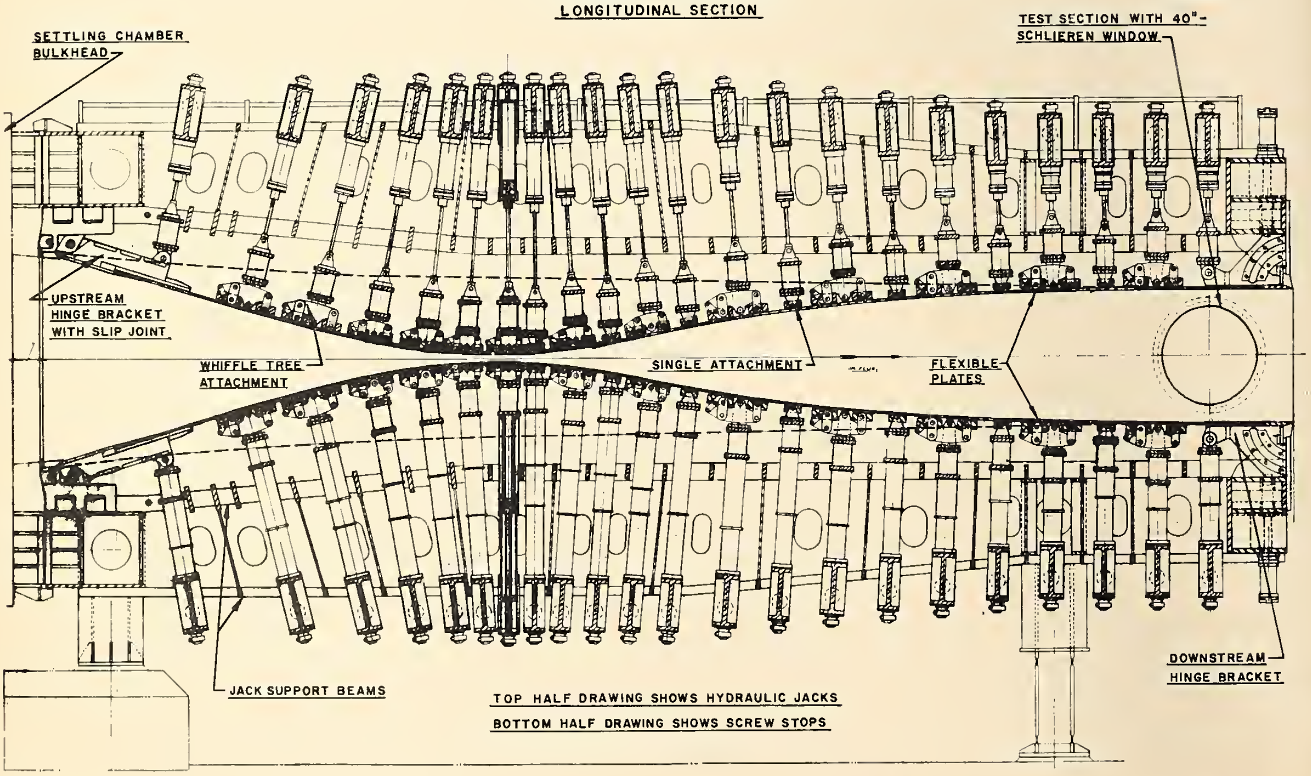
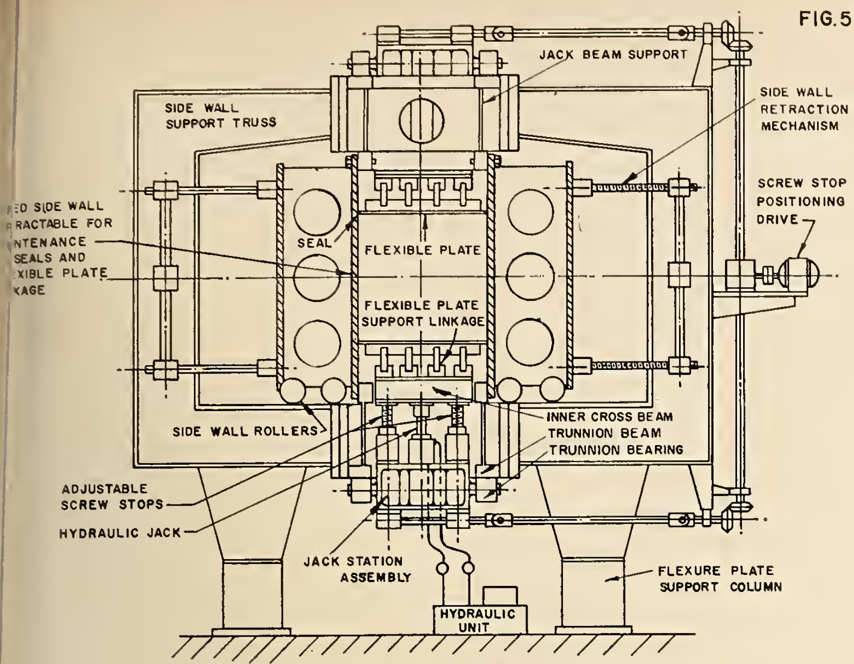


FIG. 5B.



SECTION THROUGH SUPERSONIC NOZZLE

supersonic nozzle, the settling chamber plinth constitutes the main anchorage point for the tunnel proper. As such it must transmit to the main substructure all net axial forces generated during tunnel runs.

Supersonic Nozzle

The function of the supersonic nozzle is to accelerate the airflow from subsonie speed to any desired testing speed within the operating range of the tunnel, i.e. from Mach 0.2 to 4.5. To accomplish this it is necessary to provide a wide range of varying geometric nozzle shapes. For the supersonic speed range in particular, a family of shapes or contours, is required, each member of which corresponds to a specific Mach number setting.

This variable geometry requirement is accomplished by means of a rectangular cross section flow channel bounded by two fixed parallel side walls and a pair of flexible plates forming the top and bottom walls. By flexing these plates and locking them into various positions a range of nozzle shapes can be achieved, which covers the desired range of Mach numbers. The flexible plates for the N.A.E. tunnel are machined from high tensile structural steel. They are 5 ft. wide, 45 ft. long and 0.864 in. thick.

The general arrangement of nozzle structure and plate support mechanism is illustrated in Figs. 5a and 5b. It will be seen from these illustrations that the plates are supported throughout their length by a series of 22 separate jack stations. The downstream end of each plate is bolted to a hinge bracket whose virtual centre of rotation coincides with the downstream transverse edge of the plate, thereby eliminating any discontinuity in the channel surface with changes in plate angle. The upstream end of each plate terminates with a sliding joint in a second hinge bracket which accommodates changes both in angle and in length associated with different contour settings.

Each jack station comprises an upper and lower assembly having a central hydraulic jack between a pair of mechanical screw jacks — the latter serving as adjustable stops. The various Mach number settings are achieved by positioning of the screw stops at each jack station through an electric motor driven mechanical gear train programmed and automatically controlled by an analogue control system. The plates are "locked" against these screw stops by application of force through the hydraulic jacks. The control system provides for selection of any one of 17 distinct nozzle shapes. One of these is employed for testing in the subsonic and transonic speed ranges. The other 16, each corresponding to a specifie Mach number, cover the supersonie speed range.

At the downstream end of the supersonic nozzle is a nearly parallel length of channel which serves as the test section. Provision is made in this section for installation of a pair of 40 in. diam. windows in the sidewalls for a schlieren system.

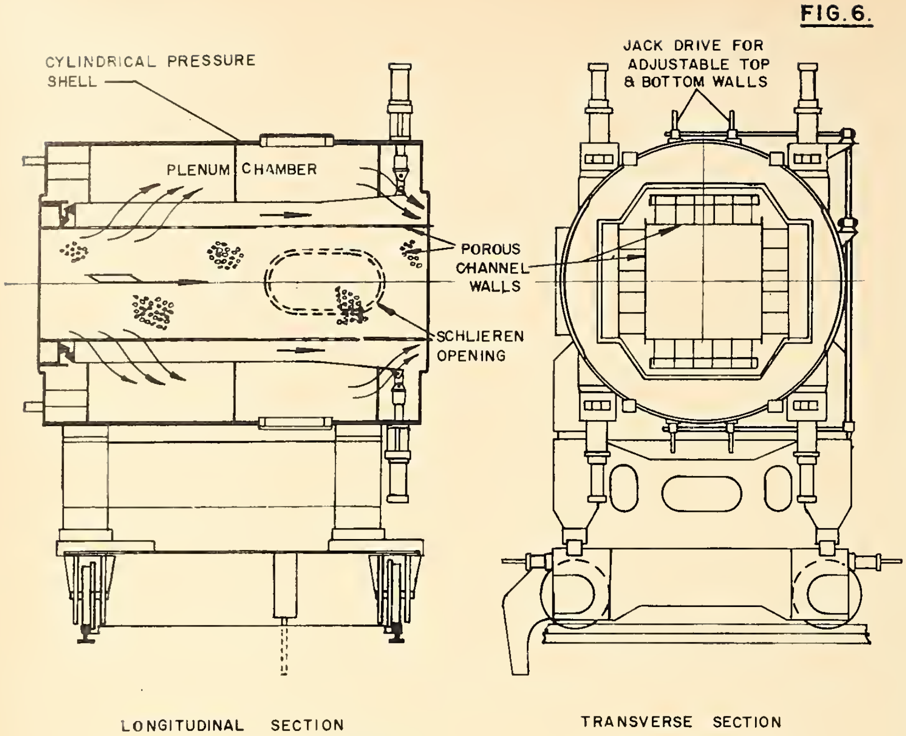
The flexible plate contours were calculated for the N.A.E. tunnel by a method developed by Kenney and Webb.[5] Computations were made by means of an electronic digital computer, the program yielding:—theoretical aerodynamic nozzle contour co-ordinates corrected for boundary layer growth; matching of the theoretical nozzle contours by the flexible plates (within the limitations imposed by the elastic properties of the plates with their finite number of supports); dimensional settings of jack stations required to reproduce the matched contour co-ordinates; and influence coefficients for various jack stations—to guide the N.A.E. in effecting final operating calibration settings for the tunnel.

To achieve a uniform velocity profile across the tunnel working section the contour of the inner surface of each of the flexible plates must match the theoretical aerodynamic contour with a high degree of precision. More specifically, this requires that deviations in surface slope be held within $\pm 0.05°$ of the theoretical at any point downstream of the nozzle throat.

To achieve this standard of precision over the full range of tunnel and pressure gradients gives rise to very stringent requirements of rigidity in the basic structure, uniformity in thickness of the flexible plates, freedom from waviness in the plate surfaces and, of course, a high degree of precision in the position settings of the flexible plate support mechanism.

To satisfy the tolerance requirements in the matching of the plate surface contours to the theoretical nozzle shapes the plates must be machined to a thickness tolerance of ± 0.005 in., surface waviness must be held within about 0.002 in. per ft. and positioning of the jacks must be within ± 0.001 in. of prescribed vertical co-ordinates. To provide the necessary structural support for the plates along their length, to keep bending due to pressure loads within acceptable limits, the plates require support at 34 points in addition to the upstream and downstream hinge points. Space limitations in the region of the nozzle throat and further downstream precluded provision of an adequate number of separate jack stations. It was, therefore, necessary to provide "whiffle-tree" support linkages of a type developed for another similar "blowdown" tunnel[6] at alternate stations to achieve the necessary number of support points.

The primary factor in the design of the basic supersonic nozzle structure is rigidity rather than stress — hence its rather massive physical



TRANSONIC TEST SECTION

characteristics. In the case of the flexible plates and their attachment linkage careful consideration has also to be given to both stress and fatigue since basic stress levels due to plate curvature are high (upwards of 60,-000 p.s.i.) and the plates are subject to a considerable number of flexure cycles during the life of the tunnel (about 100,000).

To ensure that the design would be adequate to meet operating requirements a special machine was designed and built for testing segments of flexible plate with typical stud attachments. A series of such samples was subjected to cyclical endurance tests on this machine by the Structures Laboratory of the National Research Council.

To ensure that the plates are not overstressed by bending during manipulation, a series of overcurvature gauges are provided along the length of the plates. These are connected through a control system designed to halt the operation of the hydraulic jacks in the event of plate curvature reaching dangerous levels during setting operations. These gauges require a high degree of sensitivity since in the region of maximum curvature (near the throat of the Mach 4.5 contour) a co-ordinate error of only about 0.05 in. in a single station setting would overstress the plates.

In laying down the basic design of this component and its jack position control system advantage was taken of prior successful experience by others. While the basic design concept of the supersonic nozzle for the N.A.E. tunnel is not therefore original, it is believed to represent an advance in the art in terms of precision for components of comparable size.

Transonic Section

The transonic section is employed during tests in the transonic flow regime only —i.e. from about Mach 0.7 to 1.4. It is therefore designed to permit its removal from the tunnel circuit during all other test conditions. For transonic tests the unit is coupled to the downstream flange of the supersonic nozzle — the latter being set into one of several Mach number configurations available for such tests ranging from Mach 1.1 to 1.8.

This unit which is illustrated in Fig. 6 consists basically of a 5 ft. x 5 ft. rectangular flow channel some 16 ft. long, bounded by four perforated steel plate walls and enclosed in a cylindrical pressure vessel. The entire unit is wheel mounted on rails running transverse to the tunnel centreline, thereby permitting it to be inserted in or removed from the tunnel circuit.

The purpose of the wall perforations is to permit bleed off of a small fraction of the total tunnel flow. This bleed is necessary to control interference effects between the model and tunnel walls and to compensate for changes in tunnel blockage arising from variations in model configuration and incidence.

An additional feature in the design of the transonic section is provision for angular adjustment to the top and bottom perforated walls between 1° divergent and 2° convergent. This adjustment provides a measure of compensation for variations in boundary layer growth. Actuation is effected through two pairs of power driven screw actuators.

As in the case of the supersonic nozzle provision is made for installations of schlieren windows in the pressure shell of the transonic test section. The problem of the perforated walls in the schlieren light path has been overcome in similar transonic test sections by the use of a special type of schlieren with multiple light sources, which is also planned for this tunnel.

The air by-passed through the perforated wall panels flows to the downstream end of the transonic section through a plenum chamber formed by the space between the back of these panels and the structural shell. At this point, the by-pass air is re-introduced into the main tunnel airflow by the ejector action of two pairs of adjustable angle wall flaps. These flaps form an integral part of the model support and variable diffuser structure, though their aerodynamic function relates solely to that of the Transonic Test Section.

For purposes of control, the two pairs of flaps are independently variable in angular position. The side pair are capable of preselected position adjustment by means of Acme screw jack drives. The top and bottom pair are driven by an hydraulic motor through ball-nut screws and controlled by a feedback servo control system which is monitored by a transducer sensing the differential between pressures in the plenum chamber and the desired test section pressure.

The aerodynamic configuration and control characteristics of this flap system were developed by the N.A.E. on the 1/12 scale pilot tunnel.[3]

Model Support

The model support system, illustrated by a simplified drawing in Fig. 7, serves to hold the test model and to impose upon it precisely controlled variations in both roll and pitch motions during the tunnel run. The design of this system of components posed one of the most exacting combinations of mechanical, structural and control problems in the entire tunnel.

To minimize aerodynamic interference effects at the test section, strinent limitations are imposed on the eometry and size of the model support structure yet it must provide dequate strength and rigidity to withstand the very large forces which esult from aerodynamic lift and drag f a wide variety of model sizes, configurations, attitudes and air speed onditions.

To satisfy the specified range of est conditions, the model support ystem must be capable of traversing he full range of roll (90°) and pitch (—15° to +30°) during the tunnel un. In addition, it must permit the mposition of a range of roll and pitch rates in conjunction with stops at precisely prescribed angles — all under fully automatic control. Finally, it must return the model to the zero roll and pitch position prior to the end of the tunnel run in order to minimize buffeting forces during tunnel stopping.

The test model, with integral strain gauge balance and other desired aerodynamic instrumentation, is mounted on the upstream end of a long tubular "sting" whose axis is normally colinear with that of the tunnel. Instrumentation leads pass through the hollow sting, roll and pitch mechanisms to the outside of the tunnel and thence to the main control room.

The butt of the sting is fastened by means of a detachable socket to the nose of the roll mechanism. The roll mechanism nose piece is mounted on needle bearings and is driven in rotation by an hydraulic motor through a 707:1 ratio planetary gear train. This mechanism is equipped with position and velocity transducers which supply feedback signals of roll rate and angular position to the roll control system.

The body of the model roll mechanism is mounted through an elbow joint to the model support strut. The strut, located on the tunnel centreline, has a sharp double wedge shaped cross section to minimize aerodynamic drag and interference effects under supersonic flow conditions. Pitch motion is effected by vertical movement of the support strut (mounted on roller guides) and a rod and crank linkage connecting through the support strut to a fixed pin joint mounted on the main structure. The geometry of the linkage and the length of the sting is arranged to provide pitch motion of the model about a predetermined point in the model. The entire moving assembly is pneumatically counter-balanced and vertical motion of the strut is provided by an hydraulic motor driven ball-nut screw. Transducers connected to the strut drive provide feedback signals of pitch angle and velocity for the pitch control system.

Variable Diffuser

The variable throat diffuser performs various basic aerodynamic functions.

For supersonic operation the throat is first opened to permit the starting shock wave system to move downstream as the tunnel flow is established. The throat is then closed to a narrower setting which allows reduction of the tunnel running pressure, if desired, to values less than the minimum starting pressure, thereby effecting independent variation of Reynolds number at each Mach number. At these lower pressures longer running times are also thereby obtained.

For subsonic testing, variation of the diffuser throat setting affords a means of varying Mach number. This permits the main valve to be used to control test section pressure and thereby again provides a means of independent variation of Reynolds and Mach numbers.

In both supersonic and subsonic operation at low pressures this component acts as a diffuser to effect a portion of the overall recovery of dynamic pressure in the high velocity airstream emanating from the supersonic or transonic test sections.

The model support system, the variable throat diffuser and the variable geometry flap system described in the foregoing are integrated into a single structural unit mounted on wheels and rails running in the direction of the tunnel axis. This unit is called the Variable Diffuser and Model Support (VDMS) and its principal features are illustrated in Fig. 7.

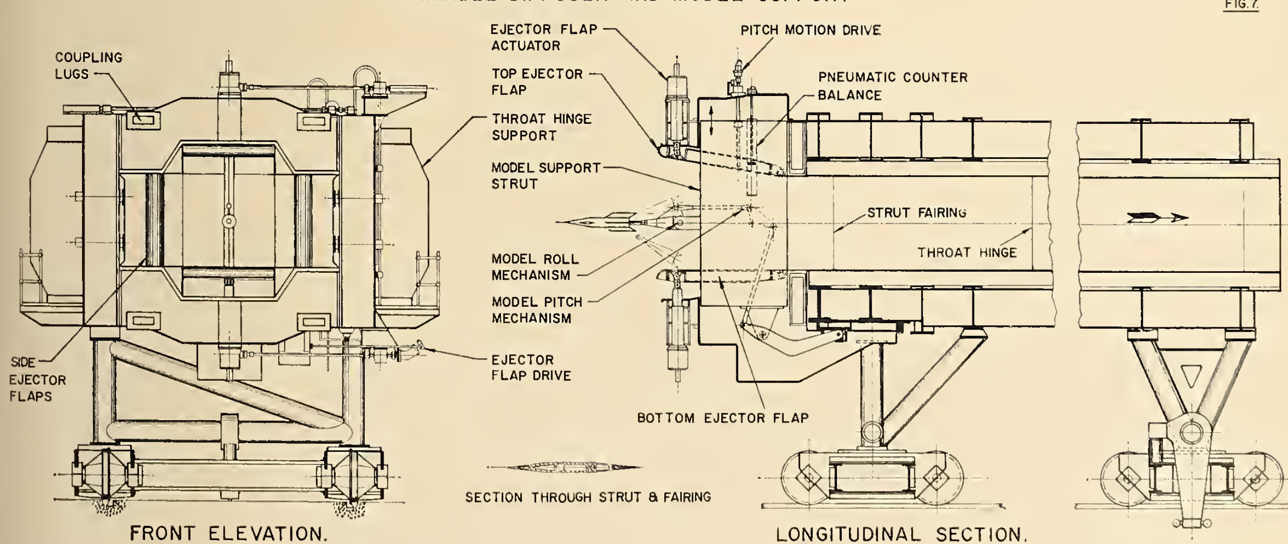
For supersonic testing, the VDMS unit is moved upstream by an hydraulic drive and connected to the downstream flange of the supersonic nozzle by a set of power operated couplings. In this configuration the test model is located on the tunnel axis at the centre of the supersonic test section, opposite the schlicren windows.

For access to the model, the VDMS unit is uncoupled from the supersonic nozzle and moved downstream. A moveable platform, wheel mounted on rails running transverse to the tunnel axis, provides ready access to the model and sting support to permit mounting, detachment and servicing of models and model instrumentation.

For transonic tests, after the transonic section has been moved laterally into position and coupled to the downstream flange of the supersonic nozzle, the VDMS unit is driven upstream and coupled to the downstream flange of the transonic section. In this configuration, the test model is

VARIABLE DIFFUSER AND MODEL SUPPORT

FIG.7



located opposite the schlieren windows in the transonic test section.

Constant Diffuser

The function of the constant geometry diffuser is to complete the deceleration process initiated by the variable diffuser and in company with its downstream screen grids, to provide acceptable flow uniformity for the exhaust silencer baffles and stack. It also provides, through its telescopic feature, means of permitting axial movement of the VDMS unit while simultaneously maintaining an adequate seal to control air leakage into or out of the tunnel circuit.

Exhaust Silencer

Between the constant diffuser and the exhaust stack a silencer is provided. This consists of a bank of acoustically absorbent panels of variable thickness and which form a series of parallel sinusoidal channels through which the air passes. The silencer is designed to produce a 40 db reduction in noise intensity over the audible frequency range. This attenuation is further augmented by the right angle bend into the stack and by the stack itself. The combined effect of these factors is calculated to reduce exhaust noise to a level acceptable to the community.

Sealing

An important factor in the tunnel design is the provision of an adequate system of seals to control leakage of air at various component and mechanism interfaces.

Extensive use has been made of inflatable type seals. Such seals are employed in the shut-off and control valves, along the edges of the flexible plates and their contiguous hinge plates, along the edges of the movable wall panels in the model support and variable diffuser and on the mating flange faces of the movable tunnel components.

Controls

Tunnel control is effected from a central control room which is physically isolated from the tunnel proper because of the high noise levels generated during blowdown. The control room is without observation windows and surveillance of the wind tunnel room is by means of a closed circuit television system.

The wind tunnel controls fall into two main groups, those required to set up the tunnel between runs and those which provide control over the tunnel during a run.

Set Up Controls

With a nominal period of 20 minutes between runs and the necessity of ensuring that the equipment is set up without error, the supersonic nozzle flexible plates, variable diffuser sidewalls and transonic section walls, are set by electric motor driven screw jacks which are controlled by central programmers. These systems run to balance potentiometers. The movements of the variable diffuser unit and the transonic test section and their couplings are controlled by hydraulic actuating systems. The model access platform is driven by an electric gear motor. Electrical control of these systems is by relays and hydraulic operating solenoids.

Safety interlocking of the main components is controlled by "fail-safe" switches, heavy duty relays and a key interlock system. A door locking system is provided to prevent access to the wind tunnel building during a blowdown.

Control During a Blowdown

With blowdowns being limited to short intervals, automatic controls are required to operate a large number of individual systems and record information during a blowdown.

High speed electro-hydraulic servo mechanisms control the wind tunnel control valve, the model support roll and pitch system and the transonic Mach number control system. The design of these systems was closely integrated with that of the mechanisms being controlled since the mass, stiffness and damping properties of the latter are primary factors in the dynamics of the control system "loops".

A blowdown sequence control system integrates the controls of all other systems and provides a safe progression of sequences before, during and after a blowdown.

After all the settings have been put into the tunnel preparatory to a run, the control of the wind tunnel is transferred to the wind tunnel operating console located in the centre of the control room. The tunnel operator then initiates the blowdown sequence control system which automatically checks interlocks and settings, initiates the "count-down" process, and starts, runs and stops the tunnel. This system is designed to be completely "fail-safe" and leaves the operator free to drive the tunnel with a minimum number of push buttons and indicators before him. During the actual tunnel run the operator therefore serves solely as a safety observer since all running control functions are fully automatic.

Data recording systems are provided for the measurement of the various pressures, temperatures and humidities throughout various parts of the tunnel.

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THE NEED FOR RESEARCH IN PLANNING MECHANIZATION

J. C. Clapham,

Head, Operations Research Section, British Columbia Research Council, University of British Columbia, Vancouver

Industrial competition continues to force companies to pursue programs of mechanization. Selecting such programs ordinarily involves assessing alternatives obtained by: surveying recent examples in the industry; drawing parallels from other industry; using creativity or ingenuity

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THIS talk presents a case for planning mechanization by the analytic methods of operations-research. This approach relates the performance of a system to its controlling factors. It offers great advantages to large and complex industries where the high number of interacting components obscure the relations between cause and effect. Present methods of selecting mechanization projects are usually not systematic and fail to provide adequate direction to the search for better alternatives. The five questions to be considered in discussing the subject are:

1) What are the reasons for mechanizing at all?

2) What are the present methods of selecting mechanization projects?

3) What are the limitations of these methods?

4) How would a more fundamental approach help?

5) How can such an approach be organized?

Reasons

Historically, an increase in mechanization has been associated with a rising standard of living and higher wages. There is no doubt that such a trend will continue. In this situation, no company or industry can remain static for very long without succumbing to a competitor who can offer higher labor rates or lower prices. Thus, every company is under competitive pressure to increase its productivity. Some increases can be achieved without major capital expenditure. However, many advances will require mechanization (using the term generally to include automation and the replacement of machines by better machines). Industries which can only mechanize slowly are likely to find themselves losing markets to their competitors.

Present Methods

There is no single method of selecting mechanization alternatives for consideration. A usual first step is to survey the latest examples in the field. This may involve discussion with manufacturers and visits to plants with recently-installed equipment. However, every plant is unique — as every manager will readily affirm. Hence, it is necessary to make allowances for differences in output and conditions between the plants visited and the plant being considered. Such allowances are usually made subjectively, although an attempt may be made to interpolate or extrapolate any trends apparent in the series of plants visited. After a study of available choices in the same industry, the next step may be to draw parallels from other industries — particularly from those which are more advanced technologically. Finally, by the relatively indefinable process of creativity or ingenuity, a mechanical way of peforming a manual operation may be devised.

Having developed one or more alternatives for consideration, management then has to assess the economic attractiveness of each. Normally, this is done by estimating the number of years which will be taken to repay the capital outlay in savings of labor or material. If the lowest pay-off period of any alternative is sufficiently short, this one will probably be selected for installation.

Limitations

There are two major limitations to these approaches. The first is the difficulty that arises in quantitatively assessing the effect of change. The second is that exploration of possibilities is not systematic. This means that there is no search for an optimum and creativity may not be concentrated where it can be most useful.

After a disastrous fire involving a rubber-belt conveyor in a coal mine in England, large numbers of fireproof steelplate-conveyors of different designs were imported from Germany and installed in British coal mines. The conditions in British mines were substantially different from German ones. Initially, the effect of differing conditions had to be assessed subjectively, although an operations-research program was initiated which subsequently provided objective data for determining the areas of profitable application of these new types of conveyor. Some of the original installations were successful but many were not. Even highly experienced managers cannot intuitively assess the effects of a complex of interacting factors to allow for the changed conditions of operation. In these circumstances, there is a tendency to follow any current trends or fashions in mechanization. The Royal Commission on the Tree-Fruit Industry of British Columbia reports that "mechanical devices are sometimes installed . . . with the emphasis on prestige rather than economy . . . If one house instals an automatic dumper, it is noted that quite a few other houses in that district will also instal automatic dumpers."

The second weakness is that exploration of possible alternatives is somewhat hit-or-miss. Although the selected alternative may be better than the present system, there may be another possibility which is better than either. The most common example of this oversight is a failure to consider simple changes to increase the efficiency of the existing system. An example may be quoted of a plan which installed two machines at a cost of $130,000. The saving in manpower apparently justified this expenditure. However, the majority of the saving was due to the $30,000 expenditure on the smaller machine. The $100,000 expenditure on the larger machine was not justified. The point being made here is not that people make mistakes. It is rather that, without a basic exploration of the factors affecting the economics of the process being considered, there is nothing to guide the selection of the best scheme of mechanization.

Use of Operations-Research

Operations-research can help in the planning of mechanization by overcoming some of the limitations of conventional methods. The fundamental feature of this approach is its development of a quantitative description of the way in which a system works. It studies each aspect of an operation and considers how it is affected by each of the various factors of the situation. This feature of operations-research is known as making a "model" — or explaining what makes the system tick. The usefulness of the method lies in the facility for manipulating the model to predict the effect of change. This indicates those aspects of the operation to which the economies are sensitive. It also helps in determining the economic level of mechanization.

Some simple examples may be given to illustrate the aspect of "sensitivity". In underground mining, there is an incentive to drive tunnels in rock quickly so as to reach the ore body sooner. It is desirable to achieve a high rate of drivage. An obvious improvement therefore would be a high-speed drill. Analysis shows that, after each drilling cycle, time has to be allowed for firing the rock down, loading it away and supporting the roof ready for the next drilling cycle. The rate of advance is affected by many factors, but the major one to which it is sensitive is the "pull", or depth of penetration in each cycle. Thus, the development of longer drills is more advantageous for high speed drivage than the "obvious" development of faster drills.

As a second example of sensitivity, a machinery manufacturer offered to guarantee a local plant that a new drive for a production machine would increase output by 18%. A guarantee of this kind would be difficult to enforce because other factors would be certain to change as well as the drive. There would be differences in raw material and production procedures from time to time. An analysis of the situation showed that the significant relevant feature was the acceleration. This would not be affected to an imporant extent by other factors. Thus, the plant should require the manufacturer to guarantee the acceleration, since this is a controllable factor. The analysis also showed that, with the anticipated acceleration, the increase in output from the machine would have been about 4%. The relationship obtained enabled the plant manager to negotiate with the manufacturers to find the acceleration rate offering the best economic return in increased production.

A third example of the importance of determining the most sensitive controlling factor may be taken from a study of a fleet of vehicles of a distributing company. To increase the productivity of the vehicles, it was desirable to reduce the round-trip time. Out of an average round-trip time of 80 minutes, only four minutes were spent in loading them. This, therefore, looked a comparatively unimportant component. However, this was only true when a small number of vehicles was operated. Consider the situation if an attempt were made to operate 25 vehicles. It would take 100 minutes to load them all, by which time the first vehicle would have been back 20 minutes. The round-trip time would therefore rise to 100 minutes and each vehicle would spend 20 minutes waiting in line to be loaded. The operation at busy times was quite sensitive to the loading time and simple changes to cut loading time to three minutes or less were easily justified.

Although the operations-research model is no substitute for creativity, it can guide inventiveness into useful channels. For example, the Research Council several years ago spent some time in developing on paper an automatic lumber sorter which could be installed by adding relatively simple additions to the conventional manual sorting-chain. As lumber came opposite its storage bay, it would be ejected onto a rough-pile at the side. However, the term "automatic sorter" is misleading. When an analysis of the problem is made, it is found that automatic segregation into sorts can be achieved simply and inexpensively in a number of ways. The expensive part of present automatic sorters consists of the mechanism for storing and transporting the sorted lumber to the stacker. Hence, we had devoted our ingenuity to a relatively less important aspect of the problem.

These examples quoted have been stripped to their essentials and have been made to appear as if the performance were sensitive to only one factor. In most problems, the performance of a system is affected in a complex way by a large number of factors. The economics of automatic lumber sorting are affected by the lumber volume, the dimensions of the pieces, the number of sorts and the proportion requiring special handling for drying. Moreover, mechanization need not be applied entirely but may only be desirable for selected types of pieces. It is in this situation that an operations-research model becomes specially important. It can test the effect of changing many factors simultaneously. It can experiment on paper, instead of in the plant. Moreover, instead of considering a limited number of possibilities, it can explore a whole range and calculate an optimum (or near-optimum) point of balance. Two simple examples will illustrate the problem of balancing conflicting factors.

In the normal method of trimming dry veneers or shingles which have one straight edge, the operator feeds the piece into a saw, making a judgment by eye of the minimum width of piece. It is possible to measure the minimum width ahead of the saw and to allow this to set the cut automatically. The more accurately the measurement and setting are made, the greater is the material saving but the greater also is the capital cost. At some point there is an optimum point of balance. In most instances of this type, the total cost will not be critical to the choice of accuracy. An approximate estimate of the way in which machine costs rise with accuracy will be sufficient to select the economic level.

In the shoe trade, soles and heels are cut from leather hides. If the operator cuts slowly, taking thought, he can avoid the serious flaws and cut high quality products. Alternatively, he can cut more rapidly, achieving a greater quantity, but lower quality output. When a study was made, it was found that the conventional shoe manufacturer's operating level was too heavily oriented to speed. The specialist cut-sole manufacturers cut more slowly and came closer to the optimum balance between speed and accuracy.

Although both these examples have illustrated the choice of the level of mechanization as affected by a conflict of two factors, most situations will have more than two opposing factors to resolve. The principle, however, is the same. A quantitative model can enable the optimum level to be calculated.

Organization of Approach

In considering how an operations-research approach to mechanization can be organized, it is instructive to examine why it is not yet widely used. Briefly, the answer is that, although the concepts are relatively straightforward, the analysis of any industrial situation can soon become quite complex when all the factors are considered. It therefore calls for a substantial research effort before worthwhile conclusions are reached. A larger company might sponsor such research on its own—and, of course, many do. However, some ask whether it is worth their while to sponsor research into industry-wide operational problems, when their competitors could readily copy their solutions, when found. Similar considerations apply to the machinery manufacturers. The larger of them could sponsor research to develop a new machine or organizational system. However, in many cases, they would be very fortunate to find anything usefully patentable at the end. It is very doubtful, for example, whether any inventor of a new automatic lumber sorter could obtain a patent which would prevent companies or manufacturers copying the essential principles. There is, therefore, a strong argument for sponsoring such research on an industry-wide basis. This is the situation in Britain where much work of this kind is carried out either by the various industry-supported Research Assocations or, of course, by the nationalized industries. There is a trend in this direction also in the United States. The Battelle Institute is making a study of the forest products industry of the South-Eastern United States. This is being sponsored jointly by the larger companies and liaison with the industry is maintained through the South-Eastern Technical Committee of the American Pulpwood Association. The study is of three years' duration and includes economists, industrial engineers and operations-research workers. Such studies of the fundamental nature of the industry pinpoint the problems and enable the creativity of engineers to be applied constructively to their solution.

Conclusions

Companies will be compelled to continue mechanizing because of pressure from competing companies and industries. Present methods of selecting mechanization projects normally involve the assessment of a small number of alternatives obtained by:

1) surveying latest examples in the industry (subjectively correcting for differences in application);

2) drawing parallels from other industry;

3) using creativity or ingenuity.

Operations-research overcomes the limitations of these methods by directing exploration and evaluation of alternatives in the following ways:

a) It makes possible a quantitative assessment of a proposed scheme in the particular circumstances to which it is to be applied.

b) By indicating the sensitivity to various factors, it can direct creativity by guiding its application to useful areas.

c) By a more systematic exploration of possibilities, it can arrive at near-optimum solutions.

Since many problems of mechaniztion are fundamental and complex, industry-wide support for research in this field is suggested.

THE HYDRAULICS OF THE PIPELINE FLOW OF SOLID-LIQUID MIXTURES

G. W. Govier, M.E.I.C.,
Professor of Chemical Engineering, Dean of the Faculty of Engineering, University of Alberta, Edmonton, Alberta.

M. E. Charles,
Research Engineer, Research Council of Alberta, Edmonton, Alberta.

Solids may be transported with liquids in pipelines either as "no-settling" or as "settling" mixtures, depending upon the magnitude of the solids velocity. "Non-settling" mixtures—those for which the settling velocity is less than 0.002 - 0.005 ft./sec.—frequently behave as non-Newtonian fluids and a high concentration (30 - 40 per cent by volume) generally approach Bingham plastic behaviour. As an example, sulphur-water slurries show adequate agreement between measured pressure drops and those predicted by the Bingham plastic and power law pseudoplastic relationships.

"Settling" mixtures cannot be treated as single phase systems except under conditions of high turbulence. As the mixture velocity is decreased from an initially high value the solid settles more and more freely until eventually the pipe blocks. Pressure gradients may be predicted with reasonable accuracy for the heterogeneous flow patterns by the empirical equation of Durand and the semi-theoretical equations of Newitt.

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

IN RECENT YEARS there has been a marked increase in interest in the pipeline flow of multiphase mixtures. Gas-liquid mixtures are being handled in oil field operations, in evaporators and in chemical reactors. The flow of gas-liquid and solid-liquid mixtures is being encountered in the development and design of nuclear reactors.

One of the applications of greatest interest is that of the pipeline transportation of solid-liquid mixtures. Slurries of cement, sand, gravel, clay, coal and various ores have been handled by pipeline over relatively short distances for many years and this method of transportation is known to be practical. It is only recently, however, that interest has developed to the point where long distance transportation is being considered. For instance, coal is now being transported 108 miles through a 10 in. diam. pipeline[1] and gilsonite, a solid hydrocarbon, 72 miles through a 6 in. pipeline.[2] The transportation of coal in an oil or water slurry is of particular interest in Canada where the distances between the coal fields and the major markets are so great. Work on this application is being carried out at the Research Council of Alberta.[3] Another possible application, and one of special interest to Alberta, is the pipeline movement of sulphur in the form of a slurry in natural gasoline or condensate. The tremendous tonnages of sulphur to be recovered from natural gas produced in Western Canada pose a marketing and transportation problem of unprecedented difficulty.

The discussion which follows is intended as a general review of the hydraulics of the pipeline flow of solid-liquid mixtures. Few new experimental data are presented. The practical problems of pipeline wear, particle size degradation, introduction of solids, choice of pumping equipment and recovery of solids, though extremely important, are not discussed.

Types of Solid-Liquid Mixtures

Liquid-solid mixtures may be divided

Joint contribution from the Department of Chemical and Petroleum Engineering, University of Alberta, and the Research Council of Alberta, Edmonton, Alta. (R.C.A. Contribution No. 152)

into two major classifications—"settling" mixtures and "non-settling" mixtures according to the magnitude of the rate of settling of the solid material. The behavior of these two types is markedly different.

Most solids have densities greater than those of the liquids with which they may be mixed. Naturally, therefore, there is a tendency for the solid material to settle. The rate of settling depends upon the particle size, shape and density; the concentration of particles; the liquid density and viscosity; and the velocity field of the liquid—which is influenced by the geometry of the confining vessel or pipe and the presence of other particles.

For low concentration systems the settling velocities may be calculated with fair precision from the general settling law:

$$W_0 = \left[\frac{4}{3C_D} gd \left(\frac{\sigma - \rho}{\rho}\right)\right]^{1/2} \quad (1)$$

where

W_0 = free settling velocity
C_D = drag coefficient
g = gravitational acceleration
d = particle diameter
σ = particle density
ρ = fluid density

The drag coefficient is a function of the particle shape and orientation and the particle Reynolds number, defined as $R' = (\rho W_0 d/\mu)$, where μ = fluid viscosity. For spherical particles the drag coefficient may be evaluated from the following expressions which apply for the ranges of Reynolds number indicated

Region 1: $R' < 0.2$

$$C_D = \frac{24}{R'} \quad (2)$$

Region 2: $0.2 < R' < 500$

$$C_D = \frac{24}{R'}(1 + 0.15R'^{0.687}) \quad (3)$$

Region 3: $500 < R' < 2 \times 10^5$

$$C_D = 0.44 \quad (4)$$

Region 1 corresponds to the range of Reynolds number for which Stokes' law is applicable and Region 3 to the range of applicability of Newton's law. The transition from Region 1 to Region 3 is covered by Region 2 for which the empirical equation (3) for the drag coefficient has been proposed by Schiller and Naumann.[4]

For non-spherical particles the drag coefficient must in general be determined by experiment. Correlations are available for a limited number of shapes.

For medium and high concentrations the settling of individual particles is influenced by the presence of others and the process is described as hindered settling. The calculation of settling velocities for concentrated suspensions may be approached in either of two ways. First, although the laws of free settling no longer apply with rigor, a fair approximation to the settling velocity may often be obtained from these expressions provided the density and viscosity of the liquid are replaced by the density and apparent viscosity of the mixture through which the particles may be assumed to be settling. (More will be said later about the consistency of the mixture.) The method is useful in predicting the settling velocities of relatively large particles in a suspension of smaller particles.

A method proposed by Richardson and Zaki[5] appears to give good results for concentrated suspensions of particles having diameters greater than 100 microns where the particles settle at the same rate, displacing the liquid rather than the mixture. Dimensional analysis indicates that the "sedimentation" velocity, W, is related to the free settling velocity, W_0, by the equation

$$\frac{W}{W_0} = (1 - C)^n \quad (5)$$

where C is the volume fraction of solids in the mixture and n is a function of the particle shape and Reynolds number as well as the geometry of the containing vessel. A similar approach has been taken by Maude and Whitmore.[6] If the influence of the containing vessel may be neglected then n has a value of approximately 4.5. Equation (5) indicates that the sedimentation velocity for a 30% mixture is about 20% of the free settling velocity.

Fig. 1 has been prepared to illustrate the range of settling velocities which may be encountered with solid-liquid mixtures. The figure is a plot of settling velocity versus particle size. Lines are shown for cubic magnetite particles, clean sand particles, coal particles and cubic sulphur particles—all suspended in water. The lines for sand and the low concentration of coal are based on experimental measurements but are extended by application of the laws of settling.

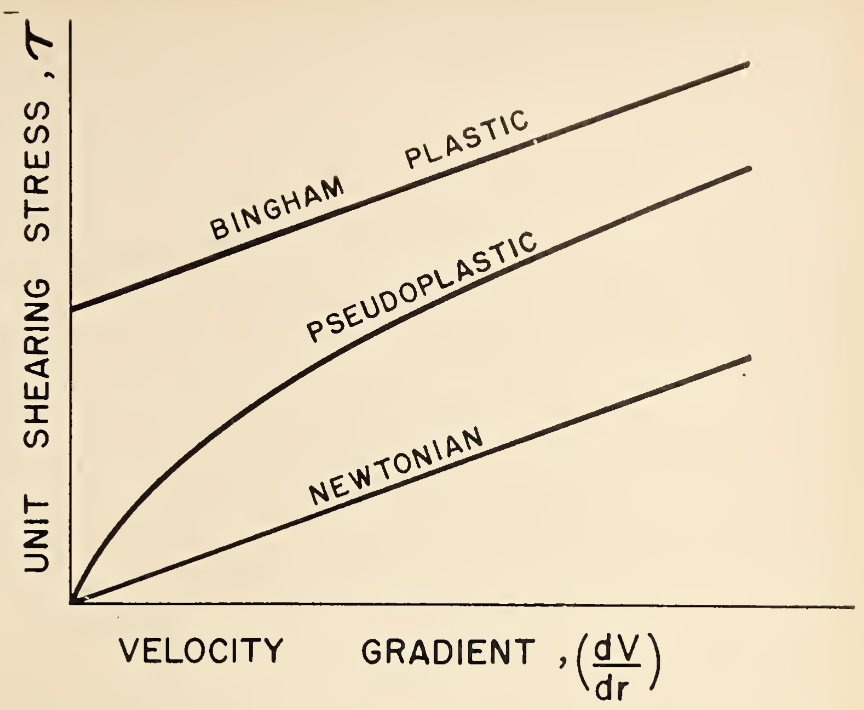
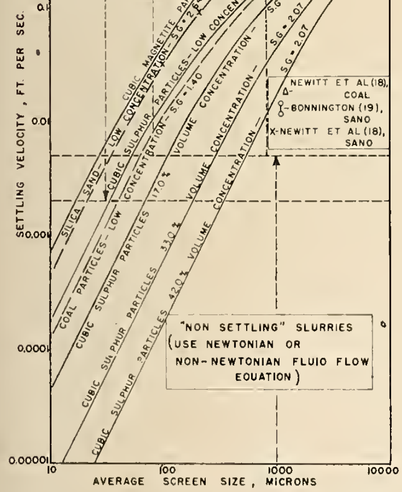


Fig. 2.

Fig. 1.



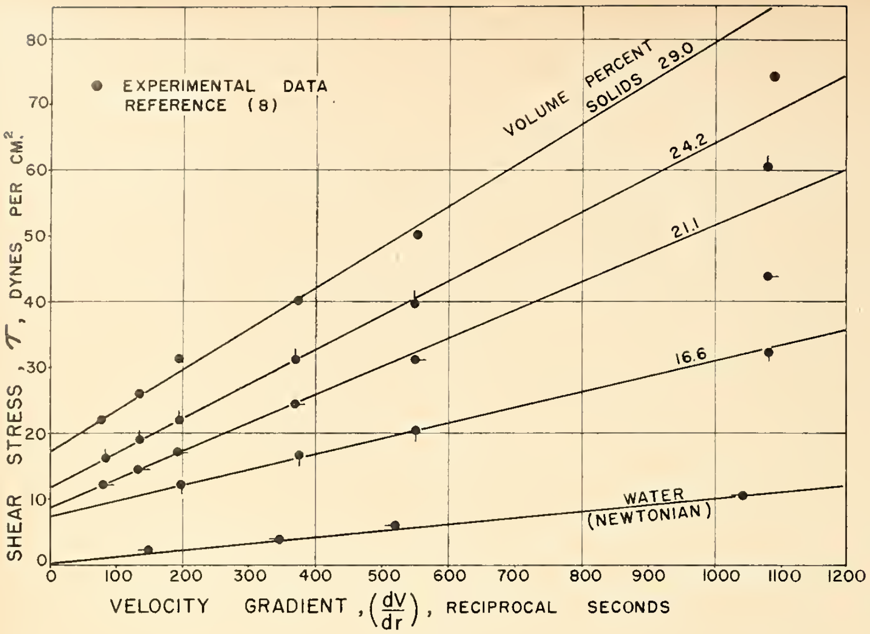


Fig. 3.

The lines for magnetite, and for all concentrations of sulphur are calculated from the free settling laws modified to take account of the density and consistency of the mixture. The figure serves to demonstrate the enormous range in settling velocities and specifically

(a) the great effect of particle diameter
(b) the effect of particle density
(c) the great effect of concentration of particles.

Experience and laboratory tests have shown that mixtures exhibiting settling velocities below 0.002–0.005 f.p.s. may be classed as "non-settling", since, in normal applications, their settling tendencies may be ignored. Such mixtures behave as pseudo-homogeneous fluids. This means that, in low concentrations, sand particles less than 20–35 microns, sulphur particles less than 30–50 microns, and coal particles less than 35–60 microns, may be considered to form "non-settling" mixtures. As the concentration of the particles is increased larger particles form "non-settling" mixtures, for example, 100, 230, 530 microns respectively for sulphur suspensions of 17, 33 and 42% concentration.

Mixtures which exhibit settling velocities above about 0.002 to 0.005 f.p.s. must be classed as "settling" mixtures although whether or not they actually settle depends upon the turbulence of the liquid stream in which they are suspended. In laminar or weak turbulent flow significant settling does take place and the mixture behaves as a heterogeneous one; in a field of adequate turbulence complete and uniform suspension may occur and the mixture may behave as a pseudo-homogeneous fluid.

"Non-Settling" Mixtures

For solid-liquid mixtures of low settling velocities and behaving as pseudo homogeneous fluids, the density and consistency of the mixture are the important physical properties rather than the density and viscosity of the carrier liquid. Such mixtures usually do not behave as Newtonian fluids but their consistency depends upon the velocity gradient. Fig. 2 indicates the rheological behavior of a Newtonian fluid, a Bingham plastic and a pseudoplastic on arithmetic coordinates.

For a Newtonian liquid the relationship between the imposed unit shearing stress and the resulting velocity gradient is given by

$$\tau = \frac{\mu}{g_c}\left(-\frac{dV}{dr}\right) \qquad (6)$$

where τ = unit shear stress
μ = viscosity
and dV/dr = velocity gradient.

The viscosity of the liquid is the constant of proportionality in the linear relation between shear stress and velocity gradient. Frequently, suspensions of solids in liquids exhibit Bingham plastic or pseudoplastic behavior. In the case of a Bingham plastic the rheological equation is

$$\tau - \tau_y = \frac{\eta}{g_c}\left(-\frac{dV}{dr}\right) \qquad (7)$$

where τ_y = yield value
and η = coefficient of rigidity

The yield value must be overcome before flow will take place. The pseudo plastic cannot be described by any universal relationship but many pseudoplastic materials follow a power law relationship over a 10 to 100 fold range of velocity gradient.

$$\tau = \frac{b}{g_c}\left(-\frac{dV}{dr}\right)^s \qquad (8)$$

where b = fluid consistency index
s = flow behavior index.

The actual rheological behavior of non-settling mixtures may best be determined by testing in a rotational viscometer. The dial deflection and rotational speed data may be interpreted in terms of unit shearing stress and velocity gradient permitting the construction of the rheological diagram for the system.[7]

Typical data[8] for non-settling mixtures of finely divided sulphur in water are given in Fig. 3. The decidedly non-Newtonian behavior is to be noted. The data may be interpreted either in terms of the Bingham plastic model or the power law pseudoplastic model. For the 29 volume percent sulphur mixture the Bingham interpretation suggests,

Yield value,
τ_y = 16.0 dynes per cm.^{2}

Coefficient of rigidity,
= 6.3 centipoise

The alternate power law pseudoplastic interpretation would give

Consistency index,
b = 5.0 dynes sec^s per cm.^{2}

Flow behavior index,
s = 0.327, dimensionless

Prediction of Pressure Gradients for the Flow of "Non-Settling" Mixtures.

Because the pseudo homogeneous suspensions are usually non-Newtonian in behavior and their consistencies cannot be expressed in terms of a "viscosity", the normal equations describing pipeline flow of fluids are not applicable.

Buckingham was the first to make a theoretical analysis of the laminar flow of a non-Newtonian fluid. For the Bingham plastic he derived the analogue of Poiseuille's equation :

$$\frac{8V}{D} = \frac{g_c}{\eta}\left[\frac{D\Delta P}{4L} - \frac{4}{3}\tau_y + \frac{1}{3}\frac{\tau_y^4}{(D\Delta P/4L)^3}\right] \qquad (9)$$

where
V = average fluid velocity
D = pipe diameter
$\Delta P/L$ = pressure gradient
g_c = dimensional conversion factor

This may be rearranged (9) to

$$\frac{1}{R_m} = \frac{f}{16} - \frac{Y}{6R_m} + \frac{Y^4}{3f^3R_m^4} \qquad (10)$$

where :

$f = \frac{g_c D\Delta P}{2V^2\rho L}$, the conventional Fanning friction factor,

R_m = modified Reynolds number, $\frac{\rho VD}{\eta}$

Y = a "yield" number, $\frac{D\tau_y g_c}{V\eta}$

This equation may be expressed as a plot of f versus R_m[9], as in Fig. 4.

The Buckingham equation, in the form of equation (10), may be compared with the friction factor form of the Poiseuille equation

$$\frac{1}{R} = \frac{f}{16} \qquad (11)$$

where $R = (\rho VD/\mu)$, the conventional Reynolds number.

The Buckingham equation has been found reasonably satisfactory for pipeline flow calculations of pseudo-homogeneous mixtures in laminar flow. While few such mixtures behave exactly as Bingham plastics many approach this behavior.

In the case of turbulent flow of Bingham plastics there is no comparable theoretical equation but extensive experimental data[10,11,12] indicate that for smooth pipe the friction factor is a function only of the modified Reynolds number. This means that the pressure drop flow rate calculations may be based on the conventional friction factor—Reynolds number correlation but with the Reynolds number calculated using the density and the coefficient of rigidity of the slurry.

The transition between laminar and turbulent flow for a Bingham plastic material does not take place at a well defined Reynolds number as in the case of the flow of a Newtonian fluid. The transition Reynolds number is a function of the yield number and varies from 2000 for $Y = 0$ to 100,000 for $Y = 200$. This is apparent in Fig. 4.

In the case of the power law pseudoplastic, theoretical analysis and experimental data show that for laminar flow in a circular pipe

$$\frac{1}{R_m'} = \frac{f}{16} \qquad (12)$$

where

$$R'_m = \frac{\rho V^{2-s} D^s}{\gamma},$$

a modified Reynolds number in which

$$\gamma = g_c\, b \left(\frac{3s+1}{4s}\right)^s 8^{s-1}$$

A plot of f versus R_m' gives a straight line of slope minus one on logarithmic paper for all fluids whose behavior may be defined by the power law model. This is shown in Fig. 5.

The turbulent flow of power law pseudoplastics has recently been investigated by Shaver and Merrill[13] and by Dodge and Metzner.[14] The latter developed a turbulent resistance law similar to the Von Karman equation for Newtonian fluids and performed experiments with several non-Newtonian fluids to evaluate unknown constants. The final form of their correlation is shown in Fig. 5.

Pipeline pressure drop measurements[8] on the previously mentioned sulphur-water suspensions are shown in Fig. 6 and compared with calculations based on both the Bingham and power law models. Laminar flow is indicated at velocities below 2.5 to 3 f.p.s. Bingham plastic behavior is approached and good agreement with the Buckingham equation is obtained. At higher velocities turbulent flow is indicated with behavior between that of a Bingham plastic and power law pseudoplastic.

"Settling" Mixtures

For mixtures with settling velocities above about 0.005 f.p.s. significant settling will take place except at flow velocities sufficiently high for the turbulence to suspend the particles. The flow phenomena which are encountered may best be visualized by considering what would take place if the volumetric input of constant composition slurry were gradually reduced from one corresponding to an initially very high velocity—say 30 or so times the solids settling velocity.

Several investigators have observed the mixture velocities corresponding with the transitions from one flow pattern to another. The transition velocities may be defined as:

V_{m1} = the mixture velocity corresponding to the transition from the pseudo homogeneous to the "heterogeneous" suspension flow pattern.

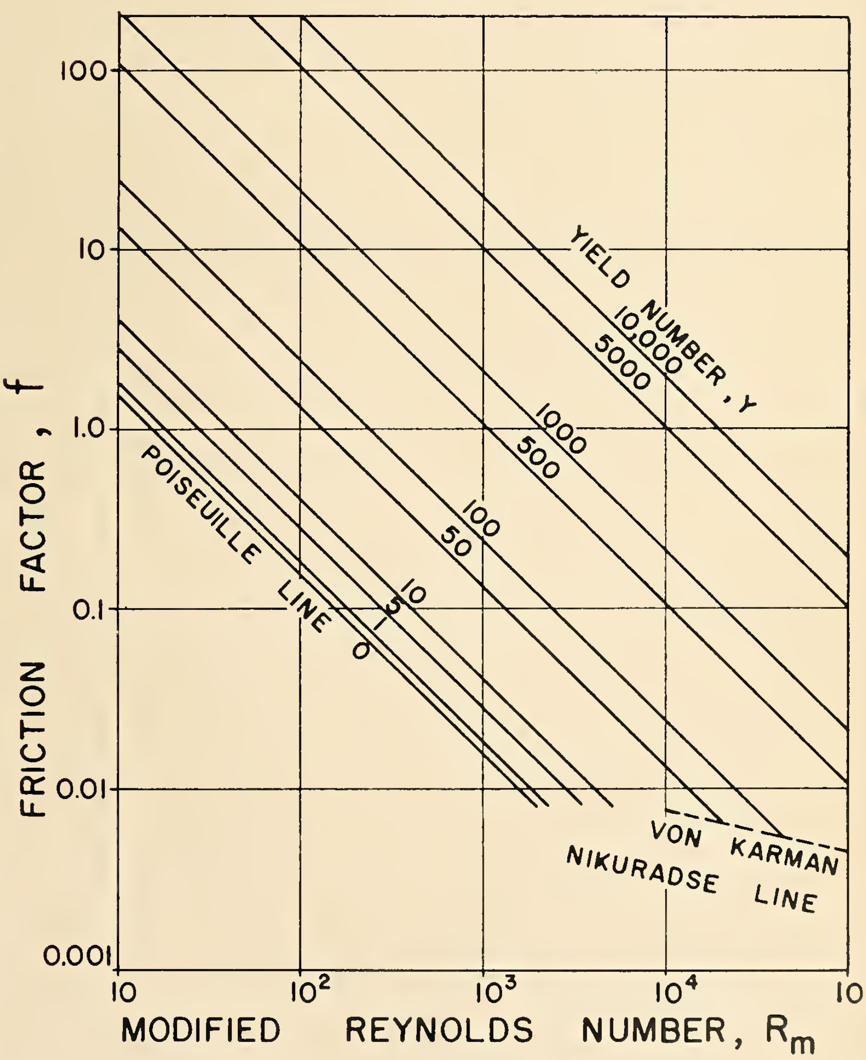
V_{m2} = the mixture velocity corresponding to the transition from the "heterogeneous" suspension to the moving bed and suspension flow pattern.

V_{m3} = the mixture velocity corresponding to the transition from moving bed and suspension to the stationary bed and saltation flow pattern.

V_{m4} = the mixture velocity corresponding to the transition from the stationary bed and saltation to where the pipe becomes blocked.

(a) *Homogeneous Suspension: Velocity Above V_{m1}*: At high velocity the solids would be fully suspended in the liquid by the transverse turbulence forces and the concentration profile would be symmetrical if not completely uniform. The mixture in fact would be flowing more or less as a pseudo homogeneous material. There would be no "holdup" of solids, the average flowing mixture having the same composition as the input mixture. If, in this condition, the mixture behaved as a Newtonian the pressure drop could be calculated using con-

Fig. 4.



ventional Newtonian methods, with the mixture density and viscosity. If the mixture exhibited non-Newtonian characteristics, as it probably would if the concentration were high, then the calculation method appropriate for the turbulent flow of the particular non-Newtonian could be used. Lack of true uniformity of concentration will result in some discrepancy between actual and calculated pressure drop.

(b) *"Heterogeneous" Suspension: Velocity Below V_{m1}, Above V_{m2}:* As the mixture input is reduced corresponding to, say, 20 times the settling velocity, the distribution of the suspended solid particles will become asymmetrical with a greater concentration in the lower half of the pipe. Some holdup of solids will occur. Here the heterogeneity is such that methods for calculating the pressure drop for single phase fluids no longer apply.

(c) *Moving Bed and Suspension: Velocity Below V_{m2}, Above V_{m3}:* At still lower input rates, some of the solids (the larger particles if the mixture contains different sized particles) drop to the bottom of the pipe to form a layer or bed which is carried along by the drag imposed by the fluid. Formation of the bed reduces the effective cross section for liquid flow and increases its velocity above the apparent value.

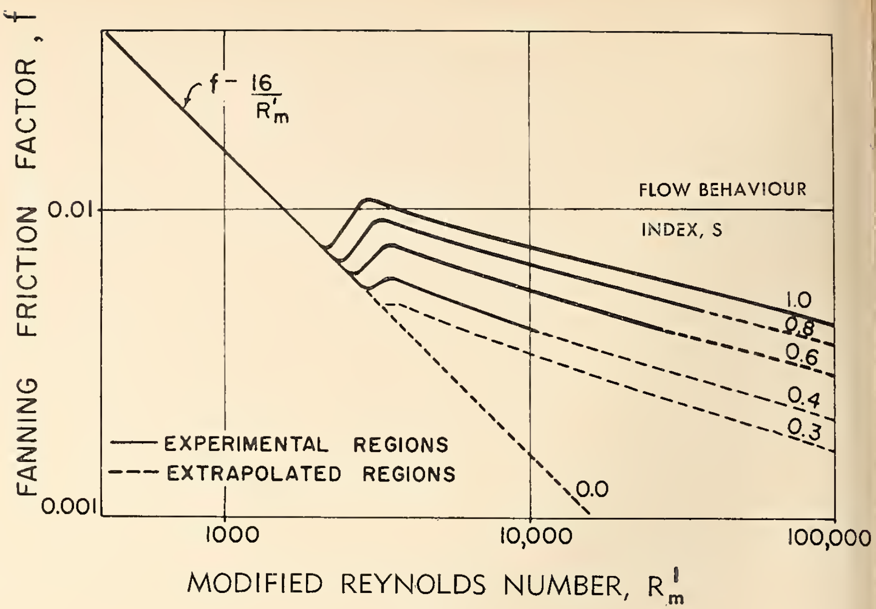


Fig. 5.

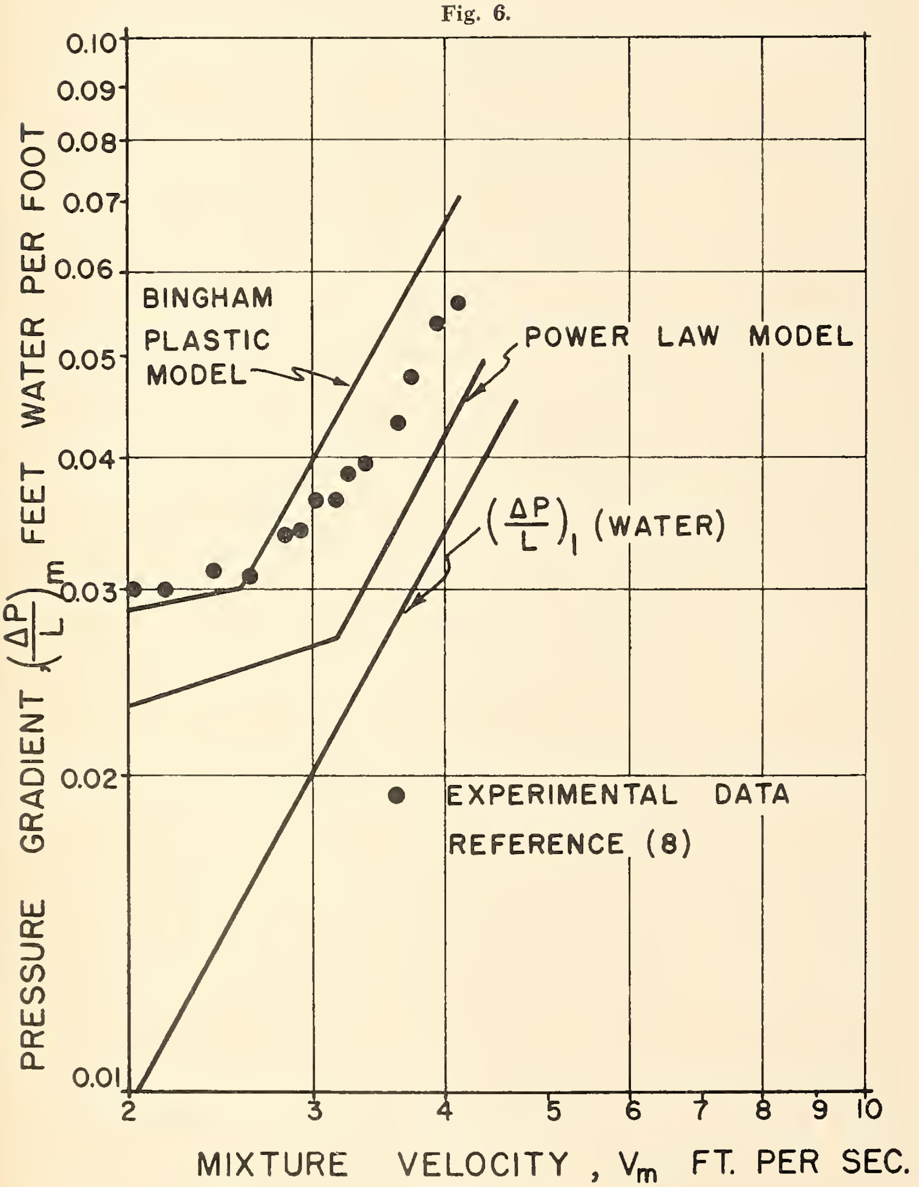


Fig. 6.

(d) *Stationary Bed and Saltation: Velocity Below V_{m3}, Above V_{m4}:* If the input of the mixture is decreased further, the bed grows in thickness; the lower part of it, protected from the liquid drag, becomes stationary and only the upper part moves. This type of movement is referred to as saltation. Solids tend to accumulate in the pipe further reducing the cross section available for liquid flow and increasing the real velocity of the liquid until the resulting increased drag on the solids transports the solids at the necessary rate to balance the input.

(e) *Blockage: Velocity Below V_{m4}:* Still further input rate reduction will cause a reduction of liquid drag, further accumulation of solids and ultimately, the bridging of the solids across the pipe and blockage (at least as far as further flow of solids is concerned).

The sequence of flow regimes may be illustrated by reference to Fig. 7 which shows schematically the manner in which the actual liquid velocity and the holdup of solids varies with reduction in mixture velocity. First, however, the concepts of holdup and slip require clarification.

Once the mixture flow rate is decreased to the point where the turbulent lifting forces will no longer maintain the solid particles in "homogeneous" suspension, the solids tend to "holdup" or the liquid tends to slip past the solids. This phenomenon is encountered in gas-liquid[15] and in liquid-liquid flow[16]. It is convenient to think in terms of a holdup ratio defined as the ratio of (a) the liquid-solid volume ratio in the supply mixture, to (b) the liquid-solid volume ratio in the flow section.

e. $$H_R = \frac{1-C}{C}\left(\frac{C'}{1-C'}\right) \qquad (13)$$

here

C = volume fraction solids in supply mixture

C' = volume fraction solids in flow section.

t may readily be shown that the holdup atio is also the ratio of the average true quid velocity, V_1, to the average true olids velocity, V_s.

.e. $$H_R = \frac{V_l}{V_s} \qquad (14)$$

Turning now to Fig. 7, the four prinipal flow regimes are related to the ariation of true liquid velocity with nixture velocity and the variation of oldup ratio with mixture velocity. Quantitative generalizations relating to the velocities or holdup ratios corresponding to the flow regime transitions are not now possible but the qualitative picture seems clear.

Fig. 7 represents the situation for a mixture of given particle size and concentration. Increasing the particle size would result in increasing the mixture velocities at which the transitions would occur. This is due to the increased settling velocities which would result. Conversely, increasing the slurry concentration would result in a decrease in settling tendency due to particle interference—and would be expected to result in a decrease in the mixture velocity corresponding to the transitions. The increased consistency of the mixture however has the offsetting effect of decreasing the turbulence so the overall effect may not be large.

Except in the case of sufficient turbulence for uniform suspension, the conventional methods of pressure drop calculation—whether for Newtonians or non-Newtonians—are not applicable. For the three heterogeneous flow patterns it has been found useful[17,18] to consider the pressure gradient to be composed of the sum of that which would have resulted had the flowing mixture been the carrier liquid, plus an excess due to the presence of the solids. This is expressed as

$$\left(\frac{\Delta P}{L}\right)_m = \left(\frac{\Delta P}{L}\right)_l + \left(\frac{\Delta P}{L}\right)_s \qquad (15)$$

where

$\left(\frac{\Delta P}{L}\right)_m$ = pressure gradient for the flowing mixture

$\left(\frac{\Delta P}{L}\right)_l$ = pressure gradient which would have been encountered had the slurry been the carrier liquid

$\left(\frac{\Delta P}{L}\right)_s$ = the excess pressure gradient due to the solids.

Durand[17] was among the first to note that for a given solid-liquid system the excess gradient could be correlated, for a range of concentrations, by the simple expediency of plotting

$$\frac{(\Delta P/L)_m - (\Delta P/L)_l}{C(\Delta P/L)_l}$$

against the average mixture velocity, V_m. Data obtained by Bonnington[19] on the flow of sand-water mixtures are shown in terms of the actual pressure gradients in Fig. 8 and as correlated by the Durand method in Fig. 9.

Durand has extended his approach with the aid of dimensional analysis to give the following general, although empirical, correlation.

$$\frac{(\Delta P/L)_m - (\Delta P/L)_l}{C(\Delta P/L)_l} = 121\left[\frac{gD(\sigma-\rho)}{V_m^2\rho}\,\frac{W_0}{\sqrt{gd[(\sigma-\rho)/\rho]}}\right]^{1.5} \qquad (16)$$

This equation has been successful in correlating data for water suspensions with solid concentrations up to about 40 volume percent over the following ranges:

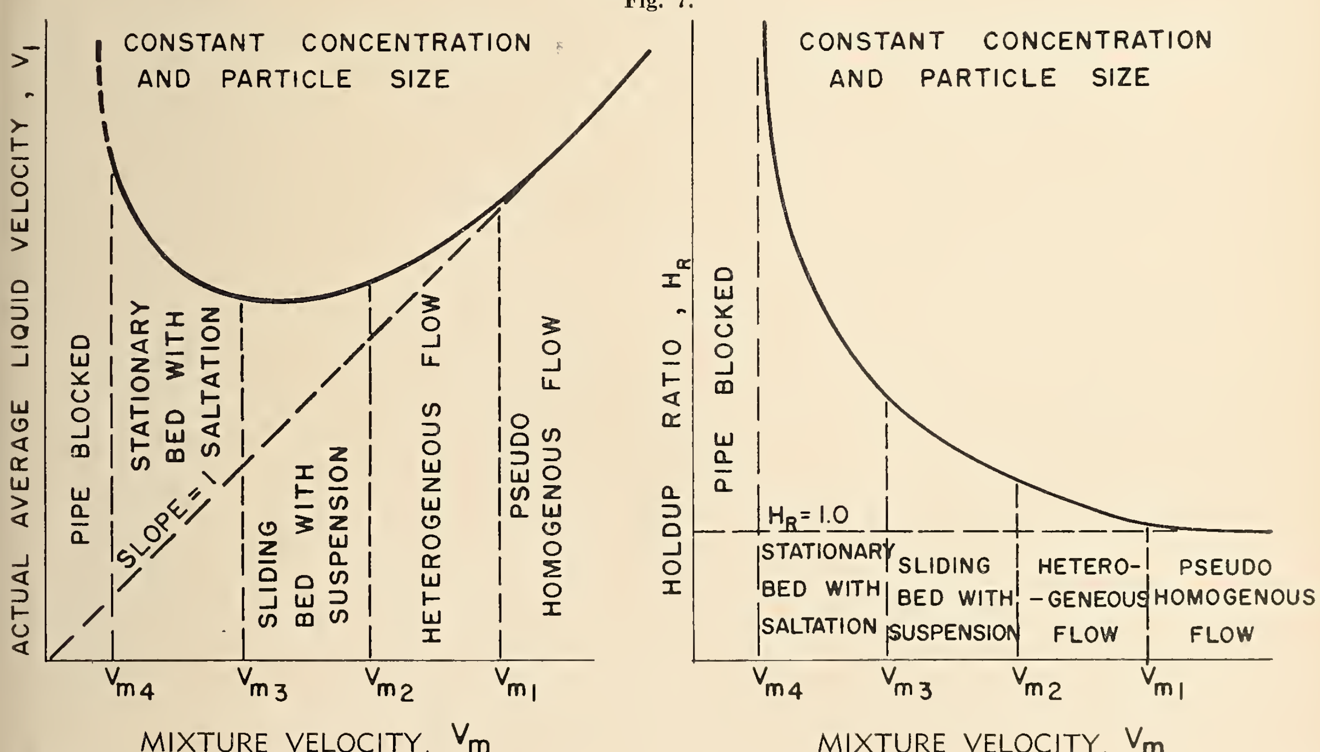
Solid specific gravity:	1.4 to 4.6
Particle size:	20 to 25,000 microns
Pipe diameter:	1 to 22 inches

The Durand equation seems to fit data for all modes of heterogeneous flow (mixture velocities from V_{m1} to V_{m4}) without taking account of the different flow regimes.

Newitt et al[18] have been the most successful in a semi-theoretical approach. By a consideration of the individual energy loss terms they were able to show that in the case of the flow of "heterogeneous" suspensions (mixture velocities from V_{m1} to V_{m2})

$$\frac{(\Delta P/L)_m - (\Delta P/L)_l}{C(\Delta P/L)_l} = K_1\left(\frac{\sigma-\rho}{\rho}\right)\frac{W_0 gD}{V_m^3} \qquad (17)$$

Fig. 7.



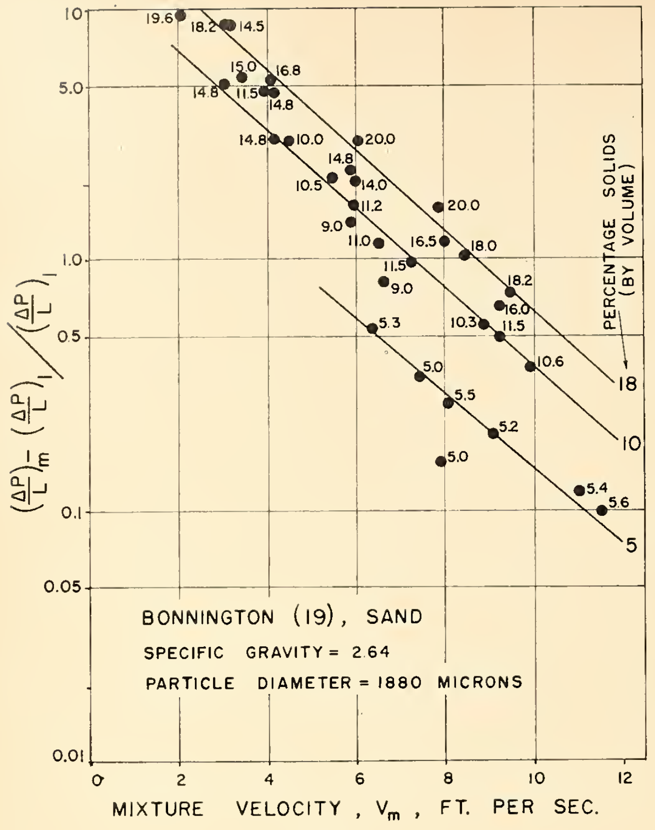


Fig. 8.

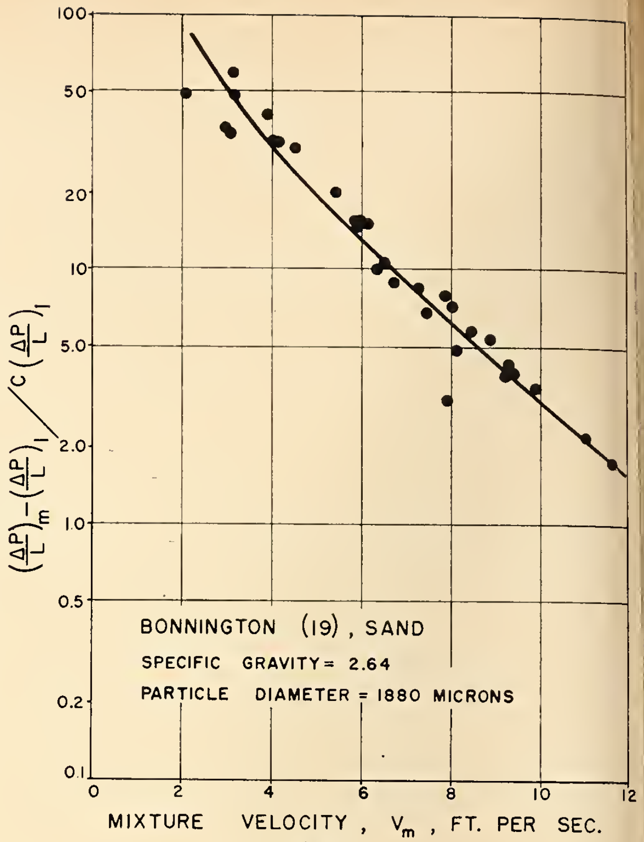


Fig. 9.

and in the cases of the moving-bed-and suspension and the stationary-bed-with-saltation patterns (mixture velocities from V_{m2} to V_{m4})

$$\frac{(\Delta P/L)_m - (\Delta P/L)_l}{C(\Delta P/L)_l} = K_2\left(\frac{\sigma-\rho}{\rho}\right)\frac{gD}{V_m^2} \qquad (18)$$

They determined values of the constants K_1 and K_2 by tests on a variety of materials in a 1-inch diameter pipe. Their values are

$$K_1 = 1100$$
$$K_2 = 66$$

Newitt also put the equation for the flow of pseudo homogeneous materials (treated as a Newtonian) in the form of those for heterogeneous flow, obtaining

$$\frac{(\Delta P/L)_m - (\Delta P/L)_l}{C(\Delta P/L)_l} = \frac{\sigma-\rho}{\rho} \qquad (19)$$

This equation applies to mixture velocities above V_{m1}. It is correct provided that one assumes that the friction factors will be the same for the carrier liquid and the suspension—reasonable for low concentrations but not in cases where the density and especially the consistency of the slurry vary much from that of the carrier liquid.

Durand referred to a minimum velocity for solid-liquid flow, corresponding to V_{m4}, and suggested the empirical relation

$$V_{m4} = 10.5D^{0.5}\left(\frac{\sigma-\rho}{\rho}\right)^{0.5} \qquad (20)$$

for particle diameters exceeding 250 microns and concentrations exceeding 10%. Durand's general equation (16) may be solved simultaneously with the normal flow equation (19) for single phase fluids to yield an expression for V_{m1}, the transition from the pseudo homogeneous to the "heterogeneous" suspension pattern. If this is done, and the small effect of solid specific gravity is neglected, one obtains

$$V_{m1} = 11.9W_0^{0.5}D^{0.5}d^{-0.25} \qquad (21)$$

Newitt's equation (17) may be solved with equation (19) to give a second expression for V_{m1}:

$$V_{m1} = 32.8W_0^{0.33}D^{0.33} \qquad (22)$$

However, Newitt on the basis of experimental data gave the following expression:

$$V_{m1} = 38.7W_0^{0.33}D^{0.33} \qquad (23)$$

Clearly equation (23) is inconsistent with his equations (17) and (19) and leads to a transition velocity greater than predicted by equation (22).

Newitt solved equations (17) and (18) to obtain an expression for V_{m2}

$$V_{m2} = 17W_0 \qquad (24)$$

Spells,[20] in an empirical approach based on dimensional analysis, presented correlations for low concentration mixtures of 80-800 micron particles for what he called the minimum velocity and the standard velocity. His minimum velocity appears to correspond with the transition velocity V_{m3} while his standard velocity corresponds with V_{m1}. Spells' equation for the standard velocity is

$$V_{m1}^2 = 0.075\left(\frac{DV_{m1}\rho}{\mu}\right)^{0.775} gd\left(\frac{\sigma-\rho}{\rho}\right) \qquad (25)$$

This may be combined with equation (1) for the settling velocity to yield

$$V_{m1} = 134C_D^{0.815}D^{0.63}W_0^{1.63} \qquad (26)$$

Equation (26) assumes a kinematic viscosity for the mixture approximately equal to that for water.

Spells' equation for the minimum velocity is equivalent to

$$V_{m3} = 54.4C_D^{0.815}D^{0.63}W_0^{1.63} \qquad (27)$$

The transition velocities have been evaluated for the sand-water system investigated by Bonnington[19]—the flow of 0.074 inch (1880 micron) diameter sand in a $1\frac{1}{2}$-inch diameter pipe—for which experimental data have been presented in Fig. 8. The calculated transition velocities are:

V_{m1}:	12.0 f.p.s.	(Durand, Eq. (21))
	14.1 f.p.s.	(Eq. (22))
	16.6 f.p.s.	(Newitt, Eq. (23))
	19.0 f.p.s.	(Spells, Eq. (26))
V_{m2}:	10.7 f.p.s.	(Newitt, Eq. (24))
V_{m3}:	7.7 f.p.s.	(Spells, Eq. (27))
V_{m4}:	4.7 f.p.s.	(Durand, Eq. (20))

These calculated transition velocities

licate that at mixture velocities in ess of about 15 f.p.s. the slurry should have as a pseudo homogeneous fluid, ile at velocities below about 4.5 f.p.s. imate blockage of the pipe would be pected.

ediction of Pressure Gradients r the Flow of "Settling" Mixtures

The Durand equation (16) and ewitt's equations (17), (18) and (19) ay be used to predict the actual presre gradients in a pipeline carrying a ettling" suspension. To illustrate the aphical form of these equations and eir application in a practical case, the edicted pressure gradients are comured with the results of Bonnington ready given. In Fig. 10 pressure gradnt predictions from the equations are iperimposed on the experimental data r volume concentrations of 5% and 8% solids. The calculated transition elocities are also indicated.

Both the Durand and the Newitt quations agree very well with the xperimental data for a concentration f approximately 5%. At the higher conentration of 18% the Newitt equations redict the experimental values somehat better. It is not possible, however, o conclude on the basis of this one comarison which equations may be used to redict pressure gradients with the nore confidence. The important differnce between them is that in the Durand quation the pressure gradient is proortional to $D^{1.5}$ whereas in the Newitt quations the pressure gradient is proortional to D. Experimental data[21] ppear to indicate that the Newitt quations give slightly better results than the Durand equation for small pipe diameters while the converse is so for larger diameters.

Although blockage of the pipe is predicted to occur at mixture velocities below about 4.6 f.p.s. Bonnington actually obtained pressure drop data for mixture velocities as low as 2.5 f.p.s. for certain concentrations. He did, however, observe that substantial deposition of sand did take place at velocities below about 3.5 f.p.s.

A final word of caution is perhaps necessary. Although adequate agreement between experimental data and correlating equations has been demonstrated in many cases, the mechanisms involved in the pipeline flow of solid-liquid mixtures are still far from being completely understood. This can lead, in certain situations—especially where a solid with a wide size distribution is involved, to rather large errors in the prediction of pressure gradient.

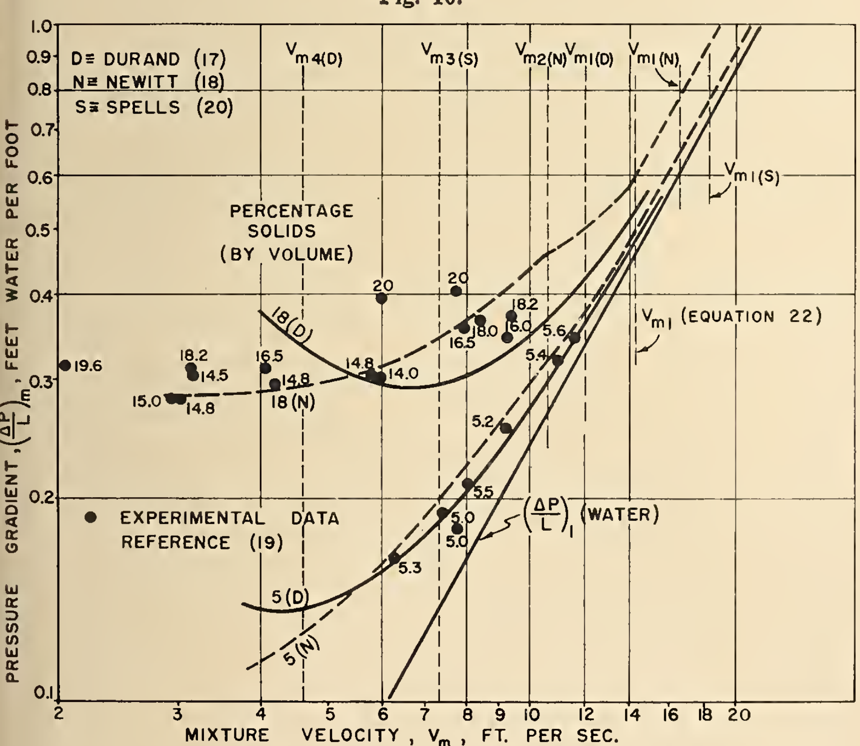
Conclusions

Solid-liquid mixtures can, in general, be divided into two groups on the basis of the magnitude of the solids settling velocity. "Non-settling" suspensions are those for which the solid settling velocity is less than 0.002–0.005 f.p.s. while "settling" suspensions are those for which the settling velocity is greater than about 0.005 f.p.s.

In the case of a "non-settling" slurry the settling effect may be neglected and the slurry treated as an homogeneous fluid. Depending upon the rheological properties of the mixture, Newtonian or non-Newtonian flow equations may be used to predict the pressure gradient accompanying the flow of these slurries.

In the case of a "settling" slurry the settling effect cannot be neglected except at extremely high velocity. As the pipeline velocity decreases the concomitant decrease in turbulence allows the solids to settle more and more freely until eventually the pipe blocks. The equations of Durand and Newitt are available to predict the pressure gradients and transition velocities for all the flow regimes encountered in the flow of "settling" slurries.

Fig. 10.



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ELECTRONIC AIDS IN CANADIAN MAPPING

J. T. Henderson, M.E.I.C.,
Applied Physics Division
National Research Council, Ottawa

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IN THE DEVELOPMENT of any new area or country, surveys and maps are always required, and constant revision is needed to keep this basic information up to date. New methods that increase the speed and accuracy of collecting and treating the field data are consequently of importance to all of us, and particularly so to engineers. In Canada, we have progressed from the rough sketches of the voyageur, from the days of the compass and chain, to the point where map making is a complex technological combination of photography, aerial support, and electronic instrumentation. Electronic devices specifically designed for surveying requirements are, comparatively speaking, late arrivals on the scene, but already they have had a profound influence on the methods employed, an influence that will undoubtedly increase.

Photography was introduced in this country as a surveying aid by Deville in 1886. It was a natural step to photograph from aircraft, so that following the development of aerial reconnaissance in the 1914-18 War, aerial photography for civil maps was introduced as a standard procedure in the early Twenties, during the same decade that regular radio broadcasting of public entertainment was emerging. Although the type and variety of aircraft and camera available have some influence on the design and weight of associated electronic equipment, these factors are not included in the present review.

Radio communications and radio time signals have long been of assistance to surveyors in the field, indeed they are essential to parties located in remote regions, but as the equipment and systems involved were not developed specifically for survey work, they are also excluded. It nevertheless seems worth mentioning that, far from being out of date, radio communication is more important than ever before and that much more complicated systems of communication for transmission and processing of data may well become important to the surveyor and cartographer. Time signals too are being continuously refined, although general surveying applications have not yet used the additional accuracy available.

Time signals have been broadcast since 1927[1] by the Dominion Observatory station CHU and have proved of great value to surveyors who frequently found themselves in areas poorly served by other time signals. The service has been revised continually since its inauguration. Recently, a stricter control of the transmitted frequencies and closer adjustment of the instant of starting of the seconds impulses was instituted.

The great development of radio navigational and position location systems during the 1939-45 war has given us additional aids. Since 1945, several devices designed for differe[nt] services during the war have be[en] adapted to the work of the ma[p] maker and nowadays equipment de[-] signed specifically for his needs is be[-] ginning to appear.[36] The prese[nt] article emphasizes the application[s] and innovations made in this countr[y] with a view to encouraging wid[er] use and further developments. Som[e] are treated very briefly because the[y] are already well described in the li[t-] erature, but are mentioned for th[e] sake of a more general picture.

Airborne Profile Recorder

The airborne radar altimeter wa[s] the first wartime development to b[e] adapted and used as a special aid t[o] surveying in Canada. An altimete[r] designed by the National Researc[h] Council was tried out by Mines an[d] Technical Surveys in 1949, and fu[r-]

Fig. 1.

ished useful additional data for mapping purposes.[2] This instrument, nown as the A.P.R. (Airborne Proile Recorder) gives essentially a coninuous graph of the clearance beween the ground and an aircraft as t flies along its course. If the variaions in altitude of the aircraft are nown from other observations, this ecord yields the profile of the ground lown over. Early experiments were ufficiently encouraging for commerial firms to develop equipment now being used extensively in this country and elsewhere.[3, 4]

The A.P.R. is a radar type device which records the elapsed time for a short pulsed radio signal to travel from an antenna on the aircraft to the ground and back to the aircraft. The chart record is calibrated in feet, assuming a velocity of propagation. When interpreting the records, one should think of the indicated distances as those between the aircraft and an area, rather than a point, on the ground below. This arises because the r.f. energy radiated from any practical antenna spreads out in a cone.

To the map maker, the usefulness of the A.P.R. extends beyond the point of merely giving elevations of the ground for vertical detail on a map. Blachut[5-8] and colleagues have used the A.P.R. for determining scale (and hence horizontal distances) on aerial photographs. They have also developed methods for using it for bridging between widely separated ground control points, a requirement when mapping a new area containing only limited known points of control. The separations involved being of the order of 200 miles, the method is applicable to areas controlled by a Shoran net. The A.P.R. has been tried successfully over mountains in Arizona, and this work is continuing at N.R.C. It is evident that the methods are already providing powerful aids to photogrammetry with additional uses to be expected.

Shoran

A pressing problem in Canada after the 1939-45 war was the rapid extension northward of the network of geodetic points required to complete the topographic surveys for mapping the area on a larger scale. The U.S.A.F. and U.S. Coast and Geodetic Survey had started an investigation on the use of the wartime navigational device known as Shoran and when this was brought to the attention of the Canadian Geodetic Survey, a parallel but modified program was begun here.[9, 10] The original objective was to use Shoran to measure the distance between points on the ground with an accuracy adequate for geodetic purposes. Since part of the equipment is airborne, it was early realized that the Shoran system might be used to control aerial photography of large areas by providing accurate information about the position of the aircraft at the time of photographic exposure. This secondary objective, important as it was, had to await development of the first because of the limited equipment available to us in the beginning.[11] Experimentation started in 1947 as a co-operative effort between the Geodetic Survey, the Army Survey Establishment, the R.C.A.F., the Meteorological Service of the Department of Transport, and the N.R.C. As the work progressed from development to use in the field, the role of N.R.C. became less important and

Fig. 2.

the work of commercial organizations using these methods for the Army became increasingly important. In fact, the history of Shoran surveying in our country in the past 10 or 12 years is almost the saga of success of a past era. First applied in the hope of speeding up the difficult and laborious work of geodetic surveying, the account today shows a vast network of points established to at least second order geodetic accuracy in our Northern Territories, in Ungava and Labrador, and stretching north to include our Arctic islands.[12, 13] In addition, areas have been covered by vertical photographs, controlled by Shoran methods, providing the data for control of maps of a vast area,[14,15] altogether a creditable performance for a decade's effort.

Figs. 1 and 2 give some notion of the magnitude of the task, but give no hint of the arduous effort of the many field parties, of the large number of people involved, or of the organization required to complete the job. A number of accounts have been written describing different phases of the work[16] and although it is obviously impossible to credit each with his share in this short article, the author would particularly mention J. E. R. Ross (formerly Dominion Geodesist) who was an inspiration and driving force behind the whole program.

The Shoran equipment is a radar transponder system consisting of two transmitters and two receivers installed in an aircraft. On the ground, at each of the two fixed points, A,B, for which the separating distance is sought, one installs a transponder. The operation and recording is done in the aircraft. Each of the airborne transmitters (on slightly different frequencies to avoid mutual interference) emits a short pulse. One is received and returned by the transponder at A, the other signal is received and returned by the transponder at B. If we know the velocity of propagation of the radio wave, we determine the slant distances from the aircraft to the points A and B. The sum of these two distances is obviously a minimum if the aircraft is vertically over the midpoint of the line AB. If the aircraft is flown until this minimum is observed and recorded, and if at the same time the height of the aircraft and the elevations of A and B are known, then we can compute the distance AB. Fortunately, these various quantities can be determined with sufficient accuracy to enable one to compute distances of two to three hundred miles. To eliminate instrumental and systematic errors, the aircraft flies a prescribed pattern, the "line crossing techniques" about the midpoint which allows for slight displacement of the aircraft with respect to the plan position of the midpoint of AB. Distances to A and B are each recorded as the plane approaches, crosses, and recedes from the line AB. The result of several crossings is a good determination of this midpoint.

Curiously enough, the velocity of propagation and, in consequence, the velocity of light "c" in vacuo was one of the more troublesome items to resolve. Aslakson[17] had noted discrepancies in the velocity from accepted values in the early U.S. work with Shoran. A number of other investigators were determining "c" about the same era by different methods. Moreover, to correct for the difference between the velocity of light in vacuo and the velocity in air, observations must be made of temperature, pressure and humidity of the air between aircraft and ground points at the time the slant distance is measured (Appendix A).

Given a method of measuring long distances accurately, it is easy to see how a known geodetic base AB can be used to locate an unknown point X by measuring AX and BX and hence by successive trilateration, build up a large network of new geodetic points. Of course, the geodesist introduces independent checks whenever he can, but these are scarce in northern latitudes. It was possible to tie the large net shown in Fig. 1 to existing well established points in a few places. When this was done and any errors distributed throughout the new net, then it can be shown the positions of the new points are located within a radius of 70 ft. to 150 ft., or expressed differently, that the average error in line measurement does not exceed 1 in 60,000, which corresponds to good second order geodetic accuracy. The impressive statistic to remember, and this of course is an educated guess, is that seven or eight years' work accomplished as much as 100 years of conventional effort.

During the earlier years of Shoran operation in this country, the equipment was undergoing extensive redesign and modification in the United States by the manufacturer and the U.S. Air Force which was using the system for geodetic work. Finally, late in 1955, the revised version, Hiran, became available here and after a season of preliminary experience in 1956, the work performed in 1957 "showed marked improvement in accuracy as judged from day to day agreement and field adjustment results".[18] Details of the new Hiran have not been included here solely

Fig. 3. Location and layout of the Ungava Project

because, as mentioned by Hamilton[13] future use of Hiran for geodetic purposes seems unlikely, although the system has undoubtedly performed a service of lasting value to the country.[19]

Turning to the second objective of using Shoran controlled photography, experimental work was started in 1949 by the Army Survey Establishment, National Research Council, and the Royal Canadian Air Force. Clearly if the ground equipment is installed at known locations the position of the aircraft can be determined from the Shoran distances to these points. If the distance readings to the two ground stations are photographed on the airborne recorder simultaneously with the time of exposure of the vertical camera, then the ground position of the area is fixed with respect to the two ground stations.

A large area of Canada had been covered by aerial photography and the Shoran geodetic points had been located and measured. These, however, were too far apart for good control for mapping purposes. Additional control was obtained by setting up ground stations at these geodetic points and flying Shoran controlled flight lines over the same area. The lines being one degree apart in longitude and 20 minutes apart in latitude, the area thus had a grid of Shoran-determined flight lines superimposed on it.[14, 15] It is worth mentioning that an area of some 600,000 square miles was covered in this way between 1952 and 1956. By then, however, more economical methods were in sight, and use of the Tellurometer on the ground offered the advantage of permanently marking the ground control points with some kind of monument.

Tellurometer

This instrument has already had an important influence on the Cana-an mapping picture. Designed by . L. Wadley[20] at the C.S.I.R. in outh Africa, it is a light weight portble instrument of high accuracy, ufficient for geodetic work when sed carefully, and of even wider genal applicability to cases where all f its potential accuracy is not eeded.[21]

It has been extensively employed establish ground control points for erial photography and Fig. 3 shows network of such points set up in a ingle season. This operation showed reat economy of time compared to se of conventional equipment for ixing the ground positions. The points vere determined by running traverse nes using the Tellurometer for meauring distances and a theodolite (reading seconds) to measure angles. The Tellurometer is best suited to disances of the order of 2 to 30 miles, although there is considerable leeway at both limits. The survey shown in the figure was completed by a party of 19 men, seven of whom were surveying personnel, in six weeks, and covered a distance of 2,700 line miles,

In fact S. G. Gamble,[22] reporting on the operation, states the principal factor limiting the progress of the traverse was the difficulty of moving the supporting camps fast enough to keep up with the surveying parties.

Before commenting on the operation of the instrument, some general remarks about length measurement by wave-lengths may be in order. Consider Fig. 4(a) and let AB be a distance x we wish to determine. If we choose a wavelength comparable to x, then energy radiated from A to B will produce at B oscillations that are retarded in phase, compared to those at A, by an amount $\theta = 2\pi x/\lambda$, i.e. $= 2\pi \cdot f \cdot x/c$. Hence, for this oversimplified case, the distance $x = \theta\lambda/2\pi$ is determined by measuring θ.

The percentage error in measuring θ is independent of the wavelength and it is obviously to our advantage to use the smallest practical value of λ in any given situation. This at once introduces an ambiguity into the distance x depending on the number of unrecognizable whole wavelengths in AB (Fig. 4(c)). All that is measurable is the fraction of the whole wavelength (as illustrated in Fig. 4(b)), whence the distance AB is found uniquely by observing only the two fractions Y_1 Y_2, the units l_1 and l_2 being known. The same pattern will be repeated in each distance A'A', which is the l.c.m. of l_1 and l_2. Introducing additional l_3 l_4 will increase A'A'.

Another way of looking at this is to say that the total phase angle θ measures the distance x, since

$$\theta = 2\pi \cdot f \cdot x/c$$

for any frequency. Using two frequencies f_3 and f_2 which would yield

$$\theta_3 \text{ and } \theta_2,$$

we can extract the phase angle

$$\theta_1 = \theta_3 - \theta_2$$

which corresponds to that we would have measured had we used a frequency $f_1 = f_3 - f_2$ (see also Fig. 4(d)).

Any angle is indeterminate, however, because

$$\theta = n \cdot 2\pi + \phi$$

where ϕ is that incomplete portion of 360° we can detect and measure (Fig. 4(c) ϕ_1 ϕ_2 ϕ_3).

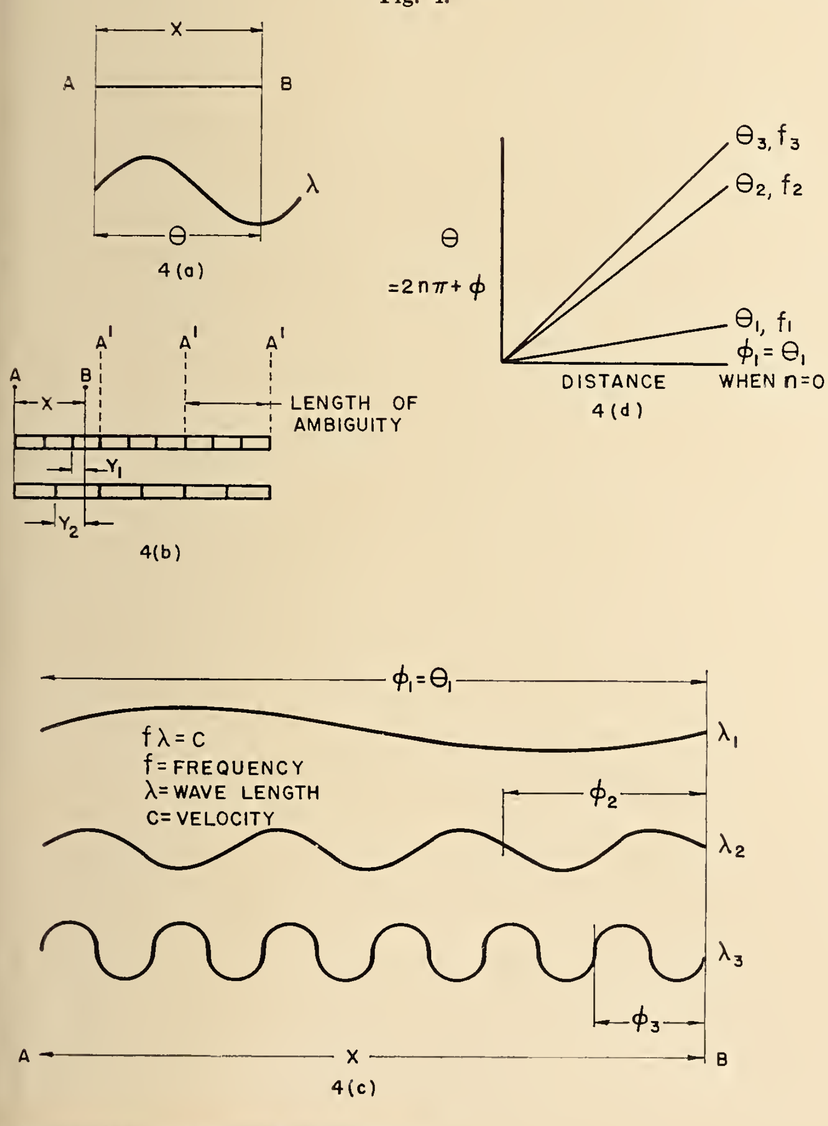
If we choose f_3 and f_2 sufficiently close together, n will be the same for each and

$$\theta_1 \text{ becomes equal } \phi_3 - \phi_2$$

The fictitious frequency f_1 is equivalent to using a longer wavelength, to remove the ambiguity. If we seek the highest possible accuracy we use the highest frequency practicable and apply this reduction of ambiguity several times over. The precision of the distance determination is set by the highest measuring frequency employed, the extent of removal of the ambiguity by the lowest fictitious frequency calculable. In the Tellurometer case, these frequencies are 10 Mc/sec. and 10 Kc/sec., corresponding to accuracies of about 10 cm and ambiguities of 15 Km respectively.

A brief description of the instrument and measurement principles follows (Fig. 5) and Wadley's paper can be consulted for further details. The equipment at point A of the line AB to be measured is called the Master Station and that at B, the Remote Station. (Actually, the sets can be built to be interchangeable in function but these details and a two-way telephone circuit are omitted for the sake of clarity.) From the master station a radio frequency carrier (3,000 Mc./sec.) is

Fig. 4.



emitted continuously. The choice of carrier frequency, largely one of convenience, is not dependent on the measuring system. The measurement frequency, from a crystal oscillator, is superimposed as frequency modulation of the carrier. The various modulation frequencies used correspond to the frequencies (or waves) employed in the previous discussion, and crudely expressed, the carrier can be regarded as just a convenient way of conveying the measurement frequencies from one end to the other. The modulation will suffer a phase retardation travelling from A to B. At B the circuits are arranged to send this phase information back to A (it will, of course, suffer a second equal retardation on the return journey) and at A, the phase of the received signal is compared with that originally emitted. At B the effect is as though the 10 Mc/sec. modulation were redirected to A without any phase change occurring in the modulation.

The measurement process can be illustrated more readily if numerical values (as shown in Fig. 5) are used. From point A the 3000 Mc carrier frequency modulated at 10 Mc/sec. is emitted and travels to B, where a small portion of the B transmitter output is used as the local oscillator to beat with the signal from A, giving an i.f. output of 33 Mc/sec. Now the 3033 Kc carrier of the remote (or B) transmitter is itself frequency modulated by 9.999 Mc. Consequently, after mixing and detection of the two r.f. waves, the 33 Mc/sec. intermediate frequency is found to be amplitude modulated by $\pm(f_B - f_A)$. The output of the second detector will therefore be 1 Kc for all corresponding pairs of modulating frequencies from the oscillators at A and B (Fig. 5). This 1 Kc is phase locked to the difference in phase $f_B - f_A$ and is used to generate a pulse (also phase locked to $f_B - f_A$) which is applied as a second modulation of the 3033 carrier, frequency modulation being used in this case also. (This pulse of 1 Kc f.m. has no effect on the first detector action at B, mentioned earlier.)

The modulated signal emitted from B is transmitted to A on a carrier of 3033 Mc/sec. and on arrival, is immediately mixed with a small portion of the A transmitter output, so that the detection process at the master receiver will be analogous to that at the remote receiver, with one important difference. The input signal to the master receiver is a 3033 Kc carrier, frequency modulated by 9.999 and also frequency modulated by a 1 Kc pulse which is phase locked to the different $f_B - f_A$. After passing through the first detector in the receiver at the master station, the i.f. frequency (again 33 Mc/sec.) has an additional frequency modulation in the form of 1 Kc pulses. The i.f. amplifier is therefore followed by two detectors in parallel. One of these is a frequency discriminator which turns the 1 Kc frequency modulation pulse into a d.c. bias pulse that is applied to the intensity control of a cathode ray tube acting to extinguish the spot (at a point determined by the phase difference $f_B - f_A$). The other amplitude detector produces a 1 Kc. sine wave (locked to the phase difference of $f_A - f_B$) which is used to generate a circular time base applied to the same cathode ray tube. That is to say, the start of one full circle of the time base is locked to the "comparison frequency" of 1 Kc formed at the Master unit from $f_A - f_B$. There is a fixed phase relationship α between the I Kc signal generating the time base at A and the 1 Kc signal blanking the pulse, because both 1 Kc signals are derived from the same pair of modulating frequencies. The magnitude of α is a function only of the length of path A-B-A. The phase α (measured at I Kc) is identical with that which would have been observed directly on 10 Mc which can be called ϕ_{10}.

There is a built-in check to eliminate internal zero error in the time base. At the remote station, an extra fifth modulating crystal of 10.001 Mc/sec. Mc is supplied. When this is used in place of 9.999 Mc/sec. the phase angle will be $-\phi_{10}$ so that the difference between the two $= 2\phi_{10}$ can be used to locate the zero point and to deduce a phase angle for an equivalent 20 Mc modulation.

This whole process is now repeated using the master frequencies 9.99; 9.9; 9.0 Mc/sec. (with corresponding remote frequencies of 9.989; 9.899; 8.999 Mc/sec.). The three phase angles so determined, ϕx, ϕy, ϕz, when subtracted from ϕ_{10} give the equivalent angles for 10 Kc., 100 Kc., and 1 Mc/sec. modulation frequencies.

The operation of the Tellurometer is much more straightforward than the above description would suggest. It has proven simple and reliable, most of its possible internal errors are self-cancelling, and the accuracy of the 10 Mc oscillator, on which the final accuracy rests, can be checked in the field by referring to standard frequency transmissions.

As is well known, microwaves can be reflected from various obstacles and multiple signal paths for the microwave carriers used could be troublesome. Such deleterious influences can be largely eliminated by repeating the distance measurement with slightly different carrier frequencies, feasible since the instruments have been designed to work in the range 2800 to 3200 Mc/sec.

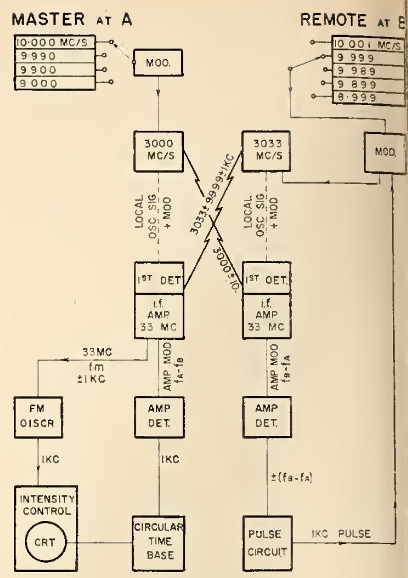


Fig. 5.

Because microwave communications demand line-of-sight paths, two N.R.C. modifications are available,[23] both of which are intended to elevate the antennae above ground so that observations can be made above tree-tops and other similar obstacles, permitting distances to be measured in wooded country without the necessity of clearing line-of-sight paths. The elevated antennae have proven useful when working over frozen lakes where abnormal decreases in signal strength have sometimes been encountered. In fact, the scientific reason for such abnormal propagation is still under investigation at N.R.C. and has occasioned some interesting investigations on surface waves in general as a by-product.

Concluding this section, we should remark that the Tellurometer has firmly established itself as an instrument of the greatest importance to Topographic Survey and others and should see further important employment in the future. In geodetic work, greater care must be exercised[24] but it is capable of great accuracy under proper conditions.

Geodimeter

It would be inappropriate to leave the subject of geodetic measurements without mentioning the Geodimeter. This instrument, developed by E. Bergstrand in Sweden[25] has been used extensively throughout the world and is used here by the Canadian Geodetic Survey and others. Three different versions of the design are manufactured. One which is relatively rge and heavy has the greatest range ıd accuracy; an intermediate model; ıd a third somewhat more compact ıd weighing about 70 lb., giving sser ranges and accuracy. The manufacturer's claims for the performance the large instrument are ranges up 20 miles with errors of ±0.4 in. +1 pm., and for the third instrument, mges up to five miles with errors ±0.4 in. +5 ppm. The third instrument is useful at short distances of ıe order of 15 yd. and is stated to e usable with care in normal daylight. The maximum range in daylight will depend on the type of reflecting target used, but can be between 500 and 2,000 yd.

A description of the principle of operation has been published by Empire Survey Review.[26] It somewhat esembles the method described by Anderson[27] in his determination of he velocity of light. Briefly, a light beam, modulated by a 10 Mc/sec. ignal, is sent to a distant reflector. Upon return to the transmitter site, he phase of the modulation is compared with a time delay generated nternally at the receiver. This is repeated with two other modulation frequencies 10 Mc/sec. ±1%, so that, f the distance is known to within 1500 metres, the exact length may be computed. A seeond square wave modulation is also superimposed on the light beam with each of these three frequencies, but although required by the circuitry adopted, does not affect the principle of determining the distance from three different modulating frequencies. In the case of the smallest model, the modulation frequency is 30 Mc/sec. which is helpful in reducing errors.

Commencing in 1956, the Canadian Geodetic Survey[28] has been using the large Geodimeter for measurements of first-order base lines. After carefully comparing geodimeter results on two lines with distances measured with invar tapes, the instrument was used to measure four new base lines varying from 12.6 to 16.9 miles. The program of observations adopted was to make at least 10 measurements a night for at least three nights, a remark which outlines a disadvantage of the system in that work has to be done at night when it is quite dark but visibility good. The results indicate accuracies of the order of 1 in. ±2 ppm.

It is, of course, necessary to correct the velocity of light in vacuo to correspond with the atmospheric conditions prevailing at the time of measurement. Pressure and relative humidity have less effect than air temperature, but all three are observed (see Appendix A). Because these quantities are observed only at the ends of the line where the operators were situated, a required condition for observation was that there should be some wind blowing.

The Geodetic Survey has continued to use the Geodimeter since its introduction and it is understood some of the provincial government survey organizations are planning extensive measurements with the more portable models.

Although both Geodimeter and Tellurometer measure distances accurately, they are not strictly speaking interehangeable instruments and each has its own role in future work in this country.

Two Range Decca

Of course the surveyor on dry land is not the only one interested in electronic aids. Maritime navigational aids have existed for a long time. One well-known system, Decca, of pinpointing the position of a vessel was developed in Britain during the war and refined for general use later. In customary practice, three transmitters are located at known geographical points, each broadcasting unmodulated cw signals on a frequency somewhere in the band 70-130 Kc. This established a reference grid, actually a hyperbolic grid, against which anyone with an appropriate receiver can determine his own position. In the hydrographic application, two stations (called the slave stations) are set up on shore and the master transmitter is located on the ship. This system was used by the Canadian Hydrographic Service as early as 1955.[29] In such a case, the Decca receiver readings are used to compute the distances from the ship to the two points on shore, and because the radio wavelength involved is long, the ship can measure these distances accurately when well below the horizon. The method has been used to fix the ship's position, while she is running sounding lines, both in the Gulf of St. Lawrence and in the Hudson Straits and Ungava Bay. The two range Decca system permits the ship to operate during conditions of unfavourable weather and increases the useful output of hydrographic records about threefold, an important economy when one remembers the cost of operating ships in Arctic waters and the short navigational season there. The two range Decca belongs in the class of systems available commercially which have already proven their value to Canadian surveying requirements, and which will undoubtedly serve well in the future.

Microwave Position Fixing System

This item is best referred to as a system because, although it is in an advanced stage of development, it is not yet in production. Designed by H. R. Smyth of the National Research Council[30] for hydrographic survey purpose, it may well have uses ashore of great importance to surveyors, as may be evident from the following brief description.

The objective, from the hydrographie point of view, is to measure the angles subtended by three fixed shore-based microwave transmitters at a distant moving ship with sufficient accuracy that the ship's course may be plotted and hence soundings and other hydrographic data correctly charted. In clear weather, optical measurements are suitable, but the radio system will operate satisfactorily under any conditions of visibility. It is an inshore system because a line-of-sight path is required from the microwave transmitter to the ship's aerial. As the ship's antenna can be placed high above the water line, and the antennae on shore can also be raised reasonably high above the ground, the range with the radio device should exeeed the visible range from the ship's bridge. In any event, the method has been under practical test at sea for the past two seasons by the Hydrographie Service of Mines and Teehnieal Surveys.

In the M.P.F.S. system, the shore based transmitters, which can be comparatively light weight and compact, emit pulsed signals, whose repetition rate and duration need be controlled to only 10%. On board ship, a highly directional receiving antenna rotates continuously. The radius vector representing the orientation of maximum received signal is thus rotating uniformly. As it sweeps over the first shore station, the input signal to the receiver will be a series of pulses of varying strength, the maximum of which will be the direction of the first station.

The envelope of these pulses will have a maximum in the direction of the shore station and if this envelope-signal is differentiated electrically, the output will be zero for the case of the antenna pattern pointing directly towards the shore station. This instant is used to trigger a short pulse, which opens a circuit serving as a gate to permit locally generated pulses to pass and be counted by an electronic counter.

The ship's antenna continues to rotate and when the direction of maximum reception passes over the second shore transmitter, a second trigger pulse is generated. This trigger pulse closes the gate to the counter which stops counting. Simultaneously, a second gating switch is opened and a second counter comes into operation to be stopped in turn when the ship's antenna points to the third shore station.

The local pulses which are counted may be produced in a number of ways. They are generated by securing a perforated disk to the axis of rotation of the revolving antenna. The disk is used to interrupt a beam of light to a photocell so that the local pulses are automatically synchronized with the antenna. The angle between any two transmitters is, of course, linearly proportional to the number of counts registered.

The angular resolution of this system is a function of the beam width of the receiving antenna pattern and of the pulse repetition rate of the transmitter and so can be varied by the equipment designer over reasonable limits to fit different application demands. In early testing work, receiving beam widths of from 1° to 2½°; rotational speeds of 1/3 to 1 rev. per sec.; and pulse repetition rates of 1½ to 5 Kc were tried.

The agreement obtained (for ship speeds of the order of 7 to 8 knots) with visual observation of the angle by sextant for 429 readings was good. 262 radio angles agreed within ±6 minutes, 356 within ±12 minutes, and 404 within ±18 minutes where sextant errors were estimated to be ±5 minutes.[30] However, repeated measurements of a single distant transmitter (i.e., measuring an angle of 360°) with the receiver at a fixed point on the ground show clearly this angle could be determined to within a minute, and give encouragement to the notion that if the system were built specifically for ground station application, this figure might be improved by a very substantial amount, and one would expect to measure angles to within say 20 sec. of arc, or better. (Fig. 6 is reproduced from Smyth's paper.) Further results from the MPFS system are awaited with interest.

Photogrammetric and Other Applications

All the equipment outlined so far has the common feature that it measures distance (or position). To complement this useful assistance, the electronic engineers have presented us with some valuable auxiliary aids for specific explorations and will no doubt turn up with more at some time or other. Mentioning only airborne scintillometers and airborne magnetometers reminds one that these have both been used extensively in this country. The latter was used commercially in 1947[31] in Canada for the first time. The recent appearance of the free precession proton resonance magnetometer is an interesting example of the rapidity with which new physical principles are being applied nowadays in most unexpected avenues. This instrument is portable and light weight and can be used on the ground or in the air, and is capable of rapid accumulation of survey data. Shipboard equipment includes portable gravimeters and echo sounders, the latter being so familiar that the electronic part of it is forgotten, although small economy sized versions for popular pleasure craft incorporating ingenious new technical points have been placed on the market lately. The variety of instruments available is continually increasing and the trend is to specialized solutions rather than towards a universal one.

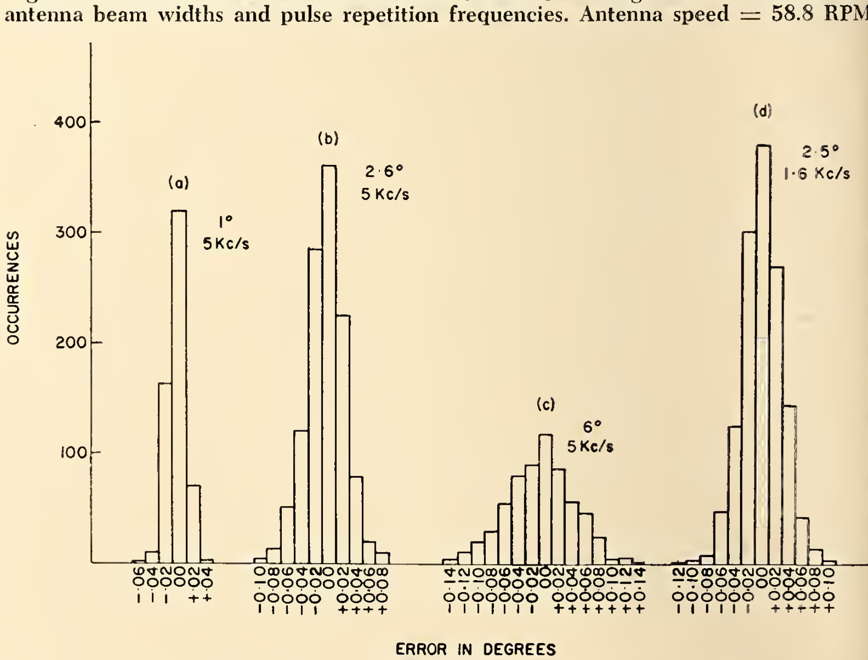
As the mass of data to be analyzed and plotted increases, one naturally thinks and turns to electronic computers for assistance in calculations. Indeed, various such calculating machines have been used with great effectiveness and despite their high cost per hour, their use often effects great economy. Again, there is no universal answer and each problem must be examined on its own merits.

Electronic machines performing our calculations are attractive and useful per se, but a useful aspect of computer circuits is the ease with which they can be incorporated as part of a machine to increase its versatility. Thus the computing portion of a machine could readily allow for changing instrumental conditions in the input information, or give instantaneous output results while the machine is continuously operating; it could yield recorded results of a complete or incomplete operation; in tabular form or in some such form as punched cards or magnetic tape, suitable for applying directly to another device as input data.

The scope is obviously very broad and has already attracted the attention of the photogrammetrist. An example of such development is the Stereomat described by G. L. Hobrough.[32] (It is also referred to as the Auscor.) This is a device that may be attached to a conventional stereoplotter to perform three functions automatically. It determines the x and y parallax at any point of the model, it eliminates the y-parallax during orientation and it corrects the x-parallax automatically. As is frequently the case, these functions are achieved by a combination of electrical circuits and electromechanical units which is a pretty broad interpretation of a "computer circuit". The Stereomat provides an excellent way of automatically drawing contour lines and the device has attracted considerable attention and many applications are envisaged.

Another Canadian development (to assist the map maker rather than the surveyor) is the Analytic Plotter described by U. V. Helava.[33] In this machine, we do not form a complete optical model as is done, for example, in the Multiplex. Instead the position of an image point is computed, allowance can be made for any number of systematic errors, including those determined experimentally. A wide variety of camera lenses can be used in the original aerial photography without upsetting the operation of the plotter, resulting in an extremely versatile instrument. Used in conjunction

Fig. 6. Distribution of error on measurements taken on an angle of 360° for different antenna beam widths and pulse repetition frequencies. Antenna speed = 58.8 RPM



ith analytical aerial triangulation iethods, it can produce the "adjusted rientation elements and co-ordinates f air stations" which data can be ecorded and used to regulate the ettings of the analytic plotter, thus iving the time usually spent on relave and absolute orientation of the hotographs. The machine has numerus advantages in the conventional hotogrammetric production line and t becomes a key link in any method hat employs other electronic data rocessing. Great potential economic dvantage is predictable by making ossible automation of some photogrammetric operations.

Part of the instrument can be decribed as a viewing-measuring deice. the other part being the comuter. For greatest flexibility and veratility, the computer was originally a hybrid of digital and analogue comuters.[34] Another suggestion by Helava to use a digital incremental computation technique has the advantage of simplifying the computer. These and other considerations have been well covered in a discussion by Helava[35] and would take us too far afield to pursue here.

Of course, these two instruments are not the only electronic devices that exist to assist photogrammetry, but were selected as examples because it is believed they have important future applications on a wide scale and represent local developments in which we can all take pride. Another important application which has been omitted here is the use of Doppler navigational systems, already used as an aid in photographic flying,[36] and which may well possess further photogrammetric applications in future.

There are still obvious gaps in equipment that could profitably be put to work for the surveyor and photogrammetrist. Despite effort in several places, no good solution to the distance measuring problem in the range, say, 30 to 100 or 125 miles exists. The recent physical development of optical masers and the production of coherent radiation at optical frequencies will probably have useful applications. The development of refined angular measurements by radio means could also be a valuable addition. Various systems exist today for establishing electromagnetic grids to enable observers with special receivers to locate themselves. One would hope in time to see great reductions in weight of equipment and substantial improvement in accuracy, and if economically justified, such systems might play an important role in definitions of lines and area boundaries, even to the point where we no longer require monuments.

This review treats many topics in a superficial way and was written to give a general account of the Canadian picture. References to work in other countries are necessarily incomplete, but can be pursued through those quoted by anyone interested. In any event, contributions by individuals in this country to the overall world picture have been significant. The large scale application of new equipment by governments and commerical services has accelerated the acquisition of knowledge of our country. The accomplishments to date already stand as a magnificent tribute to those who have played a part therein and should serve as encouragement to themselves and others to continue in the future.

Acknowledgements

The author wishes to express his thanks to all those who have helped with advice in the compilation of this review. Any errors and omissions, however, are his own. Particular thanks are due to Dr. L. E. Howlett, S. G. Gamble, Col. C. H. Smith, T. J. Blachut, H. R. Smyth, and Dr. A. G. Mungall. He also wishes to thank Department of Mines and Technical Surveys for Figs. 1 and 3, and the Directorate of Military Survey for Fig. 2.

APPENDIX A

Note on Velocity of Light

The velocity of light in vacuo, adopted in 1957 by Union Radio Scientific Internationale and by Union Geodesie et Geophysique Internationale is 299.792.5 ± 0.4 Km/sec.

In September, 1960, U.R.S.I. recommended using the formulae below for calculating refractive indices (associated with distance calculations when optical or radio methods are employed).

(a) for light waves (the Barrell and Sears formula) ·

$$(nG - 1) \cdot 10^7 = 2876.04 + \frac{16.288}{\lambda^2} + \frac{0.136}{\lambda^4}$$

where:

λ = the light group wavelengths in microns reduced to ambient conditions by

$$L = \frac{nG - 1}{1 + \alpha t} \cdot \frac{p}{760} \cdot \frac{0.000\,000\,055\epsilon}{1 + \alpha t}$$

where:

L = refractive index in ambient conditions

nG = refractive index in dry air with 0.03% CO_2 at N.T.P. (0°C, 760 mm. Hg.) for light of the group wavelength employed, calculated as above

t = temp in °C

p = atmospheric pressure in mm Hg

α = coefficient of expansion of air (0.003661) °Cu^{-1}

ϵ = partial water vapour pressure in mm Hg

(b) for radio micro-waves (the Essen and Froome formula):

$$(n_r - 1) \cdot 10^6 = \frac{103.49}{T} \cdot (p - \epsilon) + \frac{86.26}{T} \cdot \left(1 + \frac{5748}{T}\right) \cdot \epsilon$$

where:

T = Temp in °K

p = atmospheric pressure in mm Hg and:

ϵ = partial water vapour pressure in mm Hg

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Discussion

GLACIAL LAKE CLAY DEPOSITS

Determination of their original depth in the Great Lakes Region

G. T. Hughes, M.E.I.C.
Associate Professor,
R.M.C., Kingston
The Engineering Journal, February, 1961 page 58

Discussion by T. Cameron Kenney

Professor Hughes has recommended the use of the laboratory consolidation test to estimate the maximum pressures which have been applied to clay deposits. However, to accept this method we first must be willing to accept the following important implication of the method: the compressibility characteristics of a soil are dependent *solely* upon its applied stress history. This implication is not acceptable in general for the following reasons. Let us consider the case of a normally consolidated soil at the bottom of a deep body of water. Due to some geological cause the water level is lowered, and as a result of the consequent decrease in pressure of the water in the soil, chemicals come out of solution and are deposited on the soil particles thus cementing them together. If we now were to perform a consolidation test on this soil, the bonding affect of the chemical precipitates would be exhibited as an apparent preconsolidation pressure even though the stress history of the soil was that of normal consolidation. This type of condition has been reported by Bjerrum and Wu[1] for the Lilla Edet Clay in Sweden. It is also possible for a normally consolidated clay to exhibit similar apparent pre-consolidation affects due to natural hardening or thixotropy. This type of condition has been reported by Leonards and Ramiah[2] for a remoulded soil. Although no cases have been reported, it would also seem possible that a preconsolidated soil could lose some of the effects of the past loadings by becoming more compressible due to chemical processes weakening the soil structure.

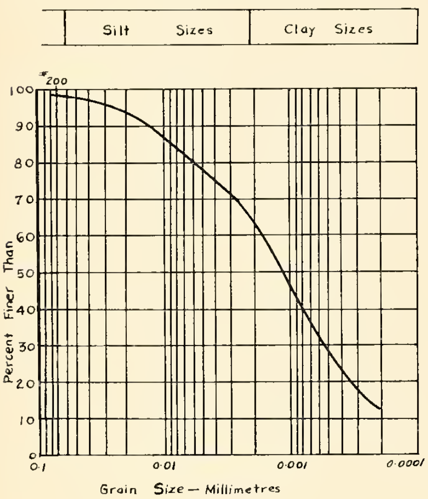

Fig 1

The foregoing considerations are very general but they point out that the compressibility charaeteristics of soils do not necessarily remain unchanged even under the conditions of constant applied stress and, therefore, the preconsolidation pressures exhibited in laboratory tests are not necessarily equal to the maximum applied overburden pressures in nature. For this reason it must be concluded that we have not reached the stage where the results of consolidation tests can *alone* be depended upon to indicate the correct maximum stress history of a soil sample.

In his paper Professor Hughes has also made passing referenee to certain test results on samples obtained from below Lake Ontario which indicate that 100 feet of overburden has been eroded from the bottom of this lake. This conclusion can be seriously questioned on the basis of the above considerations of the consolidation test, and also because of the possibility that these soil samples were of glacial till which have been subjected to the weight of overlying ice. It would be of interest if Professor Hughes would give the results of some of these consolidation tests, a typical grain size distribution curve of the soil, and the evidence he has to support the conclusion that the clay is not of glacial origin and, therefore, has not been subjected to ice loads.

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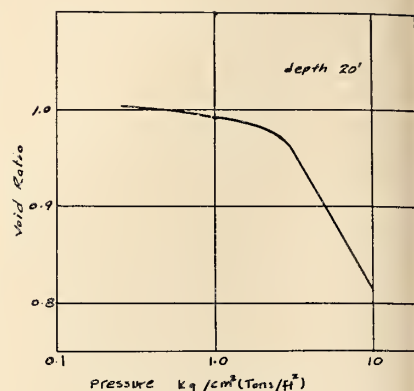

Consolidation e log p curve
Fig 2.

(2) — Leonards, G. A. and Ramiah, B. K. 1960. "Time effects in the consolidation of clays". A.S.T.M. Spec. Tech. Publ. Np. 254: 116.

Author's Reply

In his diseussion, Mr. Kenney elaims his statements are supported by the findings in two papers, one by Bjerrum and Wu [1], the other by Leonards and Ramiah[2]. I will show that the findings in these two papers do not necessarily apply to the results I have reported.

Before replying, I would like to have it clearly understood that these two papers Mr. Kenney refers to were published at a *later date* or after my article "Glacial Lake Clay Deposits" was submitted to the E.I.C. Journal for publication. For this reason, no reference could be made to them.

The papers by Bjerrum and Wu, Leonards and Ramiah have very interesting and, I am sure, reliable results. However, for the reasons to be diseussed, I believe that my findings cannot be questioned by Mr. Kenney on the basis of their results alone.

The determination of the preconsolidation load as suggested by Casagrande [3] is well recognized, and is widely used. To support his findings, Casagrande states that from a large number of tests on different types of soils it was found that for the majority of clays the preconsolidation load can be derived with a satisfactory degree of accuracy by means of the empirical method he suggests. This method was used in my analysis.

The article by Leonards and

Rmiah [2] refers to soils which have n consolidated from samples re- ulded at the liquid limit. At a load approximately 0.4 T/sq. ft. samples e allowed to sit in the consoli- meter for 12 weeks. After that lapse time, *small* pressure increments re applied and they report; "at ll pressure increments, a quasi- consolidation pressure is observed t is considerably larger than the ximum previous consolidation ssure". This increase is from an ginal 0.4 T/sq.ft. to about 0.7 sq.ft. This increase is suggested to due to a comparatively rigid bond ich may develop under such sus- ned load. However they note that s bond is susceptible to sudden eakdown as soon as the pressure ceeds a critical value. They also re- rt that if the conventional consoli- tion test is used on the samples here small increments of load are t used) the preconsolidation load is eater than that previously subjected the sample but nevertheless it is *low* the quasi-preconsolidation pres- re. This article does not show test sults for samples that have been loaded and then loaded again in e manner as illustrated by Casa- ande. Therefore there is no proof at this quasi-preconsolidation would in evidence under this type of ndition. Casagrande's [3] results in- icate that with the increments of ad as used in the consolidation test is state does not appear to take lace. The results I report were for mples that had been unloaded — nd for a long period of time, before econsolidation.

For further proof, consider the re- ort by Wu [4]. He indicates that for he soils tested, the preconsolidation oad as determined from the consoli- ation test is in good agreement with he present overburden pressures and herefore are considered normally oaded. Therefore it would appear hat for these normally loaded soils, nd using a normal consolidation test procedure, reasonable results can be btained.

Mr. Kenney refers to the bonding effect of possible chemical precipi- tates which would be exhibited as an apparent preconsolidation pressure. This phenomena was reported by Bjerrum and Wu [1] to give an increase in cohesion of only 0.1 T/sq. ft. for the soils they tested. These samples were taken from a soil deposit which had been submerged some 100 m. below sea level — *not fresh water.* Although they report a higher preconsolidation load than expected, they also report preconsolidation loads from the consolidation test to be in agreement with the maximum pressure that exists in the soil today. These results are in borehole 1. Therefore even in marine soils this bonding effect did not appear to always be present.

To check the possibility of bonding effects due to precipitation in fresh water, consider the test results for a soil deposit which has been submerged to some depth and then the water level lowered as Mr. Kenney suggests. Wu [4] reports some consolidation results for soil samples which were at one time submerged below fresh water glacial lake Maumee. Leverett and Taylor [5] report that lake Maumee was about 200 feet higher than the present day lake level. The precipitation of chemicals causing bonding as suggested by Mr. Kenney would occur due to lowering of the lake level does not seem to be apparent in Wu's results. Wu states "the good agreement between the measured preconsolidation pressures and the existing overburden indicate that most of the soft to medium clay deposits are normally loaded". No abnormally high preconsolidation load appears to be present either because the bonding effect is too small, or because these are fresh water deposits and not sea water and perhaps do not have proper chemicals for bonding. Therefore I would suggest that Mr. Kenney can not use this as a valid argument. It should also be noted that Bjerrum and Wu state "the observed phenomena reflect a special property of *this particular* clay" and "very likely the affect is limited to clays with a certain mineralogical composition". It does not necessarily mean *all* soils will behave in this way.

While discussing bonding effects due to chemicals in soils, I refer Mr. Kenney to a paper by R. M. Hardy [6] 1950, in which he shows results of the collapse of structure upon the addition of water.

Visual examination of the samples before and during drying does not reveal a condition as defined as glacial till. As to the possibility of the soil having been loaded due to overlying ice, Baker [7] reports "thinly laminated clays in the Kingston area are found from the present lake level up to an altitude of 250 feet above the lake. The laminations show no crumpling or crushing of strata as would be expected to be caused by ice moving over them".

I conclude that the results as reported are not to be seriously questioned as suggested by Mr. Kenney.

Figure 1 and Figure 2 show typical grain size distribution and consolidation test result, respectively.

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REARWARD COMMUNICATIONS FOR BMEWS

Leo J. Hammerschmid, M.E.I.C.
Terminal Equipment Engineer,
The Bell Telephone Co. of Canada

The Engineering Journal, July, 1961, page 51

Discussion by D. S. Edwards

The paper mentions that preference was given in the choice of communications routes for BMEWS to the use of commercial routes, where adaptable. It is a fact however that the reliability, and performance could only be met with so-called long-haul facilities. As a result, to provide these requirements, we were forced to rebuild one section of an existing microwave system, and to extend our existing TD-2 network.

We would like to expand a bit on Mr. Hammerschmid's paper with regard to the facilities used for R.C.S., beeause some of the techniques used in our section will be of interest to those connected with the communications industry, and this outline will serve as an indication of the magnitude of the project, to those not so closely aligned with communications.

The newly built section in our territory — about 300 miles in length and consisting of two extensions, one north, and one south from our existing TD-2 network — uses standard radio equipment and power plants. The equipment layout, buildings, and towers however are not standard. This was necessary partly because of the high cost of standard buildings and towers, and partly due to the long delivery interval for these items. Time was at a premium. The equipment layout was designed to facilitate expansion, and to eliminate out-of-service time generally associated with expansion. Buildings on their part were designed to grow from either end, again to facilitate expansion. Power plants were installed in special temporary enclosures to be moved into the old existing buildings when the replaced microwave system has been dismantled. A new and unique type of tower — a guyed tower in fact — was designed to accommodate the initial two, and final four cornucopia antennae at each site. These towers were in fact designed to deviate no more than ½° in either the horizontal or vertical plane at the antennae mounting points in a 100 m.p.h. wind while covered with ½ in. of ice.

In addition, no wire facilities were available along the rebuilt route to carry the order circuit and alarm system inherent to the TD-2 systems. The tower at one of our important centres, and terminus of the rebuilt section, was loaded to capacity. These two problems were solved in part by rerouting an existing 240 channel microwave system operating in the 6000 Mc frequency range over two hops of the TD-2 system, by using special filters and transducers to multiplex it onto the TD-2 antenna system. This then eliminated a large passive reflector load on the subject tower, and allowed the installation of the TD-2 antennae. A 450 Mc full parallel frequency V.H.F. system was installed to provide the facility for order circuit and alarm system for the rest of the route. Both the 6000 Mc system, and the V.H.F. system will be used to provide up to 240 voice circuits the case of the former, and 24 in the case of the latter for inbetween offices.

The existing TD-2 network was expanded on 320 miles of its length This expansion involved additions of second antennae over a 200 mile portion, and a complete redesign over the remainder. The southernmost 120 miles of our existing network is now carrying 5½ radio channels, and has been completely changed to enable expansion with almost no service interruption on any of the in service channels, to its theoretical maximum of 12 radio channels.

All the changes to the existing facilities, including the rebuilt portions, and the rerouted system were accomplished with no serious outage of service. The moves of the actual radio channel equipment varied from a few feet, and from one antenna system to another, to as much as a hundred miles and a completely new location, in the case of the rerouted equipment.

While we have dealt with only a small portion of one route of the R.C.S., herein, we hope it has given a small glimpse of the overall complexity of the complete system, and the enormous job of the co-ordination required to build a system of this magnitude. This of course has again only covered one part of the overall BMEWS project however it has we think indicated the approach of the communications agencies to the problem of data, and data transmission.

Discussion by G. E. Graham

It is difficult to imagine the tremendous amount of engineering knowledge and effort that is involved in providing such a system. I think that Canadian engineers can be proud of the part played by their colleagues in making it a reality.

The provision of line facilities good enough to meet the stringent transmission and reliability requirements of BMEWS created problems which only a high degree of technical competence could resolve.

In the section of line facility provided by the Maritime Telegraph & Telephone Co. Ltd., and the New Brunswick Telephone Co. Ltd., we were required to engineer, furnish and install a complete new microwave system in a period of about 14 months instead of the normal 21 to 24 months.

It would be interesting to know if the forward scatter system used on some of the routes have successfully met the reliability and transmission requirements that have been indicated as necessary by the defence authorities.

In our territories we have found that the provision of really reliable a-c power supplies is our most difficult problem. The solutions to this problem to date have been very expensive and not completely satisfactory.

The successful operation of the BMEWS system over the distances and facilities involved is a good indicator of the ability of Canadian communication companies to handle the data transmission problems of the future.

There are many experts who feel that data transmission of all sorts may soon exceed in volume the transmission of ordinary speech.

I understood that secrecy requirements make it necessary to be somewhat vague about exact technical specifications, but we might have gained more insight into the difficulties of designing, constructing and operating the BMEWS system if the stiff electrical requirements of the connecting facilities had been spelled out in precise terms. As an engineer working in the communications field, I know that the required limits could not have been met by the techniques and materials available to us ten years ago. The systems used to provide the service are generally operating at the outside limit of their cap city in the area of allowable noise the channel.

BMEWS designers have taken a vantage of a number of techniques ensure reliability. The use of redu dant routes and the selection of th encoding process would seem to e sure an essentially continuous servic

I feel that the original system en gineers did not have complete con dence in the line facilities, howeve since it is my understanding that th data system will continue to opera even if the noise level in the voic channels reaches a point which woul render these channels unusuable fo regular commercial service. The de signers have tried to get the resu they want by combining all of th methods available to them into on package.

The continued successful operatio of the system depends on the co operation and efforts of many peopl scattered over thousands of miles c country and operating a bewilderin variety of communication equipmen I feel that only the experience gaine in operating transcontinental com munication systems has made it pos sible to successfully set up th BMEWS network as it now exists.

Discussion by W. A. Logan

The New Brunswick Telephon Company and the Maritime Tele graph & Telephone Company, Ltd provided the Maritime portion of on BMEWS route to Thule. The portio of the route through Nova Scotia and into New Brunswick is routed on a microwave structure especially buil to meet the defence requirements o S.A.G.E. and BMEWS, as well as to handle ordinary message traffic Facilities previously existing providec 13 hop versus 11 for the new structure. When this project was started United Kingdom built Microwave Radio of General Electric Company manufacture offered the best answer to our various criteria.

The selection of this particular equipment involved the use of a-c powered bays as opposed to battery powered bays extensively used in North America. Reliability standards imposed by BMEWS called for a minimum interruption in the transmission path. Various systems are available to overcome interruption caused by commercial power failure. In this system, a three machine no-break set was used, consisting of diesel, flywheel, motor, alternator. The motor is normally running off commercial a-c and the alternate supplies the load. Upon power failure, the flywheel powers the alternator while the diesel is coming up to

THE N.A.E. FIVE FOOT SUPERSONIC WIND TUNNEL

K. F. Tupper, M.E.I.C.,
President, Ewbank & Partners (Canada) Limited

P. B. Dilworth, M.E.I.C.,
President, Dilworth, Secord, Meagher and Associates Limited

L. A. Jenkins, M.E.I.C.
Senior Engineer, Dilworth, Secord, Meagher and Associates Limited
Project Engineer, Dilworth Ewbank Wind Tunnel Project

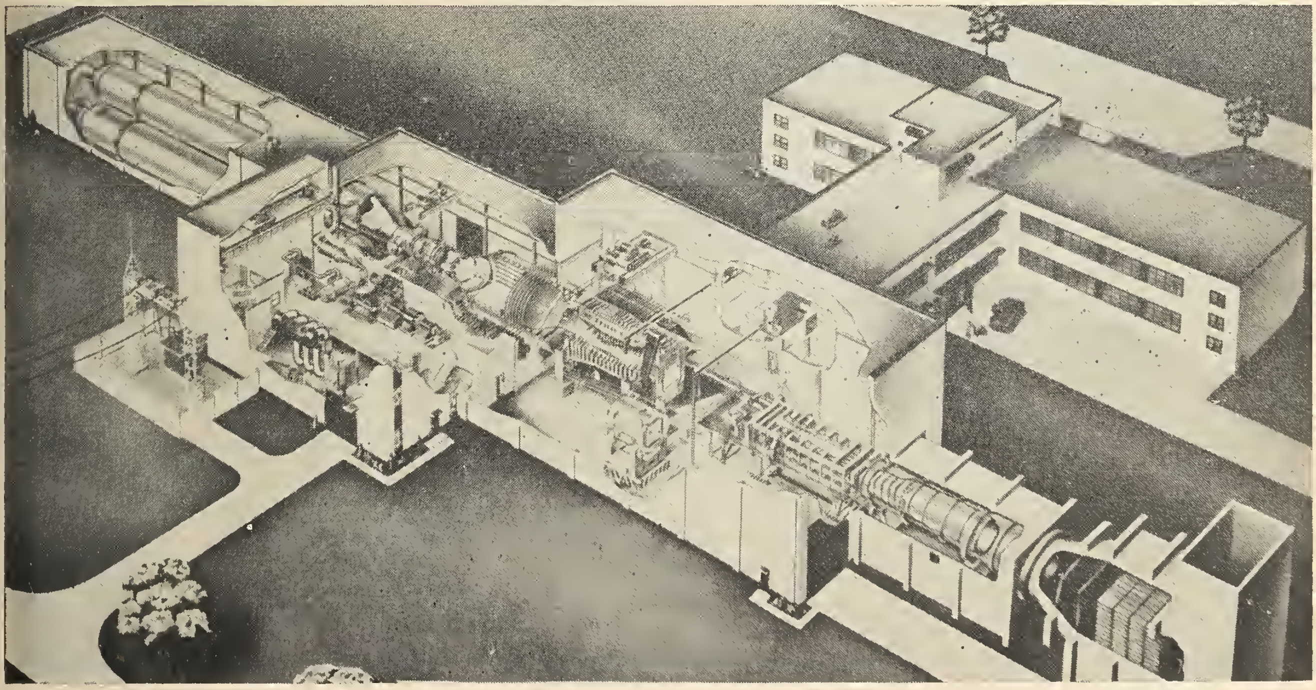
Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THE facility described in this paper is located at Uplands Airfield, Ottawa. The conception is that of the staff of the National Aeronautical Establishment, the Federal Government aeronautical research organization which will operate it. The project has been funded by the Defence Research Board and by the National Research Council. Defence Construction (1951) Limited is the contracting agency for the engineering, manufacture and construction.

This tunnel, with its 5 ft. square working section is one of the largest and most versatile of its kind. It will permit testing at relatively high Reynolds numbers throughout the subsonic, transonic and supersonic speed range from Mach 0.2 to 4.5. It is of the "blowdown" type in which compressed air is accumulated in a storage vessel during a period of 20 minutes and then released through the tunnel providing a running period of about 20 seconds. This mode of operation reduces the amount of power required to drive the tunnel to under 12,000 hp. compared with several hundred thousand horsepower for a continuous tunnel of comparable size. It also permits a much wider range of aerodynamic test conditions.

The facility is illustrated in the perspective drawing of Fig. 1 and a schematic representation of the tunnel and air supply plant is given in Fig. 2. Some idea of size may be gained from the 5 ft. square working section which is shown in the open position in Fig. 1. The magnitude of momentum and energy release may be gauged from the fact that during blowdown air mass flow rates approach three tons per sec. and kinetic energy flux in the working section is upwards of 280,000 hp.

It is interesting to note that during operation at Mach 4.5 the static pressure and temperature gradient in the supersonic nozzle is from about



14 atmospheres at 85°F upstream to 1/20th of an atmosphere at −350°F in the working section.

The air supply plant for the facility provides high pressure dry air to the storage vessels for tunnel operation. The control valve regulates the flow of air into the tunnel to maintain constant conditions during a run. Turbulence and noise are diminished and a uniform approach velocity distribution is created in the settling chamber.

Supersonic velocities are produced by accelerating the air through a convergent-divergent nozzle. Provision for transonic operation is by means of a special porous walled section of tunnel which is inserted downstream of the supersonic section.

Complex equipment and controls are provided for supporting and manipulating the model precisely and quickly while the tunnel is operating. Immediately downstream from the model support is a variable geometry diffuser used for subsonic speed control and to extend the supersonic Reynolds number range. Following exit from the variable diffuser the air is decelerated in a constant diffuser or expansion cone and it then passes out of the wind tunnel through an exhaust silencer and stack.

The buildings which house the facility include a laboratory wing containing model and instrument shops, computer equipment and offices for the research staff. Special provision is made in the design of the buildings to control the noise level both inside and outside during tunnel operation.

The design of this tunnel involved the expenditure of upwards of 100,000 engineering man hours and solution to the very broad spectrum of engineering problems required the participation of some eight distinct consultant organizations and groups in addition to that of the prime consultants. The design phase was carried out in close collaboration with the N.A.E.'s scientific staff and solutions to several important aerodynamic and control problems were found or verified through experiments in the N.A.E. 1/12 scale pilot model tunnel. Extremely useful results pertaining to the air storage thermal matrix, the noise level in the settling chamber (and its effect on tunnel flow properties) and the aerodynamics of the transonic section and ejector flaps came from these scale model tests. The pilot tunnel was also employed in developing the main control valve and valve control system. The many interesting aerodynamic features of the main tunnel and the work performed with the pilot tunnel will not be elaborated here and may be found in papers by Lukasiewicz[1, 2] and by Rainbird and Tucker.[3]

Wind tunnels of this size and kind are relatively few in number anywhere and in Canada this one is unique.

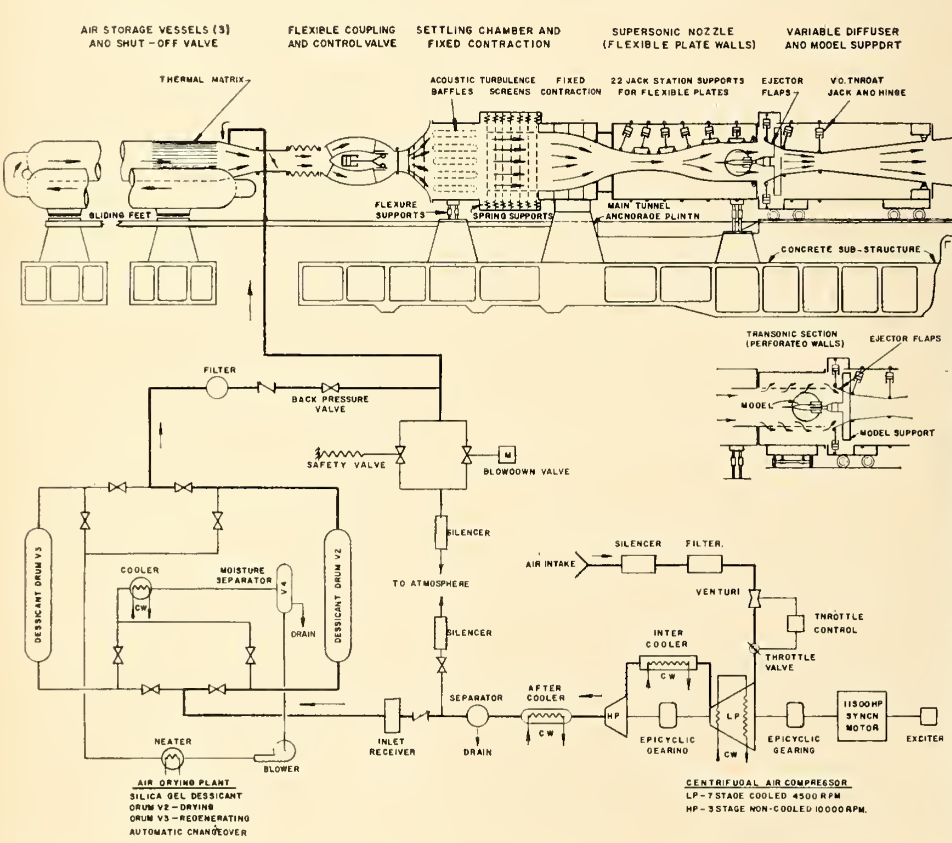
It may be of interest to note that notwithstanding the highly specialized and complex nature of this tunnel, it has been contracted almost entirely on the basis of firm prices with only about 5% of supply from outside of Canada.

Air Supply Plant and Storage

The air for driving the tunnel is drawn by the compressor plant from out-of-doors through an inlet silencer and filters and delivered at about 20 atmospheres pressure to the drier. The compressing plant consists of two co-axial units driven by an 11,250 hp., 1,200 r.p.m. synchronous motor. The low pressure unit comprises seven centrifugal stages, five of these intercooled, running at 4,500 r.p.m. The entire output of the motor is taken through a 3.75:1 Stoeckicht[7] type planetary speed increaser to drive the low pressure unit from which power is taken off to a second similar gear which steps up the speed to 10,000 r.p.m. to drive the high

N.A.E. 5'x5' HIGH SPEED WIND TUNNEL FACILITY. FIG 2.

(SCHEMATIC PRESENTATION)



PRINCIPAL DIMENSIONS AND DATA

AIR SUPPLY PLANT		**SUPERSONIC SECTION**	
Compressor Flow	40 lb/sec	Length	48'
Discharge Press	312.5 psi	Working Section	5' x 5'
L.P. Unit	7 stages	Flex Plate Length	45'
H.P. Unit	3 stages	Plate Thickness	0.864"
Motor Power	11500 HP	Plate Finish	32μ in.
Motor Speed	1200 rpm	Jack Stations	22
LP Speed	4500 rpm		
HP Speed	10000 rpm	**TRANSONIC SECTION**	
Coolers		Length	16'6"
		Wall Porosity	20%
LP Interstage	5	Dia. of Holes	0.50"
Intercooler	1	**MODEL SUPPORT**	
Aftercooler	1	Max. Lift	7200 lbs
		Max. Drag	3300 lbs
Air Driers		Pitch Rate	5°/sec.
Silica Gel	2 vessels	Pitch Range	−15° to +90°
(1 working, 1 regenerating)		Roll Rate	5°/sec.
AIR STORAGE		Roll Range	0° to 90°
Total Volume	50,000 ft³	Position Accuracy	0.05°
Vessels	3	**VARIABLE DIFFUSER**	
Vessel Dia.	11'6" I.D.	Max. Throat	5' x 7'2"
Vessel Length	170'	Min. Throat	5' x 1'3"
THERMAL MATRIX		Total Length	52'
Type	Tube Bundle	**CONSTANT DIFFUSER**	
Tube Length	90'	Inlet	5' x 7'6"
Tube Dia.	3/4"	Outlet Dia.	16'
Tube Wall	0.020"	Length	Telescopes,
Loading Density	8.6 lb/ft³		86' to 103'
Matrix Density	45.8 lb/ft³		
SHUT OFF VALVE		**EXHAUST SILENCER**	
Valve Dia.	72"	Type	Sinusoidal
Type	Butterfly		Perforated
Time to Open	60 sec.		Baffles
Sealing	Pneumatic	Attenuation	40db, .4 to
Actuation	Electric		10 kc
CONTROL VALVE		**AUXILIARIES**	
Sleeve Dia.	72"	Substation	12000 KW
Sleeve Stroke	14.6"	Circ. Water	4000 Igpm
Port Area	15.8 ft²	Cooling Tower	5°F Approach
Time to Open	0.25 sec.		to Wet Bulb
Actuation	Hydraulic	**FIXED CONTRACTION**	
Control Servo	Elec/Hyd		
SETTLING CHAMBER		Length	16'5"
		Inlet	16' dia.
Length	37'	Outlet	5' x 7½'
Sound Attenuation	50db at .5kc		
No. of Screens	7		
Screen Mesh	11		
Screen Spacing	15"		
Screen Wire	0.032" dia.		

ed. Many of the commercially ilable no-break sets provide a 1 degree of reliability for ordinary phone circuits. However, BMEWS uires virtually perfection standards eliability.

Our worst three-month period to e has shown an outage of 0.3%, which the power supply is by far principal contributor. To overne this we are now providing supmentary diesel alternators to take r when all else has failed. We are fident that these will improve the ability of the power to the extent t it should be a minor contributor overall system outage. One inesting hop of this section is the one oss the Bay of Fundy of some 50 es, almost all of which is over sea ter. On this path we have installed ble verticle space diversity. This angement when combined with e-for-one protection on different lio frequencies in reality provides tuple diversity. The propagation formance on this hop so far has en 100%.

cussion by R. G. Griffith, M.E.I.C.

The author is to be complimented his presentation of his paper cover; the BMEWS REARWARD COMUNICATIONS and if there is anyng lacking in the paper, it may be d that the paper concerns enorous engineering achievements witht making this very apparent.

One interesting feature in that part the system connecting with Thule that the northern section of one of e routes comprises a wideband subrine telephone coaxial cable sysm. The laying of these most northly cables presented considerable oblems and it would take a conlerable time to deal at any length ith the difficulties that were successlly overcome to lay these cables id get them into operation.

There is one point that would seem significance about the BMEWS ystem and this is that it would apear to underline the great impornce that communicators must place 1 the transmission of information by me division code modulation. In ct, a telegraph engineer would be clined to say, "by telegraphy". It ould seem that the demand for the ansmission of data or code informaon, such as will permit computation printing at any remote point is ore than likely to develop into a redominant feature of telecommuniitions, especially international — so uch so that it is submitted that it not too much of a flight of imaginaon to predict that it may transcend le use of the telephone. Obviously system like the BMEWS cannot be controlled by the telephone. Shall we ask why? I would suggest the answer that speech does not provide the accuracy and reliability required. Therefore such method of operation is now outmoded for high speed and accurate communication, and passing information over communication networks by what is now referred to by the deplorable term of "bits" is the best known solution to the problem. This leads me to raise a question.

The transmission of data or any information that has to be considered as a quantity or a character at a remote point, and there has to be produced with an extremely high accuracy, would seem to present the transmission engineer with the opportunity of taking full advantage of the ability, provided by the transmission of coded units of modulation, to establish at the receiving point that transmission has or has not been effected correctly. Speech transmission does not have the inherent feature to permit this to be achieved. If my understanding of the method of signalling that is used by the BMEWS System is correct, to transmit one message, it being understood that all their messages have a uniform format, it involves the sequential transmission of group of unit time elements of modulation, some 40% of which, it is understood, are used to start the receiving equipment or condition it for starting, and to give check indicators to be utilized at the receiving end for coordination of checking at that point to determine if an error of transmission has obtained, and the remaining 60% of the group of bits contains the information to be conveyed.

Perhaps the author could indicate the merits of such a method of transmission, which, it would seem, is bound up more with the design of the data equipment than representing a true solution to a transmission problem. Because the system does not necessarily indicate in what code construction the error has occurred, it does not provide any ability to correct an error. The method appears to advise that the intelligence has been mutilated. Such a method of transmitting intelligence by telegraphy does not seem to have taken full advantage of what the transmission engineer, shall I say telegraph transmission engineer, has to offer. He can provide a system of time division transmission so that any bit can be identified at the remote end as arriving in its correct or incorrect form, and so provide the receiving end with a large degree of pre-information so that by means of repetition of transmission the information can be received with absolute accuracy although the transmission may have been considerably mutilated.

It may be argued that such systems have a higher degree of redundancy of transmission than the method described by the author, but since the BMEWS transmission capacity is so far in excess of that required, the point of code redundancy would not appear to be significant. In fact, since the sequential modulation of the system is at a relatively low rate of bands per second, in respect of that which can be transmitted over a 3.4 kc/s voice channel, and therefore the application of frequency division to a voice circuit to provide two channels of voice frequency telegraph transmission could so easily be provided and thereby more than offset the redundancy demand. With such an important installation, it would seem essential to adopt a method of transmission that provides for error correcting so that each route would be self supporting for complete error check and error correction, whereas it appears with the BMEWS that the checking of performance is largely dependent upon the two separate systems provided on the different routes being in operational condition. I would like to hear what the author has to say about this.

In conclusion, I would take the liberty of saying that in my opinion the author has to be complimented on the preparation and presentation of the paper being discussed.

Discussion by C. G. Webster

The author has pointed out developing the Rearward Communications System for BMEWS has been a unique process because of:—

1. the high quality of transmission performance required
2. the degree of reliability called for
3. the number of organizations participating in the project.

As one who participated in the development stage of the BMEWS RCS I would like to comment briefly on some of the communications aspects. Many of the organizations brought together had previously only had limited opportunities for co-ordinating their activities on a technical or an operating level. Obviously, in a project such as this, the highest degree of co-ordination is essential if a reliable system is to be created and maintained.

The transmission objectives for the BMEWS circuits are those associated with high quality long-haul toll telephone circuits within the United States, normally considered as attainable over a distance of 4000 miles.

To attain the limits of transmission distortion specified these circuits must be very carefully engineered.

For BMEWS the same limits of transmission distortion are set, but they must be realized over a circuit length of 6000 miles. Since, in essence, the highest transmission quality attainable with current techniques had to be developed it was no longer possible to use the standard practice of minimizing maintenance problems by interconnecting facilities of different companies at voice frequencies. Now it was necessary to create an integrated system from the plant of several companies. For example, in some sections of the RCS as many as four agencies are involved in furnishing facilities. Integration was no easy feat as equipment manufactured to North American, British and European standards had to be incorporated. For instance, on the 1B route through Newfoundland multiplex equipment manufactured by Automatic Telephone and Equipment Company of England at the CNT terminal had to work with L1 carrier equipment at the A.T. & T Company's terminal through equipment of the M.T. & T and N.B.T. manufactured by the General Electric Company of England. Many new problems had to be faced, among them the co-ordination of signal levels, methods of synchronization, pilot frequencies, frequency assignments and impedances. One example of the degree of integration arrived at was that at both the south and north ends of its section on the 1B Route CNT agreed to use the output of the master oscillators of the connecting companies for the generation of carrier frequencies within its own multiplex equipment.

On the operating side also, very close co-ordination and a willingness to waive a degree of company autonomy have been required. Under the Control Office plan, under which a System Control Office responsible for overall direction of activities was established at Colorado Springs, a Sub-Control office established for the major segments, the individual administrations have had to relinquish to other organizations a measure of control of their staffs and facilities. It is now necessary for all the participating companies to submit to the Control Office reports on circuit failures and deterioration of performance and since the circuits are of such extreme importance permission to undertake any activity that may affect the reliability of the RCS must be obtained from the Control Office. It is quite easy to see that a great many construction and maintenance activities might conceivably reduce system reliability.

Canadian National Telecommunications is participating in the provision of circuits for the BMEWS RCS in two areas. The first is on the 1B Route Thule to Colorado Springs through Newfoundland from the south terminal of the Cape Dyer-Newfoundland cable to the facilities of the M.T. & T in Cape Breton. The second is the 2B Route Clear to Colorado Springs where it provides the link between U.S. Government facilities in Alaska and AGT facilities in Alberta through the Yukon and Northern British Columbia. I would, just briefly, like to mention some of the most interesting features of these systems.

The Newfoundland system was constructed to provide television and improved general communications to and within the Province of Newfoundland. It is a 600 channel capacity line of sight radio relay system operating in the microwave frequency range using equipment manufactured in Great Britain by Standard Telephones and Cables Ltd. The multiplexing carrier from which the voice channels are derived was manufactured by Automatic Telephone & Equipment Co. also in Great Britain. The most outstanding feature of the system and greatest problem to solve was the 70 mile over-water hop from Cape Breton Island to Newfoundland. Any over-water hop on a line of sight relay system is plagued with signal fading caused by interference between the direct beam and the beams reflected off the water. To our knowledge the spanning out of such a long over-water path at such high frequencies had never been successfully attempted until the time this system was put in service. The solution to the problem was in the use of both frequency and space diversity of signals. To accomplish this S.T. & C had to develop and produce signal combiners for the receiving end that operated directly at microwave frequencies. The performance of the long over-water hop has fully met the design objectives in spite of being located in areas having some of the worst wind and ice storms in Canada. In North-Western Canada, Canadian National is constructing a 600 channel capacity line of sight microwave system, soon to be completed, on which the BMEWS circuits will be carried. The system, which has 42 repeater stations traverses the Rocky Mountains and involves developing many difficult sites for repeater stations two of which may only be reached by aerial tramways. Th radio equipment is RCA MM60 very recently developed and manu factured in Canada.

The multiplexing carrier was manu factured by Telefunken in Germar and is completely transistorized t increase reliability, reduce pow consumption and reduce operatin costs. This equipment was the fir large capacity multiplex to be com pletely transistorized.

Author's Reply

I would like to express my appr ciation to Messrs. Edwards, Graham Griffith, Logan and Webster for pr paring discussions on my paper, an for presenting their discussions pe sonally in Vancouver. These gentl men are leaders in the communica tions field in Canada, and I am grat ful that they could find the time t contribute to the subject.

Mr. Edwards described some the modifications that had to be mad to existing facilities in Alberta t make them suitable for the BMEWS I am pleased that he has expande on this aspect of my paper, since serves to point out the complexity o the overall task undertaken by variou Canadian communication companie

Time was indeed at a premium and the fact that working main rout facilities were changed and re arranged without causing outages o service is a major accomplishmen

Mr. Graham referred to some o the difficulties that were overcom in order to meet the stringent trans mission and reliability requirement of the BMEWS. The provision of re liable a-c power supplies for tropo spheric scatter radio systems did in deed prove to be one of the majo problems. This was solved by pro viding two independent power buses one for each half of the radio equip ment in a quadruple diversity in stallation. Thus, failure of power o one bus cannot put the station ou of service. Also, standby engine-alter nators or no-break systems provid almost continuous power on each bus

Development work to make th existing commercial troposcatter sys tems suitable for BMEWS was also carried out in Canada by the North ern Electric Company. The system involved have proven extremely re liable, and from the service experi ence gained on those routes that ar operational, we have every confi dence that the BMEWS reliability re quirements will be met.

Mr. Logan also pointed out powe supply difficulties experienced in meeting BMEWS reliability require ments. The fact that supplementary

(Continued on page 73)

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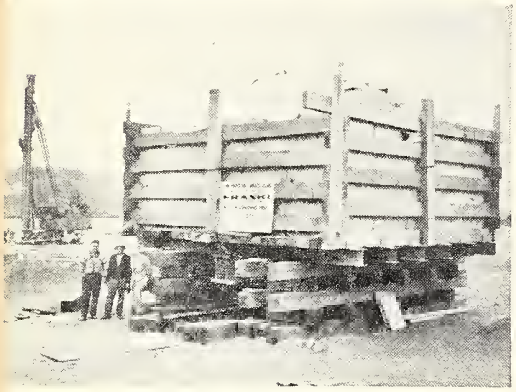
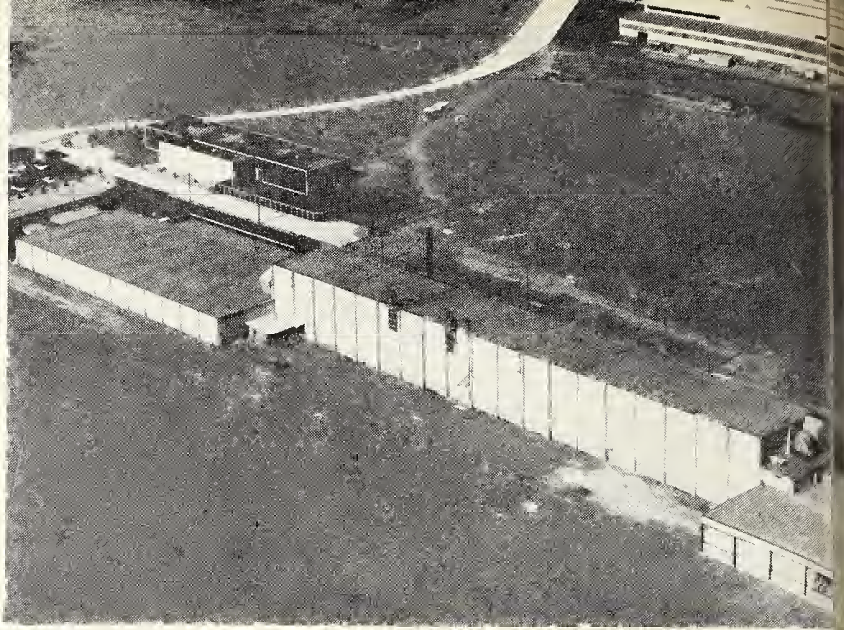
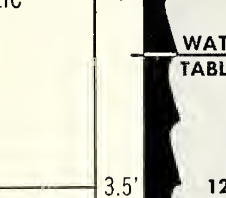


150 ton load test
showing net settlement of 0.11"



SOIL PROFILE
NEAR LOADING TEST

SOIL DESCRIPTION	EL.	DEPTH	PENETRATION TEST
	15.5'	CUT OFF EL. ↓ 4.5'	
HYDRAULIC SAND FILL	11.0'	WATER TABLE 7'	N = 12 TO 14
ORGANIC	3.5'	12' 13'	[N = 5
SOFT, SILTY CLAYEY SAND GRADING INTO LOOSE SAND (OCCASIONALLY SILTY)		14' 15'	[N = 4
		16' 17'	[N = 4
	-5.5'	20' 21'	[N = 2
LOOSE TO MEDIUM DENSE SAND (OCCASIONALLY SILTY)		EXPANDED FRANKI BASE	
		25' 26'	[N = 15



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 concept of guaranteed fou ations in granular soils proven ag

CLIENT: MacMillan, Bloedel and Powell River Ltd. (formerly Powell River Co. Ltd.)
CONSULTING ENGINEERS: Sandwell & Co. Ltd., Vancouver, B.C.
SOIL MECHANICS ENGINEERS: P. M. Cook, Vancouver, B.C.
UNIT WORKING LOAD: 120 tons

LOCATION: Annacis Island, B.C.
TYPE OF STRUCTURE: Paper Mill
STRUCTURAL ENGINEERS: Phillips, B Partners, Vancouver, B.C.
NUMBER OF FRANKI UNITS: 163 R Displacement Caissons
AVERAGE CONCRETED LENGTH O CA SONS: 16' 5"

Problem

To provide a guaranteed foundation in loose to medium-dense sand below water table for main structure of paper mill, including machine foundations, particular for several calenders transferring considerable vibration into beari

Solution

Original intention was to use 711 timber piles to be driven from a 7-foot exc at ground water level. However, engineering considerations, plus Franki's gu covering the adequacy of its foundations and economic advantages, led the e to choose 163 Franki Displacement Caissons, each of 120-ton design load.

Their enlarged concrete bases were formed in the sand strata, 21 feet below the by compacting zero slump concrete (as well as the surrounding soil) with blows of 140,000 ft.-lbs. of energy. The theory of the Franki base requires minimum of 20 such blows be used to expel the last 5 cu. ft. into the base the design load is 120 tons. The safety factor of a Franki base is at least five.

A loading test of 150 tons on one caission amounted to a settlement of 0.28"; settlement after removal of the load was 0.11".

All caissons were driven prior to excavation and construction proceeded w least possible delay, as only 22 working days were required to place the 163 Displacement Caissons.

Upon owner's request, Franki also installed an 18" dia. steel casing for an e plunger to be lowered 15 feet below the 5-foot deep elevator pit. Specif called for steel casing to be plumb and in accurate location.

FRANKI
OF CANADA LIMITE

Head Office: 187 GRAHAM BLVD., MONTREAL 16, P.

QUEBEC OTTAWA TORONTO EDMONTON VANCOU R

● DISCUSSION

(Continued from page 70)

diesel alternators are now being added to back up the no-breaks is an interesting point, and points up again the extreme standards of perfection demanded by BMEWS.

Mr. Griffith has suggested that the paper accentuates the importance of data transmission, and the author heartily agrees that data transmission will develop into a predominant feature of telecommunications. It has been said that within ten years we will see more information passed over communication circuits in the form of data than by voice. Another way of looking at this is to say that within ten years there will be more information passed between machines than between people.

Mr. Griffith suggested that instead of being merely capable of error detection, the data system should have been designed to be self error correcting. Although many arrangements for doing this are possible, it can be argued that such a refinement would be over and above the requirements for transmitting the required BMEWS information between the detection and control interfaces, which under normal operating conditions (Mode 1) means that only messages which are free of detected errors are delivered to the data processor.

The data system, as designed, is tailored to meet specific requirements of reliability and accuracy. It actually more than meets these requirements, and as such is considered to be the most reliable data system ever designed. The Triple Interleaved Parity scheme used for error detection is probably the most reliable error detection scheme that exists today. It gives a probability of an undetected error of only one in 10^5.

In addition, the principle of regeneration, namely where the received binary pulse train is regenerated and transmitted to the next repeater, overcomes the noise problem so serious in other current data systems of considerably shorter lengths.

As to the basis of choice between a purely error detection system, as against an error correcting scheme, I would think it is a matter of balance between the probability of reconstructing a message accurately, and the probability of getting highly accurate information by several means.

I would suggest that before the data system design was finalized, many possible considerations were examined and one by one rejected, finalising on a system which met all engineering considerations, including not only the technical requirements but also the economic considerations that would apply seriously to a system which is approaching world wide proportions.

Mr. Webster, in his discussion, pointed out some of the areas of cooperation required between participating companies. This was one of the most interesting facets of the BMEWS project. Canadian National Telegraphs, the COTC, and four member organizations in the Trans Canada Telephone System combined their resources to provide the routes which carry the BMEWS circuits through Canada. If we add to this list of contributors, the names of suppliers, not only in Canada and the U.S. but also in the U.K. and continental Europe, we come up with a complex inter-relationship which required the utmost in coordination and cooperation. The significance of this becomes even more pronounced when we consider that the almost impossible target dates set at the start of the project were improved substantially.

Mr. Webster's references to the second route to Clear, Alaska, point out the diversification of equipment used to establish the BMEWS facilities. It is of interest to note that the CNT's radio and multiplex equipment in northern Alberta is compatible with the proven TD-2 and L-Carrier used by AGT. The latter equipment, used by the Trans Canada Telephone System in its coast to coast radio

(Continued on page 108)

Pride takes many forms and at Provincial Engineering we take ours in the fact that the greater part of our production is devoted to building cranes for already satisfied customers. Numerous Canadian companies that bought one crane just a few years ago now have from twenty to seventy Provincial cranes in operation.

The above two 30-ton 90 foot span cranes (also a 10-ton 90 foot span crane not shown here) are in continuous service in a steel fabricating plant. Provincial DUPLEX bridge travel drive provided on these cranes was pioneered by us and has been most successfully applied to many hundreds of exceptionally long span cranes. This form of drive (without conventional cross shaft) ensures smooth travel motion as wheels are prevented from binding on rails.

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Designed and built by Combustion Engineering Superheater Ltd., the recovery unit, while larger than others built previously is a model of efficiency. Maximum chemical reduction, the primary function of this plant is achieved in several ways.

Accurate control is a prime efficiency factor. The cascade evaporators automatically compensate for the variations in density of the incoming black liquor. Liquor temperature and fuel-air ratios to maintain the atmosphere needed in the furnace to achieve high reduction are automatically controlled.

The principle of tangential firing has been applied to the secondary air zone by introducing secondary air on a tangent above the level of liquor injection. Because of the relatively high velocity of these air jets extreme turbulence is created in this area which assures the complete blending of air and gas and the rapid burning of all combustible gases from the reducing zone. The gas stream from the furnace takes a spiral path which provides maximum utilization of the furnace screen and superheater zone at practically a uniform temperature so stratification is minimized.

The upper furnace is used for generating steam as auxilliary fuel and can be fired in the secondary air position without disturbing reduction in the lower furnace. This fuel firing can be controlled and can thus carry a swing load without impeding the chemical recovery properties of this unit. An adequate supply of air for the auxilliary fuel is assured as the tangential register has multiple compartments with a guide pipe in the center. This guide pipe is there so that a gas or oil gun can be inserted.

As refractories are unable to withstand the corrosive action of molte smelt a flat water cooled decantin hearth was developed for the Celg unit. The front furnace wall tubes for a flat furnace floor. They make a 90 turn at the bottom of the furnace. Tl rear furnace wall tubes are bent to tl rear at a tangent to the floor tubes. Bo sets meet in a single header which several feet from the rear of the furnac The metal bottom is watertight becau metal strips were welded to the fins the tubes.

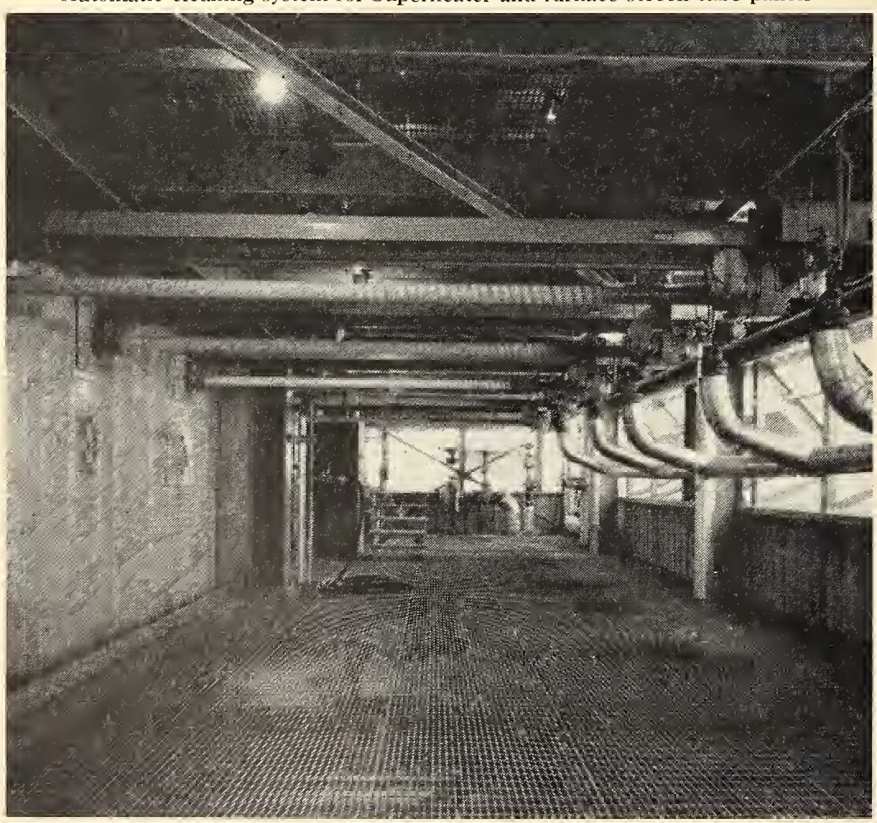
There is no refractory maintenanc because of molten smelt touching it. thin layer of refractory over the botto tubes causes the heat transfer rate to b such that a chilled layer of smelt form on top of the refractory. Thus, molte smelt only comes in contact with th chilled layer. It flows through spou located a few inches above the floo The decanting hearth insures lowe smelt temperature and a higher rate c chemical reduction. The more unifor flow of smelt from the furnace reduce the number of dissolving tank erup tions.

An automatic sequential soot blowin system continuously cleans the furnac Wide spaced self cleaning panels c tubes in both superheater and furnac screen keep slag buildup to a minimun while assuring uniform heat adsorptio across the width of the furnace.

This installation, 120 ft. tall, was de signed for the recovery of sodium sul phide produced by the furnace in th form of smelt as efficiently as possibl As the Celgar plant is a kraft mill th recovery problem is to convert spen black liquor to white liquor which ca be used in the digestors. From storag the black liquor goes through an electro static precipitator to an ash dissolvin tank, and then through a cascade evapo rator where contact with flue-gas fron the recovery boiler further concentrate it. After evaporation has taken plac the liquor is screened and sodium sul phate added by an automatic feeder The liquor flows through a primar heater to a centrifugal pump, the through a secondary heater and on t the headers which have the spray noz zles in the furnace of the chemica recovery unit. These nozzles move verti cally and distribute the heavy blacl liquor so that final drying is complete as the particles remain suspended in th hot turbulent combustion gases. Th charred particles settle to the bottom o the furnace. There burning continue

(Continued on page 106)

Automatic cleaning system for Superheater and furnace screen tube panels



International News

A-Steel Supersonic Aircraft

heffield, a city known for the quality its steel, has kept up with the de-nds of the advances in aeronautical technology. Sheffield steels are being d in the Bristol T.188, a research raft designed to investigate the com-x problems met in flying at super-ic speeds. The T.188, expected to be fastest aircraft able to land and e off from a normal runway, is in final stages of construction.

Designed to fly at 1,500 m.p.h. this craft must withstand temperatures in ess of 250°C. caused by friction and npression of the air flow.

Above Mach 2 (1,300–1,400 m.p.h.) surface of a plane in flight will, cording to the altitude, suffer such rise in temperature that its surface n will be affected. The skin surface nperature of a plane flying at 1,000 p.h. rises about 100°C. (the rise in mperature from the freezing to the iling point of water) while at Mach 2 e rise in skin surface temperature has en estimated at 180°C. In actual fact e rise in temperature is not so sharp. e plane takes time to heat and the mperature rise is offset by the lowered mperatures at high altitudes. For ex-nple, at 50,000 ft. where the tempera-re is −60°C. an aircraft has a skin rface temperature of about 110°C. ter a period of sustained Mach 2 ight. At the same height at Mach 3 e temperature rise is to 330°C.

Aluminum alloys are unsuitable for rcraft flying faster than Mach 2. At igh temperatures the elasticity of luminum alloy steel is affected. The rface skin of the plane becomes so soft at after flexing under a flight load it ssumes a permanent "set". Titanium al-y corrosion resistant steels had to be sed for the Bristol T.188. Titanium, hile difficult to extract and process ito a useable alloy, has proved, so far be the best. But even titanium alloy eel has its limitations. At temperatures f 500°C. and over (Mach 3.5 and iore) the strength and elasticity of eel declines more slowly than that of tanium.

Steel sheets were made for the fuse-ge as were specially hardened plates r the wings in order to meet the high tandards of flatness and surface finish ecessary. Steel forgings for the engine acelles, believed to be the largest steel orgings ever made for an aircraft, were lso made to order. Other high tensile orgings, the first to be used in a British lane, form the attachments for the wings and a very unusual one, 27 ft. long, was made for the "keel boom". Tubes and piping for the hydraulic system powering the undercarriage, flaps, controls, rivets and other types of fasteners were all produced in stainless steel for the Bristol T.188.

Electronic Air Traffic Control Unit

The S-C 2000 Bright Display is an electronic unit which can display alpha-numeric, symbolic and graphic data con-currently with video presentations. The combination of a completely dry print-ing process and use of the "Charactron" shaped beam tube provides bright flicker-free displays which are fail proof at speeds under two seconds for each complete presentation.

Because of the brightness and the high resolution of the displayed data it can be viewed directly on the screen of the S-C 2000 console in normal ambient light. Or, if preferred, displayed data can be projected for group viewing on a large theatre-type screen.

As a safety measure against failure the last frame displayed by the S-C 2000 is retained permanently even if there is a complete power failure.

Maps can be displayed along with radar targets and their identifying sym-bols. In air traffic control the maps assist operators in orienting targets geo-graphically. The S-C 2000 also lends itself to many types of display experi-ments on various command and control data systems.

Because of the storage facility of the instrument, information recorded by the S-C 2000 is required only once from the computer. The material in storage can be used for future reference or for the production of permanent copies.

A small dry processor is used to store information displayed on the face of the "Charactron" shaped beam tube. The tube can display information at rates of up to 40,000 separate charac-ters per second. Less than two seconds after the material is received it is pro-jected on the screen of the console.

Past images can be provided by the unit to predict the future course and position of a target under study.

Displays can be produced in up to seven colours, thus facilitating the dif-ferentiation of targets or other data. In-formation can also be viewed as white on black or black on white. The opera-tor can also select any segment of the area covered by radar and enlarge it so that it fills the entire screen of the con-sole. Category and feature selection can be effected at the console without inter-rupting the computer program.

This equipment is scheduled to be used in command and control systems studies and in experimental programs of SATIN (SAGE Air Traffic Integration). The equipment promises real advances in air traffic control study. Private cor-porations, along with the F.A.A. and the U.S. Air Force are studying the pos-sible application of the SAGE air defence system to serve as a combined military-civilian air surveillance and con-trol system.

Swedish Space Probes to Commence

Vidsel Field in Lapland will be the launching site of Sweden's first space research rockets. Due to be launched this month the rockets form part of a research project on noctilucent clouds being carried out by the International Meteorological Institute in Stockholm. Five Areas rockets have been placed at the disposal of the Swedish Space Re-search Committee by NASA (National Aeronautics and Space Administration) of the United States, and one or two of these will be used for this project.

Sweden is among the 11 European countries working together on a Euro-pean organization for space research. This would undertake such projects as; a base for high-altitude rockets in the aurora borealis zone, studies of the upper atmosphere and interplanetary space by means of small satellites, as well as studies of the moon and its en-vironment from a satellite orbiting around the moon.

First OAO Space Craft Underway

The United States' first orbiting astro-nomical laboratory is scheduled to be launched in 1963 or 1964. This pro-ject is designed to provide scientists with data on stars and planets presently un-available. Radiation from celestial sources can then be studied without being hindered by the earth's atmos-phere. The orbiting laboratory will be used mainly to measure ultraviolet radiation from extraterrestrial sources.

The OAO orbiting laboratory will be enclosed in a 1½ ton space craft and each space craft is designed to be oper-ational for one year. Three are planned at the moment. Six star trackers will be built for each orbiting lab. They will be used by the Laboratory's control system to maintain stable platforms for the observation equipment. The telescopes aboard the craft will be able to point

(Continued on page 108)

Which product i

We do not make hats. Nor is it likely that we ever will. But right here in Canada we make an exceptionally diversified range of equipment for industry. There's no company quite like it. This means that we have a very extensive pool of talent, experience and down-to-earth know-how. Those who take full advantage of A-C diversified production find extra dividends in co-ordinated planning, equipment and deliveries.

Complete engineering d on any Allis-Chalmer equipment is available fr Canadian Allis-Chalmer P.O. Box 37, Montreal.

Month to Month

REPORT OF THE ENGINEERS CONFEDERATION COMMISSION

The complete and unabridged report of the Engineers Confederation Commission will be publis[h] in the September, 1961, issue of The Engineering Journal.

Branches of the Institute will be holding special meetings to discuss this report. Members are ur[g] to attend and participate.

Individual members are invited to submit their comments regarding the report to The General Sec[re]tary, for transmission to the Council, at their earliest convenience.

Si vous désirez une copie de ce rapport en français, veuillez remplir cette formule et nous la r[e]tourner par le retour du courrier. Nous vous enverrons votre copie aussitôt qu'elle sera disponible.

The General Secretary, The Engineering Institute of Canada, 2050 Mansfield Street, Montreal 2, P.

Name (print) .... Address ....

Date .... Signature ....

Summary of the Final Report .. .... of The Engineers' Confederation .. .. Commission.. .. ..

John H. Fox, P.Eng., M.E.I.C. Chairman, Engineers Confederation Commission

J. E. Leo Roy, P.Eng., M.E.I.C. Vice-Chairman, Engineers Confederation Commission

This is a condensed version of the final report made by the Engineers' Confederation Commission to the Engineering Institute of Canada and the Canadian Council of Professional Engineers on Confederation.

The report was presented by the writer, as Chairman, and by Leo Roy, as Vice-Chairman of the Commission, to the Engineering Institute of Canada in Vancouver on May 31, and to the Canadian Council in Edmonton on June 7, 1961.

It should be understood that the report makes no recommendation for Confederation but, in accord with the terms of reference, does include a proposed constitution, by-laws and legal details. The charter has been prepared in such a manner that, in the opinion of legal counsel, it would protect the interest of all parties to any agreements and would preserve the many desirable aspects of the Engineering Institute of Canada Act of 1887 and amendment of 1918. Also, in the opinion of legal counsel, the charter as drafted will probably be accepted, in the opinion of legal counsel, by committees of the Canadian Parliament which must approve prior to being granted.

The proposed by-laws have been prepared to conform with the terms of the proposed charter.

The Final Report is divided into eight parts, under the following headings:

Part 1—Introduction; Part 2—Summary of proposals; Part 3—Charter; Part 4—By-Laws; Part 5—Budget; Part 6—Procedures for Implementation; Part 7—Other Recommendations; Part 8—Acknowledgements.

Seven appendices are attached to the report.

PART 1 of the Report—INTRODUCTION

The history and background leading to the writing of the Final Report is recorded within this section. The salient points are as follows: that Confederation talks date back to December 1925, with a conference being held in Montreal on Feb. 2-4, 1926. This original conference, held at the invitation of the Council of the Engineering Institute of Canada, was attended by representatives of each Provincial Association of Professional Engineers. The principal item on the agenda was "Co-operation with the Engineering Institute of Canada".

Concrete action was not taken until 1935 when, at the annual meeting of the E.I.C., held in Toronto on Feb. 7, 1935, the following resolution was passed unanimously:

"That the Engineering Institute of Canada in annual meeting assembled, hereby goes on record as being in favor of the consolidation of the engineering profession in Canada".

This resolution resulted in the formation of a "Committee of Consolidatio[n]" which made several recommendatio[ns]. Subsequently seven professional asso[ci]ations entered into an agreement wi[th] the Engineering Institute of Cana[da] without, however, consolidation bei[ng] achieved.

"Unity" was again strongly broach[ed] in 1953 by J. Herbert Smith and [ ] plan approved in principle by the O[n]tario Association, and the Quebec C[or]poration in 1954. At the annual meeti[ng] of the Dominion Council in 1954 [a] national committee was established [to] find ways and means of implementi[ng] unity and at the annual meeting [of] Dominion Council in 1955, it was ab[le] to report good progress. This committ[ee] then met with a similar committee fro[m] E.I.C. They subsequently worked t[o]gether through 1955 and 1956 and pr[o]duced a joint report to both the E.I.C. Council and the Dominion Council. Th[e] report recommended an organizatio[n] which would be created by Confedera[]tion.

Eventually, eight basic principles f[or] Confederation were adopted and the[n] was a joint meeting of committees repre[]senting both groups in Toronto on Ja[n.] 18, 1958. The combined committe[e] unanimously agreed to a series of gener[al] principles embodied in the first seve[n] clauses of their report and this join[t] report, which in essence expressed ap[]proval of the principle of Confederation was accepted by E.I.C. and Dominio[n] Council.

The Engineers' Confederation Com[]mission was then appointed to bring i[n]

eport, which task was to be per-
ned within the framework of the
ns of reference of the Joint Com-
tee. Numerous committees and sub-
mittee meetings were held resulting
the report which is now under con-
ration.

The Commission was composed of the
owing: Chairman, John H. Fox, Tor-
o; Vice-Chairman, Leo Roy, Mont-
l. The provinces were represented by
following: Alberta, J. McMillan and
F. McDougall; British Columbia, F. A.
ward and W. K. Gwyer; Manitoba,
E. Storey and N. S. Bubbis; New
nswick, T. C. Higginson and J. O.
ueen; Newfoundland, J. B. Angel;
va Scotia, G. F. Bennett and F. G.
il; Ontario, T. Foulkes, D. D. Whitson,
T. Carson, and L. D. Dougan; Prince
ward Island, W. R. Brennan; Quebec,
D. Gray-Donald, H. Gaudefroy, H.
non and J. Lemieux; Saskatchewan,
C. Traynor and J. B. Mantle; Yukon,
W. King. Joint secretaries were L. M.
deau and G. T. Page. Others who
ved for varying periods were: G. M.
ck (vice-chairman); J. G. Dale, Al-
rta; J. Hoogstraten, Nova Scotia.

ART 2 of the Report—SUMMARY OF PROPOSALS

The Charter will be dealt with in other section. Suffice to say that the mended charter would provide ob-
tives and activities broader in scope d more consistent with the present d future needs of the Professional gineers and would also allow for oader membership, while preserving e vested rights of present members of e Engineering Institute of Canada".

The Commission recommended that e name of the new national body be The Canadian Institute of Professional ngineers" (L'Institut Canadien des In-
enieurs Professionels). Ottawa was med as headquarters—although re-loca-
on of headquarters would be permitted nder the terms of the proposed charter d by authority of future councils.

There are 13 basic objectives, repre-
nting those of both engineering bodies hich are retained in the proposed arter and are repeated in the by-laws. very protection, it is stated, has been ven to the rights of provincial and rritorial associations, which are held violate.

lembership

The only means of gaining full mem-
ership in the new national organiza-
on would be by membership in a anadian provincial or territorial associ-
tion or corporation of Professional En-
ineers. Full membership would be rou-
ne for members holding registration in e of these associations or corporation.

The report provides for seven classes members: Fellow—the highest grade, ould be used to provide recognition r outstanding contributions to the engi-
eering profession; Member—open only professional engineers registered in anada; Junior—limited to engineers in aining or junior professional engineers gistered or recorded by the provincial ssociations; Corresponding Members—
ose who possess qualifications but by ason of non-residence in Canada would ot otherwise be eligible for member-
ip; Honorary Members—persons to whom special recognition is proposed and who are not professional engineers; Technical Associates — those persons, who, at the time of Confederation, are members of the Engineering Institute of Canada but who do not possess quali-
fications for admission to corporate mem-
bership; and Student members.

The corporate membership of the Institute shall comprise the members of the Institute who are classed as Fellows, Members, and Junior Members.

The voting membership would com-
prise all classes except Honorary mem-
bers and Student members.

Administration and management of CIPE, it was recommended, should be vested in the council, composed of a president, two vice-presidents, immediate past president, councillors appointed by councils of the participating associations together with councillors elected by the voting members of CIPE in the prov-
inces and territories of Canada. The number of councillors appointed or elected by each province shall be deter-
mined on a schedule established within the report, to provide representation based on the number of professional en-
gineers registered. Associations with 301 to 5,000 members would elect one coun-
cillor. Those with 5,001 to 10,000 mem-
bers would elect two councillors and those with more than 10,000, three coun-
cillors.

The Commission further recommended that two boards and four standing com-
mittees be formed under the council as follows:

Board on Professional Interests—This board would be composed of all coun-
cillors appointed by the provincial as-
sociations and would be responsible for the activities of the Canadian Institute in the field of professional interests, in-
cluding the co-ordination of the activities of the associations in this field.

Board on Technical Services—This board would be responsible for the ac-
tivities of the Canadian Institute in the field of technical services and for the co-ordination of the activities of the provincial associations in this field.

Four Standing Committees—Finance, Branches, Publications, and Honours and Awards.

With respect to Branches, it is antici-
pated that in those locations where there is at present one branch representing the E.I.C. or a provincial association, that branch will continue to operate under the new national organization with a minimum of transition to be consistent with the new organization. In locations where two or more branches of either group or groups are at present operat-
ing, it is anticipated that, by mutual agreement of the branch members, the provincial association and the national organization, such overlapping groups will be consolidated into one branch.

PART 3 of the Report—THE CHARTER

The Charter, which has been prepared with due reference to all legal require-
ments, requires the repeal of all former statutes but states that the said repeal "shall not in any way affect the cor-
porate existence of the Engineering In-
stitute of Canada and the Engineering Institute of Canada shall continue to be the same corporation as that con-
stituted by Chapter 124 of the Statutes of 1887 as amended by Chapter 69 of the Statutes of 1918, and to be com-
posed of the existing members of the Engineering Institute of Canada, whose rights and liabilities, except as modified by this Act, shall not be affected by the said repeal, and of those who are from time to time hereafter admitted to membership and to be the owner of and entitled to the property and estate of the Engineering Institute of Canada and subject to the undertakings and liabili-
ties of the Engineering Institute of Can-
ada".

Reference is made to the name change and the fact that the head office of the Canadian Institute is to be in Ottawa, or in such other place as is from time to time determined by by-laws.

The Charter spells out the objectives of the Canadian Institute—which are as follows:

(a) To develop and maintain high standards in the engineering pro-
fession.
(b) To facilitate the acquirement and interchange of professional knowl-
edge among its members.
(c) To advance the professional, social, and economic welfare of its mem-
bers.
(d) To assist in the development throughout Canada of uniform registration requirements and ex-
amination standards for the engi-
neering profession.
(e) To act in an advisory capacity in connection with legislative matters common to professional engineering bodies throughout Canada.
(f) To promote a knowledge and ap-
preciation of engineering and of the engineering profession and to enhance its usefulness to the gen-
eral public.
(g) To collaborate with universities and other educational institutions in the advancement of engineering education; to encourage original re-
search and the study, development and conservation of the resources of Canada.
(h) To establish and maintain a bond between associations recognized by the Canadian Institute as partici-
pating associations to promote the welfare of the engineering profes-
sion in Canada.
(i) To provide a forum for the dis-
cussion of problems common to all engineering bodies.
(j) To publish a national journal and such other technical and profes-
sional papers and transactions as may be of assistance to its mem-
bers.
(k) To promote intercourse between engineers and members of allied professions.
(l) To co-operate with other societies for the advancement of mutual or national interests.
(m) To act as a national voice speak-
ing on behalf of all the professional engineers of Canada.

The Canadian Institute would also enjoy all the rights common to a pro-
fessional organization including the right

of carrying on business affairs for the benefit of the membership.

The following associations of professional engineers and such other provincial or territorial engineers in Canada as may be recognized by the Canadian Institute in accordance with its by-laws, may be participating associations of the Canadian Institute, provided such associations give their consent and possess the capacity and power to do so, until their status as participating associations has been terminated by withdrawal or by cancellation of recognition by the Canadian Institute: The Association of Professional Engineers of Alberta; British Columbia; Manitoba; New Brunswick; Newfoundland; Nova Scotia; Ontario; Prince Edward Island; Saskatchewan; Yukon Territory and the Corporation of Professional Engineers of Quebec.

PART 4 of the Report—BY-LAWS

The proposed by-laws were prepared to conform with the terms of the proposed charter. Legal counsel has advised that these by-laws will protect the interests of all parties to any agreement and the membership as well.

Much of the vital information with respect to the By-Laws has already appeared in other sections of this digest.

That which is additional and of interest might be summarized as follows:

There shall be an emblem and corporate seal.

An Institute Branch may be established at the request of not less than 10 corporate members who reside in the same area. At the time of coming into force of the By-Laws, all existing branches of The Engineering Institute of Canada and all existing branches or sections of Participating Associations, shall become branches.

At the request of the Executive Committee of two or more branches whose territories are adjoining, the Council, after consultation with the Participating Associations concerned, may establish a Regional Branch Conference, for the purpose of bringing together members of various branches to discuss matters of technical or professional interest among them.

A Student Chapter may be established at a university at the request of not less than 25 student members of the Institute who are studying engineering within that University.

An annual meeting would be held no earlier than May 15th in any one year. One hundred members, exclusive of members of Council, would constitute a quorum.

The Institute would be financed through remittance from each participating association of an annual amount of money which represents the total of the annual assessment payable.

PART 5 of the Report—THE BUDGET

An operating budget has been set up for $500,000.

Estimated total assessment per member becomes $12.50, including branch rebate, in addition to the fees payable to the provincial associations and corporation. At the present time, the provincial associations are assessed and paying to Canadian Council $1.35 per member. Some associations are also paying $1.00 or more towards branch organization or operation.

PART 6 of the Report—PROCEDURES FOR IMPLEMENTATION

These may be summarized as follows:

(a) Approval of reports and drafts of agreement prepared by The Engineers' Confederation Commission, by the Councils of E.I.C. and the participating provincial associations and Corporations.
(b) Clearance with legislative counsel in Ottawa.
(c) Approval by referendum of the membership of the Engineering Institute of Canada, of items referred to in sub-section (a) of these procedures.
(d) Formal approval by each of the provincial and territorial associations.
(e) Signing of a "preliminary" agreement for confederation by all the Participating Associations and The Engineering Institute of Canada.
(f) Application to Parliament for a Private Act.
(g) Coming into force of the Private Act and the new By-Laws.
(h) Execution of "final" agreements between each of the Participating Associations and the Canadian Institute of Professional Engineers.

PART 7 of the Report—OTHER RECOMMENDATIONS

Under this part, six recommendations are made—four of which deal with matters in regard to transition to the new organization and implementation of the report.

There are two other recommendations in regard to "The Library" and "Employment Service" that require comment.

Library—The commission recommends that the present library service as operated in Montreal by the Engineering Institute of Canada be NOT continued as a service of the new national organization since it serves a relatively local and limited number of members and is of limited value to the membership at large.

At the same time it is recognized that it is a technical library of high quality and historic value and should not be carelessly dispersed.

It is suggested that it could be given, intact, with full recognition in the terms of the gift, to one of the newer universities entering the field of engineering teaching or, alternatively, to the National Research Council as a section of the national technical library resources.

Employment Service—The commission recommends that an employment service NOT be provided by CIPE. It will be recognized that a certain amount of day to day informal employment enquiries will be made of any national headquarters staff. However, any formal organization for employment services to be effective would be costly of time and money and would be in direct competition with the many effective agencies that are now available—such as placement offices of universities, certain provincial associations, National Employment Service, Technical Service Cou[l], private placement companies, etc.

Should the membership wish that [th]e Library and/or Employment Service [b]e continued—this can easily be done, [or] restored, however such services it m[ust] be recognized would require financ[in]g and would undoubtedly be reflected [i]n budget provision and the dues structu[re].

PART 8 of the Report—ACKNOWLEDGEMENTS

During the meetings of the Comm[is]sion, of committees, and sub-committ[ees] freedom of expression and opinion [wa]s given full play. An atmosphere of und[er]standing and appreciation of the pr[ob]lems of geographic areas and grou[ps], differing in backgrounds and intere[sts], were at all times recognized and, wh[en] necessary, compromise decisions w[ere] made.

Annual Meeting of Council

The Annual Meeting of the Council [of] the Institute was held in the Hotel V[an]couver, Vancouver, B.C., starting on [the] evening of May 29, 1961, and reconve[n]ing the following afternoon. Followi[ng] are highlights of the meeting.

Financial Statements

Treasurer E. D. Gray-Donald, rep[ort]ing for Finance Committee Chairman [J.] L. Lawton, pointed out that seve[ral] months previous the Institute chan[ged] its accounting methods from a cash [to] an accrual basis. While this has t[he] advantage of allowing a much mo[re] accurate and understandable picture [of] financial position, it makes it impossib[le] to provide statements on a comparati[ve] basis with the previous year.

Finance — Nova Scotia

Council noted that the Branches co[n]cerned in Nova Scotia now have a[p]proved the appointments of R. D. Wic[k]shire and John Kaye, both of Halifa[x], as EIC representatives to the Joi[nt] Finance Committee of Nova Scotia.

New Branch at Whitby

Council approved the formation of [a] Branch of the Institute at Whitby, On[t]. This followed a petition to Coun[cil] from Institute members in the Whit[by] area. Toronto Branch, in which area th[e] Whitby Branch now resides, was agre[e]able to the formation of the new Branc[h].

Professor Davidson said the propos[al] was a further attempt on the part [of] the Toronto Branch to increase th[e] number of members attending meetin[gs] of the Institute. Branches are being es[tablished] in the more remote suburbs [of] Toronto and the scheme is working ver[y] well. It is thought that the area even[tually] will require an overall committe[e] to co-ordinate the efforts of thes[e] various Branches but the Toronto Branc[h] thinks it has found the answer to th[e] low attendance at the Branch meetings.

Publications

The General Secretary said that con[tracts] for new and renewal advertisin[g] business in 1961 have been exception[ally] slow, not only for The Engineering Journal, but also for almost every othe[r] Canadian business publication. Advertisers have cut their advertising apopriations for the first half of the ar and will decide at mid-year hether to increase their appropriations. is expected, therefore, that the nance Committee at its next meeting ll, from the point of view of financial inagement of publications, be able chart a sensible course for the balance the year.

Engineering Careers in Canada is be- g planned in detail for publication in e autumn.

A survey of a representative sample the membership, to indicate whether ne Engineering Journal is being read, id other pertinent information which ill be of help to the advertising sales aff has been completed under ap- ropriate strict audit conditions.

962 Annual Meeting

It was noted with pleasure that C. G. ingsmill, Montreal, has accepted Coun- l's invitation to be Chairman of the 962 Annual Meeting Committee. Next ear's Annual Meeting will be held at ne Queen Elizabeth Hotel, Montreal, ine 13-15.

lectronics Conference

Members of the Engineering Institute f Canada have been invited to take art in the I.R.E. Canadian Electronics onference and Show which will be eld in Toronto Oct. 2-4, 1961. The onference theme will be "Progress hrough Electronics" and Institute mem- ers will be granted complimentary egistration.

ibrary and House Committee

T. N. Davidson, Chairman of the ibrary and House Committee, pre- ented his Committee's report. Discussed vas the future of the Institute's Library ervice.

National Productivity Council

The General Secretary read letters re- eived from the Federal Government in esponse to a letter which had been ent April 19, 1961, expressing the pinion of the Institute that the mem- ership of the National Productivity Council should include at least one ap- propriately qualified engineer, appointed primarily because of this qualification.

'Resources for Tomorrow"

Council received a letter from the Minister of Northern Affairs and Na- tional Resources inviting the Institute to be represented at the "Resources for Tomorrow" Conference which will be held in Montreal, Oct. 23-28, 1961. It was resolved that General Guy Turner be invited to be the Institute's rep- resentative.

UPADI

Dr. James A. Vance stated that the Institute, as a participating body of UPADI, is requested to approve a pro- posed amendment to the Constitution and By-Laws of UPADI which will per- mit the Convention, rather than the Board of Governors, to elect the Presi- dent of UPADI. After discussion it was resolved that the Institute approve the amendment.

Canadian Centenary Council

On the recommendation of the Ottawa Branch it was resolved that Brigadier A. B. Connelly be named E.I.C. representative to the Canadian Centenary Council.

C.C.A. Joint Committee

On the recommendation of the Ottawa Branch it was resolved that J. M. Wardle be named the Institute's representative on the National Joint Committee for Wintertime Construction of the Canadian Construction Association.

A.P.E.N.S. Representative

Council ratified a nomination made by the Association of Professional Engineers of Nova Scotia on the E.I.C. Council. Edward D. Brown was appointed, replacing Dr. J. E. Whitman.

Port Credit Councillor

On the recommendation of the new Port Credit Branch it was resolved unanimously that D. S. Moyer be elected to represent the Port Credit Branch on the Council of the E.I.C.

N.R.C. Advisory Committee

It was resolved that E. R. Smallhorn, Montreal, be invited to serve as E.I.C. representative on the N.R.C. Advisory Committee on Building Research, replacing G. Rinfret.

Meeting of New Council

Following are highlights of the meeting of the new Council of the Institute which was held June 1, 1961, at the Hotel Vancouver, Vancouver, B.C.

General Secretary

It was resolved unanimously that Garnet T. Page be re-appointed General Secretary of The Engineering Institute of Canada for the year 1961-62.

On the recommendation of the Striking Committee it was resolved unanimously that E. B. Jubien of Montreal be appointed Treasurer.

Appointed chairmen of the standing committees were: Admissions, P. W. Gooch, Montreal; Finance, G. N. Martin, Montreal; Legislation, W. B. Pennock, Victoria; Library and House, R. N. Boyd, Montreal; Publications, R. A. Phillips, Montreal; Technical Operations, S. Sillitoe, Belleville, Ont.; Editorial Review Board of Transactions, D. L. Mordell, Montreal.

Appointed chairmen of the special committees were: Board of Examiners, R. Boucher, Montreal; Branch Operations, F. L. Lawton, Montreal; ByLaws, J. S. Waddington, Brockville, Ont.; Membership, E. D. Gray-Donald, Montreal; Professional Development, W. A. Filer, Hamilton; Student Policy, J. Hahn, Montreal; IAESTE, L. A. Duchastel, Montreal; EIC-CISS, A. L. Van Luven, Montreal.

J. F. MacLaren of Toronto was appointed Chairman of the H. F. Bennett Fund and D. M. Stephens of Winnipeg was appointed Chairman of the Brace Bequest.

Students Conference

C. G. Southmayd, Chairman of the Student Policy Committee, reported, that there are 31 delegates and observers attending the Annual Students Conference, and that a most successful meeting was in progress. The students heard excellent talks by Vice-President C. V. Antenbring and the General Secretary. The President said he was most impressed by the calibre of the delegates attending the Students Conference.

Vice-Presidents' Duties

President Ballard said that Dr. Dick had ensured that the Vice-Presidents were given specific duties, and that they therefore operated during the last year much more effectively than had been the case in the past. The results had been excellent and he proposed to continue and to expand the activities of the Vice-Presidents. He thought the Vice-Presidents could do an excellent job in approaching the Branches where they can locate trouble spots and recommend and take action to overcome the problems. He said there is a definite function for the Vice-Presidents and, therefore, proposed to increase their number. This proposal would, of course, have to be confirmed by By-Law amendment.

Council approved the proposal that C. V. Antenbring continue as Vice-President in the Western Provinces, and that R. B. Chandler continue as Vice-President in Ontario for one year each, and that By-Law provision be initiated to increase the number of serving Vice-Presidents in the Western Provinces from one to two, and the number of serving Vice-Presidents in Ontario from two to three.

Annual Meeting Discussion

Discussed was the time allowed for discussion during the Annual Meeting. Several members said they felt it would be profitable to allow more time for comments. The President thanked Council for this helpful discussion regarding Annual General Meetings and Council Meetings.

(Continued on page 88)

(Continued from page 85)

Annual Meeting Committee

It was resolved unanimously that a hearty vote of thanks be accorded to Dean Myers and the members of the Vancouver Annual Meeting Committee for the excellent arrangements they had made for the 1961 Annual Meeting.

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on April 22, 1961.

Member: H. B. Bowman, Preston; W. W. Brotherton, Brockville; R. A. Coles, British Guiana; J. T. Dew, Toronto; W. M. Flanagan, Montreal; W. J. Galt, Montreal; W. D. Gilbert, Kingston; C. M. Glos, St. John's, Nfld.; G. Hake, Toronto; L. A. Jenkins, Ottawa; A. B. Johnson, Montreal; R. P. Kemp, Toronto; G. Lemieux, Quebec; M. Lepage, Quebec; J. G. McLean, Toronto; G. N. Middleton, Toronto; G. C. Morgan, Victoria; A. Opran, Montreal; D. P. Parker, Stamford Conn.; P. N. R. Payne, Sept Iles; J. Roberts, Edmonton; L. P. Ryan, Toronto; L. J. Severson, Port Cartier; T. G. Smith, Montreal; G. S. Stitt, Stettler; R. A. Sullivan, Montreal; E. C. Tucker, Montreal; C. S. Ufnal, Toronto; K. R. Wallace, Toronto; J. L. Watson, Toronto; V. S. Weiss, Montreal.

Junior: H. E. R. Brown, Asbestos; A. M. J. Hannon, Sept Iles; E. B. Law, Ottawa; J. M. Nadeau, Montreal; R. J. Paterson, Oromocto, N.B.; P. A. Pietracupa, Montreal; W. D. Smythe, England.

Affiliate: A. V. Grant, Montreal; A. K. Vincent, Toronto.

Junior to Member: D. M. Allan, Vancouver; R. A. Baillie, Montreal; J. A. Baillies, Montreal; P. C. Barlow, Montreal; P. T. Beauchemin, Montreal; W. P. Beley, Winnipeg; R. B. Bellerby, Montreal; J. P. Bergevin, Whitby; P. R. Brown, Hamilton; H. Calpakis, Montreal; R. A. Carter, Montreal; E. M. Clark, Vancouver; R. Cohen, Montreal; L. A. Crema, Coniston; G. W. Crook, Montreal; J. T. Currie, Oakville; T. J. Curtis, Port Credit; A. de Breyne, Montreal; L. H. W. de Launay, Montreal; P. E. Dessarud, Bathurst; B. V. Donnelly, Shawinigan; W. H. Doran, Vancouver; G. Douglas, London; G. J. Evans, Toronto; R. H. Fletcher, Vancouver; W. E. Heuft, Sarnia; R. C. Hinde, Toronto; W. H. Hopper, Toronto; P. M. Jangaard, Dartmouth; H. A. Lachoski, Toronto; B. Lamarre, Montreal; E. J. Lee, Lodgepole; T. B. Lounsbury, Three Rivers; D. M. Lund, Belleville; H. A. MacKenzie, Ottawa; M. J. Malo, St. Hyacinthe; E. Manuel, Schenectady, N.Y.; M. B. Martin, Campbellton; S. Mazure, Youngstown, N.Y.; M. J. McAlpine, Bancroft; R. S. McLatchie, Hamilton; R. J. Milroy, Ottawa; G. L. Mollenhauer, Toronto; A. L. Morrison, Sherbrooke; W. R. Newcombe, Hamilton; M. J. Nickerson, Moncton; A. Paquet, Quebec; A. P. Qually, England; K. I. Reekie, Hamilton; M. T. Rourke, Montreal; J. H. Schuster, New York; J. Sirys, Flin Flon; R. F. Smith, Lethbridge; R. J. Trafford, Toronto.

Student to Member: W. McGilvery, Winnipeg.

Student to Junior: G. M. Desjardins, Montreal; D. J. Morton, Sept Iles.

STUDENTS ADMITTED

Ecole Polytechnique: A. Allard, M. A. Anton, S. Antallah, N. Ayoub, E. F. R. Beauchamp, R. Beaudette, J. R. Begin, A. Beique, F. Berard, S. Bergeron, L. Bernier, R. Blais, R. Blais, G. Blanchet, L. H. Bouchard, M. Boucher, M. Brien, P. Brunet, J. Buczynski, C. Caille, M. Caron, P. Carrier, R. Carrier, P. Casgrain, P. Charbonneau, G. Chartrand, C. Choquette, Y. A. Comire, C. Comtois, C. Cossette, J. L. Cote, D. R. Couderc, P. Courteau, H. Coutu, G. Crepeau, P. Croteau, J. J. F. D'Aoust, P. D'Aragon, L. F. C. de Laberbis, Y. Delagrave, G. L. Desautels, Y. Deschamps, J. Deschenes, M. Desjardins, M. Dishi, J. E. Dizazzo, J. Drouin, L. Dubuc, G. L. Duhaime, C. E. Dumas, C. Duranleau, M. Emard, L. Favreau, P. Galipeau, G. Gauthier, J. J. R. Gervais, R. Gervais, D. Gill, R. Gonthier, J. M. Goyer, G. J. R. Gravel, R. M. Gregoire, C. Guay, D. Guay, S. Guay, Ho Duc Nguyen, J. Homier, C. Iannuzzi, G. Jannard, S. Lachapelle, R. Lafontaine, A. Lafrance, G. H. L. Lamotte, P. Laplante, L. Laporte, P. A. Larivee, J. G. Larocque, G. Larouche, J. Laurin, M. Laurin, J. G. Lavallee, J. A. H. G. Leblanc, J. Leduc, R. Legault, J. A. I. Leger, S. Lenoir, J. Lepine, S. Lepine, G. Leroux, M. Leroux, Y. Le Rouzes, G. Lessard, P. Levesque, I. Liva, A. Lize, C. Lavernoche, J. H. R. Longpre, M. Longtin, A. Maisonneuve, J. Mallett, J. H. Many, M. Marchand, R. Marchand, G. Marchessault, A. Marier, B. Marois, R. Martel, P. Menard, Y. Methot, H. Michaud, L. Michel, J. J. Monette, Y. Monette, R. W. Moreau, R. Morency, F. Ostiguy, M. Ouellet, J. G. Pelletier, L. Pelletier, L. Perron, M. Pettigrew, Phan-Hung-Duc, A. Picard, J. M. Pichette, E. Pichon, G. Pilon, Y. Poitras, V. Preiss, G. Racine, G. Raymond, R. Reid, G. Ricard, G. Riquier, J. Rivard, G. Rivest, R. Roberge, M. Robert, A. Robitaille, A. Rondeau, A. Rousseau, P. A. Roy, J. Saint-Cyr, P. St. George, C. Sauriol, G. Sauriol, R. Seguin, C. Simard, R. Sirois, J. G. Tanguay, G. Terreault, A. Tessier, R. Tetreault, A. Theberge, G. Theriault, P. Therien, J. Y. Therrien, J. Torrealba, A. Tremblay, P. Tremblay, R. Tremblay, Y. Trepanier, L. R. Trottier, J. G. Trudel, J. P. Trudel, R. Trudel, M. Turgeon, J. R. Vanasse, R. Vanasse, R. Venne, J. Verrette, A. Vigeant, F. Villemaire, G. Villemaire, P. Zaikoff.

Acadia University: E. B. Calp, D. B. Caryll, E. G. Hirtle, A. H. Lohnes, J. D. Moses, W. A. F. Nagle, A. Orlic, J. A. Veinot.

Nova Scotia Technical College: J. R. Benner, C. A. Boyd, C. L. MacKenzie, P. E. Oldhale, C. I. Polegato.

McMaster University: L. Johnson.

Saint Francis Xavier University: J. M. MacLean.

McGill University: G. Lahaie.

Student of Corporation of Professional Engineers of Quebec: T. McDermott-Fox.

Application through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective May 29, 1961.

ALBERTA

Junior to Member: R. A. Ellefson, P. Yurkiw.

SASKATCHEWAN

Members: J. H. Abrams, L. Castelli, M. J. Chorel, P. T. Cook, F. L. Crandell, J. F. Dunnett, R. A. King, B. W Kishchuk, F. E. Michael, P. N. Nikiforuk, T. Skagestad.

Junior to Member: V. G. Beckie, M. F. Clark, J. P. Melin, C. A. Pegg, D. A. Sharp.

Student to Junior: L. N. Adamache, B. A. Lundeen, R. J. Turner.

NOVA SCOTIA

Member: G. C. Smith.

Report of the Admissions Committee
May 29, 1961

Member: P. F. Bisson, Montreal; Y. Erdelyi, Montreal; K. R. Kilburn, Seven Islands; R. McClean, Montreal; W. M. Trotter, Toronto; H. Tun, Montreal.

Affiliate: L. W. Gray, Trenton.

STUDENTS ADMITTED

University of Toronto: D. R. Bedford, J. S. Brant, R. E. Flechner, J. R. McLeod, C. R. Stee.

McGill University: J. G. C. Fafard, J. Lamontagne, R. Oder, S. G. Schneller.

Nova Scotia Technical College: J. E. Dodge, W. F. Kennedy, T. A. Richardson.

Sir George Williams University: R. L. Franchini, F. A. Glasspoole.

University of British Columbia: L. G. Vanderlin.

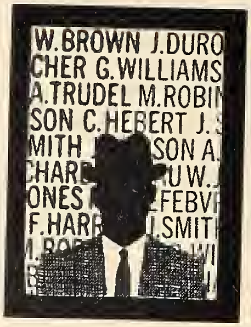
St. Francis Xavier University: J. D. Thompson.

Association of Professional Engineers of Ontario: L. W. Vriesinga.

Errata

In error the name of Prof. A. C. Davidson was omitted from the list of Councillors of the Institute in the May issue of the Engineering Journal. Prof. Davidson is a Councillor for the Toronto Branch and his term of office ends in 1963. EIC

Personals



R. Dickson Harkness, M.E.I.C., (Queen's '13) was recently elected chairman of the board of directors of Northern Electric Company Limited. Joining Northern Electric in 1913, he has spent his entire career with the Company and has been a director since 1938, and president since 1948.

Enlisting as a private in 5th Cdn Mounted Rifles early in World War I, Mr. Harkness subsequently commanded the 1st Cdn Motor Machine Gun Bde with the rank of Lt. Col. Prior to World War II he commanded HQ Sigs Area, M.D. No. 4 with the rank of Col. During the war he was appointed to the Army Technical Board and has subsequently served two terms on the Defence Research Board and was president of C.E.M.A. Mr. Harkness is a director of many leading Canadian industrial companies.

R. Dickson Harkness
M.E.I.C.

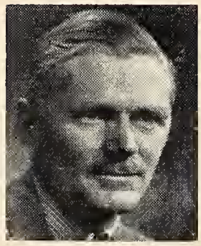
D. M. Stephens
M.E.I.C.

D. M. Stephens, M.E.I.C. (Man. '31) has recently been appointed chairman of the board of Manitoba Hydro. A past president of the E.I.C., Mr. Stephens is currently a director of Atomic Energy of Canada, and a member of the Canadian Section of the International Joint Commission.

Christopher G. R. Armstrong, M.E.I.C. (Tor. '20), was honored by the American Water Works Association at its 81st Annual Conference held recently in Detroit, Mich. At a special "Water Works Man of the Year Ceremony", Mr. Armstrong was cited for "his public service in the water works field as a consulting engineer; for his exemplary service to the Canadian Section as chairman and director, and as an ever ready leader in water works programs."

J. M. Watson, M.E.I.C. (McGill '50), has been appointed Eastern Canada sales representative for Graver Water Conditioning Co. and Smith & Loveless Company, both are division of Products Tank Line of Canada, Ltd.

J. B. Stirling
HON. M.E.I.C.



J. M. Cape
M.E.I.C.

J. B. Stirling, M.E.I.C. (Queens '11) has been appointed Chairman of the Board of E. G. M. Cape & Company Ltd. John M. Cape, M.E.I.C. (McGill '30) has been named President. Both men have been associated with the Company for a considerable length of time. Mr. Stirling, recently appointed Chancellor of Queen's University, was president of the E.I.C. in 1952.

W. F. Mainguy, M.E.I.C. (Queens '28), has been named president of the Shawinigan Water and Power Company. He had been executive vice president since 1952. **A. C. Abbott,** M.E.I.C. (McGill '26) succeeds Mr. Mainguy as executive vice-president and has been elected to the board of directors of the Company. **W. R. Way,** M.E.I.C. (McGill '18) has been appointed senior vice-president.

J. F. Chantler, M.E.I.C. (Toronto '42), has been appointed manager of Kipawa Mill, C.I.P., Temiskaming, Quebec. Mr. Chantler succeeds H. Anvik who has retired.

Williard A. J. Jackson, M.E.I.C. (Queen's '39), formerly general superintendent of North Shore Construction Co. Ltd., Montreal, has established a construction consulting firm — Consul Construction Consultants Ltd. The firm acts as consultants on construction problems to owners, contractors, engineers, surety and insurance companies, with particular emphasis on adjusting insurance cases involving engineering problems.

Georges M. Desjardins, JR. E.I.C. (McGill '59), has recently been appointed district manager, Building Specialties Division, with Sturgeons Limited. His district includes Montreal, Quebec Province, Eastern Ontario and the Maritimes.

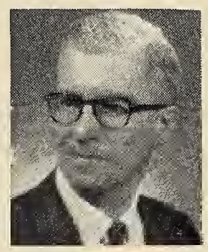
A. O. Drysdale, M.E.I.C. (McGill '41), has been elected president of the Ontario Chamber of Commerce.

Abraham Benjamin, M.E.I.C. (McGill '24) was named manager of the Special Projects Division of Surveyer, Nenniger and Chenevert, Montreal. This new division has recently been formed to serve architects and others with complete consulting engineering services for commercial, institutional and manufacturing building projects.

David J. McDougall, M.E.I.C. (McGill '52) has been appointed chairman of the Department of Engineering of Loyola College. Dr. McDougall has been on the teaching staff of Loyola since 1955, and is the author of technical papers which have been published in U.S. as well as Canadian geological publications.

David P. Rutenberg, S.E.I.C. (Tor. '61) has joined the staff of the Petroleum Process Division, Richmond Laboratory, Standard Oil of California, as a research engineer.

F. E. Hertha
M.E.I.C.



R. E. Smallwood
M.E.I.C.

F. E. Hertha, M.E.I.C. (Tor. '49), has been appointed Director of Planning for Columbia Cellulose Company Limited, as well as its subsidiaries. In this position Mr. Hertha is Chairman of the Development Committee and assists in the financial analysis of all major projects. Mr. Hertha has been with the firm since 1957.

R. E. Smallwood, M.E.I.C. (Tor. '35) was elected to the Board of Directors of the American Gear Manufacturers Association during its 45th Annual Meeting. Associated with Dominion Engineering in various capacities, Mr. Smallwood is now Product Engineer of the Gear Products Division located in Lachine, Que.

William A. Dexter, M.E.I.C. (Alta. '50), has been elected a director of Haddin, Davis & Brown Co. Ltd., a firm of engineering consultants. He has been manager for the firm in B.C. since 1957.

Other Societies

American Society for Engineering Education

More than 3,000 engineering educators attended the 69th annual meeting of the Society held at the University of Kentucky in Lexington June 26-30. "Engineering and World Affairs" was the theme.

There are important things to be done by engineers it was noted. There is not time for young engineering graduates to design unnecessary things. "We need young engineers with ideas, imagination, vision, idealism, and courage. And we need young engineering teachers who can inspire and encourage these ideas" Dr. Walker challenged the delegates in his presidential address.

Agricultural and civil engineering are of the sciences, the most vital link in the assistance of underdeveloped nations. Though engineers working in underdeveloped countries do not need the most advanced skills, they must use practical programs to cope with basic agricultural problems. The engineer who works in these countries must have the ability to communicate with many people, lead in a constructive manner, and have a real understanding of other political systems. This type of engineer is also an "ambassador for human welfare, as well as a good professional man."

What of the foreign student who comes to study in the U.S.A? Students from underdeveloped countries often learn about phases of engineering for which there is no use as yet in their own countries. It was suggested that foreign students be given an internship program to give them practical experience in American industry. Special classes in the cultural and social aspects of American life were also suggested.

There is still a basic conflict between the traditional engineering education and the emphasis on the engineering sciences. Students graduating from the new programs may not be as capable as others for the group effort, demanded by the profession.

It was suggested that Nuclear Engineering be taught at the graduate level in order to insure that the engineer has the complete education necessary.

The Society's Engineering College Research Council reported over 11,000 research programs in progress on American university campuses. It was felt that there must be more interdisciplinary research, and that every engineering faculty should occupy half its total effort in high level research. It was advocated that the society establish a Center for Engineering Education to better exploit new methods and equipment for the teaching of engineering subjects.

Society of Women Engineers

Boston was the site of the Society's 11th Annual Meeting at which Miss Laurel Van der Wal, head of bioastronautics at Space Technology Laboratories Inc., Los Angeles, received the 1961 Society of Women Engineer's Achievement Award. This is the highest honor the 600 member Society can bestow. Miss Van der Wal, known particularly for Project MIA which she originated and implemented in 1958, has worked in other areas of such research; definition of the space environment, radiation protection, weightlessness phenomena, escape and recovery systems and the design of manned spacecraft.

Miss Laurel van der Wal

The American Society of Mechanical Engineers

"New Developments in Theory and Practice" is the theme of the second International Heat Transfer Conference. Approximately 125 papers will be presented during the five days from Aug. 28-Sept. 1. These will be presented, summarized in topical groups, to be followed by written as well as oral discussion from the floor during the nine sessions which have been scheduled.

The campus of the University of Colorado at Boulder will be the site of the Conference. Sponsors and co-hosts of the Conference are the ASME and the AIME.

Societies from the U.K., Canada and the U.S.A. are participating and papers from the U.S.A., the U.K., Canada, Japan, the U.S.S.R., France, Switzerland, Australia, Italy, Germany and Sweden will be presented. Four special lectures are to be given. Various special events and activities have been planned, and there will be a special ladies program.

Second National Northern Development Conference

"Canada's New Role in Resource Development" is the theme of the Conference to be held in Edmonton, Sept. 13-15. The delegates will examine more specifically areas covered in the first Conference held in 1958. Particular study will be given to the following topics: further exploration and mapping in order to fully assess and locate natural resources in the north, the need for a modern adequate system of transportation; power development and transmission, community development, development of domestic industry to use northern raw materials, a market study for raw and manufactured materials from the north, and the attraction of large amounts of

(*Continued on page 97*)

The Associations and Corporation

Canadian Council of Professional Engineers

W. L. Wardrop of Winnipeg has recently been elected president of the council during the 25th anniversary annual meeting of the Council. Other members of the new executive include vice president D. S. Simmons of Toronto, president of the Association of Professional Engineers of Ontario and executive member Gilles Sarault of Quebec City who is vice-president of the Corporation of Professional Engineers of Quebec.

One of the most important topics discussed at the meeting was the standardization of provincial requirements for Professional Engineers. Other items of business included a study of university engineering courses, a suggestion for a Model Porfessional Engineering Act to be available as a reference for provinces, and a complete study of tarrif regulations regarding engineering drawings, designs and specifications.

ong-term development capital. Many ispects of this Conference will be international in nature as the delegates will study the experience of other northern nations. Also the discussions on how o market Canadian materials and products and how to attract foreign capital will make the Conference more international in nature.

The Institution of Mechanical Engineers

The Second International Conference on Stress Analysis is to be held in Paris next spring from April 10-14 1962. The Conference will deal mainly with the results of experimental work. Papers are invited and prospective authors may write to The Secretary of the Joint British Committee for Stress Analysis for information regarding their preparation. Official languages of the Conference will be English, French and German.

First Pan-American Symposium on Structures

The Symposium, held at the National Polytechnic Institute in Mexico City, July 24-31 brought delegates together for four main purposes. They were: to promote and increase the interchange of knowledge among North and South American civil engineers, to adopt a universal nomenclature in this field, to unify and codify, wherever possible, construction regulations, and to form a permanent Panamerican Seminary with rotating headquarters.

Coming Events

International Heat Transfer Conference, (co-sponsor EIC) Boulder, Colo., Aug. 28-Sept. 1.

National Nuclear Instrumentation Symposium, IRE, AIEE, ISA, Raleigh, N.C., Sept. 6-8.

16th Annual Instrument-Automation Conference and Exhibit, Instrument Society of America, Los Angeles, Sept. 11-15.

Engineering Management Conference, American Society of Mechanical Engineers, American Institute of Electrical Engineers, New York, Sept. 14-15.

Industrial Electronics Symposium, AIEE, IRE, ISA, Boston, Mass., Sept. 20-21.

National Power Conference, American Society of Mechanical Engineers, American Institute of Electrical Engineers, San Francisco, Sept. 24-27.

Petroleum Mechanical Engineering Conference, American Society of Mechanical Engineers, Kansas City, Mo., Sept. 24-27.

Convention, Association of Iron and Steel Engineers, Pittsburgh, Sept. 25-28.

Joint Conference on Fundamental Research, Technical Association of the Pulp and Paper Industry and Canadian Pulp and Paper Association, Oxford, England, Sept. 25-29.

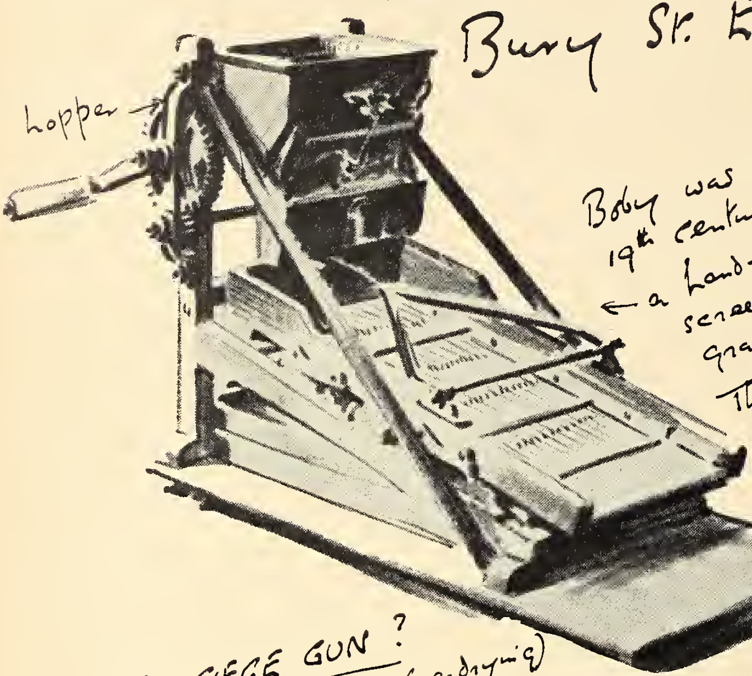
Seminar on Choosing the Right Material for the Job, American Society for Metals, Montreal Chapter, Montreal, Sept. 14-15.

Quebec Regional Technical Conference, E.I.C., Quebec City, Nov. 2-4.

No (X) → THE VICKERS GROUP

ROBERT BOBY LTD.
Bury St. Edmunds, England.

Lopper



Boby was an ironmonger in the 19th century. In 1856 he devised ← a hand-operated self cleaning screen to help farmers grade seed.
That's how all this started

Odd part is, that farme
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feel of good honest

BREWER'S SIEGE GUN?

No! A MALT RETORRIFYING (re-drying) DRUM. This massive Boby order started its journey to the customer before I had even finished sketching it!
(Talk about, "Time a tide—")

Modern Seed Cleaning Machin
This clever contraption can
seed for width a weight a
can even extract n
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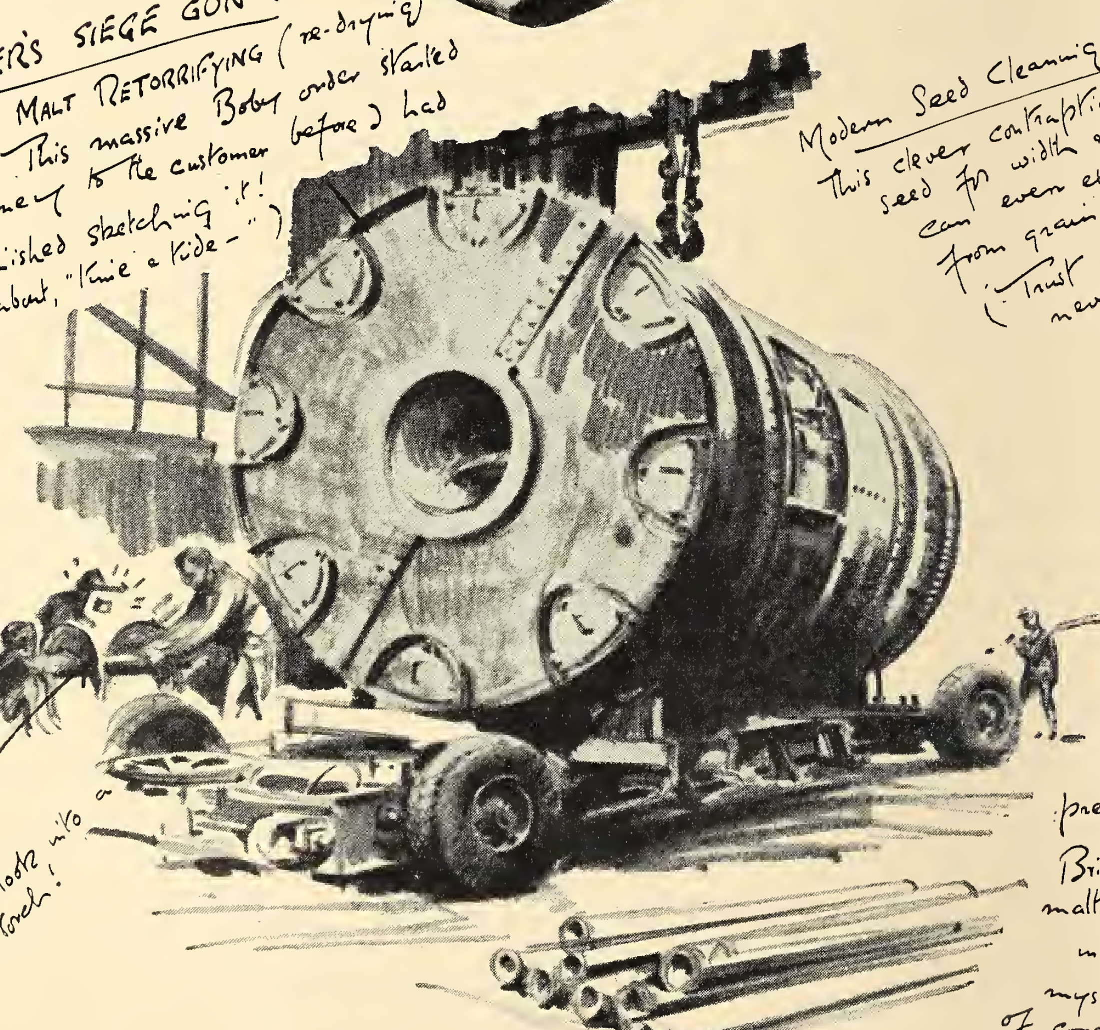

Tip: Never look into a welders torch!

Do yo
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of course)

[H]AS THIS BEEN BOBIED ?" *

"Boby's, to me, seem to be the ideal combination of individual craftsmanship based on family tradition, and membership of a large, up-to-date Engineering Group". This comment by Terence Cuneo reflects exactly the skill and care behind the specialised products of this Company of the Vickers Group.

TCA OVER

News of the Branches

Brockville

A. N. Campbell, M.E.I.C.
Correspondent

May 31 was the date of the first formal organizational meeting between the local branches of the E.I.C. and C.I.C. to work on the Science Fair program. A number of teachers from district high schools also attended. Interest and enthusiasm appear high. The three high schools in Brockville and Prescott are very much in favor. The fair, to be held in 1962, is open to participation by all high school students in the counties of Leeds and Grenville.

The following executive was elected at the meeting: Co-Chairmen: J. M. Woods, M.E.I.C., F. H. Sawden, M.E.I.C.; Secretary: R. J. Paquin; Treasurer: T. M. Eyolfson.

Work on the ambitious program which has already been initiated will proceed throughout the summer and will be handled by nine separate committees, which have already been appointed.

A golf tournament was held June 17 at the Prescott Golf Club. The members were so enthusiastic that it may well become an annual event.

Cape Breton

Lloyd Boutilier, M.E.I.C.
Correspondent

Bev Hamm, M.E.I.C., Manager, Highway Engineering, Department of Highways at Halifax, was the guest speaker at the May 24 meeting of the Cape Breton Branch. His topic was spring load restrictions and the use of the Benkelman beam. By measuring deflections in a paved highway, Mr. Hamm said, the Benkelman beam determines when it should be closed or opened for heavy loads. Color slides illustrated the test vehicle in action. Mr. Hamm described various causes of road failure, including: inferior bearing quality of sub-grade and base course; asphalt laid on frozen sub-grade; asphalt laid too early, to accommodate the travelling public; poor asphalt design in which not enough asphalt binder is used thereby producing surface holes. These surface holes allow salt applied during the winter to infiltrate and cause deterioration. Mr. Hamm said highway engineers try to lay all-weather roads which, as a result of the Benkelman beam test, will not be restricted in the spring. He mentioned Dix-seal, a fine-texture skin coat applied at high temperature. Although it produces no bearing increase it is a good defence against winter's harsh treatment.

Mr. Hamm was introduced by Jack Stevens, M.E.I.C. of Municipal Ready-Mix Ltd., Sydney Roads, and was thanked by Chairman Rod Bradley. Success of the meeting was gauged by a lively question-and-answer period which followed Mr. Hamm's address.

Central B.C.

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

Seventy-five members, their wives, and members of the B.C. Association of Professional Engineers attended a dinner meeting May 23 at which Institute President and Mrs. George McK. Dick were honoured guests. W. Nelson, Branch Chairman, welcomed the guests and introduced J. Treadgold, Alderman of Kelowna. Alderman Treadgold presented Mrs. Dick with a silver spoon as a memento of the city of Kelowna.

H. Bennet, Asst. Registrar, represented the B.C. Association of Professional Engineers, and spoke briefly.

A. Price reported on the joint visit to the Kootenay Branch on April 7 and introduced Dr. Dick who was the main speaker of the evening.

Dr. Dick spoke of the obligations of the Canadian engineer and emphasized the need to develop Canadian resources, to utilize his own ingenuity and creativity in preparation for the day when Canadian engineers will be judged on an international basis.

Estevan Section

O. P. Lesiuk, M.E.I.C.
Correspondent

Results of fracturing with the single-plane entry technique in the Steelman and Pembina oilfields were described at the May 8 meeting of the Estevan Section. The speaker was Jim Strain, area engineer for the British American Oil Co. Ltd. He explained that with the relatively new technique the well-bore is prepared at a selected point using a hydraulic or mechanical notching tool. The well is then fractured with a treatment designed to generate a single, large-areal-extent fracture. A partial monolayer of large-size propping agent is distributed in the fracture to give high-flow capacity after the treatment.

Acting upon a request from the A.P.E.S. it was agreed that the Estevan Section Secretary invite A.P.E.S. Registrar R. Bing-Wo to attend either the September or October meeting of the Section.

London

E. T. Skelton, M.E.I.C.
Correspondent

On May 6 the Branch held a meeting with the London chapter of the A.P.E.O. to tour the London plant of the Northern Electric Company. About 80 engineers visited the Telephone Manufacturing Section and viewed the plastic moulding shop, wiring assembly line, plating shop and the final assembly line. Following the tour ten people in management at the plant formed a panel and answered questions put to them by the visiting group.

The annual golf tournament was held June 13. A dinner followed which was open to golfers and non-golfers.

Moose Jaw

R. J. Tomlinson, M.E.I.C.
Correspondent

Two speakers were featured at the May 17 meeting. M. Shelley gave a talk illustrated with slides on the interior of British Columbia. The South Saskatchewan River Dam was the topic of an illustrated talk given by L. Cockerell. Officers for the coming year were elected: Chairman T. L. Salmon, Vice Chairman, M. J. Shelley, Second Vice Chairman, R. J. Tomlinson, and Secretary Treasurer, A. Brown.

Winnipeg Branch, Civil Section

Merv. Mindess, M.E.I.C.
Correspondent

A meeting of the Civil Section was held on May 10 at the Marion Hotel. Guest speaker was Thomas F. Thompson, Consulting Engineering Geologist of San Francisco, California. His topic was, "Geology and Foundation Treatment, Grand Rapids Power Project", and he was introduced by J. M. Rettie of the Manitoba Hydro-Electric Board.

The Grand Rapids project on the Saskatchewan River is situated in an area between Moose Lake, Cedar Lake, Lake Winnipegosis and the northern end of Lake Winnipeg. Most of the project overlies Palaeozoic formations consisting of dolomitic limestone of Silurian and Ordovician origin.

Ground water solution of this limestone with resulting sinkholes and Karstian topography was the major problem. There were 900 sinkholes of various sizes in the forebay area, and approximately 2000 sinkholes on the total project, which has a 17-mile long dyke oundation area.

An extensive testing program was arried out, including diamond drill oles, pressure tests at 10 ft. intervals in he holes, and the use of a special micro-nullinot device developed by Soletanche nd Rodio of Canada Limited to measure ubsurface flows within the test holes. The pressure tests were run at pressures f 1 p.s.i. per foot of depth below urface. Some limited test grouting was lso done. As a result of this work the ngineers concluded that the serious eakage problem through the rock could be corrected, and progressive deteoriation of the limestone could be stopped.

Phase one of the 17-mile long grout curtain work, on a relatively short section north of the powerhouse, is presently being done as a joint venture by Boyles-Selby, and is approximately 80% completed. A stage grouting, split spacing technique is being used. The procedure is to drill each hole, wash it out, pressure test it, which gives an indication of which of the several grout mixes to employ, and then grout. Primarily holes are spaced at 20-foot centres along the dyke centre-lines, with secondary holes half way in between. If grout acceptance in the secondary holes is too high, tertiary holes are used, bringing the spacing to 5-foot centres. Maximum depth of grout holes is 200 feet, although in most cases grouting is only carried down to an impervious stratum at a somewhat higher elevation.

The grout mixes contain dune sand filler, bentonite to keep the cement in suspension by colloidal action, and 2% calcium chloride which acts as an accelerator. General procedure is to start grouting with a loose mix and to gradually increase the viscosity. In the final stages the lowest water-cement ratio possible is used to keep grout shrinkage at a minimum. Approximately 1.1 cu. ft. of solids per foot of grout hole is being injected.

Preliminary indications are that the grouting is highly successful. This is the largest grouting job in the world to the present time.

A lively question and answer period followed Mr. Thompson's talk, and Dr. D. M. Stephens thanked the speaker.

Canadian Services College

A. L. C. Atkinson, M.E.I.C.
Correspondent

Dr. George McK. Dick paid a special visit to the student Section May 25. Cadet Squadron Leader J. R. S. Pirquet introduced him to the cadets. An informal talk followed and many cadets asked questions about the profession. Later, with members of the Vancouver Island Branch and ladies, Dr. and Mrs. Dick watched a rehearsal of the graduation drill manoeuvers.

The **CAPE BRETON BRANCH** held its annual lobster party June 21. About 90 members and guests attended. On June 15 the **NIAGARA PENINSULA BRANCH** toured the Welland Canal facilities at Thorold. Following the tour J. Trovers, M.E.I.C. gave a talk entitled "Operation of the Welland Canal".

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.

*MECHANICAL-ELECTRICAL EQUIPMENT HANDBOOK FOR SCHOOL BUILDINGS.

This handbook is devoted exclusively to the installation, care, and use of mechanical and electrical equipment in school buildings. It describes the necessary fundamental engineering aspects, but in a language understandable to a reader without technical education. The first five sections cover heating and ventilating, plumbing, sewage disposal, kitchen and cafeteria equipment, and illumination and electric wiring. In the final section and the appendix, fire prevention and first aid are discussed, and general information given on the contractor's guarantee, his responsibilities and administrative conduct relevant to school-building contracts, and on the selection and function of the consulting engineer. (Harry Terry. New York, Wiley, 1960. 412p., $9.50.)

ANTI-CORROSION MANUAL, 1960.

The third annual volume, this edition has been completely revised, and contains much new information. The first section covers industrial problems, including corrosion in the food and oil industries. Other sections cover resistant materials and their applications, both metallic and non-metallic, and including comprehensive preparatory treatment before applying protective coatings; protective coatings, including paints and primers, mastics, metals, plastics and vitreous enamel. Other articles cover spray painting, pipe coatings and tapes, protective packaging, cathodic protection, and water treatment for corrosion control. Bibliographies, as well as relevant British Standards are included, as is a buyer's guide. (London, Corrosion Prevention and Control, 1960. 404p., 60/-.)

ENGINEERING MANAGEMENT, 2nd. ed.

In this second edition, notice has been taken of the changes in industrial conditions since the first edition was published in 1948, the references brought up-to-date, and information on operations research and cybernetics included. The first section covers the "art" of management, and application in an engineering manufacturing business. Under the "science" of management are discussed scientific method, the history of engineering, the structure of industry, legal aspects, and the development of scientific management. The third, and largest section of the book covers the practical aspects of management: market research, production planning, estimating, budget, company organization, factory planning, personnel, production, and control.

Intended as a textbook, this volume will be useful for both management and students. (S. A. Robertson. London, Blackie, 1960. 467p., 30/-.)

GEOLOGY FOR ENGINEERS, 4th. ed.

A textbook of geology, with the emphasis on engineering applications. New material added in this edition includes information on permafrost, tidal surges in the North Sea, the geology of the Kariba Dam site, and methods of site investigation. The topics covered include physical geology; rock forming minerals; igneous, sedimentary and metamorphic rocks; earth movements; structural geology; stratigraphy; geological maps; geology of water supply; the geology of reservoir and dam sites; cuttings and tunnels in various parts of the world. Although the majority of the examples given refer to the British Isles, the text is useful for all civil engineers. (F. G. H. Blyth. Toronto, Macmillan, 1960. 341p., $5.00.)

HOW TO GET THE MOST OUT OF YOUR TAPE RECORDER.

Written for the user of tape recorders, this book contains information on the type of tape recorder to buy, how the machines work, features of the machines, number of heads, and cost. Adjuncts to the recorder such as microphones and tape varieties are discussed, as are good operation, frequency response, distortion, signal to noise ratio, equalization, and stereo. (Herman Burstein. New York, Rider, 1960. 170p., $4.25.)

*HYDRAULIC HANDBOOK, 2nd. ed.

This handbook was compiled by the editors of "Hydraulic Power Transmission", official journal of the (British Association of Hydraulic Equipment Manufacturers. Section 1-A summarizes the principles of hydraulics. Section 1-B describes hydraulic equipment from accumulators to valves, including electrical and remote controls, hydraulic fluids and servo-mechanisms. Section 2 contains descriptions and diagrams of hydraulic and electro-hydraulic circuits; hydraulic computation data in the form of formulae, tables, charts, and nomograms; and a glossary of hydraulic symbols and terminology. Section 3 is a Buyers' guide, containing an index of trade names, of manufacturers, and of hydraulic equipment and components. There is a precise index to the entire handbook. (Editors "Hydraulics Power Transmission", Morden, England, Trade & Technical Press, 1960. 793p., 100s.)

COMPUTING AND DATA PROCESSING SOCIETY OF CANADA. PROCEEDINGS OF THE SECOND CONFERENCE.

One of the objectives of the Society is to sponsor conferences for the exchange of ideas, experiences and information among those interested in the applications of computer technology. The papers presented at this second conference emphasized business data processing and engineering and scientific computer applications. The topics covered included T.C.A.'s electronic reservations system; E.D.P. systems; production scheduling; ship design calculations; highway maintenance costing; computers in small and medium businesses. A feature of the conference was the inclusion of five papers by manufacturers. (Ed. by A. P. Macfarlane. Toronto, University Press, 1960. 365 p., $5.00.)

PAPER-MAKING PRACTICE

Adapted from a series of articles published in The Paper Maker, this volume presents recent ideas on paper-making topics, information which would be found in periodical articles rather than text books. Bibliographies indicate where further details are to be found. The topics covered include sulphite and sulphate pulping; screening and bleaching of wood pulp; stock chest design; head-box design; the wire; felts etc. The book is intended for both students and paper makers. (H. Hardman and E. J. Cole. Toronto, University Press, 1960. 334p., $7.50.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

MODERN TIMBER BRIDGES: STANDARD PLANS

Designed for loadings to AASHO H20-S16, these plans incorporate all the principles of modern timber design, methods, materials and techniques. The drawings are complete, and include all details needed for construction and erection. It is, however, recommended that a professional engineer always be employed. Plans are provided for spans of 20 feet, 24 feet and 30 feet in width, and for varying lengths of from 15 to 100 foot clear span, up to 30 feet at 2-foot increments, and over 30 feet at 10-foot increments. In addition to the plans, bills of material are provided for quick estimating. This should prove a most useful book, and the Canadian Institute of Timber Construction is to be commended for compiling and publishing it. (Ottawa, C.I.T.C., 1960. 84p., $12.00.)

THE ELECTRON MICROSCOPE: THE PRESENT STATE OF THE ART.

An account of the theory and practice of the electron microscope, which was first used in the 1920's. The book covers the optical properties of electron microscope lenses, but omits the basic mathematics which can be found in other books; it also covers the wave optics involved with a minimum of mathematics, and the theory of resolution. Also discussed are the limitations of the instrument, and methods of testing for and reducing them, and associated instruments. The final chapter, written in collaboration with V. E. Cosslett, deals with specimen techniques and the applications of the microscope in the fields of metallurgy, biology and crystallography. (M. E. Haine. London, Spon, 1961. 282p., 55/-.)

NUCLEAR REACTOR CONTAINMENT BUILDINGS AND PRESSURE VESSELS.

The twenty-two papers in this volume were presented at an international symposium organized by the Royal College of Science and Technology in Glasgow. Much research work on the subject has been done on the subject at the College. The papers covered the analysis, design, construction and testing of containment buildings and pressure vessels used in nuclear power plants, specific topics included being: safety criteria; stress analysis; shell structures and research; engineering design, erection and testing of pressure vessels; and brittle strength and fracture. (Toronto, Butterworth, 1960. 572p., $18.50.)

CAST BRONZE BEARING DESIGN MANUAL.

This Manual covers the design and application of 360-degree bronze bearings, for full-film, boundary and mixed film lubrication. Design methods and graphs are included to reduce actual calculations, and also covered are viscosity and lubricants, bearing bronze selection;

(Continued on page 108)

Employment Service

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CIVIL ENGINEER, M.E.I.C., P.Eng. (Ontario) B.A.Sc., University of Toronto 1948. Age 33. Married with family. Twelve years' experience in construction industry, six in field and six in office management position. Available for management position with an excellent future. Present location Southern Ontario. File No. 5916-W.

CITY ENGINEER, B.Sc., M.E.I.C. Seeks advancement into the consulting field. Many years of experience in municipal engineering (planning, design, construction, maintenance, administration, and reports). Interested in office where principals are now overworked. Located in Southern Ontario. File No. 6301-W.

ELECTRICAL ENGINEER, M.E.I.C., P.-Eng. Naturalized Canadian with 12 years of diversified experience in electrical machines, controls, drives, navy orders, steam and diesel generating plants, consulting and field work. Presently on assignment in the Far North. Will be available in July or August. Preferable location Montreal. File No. 6306-W.

PRODUCTION ENGINEER, M.E.I.C., P.-Eng. Full apprenticeship toolmaking and design. Work study and value analysis. Experienced and energetic manager for all phases of small to medium manufacture. Domestic appliances, automotive, telecommunications. Seeks permanent responsible and challenging position with progressive company. File No. 6321-W.

MECHANICAL ENGINEER, M.E.I.C., hardworking and industrious, 21 years of varied experience in industry at estimating, designing, inspection, purchasing, sales and project management. Now employed but desires a change to a challenging responsible position. File No. 6339-W.

CIVIL ENGINEER, Laval 1961. S.E.I.C. Age 25, married. Undergraduate training as Assistant Town Engineer. Seeks employment with a City Staff, Consultant Firm or Contractor. Preferred location, Quebec Province. File No. 6340-W.

PROFESSIONAL CIVIL ENGINEER, Jr.-E.I.C., 3 years experience in hydraulics, hydrology and reinforced concrete design. Desires responsible position with opportunity for advancement. Initial salary of secondary importance if work is challenging and future outlook encouraging. Will consider any location but prefer Central or Western Canada. File No. 6341-W.

MECHANICAL ENGINEER, M.E.I.C., P.-Eng. (Ontario). Age 33, married. Post graduate course in advanced mathematics. 6 years analytical, design, development, test experience at project level in aircraft power plant installations (turbine and piston engines) and air cycle air conditioning systems. 2 years experience in industrial and commercial air conditioning. Desires responsible position where a specialized knowledge of heat transfer, fluid dynamics and thermodynamics is required. Location Southern Ontario. File No. 6342-W.

MECHANICAL ENGINEER, Age 26, single, bilingual, Athlone Fellow, B.A.Sc. (Laval 1959). Presently studying at Birmingham University for a M.Sc. (Thermodynamics). Summer experience in paper mills, steel plant and research establishment. Worked for a year in a steel plant and steam turbines manufacture in Great Britain. Will consider any position offering challenge and opportunities. Ready to move anywhere. Available beginning of October. File No. 6343-W.

TRANSPORTATION ENGINEER, S.E.I.C., P.Eng., (Ontario), B.Sc. 1960, M.Eng. 1961, Institute of Transportation and Traffic Engineering, University of California. Age 24, married. Desires planning or design position with a progressive planning, engineering, or transportation organization. Prefer Central or Far Western Canada. Resume of education and experience on request. Available two weeks notice. File No. 6344-W.

CIVIL ENGINEER, Jr.E.I.C., P.Eng. (Ontario), B.Sc. Queen's 1956, age 29, single, desires work in any branch of civil engineering at home or abroad. Experience includes four years with the Triangulation Section, Geodetic Survey of Canada. Presently employed on sewer design and construction with large municipality in Eastern Ontario. File No. 6345-W.

CIVIL ENGINEER, M.E.I.C., P.Eng., Ontario and Alberta. B.Sc., M.Sc. (Soils and Concrete), University of Alberta, 1949, 1952. Married with family. 12 years' field and office experience in all aspects of contract supervision and administration. Post graduate studies and 3 years experience in soils and concrete. Desires responsible position with advancement opportunities and security. Full resume on request. Now located Central Canada. Available on usual notice. File No. 6347-W.

CIVIL ENGINEER, Jr.E.I.C., P.Eng. (Quebec), B.Sc. Loyola 1958, B.Eng., McGill 1961. Age 24. Single. Summer experience in soil, surveying and construction. Would like position in construction, municipal or other interesting work. Full resume given on request. Prefer Montreal area but would move. File No. 6350-W.

CIVIL ENGINEER, B.Sc., 1947 (London), Civ. Eng. Diploma, A.M.I.C.E., P.Eng. Married, 33. Canadian citizen. Have design, materials, construction and administration experience in highways, airfields and marine fields in Canada (9 years), Europe and Africa. Seeks new opportunities preferably with consultants or large company. Willing to travel, home or overseas. Present location Central Canada. File No. 6146-W.

CIVIL ENGINEER, N.S.T.C. 1951, Jr.E.I.C., P.Eng., Que., married, 38 years, bilingual. Three years' experience in general contracting, one year in smelter construction, 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. Located in Central Canada. File No. 6181-W.

ENERGY — EXPERIENCE — CAPITAL. Professional engineer M.E.I.C., wishes to invest administrative and technical skills in manufacturing, plant engineering and maintenance, product design and development in small established and growing business, preferably electrical-mechanical or allied lines, where present owners wish to gradually withdraw capital or where additional management and capital required for expansion. Presently located in Maritime Province. File No: 6330-W.

MECHANICAL ENGINEER, Jr.E.I.C., P.-Eng. (Ont.), R.M.C. Graduate, B.A.Sc. Toronto 1959. Age 26, married, one child. Employed since graduation as technical officer with R.C.A.F. Experienced in man management and technical administration. Prefers position in engineering sales but will consider any field with progressive organization where success depends upon qualities of character and personality as well as on the application of sound engineering principles. Available January 1962. Location preferences Ontario, Quebec or B.C. File No. 6346-W.

CHEMICAL ENGINEER, Jr.E.I.C., B.Sc., University of Alberta 1956. Age 28. Married. Experience 3½ years in production and 1½ years in development work. Seeks challenging position in design or production. Located Ontario. File No: 6349-W.

SENIOR ENGINEER — M.E.I.C., Fellow AIEE, French-Canadian with wide experience in administration, education and planning would consider offers in fields suitable to his experience. File No. 6351-W.

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ENGINEERS FOR SOLID PROPELLANT RESEARCH WORK. Prominent Swiss company with extensive research program requires immediately chemists specializing and experienced in elastomer formulations and physicists specializing and experienced in solid state and rheology. Excellent working conditions. Minimum two year contract. For further details please write File No. 7304-V.

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headquarters in Montreal, the other on regional staff at Edmonton. File No. 7284-V.

CONSULTING ENGINEERING FIRM in Maritime Province wants professional engineer with experience in foundation investigation, foundation design and materials testing. Please give complete resume of experience, personal data and salary expected. File No. 7297-V.

CIVIL ENGINEER required by Toronto consulting firm. Must have experience with small dams, flood control work and hydrology studies, and able to carry out planning and write reports. Familiarity with foundation investigations and construction methods highly desirable. Position offers opportunity for a diversity of experience. Salary is open. Reply, with details of background to File No. 7300-V.

EXPERIENCED SOILS ENGINEER required by well-established consulting firm in soils and foundation engineering in Eastern Canada to take charge of a district office. Salary commensurate with experience. Reply in confidence stating qualifications and experience to File No. 7301-V.

MUNICIPAL ENGINEER with a couple of years experience required for our municipal protection engineering division. Must be bilingual. Good future. Attractive salary. Please apply by letter or in person to Canadian Underwriters Association, 10 St. Nicholas St., Montreal 1, Quebec. File No. 7305-V.

CIVIL ENGINEER required for progressive national technical association, for the lumber industry. Headquarters in Ottawa. Excellent proposition for person interested in responsible position. Apply in writing giving full particulars. File No. 7312-V.

ELECTRICAL

PROJECT ENGINEER with 3 to 5 years' experience in microwave electric engineering with broad engineering interests. Experience on or a general knowledge of reinforced plastics an asset. Forward complete resume of education, experience and personal data (all replies held in strict confidence) D. G. Mitchell, Brunswick of Canada, Box 60, Dixie, Ontario. File No. 7268-V.

ELECTRICAL ENGINEER required immediately for plant electrical engineering duties in open pit and underground iron ore mining operation in Northwestern Ontario. Must have minimum of 5 years experience and preferably be familiar with mining. Housing available in modern town 125 miles west of the Lakehead. Apply with full particulars to File No. 7293-V.

POWERHOUSE SUPERINTENDENT. Superintendent of power plant located in Iran. Must be university graduate, with degrees in Electrical Engineering preferred, or have the equivalent in engineering experience. Should have at least two years experience as service operator in hydroelectric powerhouse. Working knowledge of plant equipment necessary. Complete responsibility for disassembly repairs and reassembly of major equipment. Salary commensurate with ability. Living allowance and other fringe benefits. Eighteen to twenty-four month contract. Send complete detailed resume of experience and qualifications to Personnel Department, Harza Engineering Company, 400 W. Madison St., Chicago 6, Illinois. File No. 7302-V.

MECHANICAL

GRADUATE MECHANICAL ENGINEER wanted between ages 30 and 35 to head up Plant Engineering Department of medium size, long-established Montreal Manufacturing Plant. The position involves the usual plant maintenance duties, but in addition, offers considerable scope in product design and development, and via this route offers a good opportunity to man wishing to work into a business rather than the pursuit of straight engineering duties. The company enjoys a good reputation in its field and has additional manufacturing plants across Canada. Successful applicant will be assured of the usual company benefits, such as Insurance, Retirement Plan, etc. In replying, please give full details as to education, experience, salary required, etc. File No. 7292-V.

GRADUATE MECHANICAL ENGINEER required with 5 to 8 years' experience in the design of thermal power plants including estimating. Scheduling specification writing and draughting. Forward complete resume of education, experience and personal data to Mr. W. O. Peffers, Montreal Engineering Co. Ltd., P.O. Box 250, Place d'Armes, Montreal, Quebec. All replies held in strict confidence. File No. 7310-V.

MECHANICAL ENGINEER with 4 or 5 years' experience in design of plumbing, heating and air conditioning. Consulting firm in Ottawa. File No. 7311-V.

MISCELLANEOUS

ENGINEERS FOR SALES, Project, design, research, development, control and management. Graduates of all types and ages required by clients of The Technical Service Council, a non-profit industry sponsored placement service. Write 2 Homewood Avenue, Toronto 5, for an application. There is no charge for work done on your behalf. File No. 6648-V.

DIRECTOR OF INDUSTRIAL ENGINEERING, B.S. Degree in Mining, Mechanical or Industrial Engineering essential. M.S. Degree advantageous. Additional post graduate studies in field such as Business Administration, Industrial Psychology, Advanced Statistics, Human Relations, etc. Requires 10 years experience in Industrial Engineering including 5 years in a supervisory position. Experience must cover industrial engineering techniques, such as time and motion study, ratio delay, methods engineering, wage incentives, cost accounting, labor relations, job evaluation. Excellent opportunity — large copper company central Chilean area. Employment on contract basis in multiples of 2 year contract. Transportation both ways and salary while travelling paid by Company Provision also made to transport household effects. In reply give complete details and references. File No. 7270-V.

METALLURGICAL ENGINEER or mechanical engineer with knowledge of ferrous metal industry for production and development work in a plant in Quebec producing metal powders. Three to five years plant experience required, some design and equipment layout experience desirable but not essential. File No. 7286-V.

INDUSTRIAL ENGINEER required by progressive bleached Sulphate pulp mill located on scenic North Shore of Lake Superior. Modern young community, on new Trans Canada Highway, with excellent recreational facilities. Experience in industrial engineering desirable but not essential. Necessary training will be provided. Will consider graduate from any engineering course at recognized University with one to five years experience in any engineering field. Work is mainly on project basis in fields of work measure-

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OTTAWA, Ontario.

E60-29

ment, methods improvement, plant layout, economic evaluation and fact finding. Starting salary commensurate with experience. Please apply in own hand writing stating age, marital status, details of education and experience to: Personnel Superintendent, Kimberly-Clark Pulp and Paper Company Ltd., Terrace Bay, Ontario. File No. 7298-V.

INSTRUMENTATION AND CONTROL ENGINEER, National Research Council, National Aeronautical Establishment, Ottawa, Ontario. The National Aeronautical Establishment requires an experienced engineer capable of initiating the design of new instrumentation and transducers, data handling equipment and control systems for the Aerodynamics Sections. The laboratories of this Section are equipped with a wide range of subsonic, supersonic and hypersonic wind tunnels and short flow duration research facilities. The successful applicant will have the support of an experienced instrumentation group, mechanical design office and newly equipped workshops as well as the use of analogue and digital computers. The opportunity exists to follow a design through all stages up to the final installation and operation. Candidates must be graduates with honours from a recognized University in Electrical Engineering or Physics (or equivalent) and must have several years of pertinent experience. For example, they must be familiar with the application of electrical transducers, automatic electric and hydraulic controls, and data processing systems and must be capable of an original approach to the many instrumentation and control problems posed by aerodynamics research. Salary up to $10,000 per annum is offered for this position depending on the qualifications and experience of the applicant. Apply giving age and complete details of education and experience to the Employment Officer, National Research Council, Sussex Drive, Ottawa 2. Please quote file NAE-61. File No. 7299-V.

POSITION AVAILABLE for a designer-draftsman preferably a new university graduate. Salary commensurate with degree and experience. Location North Bay, Ontario. File No. 7303-V.

MAINTENANCE ENGINEER. Here is an opportunity for an experienced professional engineer to assume responsibility for all maintenance in a modern and expanding chemical plant. All trades will report to him through foremen. Location, Quebec Province, near a major city. Our client is a leading and well-financed manufacturer of industrial chemicals. Your enquiry will be kept in confidence and answered. Technical Service Council, 2 Homewood Avenue, Toronto 5. File No. 7309-V.

(*Continued from page 76*)

while smelting and reduction take place. The woody portion of the black liquor when burned produces enough heat in the furnace to maintain the flash drying of residual moisture, salt cake reduction and chemical smelting. The heat in the gas produces steam used for power. Processing spouts which are water cooled continually remove smelt from the furnace hearth to the main dissolving tank where it is dissolved in a water solution. The resulting product, called green liquor is treated with lime to make the white liquor used for cooking wood chips.

This basic unit in the Celgar mill could become the first stage of a more complex recovery process for use in sulphite or other similar pulping operations. Another conversion plant, capable of producing a variety of highly pure cooking chemicals in quantity enough to be used in any of several sulphite digestion methods may be added.

The value of this type of conversion unit is its high efficiency in recovering chemicals vital to the pulp and paper industry and its resulting elimination of waste. EIC

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Invites applications from qualified engineers and scientists to join a group engaged in research on structural endurance, fatique and fracture. The group enjoys a wide latitude of freedom to pursue investigations of scientific and engineering interest in its related fields which range from investigations in metal physics to material properties and operational statistics.

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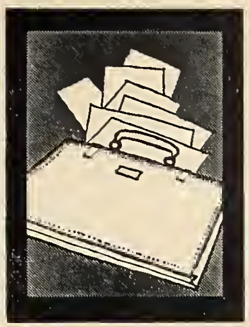
Apply giving age and complete details of education and experience to the Employment Officer, National Research Council, Sussex Drive, Ottawa 2. Please quote file NAE-64.

SITUATIONS VACANT (Cont'd)

SALES ENGINEER (Electrical) to re present manufacturer supplying tools an equipment to electrical power and com munications utilities and contractors, t operate out of Montreal in the Provinc of Quebec. Preferably bilingual with ex perience in electrical utilities work. Pleas reply with resume, giving age, educatio etc. Salary open. File No. 7315-V.

UNIVERSITY OF QUEENSLAND, BRIS BANE - AUSTRALIA. SENIOR LECTURE IN INDUSTRIAL ENGINEERING. Th University invites applications for th position of Senior Lecturer in Industria Engineering. Salary £A2520-70—£A287 Applicants should possess an Honou Degree in Mechanical or Production En gineering of a recognized Universit with further qualifications (preferably Higher Degree) and responsible industria experience in the production field. Som experience of design for production desirable. Previous teaching experienc is desirable, but not absolutely essentia The appointee will be required to conduc undergraduate and postgraduate lecture and laboratory work, and to engage i and supervise research, in Industrial En gineering, which in this University in cludes both the technical and manageria aspects of the subject. The department o Mechanical Engineering has a very ac tive research and postgraduate schoo and has already achieved world standin for its research into the mechanical mil ing of sugar cane and the application o solar energy to domestic air-conditionin It possesses well equipped laboratories, in cluding machine tool laboratory an workshop capable of precision work, an an excellent Metrology Laboratory whic is registered by the Australian Nationa Association of Testing Authorities. Th successful applicant will be entitled t participate in the benefits available the academic staff which include F.S.S.U type Superannuation, Housing Assistanc Study Leave, and Travel Grants. Add tional information on the conditions o appointment, staffing and activities of th Department, together with applicatio forms will be supplied upon request t the Registrar, University of Queenslan Brisbane, Australia with whom applica tions close on **15th September.** C. J. CON NELL, Registrar. File No. 7306-V.

Business and Industrial Briefs



Appointments and Transfers

John H. Gregory has been elected president of Canadian Blower & Forge Co. Ltd., and of Canada Pumps, Ltd. He succeeds **Henry W. Wendt** who will assume the position of Chairman of the Board of each company.

A. v.d. Luft, who since early 1960 has been manager of Du Pont of Canada's Nipissing Works, has been appointed assistant sales manager of the Explosives Division. He will be succeeded as Nipissing Works manager by **John O. Gage**, now assistant manager there.

M. L. Baxter Ltd., has announced the appointment of **Robert Beggs** as Sales Engineer for the Eastern Ontario region.

Westeel Products Limited have appointed **Allan Hally** as Assistant to the President. Mr. Hally was previously President of the operation of the A.P.V. Group in Canada.

Heading the new Silicon Rectifier department of Syntron (Canada) Ltd., Stoney Creek, Ont. is **Armand Fromanger**, who has been closely associated with the electronics industry in Canada for many years.

A. L. **Pomeroy**, formerly Purchasing Agent of the Cornwall Division of Howard Smith, has been appointed general purchasing agent of Howard Smith and subsidiary companies. He is succeeding D. Ross-Ross who, pending retirement this summer is undertaking a speeial assignment relating to the co-ordination of the purchasing organization of Dominion Tar & Chemical Company Ltd. and its subsidiaries. Mr. Ross-Ross has been with the company since 1925.

Canadian Titanium Pigments Limited has announced personnel changes in its sales organization. **Donald E. Rider** is appointed to their Ontario area sales office and is succeeded in Vancouver by **Denys J. Couch.**

Marshall, Macklin and Monaghan, Ontario Land Surveyors, Consulting Professional Engineers and Town Planners, has announced the opening of a branch office in Galt, Ont., under the management of **David R. Brotherston.**

Richard Ellis has recently been appointed Manager, Canadian Field Sales, Atlas Steels Ltd., Welland, Ont. Prior to this appointment Mr. Ellis was Manager of the Hamilton Branch. He has been with the company since 1949.

M. F. Anderson, president of Dominion Rubber Company Limited, has announced the appointment of **J. R. Falconer** as general manager of the Footwear Division and **W. H. Schmalz** as general manager of the General Products Division.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A COMPACT GRINDER for sharpening tungsten-carbide drills has been announced by Flygt Canada Limited. It is powered by the gasoline operated "Pionjar" rock drill via a flexible shaft attachment. Easy to operate the grinder has the advantage of on-the-job drill maintenance. The correct edge angle and radius when grinding are automatically given.

A 117,000 GALLON liquid oxygen storage vessel has been constructed at Sault Ste. Marie, Ont. for Union Carbide Canada Limited's Linde Gases Division. Fabricated and erected by Horton Steel Works Ltd., this cryogenic vessel is the largest vessel of its type to be built in Canada and the first large enough to require field assembly.

A NEW and complete line of Camac stainless steel centrifugal pumps for chemical service is offered by the manufacturer, Carl Buck & Associates of Essex Fells, N.J. While the complete line is new, some sizes have been in operation for years. A proven water cooled stuffing box is provided as standard. Capacities run from 10 G.P.M. to 1200 G.P.M. at heads to 200 ft. and horse power requirements from ½ to 30. The customer can choose any desired connections, flanged, hose nozzle or standard pipe threaded connections at no extra cost.

CANSULT Limited

Nine Canadian consulting engineering firms have announced the formation of a consortium to propose the export of consulting engineering services. The Consortium, recently granted a Federal charter, has head offices in Ottawa. The developing countries of Asia, Africa, Latin America and the Middle East will be the objects of CANSULT's interest.

The group represents a wide variety of engineering skills including town planning, hydro and thermal power plants, bridges, roads, geological surveys and petroleum engineering. Participating firms are: W. S. Atkins & Associates Limited, Toronto; Beauchemin, Beaton, Lapointe, Montreal; Ewbank & Partners (Canada) Limited, Toronto; Nicholas Fodor & Associates Limited, Toronto; Morrison, Hershfield, Millman and Huggins Limited, Toronto; Paul Pelletier Engineering Limited, Montreal; J. C. Sproule and Associates Limited, Calgary; Surveyer, Nenninger & Chenevert, Montreal; Vance Needles, Bergendoff & Smith Limited, Woodstock. Other associates are being considered.

DOMINION BRIDGE COMPANY has opened a sales office and facilities in Saskatoon to supply a complete range of steel warehouse materials and reinforcing steel products. The new facilities will enable the Company's Regina Branch to provide faster service to users of warehouse and reinforcing steel materials in the Saskatoon area and the northwestern section of the province. In addition, the sales office will service structural and erection contracts being undertaken in the region from Regina.

A THIRD Canadian shipyard has installed a new design fillet welding equipment to reduce costs and speed up welding operations by simultaneously producing twin fillet welds. Saint John Shipbuilding and Dry Dock Co. Ltd., Saint John, N.B., has purchased four Fusarc/CO_2 welders from British Oxygen Canada Limited. Of particular value in welding bulkhead stiffeners, the new machines are also in use at Collingwood Shipyards in Ontario and Davie Shipbuilding Limited in Lauzon, Que.

(Continued on next page)

A NEW service for Montreal's brokerage industry was inaugurated recently. Known technically as "Brokerage Accounting", the service does the broker's routine paper work involved in stock exchange transactions such as preparing transaction contracts, customer statements, and daily control reports. And it does them five times faster than previous methods. The service, done on the IBM 1401 Data Processing System, is performed in IBM's new Datacentre. This Datacentre will serve other industries such as life and auto insurance companies, railways and utilities as well as the brokerage industry.

THE TAIWAN Aluminum Corporation has ordered the world's largest single silicon-rectifier installation from Westinghouse Electric International Company. The rectifier will provide 41,600 kw. of direct-current power. The installation is part of the aluminum company's expansion program which will more than double its output, from 8,500 to 20,000 metric tons of ingots per year.

FIRST OF its kind to be manufactured in Canada is an automatic reseating temperature and pressure relief valve. This new valve manufactured by the James Morrison Brass Mfg. Co. Ltd., will provide fully automatic protection for hot-water storage tanks and heaters. It is supplied with test lever and either long or short temperature element.

CONSTRUCTION WILL begin this year in Northern Ontario on North America's first major 460,000-volt transmission line — double the highest voltage now used in the province. The line will link new Ontario Hydro power developments on the remote James Bay watershed with populated areas to the south.

CANADIAN WESTINGHOUSE is introducing three-position current limiting power circuit breakers with interrupting capacity up to 200,000 amp. for low voltage switchgear. The new DBL-25, 600 amp., and DBL-50, 1600 amp., breakers are designed for systems where available fault current exceeds the interrupting capacity of standard breakers of the same frame size. They are said to be particularly useful in protecting relatively small loads (1600 amp. maximum) where supply is from high-fault capacity systems.

AMONG EPICYCLIC gear contracts received recently by W. H. Allen Sons & Co. Ltd. of Bedford are two important export orders for gear units for boiler feed and circulating water pump drives. For installation in the Vales Point Power Station of The Electricity Commission of New South Wales, Australia, nine Allen-Stoeckicht gear units for booster and boiler feed pump drive have been ordered. Two Allen-Stoeckicht epicyclic reduction gear units for circulating-water pump drive for installation in the Komati Power Station of K.S.B. Pumps, have been ordered by Dowson and Dobson Ltd., South Africa.

THE OPENING of a new district office in Denver, Colo., has been announced by Sika Chemical Corporation. Increased demand for the company's admixtures and compounds for building and concrete construction was cited as the reason for this most recent expansion of the company. This becomes the 11th district office and second district to be opened within the past 11 months. EIC

(*Continued from page 79*)

to a predetermined star, sun or planet for extended periods of time in order to relay scientific data, previously unavailable, to earth.

Model of Jet Trainer Displayed

A model of the Saab 105 was displayed at the International Air Show in Paris, held recently. This plane, developed by the Saab Aircraft Company in Sweden, is designed to fly in the upper subsonic range.

Twin engined, the new plane is a high winged aircraft completely made of metal with the conventional retractable tricycle landing gear. The cabin which is pressurized is in front of the wings and will seat five, a pilot and co-pilot in the front and two to three at the rear. It is powered by Turbomeca "Ducted Fan" engines made in France. Top speed will be 800 km.p.h. at an altitude of 8000 m. and the cruising speed will be 640 km.p.h. The surface ceiling is 13,000 m. and the flying range, 2700 km.

Designed primarily as a trainer for both military and civilian use, the Saab 105 can be used for many purposes. As a civil flight trainer it can carry a great deal of radio and navigational equipment. It is also adaptable to other civil uses such as aerial mapping, ambulance service and general transport. As a military plane it can carry a substantial load of weapons, be they rockets, bombs or guns. Liaison and reconnaissance are other uses for the Saab 105. EIC

(*Continued from page 73*)

relay system, and completely manufactured in Canada, can now also be obtained with transistorized multiplex component. The significant point in the above mentioned compatibility is that RF signals transmitted from RCA equipment and modulated with Telefunken carrier equipment, are received in the cornucopia antenna of an AGT's TD-2 radio relay station and demodulated through L-Carrier equipment. EIC

(*Continued from page 103*)

grooving specifications; bearing fabrication and assembly, and methods of supplying lubricants. Much of the material is presented in tabular or graphical form, and a useful bibliography is included. (H. C. Rippel. Evanston, Cast Bronze Bearing Institute, 1960. 72p. $2.00.)

°CERMETS.

Twenty-three authorities in the field of high-temperature materials here discuss the fundamental aspects and properties, forming and processing, testing, and applications of oxide- and carbide-base cermets. (Ed. by J. R. Tinklepaugh and W. B. Crandall. New York, Reinhold, 1960. 239p., $9.50.)

°FUNDAMENTAL PRINCIPLES OF POWDER METALLURGY.

Dr. Jones considers his 1937 "Principles of Powder Metallurgy" to a certain extent an introduction to this present work, which "has not repeated . . . the subject matter" of the first book. In "Fundamental Principles . . ." he omits industrial processes and their products, except where they may be used to illustrate principles, with which he is wholly concerned. As well as giving the historical background of the subject, and indicating areas where research is required, the author discusses subjects which he considers of importance to those in the field, but which are not generally considered part of P.M.-ferrites, dust cores, and sintering of non-metallic materials. Contents: Manufacture of powders; pressing; shaping without pressing; sintering; attainment of specific qualities; continuous powder metallurgy; methods of control. (W. D. Jones. Toronto, Macmillan, 1960. 1032p., $25.00.)

°PLASMA ACCELERATION.

This volume contains the nine papers presented at the Fourth Symposium on Magnetohydrodynamics sponsored by the Missiles and Space Division of the Lockheed Aircraft Corp. The emphasis is on the acceleration of plasma for space propulsion. The steady state acceleration of plasma by crossed electric and magnetic fields, pulsed plasma accelerators utilizing energy from high-energy capacitor discharge, and the acceleration of ionized material by purely electrostatic means are considered. (Ed. by S. W. Kash. Stanford, University Press, 1960. 117p., $4.25.)

°CHEMICAL ENGINEERING PRACTICE, VOLUME 10: ANCILLARY SERVICES.

This, the tenth volume in a series of twelve, covers ancillary services. Specifically it treats solid, liquid, and gaseous fuels; combustion systems for these fuels; steam; electrical installations; water supplies; effluent treatment and disposal; and airborne effluents. (Ed. by H. W. Cremer. Toronto, Butterworth, 1960. 606p., $17.50.)

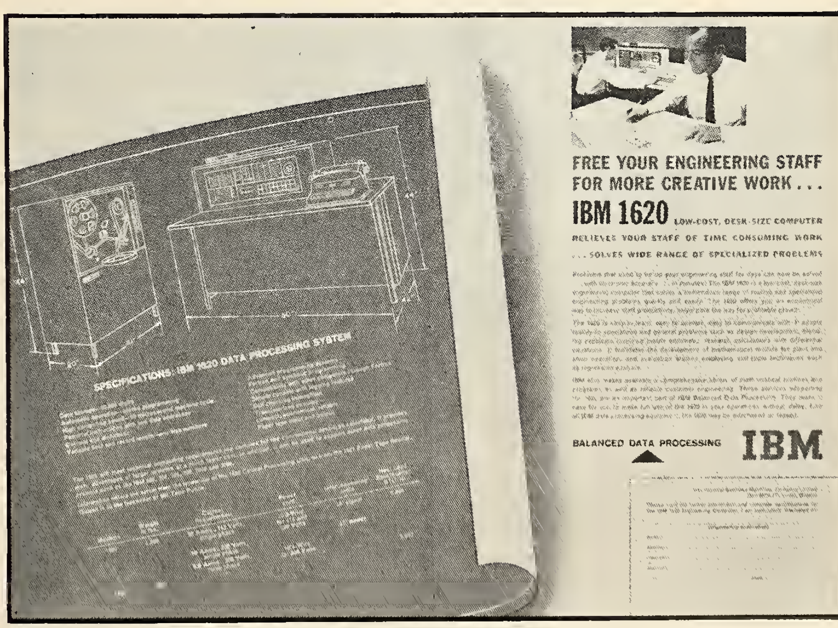
(Continued on page 110)

EIC CERTIFICATE OF ADVERTISING MERIT

Winner of the Monthly Award for the best advertisement in the May, 1961 issue of The Engineering Journal was International Business Machines Company Limited, Don Mills, Ontario. The winning advertisement, which appeared on pages 126 and 127, was a 2-colour (blue and black) double-page spread introducing the IBM 1620 desk-size computer, and headed, "Free your engineering staff for more creative work. . ." The main illustration, occupying slightly more than a full page, took the form of a simplified engineering blueprint detailing specifications of the computer. Supporting copy was mature, and directed squarely at engineering management.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION. Winners and their advertising agencies receive a framed Certificate of Advertising Merit.

The Advertising Manager for International Business Machines is R. J. Currie. The advertising agency is Thorton Purkiss Ltd., Toronto, Miss G. Race, Account Executive.



*AN INTRODUCTION TO TRANSPORTATION ENGINEERING.

This book has been written to bridge the gap in transportation literature between structural design and economic functioning of the various modes of transport in moving persons and goods, by presenting an elementary study of the technological characteristics of transport systems. The author deals with such topics as the propulsive resistance encountered by all modes of transport and the propulsive force necessary to overcome it, the suitability of a particular mode of transport for a given situation and traffic as determined by operating characteristics, route and traffic capacity as determinants of transport utility, and the frequently overlooked factors of terminals, coordination, and operational control. He also discusses the effects of these characteristics of transport systems on costs. (W. W. Hay. New York, Wiley, 1961. 505p., $11.75.)

*V.H.F. LINE TECHNIQUES.

Affiliated with the University of Manchester, the author writes primarily for the undergraduate student, discussing some methods of using transmission lines as elements to perform various functions of communication circuits. The circle-diagram technique for the solution of transmission problems is stressed: rigorous analysis of the methods discussed is given where applicable, but in every case it is shown that the circle-diagram method yields the same results more rapidly. The first chapter is devoted to the Smith Chart for transmission line calculations, and methods for its use. The next three chapters discuss single-frequency matching techniques, broad-band matching techniques, and transmission-line transformers. Additional techniques and methods of line measurements are covered in the final chapter and an appendix. (C. S. Gledhill. Toronto, Macmillan, 1960. 60p., $2.15.)

*ALLUVIAL PROSPECTING AND MINING, 2ND. ED.

The first edition of this text was written to produce a work on alluvial mining which would include material excluded from similar texts — modern hydraulic formulae for the calculation of water discharge; a detailed treatment of sluicing; and description of the working of alluvial diamond deposits. This second edition has had much new material added: discussion of earth-moving equipment; details of the forward preparation of overburden, vital to the working of low-grade deposits; examination of criteria for the selection of equipment; description of mining of beach sands, and of concentrating plants; and expansion of the chapter on alluvial diamond mining. The unaltered sections of the book deal with prospecting methods, sampling and valuation, water supply, hydraulic mining, and gravel pumping. (S. V. Griffith. New York, Pergamon Press, 1960. 245p., $7.50.) EIC

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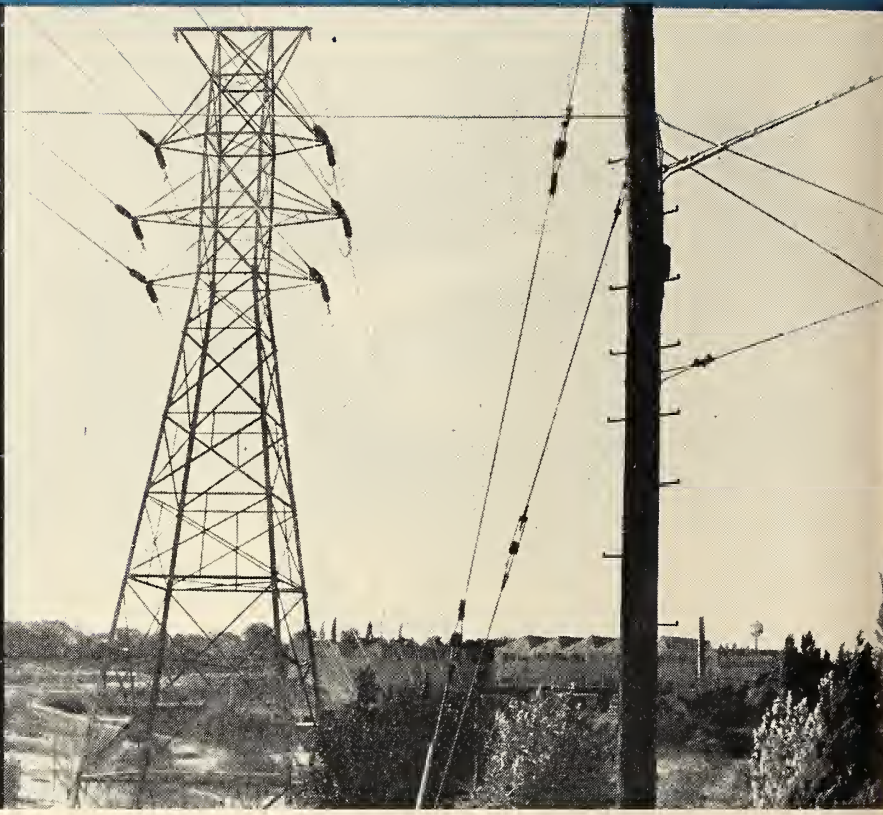

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IN THIS ISSUE

Electrical Installations on Modern Jet Aircraft covers the many forms of electricity used. In his introduction the author reviews the changeover from standard 28 volt D.C. systems to the A.C. Three Phase Constant Frequency systems now standard equipment in the new jet planes. Discussed also are the environmental, climatic, chemical and physical factors which have influenced the selection and design of electrical and other equipment and systems. The author goes on to consider the main electrical power installation of a jet aircraft in detail and briefly examines many electrical applications now in use. He concludes by indicating future trends in this field. The author, **R. W. Farren**, is well acquainted with all types of aircraft, military as well as civilian. He entered the Royal Air Force as Aircraft Apprentice and graduated in 1929 as leading Aircraftsman (Electrical and Instrument). He was commissioned in 1939 and relinquished it in 1947 when he returned to Canada, where he joined Trans Canada Air Lines as a senior electrical engineer. From Winnipeg he was transferred to Montreal in 1950 to assume a post as company Electrical Systems Engineer. His responsibilities include the evaluation of future company design requirements be they electrical, instrument and equipment, and the technical responsibility for all company aircraft electrical and instrumentation systems and support equipment, as well as all liaison with outside companies and societies in these subjects.

C. R. Jones and **J. B. Mantle**, M.E.I.C. worked together on a three dimensional photoelastic stress analysis project carried out at the University of Saskatchewan, Professor Mantle, who is head of the Department of Mechanical Engineering at the University of Saskatchewan, received his B. E. (Mechanical) degree at that University in 1941 and a M.Sc. (Theoretical and Applied Mechanics) degree at the University of Illinois in 1947. In 1945 he joined the staff of the University of Saskatchewan as an instructor and since 1947 he has been Director of the Photoelasticity Laboratory as well as supervisor of research students in experimental stress analysis. He directed the photoelastic project discussed in this present paper for Crippen Wright Engineering. C. R. Jones was born in Vancouver. In 1957 he graduated from the University of British Columbia with a B.A.Sc. degree in Civil Engineering and since that time has worked with Crippen Wright where he is now a design engineer. In the paper entitled *Three-Dimensional Photoelastic Stress Analysis of a Diamond-Head Buttress Dam* the authors discuss the stress-freezing and slicing method employed on the diamond-head-buttresses of the Dam for the Squaw Rapids Power Development. One of the new three-dimensional photoelastic materials, Hysol 6000 OF, was used. The authors discuss the techniques used for model making, and give typical calibration curves given for loading devices against clamp extension under operating conditions. Representative findings are discussed in the conclusion.

The average Canadian car owner doesn't have to be a mechanical engineer to notice that the gas consumption of his car goes way up during the cold winter months here. However, points out **F. D. Hamblin**, M.E.I.C., author of *The Combustion of Gasoline during Engine Starting at Low Temperature* little research has been done on this subject. While there has been research done on lubrication problems, the field of fuel combustion has been almost completely ignored. As it does not seem possible that the sharp rise in fuel consumption is due only to the increased viscosity of the lubricants, poor combustion must be a contributing factor. Fuel consumption should be constant both winter and summer once the engine is running. Because of the low winter temperatures a car needs more time in which to warm up. An extensive research program dealing with gasoline combustion has been started at the University of Saskatchewan. The results of the initial phase are complete and are reported in this paper. The author, a special lecturer in Mechanical Engineering at the University of Saskatchewan received all his education in England. He received a B.Sc degree in applied Science at King's College, University of Durham in 1954 and later his M.Sc degree in applied science from that University.

G. A. McNeill, author of *Non-Linear Control for Distillation Columns* was Senior Instrument Engineer of Canadian Chemical Company for the past six years where he was responsible for special systems studies, the development of new instruments and the application of analytical instruments. He has recently accepted a post with the Monsanto Chemical Company and is working on the Chocolate Bayou Project. "A balanced distillation column has inherent non-linearity in its operation," Mr. McNeill states. This principle can be used to make a simple optimizing controller which will optimize the separation. Standard control hardware is all that is required thus making this method simple and reliable. Though this method was specifically developed for use with a chromatograph analyzer it could also be adapted for other type of analyzers or conventional temperature measurement.

Some Reflections on Trends in Engineering Training by **Dr. Arthur Porter**, M.E.I.C., former Dean of Engineering, University of Saskatchewan deals with some of the basic trends in engineering education. Many changes in engineering education have been made in the past 50 years since engineering was first recognised as a university discipline. Some of the basic trends are discussed in this paper with particular reference to curricula, practical training, technological research and the employment of professional engineers. Recent developments in the College of Engineering, University of Saskatchewan are used as examples. The importance of practical training is emphasized, and the subject of "sandwich courses" now in operation in colleges of advanced technology and some university engineering schools in the United Kingdom is considered. The author began his career in education as an assistant lecturer, the University of Manchester from 1936-37. For three years he was Professor of Instrument Technology, Royal Military College of Science from 1946-49. After spending the following six years as Head, Research Division, Ferranti Electric Limited, Toronto, he accepted a position as Professor of Light Electrical Engineering, Imperial College of Science and Technology, University of London, and in 1958 he joined the faculty of the University of Saskatchewan. This fall Prof. Porter joins the faculty of the University of Toronto as head of the new Department of Industrial Engineering.

COVER ILLUSTRATION

This Vertical Take-Off and Landing (VTOL) Engine test bed is used to test propellor performance and engines for the National Research Council, Ottawa. The VTOL is 98 feet long and has a maximum diameter of 40 feet. (Photo courtesy Horton Steel Works, Limited)

ELECTRICAL INSTALLATIONS

IN MODERN JET AIRCRAFT

R. W. Farren,

Engineering Department
Trans Canada Air Lines

THE TREMENDOUS advances in air transportation during the last decade have been naturally coupled with the employment of turbo jet and turbo propeller engines and improvements in airframe structural design. Contributing to this advance are many other factors which are less obvious but which have contributed in large measure to the ability of the modern jet aircraft to adequately fulfil its function. The increasing application of electrical power has, in its own way, been no less spectacular than the advances in the use of jet power. To the casual observer or passenger, the only obvious indications of the presence of electrical power is the general interior cabin lighting and the "call" and public address systems. Hidden from view is one of the most concentrated and complex networks of electrical circuitry, performing hundreds of simultaneous functions, that are responsible in major part for keeping the aircraft safely airborne and in keeping the crew advised of the operation of integrated systems of all types that contribute to the flight of the aircraft.

To the electrical engineer not associated or familiar with modern aircraft electrical practice, there may seem to be little connection between airborne application and his own particular calling in the industrial, commercial and domestic fields. Aircraft electrical practice, as the result of early associations, is still thought of as an advanced development of automotive electrical application whereas in actual fact, on modern jet aircraft, one will encounter problems and techniques familiar to the many branches of industrial and commercial engineering. It is the purpose of this paper to attempt to outline these similarities and to explore the many other factors that have to be contended with in aircraft electrical application that are not normally met in the realms of general electrical usage.

Basic Factors Governing Modern Aircraft Electrical System Design

1. Paramount among the many factors that govern aircraft design in all its aspects is the requirement known in the industry as "airworthiness". This term implies the ability of all aircraft structural, engine and system components to operate safely and efficiently under all predicted flight conditions. Furthermore, it must include the additional high standards that will ensure continuance of services under the worst emergency conditions for sufficient time to allow the aircraft to remain operational and to make a safe landing. This requirement calls for an integrity of the highest order not usually associated with ground installations, every item comprising the system, from the smallest screw to the most complex unit having to meet rigid specification standards to achieve the desired overall system integrity. Not only do the individual items have to achieve such standards but the overall system design must incorporate safeguards that will not allow individual failures to result in the loss of any vital serviee, thus increasing the overall complexity of the installation.

2. The integrity required could be achieved more simply by duplication or triplication of the many services and by designing and building components of massive construction to withstand the many stresses to which they are submitted. This however is in direct opposition to the main function of the commercial aircraft which is to carry a profitable payload safely and regularly to its destination, so the integrity must be achieved for the lowest weight possible and within the confines of the smallest envelope, commensurate with sound design. In aircraft electrical systems this has led to the employment where possible of the best advances in materials and miniturization techniques to save space and weight. This in turn however introduces further design problems associated with temperature and mechanical strength which have had to be contended with. The overall weight of a complete electrical system in a modern jet aircraft presently exceeds 3000 lb., and since the payload factor for an aircraft of this type is

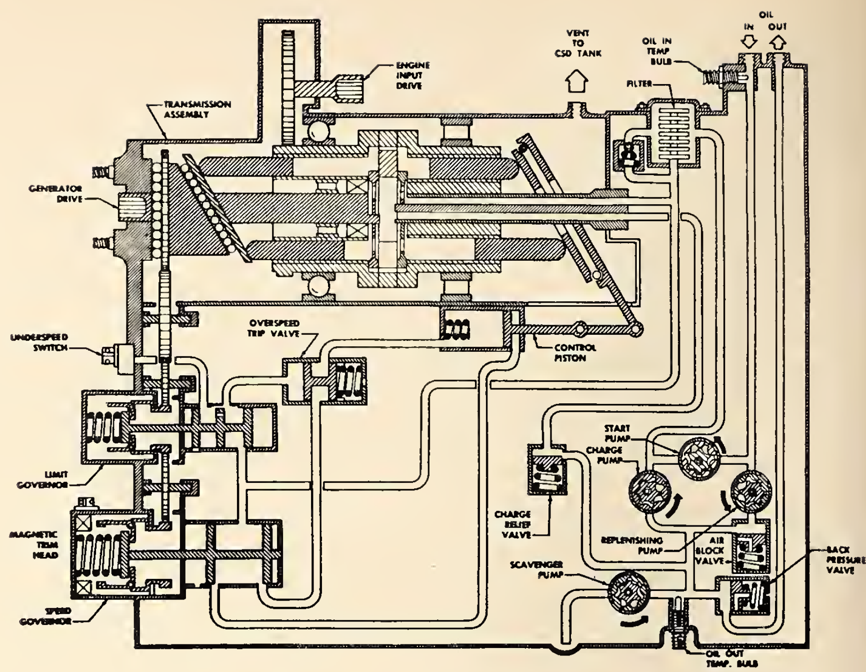


Fig. 1. Generator Constant Speed Drive Transmission — Schematic.

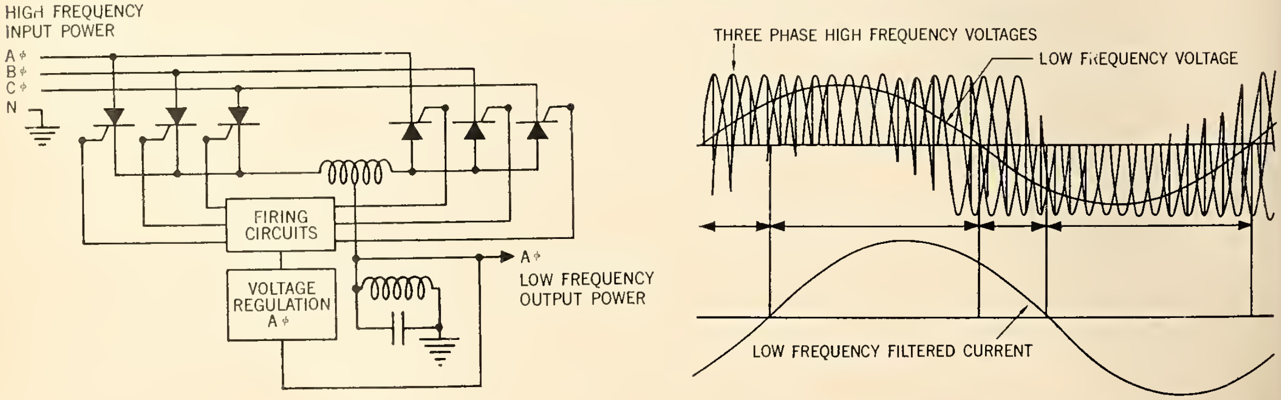
usually in the region of 10% of its gross weight for the aircraft maximum range, the total payload will be in the region of 25,000 lb. Without special attention to weight and system design techniques, the electrical system overall weight could initially be 30% more, reducing the payload by 4% direct weight, quite often the margin of profit or loss. Not only are we concerned with direct weight loss, the electrical system capacity must also be a careful compromise between generating power with sufficient reserve for emergency purposes, and the highest degree of utilization of power required for normal operation. It has been established in a modern jet aircraft, cruising at 550 m.p.h., that, with a generating efficiency of approximately 80% and a load factor of 70%, the fuel consumption to generate the required electrical power is in the order of 1000 lb. weight per hour. Inefficient design of the power generation can be reflected in a greater weight of fuel consumed with resultant range reduction and higher fuel costs, and increased drag from the additional cooling requirement, thus contributing to further reduction in revenue.

3. Integrity, weight and space requirements are further complicated by the climatic and environmental conditions to which the equipment is subjected in operation which effect both the design and installation of airborne electrical equipment. Climatic factors include altitude, temperature and humidity, the environmental effects being classified as mechanical and chemical. Vibration, acceleration and deceleration are the major mechanical factors, while chemical factors encompass the effects of condensation, ozone and synthetic fluids as used for engine lubrication and hydraulic systems, upon the conducting and insulating materials.

a) The rapid rates of change of atmospheric pressure and temperature which result from the rapid rates of climb and descent, together with the extreme operating altitudes, of the modern jet aircraft, has increased the potential deleterious effects of the above factors considerably, and has necessitated the development of new design techniques. Above 20,000 ft., brush wear increases at an alarming rate, a phenomena which is not clearly understood. The wear rate appears to be due to a combination of factors which includes the amount of water vapour in the atmosphere and its effect on the formation of a thin protective film of copper oxide, thickness 0.5 x 10—6 mm., on the commutator, which, with a superimposed graphite layer, acts as a lubricant between the brushes and commutator. Over 20,000 ft., the generator appears to experience increasing difficulty, proportionate with altitude in maintaining this film, which, once stripped, seems to act as an abrasive and produce excessive brush wear. Aircraft brushes have been impregnated with diverse materials in attempts to create the right conditions to produce the film at the higher altitudes with some success. Such materials include organic resins, fluon, barium fluroide and molybdenum disulphide. Temperature and vibration resulting from mechanical divergencies constantly work against the formation and maintenance of this film.

This has required improvements in the initial design of high altitude aircraft electrical generators and motors, to ensure very high mechanical standards for the bearings, the careful static and dynamic balancing of moving parts, improved lubricating systems and improved design of the brushes and their housings. The current advance in the design of brushless machines now becoming available will eventually eliminate this problem on current and future aircraft. One other aspect of the effect of the rarefied atmosphere at increasing altitudes is the ever decreasing protec-

Fig. 2. Variable speed — Constant frequency Regulation Single phase — Schematic.



tion against arcing. At lower pressures the air ionizes at lower voltages and adds to the problem of arc extinction in circuit breakers, switches, relays and other devices of this type. In modern jet aircraft to combat this effect such units have heavier contacts and supports to form a heat sink, and in the more critical applications, the complete hermetic sealing of the units in containers employing a vacuum or inert-gas under pressure is generally employed.

b) The rapid changes of pressure and temperature associated with the operation of jet aircraft in ascent and descent produces atmospheric condensation of a high order. The condensed vapour collects in conduits, ducts, junction boxes and components of the electrical system, and by absorbing soluble gases from the atmosphere produce mild corrosive acids which results in corrosion of a high order on metallic surfaces and forms electrical leakage paths on insulating materials. It is not unknown in a single flight to find moisture that can be measured in cupfuls in various parts of the electrical system. In jet aircraft electrical system design particular care has been taken to prevent moisture ingress into critical areas where electrical leakage may affect control functions by hermetically sealing vulnerable units, treating all metallic surfaces with anti-corrosive compounds and finishes, and providing drainage at low points where the moisture tends to collect.

c) One aspect of temperature variation has already been discussed in relation to brush life. All electrical equipment, however, has to be designed to withstand the effects of a wide range of temperature variations which are compounded of the cumulative effects of climatic ambient variations ranging from —90°C to +50°C, kinetic temperatures produced by the passage of the aircraft through the air which can exceed 65°F at 600 m.p.h. plus self induced operating temperature rises due to component installation. On present jet aircraft, the effects of direct kinetic temperature rise are mostly offset by the natural ambient temperature reduction found at increased altitudes. However, where the cooling of rotary and other air cooled equipment is important, down rating of the equipment is necessary unless special cooling means are provided. This was relatively simple in the propeller engine era by utilizing the propeller slip stream, on jet aircraft the problem is more complex due to higher kinetic heat generated at high speeds, rarefied atmospheres and operation of units in close relationship to the "hot"

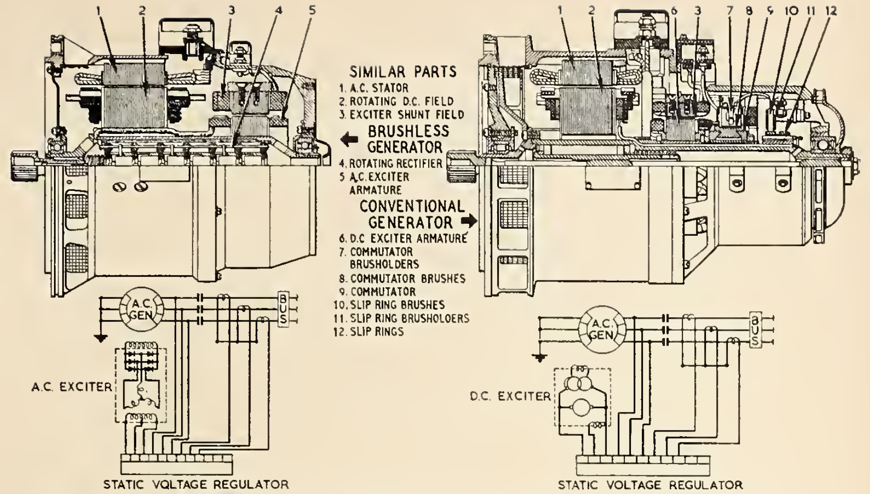


Fig. 3. Comparison of Conventional and Brushless Aircraft Alternators.

section of the jet engines. However by careful design of cooling intakes and the use of improved insulating materials to permit higher wire temperatures, "ram" cooling is still feasible without any radical down rating of equipment. Once the 1000 m.p.h. speed range becomes general however, the provision of environmental cooling will require the use of liquid or vapour cooling methods to maintain workable temperatures.

d) The effects of rapid acceleration and deceleration must be taken into account in two ways. The design of attachments for electrical equipment to the airframe structure must be designed to withstand up to 9 G's (a G being the unit of acceleration equipvalent to the earth's gravity of 32 ft. per second per second), and balanced moving parts on units, such as relays and magnetic contactors, must not operate inadvertently when subjected to normal aircraft forces. Provision is made in some jet aircraft for deactivation of the electrical system by the use of various inertia devices when the retardation of the aircraft exceeds 3G as a fire prevention measure in the event of an abnormal landing.

e) Vibration effects in jet aircraft are very complex, initiating in all three axis and over a range of frequencies that originate from many diverse sources. From the power section come high frequency, low amplitude vibration generated by the turbines which combine with the lower structural frequencies resulting from various aerodynamic stresses, and with their accompanying harmonics, produce vibration patterns almost impossible to analyze. When coupled with the inherent vibration of the electrical equipment itself, peaking at critical resonant frequencies, the overall problem of designing against vibration failure is difficult to achieve. It was assumed with the deletion of propellers and the apparent smoothness of jet flight, such problems would diminish, in actual fact, particularly in areas subject to engine generated high frequency vibrations, the effect on component life has been much more severe despite the lower amplitudes involved. As these patterns emerge however, corrective action is taken in the form of improved shock mounting, repositioning, or deliberately changing the natural resonant frequency of the affected part.

f) Operation at higher altitudes in regions where ultra violet radiation is more marked can produce ozone in sufficient quantity to have a definite deleterious effect on electrical insulating materials, particularly where natural rubber is used. This effect at present jet aircraft altitudes of 35,000 ft. does not produce obvious deterioration, but is a factor which shows up in long term effects.

g) Lubrication of jet engines require the use of ester-base synthetic oils which attack insulating materials, varnishes and other protective finishes. Particular care has to be taken in engine zones to design against ingress of these oils into harnesses and electrical equipment and to employ materials least prone to attack. Similarly the employment of non inflammable hydraulic fluids of the synthetic base type creates the same problem in airframe zones where the fluid, in the form of deposited film, can penetrate into many areas. Once again, these effects are usually of the long term type and are constantly guarded against by good initial design and frequent inspection.

From the above it will be seen that in designing a modern electrical aircraft system, a wide variety of problems and conditions are present which are not normally met in ground installation systems and the final product must provide a satisfactory compromise between many conflicting requirements.

Electrical Power Generation—Historical

To appreciate present day jet aircraft system design, it is first desirable to trace briefly the historical developments leading to the systems now in use. Electrical application was present in its most elementary form on the earliest aircraft to provide ignition for the engine. As aircraft developed to include cross-country and night flying the first simple lighting systems to provide illumination for the few instruments were added, operating from a battery source. Regulations for night flying required the use of standard navigational lighting, and the reliability of the battery system became essential to operation and to increase flight duration, so generators were added to maintain and extend battery life. Since no provisions were incorporated for power take-off on the engine the first aircraft generators were air driven using simple windmills. As speeds increased the necessity for voltage control arose and this was first accomplished by using variable pitch windmill drives on the generators. The standard method of starting engines by hand swinging became more difficult and dangerous as engine powers increased and electrical starting was introduced. At this stage the first electrical systems of integrated design were in being employing 12 volts in line with existing automotive practice and with system capacities up to 150 watts. As demands increased the requirement for larger generators eventually led to the provision of "take-off" provisions on the engine, and engine driven generators replaced the early air driven windmill type.

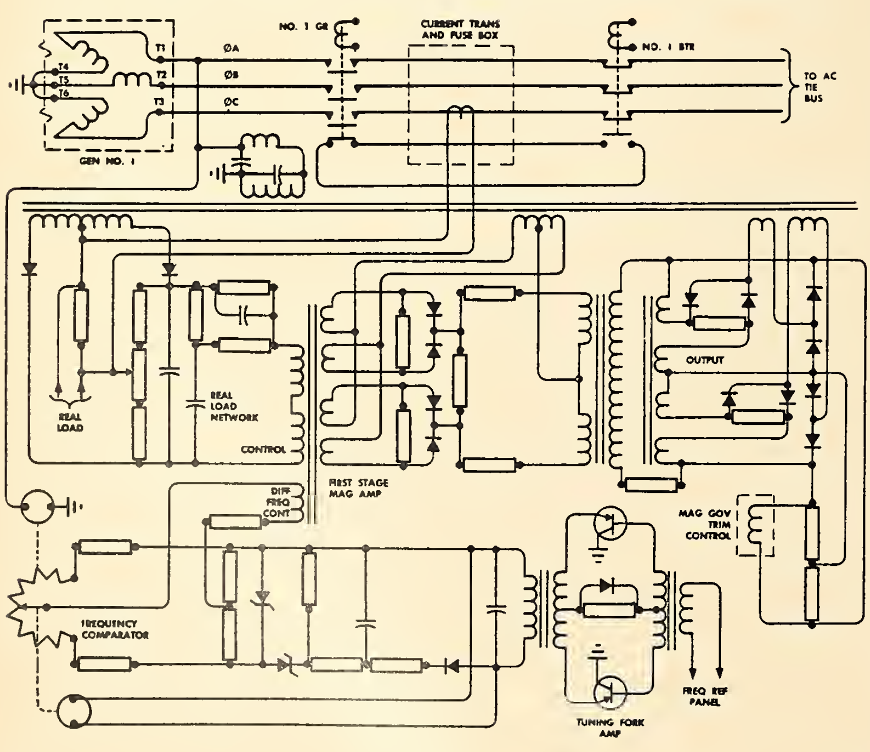
No attempts at this time were made to keep down the weight of electrical equipment and cables, and it was this weight factor that led to the decision to replace the 12 volt systems with 28 volts (nominally termed the 24 volt system). Wider variations in engine speed and load led to adoption of the first modern voltage control system, replacing the early Tirrill regulators, compounding and third brush regulation with carbon pile type regulators. The use of multiple generators on aircraft employing two or more engines next led to the employment of the first paralleling and control systems to ensure proper load sharing. The 28 volt D.C. generator system remained the basic design for aircraft until well after World War II, the systems steadily increasing in power until individual generators of 6 kw. output became standard equipment. In step with the increased availability of power the aircraft electrical system applications increased and many functions, which had been achieved by mechanical, pneumatic and hydraulic means, were replaced by electrical devices to perform the same operation.

The increasing use of radio and electronic navigation aids requiring A.C. power led to the requirement for secondary A.C. power sources and this was met by DC-AC conversion devices of the Motor Generator type, usually known as invertors. By international agreement, the AC power requirements for aircraft were fixed as three phase 110 volt 400 cycles and this has remained the standard for AC power systems today.

The ultimate use of 28 volt DC power system was reached during the middle period of the 1950-1960 decade to meet the electrical requirements for the large strategic bombers and commercial transport aircraft such as the Lockheed Constellation and Douglas DC-7. The advances made in the use of electronic devices for navigation and flight, requiring expanded use of AC power, coupled with the fact that the increased power demands had shown definite limitations in the ability of DC generators to operate efficiently at powers over 12 kv. due to cooling problems, plus the unwieldiness of the heavy duty service cables employed, led to consideration by designers of higher voltage systems. Several schools of thought emerged, the British favoured the use of mixed 112 v.-28 v. DC systems, the higher voltages being used to supply heavy duty loads such as starting.

The biggest drawback to this concept was the lethal nature of the 112 DC voltage and the severity of the brush problems experienced with increasing altitude requirements, however on the favourable side was the relative simplicity of the DC control system and the ability to utilize existing designed equipment. Several modern turbo propeller aircraft are presently successfully using this split DC voltage system. Military requirements dictated the trend in the U.S.A., the elaborate electronic requirements for the first jet type strategic bombers, and the high altitudes at which they operated, sparked the study for the use of Three Phase Constant Frequency AC Systems. For the first time in aircraft history electrical systems design moved into AC application on a large scale with all its attendant complexities, particularly that of providing a constant speed drive capable of maintaining close voltage and frequency regulation from a variable speed source such as the jet engine. In addition, to ensure best utilization of available power under all emergency conditions, the requirement for parallelling the sep-

Fig. 4. Typical Frequency and Real Load Control Circuit — Schematic.



arate generators, with the attendant problems of phasing and real load division further complicated the design. The same aircraft manufacturers producing the military aircraft also built the first commercial jet aircraft, and the change over to constant frequency systems from the 28 v. DC systems became an accomplished industrial fact without further experimentation. Present U.S. commercial aircraft including the Boeing 707, Convair 800, Douglas DC-8 and Lockheed Electra use almost identical concepts in their AC system design.

One other variant of power supply design which is employed on the latest TCA aircraft, the Vickers Vanguard is worth mentioning. This system is a compromise between the old and the new consisting of a three phase "frequency wild" AC generating system with a capacity of 300 kva. supplied from six 50 kva alternators. Such a system cannot be paralleled and the alternators are used to independently supply, through separate bus bars, those heavy AC loads which are not frequency critical and are free from capacitance or inductance. These are mainly the heating loads employed for functions such as tail de-icing, propeller blade, cowl and intake scoop de-icing, windshield heating and galley loads. Part of the output from four of the alternators is independently converted and rectified through transformer-rectifier units of the silicon type to produce 15 k.w. of power at 28 v. DC. The four outputs are paralleled and balanced on a common bus system, and supply the operating and control systems much in accordance with previous standard 28 v. DC system practice. The virtues of this system still requires proving. it has the elements of simplicity in not employing constant speed drives and AC paralleling and control systems, on the other hand the system requires elaborate switching and busbar arrangements to ensure full protective coverage.

The constant frequency system, however, has established itself at the present time as the accepted method of supplying electrical power and will almost certainly be used exclusively on the next breed of military and commercial aircraft.

This paper will therefore only review in some detail the design of the constant speed frequency system.

Constant Speed Drives—Mechanical Hydraulic

The constant speed drive itself is not an electrical unit in the literal sense, however, since the whole constant frequency concept revolves around the operation and control of

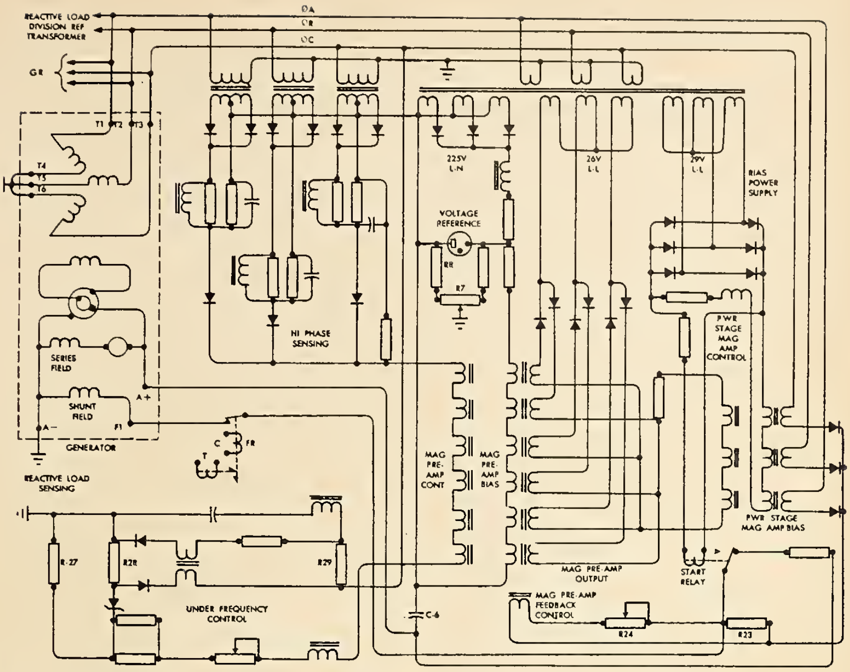


Fig. 5. Typical Voltage Regulators — Reactive Load and Under-Frequency Control — Schematic.

this unit, its operating principles are worth examining. First, the speed range over which these drives have to exercise control governs the detailed design of the unit. On present and proposed aircraft, the engine speed ranges are:

Propeller turbines—7000 to 17,000 r.p.m.

Pure jet turbine—2500 to 10,000 r.p.m.

Constant speed drives do not encompass the full engine range, and the input shaft drives are usually geared to cover an equivalent engine speed range at 3000 to 8000 r.p.m. The output of the drive is designed to be controlled at steady speeds of 6000 or 8000 r.p.m. with a tolerance ± .25%. Different methods are used for producing the constant speed. Most present designs employ mechanical hydraulic motive power, while later designs are turning to air turbine application. The mechanical hydraulic application utilized by the two main manufacturers of this equipment are similar in principle but not in detail. A brief account of these units will serve to illustrate the principles employed.

Constant Speed Drive

From the illustration (Fig. 1) it will be seen that the system uses a form of variable displacement pump and fixed displacement hydraulic motor housed in the same casing and mounted on a common base with interconnecting ports. The pump unit as it revolves applies pressure on a circular swash plate by means of free pistons working in cylinders around the circumference of the assembly as it rotates. With the swash plate tilted and rotation in one direction, oil is transferred from the upper to the lower section of the pump. If the swash plate is parallel with the assembly face, the pistons are stationary and no transfer of oil takes place, with the swash plate tilted in the opposite direction oil is transferred from the lower to the upper half of the pump. The output hydraulic motor is similar in construction to the pump, the pistons exert pressure on a swash plate as they rise and fall, and since the plate is free to rotate on the assembly the axial motion is converted to rotary motion, the direction of rotation depending on the direction of oil flow from the pump unit. The rotating swash plate thus revolves on the assembly according to the relative position of the stationary pump swash plate and encompasses a speed range of ± 4000 r.p.m. The input shaft of the unit drives the torque converter of the pump unit while the swash plate of the motor is geared to the output shaft. The tilt of the stationary swash plate is controlled by a centrifugal governor operated by the output shaft control through hydraulic linkage. A magnetic trim control which senses the difference between a master frequency control and the alternators output frequency trims the main centrifugal governor to obtain the close tolerances required. Thus over an input shaft speed range of 3600 to 7070 r.p.m. the output shaft stays steady at 8000 r.p.m. by adding up to 4400 r.p.m. to the lower limit and 930 r.p.m. at the upper limit with smaller increments at intermediate speed levels. The system is not self priming and requires a closed circulating oil system, employing a pressure pump to maintain pressure for both the converter and the governor. Overspeed control is achieved by use of a secondary mechanical ball type governor actuating an underspeed switch which reduces the control speed and for safety stays locked in this position to prevent surging. Once an overspeed has been experienced, a mechanical reset on the unit must be operated to restore normal operation.

Overheat warning devices, oil pressure and temperature warning devices and cooling provisions all add to the complexity of the constant speed drive system.

In operation the system, from a control viewpoint, is remarkably accurate and maintains aircraft frequency within one cycle of the designed 400 cycle requirement. Maintenance in service is not easy and it is often more practical to change the entire engine than replace a drive if the occasion demands. Overhaul costs are prohibitive, and complex test facilities and tooling are required to ensure efficient overhaul and setting up of the unit after overhaul. Combined with a weight penalty of 80 lb. per unit or 320 lb. per aircraft, this offsets much of the weight gain achieved in changing over from DC to AC.

Considerable research is underway to produce alternate methods to provide constant speed drives and prototypes of both improved hydraulic designs and pneumatic (air motor) types are undergoing trials. The airline operator however would welcome a return to direct engine driven alternators from both the weight and economics viewpoint and present development offers a hope of this by employment of a system called the Variable Speed Constant Frequency (V.S.C.F. system). This new method takes the frequency wild output from alternators of the Homopolar inductor type in a frequency range of 1600 to 3500 cps, which are converted to a fabricated 400 cps sinusoidal wave form by use of silicon switching rectifiers. The input signals are chopped by 18 silicon controlled rectifiers, six in each phase, three being used to conduct the positive half cycle and three the negative. Fig. 2 illustrates the connections of six silicon rectifiers necessary to fabricate one regulated phase. The output of each phase is filtered to convert the chopped elements into smooth sinusoidal form.

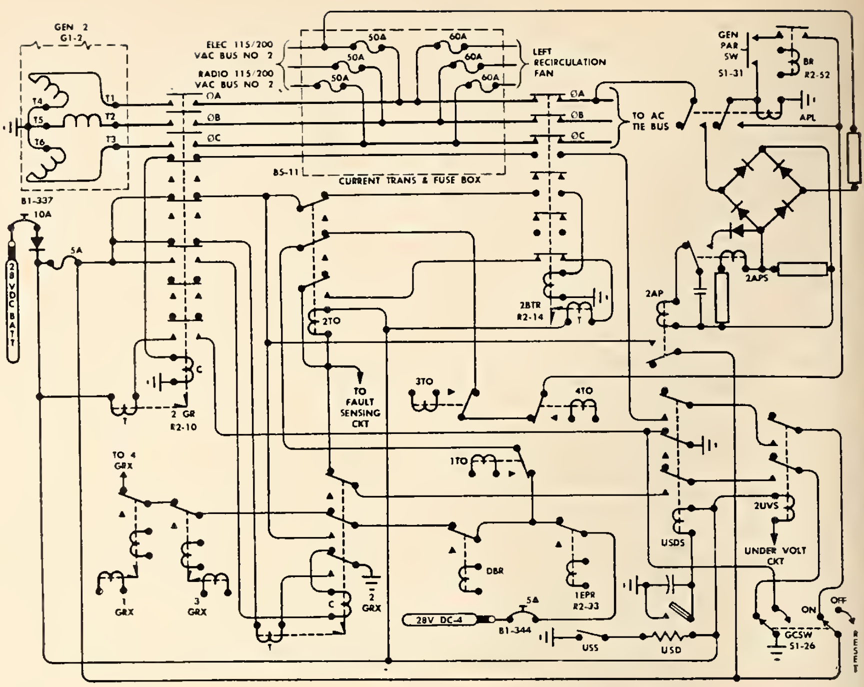


Fig. 6. Typical Auto Parallel and Preferential Tie Circuit — Schematic.

Alternators

Aircraft alternators presently in service are of the rotating field type. With this arrangement the heavier current carrying windings responsible for most of the heat generated are disposed around the casing of the machine for improved cooling. Field excitation is from a DC source, usually an inbuilt exciter of the permanent magnet type or are self excited.

The stator is generally of the two layer type clamped in a spun-over steel shell. High speeds and high temperature make design of the rotor difficult. The six salient poles are obtained either by slotting a circular stack of laminations or by keying separate laminated poles to the shaft. Due to the limited space available in these units careful design to eliminate hot spots is necessary and all insulation must be of the high temperature variety to stand up in operation. Cooling passages in, or between, the poles assist the limited cooling available in the confined space. All end windings have to be specially reinforced to withstand the high speeds. Slip rings are spun cast of cupron nickel or monometal, and brushes are conventionally box mounted, but employ higher pressures than are normal in industrial machines. Three brushes, spaced evenly around the slip ring is normal practice and they require precise bedding to stand up in service. Bearings are grease lubricated but difficulty is experienced in finding greases that will stand up for prolonged periods at the hgh temperatures encountered. Attempts have been made to lubricate them from the main engine oil system but the problem of making seals adequate to keep the oil from leaking into the alternator housings make this method unsatisfactory. Cooling is by blast air supplied from ram air intakes on the aircraft. Despite this it is difficult holding the temperature rise within 100°C from an ambient of 50°C, requiring particular care in the insulating standards employed and the use of brazed connections for all joints. When reviewing the environmental conditions in a previous chapter the problem of brush life was reviewed in operation — this is the limiting factor which governs the period between unit overhaul, usually around 1000 hours if operations are normal. The standard voltage for alternators is 115 volts phase to ground and 200 volts between phases with a frequency of 400 cycles per second.

Brushless alternators are now beginning to supersede the present type. A comparison between the two types is interesting. From Fig. 3 it will be seen that the only common features are the stator, rotating DC field and the exciter shunt field. Six rectifiers mounted in finned aluminum tubes are incorporated in the rotors of the brushless type machine, and high capacity silicon diodes installed end to end in the hollow rotor shaft from which they are insulated by a silicon glass fibre tube and cooled by air through the rotor. The exciter comprises a stationary field with six poles and two windings, one for regulation, the other for damping, and a rotating armature. Permanent magnets embedded in the exciter stator assist "build up" of the field. The rotating pole structure contains eight poles especially wound to assist heat dissipation. With this design the excitation current is generated as AC and the stator regulators and control field windings are energized by rectified outputs from the voltage regulator and current transformers. From early reports this type alternator is doing extremely well in service and overhaul life expectancy of these units has already been doubled. Aircraft alternators capable of 60 kva. output are now available and their weight and volumetric size are in startling contrast to their industrial counterparts. Coupled with the severity of the conditions under which they operate, the industrial engineer will no doubt appreciate the problem of designing and effectively maintaining this unit.

Constant Frequency—Paralleled Systems

So far we have taken a brief look at how the power is generated and it is now proposed to outline the methods used to ensure proper voltage regulation and load sharing and the means employed to keep the alternators in synchronism on a common bus-bar when paralleled. Two essentials for efficient paralleling are for the alternators to be in synchronism and that they maintain identical speeds. Assuming two alternators are operating at a nominal speed of 4000 r.p.m. it would only require one second for the phases to be out by half a cycle with a variation of only 5 r.p.m. between them. It is essential therefore for the drive system not to be too rigid and sufficiently "soft" to maintain paralleling under "slight out of synchronism" conditions, yet firm enough to maintain drive without slip under overload conditions. The hydraulic drives presently employed have demonstrated their ability to provide the flexibility required. However means must be supplied to ensure that in the event of an "over" or "under" frequency condition arising the alternator must be immediately isolated from the bus and/or load so that it runs "free" until re-synchronized and re-coupled to the system. In practice each alternator is allocated its own bus bar and loads, so that if necessary all alternators can be isolated and the aircraft loads still provided for. In this way the integrity of the system can be maintained despite possible rapid failure of one or more alternators with resultant overloading of the rest of the system.

Load sharing is achieved by discriminating between the "real" and reactive loads, and is directly related to the power input to the constant speed drive input shaft which is a torque converter, the variations in load balance are corrected by adjustment to the drive shaft torque control. These variations in load of course are absorbed by the prime mover, the engine, without undue variations except for very minor changes in speed.

The "reactive" load sharing is obtained by provision of means for inter-relating voltage regulator adjustments so that the inductive and capacitive currents are shared in proportion to the field strengths of their excitation systems. This type of control to be effective requires considerable design study to ensure proper distribution of the aircraft load between the various independent bus systems to obtain reasonable relationships between current and voltage loading of the phases.

The following basic requirements must therefore be provided and co-ordinated into a single system to obtain the precise type of electrical power operation required in a modern jet aircraft.

Control

1. Frequency
2. Real Load Division
3. Voltage Regulation
4. Reactive Load Division
5. Auto Parallel and Preferential Tie

Fig. 7. Typical Aircraft Power Control System — Functional.

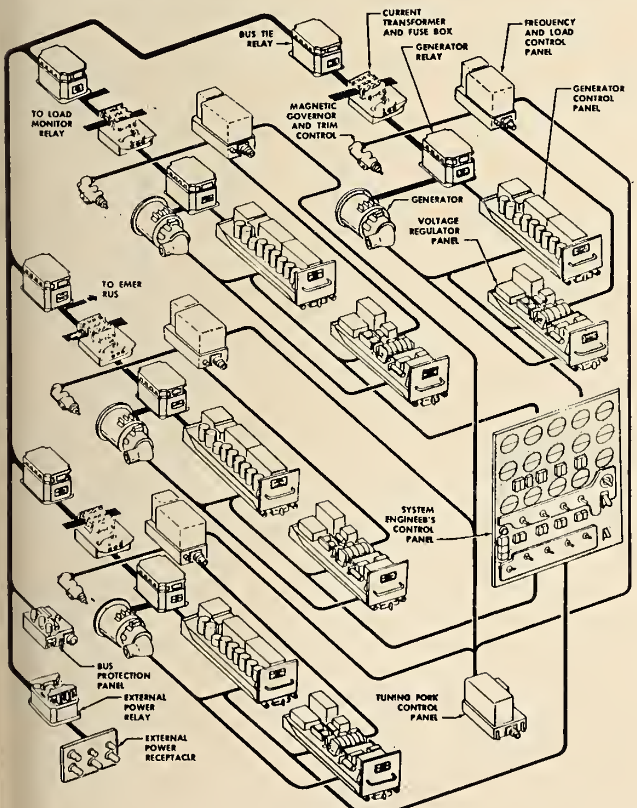
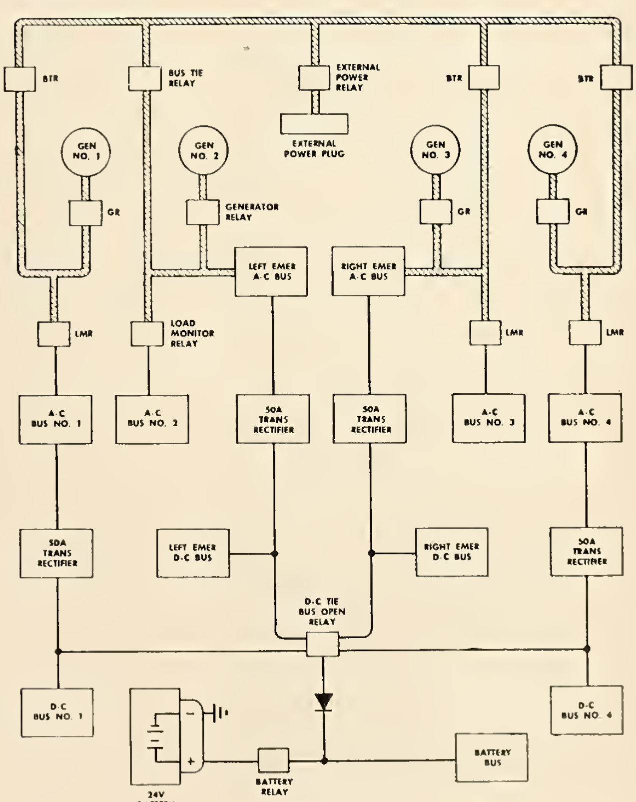


Fig. 8. Typical Bus Bar AC and DC Distribution System — Schematic.



In addition the aircraft electrical system must be protected against many faults and conditions including:

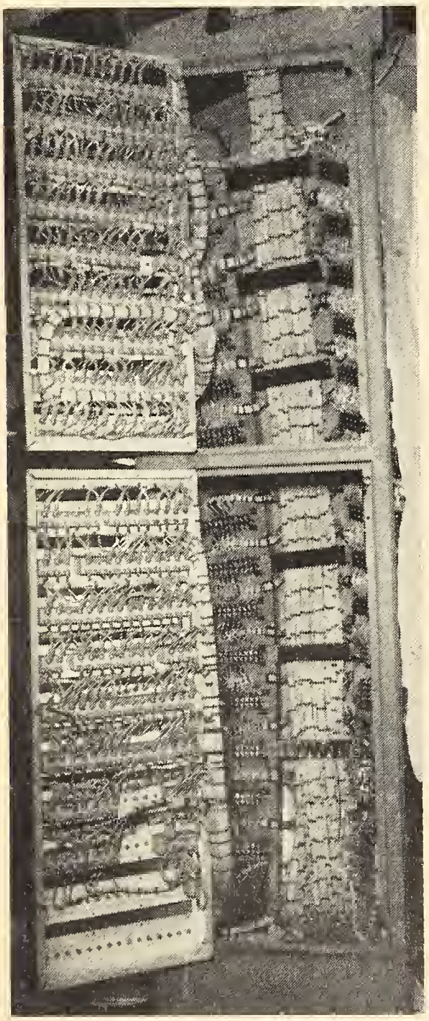
1. Overvoltage and Undervoltage
2. Underfrequency
3. Differential Faults
4. Bus bar faults—line to line etc.
5. Phase Sequence protection — Ground Power

It will only be possible to give a bare outline of these functions, which are attained by the employment of complex equipment and circuits which are housed in various control boxes to suit the physical layout in the aircraft.

Control Systems

1. *Frequency Control:* Frequency control provides a means of insuring proper generator frequency to allow paralleling of all the generators. The output frequency of each generator is supplied to its individual Frequency and Real Load control panel where it is compared to a reference frequency supplied from a very accurate 400 cps tuning fork control circuit. Any difference between the two frequencies is translated into a D.C. voltage which in turn is used as the input to the control winding of a magnetic amplifier. The output of the magnetic amplifier sends a correction signal to a coil in the magnetic trim head of the constant speed drive governor of the affected system which repels or attracts magnetized flyweights which are part of the mechanical centrifugal flyweight speed governor. The regulated speed governor corrects the generator drive output speed by controlling the fluid flow to the constant speed drive pump as previously outlined in the section on constant speed drives.

Fig. 9. Typical aircraft electrical distribution centre.



2. *Real Load Control:* Provision for Real Load control is included in the frequency control unit. When the generators are operating in parallel, bus voltage and frequency of individual generators cannot be changed, however excitation of an individual generator and the torque of the generator drive can be varied. Real load control is achieved by sensing the real current from each generator through separate current transformers which are connected in series to form a loop. Any variation in real load current of a generator from the average produces an error signal which is fed to the magnetic amplifier controlling the magnetic trim head of the speed governor thus varying the torque of the affected generator drive until its current output falls in line with the other generators.

3. *Voltage Regulation:* To avoid subjecting single phase loads to excessive voltages under abnormal operating conditions the regulator control always senses the highest phase voltage of each generator, by use of a high phase sensing circuit. The output of this circuit is rectified to a DC signal which is then compared to a reference voltage. The reference voltage circuit is a transformer coupled to the three phases of the generator the outputs of which are rectified and filtered to obtain an average DC voltage. This voltage is applied to a VR tube which ionises and maintains a constant voltage drop across the tube. A bleeder network is connected in parallel with the tube which is tapped and used for the reference voltage and remains constant under all variations of generator output. The difference between the voltage from high phase sensing circuit, which varies with generator output, and the reference circuit output voltage will cause an increase or decrease of current flow in the first stage of a magnetic pre-amplifier control winding which, in turn, is connected to the control winding of a power stage magnetic amplifier. A decrease in generator output results in a smaller current flowing in the pre-amplifier output winding and the power stage control winding. This action will cause an increase in current supply to the generator exciter shunt field and so restore the generator voltage output to normal.

A special bias power supply applied to each of the power stage magnetic amplifiers ensures that they are preset to operate on the desired point of the saturation curve, for proper control.

A start relay is connected in the circuit so that the generator exciter is self excited during starting to allow rapid build up, and once the output voltage of the generator reaches its specified value the relay opens and transfers the shunt field regulation to the regulator. Positive and negative feed back circuits are incorporated to provide stability during the rapid build up and for voltage control under transient load conditions.

4. *Reactive Load Division:* As in real load division, reactive load equalization is accomplished by a current transformer equalizing loop which senses the difference between the current from a single generator and the average current being carried by all paralleled generators. When current unbalance is present it is sensed and applied to a ring demodulator in the affected voltage regulator which receives a constant current from a regulator voltage reference circuit. A change in the ring modulator signal will bias the magnetic pre-amplifier winding which causes the affected generator excitation to increase or decrease thus equalizing the reactive load division between the paralleled generators.

5. *Auto Parallel and Preferential Tie Circuit:* It is necessary before paralleling the generators to ensure that they are in phase and secondly, that they are connected to the common tie bus in a preferred sequence. This is achieved by an intricate system of relay functions which can only be energized when all conditions for paralleling are present and by the use of a preferential circuit which controls the order of connection.

The actual phase sensing is done by means of a rectifier bridge housed in each voltage regulator one side of which is connected to Phase A of the generator and the other side to the tie bus, to which the output of the generator selected to be the master generator has already been automatically connected. Any voltage across the rectifier bridge due to phase difference between the two will energize a paralleling lockout relay which results in a condenser being charged through a rectifier equal to the value of the voltage difference. The maximum condenser voltage will be when the voltages are 180° out of phase and as the phases drift into step the lockout relay opens and the condenser then discharges through a second paralleling relay which energizes and closes the affected bus tie relay, paralleling the generator with the master generator on the tie bus.

Protective Systems

1. *Overvoltage and Undervoltage Protection:* Protection against faulty generator excitation is provided by overvoltage and undervoltage circuits. In both cases protection is achieved by removing the excitation from the generator and isolating the faulty unit from the bus bar.

Overvoltage protection for each generator is achieved by a special reactor circuit which is activated by its own overvoltage sensing transformer. When the input voltage from Phase C of the generator exceeds 130 volts a saturable reactor provides progressive saturation of a gate winding which, once saturated, allows current to flow through the gate winding. This in turn permits a connected transistor to conduct, energizing an overvoltage slave relay which, through its contacts, opens a field relay removing excitation from the faulty generator and disconnecting the unit from the line.

Undervoltage protection for each generator is achieved through a series of interconnected relay actions which are triggered from 3 phase full wave rectifier circuits connected to each generator. This circuit controls an undervoltage relay which energizes when the generators output voltage reaches 105 volts, and de-energizes at a value of 92 volts. Closing and opening of each of the undervoltage relays is completed through a series of relay actions and time delay circuits, which in turn will trip the field relay of the affected generator, removing excitation and disconnecting the faulty generator from the system.

2. *Underfrequency Compensation:* To prevent damage to magnetic components such as transformers at low engine speeds equivalent to generator frequencies of 300 cps or less, each of the voltage regulators are supplied with a voltage signal directly proportional to the frequency of its matching generator. This allows the voltage regulators to reduce generator voltages to a safe level as frequencies are reduced. The circuits are not effective when generator speeds approach the 400 cps level.

The frequency compensation is achieved by increasing the current through the voltage regulator control winding with diminishing generator speeds, increasing the voltage regulator output, reducing generator excitation and consequently generator output voltage. The compensating circuit is comprised essentially of a saturable reactor amplifier with two rectified windings and a series resonant circuit.

When frequencies exceed 350 cps the series resonant circuit, which is in parallel with the reset winding of the regulator, will have a high impedance and current will therefore flow primarily through the reactor reset winding, keeping the gate winding current small so that it cannot saturate the core. Below 350 cps the impedance will reduce in step with frequency until the gate winding becomes saturated, which then provides a parallel path to the ground for the voltage regulator winding current through a zener diode, with subsequent reduction in generator output voltage.

3. *Differential Protection:* Protection is provided for each generator for faults that may occur between a power lead and ground on any phase of the generator, through the action of a differential protection circuit. This circuit consists of six current transformers connected to a full 3 phase rectifier bridge, each pair of transformers for each phase comparing the magnitude of the current at the generator bus with the magnitude of the current at the ground end of the generator winding. Any difference represents a fault in a generator or its feeder, and results in a signal from the rectifier bridge which operates the field trip relay and removes generator excitation.

4. *Bus Fault Protection:* Faults on the generator buses and AC tie bus are protected against by provision of a zero negative sequence relay circuit. The function of this circuit is to sense voltage unbalance, either line to line, or line to ground when faults occur, the voltage unbalance being proportionate to the fault current. In addition the zero negative sequence circuit will detect open phase and reverse phase conditions and is designed to sense the sum of these unbalances.

With a line to line fault the circuit is designed so that it first disconnects the generator from the paralleling AC tie bus but still allows it to operate and supply its own bus. If the fault persists a thermal delay relay in the next two to four seconds activates a second round of relay actions to trip the generator field relay, deactivating and disconnecting the generator from its bus bar. Once the fault has been removed by isolating the offending circuit, manual operation of a reset switch will allow the bus tie relay to operate and reconnect the generator loads to the AC tie bus.

Current unbalance between paralleled generators is protected against by use of an unbalanced current protective circuit employing four current transformers connected in a loop circuit. Each transformer is paralleled with a full wave rectifier bridge which operate an unbalance current relay. Any unbalance of the paralleled induce a voltage across the unbalanced current relay which through a series of other relay functions, will trip the bus tie relay. A 4-6 second time delay in the circuit retards the action of any out-of-balance current signal to prevent nuisance trips due to transient system changes. When all generators are operating as isolated units, shorting contacts disable the balance loop during the unparalleled condition.

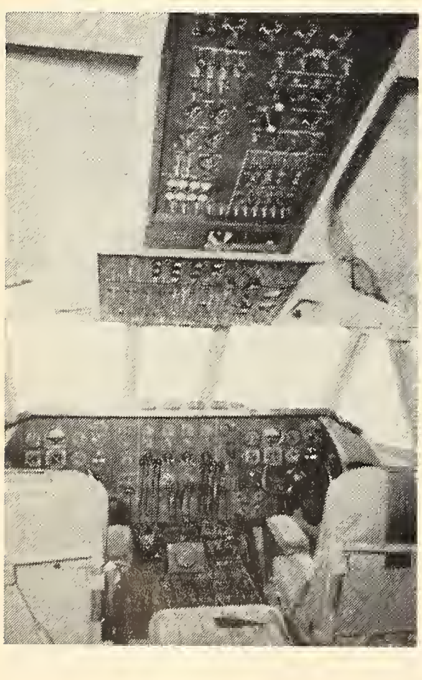
5. *Phase Sequence Protection — External Power:* When the aircraft engines are not running and it is necessary to operate the aircraft electrical system, an external power supply in the form of a mobile ground power unit is employed. It is necessary to ensure that the phasing sequence of the external supply is always in the proper phase relation order A.B.C. When external power is applied to the external power receptacle, phase A is supplied through an inductance coil and phase B through a dropping resistor. These phase voltages are then combined and applied to one side of a rectifier bridge while phase C of the supply is applied directly to the other side. If the phase order is correct the voltage differential across the bridge will be sufficient to energize a phase sequence relay and so connect the external power to the bus bars.

The above brief outline of the main control and protective functions does not include the complex interconnecting circuit controls and the many secondary switch and relay actions which go to make up the total system nor the numerous indicating warning and protective devices which indicate to the pilot when the system is not operating as designed. A total description of the system is beyond the scope of this paper. The control and protective equipment and wiring are housed in the aircraft electrical control centre in "black boxes" which are assembled and designed to facilitate servicing and trouble shooting. Reference to Fig. 7 showing the functional layout of an aircraft power system will convey some idea of the relationship of the components which go to make up a total control and protective system.

Distribution

Under this rather general heading it is proposed to examine some of the facets of this subject which perhaps will show the widest diversity between aircraft and general ground electrical practice. Keeping in mind the constant limitations imposed by "airworthiness" requirements, weight and space factors and the environmental conditions always present, the methods employed for distributing power to the operating systems are governed first by the necessity to always ensure adequate emergency coverage by the use of a multiple bus bar system. Next all feeds must be adequately protected, no matter how short, to minimize fire hazard, and the protective device rating is selected to protect the wire and not the component. Efforts are made to match the two requirements where possible and individual "built in" protection of vulnerable units is often employed in addition to the circuit protection. The geographical layout of the electrical distribution system in aircraft, until the advent of the jet aircraft was usually haphazard, the electrical centres and sub distribution items being positioned where space

Fig. 10. Typical jet aircraft cockpit panel layout.



permitted after all other requirements had been met. This led to unnecessarily complex routing and grouping problems, inaccessibility, with electrical devices and wiring situated in acutely vulnerable areas.

Certain items of necessity are still positioned in difficult and vulnerable areas to properly achieve their purpose, for example, the constant speed drives and alternators cannot be divorced from the engine, however on present day jet aircraft the electrical systems are included as part of the integrated design of the aircraft. This design now provides an electrical control centre where the whole of the control and main distribution devices are centralized and easily accessible, with provision for properly built in ducting to lead out the cable bundles to their sub-distribution centres and avoiding vulnerable areas. Even with this planning the ideal and shortest distribution arrangement is not possible since for operational requirement, the subsystem protective devices in the form of circuit breakers must be positioned collectively in the cockpit area. Since the main feeder cables, which can be up to 4/0 in size, represent a major item in the weight penalty of the electrical system, every effort is made to keep them as short as possible by the use of remote controls.

Bus Bar System and Components

The simple schematic bus bar system illustrated in Fig. 8 will serve to illustrate a typical modern jet layout and the relationships of the components required for both control and distribution. Such a system is designed to allow four alternators to be operated in parallel, or as independent units. The three phase power from the generators is distributed over a three wire, star connected distribution system with an earthed neutral, supplied by bonding to the metal structure of the aircraft. Provision is made in each channel to connect the power to the individual distribution bus-bar, by means of generator relays energized by the control system. To allow the generators to be paralleled when synchronization and speed are in proper relationship, four bus tie relays interconnect the individual outputs through a main synchronizing bus bar.

Operation of the aircraft systems on the ground when the engines are not functioning is achieved by provision for connection of externally operated ground power units through an external power relay which connects with the synchronizing bus and at the same time, by means of interlocking circuits, ensures the alternators and control systems are off line. A phase sequence protective device ensures that the ground power cannot connect to the bus bar unless the phase sequence is correct. To ensure emergency coverage, when any alternator is taken off the line, an automatic interlocking system allows its bus bar to be supplied by the other alternators which assume the additional load.

Even with AC aircraft systems, it is still necessary to utilize equipment operating with lower AC and DC voltages for speeial requirements, and these are supplied by conversion of the main AC supply by means of transformer rectifier units, feeding separate sub bus-bars.

For final protection against complete system failure a special emergency bus bar is incorporated to which is connected those vital circuits which are necessary to maintain safe flight, and sufficient to allow the aircraft to be landed. Special emergency switching arrangements allow the output of at least two of the alternators to be connected independently and directly to the emergency bus bar, completely by-passing the normal bus bar system.

Careful planning of the actual distribution of the loads to each bus bar is very important, first to ensure that circuit characteristics are reasonably matched to assist phasing, and secondly to ensure multiple essential circuits are not vulnerable to the failure of a single alternator. For example, the fuel pumps, ignition, fire detection, extinguishing and engine control systems are divided between the individual bus bars to obtain maximum protective coverage.

The bus bars themselves are usually standard rectangular sections of high conductivity copper or aluminum produced by cold rolling and selected as a compromise between weight, rigidity and electrical requirement. Circuit density is of the order 2500 amp. per sq. in. with a width ratio of 8 to 1 on main bus bars. Depending upon installation position they are hot tin dipped and wiped down with a Tallow rag to achieve a bright surface, however if prone to access by foreign objects they are insulated by either shrinking on P.V.C. sleeving or by spraying with liquid plastics of a suitable type. Connection to the bus bars is by means of brass and copper terminal screws in tapped holes for light connections, for heavier connections bolts or studs screwed tightly to the buses are necessary. On aluminum bus bars cadmium plated stainless steel studs only can be used to avoid corrosion.

Cables and Terminations

A complete separate paper could be devoted to cover the bare elements of this aspect of aircraft electrical systems since most of the cable and connector designs are special to aircraft requirements. Materials and construction of these items are once again determined by weight and space requirements, the necessity for standing up to environmental conditions, and in meeting a multitude of different applications.

Cables

Cable design has moved through many changes since the early days of aviation. The use of multicore cables was considered the best method of conserving weight and space, but as the operating and manufacturing requirements became more severe with the increased complexity of systems and operating conditions, the use of single wires grouped by circuits into looms are now standard with branches to divert circuits as required and the cables carefully "combed" to ensure easy replacement. The whole loom is laced together with straps to produce a very compact multicore bundle of great strength and reliability. Each bundle is limited to twenty conductors to permit easy servicing.

Aircraft cable construction is closely controlled by specification in their countries of manufacture which require that very rigid standards be met for such requirements as resistance to fire, flexibility over ambient temperature ranges of —75°C to +100°C, resistance to contamination peculiar to aircraft fluids such as synthetic organic esters and complex hydrocarbons, resistance to corrosion of the conductors by reaction with the synthetic insulating materials employed in their construction, high dielectrie breakdown capability to withstand high voltage transients, with sufficient tensile strength to stand up to the forces imposed by flexing and vibration in flight. It is not possible to detail the great variety of types and materials used except to note that most wires employ insulating materials produced from polymerisation used in conjunction with glass fibre, asbestos and natural rubber. Outer coverings are mainly of nylon sheath, braided and lacquered for normal temperatures up to 105°C, terylene sheaths for temperatures up to 190°C and sintered polytetraethylene and glass braid up to 240°C. In areas where fire is possible the special fire resistant cables used must prove their capability to withstand temperatures of 1100°C for five minutes before failing. The above represent the bulk of aircraft wiring however in addition are a large range of miniaturized and subminiaturized cables, screened and unscreened for the numerous electronic functions, special high frequency wires for antennae use, compensated cables for thermal applications, radio frequency coaxial cables and special ignition cables. The conductor sizes for aircraft cables range from No. 26 gauge for the miniatures to 4/0 for the main starting and power cables. It may be of interest to record that the modern jet aircraft employs over 35 miles of wiring in its make-up.

Terminations

Like most other items in aircraft use the methods employed for attachment of wires has passed through a wide variety of design changes and soldering was the main means for fixing such terminations. Unless perfectly executed, however, soldered attachments were prone to failure due to vibration and for many years unserviceability of aircraft systems due to this cause represented one of the major problems in the maintenance of aircraft. The development of improved techniques for the crimping of ring and pin terminations, particularly the ability to crimp onto the cable dielectric with an insulated sleeve provided with the attachment for improved support, has now led to universal adoption of this technique for aircraft use. Both copper and aluminum terminations over the full range of cable sizes from #26 to 4/0 are attached in this manner.

The requirement to be able to rapidly remove and replace equipment for repair, adjustment or overhaul, led to the adoption of a wide variety of plug and socket type connectors from the earliest days. Much of the advance in design of these conneetors, which are also widely used in industrial and commercial fields, has stemmed from the continuous fight to get them to stand up to the operating conditions in aircraft. Failure due to ingress of moisture from condensation has been, and still remains, the biggest problem and one of the major causes of system unserviceability. Inadvertent operation of equipment from surface flashover of the dielectric between adjacent pins caused by surface deposition of carbonized material and, more lately, the ingress of synthetic fluids which cause the insert material to swell, and deform, requires constant attention and the need for improved designs. On jet engines the high engine frequencies and temperatures have added further problems requiring special attention to installation design, "Potting" being resorted to on a large scale in vulnerable areas but its value to date has been doubtful.

Wide use is also made of terminal blocks for circuit connections of a semi-permanent nature which may number up to 6000 points in a modern jet aircraft. Unless properly designed these break points also become vulnerable under the operating conditions present, yet for space and weight saving they must be made as compact as possible. Moulded nylon with studs of stainless steel are now the latest type in use and are proving far superior to previous types. One other source of electrical circuit trouble has been the problem of leading masses of cabling from pressurized to unpressurized zones. Once done with plug and socket connectors this is now achieved by the use of carefully designed grommets or "bungs" consisting of flanged conical housings and tapered insulated inserts through which the cables are led and sealed by locking rings. The design is such that pressure differentials always tend to force the insert into the housing thus improving the seal.

To complete this section on distribution mention should be made of the protective devices employed and of other control devices common to most circuitry in jet aircraft. The design of circuit protection is very complex and requires an integrated apporach for the whole system. In aircraft the result of even a minor cable failure can produce undesirable effects not normally considered of importance in industrial use, the overheating of aircraft type cable producing pungent smoke and odours not conducive to passenger confidence. The wide variety of cable types in use, the locations in which they run, and the method of bundling and routing employed, requires more than the standard assessment of their normal working limits when selecting suitable protection. Adjustments to circuit protection rating is often a continuous process, even after the aircraft is designed, and experience and continuous inspection indicates the need for adjustment. Switch type thermally operated circuit breakers of a miniaturized type, fuses, and limiters with high temperature rupturing capacity, are employed according to requirement. In general, circuit breakers are used where it is desirable as an operational requirement to allow resetting of the circuit in flight, fuses are used usually for sub-distribution to non-essential circuits and limiters for sub-feed protection to heavy duty devices. As previously mentioned protective devices are collected together on panels, all essential circuit protection being located on the flight deck for access in flight, with non-essential protection located in the most favourable position to facilitate local distribution.

The very nature of the modern aircraft has led to the wide use of electrical remote control devices, space considerations in the cockpit making it impossible to accommodate a multitude of controls of the mechanical type. Space once again will not permit individual enumeration and discussion of the multiplicity of relay types in use, except to note that they consist of practically every known variation of the hinged armature, solenoid, rotary action, latching and polarized types to meet the particular needs of the systems. As the severity of the operating conditions have increased so their selection and design have been improved to keep pace in order to provide the reliability essential to safe operation and hermetic sealing and potting are now being employed on an ever increasing scale. Switch designs have similarly developed to encompass a wide variety of types, miniaturized to save space and weight and yet capable of giving long life and reliable repeat operation. Standard control switches of the "dolly" type employ quick make and break mechanisms and are built in a comprehensive range of combinations. Rotary switches and push button switches of many types, from simple call switches to elaborate units employing magnetic "hold in" features are used to facilitate system control.

Fig. 7 of a typical jet aircraft cockpit layout will serve to demonstrate better than any words, the concentration of electrical control, indicating and protective devices that must be brought together in a limited space to serve the flight crews.

Aircraft Systems

This article to date has endeavoured to outline briefly the basic requirement for the supply and distribution of electrical power but has not yet examined how the power is utilized. To be repetitious, space will not permit detailed examination of these many ingenious and complex systems that contribute to aircraft operation, however it is proposed to examine them broadly to illustrate how many specialized electrical applications are brought together and utilized in the make up of a modern jet aircraft. The air conditioning engineer will find much in common with the principles employed in the control of pressurization, air replenishment, heating and cooling of the aircraft interior, the lighting engineer with the methods to obtain efficient cockpit and interior lighting, the electro-mechanical application engineer with the complex servo control system that provides for automatic flight and primary system control, the domestic apparatus engineer with the ingenious galley designs, the control engineer with the many devices that contribute to jet engine control and performance, the electronics engineer with the tremendous diversity of systems that provide for radio communication, radar and navigational requirements, and the instrument engineer with the display that imparts to the pilot the story of what is happening at every instant in flight.

Air Conditioning Systems

Of the many systems in jet aircraft use perhaps none has made more contribution to the acceptance of air travel as the ability to provide living room conditions over the wide gamut of environmental conditions encountered in flight. This system is a compounded arrangement which takes heated air from special turbines to maintain the cabin at pressure levels commensurate with comfort when flying at altitudes of 35,0000 ft. and with exterior temperatures down to —90°C. Not only must this air be held at comfortable levels of pressure and temperature, it must be continuously replenished and mixed with fresh cold intake air so that it is renewed at least once every three minutes. Individual cold air outlets are also included for passenger use and the humidity artificially controlled to ensure maximum comfort. In reverse, when high exterior temperatures make for discomfort Freon refrigeration systems are employed to reduce temperatures to a comfort level. Electrical systems play an important part in providing the ability to automatically control these requirements. Cabin altitude and differential pressure sensing units coupled to control units monitor the exterior and interior pressure relationships to ensure smooth transition with changing pressure levels. Temperature sensing devices positioned in the cabin and hot air distribution system continuously monitor the cabin temperature selected by the stewardess and automatically operate the air mixing system to provide the level desired. Similarly humidity detectors and controls sample, and adjust the moisture content of the air to ensure comfort level is maintained. The electrical system not only contributes the sensing and control facilities but provides much of the motive equipment in the form of coolant pumps, condensers, recirculating fans with outputs of 17 kva., auxiliary heating devices and various electrical actuators that operate the various control and mixing valves that make up the total installation.

Anti-Atmospheric Systems

The natural elements still provide the major challenge to aircraft operation and a continuous program of development has been maintained for many years to provide the means to operate aircraft under the worst conditions of fog and ice deposition.

The greater speed of aircraft, the more dangerous does the effects of ice formation on the wings and control surface aerodynamic operation become and means must be provided for rapid dispersal of any ice. Ice build-up around the numerous air intakes must also be controlled to prevent ingress of ice into the engines with subsequent loss of power, and into intakes that provide air supply for the cooling and operation of many other functions. Individual units that project into the air stream such as instrument probes, antennae and other sensing devices must also be kept free of ice to perform their function. The pilots windshields must be kept defrosted for visibility, and at the same time be maintained at a temperature that will prevent shattering in the event of a bird strike. The availability of AC power in quantity now greatly facilitates the ability to successfully perform these functions. Wing deicing is achieved by cycling bleed air from the engines through the leading edges, the rate of cycling being controlled through electrically operated valves and timing units to produce the desired time sequence. On some jet aircraft, the smaller control surfaces are kept ice free by the use of electrically heated surfaces or "spray mats" which incorporate electrical resistance elements embedded in the surfaces which are sectionalized and heated in rotation by other electrical cyclic devices.

Engine air intakes and other air scoop entrances are ringed by heated elements that maintain steady temperatures and constantly reduce any tendency for ice build up. The purpose of cyclic heating devices is to allow some ice to build up during the "Off" cycle period and when the "On" cycle is applied, the electrically generated heat is sufficient to weaken the bond between the ice and the surface and the ice is carried away by the slipstream. Windshield deicing is achieved by employing sandwhich type glass in which a layer of metallic oxide or other heating elements are fused to the inner surface and in contact with a viny layer. Part of the heat supplied assists the vinyl layer in opposing shattering at low temperatures, while the balance of the heat supplied keeps the glass free from frost and ice build up on the outer surfaces.

Steady temperature conditions are achieved by built in thermo control devices that monitor the power supply to the metallic heating elements and/or oxide layer for all variations of temperature. The vinyl and metallic oxide layers are so thin that the normal light transmitting characteristics of the glass are unaffected.

Avionics

Perhaps the most rapidly expanding area of change in modern aircraft has been in the application of electronics to a diversity of functions required for communications, navigation, weather and collision avoidance and systems control. The term Avionics has been coined to cover this very wide and complex section, each part of which is a study in itself. In this paper it is proposed only to list some typical applications and the functions they perform, and in so doing it will serve to illustrate another facet of electrical application in modern aircraft. The "black" boxes for these systems are concentrated together in a rack usually positioned on the flight deck, with the power supply and wiring from the automatic controls designed as an integrated system for the complete rack. By industry agreement all units are housed in standard type cases and fitted with standard quick removal, mounting devices which permits quick interchangeability of the units, and in the design layout of the racks. The automatic operating controls are centralized, usually on the throttle pedestal and an overhead panel situated between the pilots, for easy access.

On long range jet aircraft for communication purposes it is necessary to carry both high frequency (HF) and very high frequency (VHF) systems. The high frequency is used for long range communication, especially when operating over open water, while the VHF, by virtue of its straight line operation characteristics is employed mainly as a direct link between aircraft and aircraft, and aircraft and ground.

One of the major uses of avionic equipment is to provide means to navigate the aircraft safely through the crowded airways of the world and to ensure safe landings at its destination. Diverse systems are now employed with many more under development and a brief survey of these may be of interest. For long range navigation over the oceans the Loran system is used which operates in conjunction with transmitting stations positioned over 1000 miles apart and whose signals are received and displayed in the form of a trace on an oscilloscope. To "fix" the aircraft position two sets of readings are used and it requires considerable skill to analyze the presented information. Other current systems in use for shorter range navigation include Automatic Direction Finding (ADF) which make use automatically of the "homing" finding qualities of a loop, and by taking bearings from different transmitting stations the crew can accurately determine the aircraft position. In North America, a short range navigational system is additionally employed known as VHF Omni Range (VOR), a more complex system which transmits two simultaneous signals, one a fixed omni-directional signal, the other a rotating directional beam. With this arrangement it is possible to first establish the aircraft bearing to true north over the radial which the aircraft is flying, and by signals from VOR beacons on the ground the aircraft's position can be pin-pointed.

Instrument landing systems installed in the aircraft, working in combination with special ground installations at each airport, provide the ability to bring the aircraft locally on course in line with a runway and to make a safe controlled approach, without visual contact, down to 300 ft. The use of instruments with special aircraft attitude visual representation, combined with audio signals permit the pilot to track the approach path and to follow a glide path down at an angle of 2½°, with markers that advise him of his progress along the beam at crucial points.

Radar is now standard equipment on jet aircraft to obtain weather information in flight by use of a scanner and receiving system which can detect heavy rain and storm areas ahead of the path of the aircraft. The information is presented visually on a radar screen which enables the pilot to pick the path of least turbulence for passenger comfort. Another current application of radar technique is the radio altimeter which is used for indicating height above the ground, is unaffected by continuous barometric variations, and provides accuracies of 5 ft. up to an altitude of 500 ft.

Several systems presently under development are being designed to operate in conjunction with extensive ground installations to provide distance measuring information on the airborne equipment (DME) so as to allow the pilot to continuously plot his position. One system known as tactical air navigation (TACAN) utilizes in a modified form the signals from existing VOR stations and presents the information to the pilots on dial type instruments. A second system, now being installed on TCA aircraft, termed Doppler, measures ground speed and drift but differs from DME in that it does not utilize ground signals, instead making use of the Doppler phenomena of the foreshortening of radio waves in transmission between two points in motion when approaching, and widening of the waves when moving apart. This equipment measures the change in wave lengths transmitted from the aircraft in flight and this difference is a measure of the aircraft speed.

Other developments include systems for assisting air traffic control called transponders which respond to signals from ground radar, and by special transmittal codes allows the aircraft position and height to be automatically tracked on the Air Traffic Control interrogators. The use of an airborne teletype system for printing out weather information to the pilots over the oceans will shortly be available, and a system for individually passing information to each aircraft, by a selective visual cockpit indicating system, in place of the pilot having to sort out the relevant information for his flight from the continuous stream of transmitted information, is also in being.

With such a diversity of avionic equipment, provision must be made for an array of suitable antennae to suit the individual needs of each of the systems. Positioning these antennae so that they have the correct polar field and at the same time do not interfere with each others polar field, and to install them so that they do not increase aircraft "drag", by inserting them into the line of the aircraft structure presents a major problem. In concluding these comments mention must also be made of the aircraft intercommunication systems, public address and other auxiliary electronic units used for system control, which go to make up that portion of the aircraft electrical system classed under Avionics.

Flying Surface Controls

Perhaps in no other way does the application of electrical power take its place as a primary system than in its use as a means for supplying or aiding the physical control of the aircraft through its flying controls. Until the advent of the heavier, high speed, jet aircraft such control was achieved by traditional mechanical methods, but the radical changes in aerodynamic designs and the necessity to keep stick forces within the capabilities of the pilot, are steadily leading to the wider use of power assisted control systems. Present jet aircraft use a form of electro hydraulic power in which the main control operating force is monitored by the pilot's actions on the cockpit controls. Such systems require the use of artificial "feel" devices so that the manual efforts of the pilot bear a proper relationship to the control forces applied. Such electro hydraulic servo units are usually comprised of an electric motor, hydraulic pump and ram, and differential control, and in some cases irreversible screw jacks are employed.

According to requirement they are used to operate the Aileron, Rudder, Elevator and Flap Controls, with a secondary application for "trimming" the aircraft controls by use of trim tabs.

Although usually included as part of the Avionic group the modern automatic pilot systems in use, which are complete electronic systems responding to gyroscopic signals induced by aircraft attitude in the three main axis and from directional information supplied by remote reading compass systems, are really part of the flying control group since their main purpose is to maintain control of the flight of the aircraft without human aid by operating through the flying servo control systems already outlined.

Engine Controls

On the modern jet engine many of the control and indicating functions are achieved by electrical means. Practically all engine starting up to the advent of the large jet engines employed electrical starters, however the time taken to accelerate a jet engine up to the desired speed by this method led to the development of alternate systems providing greater acceleration. Modern jets employ solid fuel starters comprising an impulse turbine powered by solid chemical fuel detonated electrically by a cartridge, or operated from a high pressure pneumatic source. Liquid fuel starters and fuel air starters which are similar in principle to the solid fuel units are also in use, but the general trend has been to low pressure air starters which employ light weight turbine units driven from air pressure sources of 30 p.s.i. It should be noted that although not supplying the primary power, electrical control is used with these various alternate systems.

High energy ignition systems have replaced the classic magneto systems on jet engines as ignition is only required for starting and for possible air relighting. At high altitudes, with high mass air flows and rapid thermal dissipation, it requires a stored energy of 12 joules to produce a suitable spark discharge at the igniters to ensure combustion. Igniter boxes employing an induction coil charging capacitors through a rectifier circuit, produce a peak energy of discharge of more than 100,000 w. across special igniter plugs, which differ from standard spark plugs in that they have no air gap but discharge across a semi-conductor which separates the electrodes.

The means for supplying monitoring and measuring the fuel to the engines employ many electrical applications. Electrical fuel pumps are standard equipment on modern jet aircraft, two pumps usually being installed per tank system to ensure absolute integrity of supply. Fuel control units which sense engine speed and temperature regulate the fuel supply to prevent engine overspeed and temperature. Fuel flow indicating systems which automatically correct for inflight variations of the fuel due to specific gravity and temperature so as to indicate true mass flow, keep the pilots continuously informed of the fuel being consumed, while special capacitance type gauge systems display the changing contents of the many fuel tanks for pilot information. Transfer of fuel in the aircraft is achieved by the use of electrically controlled fuel cocks and indicators to keep the fuel weight evenly distributed.

To control the performance of the engines the pilots must be continually informed of such things as the high and low turbine blade speeds, engine interior temperature conditions, the ratio of pressures between intake ram and engine for assessing power available, and the temperature and pressure of lubricating systems. These functions are performed by electrical transmitters such as thermocouple harnesses, small rotary tachometer generators, magnesyn or autosyn type pressure transducers which sense the information and register the outputs on suitably matched instruments mounted on the cockpit panels. Electrical fire detection systems consisting of sensitive "strip" detectors which festoon the engine signal immediately, through suitable amplification units, a warning to the crew when a source of overheat is present, while electrically operated extinguishing systems respond at a touch of the pilot's button to flood the engine with extinguishing agents. The whole of the wiring of the engine and power plants are integrated into harnesses designed to permit quick replacement and to protect the wiring from the extreme variations of vibration and environmental conditions experienced in flight.

Lighting

For many years lighting in aircraft received very little attention but as speed increased, and airlines became more competitive, the provision of first class illumination for both operational use and passenger attraction became increasingly important. In today's modern jet it is possible at any one time for over 1500 lights of different categories to be operating, from the miniature "grain of wheat" bulbs in integrally lighted dashboard instruments to specially designed fluorescent tubes which contribute to warmly lit and attractive cabin interiors.

International regulations require all aircraft to employ exterior lighting which includes provision of navigational lights, anti-collision lights of the flashing beacon or intensive "cold" discharge type and high powered landing and nose wheel taxi lights. For other exterior uses, anti-icing flood lights which illuminate the wings and engines in flight for visual inspection of ice build up by the pilot are a necessity, plus service lighting to illuminate the freight holds and other external service areas.

Passenger comfort is looked after by provision of attractive main lounge lighting of mixed incandescent and fluorescent types with alternate "blue" night levels to allow sleeping, individual passenger reading lights, aisle lights at floor level and provision of well defined illumination in lounges, washrooms and entrances. Individual service call systems, using both light and audio devices are employed for passenger service convenience, while a "built in" lighting signal system advises the crew when the aircraft intercommunication system is being employed.

It is in the cockpit area however that lighting achieves a high state of the art. Cockpit lighting has been the subject of years of research and controversy since its efficiency has a direct bearing on flight safety. The complex array of dials of all shapes, and the numerous controls and switches which are vital to aircraft operation require close concentration by the pilot for quick decision taking, even under daylight conditions, and under night conditions the problem is accentuated. Not only is it a question of being able to quickly interpret information but the lighting must be capable of sufficient balance and adjustment so that the pilot's eyes can adjust quickly from viewing his lighted panels and of looking out into the varying degrees of darkness, without his vision having to undergo any protracted adaption to the change. In immediate contrast, when flying directly into a brilliant winter sun, unless provided with right level of illumination the cockpit appears to be a "black well" of darkness when the eyes move from outside to view the panels. It has taken many years to produce a balanced system that meets these extremes, and it has been achieved by integrally lighting each instrument individually to produce balanced red illuminated dials. The many variations of dial configurations in use, the necessity of avoiding "high lights" on the dials and of obtaining from individual instrument manufacturers a standard of light level has made this a lengthy and difficult development. Individual lighting of the dials produces an effect of "floating" in the dark which can result in nausea and changes in the crew's sense of orientation. This affect is overcome by provision of controlled floodlighting that enables the pilot to relate the instruments to the surrounding structure.

Both red and fluorescent white floodlighting are used for this purpose, and by adjustment of the integral lighting in conjunction with the red and white "floods" the whole gamut of light conditions encountered is catered for. In obtaining a balanced design further difficulties from halation or reflections in the dials and windscreens require the careful use of anti-glare shields. Integral lighting does not cater for cockpit controls, other than the instruments, and the host of engraved dial inscriptions required for pilot guidance, must be capable of being read under night conditions. This led to the development and use of special trans-illuminated, back lit panels which, by bonding together a mixture of laminated transparent and opaque plastic sheets suitably engraved, coupled with back mounted lights employing red filters, produce inscriptions which glow red by night and appear white by day in perfect harmony with the rest of the cockpit panel lighting. A balanced cockpit lighting scheme must also take into account the varied array of warning lights of red, amber and blue which must efficiently attract the pilot's attention, but not upset the careful balance in illumination level. Lighting of the modern jet cockpit is indeed a very fine example of the illuminating engineer's art.

Conclusion

Space will not permit further enumeration of many other electrical applications used for such systems as hydraulic, pneumatic and water that require electrical devices for their operation and control, or to go into the details of the efficient electrical kitchens or "galleys" that must be able to produce a hundred hot meals and beverages in a limited flight time, and from which development of the present day domestic "frozen food" was evolved. Neither can we cover many other secondary aspects of aircraft electrical operation such as the complex array of ground power and servicing units required for ground operation and the trouble shooting of systems, or the elaborate overhaul requirements necessary to ensure that the airborne equipment is maintained at a high peak of efficiency over their long operating lives. In concluding a brief glimpse of the use of electricity future aircraft may be of interest.

Before the advent of the "supersonic" airliners predicted by industry for use in the late 60's or early 70's, most operators are planning to introduce improved jet aircraft of the present breed around 1964. No major changes from present standards, or systems presently in use are likely since the design specification of the operators must be finalized at least three or four years ahead.

Some innovations however will no doubt be introduced. The most important perhaps will be the introduction of integrated systems that will combine the automatic pilot system with coupler systems designed to receive heading, approach and radio information from the airport approach system, and by further coupling with the radio altimeter and some of the engine and system controls, provide the means for the aircraft to make an automatic approach down to the ground. The final objective of this development is to achieve full automatic landing, however, it is anticipated that the next aircraft will be automatically controlled down to the final "flare out" before landing. This in itself will be a major contribution to overcoming the operators highest priority problem of trying to "beat" the weather. To ensure maximum integrity of all systems used in this integrated concept, multi-system installation will be necessary.

With the increase in circuit complexity and application the ability to service and troubleshoot aircraft to avoid the delays which cost airlines several thousand dollars for every hour of scheduled flight time becomes an increasingly pressing problem. The use of automatic ground computer devices capable of piecemeal checking of systems by application of "stimuli" signals and "good—no good" answers, to simplify fault finding are being studied. This will necessitate provision in the design stage of the new aircraft of carefully planned circuit check out points wired to a centralized test centre, where the ground test signals from the automatic ground system check can be quickly applied.

The use of "in flight" magnetic tape recording to record, in digital form, the important parameters of the many systems at frequent intervals has been under study for several years and will be employed for improved control of the economic aspects of overhaul and servicing, as well as providing the ability to analyze the flight performance and equipment operation. This development will necessitate the utilization of modern automatic ground data processing techniques, already employed in the control of other important aspects of company operation.

The high cost of jet engine operation and the requirement to predict loss of performance and possible failure symptoms requires the use of improved instrumentation to provide data that can be quickly analyzed in flight, and will include such systems for vibration monitoring and temperature time analysis.

The eventual introduction of the "super sonic" aircraft for general commercial use will obviously raise many new problems and require new techniques which have yet to be explored. Missile and supersonic military aircraft experience are already contributing to the understanding and solution in many of these areas, such as the ability to keep the aircraft and equipment operative despite the high temperatures generated by kinetic heat, of maintaining passenger comfort under the increased stresses which will be present, and the use of automation on a large scale for precise "in flight" planning and control. There are no alternatives to the use of electricity to provide the precise control, flexibility and cleanliness that will be required. Much of the expanded electrical equipment which will be required to make up the bulk and weight of future systems, should, by the advent of the supersonic jet, have benefited from the present intensive research into the miniaturization of equipment using "solid state" and other comparable electronic techniques.

Although it has taken many years for electrical application to come of age it matured in meeting the requirements of today's jet aircraft, and will undoubtedly play an ever-increasingly important role in the progress of the aircraft of the future. EIC

THE COMBUSTION OF GASOLINE DURING ENGINE STARTING

AT LOW TEMPERATURE

F. D. Hamblin, M.E.I.C.,
Special Lecturer in Mechanical Engineering, University of Saskatchewan, Saskatoon

THE MECHANICAL engineer with a specific interest in internal combustion engines, experiencing his first Canadian winter, finds his attention drawn to the effects of the low temperatures on engine performance. The average Canadian car owner knows that the fuel consumption of gasoline engines is increased during the winter months; yet a library study indicates that very little work has been done in this field. The main part of the available information is concerned with lubrication problems, while the combustion of the fuel has been almost entirely ignored.

The increased fuel consumption is no doubt partly due to the increased viscosity of the lubricants in the engine, transmission and rear axle. However, it does not seem credible that the magnitude of the increase can be attributed to lubrication alone; suggesting that poor combustion of the fuel might also be a contributing factor.

The period for which an engine is used during any one operation may be divided conveniently into three distinct phases, namely:

(i) Starting—the cranking period before the first explosion and the first explosion itself;

(ii) Warm-up – the phase between starting and the engine reaching a constant operating temperature;

(iii) Running — the phase after the operating temperature has become constant.

The fuel consumption should be approximately constant during phase (iii), since the engine operates at about the same temperature in both winter and summer. Thus, the increase must occur during phases (i) and (ii). Compared with summer temperatures, the starting phase may extend over a longer period and the warm-up phase is most definitely prolonged at low ambient temperatures. Drivers making long journeys notice no significant change in their automobiles' fuel consumption but the average driver, who rarely uses his engine for a long enough period for it to reach the running phase, finds that his has increased.

An extensive research program, dealing with the combustion of gasoline during the starting and warm-up phases, has been started at the University of Saskatchewan. It seemed logical to consider the starting phase initially, with an extension into the warm-up phase in the light of the results of the starting tests. The initial investigation is now complete and the results are reported in this paper.

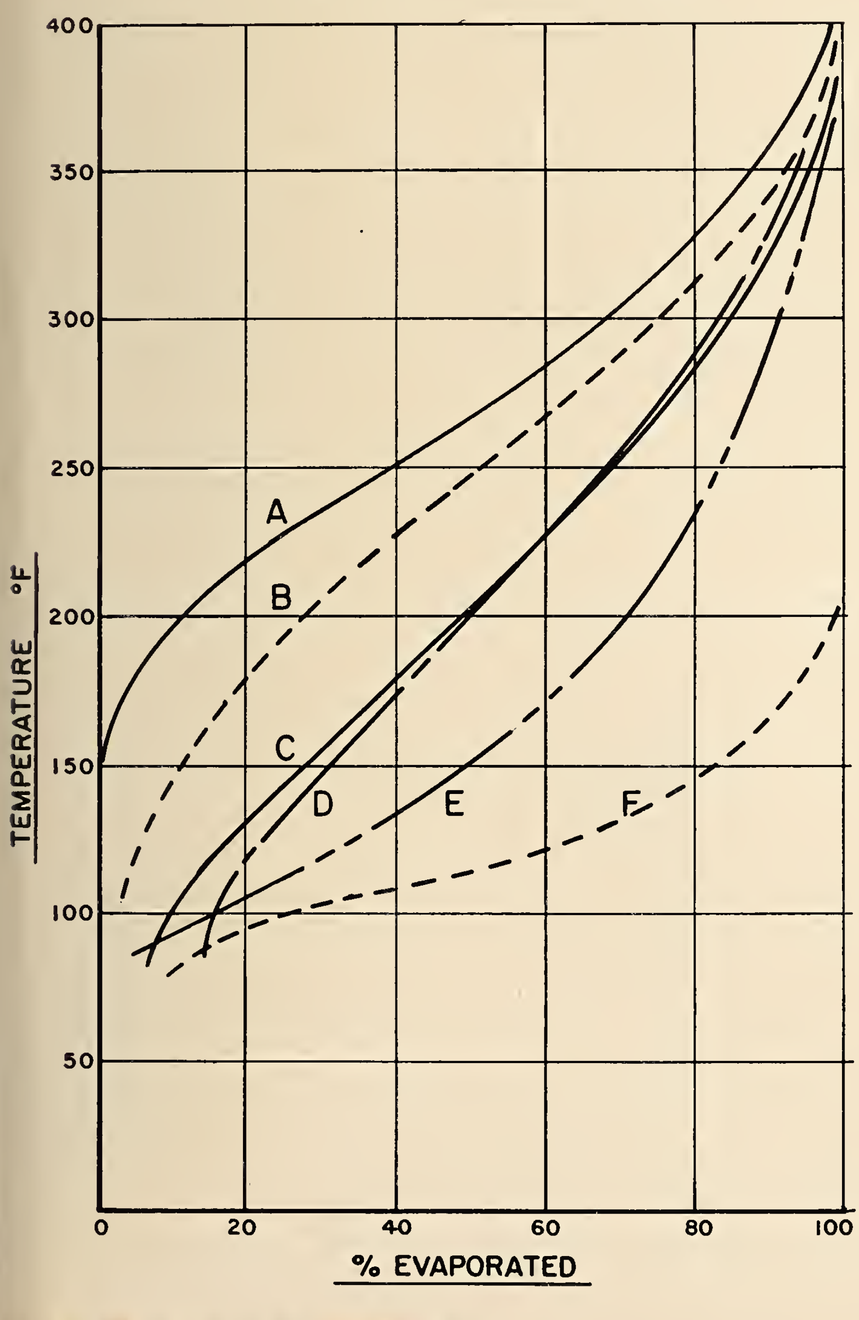
Notation

N Cranking speed, r.p.m.
r Compression ratio.
t Temperature, °F.
Δp Pressure rise during combustion, psi.
ΔT Time period, m.sec.
θ Spark advance, °before TDC.

Subscripts:

$_a$ Period between spark and visible rise in pressure.
$_b$ Period between visible rise in pressure and maximum pressure.
$_e$ Engine.
$_n$ Speed of N r.p.m.
$_{10}$ 10% point on A.S.T.M. evaporation curve.
$_{300}$ Speed of 300 r.p.m.

Fig. 1. A.S.T.M. Evaporation Curves for Test Fuels.



Review of Previous Work

The amount of available literature on the combustion of gasoline at low temperatures during starting is relatively small. In addition, the majority of the work was carried out over 20 years ago, before the petroleum industry had reached its present advanced state. It would not be practicable to review the previous work in detail, but it is desirable to make a general study of the previous experimental techniques and the results obtained.

The early work on engine starting was undertaken as a Co-operative Fuel Research program by the Bureau of Standards. The qualitative results of preliminary tests[1-4] indicated that the starting problem was essentially to provide a sufficient supply of air and fuel vapour to form an explosive mixture, then to provide a suitable spark with which to fire it. This work showed that the quantities of air and fuel required to form an explosive mixture were influenced by the volatility of the fuel and its temperature.

The program was continued[5-7] to obtain quantitative results, using multi-cylinder engines. The engine under test was driven at a constant speed by a dynamometer with the fuel shut off initially. When the engine conditions were constant, the fuel was turned on and the time required to produce an audible explosion was recorded as the "starting time". Immediately this explosion was heard, the fuel supply was terminated so that the air-fuel ratio could be determined. Results showed that as the air-fuel ratio was increased, the starting time increased. It was found that a spark advance of about 35° before TDC produced minimum starting times and that the effect of ignition timing was more pronounced with less volatile fuels. The results also showed that choking was advantageous during starting. Tests with fuels of varying volatility showed that, for a constant air-fuel ratio, the starting time was increased with less volatile fuels. Using the same fuel, it was found that the starting time increased as the ambient and engine temperatures were reduced.

The Bureau of Standards' work suggested that there was a definite relationship between the fuel volatility, as given by the A.S.T.M. evaporation curves, and starting time. The method of evaporation in the A.S.T.M. distillation test is so different from the vaporization in an engine that the final Bureau of Standards' work used the equilibrium air distillation method to compare the fuels. However, similar results were obtained using both methods.

The University of Michigan made an extensive study of the volatility of motor fuels; part of this work was concerned with ease of starting.[8] The technique was very similar to that described above, except that the engine was cranked by its starter motor, which received its power from the same battery as the ignition system. The general trend of the results was also similar to the previously described work. This work suggested that an engine may be started at low temperature if the 10% point on the A.S.T.M. evaporation curve for the fuel did not exceed the temperature given by the equation,

$$t_{10} = 1.25(100 + t_e)$$

provided that the battery had sufficient capacity to crank the engine until it started.

Research on the cold starting of gasoline engines was carried out in the United Kingdom under the auspices of the Automobile Research Committee of the Institution of Automobile Engineers.[9-12] The test technique was similar to the other investigations in that the number of revolutions the engine made before producing an audible explosion was considered as a measure of the starting characteristics of fuels. The engine was cranked at constant speed by a dynamometer as in the Bureau of Standards' work; the main difference between this and the previously described investigations was in the method adopted for the measurement of mixture strengths. In the other work, the mixture strengths were actually measured during the starting tests, whereas they were determined by entirely separate tests in the British investigation. The results indicated that to start an engine at low temperatures it is necessary to supply the cylinder with a suitably rich mixture, the cranking speed should be as high as possible and, at very low cranking speeds, it may be necessary to retard the spark.

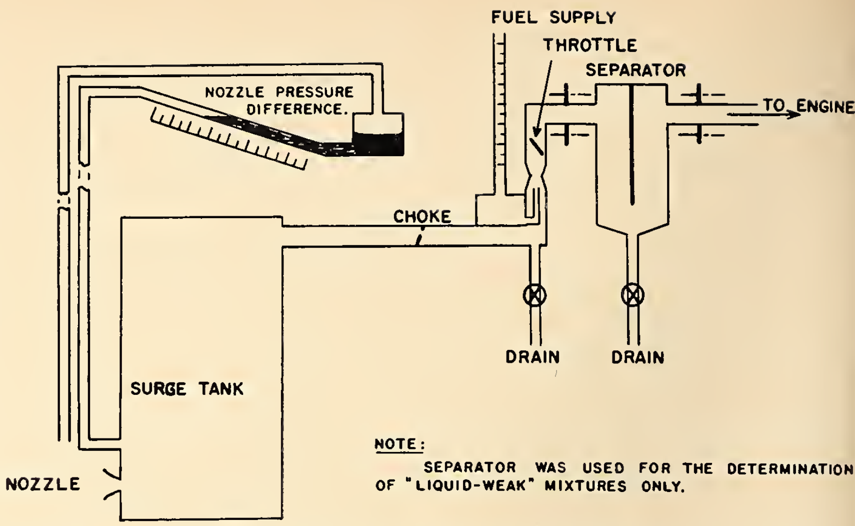


Fig. 2. Diagrammatic Arrangement for the Determination of Mixture Strengths.

Experimental

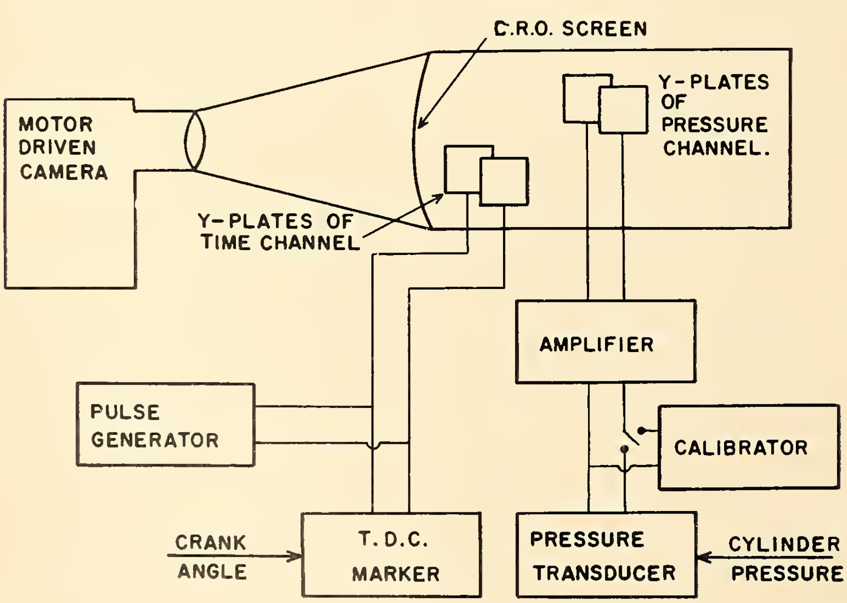
The starting tests in the current program were designed to make a detailed examination of the combustion process during the initial explosion. This was achieved by obtaining cylinder pressure-time diagrams from an engine as it was started at temperatures in the range 32°F to —30°F. Gasolines having different volatilities were used at compression ratios of 5.5, 6.2 and 7.3 with spark advances of 5°, 20°, 40° and 60° before TDC. In this work the engine was cranked by its starter motor, which received its power from the same battery as the ignition system.

Since accessories can be used in practice to decrease the viscosity of the engine lubricant and to provide enough battery capacity to start the engine, these were regarded as separate problems and not considered in the investigation. Consequently, low viscosity lubricants were made up by blending SAE 10 oil and kerosene in various proportions; these lubricants were used in the engine so that the cranking speed at all temperatures was in the region of 300 r.p.m. In addition, the battery was kept well charged and remained outside the cold test area.

A single-cylinder engine was desirable for the tests, so the measurements taken from the observed cylinder could not be influenced by any unknown effects from another cylinder. A single-cylinder, four-stroke cycle, air-cooled engine of 3 in. bore and 3¼ in. stroke with coil ignition and starter motor was used for the tests. The up-draught carburetor supplied with the engine was used in all tests and various cylinder heads were used to provide the required compression ratios.

Four samples of winter gasoline were purchased from various oil companies, but all exhibited very simila

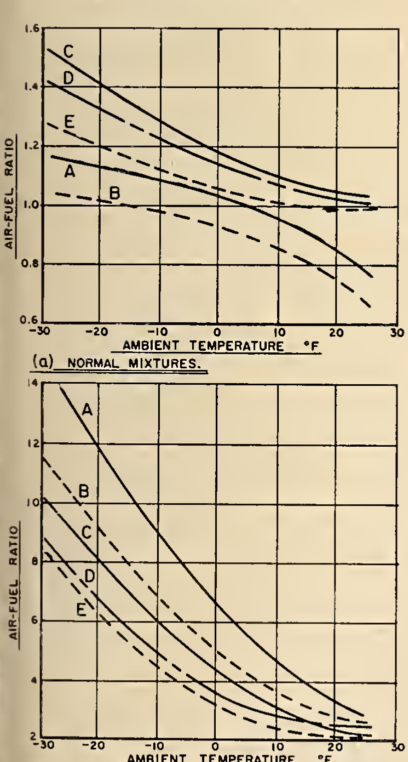
Fig. 3. Diagrammatic Arrangement of Engine Indicator.



volatility characteristics. The previous work had shown that fuel volatility had a great effect on starting times, so this factor was considered very important in the present investigation. Consequently, six gasolines were used for the tests, two (C and D) being commercial types, while the remainder were blended using various proportions of the commercial fuels, thus providing the required wider range of volatility. The A.S.T.M. evaporation curves for the test fuels are shown in Fig. 1.

It seems reasonable to assume that during low temperature starting, the charge enters the cylinder as a mixture of atmospheric air, gasoline vapour and liquid gasoline dispersed throughout the mixture in fine droplets. The temperature of the cylinder contents gradually increases during the compression stroke, thus some of the liquid fuel entering the cylinder is vapourized as compression occurs. At the start of combustion, the temperature is further increased in the vicinity of the flame front; hence, any remaining liquid may be vaporized as the flame front advances through the combustion chamber. So the factor determining if an initial starting explosion will occur or not is the air-vapour ratio at the time of the spark, rather than the air-fuel ratio entering the cylinder. Therefore, in addition to measuring the air-fuel ratio, the mixture strength was also determined

Fig. 4. Mixture Strengths.



when the majority of the free liquid was removed from the mixture supplied by the carburetor ("liquid-weak" mixtures).

Air-fuel ratios were determined using the arrangement shown in Fig. 2; the separator was used in the determination of "liquid-weak" mixture strengths only. This separator acted in the same manner as a separating calorimeter used for the measurement of the quality of a wet vapour, in that the mixture experienced a change in direction, causing some of the unvaporized gasoline to fall out of suspension. The mixture strengths were measured at test conditions similar to those in the starting tests, but the ignition system was not energized.

Pressure-time diagrams were obtained for the starting tests by applying the cylinder pressure to a piezo electric pressure transducer by means of a small bore tube passing through the spark plug wall. The signal from the transducer was applied to the y-plates of one channel of a dual beam oscilloscope, via an amplifier and calibration unit. The output of a pulse generator, producing a square wave at a frequency of 500 c.p.s., was applied to the y-plates of the second channel. A small generator, driven by the test engine, was connected across the output lines of the pulse generator. This connection was made through a set of contacts, operated by a cam mechanically coupled to the engine shaft, which were timed to close at TDC and re-opened at about 5° after TDC. During the period these contacts were closed the two generators were connected in parallel, hence reducing the voltage applied to the y-plates of the oscilloscope timing channel.

A motorized camera was attached over the oscilloscope screen so that the film moved horizontally at 12 in./sec. The horizontal motion of the film, combined with the vertical deflection due to the cylinder pressure produced a continuous pressure trace. In the same way, the output of the pulse generator produced two dashed lines, the length of each dash being 1 m.sec. The distance between these lines was decreased whenever the piston reached TDC, thus providing a marker on the film record indicating TDC.

The engine indicator described above is illustrated diagrammetrically in Fig. 3. The generator connected to the engine shaft and the cam operated contacts have been combined in this diagram and termed "TDC Marker".

The engine was set up in a cold chamber, with all its subsidiary equip-

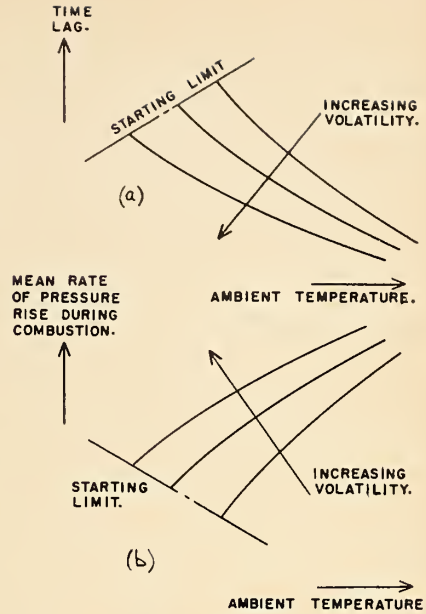


Fig. 5. Expected Results.

ment and instrumentation attached. The crankcase lubricant was changed at each temperature change, in an endeavour to maintain the cranking speed constant throughout the investigation. Tests were commenced when the ambient temperature within the chamber and the engine block temperature were sensibly the same (within ±2°F). Tests were made at various points in the temperature range considered with the choke fully closed and the throttle clamped approximately a quarter open.

Fuel C was tested at the three compression ratios and four spark advances considered. Tests were made with the remaining fuels at compression ratios of 5.5 and 7.3 with spark advances of 5° and 40° before TDC, for comparison purposes. Upon the completion of a series of tests with a particular fuel, all components between the surge tank and the point where the inlet manifold was attached to the engine block were completely dismantled and thoroughly cleaned. When they were reassembled on the engine, it was cranked for a period of not less than two minutes in order to purge any fuel which may have remained in the engine from the previous test series. The spark plug and pressure transducer assembly was dismantled and thoroughly cleaned at frequent intervals to ensure that it was not fouled by deposits.

In addition to the above tests, starting tests were made with "liquid-weak" mixtures using fuel C at a compression ratio of 6.2 with spark advances of 5° and 40° before TDC. These tests were designed to investigate the effect of the free liquid in the mixture entering the cylinder.

In making a particular test the starter button was depressed before energizing the ignition system, to allow the cranking speed to become constant. The film was set in motion after the engine had made about ten cycles and the ignition turned on when it had completed twelve cycles. Cranking was continued until an explosion occurred, as indicated by an increased deflection on the oscilloscope channel representing pressure. If an explosion did not occur before the 21st cycle, the test was discontinued and recorded as "no start". All these cases were checked by a second test, carried out without using the camera, in which the engine was cranked for a period of one minute, to determine if an explosion would have occurred later than the 20th cycle. In all cases this check still produced no explosion.

Discussion of Results

Mixture Strengths: The mixture strengths obtained for the test fuels are given in Fig. 4. Preliminary starting tests with fuels A and B showed that they would not produce a start with the usual fuel flow rate to the carburetor, so it was increased for these two fuels. Mixture strengths are not available for fuel F because the preliminary work showed that this fuel would not start with any carburetor setting and it was subsequently blended with less volatile fractions to form fuel E.

The increase in air-fuel ratio with decreasing ambient temperature, for any particular fuel, shown in Fig. 4(a), is due to a smaller quantity of fuel being vaporized as the temperature was reduced. Thus, a larger amount of fuel was drained from the air intake, the result of using an updraught carburetor. This effect would not be so pronounced with a downdraught carburetor.

The air-vapour ratios supplied by up- and down-draught carburetors at any given temperature should be sensibly the same. The curves of Fig. 4(b) give an indication of the air-vapour ratios, but the separator probably only removed between 80% and 90% of the unvaporized gasoline. Attempts to measure the efficiency of the separator, by absorbing the remaining free liquid after the mixture passed through it, failed because of evaporation during the subsequent weighing process. However, these attempts did indicate that all the free liquid was not separated from the mixture — in the same way as the quality of a wet vapour cannot be measured by a separating calorimeter alone.

Starting Tests: The indicator diagrams obtained for the starting explosion were analysed to determine

(i) the time interval between the occurrence of the spark and a visible rise in pressure;

(ii) the pressure rise during combustion;

(iii) the duration of the pressure rise during combustion.

The point at which the spark occurred could not be determined directly from the indicator diagrams because the crank of a single-cylinder engine operating at low speeds must undergo an angular retardation due to compression alone. This difficulty was overcome by obtaining a set of indicator diagrams from the engine when it was cranked at the test speed with marks at points corresponding to the spark advances used in the starting tests. Then, by taking the correct proportion of the distance between the TDC marks for the suction and compression strokes of the cycle immediately before that in which combustion occurred in the starting tests, the position of the spark could be marked in the latter cycle.

During analysis of the indicator diagrams it was found that the cranking speed had varied from a maximum of 350 r.p.m. to a minimum of 260 r.p.m. Consequently, the effect of varying cranking speeds was investigated by a series of tests using fuel C at a constant temperature of −7°F with a compression ratio of 6.2 and a spark advance of 5° before TDC. The cranking speed was deliberately varied in these tests by adjusting the power supplied to the starter motor. The results showed that the time interval between the occurrence of the spark and a visible rise in pressure remained constant in the range of cranking speeds of the investigation. For this range of cranking speeds, the pressure rise during combustion and its duration had linear relationships with cranking speed. The results of the starting tests could be converted to a constant cranking speed of 300 r.p.m. by the equations

$$(\Delta T_a)_{300} = (\Delta T_a)_n$$
$$(\Delta p)_{300} = (\Delta p)_n - 0.447(300 - N)$$

and

$$(\Delta T_b)_{300} = (\Delta T_b)_n - 0.0457\ (300 - N)$$

The most convenient graphical form for the results is to show the effect of ambient temperature on

(i) the time interval between the occurrence of the spark and a visible rise in pressure, termed "time lag", i.e. ΔT_a;

(ii) the mean rate of pressure rise during combustion corrected to 300 r.p.m., i.e. $(\Delta p/\Delta T_b)_{300}$.

The trends that these results might be expected to take, based on the previous work, are shown in Fig. 5.

Fuel A failed to produce a start at any temperature in the test range, although its flow rate to the carburetor was adjusted to its maximum value.

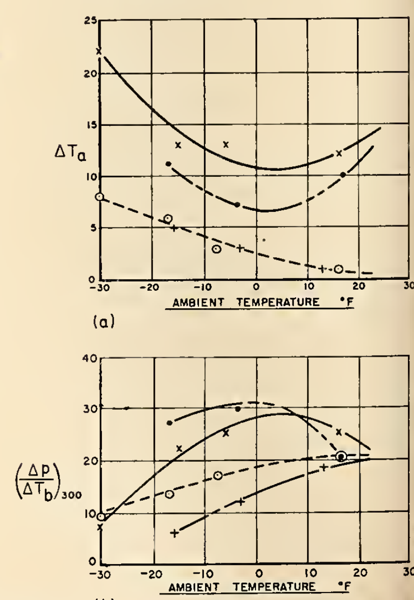
Fuel B did not produce a start at all conditions of the investigation, although its flow rate to the carburetor was also adjusted to a maximum. The results of tests in which this fuel did start were very inconsistent.

Fuels, C, D, and E started consistently at all test conditions. In some cases with an early spark, the increased pressure due to combustion overcame the starter motor, causing the piston motion to be reversed in the same way as an engine may "kick" during manual cranking with the ignition advanced.

The above results show that there is a limiting lower volatility, since fuel A did not start at any temperature in the test range. The lowest temperature at which fuel B would start was about −15°F, although this fuel was unreliable at all temperatures up to 0°F. The results obtained with this fuel were inconsistent throughout the test range, suggesting

Fig. 6. Effect of Free Liquid.

Legend:
O — θ = 5° with normal mixtures.
× — θ = 40° with normal mixtures.
+ — θ = 5° with "liquid-weak" mixtures.
● — θ = 40° with "liquid-weak" mixtures.



that it represents the limiting lower volatility at the upper temperatures in the range investigated.

The test results suggest that there is also a limiting upper volatility, since the most volatile fuel (F) tested did not produce a start at any temperature in the range considered. It will be seen in the following discussion that this result agrees with the general trends obtained in the entire investigation.

It is impossible to show the results obtained for all conditions of the investigation in this paper; so typical curves have been chosen which will suffice for the following discussion.

The Time Lag: The time lag is made up of two different components; initially, the delay period in which no combustion, as such, is taking place, followed by the first stages of actual combustion which produce an immeasurably small pressure rise. The variable cranking speed tests produced no change in the total time required for these two components in the range of cranking speeds encountered in the starting tests. So the time taken by the first stages of actual combustion must be reasonably constant, since turbulence is probably the factor having the greatest effect. A second factor is suggested later, however, which will also have an effect.

If it is assumed that turbulence is the only factor effecting the time in which combustion produces an immeasurably small pressure rise, this time was constant throughout the investigation. Then, curves plotted for the delay period against ambient temperature must have the same shape as those obtained for the time lag, but the time scale is enlarged.

Effect of Free Liquid in Mixture: The results obtained using normal and "liquid-weak" mixtures with fuel C at a compression ratio of 6.2 are shown in Fig. 6. The curves of Fig. 6(a) show that with a spark advance of 5° before TDC there was no significant change in the time lag, hence in delay, when using both normal and "liquid-weak" mixtures. A spark advance of 40° before TDC resulted in a decreased delay with "liquid-weak" mixtures compared to normal mixtures. So the important mixture strength in low temperature starting is the air-vapour ratio; rather than the air-fuel ratio, since if the free liquid was important the delay would be expected to increase with "liquid-weak" mixtures. It even appears that to a certain extent the free liquid is a hindrance during the delay period. However, "liquid-weak" mixtures with fuel C did not produce a start at —26°F, while normal mixtures with this fuel started below this temperature. Some of the free liquid in normal mixtures is vaporized during compression, thus decreasing the air-vapour ratio at the time of the spark. So, it appears that too little fuel was available for vaporization during the compression of "liquid-weak" mixtures to produce a start at the lower temperatures.

Effect of Fuel Volatility: Fig. 7 gives the results obtained using fuels C, D and E with a compression ratio of 5.5 and a spark advance of 5° before TDC. Fuel B has been omitted from the Figure due to the inconsistency of its results. On the premise that the delay-ambient temperature diagram has the same shape as those in Fig. 7(a), there is an ambient temperature at which the delay is a minimum. The value of this temperature varies, depending upon the fuel volatility; as the volatility increases, minimum delay occurs at a lower temperature.

The Delay Period: The shape of the time lag-ambient temperature diagrams suggests that there is a characteristic delay curve for all gasolines, as shown in Fig. 8(a). The results of

Fig. 7. Effect of Volatility.

Legend: O — Fuel C.
+ — Fuel D.
× — Fuel E.

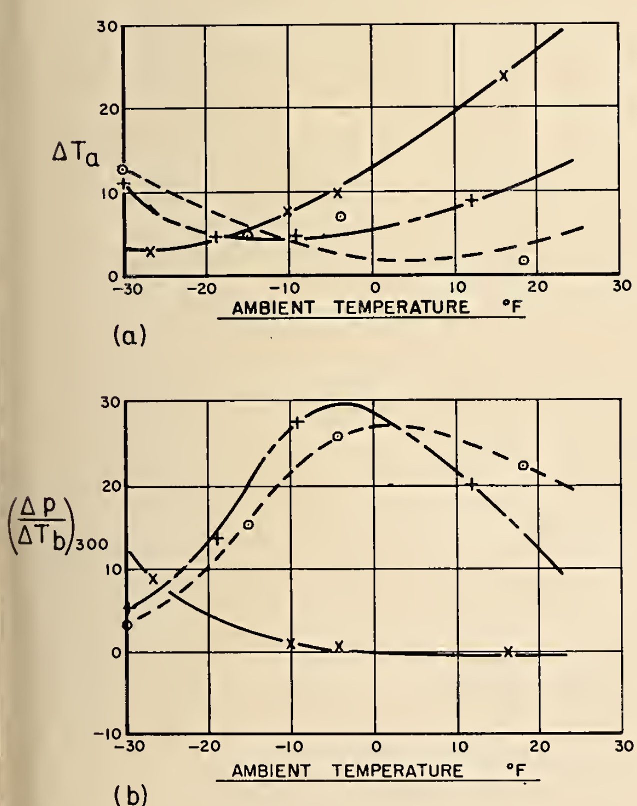
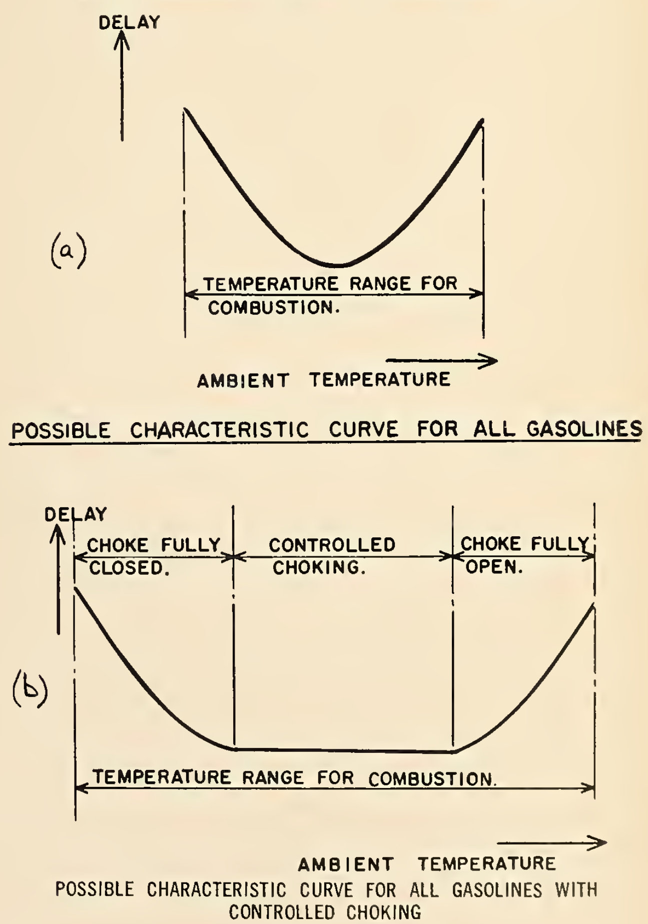


Fig. 8. Characteristic Delay — Temperature Curves.



the entire investigation also suggest that this characteristic curve moves to the left or right, depending on the fuel volatility. They also indicate that the delay scale is not necessarily the same for all fuels, that is, different fuels may also move the curve up or down; although variations in the time lag with different fuels may be partly due to variations in the time taken by the immeasurably small pressure rise at the start of actual combustion. However, it will be seen later that the delay and this time are connected.

The curve of Fig. 8(a) shows that there is a temperature range outside which the delay is so great that the fuel will not produce a start. This range is indicated in Fig. 8(a); in this case the term combustion is applied specifically to engines, the fuel would undoubtedly oxidize at temperatures outside the range if sufficient time was available. This temperature range explains why fuels A and F did not produce a start and why fuel B only started at the higher temperatures in the test range. Thus, fuel A would start in some range having the minimum above 30°F, while fuel F would produce starts in a range having its maximum value below —30°F.

As tests were made with the choke fully closed, it should be possible to extend the temperature range for combustion by judicious control of the choke (agreeing with standard practice), as shown in Fig. 8(b). With increasing ambient temperature and a fuel of given volatility, the lower temperature at which a start occurs is reached with the choke fully closed — this temperature will be the same in Figs. 8(a) and (b). The delay then decreases to a minimum with the choke fully closed, as in the investigation. It should now be possible to maintain the delay at its minimum value by a controlled opening of the choke. Then when the choke is fully open, the delay increases until it is too great for combustion to occur. This suggests that the maximum temperature of the range for fuel F is much lower than —30°F, because in fact this fuel failed to start with varying degrees of choking.

The shape of the characteristic curve of Fig. 8(a) offers an explanation for the delay period, described by Pye[13] as an incubation period in which the fuel is preparing to burn. At constant ambient pressure, the air density is inversely proportional to the ambient temperature; so the density increases as the temperature decreases. Hence, the number of oxygen molecules entering the cylinder increases as the temperature decreases. It has already been found

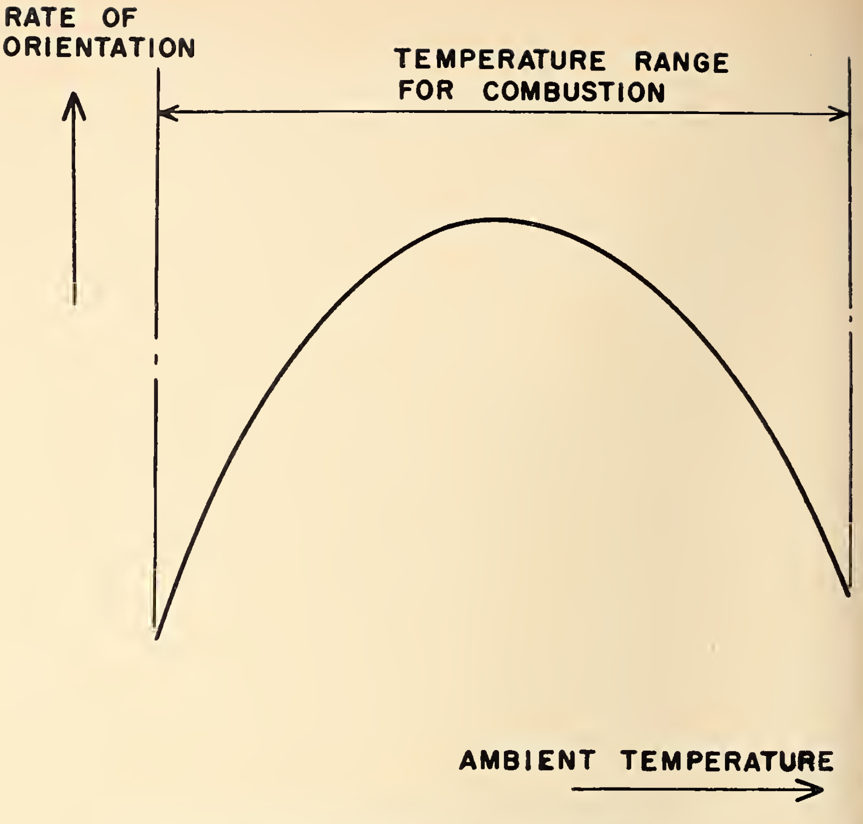


Fig. 9. Characteristic Orientation Rate — Temperature Curve.

that the quantity of fuel vapour at the time of the spark is important in the delay period. Measurements during the "liquid-weak" mixture strength tests showed that the quantity of vapour entering the cylinder decreased with ambient temperature; so the number of suitable fuel molecules decreases with ambient temperature at a constant spark advance.

Suppose that during the delay period, the suitable fuel and oxygen molecules take up some orientation necessary for combustion, and that combustion cannot start until a certain number of molecules are correctly orientated. At the higher temperatures in the combustion range, it becomes easier for the orientation to take place because the number of oxygen molecules increases. However, the number of suitable fuel molecules decreases with ambient temperature, so at the lower temperatures in the combustion range it becomes more difficult for the fuel and oxygen molecules to take up the correct orientation. Thus at some intermediate temperature the rate of orientation reaches a maximum, resulting in minimum delay. An examination of combustion theories shows that this orientation process agrees with both the hydroxylation and the more popular chain-reaction theories for the combustion of hydrocarbons.

The above orientation theory results in the characteristic curve for the variation in the rate of orientation with ambient temperature as shown in Fig. 9. This curve depends upon fuel volatility in a similar manner to Fig. 8(a). Fig. 8(b) implies that the maximum rate of orientation can be maintained over a range of ambient temperatures by suitable control of the choke, that is, by maintaining the correct proportion of oxygen and suitable fuel molecules for the maximum rate of orientation.

Effect of Ignition Timing: The results obtained for fuel C with a compression ratio of 5.5 are shown in Fig. 10. The curves of Fig. 10(a) show that with constant fuel volatility, ambient temperature and compression ratio, the delay period decreases with spark advance. This result agrees with the above orientation theory, since if the spark occurs late in the stroke, the temperature of the cylinder contents is higher than if it occurred earlier. According to the kinetic theory, temperature is a measure of the activity of the molecules; so when the spark occurs at a higher mixture temperature, the molecules of oxygen and suitable fuel are more active. They, therefore, take up the correct orientation more rapidly, thus reducing the delay.

Considering "liquid-weak" mixtures, the increase in temperature at any given crank angle due to compression would be greater than with normal mixtures, because less fuel was available for evaporation during compression. This increased mixture temperature had a distinct effect on the delay with a spark advance of 40° before TDC, but no apparent effect when the spark occurred at 5° before TDC—see Fig. 6(a). The latter result was probably obtained because it was only possible to measure times to the nearest millisecond. As the delay associated with a spark advance of 5° before TDC was small, any decrease in it may have been too small to be observed.

The Mean Rate of Pressure Rise during Combustion: The experimental technique used in the investigation only allowed the detection of the orientation process during the period before combustion caused a visible rise in pressure. The suggested orientation process is, however, synonymous with the hydroxylation and chain-reaction theories. Both these theories basically state that the combustion process is not an instantaneous oxidation of a hydrocarbon into the products of combustion, but consists of a series of reactions resulting in intermediate compounds. So, according to these theories, the orientation detected immediately after the spark continued throughout the whole combustion process. This would result in curves of a similar shape to that shown in Fig. 9 when considering the effect of ambient temperature on the mean rate of pressure rise during combustion. The results of the investigation agree with this proposition, see Figs. 6(b), 7(b) and 10(b).

Fig. 6(b) indicates that with a spark advance of 5° before TDC the rate of pressure rise during combustion is less with "liquid-weak" mixtures than with normal mixtures over the majority of the temperature range considered. Bearing in mind that the rate of orientation is approximately the same with both mixtures during the delay period, this result is quite reasonable, since with a smaller quantity of fuel available the maximum pressure is reduced. Referring again to Fig. 6(b), the rate of pressure rise during combustion with a spark advance of 40° before TDC and "liquid-weak" mixtures is greater than with normal mixtures at the lower temperatures, but this is reversed at higher temperatures. At the lower temperatures, it appears that the increased orientation rate with "liquid-weak" mixtures is the predominant factor, but, as the ambient temperature rises, the quantity of fuel available for combustion has a greater effect, so that the normal mixtures produce a larger pressure rise.

The values obtained for the mean rate of pressure rise included variations in pressure due to the piston motion as well as those caused by combustion. Using the results of the investigation, it was not possible to investigate these effects separately. This resulted in some tests having very low rates of pressure rise; for, if the orientation rate was low, the combustion continued into the expansion stroke in which the piston motion alone causes a decrease in pressure. So, although the rate of pressure rise due to combustion was low, it was exaggerated by the outward motion of the piston.

In general, a small spark advance produced a more rapid rate of pressure rise than a large advance. Cases in which this trend was reversed may also be attributed to the motion of the piston; for the increasing tempera-

Fig. 10. Effect of Ignition Timing.

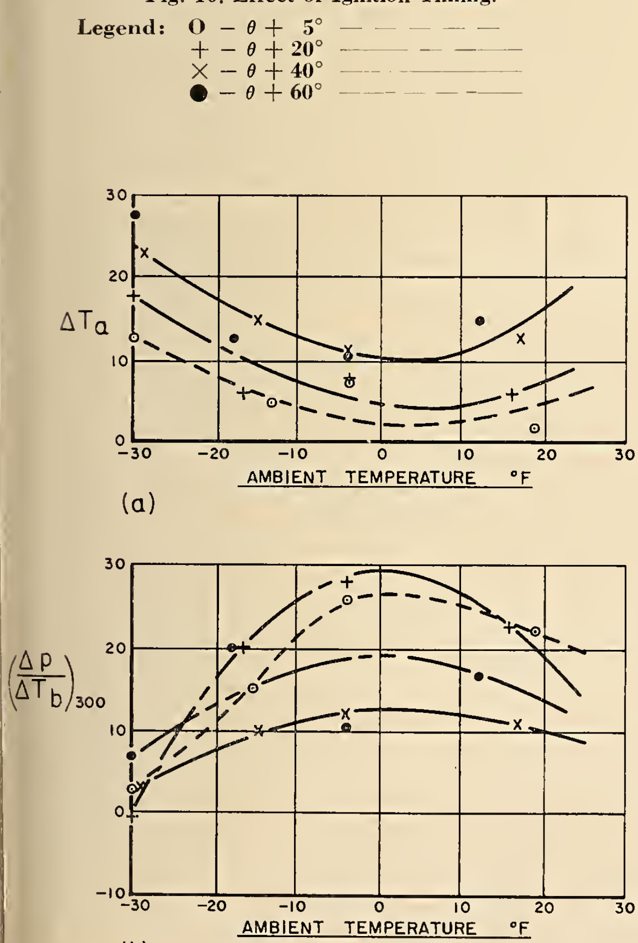
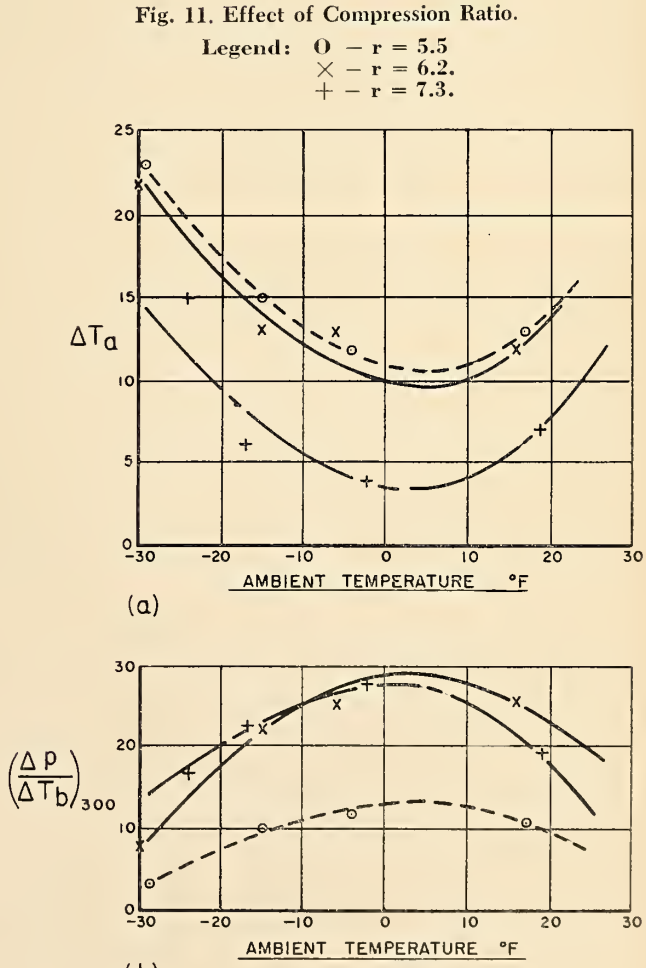


Fig. 11. Effect of Compression Ratio.



ture due to compression may well cause the orientation rate to increase rapidly. Consequently, the combustion rate increases rapidly, increasing the rate of pressure rise, and in some cases the pressure becomes so great as to reverse the piston motion.

In investigating autoignition associated with hot starting, Bowditch and Stebar[14] obtained flame photographs of the combustion which showed that in some cases combustion was initiated at isolated points throughout the mixture, apparently by compression ignition. This would be expected from the above theory; since if the orientation forms the necessary intermediate compounds at a rapidly increasing rate, they might well become concentrated at isolated points in the mixture and then burn from those points. A comparison of the indicator diagrams taken in the two investigations are identical in the region of increasing pressure during combustion. In the other work, the engine was cranked by a dynamometer through a reduction gear and the rapid increase in pressure did not apparently reverse the piston motion, as it did in the investigation described in this paper.

The scale shown for the mean rate of pressure rise during combustion in Fig. 7(b) may only be correct for fuel C, since the corrections used to convert the results to a cranking speed of 300 r.p.m. were obtained with this fuel. The curves shown for fuels D and E, however, do indicate the trend, provided the pressure rise during combustion and its duration have linear relationships with cranking speed in the range encountered in the starting tests. This would seem to be a reasonable assumption, since the turbulence at any given cranking speed is independent of the fuel. Also, the trends indicated agree with the general pattern suggested by combustion theories.

The Immeasurable Pressure Rise: It was assumed in the discussion concerning the time lag that the time taken by the immeasurably small pressure rise at the start of combustion was constant. It was later stated that the orientation process detected during the time lag continued at a somewhat similar rate throughout the subsequent combustion. Hence the time taken by the immeasurably small pressure rise is not constant, but depends on the rate of orientation. So, the delay-ambient temperature curve does not have exactly the same shape as the time lag curve, as was assumed initially, and will tend to show less deviation from the minimum value than was apparent from the earlier assumption.

Effect of Compression Ratio: Increasing the compression ratio increases the mixture temperature at any given crank angle; so it might be expected that the rate of orientation should increase with compression ratio. Thereby decreasing the delay and the rate of pressure rise during combustion. This is true in general, as indicated in Fig. 11, but a change in compression ratio may also move the characteristic curves to the left or right, in the same way as changes in fuel volatility, in an apparently haphazard manner. This might occur if the evaporation curves shown in Fig. 1 were stepped rather than smooth curves, then more or less fuel vapour may be available for orientation depending on the mixture temperature. This is the only case in which the results of the investigation suggested that fuel volatility might be better indicated by the E.A.D. method.

Comparison with Previous Work: The results discussed above do not entirely agree with the results of previous investigations. It must be remembered, however, that they were made about 20 to 30 years ago, with the majority falling into the latter category. The majority of the gasolines used were manufactured commercially; it appears that any specially blended fuels were made less volatile than those available commercially. At the time of the investigations, the oil companies supplied the same fuel throughout the year, rather than the current practice, so the initial boiling points were higher than those used in the present work. It is understandable then that the earlier workers should only detect a limiting lower volatility, since it was virtually impossible for them to test fuels with volatilities even approaching the upper limit. If the present work had used fuels A and B with others of which fuel C was the most volatile, the results obtained indicate that the trends would be identical to those previously observed.

Conclusions

The combustion of gasoline during engine starting has been studied at ambient temperatures in the range 32°F to —30°F. The following conclusions are drawn:

1. The winter gasolines available commercially are suitable for the temperature range considered;

2. (a) At low ambient temperatures the carburetor supplies a mixture of atmospheric air, gasoline vapour and liquid gasoline during starting.

(b) The air-vapour ratio at the time of the spark is the important mixture strength in low temperature starting, but the combustion of the gasoline is not necessarily improved by the use of a highly volatile fuel;

3. (a) The delay period is the result of a chemical orientation process in which molecules of oxygen and fuel, in the form of vapour, react to form intermediate compounds.

(b) With the choke fully closed, there is a unique ambient temperature, depending on fuel volatility, at which the orientation rate is maximum, resulting in minimum delay;

4. (a) Gasolines have a definite range of ambient temperatures, outside which a start will not occur.

(b) The "limits of inflammability" are the air-vapour ratios at which the rate of orientation has its minimum value for the combustion to serve any useful purpose in the engine cylinder;

5. (a) The chemical orientation continues throughout the complete combustion process and the rate at which the combustion proceeds is governed by the rate of orientation.

(b) Starting with a large spark advance can cause the rate of orientation to increase rapidly during combustion, with the result that combustion occurs in the same manner as during detonation;

6. The results suggest that it is possible to maintain the maximum rate of orientation over a distinct range of ambient temperature by controlled choking.

Acknowledgement

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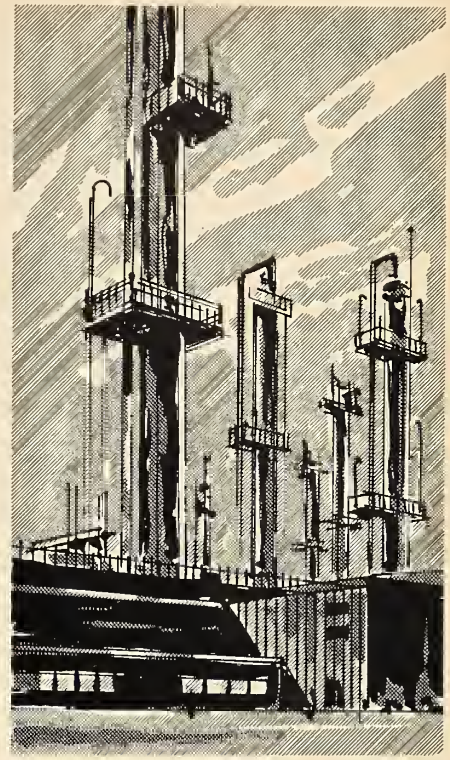


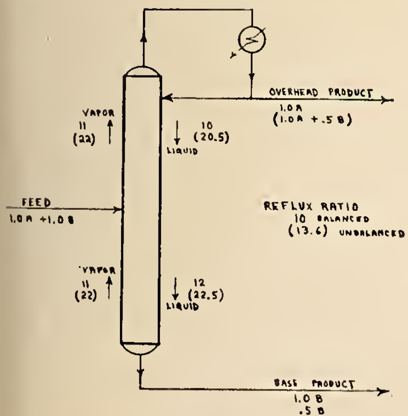
G. A. McNeill,
**Canadian Chemical Company*
Edmonton, Alberta.

Non-linear Control for Distillation Columns

A BALANCED distillation column has inherent non-linearity in its operation. This can be used to effect a simple optimizing controller which will optimize the separation. Only standard control hardware is required which makes for simplicity and reliability.

The method was specifically developed for use with a chromatograph analyzer but could also be adapted to conventional temperature measurement or other type of analyzers.

Fig. 1. Balanced vs unbalanced operation



Concept of Balance

Before discussing the optimizing control which has been developed it is necessary to outline the concept and problems of "Balanced Distillation Control". The term "Balanced" is defined as the unique division of the feed between the overhead and base which gives the maximum purity to both streams. This is the balanced condition and since the overhead product is taken up as a vapor, and the base product down as a liquid, this material balance is intimately connected with the heat balance. If this balance is not exact, overhead product will be forced out the base or base product forced out overhead.

Unbalance is not an abnormal case. Actually, all distillation columns are continuously in some state of unbalance, with the degree of unbalance being a measure of the success with which they are controlled. It must be recognized that unbalance and its effect on product composition is quite independent of the number of trays or the efficiency.

Fig. 1 illustrates that balance is quite independent of reflux ratio, boilup ratio or number of trays in the column. The upper numbers indicate a balanced condition and the lower figures in parenthesis indicate an improved reflux ratio but a reduced purity overhead due to unbalance (overstripping).

The balance concept applies to all columns and while balance may not have been considered in the design of the system it nevertheless functions and effects the controllability. There are several reasons why we have been able to apply distillation controls successfully with little knowledge of balance:

1. Any temperature control has at least some response to tower balance.

2. Most columns operate nearly steady state since efforts are made to stabilize the feed, the pressure, the steam ratio, etc.

3. Many systems have a recycle stream and can be operated unbalanced, i.e. with continuous overstripping or understripping. This allows one stream to be kept pure while the other one takes all upsets and variations to the balance.

It is only recently that several people have investigated the concept of balance, and while there can be no doubt as to its validity very little data has

**Now with*
Monsanto Chemical Company
San Francisco, California.

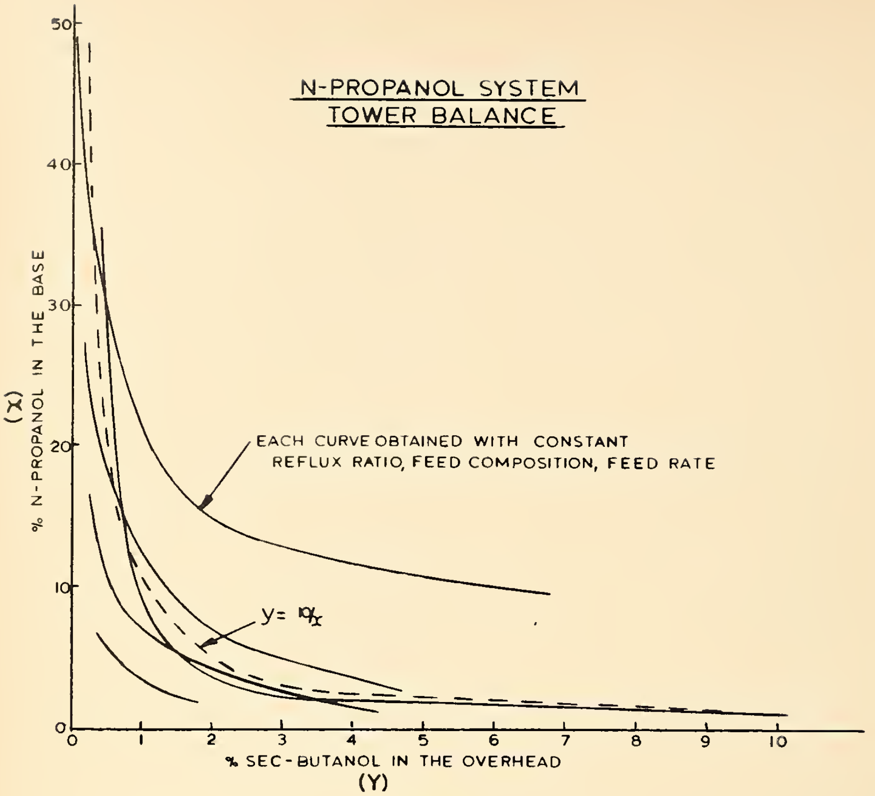


Fig. 2.

been presented and the theory has not yet been fully developed. With the assistance of a modern Process Chromatograph we have obtained considerable dynamic data from an operating process which has allowed us to develop the concept of balance somewhat further.

Operating Data

Fig. 2 was obtained by using an automatic process chromatograph continuously monitoring both the overhead and base of an operating distillation column. The separation is not a simple binary but the stripping of light component from a variable mixture of heavy boilers. The process and compositions are shown in Fig. 3. Since only 1.7°C exists between the key components, temperature control of this tower is impossible and the tower was normally controlled on material balance using lab analysis every 24 hrs. This resulted in large deviations from balanced operation and presented us with a wide range of data. Each curve represents a different condition of feed rate or composition. All changes were relatively slow so that most of the data is representative of steady state operation.

Enlargement of the Balance Theory

First consideration of the balance theory would lead us to expect composition curves approximating right angles with little change of base purity when overstripping, and little change of overhead purity when understripping. The curves in Fig. 2 not only round out in the corner but also have some slope to the sides. This means that the effective trays for the overhead or base separation can vary. The explanation is relatively simple. If the tower is balanced the composition at the feed tray is approximately the same as that of the feed stream and the effective trays are the exact number above and below the feed tray. If the tower is overstripped however the composition profile shifts upward and the tray with feed composition is considerably above the feed point which effectively gives more trays for the base separation and less for the overhead. This is possible since the feed rate is only a fraction of the liquid or vapor rate in the tower and the composition at the feed tray can be appreciably different from the feed composition.

It is useful to consider the extreme case in which the feed is reduced to zero and the tower operates on total reflux. All trays can act as though they were above or below the feed tray since feed composition could be obtained anywhere in the column depending on the balance.

Ridiculous as it may seem, this means that a 50/50 binary mixture could be fed to the top tray of a distillation column and yet a 98% product could be taken overhead. It only requires a large reflux ratio (25 : 1) and sufficient trays below the feed. This is readily visualized as a batch distillation with an occasional amount of feed added to the overhead and an occasional amount of overhead product withdrawn.

Control Problems

With further examination of Fig. 2 it is evident that there are two basic control problems. One is that since the curves approximate a right-angle, measurement of the overhead product purity is relatively insensitive to understripping, and measurement of the base product purity is relatively insensitive to overstripping. This would suggest that for good control some measurement of both the overhead and base purity should be made, particularly if the tower is operated close to the balance point. The larger the reflux ratio the more critical this will be. Since the balance point is not well defined the best criterion of the balance point is when the composition at the feed tray is the same as the composition of the feed. For multicomponent mixtures this may not be possible and it is suggested that for a balance criterion, the vapor pressure of the feed tray should be the same as the vapor pressure of the feed. This balance point may not be the same as the optimum point as will be shown later.

The second control problem evident in Fig. 2 is that a fairly large family of curves was obtained, with obvious shifts of the optimum control point. To follow these optimum corners it is apparent that neither fixed base purity nor fixed overhead purity is a suitable method of control. Refer also to Fig. 4.

Optimum Control

Some consideration must now be given to the exact determination of these corners or optimum control points. Consider the case where any purity is acceptable product, but a loss value can be placed on both the overhead and base impurity. A set of simplified composition curves is shown in Fig. 4 to illustrate the case. It is apparent that the sharp corners are the optimum points regardless of the value of the losses. The Fig. 2 curves are not as simple however. In fact, they suggest that an optimizing computer might be necessary. An optimizing computer can make exploratory steps and seek the optimum operation. However, the expense of an optimizing computer will not likely be justified for most distillation columns and we have therefore attempted to develop something similar but necessarily simpler.

The Fig. 2 curves suggest that the optimum points lie fairly close to a constant ratio line. The simplified Fig. 4 also suggests this. Such a line must go through 0,0 and have a slope making a best fit line to the optimum points.

In Fig. 2 the optimums are not readily discernible, and since there may be some doubt if an optimum even exists, a mathematical check is appropriate.

The curves are fairly well approximated by a reciprocal expression.

$y = A/x$ where y = % losses in the overhead
x = % losses in the base
A = a constant

The reciprocal curve with $A = 10$ has been dotted in on Fig. 2 and is very similar to the actual process curves.

Let L = total dollar loss

B = value of loss x (in Dollars per year per %)
C = value of loss y (in Dollars per year per %)

Then $L = Bx + Cy$
$= Bx + CA/x$

For minimum losses $dL/dx = 0$

$$B - (CA/x^2) = 0$$
$$x = \sqrt{CA/B}$$

Which is the point at which the value of the overhead and base loss is equal i.e. if $Bx = Cy$, $Bx = CA/x$,

and $$x = \sqrt{\frac{CA}{B}}$$

This is of particular interest since it means that the optimum balance of a column will shift directly with product value changes and the criterion is very simple. Adjust the balance to equalize the overhead and base dollar losses. Note that flow rates are taken into account in terms B and C.

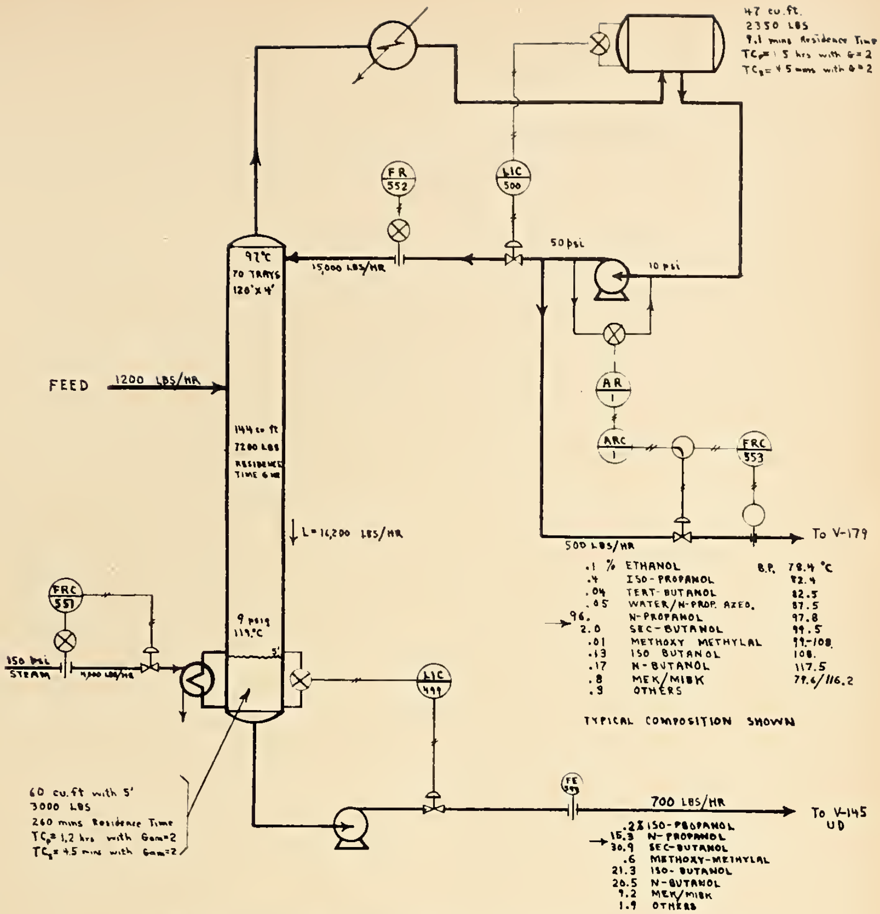


Fig. 3. Chromatograph control for the N-Propanol tower

Control Hardware

As was illustrated above, optimum control can be achieved by holding the ratio of overhead losses to base losses constant. Because of the inverse relationship between x and y we can hold a constant ratio by subtracting Bx from Cy and forcing the error to go to zero. This can be accomplished by feeding By to the set point of a conventional controller and Cy to the normal process variable input (Pv.). The output is then used to balance the tower.

This results in:

$$\text{Output} = K(Cy - Bx) + \text{Reset} + \text{Derivative}$$

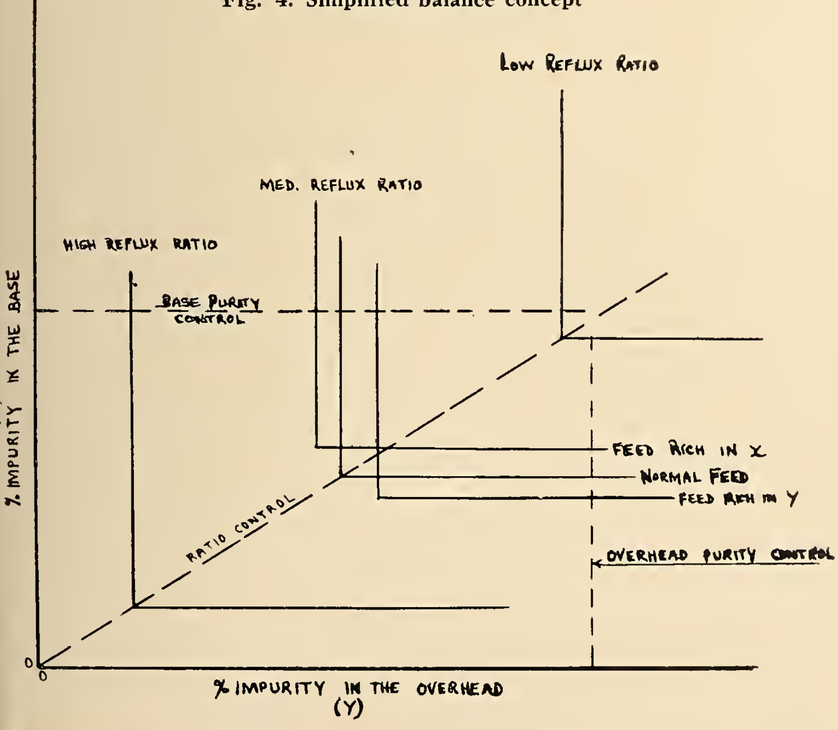
K is the gain of the controller and C and B can be introduced in the attenuator of the analyzer. Fig. 5 illustrates this system and its relation to the process.

This control system has several advantages: the requirement of measuring both overhead and base is satisfied. Additional time delay is not introduced since both measurements are used for control. It may well be that time delays are reduced since either the overhead or base composition may give an earlier response to a disturbance depending on where it originated. Set point adjustments are unnecessary and impossible since no manual set point exists. The ratio can be adjusted by the attenuators but the requirement should be very seldom. A two-pen recorder is used and low coincident records provide simple visual indication that good separation is being obtained.

Control Evaluations

The control system outlined has not been evaluated to date since the economics on the process outlined has changed. It was no longer desirable to make the best separation but rather to hold the N-Propanol specification at

Fig. 4. Simplified balance concept



96%. Only this purity was required and increasing it was uneconomical. In addition, control evaluations on this process are very difficult. Operating conditions are continually changing and to obtain any reliability it is necessary to alternate the proposals at least four times, with each one held for a week. The control system which was finally installed, uses overhead measurement of the impurity (sec-Butanol) to directly control the base draw-off rate. This permitted holding the overhead composition at a constant value equal to the previous erratic average, with the base losses reduced from 18% to 12%, a reduction of 33%. The reasons for this lie in the non-linear characteristics shown in Fig. 2. The results of the control improvement are shown in Fig. 6.

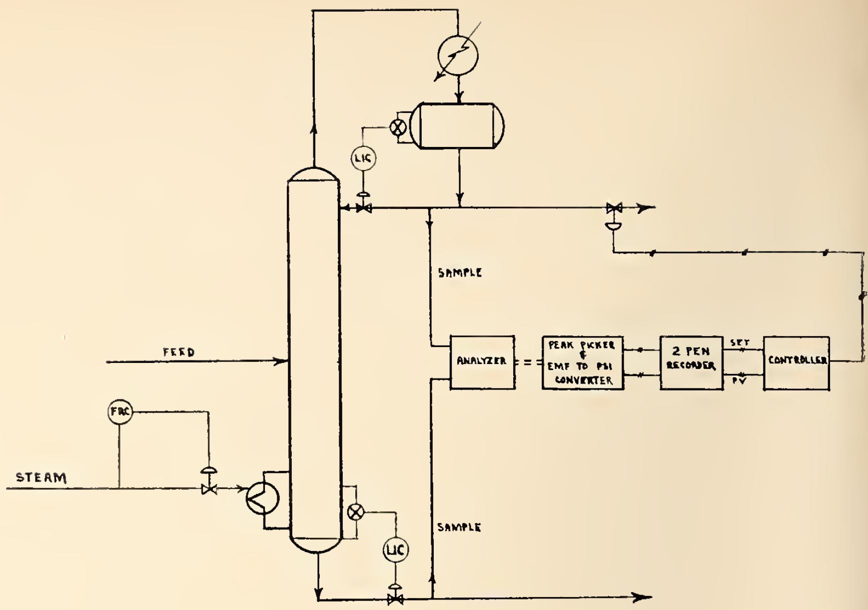
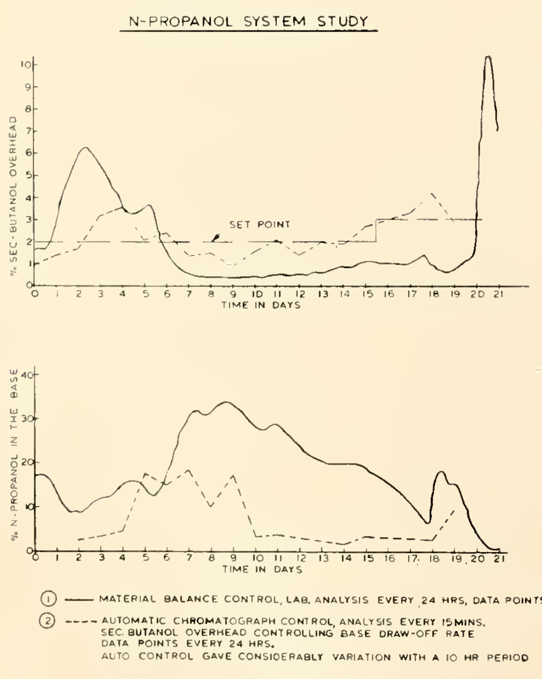


Fig. 5. Optimizing ratio control

Some aspects of the control stability were investigated. An open loop response was taken which indicated a rate response (i.e. T) of 120 mins. and a lag (L) of 80 mins. This was obtained by decreasing the base draw-off rate and observing the overhead purity. There are still some complications to these results however since the observed response only accounted for 40% of the calculated change in overhead composition. We suspect that this is the initial response due to the change of L/V ratio and that the remaining response is in the order of 10 hours and is the time required for the base product to accumulate and make a major change of the towers composition profile. In any event a lag of 80 mins. or more will require a controller with a reset rate of approximately 0.006 repeats/mins. and a derivative setting of 40 mins. Such a slow response is difficult to achieve and not commercially available. It is therefore desirable to use a high gain setting to eliminate offset. It was found that direct control on either reflux or steam was extremely poor if not impossible. A gain setting of less than 0.05 was used and the process was still slightly unstable. The low gain requirement is apparent since a change of 1% in reflux rate with a 40 : 1 initial reflux ratio will change the reflux ratio to 28 : 1 and will force the impurity in the base or overhead from 0 to 28%. In addition, a change of steam rate will affect the overhead vapor rate before the overhead composition, therefore the correction is much better with the reflux on tight level control and with overhead composition controlling product draw-off rate. When this was tried a gain setting of 2.5 was possible and good control was obtained. Standard temperature control of distillation columns gives less trouble with stability since the transmitter is usually located between the feed and product and the response time of the loop is very much shorter. It is also probable that some degree of internal negative feedback exists because of the pressure temperature complex. For example, if the steam rate is increased a rise in base pressure and subsequently temperature will precede the composition change thus giving negative feed back for rapid changes.

Fig. 6.



Summary

The results of this system study have greatly increased our knowledge of distillation control, and the balance concept. The study has been complicated by having a multicomponent mixture with considerable fluctuation but then this is the type of system that has justification for improved control. We hope to evaluate the optimizing control which was developed on the next balanced distillation column study but perhaps some of our readers will have an earlier opportunity.

In conclusion we wish to leave the suggestion that in distillation columns with large reflux ratios it should be possible to attain good control by controlling the composition or temperature in the tower at the vicinity of the feed tray.

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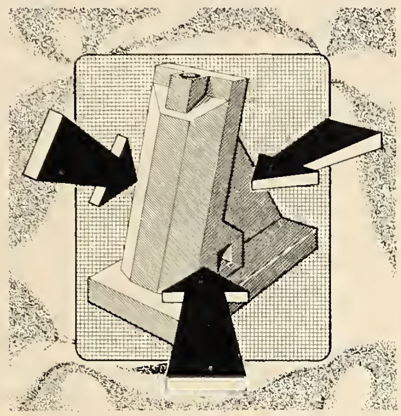
THREE-DIMENSIONAL PHOTOELASTIC ANALYSIS OF A



DIAMOND-HEAD BUTTRESS DAM

C. R. Jones,
Crippen Wright Engineering Ltd., Vancouver.

J. B. Mantle, M.E.I.C.,
Head, Department of Mechanical Engineering, University of Saskatchewan, Saskatoon, Sask.

THE PHOTOELASTIC stress analysis described in this paper was carried out in connection with part of the design of the dam for the Squaw Rapids Power Development on the Saskatchewan River.[1] The dam is being built for the Saskatchewan Power Corporation.

The main portion of the dam will be of the earthfill type with dikes extending out from it. The latter are necessary because of the flat nature of the valley. In order to form a transition between the concrete spillway and the earthfill it was decided to use the diamond-head buttress type of dam. Three buttresses, each an independent unit, are to be constructed on each side of the spillway. Each buttress will be roughly triangular in section and approximately 100 ft. high, 50 ft. wide and 100 ft. long. The two buttresses adjacent to the spillway will each contain a circular stairwell and two horizontal galleries (Fig. 1).

Actual structure design loads considered to be acting on the diamond-head buttress were those due to water alone, earth fill alone and combinations of both, there being a linear increase with depth in all cases. The fill loads were taken as earth pressures at rest and were applied on the basis of an equivalent fluid of density depending upon the inclination of the loaded surface and the degree of saturation of the fill. The upstream faces were subjected to water pressure (62.5 lb. per cu. ft.) from high water level at elevation 1041 ft. down to elevation 1000 ft. (Fig. 1). From that point down to the base of the dam at elevation 950 ft. there was a combination of water and earth fill at an equivalent fluid density of 118.5 lb. per cu. ft. The downstream faces from elevation 987 ft. down to the base were subjected to earth loading considered to be produced by a fluid of density 50 lb. per cu. ft. except for the vertical face near the drainage gallery which was taken at 52 lb. per cu. ft. On the toe of the web earth loading started at 982 ft. and was considered to have an equivalent density of 136 lb. per cu. ft. The vertical sides of the web in the actual structure would also be subjected to some earth loading but no attempt was made to duplicate this in the model.

The complex nature of this structure and also of the loading made calculation of the stresses extremely difficult. Therefore, the three-dimensional photoelastic *frozen-stress* technique was adopted to obtain an indication of the stresses that might be expected in the buttresses; especially those in the regions of the stairwell and galleries.

The frozen-stress phenomenon depends upon the diphasic properties of some plastics when heated to their critical temperatures. At its critical temperature this type of plastic, under load, will show fringe patterns when viewed in a polariscope. The pattern, from which the stress distribution can be calculated, will remain after subsequent controlled cooling and removal of the load. This "freezing" of the fringe pattern makes it possible to slice the model and analyse the slices by normal two-dimensional photoelastic methods.

The frozen-stress method of analyzing a buttress dam has been used by both Hendry[2] and Rydzewski.[3] The latter's investigation was limited to the buttress web; whereas, Hendry's analysis included the complete dam. However, the dimensions and loading conditions of these dams were quite different from those of the dam described in this paper and therefore only the general approach used by these investigators could be utilized.

Model and Loading Technique Adopted

Models: Several models had to be

constructed in order to obtain all the necessary slices. The base, the web and the diamond-head of each model were machined separately. These components were cut from a 2 in. slab of commercially available photoelastic material known as Hysol 6000 OP. So that machining stresses would be eliminated very light cuts, in the order of a few thousandths of an inch, were taken off successively until the required dimensions were reached. Several of the smaller faces had to be hand-filed to their final angles. After machining and filing the three pieces were cemented together with a special Hysol adhesive. It has been shown previously[4] that little, if any, distortion of fringes occurs at these joints if care is taken to avoid formation of air bubbles when cementing the components. Of course, it was also important to take precautions to prevent the formation of time-edge stresses[5] at these joints prior to glueing.

The time-edge stresses mentioned above cause the photoelasticians a great amount of trouble. These stresses are thought to be caused by the absorption of moisture, as fringes appear at the boundaries of a photoelastic model left exposed to the air even for a relatively short period of time. Annealing does not usually remove these fringes. This time-edge fringe pattern will be superimposed on any fringe pattern produced by the model loading and will distort the latter pattern near the edges. The basic requirement for combatting this undesirable effect is to keep the length of time from initial machining to final analysis as short as possible.

The stress distributions around the stairwell and galleries were the ones with which this investigation was most concerned. Therefore, these holes were not cut until immediately before the stress-freezing cycle so as to lessen the time-edge effect. The stairwell could be drilled to its required size but the galleries had to be drilled and then hand-filed to their final dimensions.

Prior to actual model work deep holes were drilled in a Hysol test block with high speed twist drills turning at 180 r.p.m. and sharpened to 75°. Sharpening the drills from the normal 118° reduces the chances of chipping when the drill breaks through. The test block was then loaded in compression, stress-frozen and sliced normal to the axes of the holes. Examination of these slices in the polariscope indicated that there were negligible tool stresses left by the drilling operation.

Photoelastic materials have differing photoelastic constants from sheet to sheet so that each must be calibrated. The constant moment beam method was employed in this analysis. Two beams machined from the 2 in. Hysol were calibrated and an average value of 1.35 p.s.i per fringe per inch in tension or compression was obtained. An error in the calibration of the material fringe value would, of course, cause an error in the final results. Although there was a 10% difference in material fringe value calculated for the two calibration beams the average of these two was considered to be a reasonably accurate evaluation of the calibration figure. Furthermore, the average value checked very closely with that listed by the manufacturer.

The beams mentioned above were machined using brass templates and a high speed milling cutter. The beams with dimensions of about 3 x ½ x ¼ in. were loaded and stress-frozen with a known constant moment to give several fringes on either side of the neutral axis. As the loading and dimensions were known the fringe value could be easily calculated. The relationship between fringe count and stress is discussed more fully later.

Hysol 6000 OP has a critical temperature of about 270°F. To stress-

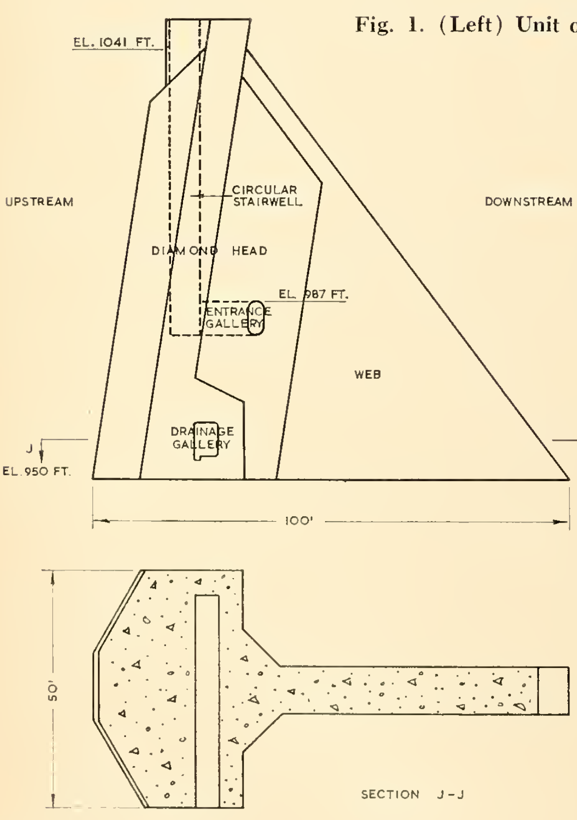
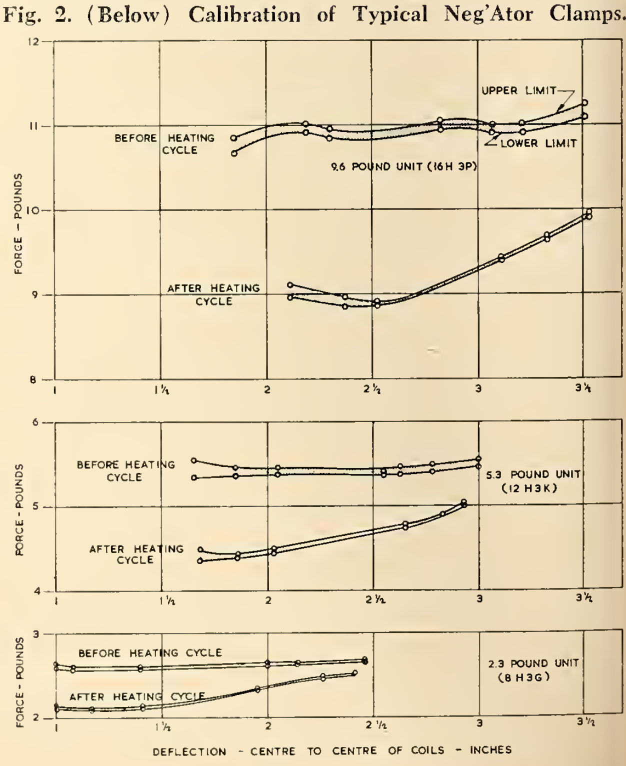


Fig. 1. (Left) Unit of Diamond-Head Buttress Dam.

Fig. 2. (Below) Calibration of Typical Neg'Ator Clamps.



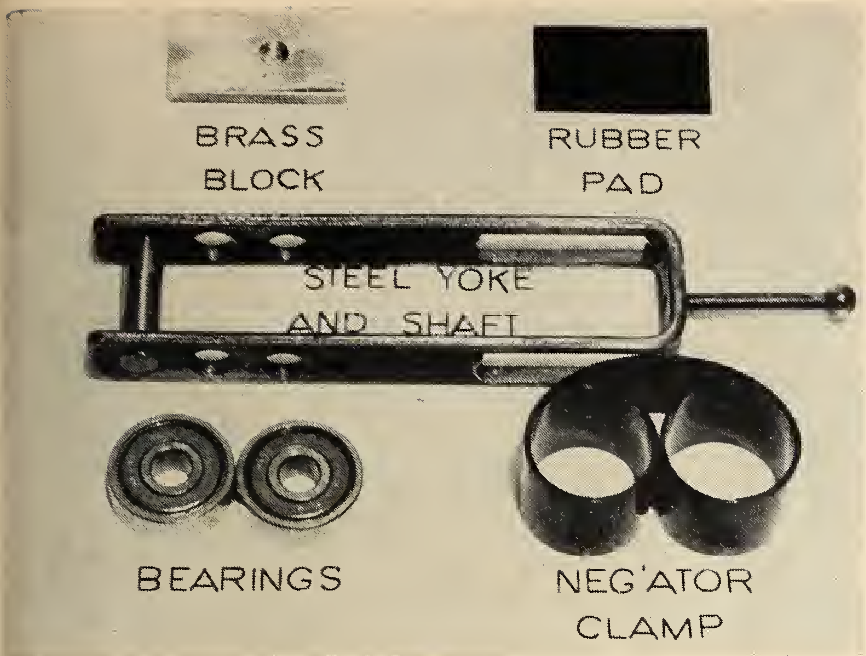


Fig. 3. Exploded View of Loading Device.

freeze the models they were heated to 270°F, under load, in an oven and maintained at this temperature for several hours to ensure that the models were thoroughly heated. They were then cooled to room temperature at an average rate of approximately 8°F per hour. The necessary slices were taken out of the model after removing it from the oven and loading rig.

Loading: Any method of applying load to a photoelastic model in the stress-freezing technique must be such that it does not change appreciably in magnitude as the associated model deformation takes place. In other words, the load must be able to follow the model. This, generally, precludes the use of screws or ordinary helically coiled springs.

Hendry[2] used banks of hydraulic rams to produce the equivalent hydrostatic model loads. This method was tried in this investigation but proved unsatisfactory as trouble was encountered with pistons sticking in the cylinders and correcting this fault caused excessive leakage of fluid from the cylinders. Rather than have uncertainties in loading a different approach was looked into.

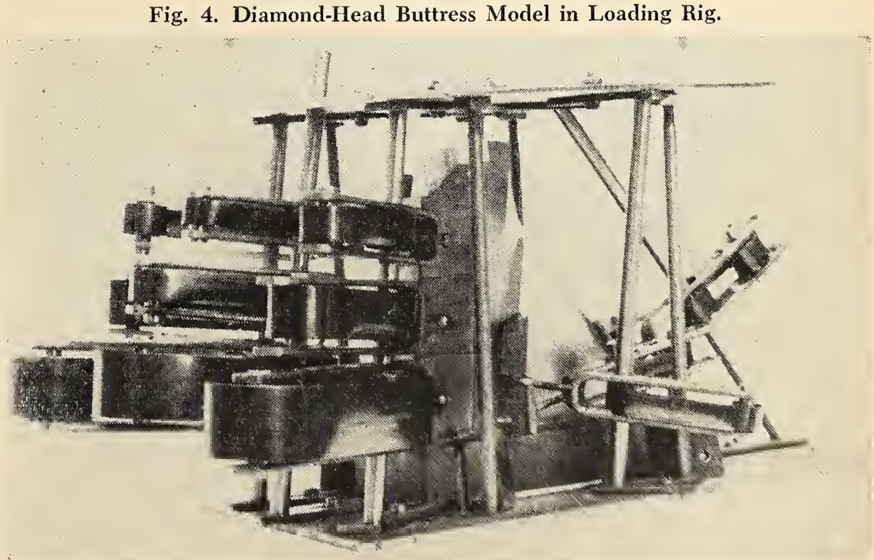
After a series of development steps the authors adapted special clamps to act as force application devices. These clamps were advertised as having constant force over a wide range of deflection but were essentially tension springs. By means of the slotted yoke arrangement shown in Fig. 3 and 4 they were made to act as compression springs. Friction effects were reduced to a negligible amount by placing bearings inside the coils of the clamps. Fortunately, these clamps were available in a variety of sizes in the range required for this loading. To bring the load to bear on the model rubber-brass pads were used. Triangular loading, rather than stepwise, was produced by applying the load slightly eccentrically on the pad through a ball and socket joint.

The clamps, although nominally of constant force, change with extension and differ considerably from one to the other. As a result each one had to be calibrated over the range of operation. Each clamp was calibrated at room temperature using a precision platform weigh scale. However, upon checking the clamps after the stress-freezing cycle it was found that their strength decreased between 10 and 20% as can be seen in Fig. 2. To eliminate this initial reduction each clamp was heated to about 300°F, slowly cooled and then recalibrated. After this heating cycle the strength of the clamps remained fairly constant. The difference between upper and lower limits shown in Fig. 2 represents the amount of friction present.

Fourteen clamps of various sizes were applied to the faces of the model by means of the loading rig shown in Fig. 4. The positions and extension of the clamps were chosen so as to simulate the complex loading of earth and water on the structure. The worst loading condition was assumed which was maximum water surface elevation and earth pressures at rest. Several faces near the top of the model could not be loaded because of their small area and angle of loading. However, as these surfaces were very close to the maximum water level the loads on them would have been comparatively small and would have had little effect on the results. Also, two small surfaces on the downstream side of the diamond-head above the lower gallery were not loaded. It was possible to check the effect of loading these surfaces by applying a compressive force to one of the stress-frozen slices while in the polariscope. The result was a local redistribution of stresses and a slight decrease in the tension stresses around the gallery.

A difficulty arises when analyzing a three-dimensional model of complicated shape and loading; namely, to estimate the magnitude of the load to apply so that enough fringes are produced to show stress concentrations without unduly distorting the model. After one unsuccessful attempt the authors found that a loading of about one-seventh of the actual

Fig. 4. Diamond-Head Buttress Model in Loading Rig.



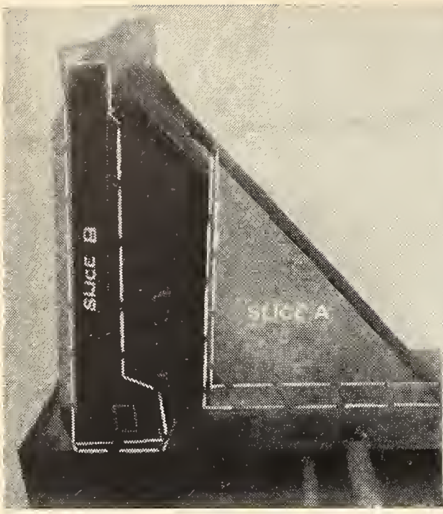


Fig. 5. Location of Slices A and B.

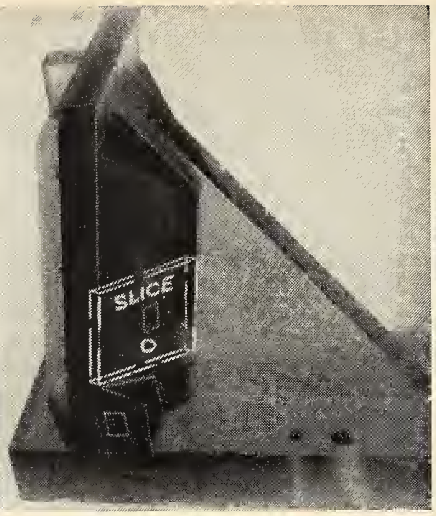


Fig. 6. Location of Slice O.

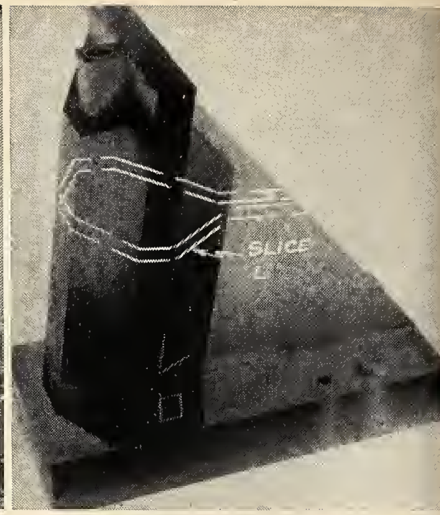


Fig. 7. Location of Slice L.

pressures on the structure produced negligible distortion and a reasonable fringe count. As the model distortion during the stress-freezing cycle was so small as to be unmeasurable no change of load due to reduced clamp extension occurred.

Time did not permit an investigation of gravitational forces to be carried out. However, these forces, as shown by Hendry, would have little effect on the horizontal stresses in the diamond-head and around the stairwell. Of course, this is not true for the vertical stresses. Nevertheless, any vertical stresses due to gravitational loading would tend to decrease the tension, resulting from water and earth pressures, in the areas of the galleries.

Slicing and Other Photoelastic Techniques

The positions of typical slices taken from the models after stress-freezing are shown in Fig. 5 to 7. Several vertical slices normal to the axis of the drainage gallery, the lower gallery, were taken out so that a distribution of stress along the length of the gallery could be determined. Slice B shown in Fig. 5 was one of these. Several slices were also taken through the entrance gallery, the upper gallery, for two shapes checked. One of these was oblong and the other rectangular. Slice O in Fig. 6 is a typical one containing the rectangular-shaped gallery. Slice L, Fig. 7, is one of several containing the stairwell from which a plot of the maximum tangential stress was made. To obtain the stress distribution in the web it was necessary to take out slice A as shown in Fig. 5.

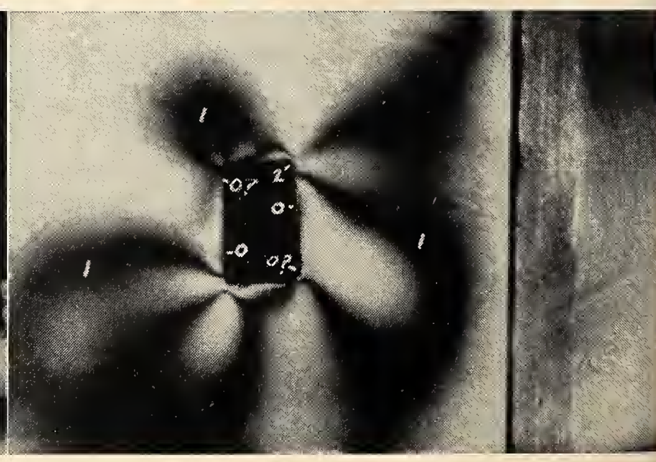
The slices were cut out by hand with a fine-toothed fretsaw, approximately 16 teeth per inch. A 1/16 in. thick metal jig, bent and slit, acted as a guide for the saw blade. After sawing out the slices, they were stuck to a lathe faceplate with double-sided masking tape and the faces cut parallel. Tool stresses were prevented by taking very light cuts. The variation in thickness over a slice could be kept to ±0.001 in. by using the lathe method. In addition, using the lathe rather than coarse emery paper to produce parallel sides reduced the bevel-edge effect usually encountered with the latter.

To remove the scratches left by the lathe each slice was ground on two grades of silicon carbide paper: No. 320A and No. 600A respectively. These were placed on pieces of plate glass and the slices then rubbed on the paper. No. 600A left a finish that could be polished transparent with ferric oxide (jewellers' rouge) and water. This final step was accomplished by using a revolving felt-covered disk.

Isochromatics, or fringes, which are the loci of equal differences in principal stresses and also of equal maximum shear stresses are shown in the photographs of Fig. 8, 9 and 10 for some typical slices. These photographs were taken through a circular polariscope using sheet film. They are all dark field photographs, taken with polarizer and analyser crossed,

Fig. 8. Isochromatics — Slice B.

Fig. 9. Isochromatics — Slice O.



and show the whole fringes. Half fringe values may be obtained with polarizer and analyser parallel.

The equation relating fringe order and structure stresses is:

$$p-q=\frac{nfc}{t}$$

where p, q = principal stresses = psi
n = fringe order
f = material fringe value = p.s.i./fringe/in. (tension or compression)
t = thickness of slice = in.
c = constant to convert model stress to structure stress.

At the boundaries the p and q stresses can be readily separated as one of these stresses is usually known. However, a method known as graphical integration had to be employed to separate the stresses in the web. The distribution of principal stresses shown in Fig. 13 is the result obtained by this method which is a graphical evaluation of Filon's transformations of the Lamé-Maxwell equations.[6] It was necessary to use this method rather than the relaxation method[7] for the web because of the fact that the principal stress distribution along one boundary only was known.

Plane polarized light is produced when the quarter-wave plates are removed from a standard polariscope. With plane polarized light dark areas appear over the isochromatics. These dark areas, called isoclinics, move as the polarizer and analyser are rotated simultaneously. The directions of the principal stresses at any point are parallel and perpendicular to the plane of polarization when the darkest portion of an isoclinic covers the point in question. These isoclinics were required to obtain the data shown in Fig. 13.

Some Test Results and Stress Analysis

Isochromatic patterns are shown in Figs. 8, 9 and 10 for representative slices.

Fig. 8 shows a dark field photograph of the isochromatics for a typical slice (B) in the area of the drainage gallery. The tangential stress distribution around the drainage gallery as calcuated from the isochromatics of another slice (H) is given in Fig. 11. This latter slice contained the highest tension stress found in this gallery and was located close to the centre of the model.

The tangential stress distribution for one of the two shapes of entrance gallery assumed appears in Fig. 12. The rectangular-shaped entrance gallery gave lower tension stresses than the oval-shaped one. This seemed odd but was no doubt caused by a redistribution of stresses.

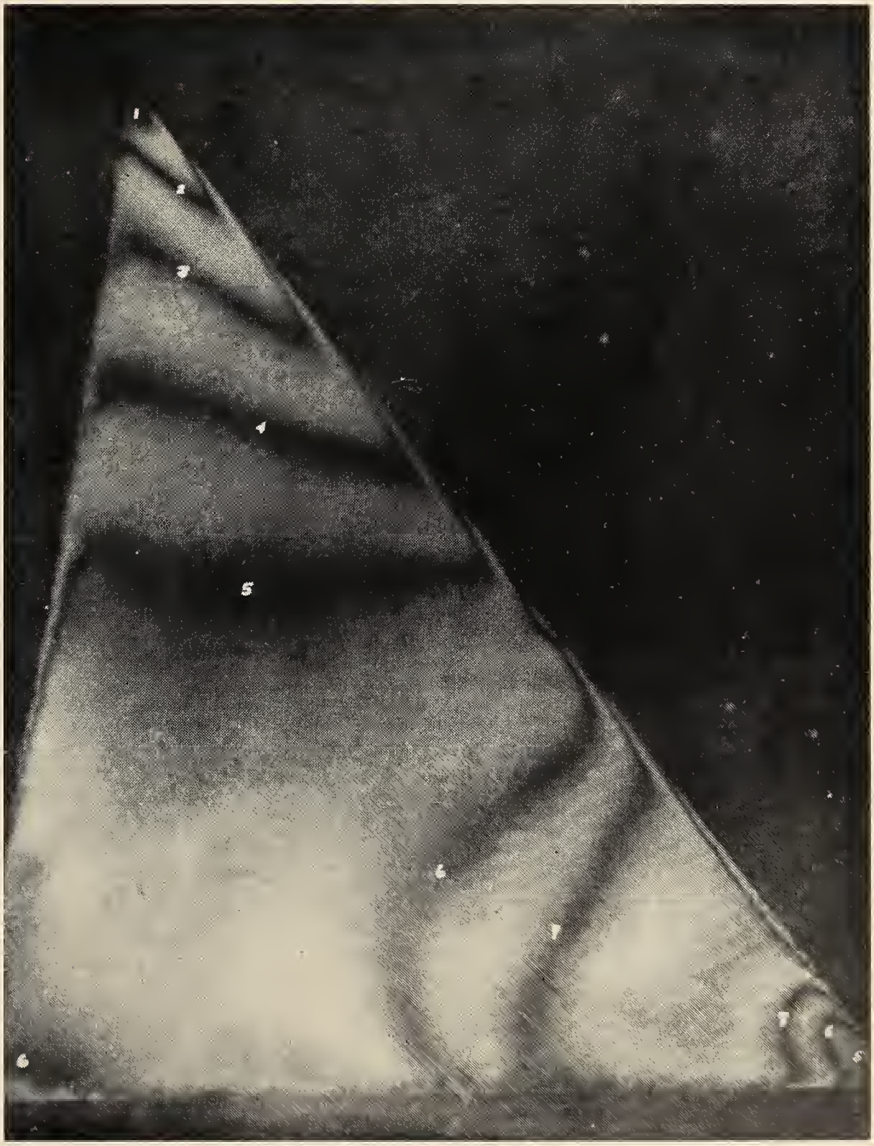
In some cases, particularly around the entrance gallery, tests indicated a change from compression to tension on the boundary when no zero fringe was evident at the point of change. These points are marked with an "0?" on the isochromatic photograph of Fig. 9. In these instances it must be assumed that the zero fringe does not follow a course through the slice normal to the surface and so does not show up as a dark area on the isochromatic pattern.

The web, for which Fig. 10 shows the isochromatic photograph, was combined with a vertical slice through the centre of the diamond-head so that the isoclinics could be traced and thus the stress trajectories drawn. These stress trajectories indicated the angle at which the diamond-head had to be sliced so that one of the principal stresses, in the vicinity of the stairwell, lay approximately in the plane of the slice. Slice L of Fig. 7 indicates a typical slice position. This meant that the investigation of the stairwell stresses could be carried out by the normal two-dimensional techniques. Fig. 13 shows the magnitude and directions of the principal stresses in the web. The directions were taken directly from the isoclinics as described above while the magnitudes were calculated by the graphical integration method.

Discussion and Conclusions

The loading apparatus designed to reproduce the hydrostatic and earth loads in this photoelastic stress analysis functioned satisfactorily although it required more calibrating than was originally thought necessary. After the initial falloff in strength of the clamps negligible decrease in strength was noticed. Further proof of this was the consistency of results between the models. The effect of the gravitational loads, not included in this investigation, would have been beneficial to the results wherever

Fig. 10. Isochromatics — Slice A.



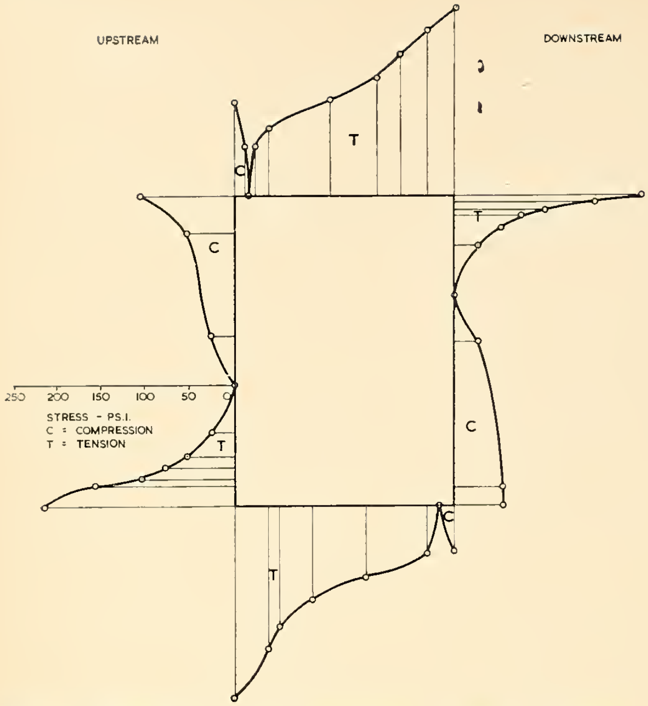


Fig. 11. Tangential Stress Distribution Around Drainage Gallery (Slice H.)

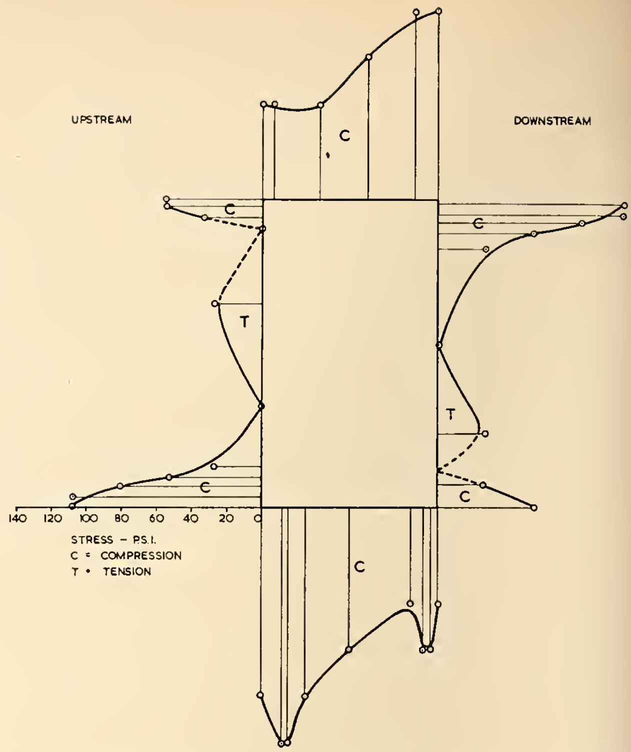


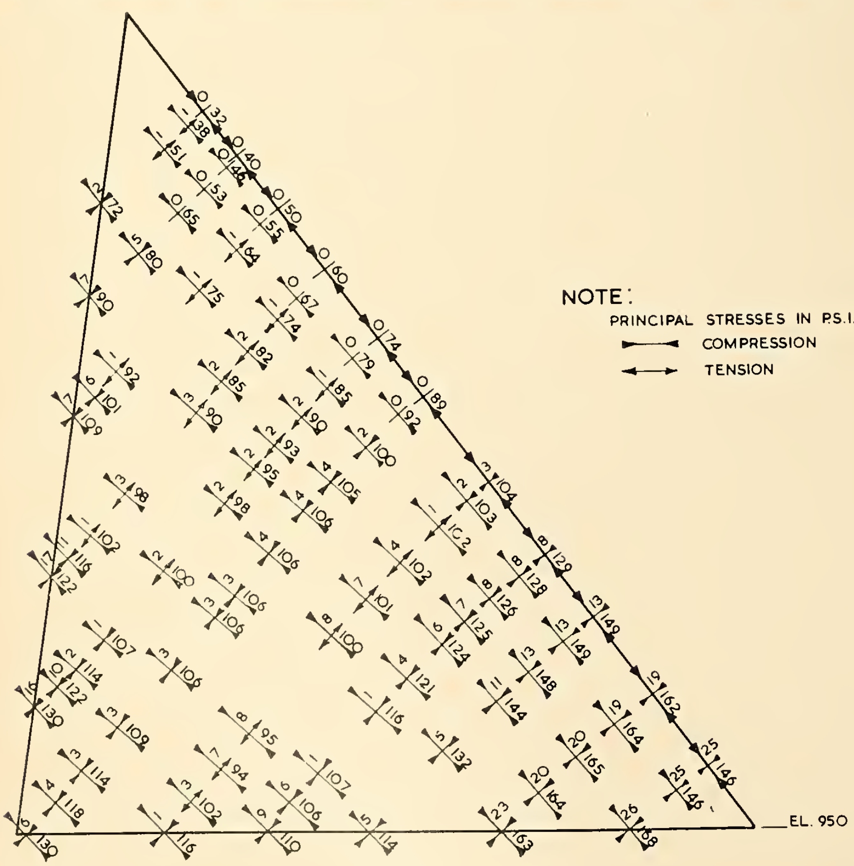
Fig. 12. Tangential Stress Distribution Around Entrance Gallery (Slice O)

they were significant.

The photoelastic material Hysol 6000 OP was found to be quite satisfactory but did show signs of time-edge stresses after a short length of time. This undesirable effect was kept to a minimum by machining, stress-freezing and analysing in as short an interval as possible. The cemented joints of the model did not seem to affect the results if a reasonable amount of care was taken when cementing the components together. This method can certainly be recommended for simplifying the construction of complicated photoelastic models.

The results of this analysis did not show up any extreme stress concentrations and proved the original design quite adequate. The final design of the structure called for reinforcement to be placed around the stairwell and galleries and for fillets to be provided at the corners of the galleries.

Fig. 13. Directions and Magnitudes of Principal Stresses in Web. (Slice A)



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TRENDS IN ENGINEERING TRAINING

Arthur Porter, M.E.I.C.,
Dean of Engineering, University of Saskatchewan, Saskatoon.

THE TERM *engineering training* is used in this paper in a generic sense and is assumed to cover all aspects of engineering education as practised in lecture room, laboratory and workshop (or factory).

The past decade has been a period of soul-searching for many schools of engineering in the Western world, and the fundamental requirement has been the adjustment and modification of engineering curricula and programs to deal with the highly dynamic character of technological advance. It is a massive problem. And the situation is further complicated because, in planning undergraduate courses, each University or Institute of Technology must be guided to some extent by local conditions, and as a result it is not meaningful to refer to an "optimum engineering curriculum or course". Moreover, even though a particular course is regarded as almost optimum at a particular time, it is unlikely, in a constantly changing environment, that this state of affairs will persist for long. The planning of higher educational facilities is a laborious and time-consuming task, and the practical realisation of the plans, even if adequate financial backing is available, may be still more time-consuming. Although it is true that lecture courses in most engineering subjects can be kept reasonably up-to-date, the allied problem of keeping associated experimental laboratories up-to-date is appreciably more difficult. The result is that a "time-lag" is inherent in the educational system, and it would appear to be a major task of the engineering educator to ensure that all programs of study and experimentation are based on solid foundations and at the same time are sufficiently modern to attract and to inspire high-quality students.

Further, the complexity of the problem of devising new curricula in engineering in keeping with the rapid advance of technology, is in part due to the failure of educationalists to carry out adequate research in their field. It has been pointed out on many occasions that the research effort in education, as a proportion of total expenditure in education, is appreciably less than in any other university discipline.

Perhaps some new ideas in the field of engineering education will arise from the investigations which are currently being undertaken by psychologists and communications and control engineers in the study of learning processes.[1] It is already well known, for example, in the biological sciences that learning through association, eventually leading to conditioning, is perhaps the most fundamental learning mechanism of all. And we can certainly expedite the learning and conditioning process in training young engineers, although it is improbable that we can induce creativity. However, an environment can be provided which will stimulate creativity and perhaps guide the powers of gifted students into useful directions.

The main topics considered in this paper are:

(i) The pattern of employment of professional engineers in Canada in order to obtain some guidance concerning the most suitable type of engineering courses in the universities;

(ii) The justification for engineering science courses from the university standpoint;

(iii) General comments on the tendency to introduce advanced mathematics into some undergraduate engineering courses;

(iv) The important role of industry in the training of engineers;

(v) The place of technological research in a university;

(vi) Some general conclusions.

TABLE I

Percentage distribution of engineers with (i) bachelor's degree and (ii) higher degrees according to function. (Year of bachelor graduation 1948-1957).

Function	*With bachelor's degree*	*With higher degree*
Research and development	11.0	28.0
Designing and draughting	12.2	9.9
Testing, inspection and laboratory services	3.5	3.3
Production and operation	30.8	11.5
Administration, executive and management	26.4	23.1
Teaching, instruction and extension work	1.1	12.6
Purchasing, sales and service	8.7	5.5
Consulting and private practice	4.1	5.5
Other	2.2	0.6
Total, percentage	100.0	100.0
number	2,588	182

Employment of Professional Engineers

In charting a future course for engineering training it is important to bear in mind the nature of the employment of professional engineers. It would appear unlikely that there will be an appreciable change in the nature of this employment in the future although it can be anticipated that a higher proportion of engineers will become scientifically oriented and will tend to undertake research and development work rather than enter manufacturing or sales. There is clearly a broad spectrum of ac-

TABLE II

Percentage distribution of engineers by function and field of specialization. 1956

Functions	*Civil*	*Engineering* *Electrical*	*Mechanical*	*Mining and Metallurgical*
Research	1.7	2.7	2.3	7.4
Development	2.3	8.9	7.7	10.3
Design and Draughting	20.9	15.5	18.7	1.6
Testing, inspection and laboratory services	2.6	5.5	2.5	4.8
Production and operation	2.7	9.3	10.5	21.6
Maintenance, construction, installation, etc.	39.5	19.3	14.9	4.1
Administration, executive and management	20.9	22.2	23.1	36.9
Teaching and writing	1.9	2.1	1.8	1.7
Other	7.5	14.5	18.5	11.6
Total, percentage	100.0	100.0	100.0	100.0
number	6,640	5,275	6,223	2,832

tivities into which professional engineers can be fitted, and these activities range from essentially technician-like duties through to research work in the pure sciences. Thus there is evidence that the more highly trained the engineer, the greater the probability that he will be involved in research and development work.

Table I gives, for example, the percentage distribution of engineers with a bachelor's degree, and also those with higher degrees carrying out various functions, and demonstrates this feature.[2]

Table II gives a more detailed break-down of function according to field of specialization.[3] The percentage of mining and metallurgical engineers, and to a lesser extent the percentages of electrical and mechanical engineers, undertaking research and development activities is appreciably greater than the percentage of civil engineers engaged in such activities. But in the construction and installation fields, the percentage of civil engineers involved is appreciably greater than the percentage of other classes of engineers so involved.

Table III shows that the majority of engineers are employed in industry, and comparatively few in the universities and in Federal government laboratories. But in the case of scientists the situation is quite diferent as shown in Table III.[2] Many more scientists, comparatively, are employed in the universities and by the Federal government, although the number of scientists employed by industry nevertheless still constitutes the majority. In general engineers with average qualifications are more likely to be employed in industry than engineers possessing higher degrees.

The employment patterns inherent in the tables presented above give

TABLE III

Percentage distribution of engineers and scientists according to employment sector, 1957. (Year of bachelor graduation 1948-57).

Employment Sector	*Engineers*	*Scientists*
Industry	80.9	54.9
Universities	1.8	10.6
Federal government	10.1	18.6
Provincial and Municipal government	7.2	12.4
Technical and high schools	0.0	3.5
Total, percentage	100.0	100.0
number	2,770	1,946

some guidance concerning the most appropriate type of training to be provided for both the professional engineer and the sub-professional. Clearly some of the professional engineers at present engaged in testing, inspection, draughting and maintenance work could, in many cases, be replaced by high-grade technicians and this accents the need for appreciably more extensive facilities for technical training in Canada. The employment of professional engineers as technicians must, at best, be regarded as a very uneconomical process.

Perhaps on the basis of the statistical evidence, coupled with the evidence of standards in the universities, it may be justifiable to break down the existing engineering undergraduate population at the universities into the following very general grouping.

(i) The group,* consisting of perhaps between 25% and 35% of the engineering undergraduate population, who should not be admitted to the universities because of lack of ability, and who should enter technical colleges (undoubtedly many of the places vacated by these students could be allocated to other students who may not have registered at a university or who may have registered in other disciplines).

(ii) The second group, consisting of perhaps between 45% and 60% of engineering students, who should take courses biased essentially towards technology.

(iii) The group, consisting of perhaps between 12% anl 24% of engineering students, who show a particular flair for mathematics and physics.

It is suggested that group (iii) should take courses oriented towards science. At the University of Saskatchewan, for example, it is expected that the average intake into the engineering science courses at the end of the first year will be 15% of the freshman class.

It is anticipated that future engineering science graduates will probably gravitate towards research and development fields of activity, and that a reasonable proportion will return to the universities as teachers after a spell in industry or in government laboratories.

Justification for Engineering Science Courses

A brief note on the engineering science courses at the University of Saskatchewan is given in the Appendix.

The elementary statistics presented in the previous section suggest that only a comparatively small percentage of engineering students should be trained as research and development specialists. The vast majority of engineering graduates are required throughout industry in a variety of other roles and there would appear to be little evidence to justify sweeping and widespread changes in the existing engineering curricula at Canadian universities.

On the other hand it is almost a truism that in order to attract high-quality staff to university engineering departments it is essential to build up strong post-graduate courses and research activities. And since the scientifically oriented students are more likely to undertake research work than the remainder, there is little doubt that engineering science courses can be justified on these grounds alone. Moreover, such courses will have a stimulating and motivating effect on staff members.

Further evidence to justify the introduction of engineering science courses (certainly at the University of Saskatchewan and probably in other universities, can be found in Ph.D. statistics. The majority of Ph.D.'s in applied science (not including medi-

* The majority of this group do not survive beyond the 2nd year at the University.

cal science or agricultural science) have been awarded at the U. of S. to chemical and geological engineers and to engineering physicists. And, until comparatively recently, no candidates for the degree of Ph.D. have been registered in the "classical" engineering departments. Moreover, with few exceptions, this has been a national pattern.

But, with the increasing importance of research and development in all branches of engineering, more scientifically oriented civil, electrical and mechanical engineers will be required. Clearly, the classical approach to engineering education is inadequate to prepare students for highly complex and exacting engineering design and research activities and engineering scientists will be required in increasing numbers for such work. Accordingly, we have endorsed the present trend in many engineering schools towards the scientific bias and away from the empiricism which has characterized so many technological developments in the past, but we also have been at considerable pains to emphasize the importance of the empirical approach in many branches of engineering.

In considerations relating to curricula it should be borne in mind that, in many university engineering departments, there is a broad range of ability in the student body, and this fact, coupled with the wide spectrum of technological development, suggests that special consideration should be given to those students who are particularly gifted in mathematics and in the physical sciences. This must be regarded as a justifiable conclusion because a major attribute of engineering science, as a university discipline, is that it bridges the gap between the physical sciences on the one hand and technology on the other. And there is an increasing recognition that future advances in the sciences and the applied sciences will be appreciably enhanced by inter-disciplinary activities and the engineering scientist appears to fit effectively into such a pattern.

Mathematical Content of Some Engineering Courses

The courses in engineering science, as planned at the University of Saskatchewan,[4] emphasize fundamental principles, and a good grounding in mathematics (both classical and modern) and physics is essential.* But every effort has been made to ensure that theory and practice proceed along parallel paths and complement each other. Engineering is both art and science, and undue emphasis on the mathematical aspects of a particular topic at the expense of the practical aspects may be undesirable, and may even have the effect of inhibiting the inventive capabilities of students. The theoretical "engineer" is frequently guilty of over-idealizing systems, and sometimes the impression is gained that he works on the basis of "fitting engineering design problems to mathematical techniques", rather than vice versa. And, in addition, over-generalization of mathematical analyses can tend to mystify rather than to clarify, and unless the physical significance of the mathematical treatment and its practical limitations are stressed, there is a danger that from an educational viewpoint such procedures are worthless.

An example of the "mathematical" approach to engineering education is provided by some of the courses in the electrical engineering undergraduate curriculum at the Massachusetts Institute of Technology.[5] These much publicized courses, especially the course in "Electromechanical Energy Conversion", exemplify undesirable trends in engineering education.[6] Abstract mathematical treatments have replaced solid "down to earth" engineering treatments of such basic electrical engineering topics as ac and dc machines. And the fundamental engineering problems of electrical machine design appear to have been sacrificed in order to devise pseudo-generalizations which are convenient for mathematical description; it is symptomatic of this approach that such vitally important problems as "thermal effects" and "commutation" are ignored.

Abstract presentations of essentially practical topics, especially when the abstract models do not adequately represent practical systems, which are often far too complicated for mathematical representation of this kind, may in the long run inhibit the creative powers of the young engineer. If the engineering graduate is continually seeking an abstract mathematical model before he is in a position to design a system, it is not improbable that the art of invention will be discouraged. The truly great engineers of the past and the majority of those active at present have made great contributions to technology through their engineering "sense" and practical experience, and not through highly sophisticated mathematical models, and the author would venture to remark that few of these great engineers have been mathematicians in the recognized sense of the word. Perhaps even a modern Michael Faraday would not pass the M.I.T. "Electromechanical Energy Conversion" course!

The most fundamental requirement of any educational system is to inspire confidence in the student and in engineering this must be regarded as especially important. The young engineer, confronted with highly abstract mathematical models of impracticable situations, may well be discouraged and, far from stimulating his creative powers (it is understood that the sweeping changes in the curricula of the department of electrical engineering at M.I.T. were introduced for this reason) the new courses may well have the opposite effect however bright the students.

The most effective bridge between theory and practice in engineering education is through the medium of the laboratory.[7] And the laboratory should not only be a place where the student is introduced to physical phenomena, to measuring techniques, and to engineering design methods, but also a place where he can be taught the physical significance of important mathematical techniques and tools. The use of analogues and simulators in the students' laboratory is of particular importance.* For example, it is suggested that, for the majority of electrical engineering students, the concepts of field theory are only truly meaningful when well-designed experiments are available to demonstrate the principles and properties of such fields. Accordingly, the fact that the distribution of electric current in a conducting medium is closely analogous to the distribution of magnetic flux in a geometrically similar magnetic field can form the basis of a set of experiments which reveal Laplace's equation to the student as something very real.

The "analogue" experiments which Barker has devised at Imperial College, London, for students in all branches of engineering in their first, second and third years have produced highly satisfactory results from an educational point of view.[8, 9] There is little doubt that a student who spends two or three hours in Barker's laboratory investigating the behaviour of potential fields is far better off educationally than a student who has had no laboratory experience in these

* In the case of engineering science (chemical) there is the additional requirement of pure chemistry.

* Note that at undergraduate level education is largely a "conditioning" process, and pattern recognition is a vitally important attribute in the student. The engineering student is much more at home with physical models ("patterns") than with abstract models (patterns).

areas and who has learned the appropriate theory of the subject in the lecture room or from the text book. Further, many other comparatively difficult areas of engineering science can be handled through the laboratory. The author has used for many years the mechanical differential analyser as a means of introducing students to some of the more difficult differential equations encountered in engineering science. Since the engineer works with brain, eyes and hands it must be obvious that the physical model approach to certain branches of engineering education must be regarded as desirable. Certainly the majority of students who have solved a few differential equations relating to a specific dynamic problem (e.g. a torsion pendulum damped with a non-Newtonian fluid) appear to have a good understanding of the physical and mathematical significance of the situation.

In like manner experiments in fluid dynamics, heat conduction, and diffusion, aimed at clarifying the mathematical treatment of such phenomena have been developed, and there are clearly almost limitless possibilities in all branches of modern engineering theory and practice where analogues can be used to clarify theory. As at present being planned at the University of Saskatchewan such a laboratory will be developed essentially as an inter-departmental laboratory (there is no real reason why the laboratory should not be inter-disciplinary) and it is perhaps most appropriately described as a "Basic Process Dynamics Laboratory".

Bearing in mind the high proportion of engineering graduates who will eventually be employed in non-research and non-development work, a strong case can be made for the retention of most of the material at present taught in the normal engineering courses in Canadian universities. Many of these courses have been developed over many years and clearly they must, for the main part, be based on sound practice. On the other hand, it is considered that certain basic changes must be introduced within the next decade, the most important of which is the introduction of all engineering students to the power and potential of modern electronic computers with appropriate examples in their field of specialization. And perhaps also the physical model ideas mentioned previously and the Process Dynamics Laboratory may be valuable as a basic aid in the essentially technologically oriented stream. In spite of the great advances in the design and application of electronic digital computers there is nevertheless still an important part to be played by analogue computers and these are most conveniently introduced in a Process Dynamies Laboratory. Perhaps also, even in the case of the technologically direeted stream, there will be less emphasis in the future on engineering drawing and on some of the more out-dated classical experiments still to be found in university engineering laboratories. There is little doubt that the normal engineering courses will gradually change in character in the future although it is certainly not anticipated that they will ever become as mathematical and scientific in content as the courses for the engineering scientists.

Training in Industry

The schools of engineering at universities have always realized that they can do little more than present the basic principles of engineering in the courses leading to the bachelor's degree and that reliance must be placed on industry for the remainder of their training. The situation is analogous to the training of medical men where high importance is placed on the clinieal aspects of the curriculum and the associated training in the hospitals. It is also undoubtedly true that the graduate apprenticeship training schemes which have been a feature of engineering educational programs in the United Kingdom and Europe for many years have been appreciably more highly developed than the equivalent schemes in Canada, or for that matter in the United States. In a brilliant Inaugural Address as President of the Institution of Electrieal Engineers (London), Sir Willis Jackson[10] emphasized the extreme importance of practical training at graduate level. The training facilities to whieh he referred have been established in many of the large industrial organizations in U.K. and they provide a two years' course of practical study supplemented by lectures. In Canada a few universities insist on a modicum of practical training being obtained by the student in industry as a prerequisite to graduation at bachelor's level.* But this is by no means general and no doubt the standard of the practical training is not at the high level which obtains in the industrial organizations in Europe where this problem has been studied for many years. It seems to the author that the industrial training available in North America is much more ad hoe in charaeter and, in general, it is suspected that in few cases have the practical programs been drawn up as a result of mutual study by the schools of engineering and the industrial organizations.

This question of the training of professional engineers in an industrial environment will clearly increase in importance in the future and the initiative will almost certainly have to be taken by industry. Moreover, the problem of providing the professional engineer with a suitable industrial background is by no means disassoeiated from the problem of training all grades of technieians and craftsmen in industry. Just as in the case of the universities, the technical colleges and schools can only provide their students with the basis of their training and a great deal must inevitably by left to industry.

It is suggested that the stress on the humanities in undergraduate engineering courses in many schools in the U.S.A. might not be necessary if adequate facilities for postgraduate training in industry were available. Certainly in Europe an appreciable portion of a student's education in the hmanities is obtained in industry both at a practical and a theoretical level—for example, many postgraduate training schemes incorporate lectures on such subjects as management and economics.

It can be argued that no engineering student (and certainly no engineering scienee student) should be coerced into undertaking compulsory subjects with a humanities flavor if he has no interest in these subjects. The argument that the student should be interested in such areas cannot be upheld. On the other hand, the engineering student who is interested in the humanities and the arts and languages should be given every encouragement to pursue these interests. This principle has been applied in many engineering schools in Europe for many years and the results have been very satisfying.

How is training in industry related to the need for professional engineers to be versed in the humanities? In the well-established graduate apprentice training programs (as found, for example, in several large industrial organizations in the United Kingdom), the graduate engineer acquires both a theoretical and pactical introduction to the humanities. The advantages of this approach over a university program of lecture courses in the hu-

* Special mention must be made, however, of the combined academic-industrial training program for engineers at the University of Waterloo, Ontario. This program clearly has great merit and high potential for the future. It is understood that similar programs have been established in the U.S.A.—they are also similar to the U.K. "sandwich courses" in character.

manities can be summarized as follows:

(i) As a graduate apprentice the embryonic engineer is more mature and therefore more capable of understanding the complex problems of human organizations and relationships than is the university undergraduate;

(ii) Such factors as the motivations of the non-professional work force, their relationships with management and the mechanism of trade unions are usually more effectively studied at first hand on the "shop floor";

(iii) The voluntary lecture courses in the social sciences, presented in an industrial environment to mature students, must surely have a far more lasting and important influence on them than a series of university lecture courses whose sole motivating effect is usually "credit" towards a degree.

Turning to the more professional aspects of graduate training programs in industry, the features of the industrial scene, outlined below, are given special attention-taken by and large, the whole program is essentially one of familiarization.

(i) An introduction to modern methods of fabrication and of assembly-line techniques;

(ii) An introduction to the role of management and the structure of an industrial organization;

(iii) An introduction to the design offices, model shops, and drawing offices, and their role in the organization;

(iv) An introduction to the objectives and mechanism of industrial research;

(v) The place of the sales department;

(vi) A detailed study of a special field of interest.

In addition to the above practical aspects of the graduate training program, and in addition to the lecture courses in economics, management and the social sciences in general, there are also provided series of lectures at graduate level in mathematics and the application of mathematics to engineering design problems. Also in recent years there has been increasing emphasis in all programs on the utilization of digital computers in engineering design.

In general, the graduate training programs cater to new graduates in engineering and to a lesser extent the physical sciences, and the programs are of rather less than two years duration. However, during the past few years, special programs which combine study at universities, or colleges of technology, with industrial training have become increasingly important. There are two varieties of "sandwich course" in operation in the U.K. at present. The most common course is the six years' course in which each student spends six months of the year in industry and the remaining six months at a technical college or a college of advanced technology. Normally this course does not lead to a university bachelor's degree although an equivalent technological qualification can be acquired. The less common "sandwich course" involves one year in industry, three years at a university reading engineering (the normal bachelor's degree in U.K. universities is of three years' duration) and a final year in industry. Moreover the summer vacations are also spent in the industrial organization concerned. These schemes are financed absolutely by industry, and selected students have their university (or technical college) fees paid and in addition normal apprentice wages are paid throughout the five (or six) years of the course (these wages are equivalent to a maintenance grant of approximately $1500 per annum). Further, there is no obligation, neither legal or moral, for a student, on completion of his course, to remain in the industrial organization which financed his engineering education.

There is little doubt that these courses have been highly successful and that the general idea will be expanded in the future. Obviously industry in the U.K. feels that such not inconsiderable investments in young engineers are well worthwhile. The great merit of such schemes, and it should be pointed out that equivalent schemes are in operation in various countries in Europe, is that close integration is achieved between university and industrial work. As far as the author knows there are no equivalent "sandwich" schemes in North America and perhaps one of the reasons is that the salaries paid to new graduates in engineering are much inflated. But this subject is somewhat beyond the scope of this paper.

If integrated schemes such as those outlined above are not practicable, and this would appear to be the case in North America for some time to come, there must be some mechanism whereby engineering faculty members can be kept in very close contact with industrial developments. Otherwise engineering courses will tend to become more and more unrealistic. Indeed, Sir Willis Jackson has suggested that an ideal arrangement would be for university staff to spend several years in industry alternated with several years in university engineering departments. He has also suggested that the great national scientific laboratories (he mentioned the National Physical Laboratory in United Kingdom) should be brought within the educational orbit, so that graduate students in engineering might study and carry out their research in these laboratories and thereby the scope of postgraduate facilities would be considerably extended. This seems to the author to be an admirable idea.

At the present time the only mechanism whereby engineering faculty members can be kept in contact with industrial activities is through consulting work. Perhaps the day is not too far off when university teachers of engineering will be required by the university to carry out consulting work in order to keep abreast of the technological advances in their particular speciality. And certainly teachers should be required every two or three years to spend a long summer vacation in industry if arrangements can be made. However, this is a massive problem and justice cannot be done to it in the space of a few paragraphs.

The Place of Technological Research In a University

It has already been stressed that the major object of introducing engineering science courses is to encourage students to undertake research work after graduation. And there are very many reasons for encouraging active research programs in departments of engineering. But there is also some justification for the viewpoint that most technological research can be more effectively executed in industry or in large government-supported laboratories, because of the high expenditures involved. Indeed, it cannot be denied that in many areas of technology the universities are lagging appreciably behind industry and government laboratories.

The question should be asked, therefore, "is there a place for technological research in a university?" The author believes it is justified for the following basic reasons:

(i) The strength of technological research in a university is derived essentially from the close proximity of other disciplines. Inter-disciplinary research can be regarded as the basic manifestation of the "universitas facultatum" concept and indeed its justification;

(ii) Technological research in the university keeps university faculty members abreast of the frontiers of knowledge in their special field of interest, and complements their industrial contacts and consulting activities;

(iii) Research programs provide a suitable environment for training graduate students especially in the "research method";

(iv) The university provides scope for the highly speculative researches which may "leap-frog" by several years developments in industry. Frequently industry is not in a position to sponsor long-term research of this nature.

However, all university research in engineering cannot be of a truly fundamental character and much of it will essentially be of an ad hoc nature. But this is by no means a disadvantage because:

(a) Research which is initiated to solve an ad hoc problem frequently leads to investigations of general interest;

(b) Problems of an ad hoc character are most essential in university engineering departments because they provide thesis material for graduate students who cannot be expected to undertake more speculative researches (except perhaps at Ph.D. level) which are more appropriate for senior research workers;

(c) In the establishment of interdisciplinary research, which by definition involves the crossing of departmental boundaries, it is essential to inspire confidence and the author has found that the solution of comparatively unsophisticated ad hoc problems serves admirably in this respect. The recent successful collaboration between the Colleges of Engineering and Medicine at the University of Saskatchewan has been due in the first place to the successful completion of the development of new instruments and measuring techniques.

However, it is the fundamental research which usually pays the highest dividends in a university and some of the new ideas which permeate certain branches of technology today (e.g. thermodynamics, communication theory, feedback control theory, etc.) are already having an important influence on many fields of knowledge which would appear, at first sight, to have little in common with engineering. As an example of the salutary effects of inter-department collaboration it may not be out of place to mention the University of Saskatchewan Jubilee Symposium on "Memory, Learning and Language", which was held at Saskatoon in September, 1959.[11] The idea of the symposium was due to an engineer and a neuro-surgeon and eventually papers were presented by a classical scholar, a biochemist, a physical chemist, two neuro-surgeons and an engineer. Such activities must be regarded as the very "life blood" of the universities.

General Conclusions

The development of facilities and programs to train adequately the increasing numbers of professional and semi-professional engineers who are required to guarantee the economic future of Canada constitutes a tremendous task. And with the increasing importance of engineering science courses and the rapidly expanding engineering postgraduate schools, the problem might appear to be almost intractable. Nevertheless if the schools of engineering are given adequate financial support in the future there is little doubt that the challenge of modern technological education will be met effectively.

It is encouraging to note that few, if any, engineering schools in Canada are being stampeded into programs involving radical changes in outlook and curricula. There is a real danger that well-tried methods of training professional engineers may be cast aside and replaced by untried methods-control system engineers know very well that sudden changes in the environment of a process often lead to disastrous consequences! On the other hand, we must recognize that change is inevitable and if we build on solid foundations bearing in mind that engineering is both art and science and do not forget the triumphs of classical engineering, it may transpire that within the next decade or two our schools of engineering will be in the very first rank. But considerable financial support will be necessary, not only for the university engineering departments, but also for the provision of adequate facilities to train an ever-increasing number of high-grade technicians.

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Appendix

The engineering science courses at the University of Saskatchewan are essentially a logical extension of the scientifically oriented engineering courses, already available, (e.g. chemical engineering, geological engineering, and engineering physics) to embrace all the departments of engineering. In consequence it will henceforth be possible to take honors in agricultural, civil, electrical and mechanical engineering.

Brief notes on the general nature of the course requirements are given below:

(i) The courses will be open to all students registered in the College of Engineering who have achieved a minimum average mark of 70% in the first year examinations - special requirements for students electing the course in engineering science (chemical) must also be met;

(ii) Three basic options are available in the second year of study for specialists in (a) chemical engineering; (b) geological, petroleum or geological engineering (geophysics); (c) agricultural, civil, electrical, mechanical, or engineering physics; respectively. With the exception of the engineering science (chemical), the final choice of specialization will normally be deferred until the end of the second year. The main purpose of the second year courses is to provide a basic training in mathematics, mechanics, and the appropriate pure sciences, especially physics, upon which to build the more specialized training in subsequent years. Provision is also made for the majority of the engineering science students to take one elective from an approved list and this will normally be in a non-technological and non-scientific field;

(iii) Entrance to the third and fourth year courses will be limited to those students who have maintained a high standing in the first two years. Specialization will begin at this stage although there will be continuing emphasis on the application of mathematical methods and physical principles to engineering problems of a basic kind.

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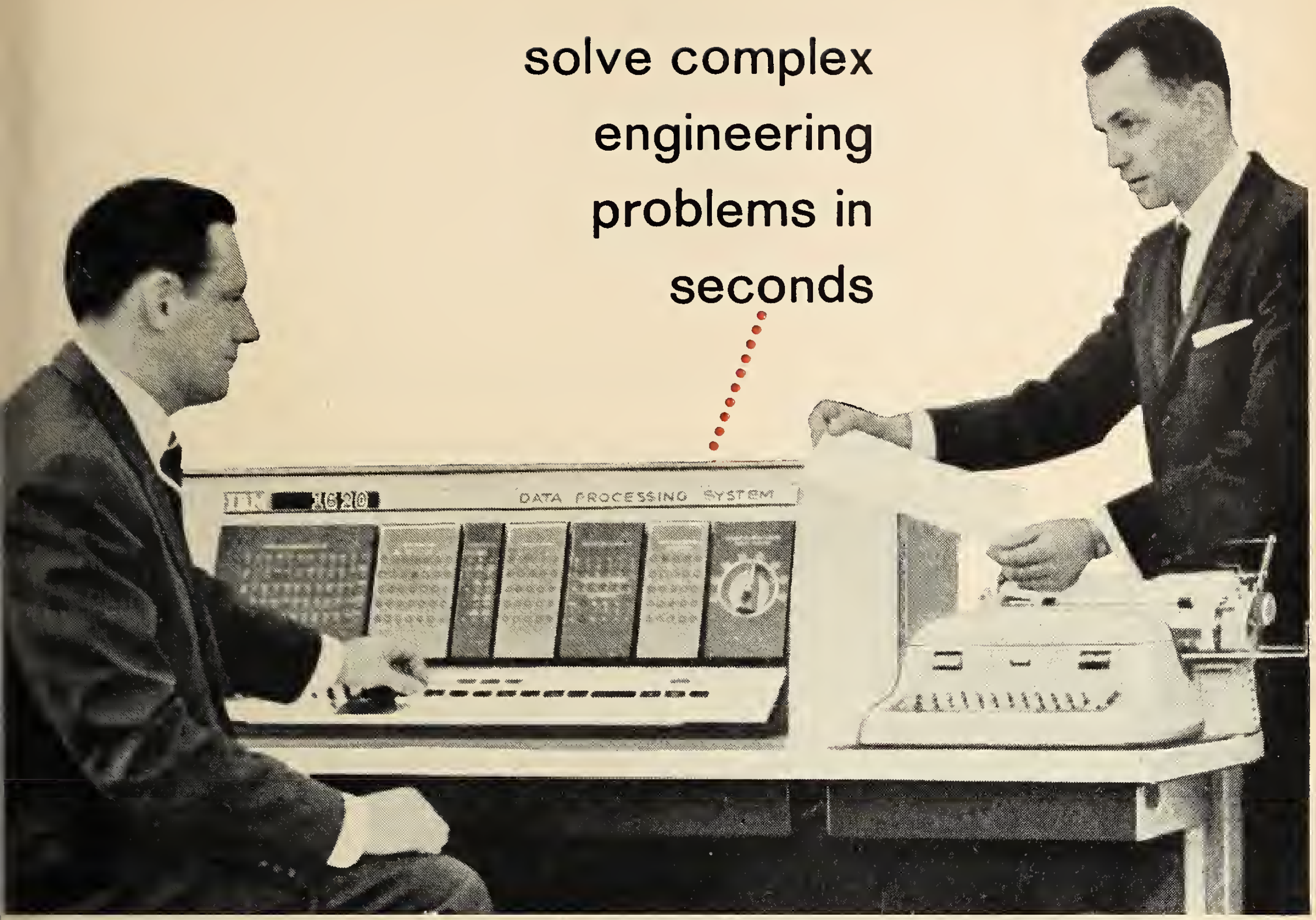

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Discussion

THE YARD OR THE METRE WHICH?

From a panel diseussion held during the 1960 Annual General Meeting of the E.I.C. at Winnipeg, Man.
The Engineering Journal, June 1961 page 43

Discussion by S. Barbosa

It seems to me that both parties missed the point which really worries engineers on the purchasers's side: it does not matter drillings 1" or 2.5 cm apart—but the interchangeability of the nuts and bolts involved. It is not rare to have to resort to turn in a centre lathe a BA or a special metric part in certain countries. This should point to the solution which ought to be sought—a long term changeover to the most convenient precision system, either in metric or inch base and an immediate change to tolerances which would produce a thread, drill and pipe interchangeable between industries using either standard and not involving a radical change of system of units, gauges or tooling.

We are however starting a much deeper discussion now — how could this be done and on what grounds? I hope to see this done in my lifetime, however . . .

THREE-DIMENSIONAL PHOTOELASTIC STRESS ANALYSIS OF A DIAMOND-HEAD BUTTRESS DAM

C. R. Jones
Crippen Wright Engineering Ltd., Vancouver
J. B. Mantle, M.E.I.C.
Head, Department of Mechanical Engineering, University of Saskatchewan, Saskatoon
The Engineering Journal, September, 1961, page 89

Discussion by W. B. Rice

The photoelastic analysis of the stresses in structures is most satisfying particularly when the leading conditions can be simulated as well as they are in this case by the ingenious use of Neg'ator clamps.

Like magicians, the authors leave the impression that photoelastic analysis is easy. However dependable stress values are the result of careful machining, cementing, cutting, polishing and calculating. The authors are to be commended for their technique, and for an interesting paper describing the successful application of a powerful method of analysis.

Discussion by W. O. Richmond

This paper describes the application of the photoelastic stress-freezing technique to the analysis of stress in a structure. The authors are to be complimented on their skill and ingenuity in solving the problem of obtaining simulation of the stresses in an actual structure by loading a small scale model. As in most stress analysis model studies, St. Venant's principal of equivalent stress distribution comes to the rescue of the stress analyst when he replaces an actual loading condition with one statically equivalent. An error exists, however, in the vicinity of the area of load application, though this is likely not significant in this case, since an attempt was made to simulate the actual loading by distributing the applied concentrated loads by means of rubber pads so that the loading may be considered to approximate fairly closely the actual hydrostatic loading. Then, too, the areas of high stress are reasonably far away from the area of loading so that the loading technique may be considered satisfactory.

Another difficulty that occurs to mind is the selection of the location of the slices, and particularly their direction, in order to obtain the true maximum stresses. It is desirable that the face of the slice be one of the principal planes of stress so that the true maximum stresses in the other two directions are obtained from the analysis of the fringes observed in the slice. In at least one slice, the authors attempted to achieve this condition by a study of the stresses in the web of the structure, which is sufficiently thin so that plane stress conditions exist. However, is it necessary that the plane so located is a principal plane throughout the model? It would seem more likely that the principal stress directions change so that the principal stress surface is curved. This situation has apparently developed in one slice, namely slice 0, since the authors state that the zero fringe does not follow a course normal to the surface of the slice. A true three-dimensional analysis would presumably require the analysis of at least two slices at right angles at each point and would therefore involve a prohibitive amount of labour. Fortunately, it is likely that a sufficiently accurate orientation of one of the principal planes can be obtained from judgment and symmetry conditions. The writer would be interested in the authors' estimate of the error in the maximum stress likely to develop from this uncertainty, and also their comments on this aspect of the photoelastic stress freezing technique applied to three-dimensional models, where the principal stress directions are not normal to a plane surface so that data from flat slices cannot be used to determine principal stresses directly.

Discussion by I. W. Smith

The paper entitled "Three Dimensional Photoelastic Analysis of a Diamond-Head Buttress Dam", by Mr. C. R. Jones and Professor J. B. Mantle will be of considerable interest to both designers of this type of dam and to general users of the photoelastic technique. It outlines a method whereby an adequate evaluation of the critical stresses in a structure having a fairly complex geometry and loading system may be obtained by application of conventional two-dimensional photoelastic methods. Through judicious selection of the stress planes to be studied, and by virtue of free surfaces on which critical stresses could occur (e.g. gallery walls), the more difficult task of orientating and evaluating the three principal stresses at an interior point

(Continued on page 156)

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A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on July 13, 1961.

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McGill University: S. R. Goswami.
University of Toronto: G. A. Fernandes.
Ontario Agricultural College: W. H. D. Rowan.
Prof. Engs. of Ont.: D. Pearce, R. A. Stott, J. M. Vanden Hoven.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective July 13, 1961.

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Junior to Member: W. E. Curtis, W. N. Hasegawa, P. H. Hudz.

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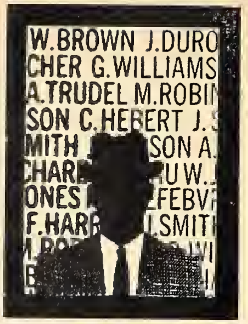
Members: C. A. Chappel, A. B. McLean, R. F. Palmer, F. W. A. Smith.
Junior: H. Heimark.
Junior to Member: R. A. Baumgartner, K. A. Birch, R. L. Blanchette, G. A. Bowman, R. A. Doull, D. A. Dunsire, M. D. Glazier, F. R. Hill, J. D. Holden, N. W. Ledray, A. I. Massier, R. W. Nordquist, W. F. Peterson, B. J. Pfeffer, J. W. Rittinger, G. W. Salberg, L. A. Yaskowich.
Student to Junior: M. A. Blackwell, R. B. Clunie, D. P. Foley, M. J. Herasymuik, L. P. Jonassen, A. W. Kempthorne, S. L. Koroluk.
Students: V. P. Suderman, J. S. Yee.

NOVA SCOTIA

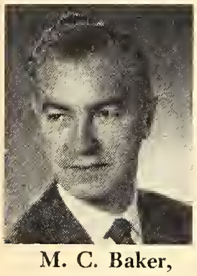
Members: J. H. De Lory, F. C. Turner.
Junior to Member: P. M. Gillham, D. W. Street.

Personals



D. McKim, JR.E.I.C. (McGill '47) has been named acting superintendent, Quarry Division, Shawinigan Chemicals Limited. Since 1947 Mr. McKim has been with Shawinigan Chemicals.

M. C. Baker, M.E.I.C., (McGill '43 and '50) has joined the staff of the Division of Building Research, National Research Council, to work in the Building Practice Section of the Division. A civil engineer, architect and teacher, he brings to the Division the benefit of active practical experience in engineering and the private practice of architecture.



M. C. Baker, M.E.I.C.

G. Molleur, M.E.I.C.

Gerald Molleur, M.E.I.C. (Ecole Poly. '24) has been appointed assistant general manager in charge of personnel of the Quebec Hydro-Electric Commission. Mr. Molleur was formerly Director of auxiliary services.

Graham Langley, M.E.I.C. (N.S.T.C. '57) has been appointed industrial agent for Canadian National Railways Atlantic region. Among his new duties will be helping new industries to settle in the Atlantic Provinces. His appointment has been announced by Robert Thomas, manager of Industrial Development. Mr. Langley is the first person to hold this post at a regional level in the Atlantic provinces.

A. H. Heatley, M.E.I.C. (Tor. '37) has joined the faculty of the University of Waterloo as professor of Chemical Engineering. Dr. Heatley, a well known chemist and chemical engineer is director of patents for Shawinigan Chemicals Ltd. He will remain in this position and devote two-thirds of his time to the University.

John N. Flood, M.E.I.C. (U.N.B. '16) was re-elected chairman of the board for the third consecutive three-year term at the 18th Annual Meeting of the board of trustees of the Maritime Hospital Service Association.

W. R. Staples, M.E.I.C.

F. H. Edmunds, M.E.I.C.

W. R. Staples, M.E.I.C. (Sask. '42), has been appointed assistant dean of engineering at the University of Saskatchewan. Prof. Staples has been assistant to the dean for three years. His new position entails more responsibility in the administration of the College of Engineering. **F. H. Edmunds,** M.E.I.C. (Liverpool '23) has been named head of the Department of Geological Sciences. He replaces **Dr. J. S. Mawdsley,** M.E.I.C., who is now dean of engineering.
O. L. Symes, M.E.I.C. (Sask. '48) has been made professor and head of the Department of Agricultural Engineering. Prof. Symes succeeds **Dr. C. D. Stewart,** M.E.I.C. (Utah Agcl. Coll. '53) who has resigned to enter private business.

O. L. Symes, M.E.I.C.

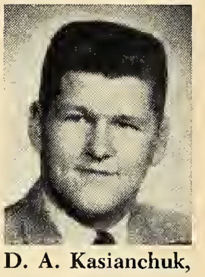
C. D. Stewart, M.E.I.C.

W. J. O'Reilly, JR.E.I.C. (Tor. '51) has accepted a position in Nantes, France, with the International Division of the American Can Company of Canada Limited. An active member of the Institute, Mr. O'Reilly has had to resign as chairman of the Niagara Branch.

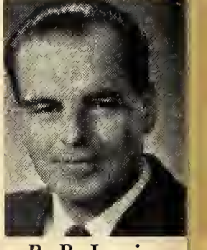
Emile Huni, M.E.I.C., (Zurich '37) formerly manager of the Canadian branch of the Soletange and Radio contracting group has opened a consulting practice in Vancouver. Mr. Huni, who has had 20 years experience in foundation problems, will act as consultant in soil investigation, drainage and foundation engineering.

C. H. Rosier, M.E.I.C. (N.S.T.C. '39) has been appointed vice president (Board Products) Abitibi Power and Paper Company, Limited, D. W. Ambridge, president announced recently. Mr. Rosier joined the Company in 1959 as vice president and general manager of the Alpena, Michigan office.

D. A. Kasianchuk, JR.E.I.C. (Man. '58) has left his post in the engineering department of Canadian National Railways, to join the staff of R. M. Hardy & Assoc. Ltd., Edmonton, Alta.



D. A. Kasianchuk, JR.E.I.C.



B. R. Lewis, M.E.I.C.

B. R. Lewis, M.E.I.C. (Sask. '47) formerly chief engineer of Omark Industries Ltd. Guelph, Ont., has been transferred to Portland Oregon as Chief Engineer of the parent firm, Omark Industries, Inc.

E. A. Allcut, M.E.I.C. (Birmingham '09) received the certificate of award for outstanding leadership in developing standards and codes, sponsored by the American Society of Mechanical Engineers.

G. Ross Lord, M.E.I.C. (Tor. '29), presented the certificate at the final joint spring meeting of the Ontario Section ASME and the Power Section of the Toronto Branch of the EIC.

Donald G. Laplante, JR.E.I.C. (Ecole Poly '52) formerly Sales Engineer with Dominion Bridge Company, Limited, Montreal, has been appointed Acting Manager, of the Company's Ottawa Plant.

John B. Carswell, M.E.I.C. (Glasgow '11) was recently elected to the board of directors of Bucyrus-Erie Co. of Canada Ltd., Guelph, Ont. A well known consulting engineer in Canadian business engineering and construction circles, Mr Carswell is a board member of The Mercantile Bank of Canada and the Guaranty Trust Co. of Canada.

(Continued on page 160)

FINAL REPORT OF THE ENGINEERS CONFEDERATION COMMISSION

Message from the President

Not since its inception has the Institute been confronted with a decision so important as that posed by the issue of Confederation. I urge you, therefore, to apply the same critical analysis that you would devote to any major engineering problem.

MISCONCEPTIONS

It is becoming obvious that there are misconceptions regarding Confederation. I have learned that a substantial number of our members are under the impression that the previous referendum gave a mandate to proceed with Confederation, and that we are now in the process of determining the basis on which it will be implemented. This is not the case. The vote merely granted authority to proceed with a fully detailed proposal indicating the organization, by-laws and procedure which the Engineers Confederation Commission would deem desirable for the implementation of Confederation. This proposal would then be submitted to the constituent bodies for their consideration. There was no implication that the membership should accept Confederation unless and until a plan can be drawn up which is satisfactory to the membership.

PLAN FOR PROCEDURE

Council proposes to obtain as much guidance and as many comments as possible from the Branches and from the individual members and if, as a result, changes in the present Commission Report appear to be desirable and are acceptable to both the Engineering Institute of Canada and the Canadian Council of Professional Engineers, revisions will be made and the revised report submitted for vote to the membership. If the type of Confederation proposed is acceptable in principle, the necessary EIC by-law changes will be drafted and submitted to the membership for further vote.

DISAPPOINTING INTEREST

It is very disappointing that only 34% of our membership voted on this important issue when an expression of opinion was sought in June, 1959. I want to emphasize that the Institute is not a Council and a President, it is not a headquarters organization, it is *you*. Council and headquarters are endeavouring to interpret *your* wishes and to make this Institute what *you* want it to be. If they are to succeed, you must express your desires and cooperate in every possible way. A 34% vote is not an adequate expression of opinion. This issue is so important that every voting member must study it carefully and make an unemotional assessment of the proposal itself and its implications. Express your views so that Council can interpret your wishes reliably. Your Branch is being urged to discuss the issue fully. Please do not fail to participate actively because the decision we make now may be irrevocable.

THE INSTITUTE'S REPUTATION

The Engineering Institute is essentially a learned society dedicated to the advancement of the engineering profession. It provides forums for the development of new engineering concepts and the dissemination of the information on these concepts to its members for their benefit and the benefit of Canada. The Engineering Institute has a long and honourable record. It has made very substantial contributions to engineering in Canada and its strength, particularly during the past few years, has increased notably. The quality of its publications has improved correspondingly, and they are winning the respect and even admiration of other engineering societies not only in Canada but abroad. I have heard non-members speak with envy of our achievements. We have provided a forum for engineering professors to permit the exchange of views on engineering education and I am convinced that the profession has gained as a consequence. Our technical activities are exciting interest. Our student program is highly regarded both by students and university staff, and I am certain that it has contributed to the effectiveness and the careers of many of our present members. We have sponsored technical studies (a current study deals with the problem of water pollution in Canada), and we have participated in many studies jointly with other organizations. Our contributions need no apology.

THE FUTURE OF THE INSTITUTE

Some members hold the view that the Institute can not survive except through Confederation. Without arguing the merits or demerits of the proposed Confederation plan, I do not believe that this viewpoint is warranted. I am convinced that the Institute can survive independently, and I believe that its increasing strength and activity is ample evidence of this fact. The question with which we are confronted is not that of survival of the Institute, but rather whether the profession will be best served by a merger or by continuance of the independent bodies now considering Confederation. Fear for the future of the Institute should not be a factor in the decision.

CRITICAL STUDY NEEDED

If we are agreed that the Institute's objectives are desirable, each member should satisfy himself that his decision will result in a continuing Institute of the kind he wants to have. If Confederation is adopted, our Institute will be vastly different from the one we know now. The objectives of the Engineering Institute and of the Provincial engineering bodies are very different. If you consider these objectives desirable, satisfy yourself that your decision will not affect them adversely, and that the objectives of the two groups are compatible for a joint Institute. The Engineering Institute, even more than the Provincial bodies, must give most serious consideration to the proposal because the adoption of the plan would mean a new charter, a new organizational structure, new by-laws and a new name, while the provincial bodies would remain essentially unchanged except that their members would be compelled to pay additional fees.

THE DECISION IS YOURS

If Confederation is adopted, it is inevitable that the compromise made by the Engineering Institute will not be attractive to our membership in all respects. Whichever way you decide, make certain, in your own opinion, that the advantages outweigh the disadvantages.

There are three choices: (1) Confederation may be adopted essentially as proposed by the Engineers Confederation Commission; (2) it may be modified; (3) the basic concept of Confederation can be rejected. Before you make your decision, read the report carefully. Weigh all the factors and then give Council the benefit of your views. The importance of the decision to be made can not be overestimated.

B. G. Ballard.

BRISTOW GUY BALLARD, Hon. M.E.I.C.
President, 1961-62
The Engineering Institute of Canada

FINAL REPORT
OF THE
ENGINEERS CONFEDERATION COMMISSION

On April 22, 1961, the E.I.C. Council received copies of the Final Report of the Engineers Confederation Commission, and authorized distribution at that time to Councillors-elect and to the Chairmen of EIC Branches and Sections. It was also decided that the entire membership of the Institute should be informed of the contents of the report, and instructions were given that the complete text be published in the September, 1961, issue of The Engineering Journal.

"The report was received officially of the E.I.C. at the 1961 Annual General Meeting held in Vancouver on Wednesday, May 31, 1961, and by the Canadian Council at their Annual Meeting in Edmonton on Wednesday, June 7th, 1961. At these meetings Mr. John H. Fox and Mr. Leo Roy, Chairman and Vice-Chairman respectively of the Engineers Confederation Commission, presented the report on behalf of the Commission.

"Both the E.I.C. Council and Canadian Council have taken action to appoint a committee to study and deal with the report in detail and to recommend regarding it to their respective Councils. Members are urged to read the report carefully and should they have views which they wish to express and draw to the Councils' special committees who will be studying the report, they may do so either directly by mail addressed to the General Secretary of the E.I.C. or through their E.I.C. branch Councillor, or through their Provincial Association or Corporation".

• • • • • • • • • • • •

The Engineers Confederation Commission begs to submit to the Canadian Council of Professional Engineers and its constituent bodies, and to the Engineering Institute of Canada, the following report of its activities, deliberations, conclusions and recommendations relating to the proposed confederation of the Canadian Council of Professional Engineers and the Engineering Institute of Canada.

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THE ENGINEERS CONFEDERATION COMMISSION
FINAL REPORT
INDEX

PART 1: INTRODUCTION

1.1 HISTORY AND BACKGROUND

Since 1925, the individual Professional Engineer in Canada has often been thinking of "Unity" for his profession. In December of that year, an invitation was sent by the Council of the Engineering Institute of Canada to each Provincial Association of Professional Engineers for a conference that was to be held in Montreal on February 2, 3, 4, 1926. The principal item on the agenda of that meeting was "Co-operation with the Engineering Institute of Canada".

It was not, however, until 1935 that concrete action was taken, when at the annual meeting of the E.I.C., held in Toronto on February 7, 1935, the following resolution was passed unanimously:

"That the Engineering Institute of Canada in Annual Meeting assembled, hereby goes on record as being in favour of the Consolidation of the Engineering Profession in Canada."

As a means of implementing the above resolution, a resolution constituting the "Committee on Consolidation" was passed. Attention is drawn to the fact that this movement was not initiated by the Council of the Institute.

Members appointed to the Committee on Consolidation were: R. E. Jamieson, Robert F. Legget, O. Lefebvre, G. J. Desbarats, A. R. Decary, J. B. Challies, Gordon McL. Pitts.

This committee made several unanimous recommendations, including the following:

"That in view of the general approval which has been given the broad principle of consolidation by the profession in Canada, The Engineering Institute of Canada take immediate steps to put the same into effect with those Provincial Professional Associations with whom satisfactory arrangements can be made",

and;

"That the Institute agree to act as the national body in the event of consolidation being consummated with any or all of the Provincial Professional Associations."

Since 1935, the following Professional Associations entered into an agreement with the Engineering Institute of Canada:

The Association of Professional Engineers of the Province of Nova Scotia—January 25, 1940

The Association of Professional Engineers of the Province of New Brunswick—January 12, 1942

The Corporation of Professional Engineers of Quebec—January 25, 1945

The Association of Professional Engineers of the Province of Manitoba—December 9, 1950

The Association of Professional Engineers of Saskatchewan—October 29, 1938

The Association of Professional Engineers of Alberta—December 14, 1940

The Association of Professional Engineers of the Province of Prince Edward Island—September 25, 1957.

The ultimate results envisaged by the committee were not reached and total "consolidation" was still an objective to be arrived at in the year 1953. In that year, the subject was again brought to the fore in the thinking of Canadian Professional Engineers, when J. Herbert Smith, P.Eng., delivered his famous and inspirational address outlining his plan for "Unity". This speech was published in the December issue of "The Professional Engineer", by the Association of Professional Engineers of the Province of Ontario.

The plan was approved in principle by the Ontario Association and by the Quebec Corporation in 1954.

At the annual meeting of Dominion Council in 1954, it was agreed unanimously to establish a national committee under the chairmanship of J. Herbert Smith, and composed of L. B. Stacey (Western Canada), R. F. Shaw (Central Canada) and D. S. MacNeil (Eastern Canada), representing the Dominion Council; and R. E. Heartz representing the E.I.C. This committee was requested to try to find ways and means of implementing the "Plan of Unity" as outlined by the Chairman. The Canadian Institute of Mining and Metallurgy and The Chemical Institute of Canada were both invited, but declined to participate at this stage.

At the annual meeting of Dominion Council in 1955, the "Committee on Unity" reported good progress. The Committee was then asked to meet with a committee which had been carrying on a similar assignment within the E.I.C., under the chairmanship of R. E. Heartz. The two committees worked together throughout 1955, and in May, 1956, these committees produced a joint report which was submitted to both the E.I.C. Council and the Dominion Council, at their annual meetings of that year.

The report recommended the basic organization and objectives for a proposed national organization which would be created by confederation of the E.I.C. and the Dominion

Council of Professional Engineers. An estimate of the annual costs of operating a national organization was also included.

At the annual meeting of Dominion Council in 1956, the report was considered and several resolutions were made regarding the "Plan for Unity". It was resolved to receive the report, and it was recommended that it be sent to all Provincial Associations and the Corporation for study. Each Association and the Corporation were asked to form committees to report views and make recommendations to the Dominion Council Committee on Confederation, so that the latter could submit its final report direct to Dominion Council at the earliest possible date.

The E.I.C. Council, which had also reviewed the joint report, formed a Committee on Confederation. This Committee met separately on several occasions and also jointly with the Dominion Council Committee. The members of the committees were:

E.I.C.	Dominion Council
I. R. Tait, Chairman	J. Herbert Smith, Chairman
T. Foulkes (Ontario)	O. Turnbull (Atlantic Provinces)
H. Gaudefroy (Quebec)	G. Piette (Quebec)
H. W. L. Doane (Atlantic Provinces)	John H. Fox (Ontario)
L. Hammerschmid (Quebec)	J. G. Dale (Prairie Provinces)
H. Libby (Pacific)	W. O. Richmond (Pacific)
J. McMillan (Prairie Provinces)	
W. S. Wilson (Ontario)	
L. A. Wright (ex-officio)	

At the annual meeting of Dominion Council held in Halifax on May 24, 1957, it was resolved to adopt eight basic principles for confederation. Once again, that Council reaffirmed its stand on the desirability of "unity" and its belief that all possible efforts should be made to hasten its achievement.

A report containing the same eight basic principles was forwarded to the E.I.C. and was discussed at the annual meeting of the E.I.C. Council held in Banff, Alberta, on July 11, 1957.

After the adoption of the eight basic principles for confederation at the 1957 meeting of Dominion Council, a committee under the chairmanship of John H. Fox was appointed with instructions to meet with a similar committee appointed by the E.I.C. to investigate the feasibility for the confederation of the two organizations under one national organization. The latter committee was under the chairmanship of Irving R. Tait.

The first joint meeting of the two committees was held in Toronto on January 18, 1958.

The combined committees unanimously agreed to a series of general principles embodied in the first seven clauses of their report. A joint subcommittee was appointed to investigate the budgetry and staff requirements for a national organization and they agreed unanimously on the eighth clause covering this subject.

A report, signed by John H. Fox on behalf of C.C.P.E. and Henri Gaudefroy on behalf of E.I.C. was submitted to and approved in principle by the Canadian Council, (formerly the Dominion Council) at its annual meeting at Vancouver on May 9, 1958 and by the E.I.C. at a plenary meeting of Council held in Quebec City on May 19, 1958.

Canadian Council agreed that the general principles should be submitted to the respective provincial councils but that the membership should not be consulted until a final constitution and by-laws were agreed upon.

Following the annual meetings in 1958 of Canadian Council and of the E.I.C. Council, the same committee was re-appointed with instructions to continue its work and prepare as quickly as practicable, a statement embodying an outline of objectives for a national organization all for presentation to, and if possible balloting by the membership of E.I.C. and approval by the Council of each Provincial and Territorial Association and Corporation.

A joint committee report was submitted on November 6, 1958. It had been approved unanimously by all sixteen members of the committees. At the E.I.C. Council meeting on January 31, 1959, the following motion was approved:

"That this meeting of the Council of the E.I.C. 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 9th, 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."

The final report of the Joint Committee was presented on March 18, 1959. (See Appendix "A".)

1.2 AUTHORITY AND TERMS OF REFERENCE

In accordance with Part E of the report of the Joint Committee on Confederation, the following ballot was submitted to all paid-up corporate members of the E.I.C. in June, 1959:

"Do you approve of the principle of Confederation of the engineering profession in Canada on the basis of the outline submitted in the accompanying report and on the understanding that a fully detailed and final proposal, including the necessary regulations and by-laws, to be drawn up by the Engineers Confederation Commission, will be submitted to you for approval?"

10,835 ballots were mailed and 3,837 ballots were received, and the result as follows:

(a) in favour	3,628
(b) against	192
(c) spoiled	2
(d) unidentified outer envelopes	15

Following this ballot, the Council of the E.I.C. appointed its representatives to the Commission.

The following resolution was adopted unanimously at the 22nd annual meeting of Canadian Council held in Winnipeg on May 22, 1959:

"Resolved that Canadian Council of Professional Engineers approves the report of the joint Committee on Confederation dated March 8, 1959, and adopts same, it being understood that the Associations and the Corporation are not hereby committed to approve the final Constitution of the proposed National Body until and unless they have formally accepted this final document, and that the Canadian Council of Professional Engineers and the various Associations and Corporation appoint their representatives to the Engineers Confederation Commission so that action may be taken as soon as approval of the Engineering Institute of Canada is received."

The duties of the "Commission" were to be:

To draw up a constitution, by-laws, and legal details for the confederation of the Engineering Institute of Canada and 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 being used as an interpretive guide to the Commission.

1.3 COMPOSITION OF THE COMMISSION

The "Engineers Confederation Commission" was composed of the following members:

Chairman	—	John H. Fox
*Vice-Chairman	—	George McK. Dick, succeeded by Léo Roy
†Alberta	—	J. McMillan, J. G. Dale, the latter succeeded by J. F. McDougall
British Columbia	—	F. A. Foward, W. K. Gwyer
Manitoba	—	T. E. Storey, N. S. Bubbis
New Brunswick	—	T. C. Higginson, J. O. Dineen
Newfoundland	—	J. B. Angel
‡Nova Scotia	—	G. F. Bennett, J. Hoogstraten, the latter succeeded by F. G. Vail
Ontario	—	T. Foulkes, D. D. Whitson, C. T. Carson, L. D. Dougan
Prince Edward Island	—	W. R. Brennan
§Quebec	—	E. D. Gray-Donald, H. Gaudefroy, H. Cimon, L. Roy, the last succeeded by J. Lemieux
Saskatchewan	—	J. C. Traynor, J. B. Mantle
Yukon	—	E. W. King
Joint Secretaries	—	L. M. Nadeau, Garnet T. Page

NOTES:

*Léo Roy was appointed Vice-Chairman when George Dick resigned to become President of E.I.C. in May, 1960.

†J. F. McDougall was appointed to replace J. G. Dale when the latter resigned to become President of C.C.P.E. in May, 1960.

‡G. F. Vail was appointed to replace J. Hoogstraten when the latter moved from Halifax to Winnipeg in the spring of 1961.

§J. Lemieux was appointed to replace Léo Roy when the latter became Vice-Chairman of this Commission in May, 1960.

1.4 MEETINGS—COMMITTEES—SUMMARY OF OPERATION

The Commission held four plenary meetings in Toronto.

FIRST MEETING—October 18, 1959

At this meeting D. O. Turnbull, President of C.C.P.E. and J. J. Hanna, President of E.I.C. expressed hope that a final report would be forthcoming in time for consideration at the annual meetings of the two bodies in 1961.

At this meeting also, the Commission members were 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 were:

Committee on Charter—To draft a complete charter using the E.I.C. charter as a basis if possible.

Committee on By-Laws—To draft all necessary By-Laws assuring that these are consistent with the charter.

Committee on Administration—To spell out the broad lines of how the new national organization will be administered.

Committee on Finance—To work out the details of how the new body will be financed in co-operation with the Committee on Administration

Committee on Branches—To determine how the branches will be formed, financed, operated, etc., and their relationship with the national organization and the Provincial Associations.

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 societies) as distinct from the two participating groups.

Committee on Services—To outline the various services to be performed by the new national organization.

Committee on Relationship with the Provincial Associations—To establish the relationship between the new national organization and the Provincial Associations.

Co-Ordinating Committee—To co-ordinate the work of the committees and to establish the details of implementation of the decisions of the commission.
The members of this committee were the chairmen and/or vice-chairman of all committees. Its chairman and vice-chairman were the Chairman and Vice-Chairman of the Commission.

SECOND MEETING—April 23, 1960

A meeting of the Co-Ordinating Committee was held on March 6, 1960 to review the work of the different committees. Much work had been done, and a second plenary meeting became necessary, and was held on April 23, 1960. A progress report was then submitted but no concrete proposals were as yet ready for publication. Since the Commission was responsible, and had to report to the Councils of E.I.C. and C.C.P.E., it adopted as a policy that information relative to details of its work would not be made public until firm and definite decisions had been made. At this meeting it was decided to obtain legal opinion regarding the charter and by-laws.

THIRD MEETING—November 25, 26, 27, 1960

Following the third plenary meeting a news release was issued, including the following statements:

"The Commission received for consideration the complete text of a proposed charter and proposed by-laws for a new national organization as required under the Terms of Reference of the Commission, and preliminary proposals for the financing of this proposed organization.
This was the culmination of a tremendous amount of work and study by a representative group of 25 engineers from all parts of Canada who have been given the responsibility, by their profession, of drafting a complete and detailed proposal for the consideration and unification of the engineering profession in Canada.
Since October 1959, when the commission and its eight committees became operative, a total of 68 recorded formal meetings and a large number of informal meetings were held, during which some 8,000 man-hours were spent by the 25 delegates who had to travel collectively an estimated total of 300,000 miles to attend these meetings.
After thirteen months during which each important aspect of the plan was carefully studied, both individually and in relation with other aspects, the commission was finally in a position to consider a complete project and, as a result, several important decisions were taken although many details remain to be worked out."

FOURTH MEETING—March 1, 1961

At the fourth plenary meeting of the Commission final decisions were reached and are here reported. It was agreed that this complete report be made available in the English and French languages.

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PART 2: SUMMARY OF PROPOSALS

2.01 PREAMBLE

This section deals with decisions taken to provide the basis and procedures for "confederation". The terms of the report of the Joint Committee on Confederation, dated March 18, 1959, have been retained to provide the principles for all decisions. That report will henceforth be called the "Joint Report".

The details of procedure to accomplish, and the organization of, a confederated body of Professional Engineers are here outlined. The Commission believes that these details are consistent with the terms of reference of the Commission.

The terms of reference of this Commission clearly state that it shall be concerned with the drawing-up of a constitution (Charter or Act), By-Laws, and with the preparation of legal procedural details for confederation. (See Part "D", para. 4, sub-section (a) of the Joint Report.)

Therefore no recommendations are made in regard to the desirability of confederation or not. This report deals only with matters of charter, by-laws, and legal procedures to accomplish such confederation, within those terms of reference.

2.02 CHARTER

It is recommended that the present charter of the Engineering Institute of Canada, granted in 1918 as an amendment of the original charter of 1887, be amended by an Act of the Parliament of Canada. Under this plan all of the original and extensive privileges of the Acts of 1887 and 1918 would be retained, the properties and assets would be continued within a continuing corporation, and membership rights would be protected.

The amended charter would provide objectives and activities broader in scope and more consistent with the present and future needs of Professional Engineers.

The new charter would also allow for broader membership, while preserving the vested rights of present members of the Engineering Institute of Canada.

The proposed charter is published in complete detail in Section 3 of this report.

Full Membership is to be confined to members of the Canadian provincial and territorial associations and corporation of Professional Engineers. Membership qualifications are established within the proposed By-Laws (see Section 4 of this report). Grades of membership are permitted within the charter.

Retention of the present charter, fully amended, was judged to be the best course; after having given full consideration to other possible procedures.

2.03 NAME

It is recommended that the name of the new national body be "The Canadian Institute of Professional Engineers".

Throughout the balance of this report, this title will be referred to by the initials "CIPE".

It was felt that the selection of any name should contain components of words significantly indicating that the body was one of national scope; that it would be very desirable to retain for historical reasons the word "Institute"; and, most essentially, that the title of the organization indicate that it was one of Professional Engineers.

These elements have been accomplished in the name recommended.

2.04 HEADQUARTERS

Clause 7 of the Joint Report states that the location of headquarters would be the responsibility of the early councils.

In the preparation of the proposed charter and proposed By-Laws for the new national organization it is clearly stated that the location of the national headquarters shall be in the City of Ottawa.

Re-location of the headquarters is permitted under the terms of the proposed charter by revision of the By-Laws only.

It will be recognized that, in drafting any charter or by-laws, positive statements as to location must be made. The definite statement as to location is not inconsistent with Clause 7 nor the comments in regard to that clause in the Joint Report.

2.05 OBJECTS

Throughout all of the deliberations an effort was made to ensure that the original "objects" of the two parties to confederation would be retained. This has been done. The original "objects" of both parties to the proposed confederation have been combined and enlarged and yet remain consistent with the terms of Clause 1 and comments applicable to that clause of the Joint Report.

Thirteen basic objects are detailed in the proposed charter (Part 3 of this report), and are repeated in the proposed by-laws, (Part 4 of this report). These objects are broad in concept, and their scope would permit the functioning of the organization to the greatest benefit to the Profession in terms of the Act and the By-Laws are considered to be permissive and not restrictive.

2.06 PARTICIPATING ASSOCIATIONS

Under the terms of the Joint Report, this Commission has confined all of its deliberations and recommendations to the joining together of the Engineering Institute of Canada and the Canadian Council, in association with the eleven Canadian provincial and/or territorial Associations and the Corporation of Professional Engineers.

Provision has been made within the proposed charter and by-laws for affiliation or agreement with any body or society having objects similar or comparable to the proposed new national organization. Under this provision, future councils may develop association with other groups of Professional Engineers, who are recognized to have qualifications consistent with and objectives compatible with those of CIPE.

2.07 RIGHTS OF PROVINCIAL ASSOCIATIONS

The protection of the rights of provincial or territorial associations was paramount in all deliberations. According to the proposed charter those rights are inviolate, (see Part 3, item 13). The proposed by-laws ensure that items concerning joint activities with provincial associations are consistent with activities of the provincial assocation concerned. The proposed charter and by-laws clearly state that membership in CIPE does not grant the right or privilege to practise the profession of engineering. This is a provincial responsibility.

2.08 MEMBERSHIP

Clause 2 of the Joint Report stated positively that the only means of gaining full membership in the new national organization was by membership in a Canadian provincial or territorial association or corporation of Professional Engineers. Full membership is routine for members holding registration in one of these associations or corporation. Problems, however, did exist to make provision for the adequate legal, financial, and residential status of the various grades of membership within the Engineering Institute of Canada; provision has been made in the proposed charter to allow for their continued membership through appropriate grades.

2.081 Classes of Membership

The proposed By-Laws outline in detail the classes of membership, (see By-Laws, Articles 6 to 14), as follows:

(a) **Fellows**—a selected group of Members, to be elected from the body of Members in recognition of outstanding engineering accomplishment. Professional Engineers holding Honorary

Membership in the Engineers Institute of Canada and, at the request of the participating associations, professional engineers holding such Honorary Memberships in these associations would be offered this classification at the time of confederation.

(b) **Members**—those persons registered by a Canadian provincial or territorial association or corporation of Professional Engineers.

(c) **Junior Members**—those persons duly registered or recorded by a Canadian provincial or territorial association or corporation as a junior Professional Engineer or engineer-in-training.

(d) **Corresponding Members**—those persons who possess qualifications acceptable for registration in a Canadian provincial or territorial association or corporation, yet who by reasons of non-residence in Canada cannot gain such registration and would otherwise be denied membership in CIPE.

This class of member, by reason of non-residence, will always be unable to hold office and cannot gain registration by a Canadian provincial association for the purposes of the practice of Professional Engineering. He can however participate in the technical aspects of the proposed national body.

(e) **Honorary Members**—This class of membership is provided for those persons to whom special recognition is proposed. They shall be persons of distinction in fields of endeavor allied to or associated with the engineering profession. They may not be registered as professional engineers in Canada.

There may not be more than 25 living Honorary Members at any one time.

Election to Honorary Membership would be gained through national council action only. Those persons presently holding Honorary Membership in the Engineering Institute of Canada and not registered as professional engineers in Canada would be offered this grade of membership at the time of Confederation.

(f) **Technical Associates**—those persons who, at the time of confederation, are members of The Engineering Institute of Canada and who do not possess qualifications for admission to corporate membership in the Institute shall be admitted as Technical Associates. This special class of membership shall be limited to such members of The Engineering Institute of Canada and after the date of confederation no further persons shall be admitted as Technical Associates.

(g) **Student Members**—engineering students so registered or recorded by a Canadian provincial or territorial association or corporation of professional engineers either attending a recognized university or school of engineering, or preparing for the regular examinations of one of the aforementioned bodies.

2.082 Corporate and Voting Membership

The corporate membership of the Institute shall comprise the members of the Institute who are classed as Fellows, Members and Junior Members.

The voting membership of the Institute shall comprise all classes of membership except Honorary Members and Student Members.

2.083 Protection of Rights of Present Membership

As stated at the outset of Section 2.08 of this report, no problem existed in regard to provision for the membership of the provincial associations. Certain problems did exist for the various grades of membership within the Engineering Institute of Canada. With the provision for grades of membership as detailed in the proposed by-laws and as briefly explained in Section 2.081 of this report, it is believed that adequate provision has been made for the vast majority of the membership.

There is a group within the membership of the Engineering Institute of Canada who, for various reasons, have not sought registration in a Canadian provincial association or corporation of Professional Engineers. To provide for their membership in CIPE, which is an essential requirement of Confederation, a special membership classification known as "Technical Associate" is established. Technical Associates would have full voting power in CIPE.

This classification would comprise members, junior members and life members of the Engineering Institute of Canada who, at present, are not registered in a Canadian provincial association or corporation. Technical Associates could transfer to the grade of Member by registering, if qualified, in one of the Canadian provincial registering bodies.

Admission to the class of Technical Associate would be closed when confederation is completed and no additional members would be accepted in this category.

2.09 ORGANIZATION AND MANAGEMENT

2.091 The Council

The affairs of CIPE would be administered by a Council within the terms of the proposed charter and the by-laws.

Membership of the Council would be composed of both elected representatives and appointed representatives from each of the Canadian provincial or territorial associations or corporation of Professional Engineers, all to be supported by permanent staff adequate to administer the policies and programmes developed by Council.

Section 15 of the proposed by-laws outlines in detail the composition of the membership of the Council, the method of securing proportional and territorial representation, those offices that are elective, and those that are appointive. Appendix "B" of this report details a recommended distribution of representation on the first Council.

Sections 16 to 21 of the proposed by-laws outline in considerable detail the duties and responsibilities of the Council, the Officers, the Councillors, the Executive Committee, the appointed General Manager, and their terms of office. These sections of the proposed by-laws would, with some exceptions, become operative at the time of the election of the first Council.

Appendix "C" of this report outlines a method of accomplishing a rotation of membership and length of term on the first elected Council, so that a proportion of Council members would remain on Council each year to provide continuity of council experience.

2.092 Boards

The principal areas of activity of the national organization would be divided into two parts.

The Board on Professional Interests would deal with matters of professional interest, while the Board on Technical Services would deal with matters of a technical connotation. Both Boards would be responsible directly to the Council.

Reference should be made to the organization chart in Appendix "D" for an understanding of the proposed organization and the proposed lines of responsibilities. It is contemplated that the representatives appointed by the participating associations would compose the membership of the Board on Professional Interests, because the functions of that board concern directly the activities of the provincial associations.

The Board of Technical Services would be composed, in the majority, of representatives elected by the membership. Their concern would be with matters dealing, for example, with technical education, student affairs, development of technical papers, and matters concerned with the development of the individual's technical interests and competence.

The composition and details of the duties of the boards and their committees is outlined in detail in the proposed by-laws, Sections 22 to 26.

2.093 Committees

The functions of standing committees would concern matters which cannot logically be dealt with by one or the other board since they embrace both categories of activities.

The four proposed standing committees are as follows:

(a) **Publications Committee**—to deal with the publication of a journal, transactions, etc., in accord with membership needs under direction of the Council.

(b) **Finance Committee**—to deal with the financial operation of the CIPE.

(c) **Honors & Awards Committee**—to administer present or future awards; to ensure that deeds of trust are complied with; and to ensure that worthy candidates are recommended for recognition or award. Scholarship programmes would be administered by this committee.

(d) **Committee on Branches**—this committee may be considered to be one of the most important groups within the national organization.

It would be charged with the encouragement, development, and organization of branches, all in the fullest co-operation with the provincial associations.

This committee would endeavor to co-ordinate and unify branch activities and in every way promote a dynamic membership activity through branch programmes.

It is recognized that, as time goes forward and programmes are developed, many more committees will have to be formed from the membership, all in addition to the above named Standing Committees.

2.10 BRANCHES

Under the terms of Clause 5 of the Joint Report, it was indicated that branches should be formed.

Under the terms of the proposed charter branches may be developed and operated within CIPE.

Sections 27 to 37 of the proposed by-laws outline in considerable detail the programme envisaged to provide for the development of branches, the method of co-operation with the provincial associations, and the services and assistance that may be given to branches by the national organization.

It is anticipated that in those locations where there is at present only one branch representing the Engineering Institute of Canada or a provincial association, that branch will continue to operate under the new national organization with a minimum of transition to be consistent with the new organization. In locations where two or more branches of either group or groups are at present operating, it is anticipated that by mutual agreement of the branch membership, the provincial association, and the national organization, such overlapping groups will be consolidated into one branch.

To assist in the formation and the unification of branch proceedings, compatible with the proposed by-laws, a suggested draft of a Branch Model By-Laws is given in Appendix "C".

2.11 REGIONAL BRANCH CONFERENCES

As an extension of branch interest and activities, sections 38 to 44 of the proposed by-laws provide for the development of Regional Branch Conferences should such development be requested. It is visualized that the members of two or more neighboring branches may wish to meet together to discuss mutual professional or technical problems. It is considered that such activities are to be encouraged.

2.12 STUDENT CHAPTERS

As an extension of branch activity, provision has been made within sections 44 to 49 of the proposed by-laws for the continuance or formation of student chapters at those universities which offer courses in engineering. Suggestions are made as to the methods of administering a student chapter, at all times consistent with the co-operation and assistance of the provincial association of the province in which the university is located.

2.13 FINANCES

The proposed charter and by-laws make provision for the handling and administration of funds—either in the forms of assessment income, investments, or trusts.

The details of financial administration as at present envisaged are dealt with in sections 62 to 67 of the proposed by-laws.

A complete survey of financial needs was made in the light of to-day's conditions and costs, an initial programme combining the essential activities of both the Canadian Council and the EIC and an anticipated membership of 40,000. A complete budget has been established and is published in Part 5 of this report. It is planned that this budget would be the average required for each of the first three years of operation. This plan is consistent with the terms of the proposed by-laws in that assessments are subject to revision at intervals of not less than three years. (See Section 64, sub-section (a) of the proposed by-laws.)

It is anticipated the collection of CIPE dues would be made through the provincial or territorial association or corporation.

No statement is made in regard to the many real or invested assets, particularly those held in the name of the Engineering Institute of Canada. It is felt that incomes from such investments be used to maintain the prizes and awards now in effect, to capitalize those memberships now held on a paid-up basis, or any other approved purposes.

No income has been indicated as being available from the publication of a national journal. At the present time, it is felt that there are too many uncertainties as to this potential source of income. Income could probably be developed as time goes on. At present it would almost certainly be capable of being a self-sustaining operation with the possibility that it may be capable of sustaining other publications on a no cost basis as well.

It is recommended that the Library and Employment Services be discontinued and no budget provision appears for these items.

2.14 DISCIPLINE

Disciplinary action of CIPE is provided within the proposed charter and by-laws, insofar as membership in the national body is concerned. It is anticipated that any disciplinary actions will reflect such actions by the Canadian provincial and territorial associations or corporation and would follow them.

Direct disciplinary action is provided for special classes of members who are not governed by provincial associations.

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PART 3: THE CHARTER

A draft of a proposed charter has been prepared, entitled: "The Canadian Institute of Professional Engineers Amendment Act 19—"

The charter has been prepared in such a manner that, in the opinion of legal counsel, it would protect the interest of all parties to any agreements, preserve the many desirable aspects of the Engineering Institute of Canada Act of 1887 and amendment of 1918, and also would give flexibility to the development of a national organization of professional engineers.

In the opinion of legal counsel, this charter as drafted would probably be acceptable to the parliamentary committees who must approve it prior to being granted.

The draft of the charter is presented here in complete detail.

THE CANADIAN INSTITUTE OF PROFESSIONAL ENGINEERS AMENDMENT ACT, 196 AS APPROVED BY THE ENGINEERS CONFEDERATION COMMISSION AT ITS MEETING OF MARCH 11, 1961

WHEREAS The Engineering Institute of Canada, a corporation incorporated by an Act of the Parliament of Canada has by its petition prayed that it be enacted as hereinafter set forth and it is expedient to grant the prayer of the petition: Therefore Her Majesty by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:—

1. This Act may be cited as The Canadian Institute of Professional Engineers Amendment Act, 196—.

2. Chapter 124 of the statutes of 1887 and Chapter 69 of the statutes of 1918 are repealed and their provisions are replaced by the provisions of this Act.

3. The said repeal shall not in any way affect the corporate existence of The Engineering Institute of Canada and The Engineering Institute of Canada shall continue to be the same corporation as that constituted by the said Chapter 124 of the statutes of 1887 as amended by Chapter 69 of the statutes of 1918 and to be composed of the existing members of The Engineering Institute of Canada, whose rights and liabilities, except as modified by this Act, shall not be affected by the said repeal, and of those who are from time to time hereafter admitted to membership, and to be the owner of and entitled to the property and estate of The Engineering Institute of Canada and subject to the undertakings and liabilities of The Engineering Institute of Canada.

4. The name of The Engineering Institute of Canada is hereby changed, in English, to The Canadian Institute of Professional Engineers, and in French, to L'Institut Canadien des Ingénieurs Professionnels, hereinafter called "the Canadian Institute",: but such change in name shall not in any way impair, alter or affect the rights or liabilities of the corporation nor in any way affect any suit or proceeding now pending or judgment existing either by or in favour of or against the corporation which notwithstanding such change in the name of the corporation may be prosecuted, continued, completed and enforced as if this Act had not been passed.

5. The head office of the Canadian Institute shall be in the City of Ottawa, in the Province of Ontario, or in such other place in Canada as is from time to time determined by by-law by the Canadian Institute.

6. The objects of the Canadian Institute shall be:—

(a) To develop and maintain high standards in the engineering profession.

(b) To facilitate the acquirement and interchange of professional knowledge among its members.

(c) To advance the professional, social and economic welfare of its members.

(d) To assist in the development throughout Canada of uniform registration requirements and examination standards for the engineering profession.

(e) To act in an advisory capacity in connection with legislative matters common to professional engineering bodies throughout Canada.

(f) To promote a knowledge and appreciation of engineering and of the engineering profession and to enhance the usefulness of the profession to the general public.

(g) To collaborate with universities and other educational institutions in the advancement of engineering education; to encourage original research and the study, development and conservation of the resources of Canada.

(h) To establish and maintain a bond between associations recognized by the Canadian Institute as participating associations to promote the welfare of the engineering profession in Canada.

(i) To provide a forum for the discussion of problems common to all engineering bodies.

(j) To publish a national journal and such other technical and professional papers and transactions as may be of assistance to its members.

(k) To promote intercourse between engineers and members of allied professions.

(l) To co-operate with other societies for the advancement of mutual or national interests.

(m) To act as a national voice speaking on behalf of all the professional engineers of Canada.

7. The following associations of professional engineers and such other provincial or territorial associations of professional engineers in Canada as may be recognized by the Canadian Institute in accordance with its by-laws may be participating associations of the Canadian Institute, provided such associations give their consent and possess the capacity and power to do so, until their status as participating associations has been terminated by withdrawal or by cancellation of recognition by the Canadian Institute:

- The Association of Professional Engineers of Alberta
- The Association of Professional Engineers of the Province of British Columbia
- The Association of Professional Engineers of the Province of Manitoba
- The Association of Professional Engineers of the Province of New Brunswick
- The Association of Professional Engineers of the Province of Newfoundland
- The Association of Professional Engineers of the Province of Nova Scotia
- The Association of Professional Engineers of the Province of Ontario
- The Association of Professional Engineers of the Province of Prince Edward Island
- The Corporation of Professional Engineers of Quebec
- The Association of Professional Engineers of Saskatchewan
- The Association of Professional Engineers of the Yukon Territory

8. The property and affairs of the Canadian Institute shall be managed and directed by a Council possessing such powers and consisting of such elected or appointed members as the by-laws of the Canadian Institute may provide.

9. Subject to the approval of the Council the Canadian Institute may from time to time enact, amend and repeal by-laws and regulations not contrary to law, nor inconsistent with the provisions of this Act for any and all purposes of the Canadian Institute, and in particular, without limiting the

generality of the foregoing, the Canadian Institute shall have power to define and regulate:

(a) the terms and conditions of membership and of classes of membership in the Canadian Institute and the qualifications for admission, the grounds for expulsion and the rights, duties and privileges of members;

(b) the terms and conditions on which an association may be recognized as a participating association and on which such recognition may be withdrdawn;

(c) the membership of the Council of the Canadian Institute;

(d) the number of members which each participating association may appoint to the Council of the Canadian Institute and the method of making such appointment;

(e) the administration, management and control of the property, business and other affairs of the Canadian Institute and for the delegation of these powers to the Council;

(f) the appointment, designation and the determination of the functions, duties and remuneration of all officers, agents and servants of the Canadian Institute;

(g) the appointment of committees and the designation of their powers and duties;

(h) the calling of meetings, annual or special, of the Canadian Institute and of meetings, periodical or special, of the Council of the Canadian Institute and of committees;

(i) the fixing of the quorum necessary at, the procedure in all respects at or concerning all and other requirements of, any meeting of the Canadian Institute or of its Council or committees;

(j) the establishment, objects, membership, management, responsibilities and dissolution of branches, regional branch conferences and student chapters;

(k) the mode of enacting, amending and repealing by-laws and regulations;

(l) the indemnification or other protection of officers and members of Council or of a committee against liability in performance of their official duties;

(m) all other matters relating to the administration and management of the business and affairs of the Canadian Institute and the furthering of its objects and purposes.

10. Upon coming into force of this Act, the present by-laws of the Canadian Institute shall be repealed, and the by-laws of the Canadian Institute shall be the by-laws heretofore approved, subject to the condition that this Act shall come into force, by letter ballot by members of the Canadian Institute, until such by-laws are amended or repealed. The officers and members of Council of the Canadian Institute holding office at the time of the coming into force of this Act shall continue to hold office until their successors have been appointed or elected in accordance with the provisions of the by-laws.

11. The Canadian Institute may for the purpose of carrying out its objects:

(a) subject to provincial laws:

(i) acquire by purchase, lease, gift, legacy or otherwise and real and personal estate and property, rights and privileges;

(ii) own and hold any such estate, property, rights or privileges and;

(iii) sell, manage, develop, lease, mortgage, dispose of or otherwise deal therewith in such manner as the Canadian Institute may determine;

(b) Make, accept, draw, endorse and execute bills of exchange, promissory notes and other negotiable instruments;

(c) invest funds of the Canadian Institute in such manner and upon such securities as may be determined;

(d) borrow money as and when required for the purposes of the Canadian Institute;

(e) establish branches, regional branch conferences and student chapters;

(f) apply for, promote and obtain any statute, ordinance, order, regulation or other authorization or enactment that may seem calculated directly or indirectly to benefit the Canadian Institute or its members and to oppose any proceedings or application that may seem calculated directly or indirectly to prejudice the interests of the Canadian Institute or its members.

(g) establish and support or aid in the establishment and support of associations, institutions, funds, trusts and projects calculated to benefit the Canadian Institute or its members in any way and subscribe or guarantee money for educational or scientific objects or for any public, general or useful object;

(h) do all such other lawful acts and things as are incidental or may be conducive to the attainment of the objects of the Canadian Institute.

12. The Canadian Institute may affiliate or make agreements with any body or society having objects similar or comparable to those of the Canadian Institute.

13. Nothing in this Act shall be deemed to encroach upon the rights and privileges conferred by and/or granted to any association of professional engineers under the laws of any province or territory of Canada or which may hereafter be conferred by and/or granted to any association of professional engineers under the laws of any province or territory of Canada.

14. Nothing in this Act shall be interpreted as giving the Canadian Institute the power to give to its members the right to practice the profession of engineering or to use the title "Professional Engineer" or "Engineer".

PART 4: THE BY-LAWS

The proposed by-laws have been prepared to conform with the terms of the proposed charter. Legal consel advises that these by-laws will protect the interests of all parties to any agreement and the membership from the legal point of view.

The basic intent of the proposed by-laws is to provide for permissive action and not to restrict a broadening of activities, should such seem desirable, in the opinion of the Council or the Membership.

The complete text of the proposed by-laws follows:

THE CANADIAN INSTITUTE OF PROFESSIONAL ENGINEERS BY-LAWS AS APPROVED BY THE ENGINEERS CONFEDERATION COMMISSION AT ITS MEETING OF MARCH 11, 1961

1 NAME

The name of the Institute is, in the English language, "THE CANADIAN INSTITUTE OF PROFESSIONAL ENGINEERS" and, in the French language, "L'INSTITUT CANADIEN DES INGENIEURS PROFESSIONNELS".

The approved abbreviation for the name of the Institute is, in the English language, "CIPE" and, in the French language, "ICIP".

2 OBJECTS

The objects of the Institute are:

(a) To develop and maintain high standards in the engineering profession.

(b) To facilitate the acquirement and interchange of professional knowledge among its members.

(c) To advance the professional, social and economic welfare of its members.

(d) To assist in the development throughout Canada of uniform registration requirements and examination standards for the engineering profession.

(e) To act in an advisory capacity in connection with legislative matters common to professional engineering bodies throughout Canada.

(f) To promote a knowledge and appreciation of engineering and of the engineering profession and to enhance the usefulness of the profession to the general public.

(g) To collaborate with universities and other educational institutions in the advancement of engineering education; to encourage original research and the study, development and conservation of the resources of Canada.

(h) To establish and maintain a bond between associations recognized by the Canadian Institute as Participating Associations to promote the welfare of the engineering profession in Canada.

(i) To provide a forum for the discussion of problems common to all engineering bodies.

(j) To publish a national journal and such other technical and professional papers and transactions as may be of assistance to its members.

(k) To promote intercourse between engineers and members of allied professions.

(l) To co-operate with other societies for the advancement of mutual or national interests.

(m) To act as a national voice speaking on behalf of all the professional engineers of Canada.

3 EMBLEM AND CORPORATE SEAL

There shall be an emblem and a corporate seal of the Institute which shall be as prescribed by the Council of the Institute.

The emblem shall be used only on official Institute stationery including the stationery of branches, divisions, chapters and committees, on official badges, seals, and other articles as may be approved by the Council, and on the Institute's publications. This emblem shall not be used on the letterheads and other stationery of members. Members of the Institute who wish to identify themselves as such shall do so solely by the designation of their grade of membership as defined in these By-laws.

The Corporate Seal of the Institute shall be used only as directed by the Council of the Institute on documents which may require official certification. When used, the Corporate Seal must be countersigned by the President or one of the Vice-Presidents, and by the General Manager.

4 HEAD OFFICE

The head office of the Institute shall be in the City of Ottawa, in the Province of Ontario.

5 PARTICIPATING ASSOCIATIONS

In furtherance of the objects of the Institute as stated herein, and in the charter and subject to the signing of an agreement between their Councils and the Council of the Institute, the following associations shall be Founder Participating Associations:—

The Association of Professional Engineers of Alberta

The Association of Professional Engineers of the Province of British Columbia

The Association of Professional Engineers of the Province of Manitoba

The Association of Professional Engineers of the Province of New Brunswick
The Association of Professional Engineers of the Province of Newfoundland
The Association of Professional Engineers of the Province of Nova Scotia
The Association of Professional Engineers of the Province of Ontario
The Association of Professional Engineers of the Province of Prince Edward Island
La Corporation des Ingénieurs Professionnels de Québec
The Association of Professional Engineers of Saskatchewan
The Association of Professional Engineers of the Yukon Territory.

The status of Participating Association shall not become effective until the Council of the Association concerned and the Council of the Institute have signed an agreement whereby the Association consents to participate and agrees to be bound by the provisions of the Institute's Charter and of these By-laws for a minimum period of five years.

Such agreement may be terminated by the withdrawal of a Participating Association from the Institute upon presentation of a written notice to this effect from its Council to the Council of the Institute. Such withdrawal shall not be effective before the end of the fiscal year following the fiscal year in which such notice is received by the Council of the Institute. It may also be terminated at the request of the Council of the Institute but such action shall require the affirmative vote of two-thirds of all members of Council.

Other provincial and territorial associations of Professional Engineers may, on application to the Council, become recognized Participating Associations by decision of the Council of the Institute, and with the approval of the Councils of all existing Participating Associations.

Participating Associations shall be represented on the Council of the Institute and shall take part in the activities of the Institute as provided for herein.

MEMBERSHIP

6 CLASSES OF MEMBERSHIP

Classes of membership in the Institute are as follows: Fellow, Member, Junior Member, Student Member, Honorary Member and Corresponding Member. Fellow, Members and Junior Members shall constitute the corporate membership of the Institute. Notwithstanding the foregoing provisions of this By-law, for a limited period of time after coming into force of these By-laws, there shall also be provided a special class of membership called Technical Associate.

7 FELLOW

A member of the Institute may be elected a Fellow by the Council of the Institute to recognize his outstanding contribution to the engineering profession either in technical or professional practice or in the fields of administration or teaching.

The Council shall elect Fellows by secret ballot, and only upon the unanimous recommendation of the Standing Committee on Honours and Awards. The election of Fellows shall require an affirmative vote by a simple majority of the total number of the members of Council. Not more than twenty-five Members may be elevated to this classification in any one year and the total number of Fellows at any time shall not exceed one per cent of the total number of Corporate Members. Advancement to the class of Fellow is not automatic and is not subject to application by the individual members themselves. There is no obligation on the part of the Council to accept the recommendation of the Standing Committee on Honours and Awards or to elect any Fellows at any time.

Notwithstanding the foregoing provisions of this By-law, for the first two years after coming into force of these By-laws, the limit of twenty-five as the total number of Fellows to be elected each year shall be waived to provide for the establishment of the class of Fellow and to permit recognition of Members who possess the necessary qualifications for election as Fellows at this time, as provided for in this By-law. At the end of this two year period, the total number of Fellows elected shall not exceed one half of one per cent of the total number of Corporate Members. At the time of the coming into force of these By-laws, the classification of Fellow shall be offered to Honorary Members of The Engineering Institute of Canada who are registered as professional engineers by a Canadian provincial or territorial association or corporation of professional engineers. The classification of Fellow shall be offered at the same time to Honorary Members of the Participating Associations at the request of the Councils of the Associations concerned, provided that these Honorary Members are duly registered Professional Engineers.

8 MEMBER

A member of the Institute must be a Professional Engineer duly registered by a Canadian provincial or territorial association or corporation of professional engineers. Such a Professional Engineer becomes and remains a Member of the Institute by virtue of his being recorded as such by one of the aforementioned bodies.

9 JUNIOR MEMBER

A Junior Member of the Institute must be an individual duly registered or recorded as an engineer-in-training or a junior professional engineer by a Canadian provincial or territorial association or corporation of professional engineers. Such an individual becomes and remains a Junior Member of the Institute by virtue of his being recorded as such by one of the aforementioned bodies. A Junior Member shall be advanced to the grade of Member upon notification by his Participating Association to the effect that he has been duly registered as a Professional Engineer, and by virtue of his being recorded as a Member of the Institute by this Participating Association.

10 STUDENT MEMBER

A Student Member must be an engineering student so registered or recorded by a Canadian provincial or territorial association or corporation of professional engineers either attending a recognized university or school of engineering, or preparing for the regular examinations of one of the aforementioned bodies. Such an engineering Student is considered a Student Member by virtue of his having been registered or recorded as such by one of the aforementioned bodies.

A Student Member shall be advanced to the grade of Junior Member upon notification by one of the Participating Associations to the effect that he has been duly registered or recorded as a Junior Professional Engineer or Engineer-in-Training, and by virtue of his being recorded as a Junior Member of the Institute by this Participating Association.

11 HONORARY MEMBER

Honorary Members of the Institute are persons to whom the Institute wishes to grant special recognition and who are not registered as professional engineers by a Canadian provincial or territorial association or corporation of professional engineers. They shall be persons who have attained eminence in engineering or have achieved distinction in fields of endeavour allied to or associated with the engineering profession.

The Council shall elect Honorary Members by secret ballot, and only upon the unanimous recommendation of the Standing Committee on Honours and Awards.

The election of Honorary Members shall require an affirmative vote by a simple majority of the total number of the members of Council. There shall at no time be more than twenty-five living Honorary Members.

Notwithstanding the foregoing provisions of this By-law, at the time of the coming into force of these By-laws, Honorary Membership shall be offered to Honorary Members of The Engineering Institute of Canada who are not registered as professional engineers by a Canadian provincial or territorial association or corporation of professional engineers.

12 CORRESPONDING MEMBER

A Corresponding Member of the Institute shall be an engineer non-resident in Canada who, except for the residence requirement, is qualified for registration by a Canadian provincial or territorial association or corporation of professional engineers. He shall be admitted as a Corresponding Member by the Council of the Institute on the recommendation of the Board on Professional Interests whose duty it shall be to examine and approve the qualifications of the applicant. Corresponding Members shall have the rights and privileges of Institute membership as defined in these By-Laws. If a Corresponding Member establishes Canadian residence, he shall cease to be classified as such. He may then apply for registration as a corporate member.

Corresponding Members shall pay an annual fee to be determined by the Council of the Institute.

13 CORPORATE MEMBERSHIP AND VOTING MEMBERSHIP

Corporate membership of the Institute shall comprise the members of the Institute who are classed as Fellows, Members and Junior Members.

The voting membership of the Institute shall comprise all classes of membership except Honorary Members, Student Members and Corresponding Members.

14 DESIGNATIONS OF CLASSES OF MEMBERSHIP

Members of the Institute shall have the right to use the following designations of their classes of membership. They shall not identify themselves as members of the Institute by any other means. The French language and English language designations appearing below have the same validity:—

	French Language	English Language
Fellow	Fellow I.C.I.P	Fellow C.I.P.E.
Member	M.I.C.I.P.	M.C.I.P.E.
Junior Member	Jr. I.C.I.P.	Jr. C.I.P.E.
Student	Et. I.C.I.P.	S.C.I.P.E.
Honorary Member	Membre Hon. I.C.I.P.	Hon. Member C.I.P.E.
Corresponding Member	C.I.C.I.P.	C.C.I.P.E.

15 SPECIAL CLASS OF MEMBERSHIP — Technical Associate

At the time of coming into force of these By-Laws there shall be a membership class of Technical Associate. A Technical Associate shall be a person who at that time was a member of the Engineering Institute of Canada and who does not possess qualifications for admission to corporate membership in the Institute.

This special class of membership shall be limited to such members of the Engineering Institute of Canada and after the date of coming into force of these by-laws, no further persons shall be admitted to membership as Technical Associates.

This class of membership shall comprise the Members, Junior Members and Life Members of The Engineering Institute of Canada who, at the time of coming into force of these By-laws, are not registered or recorded by a Canadian provincial or territorial association or corporation of professional engineers. Technical Associates shall have all the rights and privileges of membership except as otherwise provided in these By-laws. Technical Associates shall remit annual fees to the Institute in an amount to be determined by the Council. Technical Associates who are former Life Members of The Engineering Institute of Canada shall be exempt from payment of such annual fees.

MANAGEMENT

16 COMPOSITION OF COUNCIL

The Council is the governing body of the Institute. It determines the policy and administers the affairs of the Institute, and has such other powers as are prescribed by the Charter and these By-laws.

The Council is composed of the President, two Vice-Presidents, the immediate Past President, one Councillor appointed by the Council of each of the Participating Associations and Councillors elected by the voting membership of the Institute in the provinces and territories of Canada. All members of the Council shall be Corporate Members of the Institute.

The President is elected by the voting membership of the Institute.

The Vice-Presidents are elected by the voting membership of the Institute. They shall not reside in the same Province or Territory of Canada nor in two adjoining such provinces or territory.

For the purpose of this By-law, the following Provinces and Territories are considered to be adjoining:
Newfoundland and Nova Scotia; Newfoundland (Labrador) and Quebec; Newfoundland and Prince Edward Island; Nova Scotia and New Brunswick; Nova Scotia and Prince Edward Island; New Brunswick and Prince Edward Island; New Brunswick and Quebec; Prince Edward Island and Quebec; Quebec and Ontario; Ontario and Manitoba; Manitoba and Saskatchewan; Saskatchewan and Alberta; Alberta and British Columbia; Alberta and the Yukon Territory; British Columbia and the Yukon Territory.

To ensure adequate geographical representation at the Vice-Presidential level, the Vice-Presidents shall reside in areas chosen, whenever possible, with the object of dividing the country into the two regions generally referred to as Eastern Canada and Western Canada.

The number of elected Councillors is determined as follows: —Provinces or territories in which the provincial association or corporation has between 301 and 5,000 members elect one Councillor. Those with 5,001 to 10,000 members elect two Councillors and those with over 10,000 members elect three Councillors.

Notwithstanding the foregoing provision of this By-law when, by reason of any change in the number of members in any province or territory, the number of elected councillors is to be increased, the additional councillor shall be elected at the next annual election of councillors and before such election the Council shall determine whether the initial term of office of such councillor shall be a one-year or two-year term in order to ensure a suitable rotation of elected councillors.

Elected Councillors shall not be members of the Councils of their Participating Associations.

Appointed Councillors should preferably be members of the Councils of their Participating Associations.

17 DUTIES OF COUNCIL

The Council of the Institute determines the policies and administers the affairs of the Institute. It directs the investment, care and use of the funds of the Institute. It appoints each year the chairman and the members of the Standing Committees, Boards and such Special Committees as may be required, with the exception of the chairman and the vice-chairman of the Board on Professional Interests.

The Council appoints annually an Executive Committee composed of the President, the two Vice-Presidents and three other members of the Council, one of whom shall be the Treasurer of the Institute.

The Council meets at least three times a year, at dates and places which it determines. The quorum at Council meetings shall be two-thirds of the members of Council. In the interval between meetings, the Council may delegate any of its powers to the Executive Committee. Special meetings of the Council may be called for specific purposes by the President or upon written request of at least ten Councillors. A minimum of two weeks notice is required for all general and special meetings of the Council.

The Council shall transmit to each Councillor of the Institute and to the Council of each Participating Association, a copy of the agenda of its meetings at least two weeks prior to each meeting, and a copy of the minutes of its meetings within one month after each meeting.

The Council shall present a short report at each annual meeting of the Institute. This report shall include a review of the financial and other activities of the Institute and shall be accompanied by the statement of the appointed auditors.

The Council shall appoint the Treasurer of the Institute annually, from among the members of Council.

The Council shall appoint a General Manager who shall be the executive officer of the Institute.

No decisions by the Council of the Institute shall be binding upon the members of the Canadian provincial or territorial associations or corporation of professional engineers 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.

18 OFFICERS

The officers of the Institute are the President, the two Vice-Presidents, and the Treasurer. The executive officer is the General Manager of the Institute.

(a) **President:** The President presides at all general meetings of the Institute, at Executive Committee meetings and at meetings of the Council. He is an ex-officio member of all Boards and Committees, He has general supervision over the affairs of the Institute. He holds office for one year and is ineligible to serve for two consecutive terms.

(b) **Vice-Presidents:** The Vice-Presidents give such assistance to the President as he may request. The Vice-Presidents hold office for two years and are ineligible to serve for two consecutive terms. At the time of his election, a Vice-President is known as Second Vice-President. After one year of office, his title is First Vice-President.

The First Vice-President replaces the President in case of his temporary inability to fulfill his duties.

The Second Vice-President acts as chairman of the Finance Committee. He replaces the First Vice-President in case of his temporary inability to fulfill his duties.

(c) **Treasurer:** The Treasurer ensures that the decisions of Council and of the Finance Committee regarding the financial policies and practices of the Institute are properly implemented.

He presents the financial report and reports of aduitors to the Council and to the Annual Meeting of the Institute, and is generally responsible for the supervision of the financial operations of the Institute.

He acts as adviser to the General Manager in all matters of implementation of the financial policies of the Institute.

He serves as a member of the Finance Committee.

(d) **General Manager:** The General Manager is the executive officer of the Institute. He acts under the direction of the Council. He is responsible for the work of all employed personnel, for the physical property, records and Corporate Seal of the Institute, and shall administer the funds of the Institute within an approved budget and in accordance with the procedure outlined in these By-laws. He is responsible for the editing of all publications of the Institute, and for such other duties as may be assigned to him by the Council.

He holds office subject to removal by an affirmative vote of two-thirds of the total number of members of the Council. His entire time is devoted to the affairs of the Institute unless otherwise authorized by the Council. He has no voting power at Council meetings.

19 HONORARY OFFICERS

The Council may appoint temporary officers of the Institute as Honorary Vice-Presidents to serve during a limited period of time as official representatives of the Institute on special occasions.

20 COUNCILLORS

It is the duty of the Councillors to attend all Council meetings. They are expected to act on Council's Boards and Committees. They serve as liaison between the Council and the branches located in the geographical area of their Participating Associations and are expected to visit branches or regions as Council's representatives.

The appointed Councillors have, in particular, the responsibility and function of representing to the Council the views of the Councils of the Participating Associations which they represent. It is also their responsibility to report to the Councils of the Participating Associations regarding the activities of the Council, Boards, Committees and of the Institute as a whole.

All Councillors hold office for two years. They are ineligible to serve as Councillors for more than two consecutive terms.

In the event of a Councillor appointed by a Participating Association being unable to attend a meeting of the Council of the Institute, the Participating Association which he represents may appoint an alternate to replace him for that meeting. Such alternate shall have all the rights and privileges of the official Councillor he is replacing.

In no case is a Councillor permitted to vote by proxy.

21 VACANCIES ON COUNCIL

(a) **President:** A vacancy in the office of President shall be filled by the First Vice-President for the remainder of the President's term of office.

(b) **Vice-Presidents:** A vacancy in the office of First Vice-President shall be filled by the Second Vice-President for the remainder of the term of the vacant office. A vacancy in the office of Second Vice-President shall be filled for the remainder of the term of the vacant office by an appointee of the Council, chosen from among the Councillors of the Institute.

(c) **Councillors:** A vacancy in the office of a Councillor appointed by a Participating Association shall be filled for the remainder of that Councillor's term of office by another appointee of the said Participating Association.

A vacancy in the office of an elected Councillor shall be filled for the remainder of that Councillor's term of office by a corporate member of the Institute chosen by Council from among members residing in the geographical area of the Councillor to be replaced.

22 EXECUTIVE COMMITTEE

The Executive Committee is responsible to Council for all matters that may be delegated to it by the Council. It assists the President in carrying out the instructions and policies of the Council. It meets at the call of the President not less than once every two months, the quorum at these meetings being four (4).

BOARDS AND COMMITTEES

23 BOARDS

The Council appoints each year the members of the following Boards:

(a) **Board on Professional Interests:** This Board is responsible for the activities of the Institute in the field of professional interests and for the co-ordination of the activities of the Participating Associations in this field. It is composed of all the Councillors appointed by the Participating Associations. These Councillors each year appoint their own Chairman and Vice-Chairman from among their own number. The Chairman continues in office until his successor has been duly appointed. The Chairman presides at all meetings of the Board and reports to Council. He retains his vote as a member of the Board and casts the deciding vote when the votes of the members of the Board are equally divided. In the absence of the Chairman, or if he is unable to act, the Vice-Chairman performs all the duties of the Chairman.

In the event of a member of the Board being unable to attend a meeting of the Board, the Participating Association which he represents may, either through its Council or its President, appoint an alternate to replace him for that meeting of the Board. Such alternate has all the rights and privileges of the member he is replacing except that of serving as Chairman of the Board. In no case is a member permitted to vote by proxy.

Each Participating Association may appoint observers to attend meetings of the Board but these observers act only in an advisory and non-voting capacity.

(b) **Board on Technical Services:** This Board is responsible for the Activities of the Institute in the field of technical services and for the co-ordination of the activities of the Participating Associations in this field. It is composed of five members of the Council and five corporate members chosen from among the chairmen of the Board's committees. Council appoints the chairman from among the five councillors appointed as members of the Board. The Board, with the approval of Council, has the right to add to its members from the general membership, but these additional members act only in an advisory and non-voting capacity.

24 STANDING COMMITTEES

The Council appoints each year the Chairman and members of the following Standing Committees. These Standing Committees report directly to Council.

(a) **Committee on Finance:** This Committee is composed of the Second Vice-President of the Institute as Chairman, two Councillors, one of whom shall be the Treasurer, and two members of the Institute, chosen from each of the two regions generally referred to as Eastern Canada and Western Canada.

The Finance Committee prepares a budget for consideration and adoption by Council; in collaboration with the Treasurer it generally supervises and reports to Council on the financial operations of the Institute and their relation to the budget; ensures that an annual audit is made; advises the Council or the Executive Committee on the purchase and sale of securities and other investments; performs such other duties as may be assigned to it by Council.

The Finance Committee meets at the call of its Chairman. The quorum of the Committees is three.

(b) **Committee on Branches:** This Committee is composed of at least five members of the Institute including the Chairman who is selected from among the members of Council. It sponsors and/or assists in the formation of branches in co-operation with the Participating Associations concerned; supervises and assists in the operation of branches jointly with the Board on Professional Interests and the Board on Technical Services and with the Participating Associations concerned; prepares and keeps up-to-date branch model charter and by-laws; generally deals with all problems concerning Council's policy relating to the formation and operation of branches.

(c) **Committee on Publications:** This Committee is composed of at least seven members of the Institute including the Chairman, who is selected from among the members of the Council. At least two members are appointed by Council on the recommendation of the Board on Professional Interests and two upon the recommendation of the Board on Technical Services.

The Committee on Publications assists the Council in establishing the Institute's policy regarding its publications: technical journals and transactions, news bulletins, information material, directories, books, manuals of procedures and other media of information for the members or for the public such as films, film strips, etc. It formulates under the direction of Council and with the co-operation of the Board on Professional Interests and the Board on Technical Services, a policy for each publication covering every aspect of its content including technical and non-technical material, advertising, etc.

Within the above mentioned terms of reference, the Committee on Publications supervises and directs the publication of a national journal and, at the Council's request, of transactions.

With the approval of Council, the Committee on Publications appoints an Editorial Board, the members of which are representatives of the major areas of engineering specialization, to advise the Committee on Publications on the publication of the Journal and of Transactions. If deemed necessary, it also appoints other editorial boards to advise the Committee regarding other publications of the Institute that may be authorized by the Council.

With the assistance of the editorial boards, the Committee assists the Finance Committee in establishing and administering the publications budget of the Institute. It develops rules and regulations covering standards and acceptability of technical papers and other material considered for inclusion in the Institute's publications. These rules and regulations, once approved by Council, shall be used as a guide by the editorial boards.

The Publications Committee advises and assists the General Manager in the implementation of the publications policy of the Institute. The quorum at the meetings of the Committee on Publications is five.

(d) **Committee on Honours and Awards:** This Committee is composed of seven members of the Institute, the Chairman being appointed by Council. Three members are appointed by Council from a list of nominees submitted by the Board on Professional Interests and three members are appointed by Council from a list of nominees submitted by the Board on Technical Services.

This Committee makes recommendations to Council matters related to Honorary Membership, the appointment of Fellows, the selection of recipients of prizes and awards established or to be established by Council. It presents to Council nominations for the election of Honorary Members and Fellows according to the provisions of these by-laws; it recommends to Council the establishment and implementation of regulations concerning the selection of recipients of prizes and awards; it appoints sub-committees as required and supervises their work to ensure proper implementation of the established regulations for the selection of Honorary Members, Fellows and recipients of prizes and awards.

This Committee meets at the call of its Chairman. The quorum at its meetings shall be five. No recommendation for the election of Honorary Members and Fellows shall be made to Council unless it is approved unanimously by secret ballot of the members of the Committee present at the meeting.

25 DUTIES AND RESPONSIBILITIES OF THE BOARD ON PROFESSIONAL INTERESTS

Having due regard to the Constitutional rights of the Provinces, the Board on Professional Interests is responsible, on behalf of the Council, for the supervision and direction of all the activities of the Institute related to the professional interests and welfare of the engineer at the national level. The Board assists the Participating Associations in co-ordinating and standardizing their activities in these fields, as well as in the field of public relations.

The Board on Professional Interests shall hold at least three meetings per year including one immediately preceding the annual meeting of the Institute. The Board shall also meet at any other times that may be deemed necessary. The Board shall transmit to the Council of each of the Participating Associations, a copy of the agenda of its meetings, if possible, one month prior to each meeting, and a copy of the minutes of its meetings not later than one month after each meeting. The Board on Professional Interests is responsible directly to Council.

The quorum of the Board is seven members and no resolution shall be declared "carried" with less than six affirmative votes.

The Board on Professional Interests shall each year recommend to Council the appointment of the Chairmen and members of continuing committees and of any other committees that it may deem necessary to carry out the responsibilities described above, and to deal with any other matters which may be referred to it by Council, such as:—

(a) **Committee on Legislation:** The field of activities of this Committee are:—

(i) To maintain a continuous scrutiny of all federal legislation affecting the profession and, when necessary, recommend action or, in cases of emergency, initiate action in consultation with the Chairman of the Board on Professional Interests and the Executive Committee.

(ii) To gather and disseminate information on federal, provincial and foreign legislation concerning or affecting the profession.

(iii) If requested by Participating Associations to provide information and/or advice to them on matters of legislation.

(iv) To prepare and maintain a model professional engineers act.

(v) To perform any other duties which may be required in this general field.

(b) **Committee on Professional Development:** The responsibilities of this Committee are to organize, co-ordinate and/or assist in:—

(i) Professional development programs for young engineers in order to help them to become integrated into the profession.

(ii) Formulating plans to help industry and government in developing young engineers for early advancement and professional responsibility.

(iii) Within the above terms of reference, extending its services to university students and high school students in order to provide potential members of the profession with adequate and accurate information about professional engineering.

(iv) The study of all related matters referred to it by the Board.

(c) **Committee on the Welfare of the Professional Engineer:** The responsibilities of this Committee are:—

(i) To study problems of relations between engineers and their employers.

(ii) To carry out, co-ordinate or supervise salary surveys on a national basis.

(iii) To prepare and disseminate salary information.

(iv) To sponsor and assist in the preparation and maintenance of a uniform and up-to-date Schedule of Minimum Fees.

(v) To participate in the preparation of minimum work standards for consulting services and of standard contract forms.

(vi) To co-ordinate the work of provincial committees on consulting practice and maintain liaison with other associations or groups whose activities are of concern or interest to consulting engineers.

(vii) To conduct studies and submit recommendations to the Board regarding insurance, pension and other welfare plans for members of the Institute.

(viii) To organize and supervise the operations of an adequate employment service for the membership if and when such a service is established by the Institute.

(ix) To deal with all matters concerning the welfare of Canadian Professional Engineers which may be referred to it by the Board, and, if necessary, to appoint sub-committees as may be required in the performance of all its duties.

(d) **Committee on Registration Standards:** This Committee deals with the following matters with the object of bringing about uniformity among Participating Associations in the establishment of standard requirements for registration as a Professional Engineer:—

(i) The acceptance of Canadian and foreign university degrees.

(ii) Procedures for the transfer of registration between one Participating Association and another.

(iii) Maintenance and revision of the uniform syllabus which serves as a basis for the examinations required for admission to practice.

(iv) Any other matters relating to the uniformity of registration and licensing requirements.

(e) **Committee on Ethics:** The responsibilities of this Committee are:—

(i) To maintain a close scrutiny of the various codes of ethics as they are adopted in Canada and abroad.

(ii) To transmit to the Participating Associations all available information on professional codes of ethics.

(iii) To assist the Participating Associations in the establishment of a uniform code of ethics, and of uniform rules of ethics in Canada. If requested by a Participating Association, to advise and assist in the formulation, interpretation, application and implementation of the Association's code and rules of ethics.

(iv) To participate and assist in efforts toward the dissemination of adopted codes of ethics among professional engineers in Canada, and the implementation by them of the rules of ethics based on these codes. To extend these services to university students who are preparing themselves for a career in engineering, in order to help them acquire, at their early stage of development, a proper ethical approach to the practice of engineering, and assist them in their integration into the profession.

26 FUNCTIONAL DIVISIONS

The Board on Professional Interests will, at the request of Council, proceed to organize functional divisions. The purpose of a Functional Division is to bring together members of the Institute having common professional interests and problems.

The Board will maintain up-to-date the list of the members who have expressed to their branch the desire to participate in the activities of each Functional Division, established by Council and shall provide a mechanism for the members of each Division to associate themselves with the activities of the Division at the branch level, at the level of the Participating Associations, and at the national level. Each Division shall orient its activities towards one of the various aspects of the professional life of the engineer, such as: the engineer in consulting practice, the engineer in industry, the engineer in government service, etc., as specified by the Council.

The Board on Professional Interests, through the establishment of the Committee on Functional Divisions shall supervise, direct and/or assist the branches of the Institute in their activities within the scope and objectives just defined. In the performance of these duties, the Committee on Functional Divisions shall call upon any other Committee of the Institute to assist in furthering the work of the Functional Divisions.

27 DUTIES AND RESPONSIBILITIES OF THE BOARD ON TECHNICAL SERVICES

With the approval of Council, the Board on Technical Services provides leadership at all levels of the Institute, to ensure the proper operation and development of the technical activities of the Institute, with the object of providing the optimum technical program for the profession of engineering in Canada.

It initiates and maintains ways and means of disseminating technical knowledge among the members of the Institute through the various administrative groups of the profession. It supervises, directs and/or assists the branches of the Institute in the operation of their technical programs, and co-ordinates the work of the Participating Associations in this field. It is responsible for the technical meetings of the Institute and for all other matters relating to the technical activities of the Institute.

It shall co-operate fully with the Standing Committee on Branches and the Standing Committee on Publications and provide assistance to them in all matters of common concern.

The Board on Technical Services shall hold at least three meetings per year, including one immediately preceding the annual meeting of the Institute. The Board shall also meet at any other times that may be deemed necessary. The Board on Technical Services is responsible directly to the Council.

The quorum of the Board is six members.

The Board on Technical Services shall recommend each year to Council the appointment of the Chairmen and members of continuing committee and of any other committees that it may deem necessary to carry out the responsibilities described above, and to deal with any other matters which may be referred to it by Council, such as:—

(a) **Committee on Technical Division:** This Committee organizes and maintains Technical Divisions. The purpose of a Technical Division is to bring together members of the Institute having common technical interests and problems. The Committee shall maintain up-to-date the list of the members who have registered at their Branch to participate in the activities of each Technical Division established by Council and shall provide a mechanism for the members of each Division to associate themselves with the activities of the Division at the branch level, at the level of Participating Associations and at the national level. Each Division shall orient its activities toward one of the various broad areas of technical interest of the professional engineer, such as: mechanical engineering, civil engineering, electrical engineering, etc., as specified by the Council. Each Division may in turn subdivide its operations, through the creation of technical committees to deal with more limited aspects of the professional engineer's technical work and responsibilities.

In the performance of these duties, the Committee on Technical Divisions may freely call upon any Committee of the Institute to assist in furthering the work of the Technical Divisions.

(b) **Committee on Engineering Education:** This Committee:—

(i) Concerns itself with matters related to engineering education which may come before the Institute, and in particular advises the Institute's Council on such matters;

(ii) Provides for the participation of the Institute members in Engineering Education Conferences which may be sponsored by the Institute or co-sponsored by the Institute and other national bodies, either in Canada or abroad;

(iii) Submits recommendations to Council regarding the establishment of scholarship programs, and other plans for financial assistance to engineering students, and operates such programs under the general direction of the Council.

(iv) Co-operates closely with the Committee on Student Affairs.

(v) Collects and correlates statistical and other information on Engineering Education in Canada and abroad, which may be of interest to engineering educators and/or to the membership of the Institute.

(vi) Conducts studies and surveys on the training of engineers and engineering technicians through various programs including formal university education, short courses, summer training, evening and part-time training and recommends to Council regarding policies to be adopted in this field.

(vii) Assists in the co-ordination of the activities of the Participating Associations in the field of engineering education.

(c) **Committee on Public Affairs:** This Committee:—

(i) Ensures that technical knowledge is properly disseminated and made available to the public in general, to governments and other civic groups for the proper consideration of technical problems of general interest to society.

(ii) Submits recommendations to Council regarding appointment of Institute representatives on public bodies dealing with problems of a technical nature;

(iii) Submits recommendations to Council regarding the Institute policies on such problems;

(iv) Appoints as may be deemed necessary sub-committees to deal with specific problems assigned to them by the Committee.

(v) In the performance of its duties, may call upon the Committee on Technical Divisions for advice and assistance for the furtherance of the work assigned to it.

(d) **Committee on Student Affairs:** This Committee:—

(i) Sponsors and/or assists in co-operation with the Participating Associations and the Institute branches, in the formation of student chapters at Canadian universities and colleges;

(ii) Generally supervises and assists Institute branches in the operation of such student chapters, jointly with other Committees of the Institute and with the Participating Associations concerned;

(iii) Prepares and keeps up-to-date student chapter model Charter and By-Laws.

(iv) Generally deals with all problems concerning the Council's policy for the formation and operation of student chapters.

BRANCHES

28 FORMATION AND TITLE

An Institute Branch may be established at the request of not less than 10 corporate members of the Institute who reside in the same area and who desire to form themselves into such a Branch. A request to form such a Branch in a given geographical area shall be presented by a provisional Executive Committee to the Council of the Participating Association concerned, with copy being sent to the Council of the Institute. The Council of the Participating Association shall, within four months of its receipt, transmit the request with its recommendations to the Council of the Institute. If approved by both Councils, the request shall be granted and authority to organize the Branch shall be given by the Council of the Institute to the provisional Executive Committee of the Branch. This Executive Committee shall proceed to prepare its Branch By-laws and shall submit them to the Council of the Institute for approval. If these By-laws are found acceptable, the Council, after consultation with the Participating Associations concerned, shall issue them and deliver the official charter to the Branch, authorizing the election of the regular Executive Committee of the Branch. A copy of the Charter and By-laws of the Branch shall be forwarded to the Participating Association concerned. Under this procedure, all such branches shall become branches of both the Institute and of the Participating Association concerned.

At the time of coming into force of these By-laws, all existing branches of The Engineering Institute of Canada, and all existing branches or sections of Participating Associations, shall become branches as defined above. In cases where branches of The Engineering Institute of Canada and of a Participating Association operate in the same geographical area, the Council of the Institute and the Council of the Participating Association concerned shall when desirable and/or necessary adjust the territorial limits of these branches in order to amalgamate the existing groups into a branch as defined above, and shall make any necessary reorganization in the management and operation of the branch. As soon as possible after the coming into force of these By-laws, the Council of the Institute shall issue a new Charter and By-laws to each of the branches.

29 OBJECTS

The branches shall promote the objects and interests of the engineering profession as defined by the Institute and by the Participating Associations. They shall encourage and facilitate the study, discussion and exchange of ideas and information among the members, on all questions of interest to them as professional engineers and as citizens. With the assistance and co-operation of the Institute and of the Participating Associations, branches shall extend their services to engineering students at universities and colleges, and also to high school students, to provide potential members with adequate information about the profession of engineering.

30 MEMBERSHIP

Membership in a Branch shall be established in accordance with the Branch By-laws and shall be open to all classes of membership of the Institute. Admission of a Corporate Member of the Institute as a member of a Branch shall be made in accordance with the procedure established by the Council of his Participating Association. He shall be considered a member of a Branch by virtue of his being recorded as such by his Participating Association, which will notify the Council of the Institute to this effect. Technical Associates shall be members of the Branch operating in the area in which they reside.

31 BRANCH FINANCE

The financial revenue of a Branch shall be established by arrangement with the Council of its Participating Association and with the Council of the Institute. A Branch may receive financial assistance from either or both of these bodies. In consultation with its Participating Association, the Executive Committee of a Branch may, if necessary, establish an annual branch fee. Such fee shall be collected from Corporate Members by arrangement with the Participating Association and returned to the Branch Committee, to support the operations of the Branch. Technical Associates shall pay the annual branch fee directly to the Institute, for transmission to the Branch Executive Committee concerned.

32 BRANCH MANAGEMENT

The affairs of a Branch are managed by an Executive Committee in accordance with its Branch By-laws. The Executive Committee is composed of a Chairman, a Vice-Chairman, a Secretary and a Treasurer or a Secretary-Treasurer, the immediate Past-Chairman and one or more Branch members, all of whom shall be Corporate Members of the Institute, the immediate Past-Secretary of the Branch for a period of one year and a member appointed by the Council of the Participating Associations. Members of the Councils of the Institute and of the Participating Association concerned, who are members of the Branch, are ex-officio members of the Executive Committee.

The Executive Committee governs the operations of the Branch within the terms of reference set forth in the By-laws of the Institute and its own Charter and By-laws. It shall receive services and assistance from both its Participating Association and the Institute.

33 BRANCH TECHNICAL DIVISIONS

At the request of ten Branch members, the Executive Committee may authorize the formation of a Branch Technical Division for the purpose of bringing together professional engineers having common technical interests. Each Branch Technical Division may incorporate into its activities one or more of the established fields of engineering, i.e., civil, mechanical, electrical, etc., corresponding to the technical divisions organization established by the Institute.

The Executive Committee of the Branch shall inform the Institute's Committee on Technical Divisions and the Council of its Participating Association of the establishment of a Branch Technical Division. It shall maintain up-to-date the list of the members of each Branch Technical Division, this list being transmitted to the Committee on Technical Divisions of the Institute, and to the Council of its Participating Association with amendments as required. The Branch Technical Divisions and their Committees shall provide liaison between their members and the organizations provided on the one hand by the Institute, through its Committee on Technical Divisions and its associated Technical Committees, and, on the other hand, by the Participating Association concerned.

34 BRANCH FUNCTIONAL DIVISIONS

At the request of ten Branch members, the Executive Committee may authorize the formation of a Branch Functional Division for the purpose of bringing together professional engineers having common professional interests and problems. Each Division shall adjust its operations to conform with the functional divisions organization provided for by the Institute and the Participating Associations. The Executive Committee of the Branch shall inform the Institute's Committee on Functional Divisions and the Council of its Participating Association of the establishment of a Branch Functional Division. It shall maintain up-to-date the list of the members of each Branch Functional Division, this list being transmitted to the Committee on Functional Divisions of the Institute and to the Council of its Participating Association, with amendments as required. The Branch Functional Divisions and their Committees shall provide liaison between their members and the organizations provided, on the one hand, by the Institute through its Committee on Functional Divisions and, on the other hand, by the Participating Association concerned.

35 GEOGRAPHICAL SECTIONS

A Branch may establish geographical sections within its territory for the purpose of better serving members of remote communities. The operation of these sections shall be governed by regulations provided for in the Branch By-laws.

36 BRANCH RELATIONS WITH STUDENT CHAPTERS

The Branch Executive Committee shall encourage and assist in the establishment of Student Chapters of the Institute at Canadian universities and colleges. Branches shall provide services and give whatever technical assistance may be required to the Executive Committees of Student Chapters. Branches shall be responsible for supervision of the operations of Student Chapters located within their territories.

37 BRANCH REPORTS

Each Branch shall prepare an annual report of its proceedings and of its finances in a form and at a time prescribed by the Council of the Institute and shall forward it to both the Council of the Institute and the Council of the Participating Association concerned.

38 BRANCH RESPONSIBILITY

A Branch shall not publicly enunciate any policy or take any public action without first consulting the Councils of the Institute and of the Participating Association concerned and obtaining their approval. The Branch Executive Committee shall be responsible for the operation of the Branch within the provisions of its Charter and By-laws and the Charter and By-laws of the Institute. No action taken by a Branch or its officers without prior approval by the Institute or the Participating Association concerned shall engage the responsibility of or be binding upon either of these two bodies.

REGIONAL BRANCH CONFERENCES

39 FORMATION AND TITLE

At the request of the Executive Committee of two or more branches whose territories are adjoining, the Council, after consultation with the Participating Associations concerned, may establish a Regional Branch Conference for the purpose of bringing together members of various branches to discuss matters of technical or professional interest common to them.

40 OBJECTS

The objects of a Regional Branch Conference are to promote the exchange of views between professional engineers of different branches located in a given geographical area, to permit collective representations from groups of branches to either the Councils of their Participating Associations or to the Council of the Institute, and in general to encourage group activities combining the effort of a large number of engineers during the period of time intervening between annual meetings of either the Participating Associations or the Institute.

41 MANAGEMENT AND OPERATION

A regional Branch Conference is managed by a Conference Committee composed of:

(a) The chairmen and secretaries of the branches participating in the Conference or their appointed alternates.

(b) The members of the Council of the Institute resident in the area of the Conference.

(c) One member appointed each year by the Councils of the Participating Associations concerned.

The Chairman and Secretary of the Conference Committee shall be chosen from amongst the Committee Members and shall continue in office until they are replaced.

The Conference Committee shall meet at least once a year at the call of the Chairman or at the request of the majority of the chairmen of the branches forming the Conference. At its first meeting in each year, it shall appoint its Chairman and Secretary. It conducts its activities in conformity with the objects of Regional Branch Conferences and aligns them as closely as possible to meet the needs of the branches to be served. It has the power to establish special committees to promote the work of the Branch technical and functional divisions operating within its geographical area. When advisable, it organizes Regional Branch Conference meetings for the direct benefit of the members of the branches composing it, which all members of the Institute shall have the privilege of attending.

In the discharge of these duties, the Conference Committee shall receive assistance and services from both its Participating Association and from the Institute.

42 FINANCE

The cost of operating Regional Branch Conferences shall be by arrangement between the branches concerned and their Participating Associations.

43 REPORTS

The Conference Committee shall prepare an annual report of its proceedings and of its finances in a form and at a date prescribed by the Council of the Institute and shall forward it to the Council of the Participating Association concerned and to the Council of the Institute.

44 AUTHORITY AND RESPONSIBILITY

Regional Branch Conferences are operated in accordance with these By-laws and in conformity with procedures and policies established from time to time by the Council of the Institute after consultation with the Councils of Participating Associations. A Regional Branch Conference shall not publicly enunciate any policy or take public action without first consulting the Council of the Institute and of the Participating Association concerned and obtaining their approval.

STUDENT CHAPTERS

45 FORMATION AND TITLE

A Student Chapter may be established at a university or college of engineering at the request of not less than twenty-five Student Members of the Institute who are studying engineering within that university. The request shall be made in writing to the Council of the appropriate Participating Association. It shall be supported by a statement from the university authorities agreeing to the establishment of a Student Chapter at their institution, and by a statement by the appropriate Branch Executive Committee, concurring in the application. The Council of the Participating Association shall, within four months of its receipt, transmit the request with its recommendation to the Council of the Institute. If approved by both Councils, the request shall be granted and authority to organize the Student Chapter shall be given by the Council of the Institute to the Executive Committee of the Branch concerned. This Executive Committee shall then proceed to organize the chapter in accordance with the established practice and within the regulations contained herein. Upon due advice from the Branch Executive Committee that the Student Chapter is established, the Council of the Institute shall issue the Student Chapter Charter to the Executive Committee of the Student Chapter. A copy of the Charter shall be transmitted to the Participating Association concerned and to the Executive Committee of the Branch under which the Student Chapter shall operate. Under this procedure, all Student Chapters are Student Chapters of the Institute as well as Student Chapters of the Participating Associations concerned.

At the time of coming into force of these by-laws, all existing Student Chapters of The Engineering Institute of Canada and all existing Student Chapters of the Participating Associations shall become Student Chapters of the Canadian Institute of Professional Engineers as defined above. In the case where a Student Chapter of The Engineering Institute of Canada and of a Participating Association operate at the same university, the Council of the Institute and the Council of the Participating Association concerned shall arrange to merge the chapters, and shall make any necessary re-organization in the management and operation of these chapters. As soon as possible after the adoption of these By-laws, the Council of the Institute shall issue a new Charter to each Student Chapter.

46 OBJECTS

The objects of all Student Chapters are to encourage and facilitate the study, discussion and exchange of ideas among engineering students to prepare them to integrate themselves as members of the profession upon their graduation.

47 MEMBERSHIP

Membership in a Student Chapter shall be restricted to Student Members of the Institute and shall be obtained by requesting such membership from the Executive Committee of the Branch under which the Chapter operates, and by agreeing to pay the applicable Student Chapter fee.

48 FINANCE

The finances of a Student Chapter shall be closely supervised by the Executive Committee of the Branch under which it operates. Student Chapters will be financed by funds provided by the Institute supplemented, if necessary, by an annual student fee. This fee shall be established by the Branch, in consultation with the Executive Committee of the Student Chapter and with the Council of the Institute. The Branch Executive Committee shall make local arrangements for the collection of the annual student fee. The Student Chapter Executive Committee administers the annual budget of the Chapter under the guidance of the Executive Committee of the Branch under which it operates, all major expenditures being subject to approval by the Branch Executive Committee.

49 MANAGEMENT

The affairs of a Student Chapter are managed by an Executive Committee composed of a Chairman, a Vice-Chairman, a Secretary-Treasurer and two other members, all of whom must be Student members of the Institute.

The Council of the Participating Association concerned and the Executive Committee of the Branch shall together appoint one Member and one Junior Member of the Branch as ex-officio members of the Student Chapter Executive Committee. The immediate past-Chairman of the Student Chapter is also an ex-officio member of the Executive, which also includes a faculty representative appointed by the university authorities, if they so wish.

The Executive Committee meets at the call of the Chairman, or of one of its ex-officio members.

The Executive Committee conducts the operations of the Student Chapter in accordance with established practice, and under the general supervision of the Executive Committee of the Branch and receive assistance from the Participating Association concerned and from the Institute.

Each Student Chapter shall prepare an annual report of its proceedings and of its finances in a form and at a time prescribed by the Branch of the Institute under which it operates. This annual report shall form part of the annual report of the Branch.

ANNUAL AND SPECIAL GENERAL MEETINGS

50 ANNUAL GENERAL MEETINGS

The members of the Institute shall hold an annual meeting which shall be called by the Council of the Institute. This annual meeting shall be held at a time and place designated by the Council of the Institute, but in no case earlier than May the 15th in any year. Notice of the meeting shall be mailed to the membership at least six weeks in advance of the meeting. The notice will contain a provisional agenda including, if possible, any special business to be transacted at the meeting.

One hundred members, exclusive of members of Council, shall constitute a quorum.

The Council shall lay before the meeting a report of the proceedings of the Institute for the year ended the thirty-first day of March preceding. This report shall be approved by the Council in advance, and signed by the President and the General Manager. The financial statement of the Council and the report of the official auditors as well as the reports of the Boards, Standing Committees, Branches and such other reports as the Council may determine, shall be presented. The results of the ballot for the election of officers for the incoming year shall be announced and a Committee of Scrutineers for all letter ballots shall be appointed for the ensuing year. Any other business of interest to the Institute may be brought before the meeting by the Council.

Members of the Institute may bring before the meeting any matters of concern to the Institute. If they wish to have such matters included on the official agenda, they shall give written notice of their proposed motion to the General Manager fifteen days before the date of the meeting. They may also submit their business at the annual meeting without such notice, but in this latter case, such matters shall be considered only after all of the official business of the agenda has been completed.

The official agenda shall be approved by the Council, and the business which it contains shall be brought before the meeting in the order approved by the Council.

The Council shall on the occasion of the annual meeting, make arrangements for an appropriate program of technical and professional meetings for the benefit of the membership and in the interest of the profession.

51 SPECIAL GENERAL MEETINGS

Upon receipt of a written request for the calling of a special general meeting signed by one percent of the total corporate members and stating the business to be transacted at such meeting, the Council within three months from the receipt of such notice, shall either approve the calling of a special general meeting as requested and call such meeting or notify the persons signing such request of the reasons for the non-approval of the calling of such meeting. The notice calling a special general meeting shall state the time and place of the meeting and the particular business to be transacted thereat. Such notice shall be mailed to the membership at least thirty days before the date of the meeting. No business other than that for which notice has been given shall be transacted at the meeting. One hundred members, exclusive of members of Council, shall constitute a quorum.

52 PROCEDURE

The President presides at all general meetings of the Institute.

The President has no voting power at a general meeting except when the votes are equal, in which case he casts the deciding vote. Unless otherwise provided for in these By-laws, a motion is considered carried if it receives a simple majority of the votes cast.

The conduct and procedure of all general meetings of the Institute is governed by the standard rules and usages of Parliamentary Procedure as followed in the Parliament of Canada.

NOMINATIONS AND ELECTIONS

53 NOMINATIONS

Nominations for election of officers and councillors of the Institute shall be made by (a) the Nominating Committee; and/or (b) by petition by the membership in accordance with the following By-laws.

54 COMPOSITION AND APPOINTMENT OF THE NOMINATING COMMITTEE

The Nominating Committee consists of the immediate past president, of one Member from each of the provinces and territory which appoint or elect one or two councillors and of two Members from each of the provinces which appoint or elect more than two councillors. The members of the Nominating Committee are appointed by the Council of the Institute during the first two months following the Annual General Meeting each year, preferably from nominations which will have been received from branches of the Institute and from the Participating Associations during the month following the Annual General Meeting. The Chairman of the Nominating Committee is the immediate past-President of the Institute, who shall have no voting power. At least five of the members of the Committee shall have been members of the Council of at least one Participating Association. The membership of the Committee shall be announced by the Council to the membership in the official publication of the Institute, and shall be transmitted in writing by the General Manager to each Branch Executive Committee, and to the Council of each Participating Association.

55 DUTIES OF THE NOMINATING COMMITTEE

The Chairman of the Nominating Committee shall, prior to September 15th of each year, transmit to the branches and to the Participating Associations a list of the offices of the Council to be filled by election at the next annual meeting, inviting the branches and the Participating Associations to submit nominations for the offices with which they are concerned. Such nominations by the branches shall be received by the Chairman of the Committee not later than November 30th of each year.

The Chairman of the Nominating Committee shall ensure that these vacancies are announced to the membership in the official publication of the Institute prior to September 15th of each year.

Prior to December thirty-first, the Nominating Committee shall prepare a list of nominees for the next election of officers. This list shall contain the names of the nominees whose names have been forwarded by petition of the membership and have been found valid. It shall also contain the names of nominees selected by the Nominating Committee, preferably from the nominations made by the branches and the Participating Associations as provided for herein. The list shall contain one or more nominees for each office to be filled. However, if there are no nominations by petition for the offices of President and Vice-President, there shall be only one nominee for each of these offices.

The report of the Committee, signed by its Chairman and two other members, shall be forwarded to the President of the Institute for presentation to the Council. It shall contain the final list of nominations prepared by the Nominating Committee, indicating clearly for each nominee whether the nomination has been made by the Nominating Committee or by petition of the membership. This list shall be accompanied by a written statement from each nominee to the effect that he accepts the nomination and is willing to serve if elected. Upon approval of the report of the Nominating Committee by the Council of the Institute, the Committee shall be discharged.

56 ADDITIONAL NOMINATIONS BY PETITIONS

Members of the Institute may make nominations for any of the elective offices of the Council by petition addressed to the Chairman of the Nominating Committee and signed by fifty Corporate Members who are entitled to vote for the office concerned. Such petitions must be received by the Chairman of the Nominating Committee prior to November 30th of each year and must be accompanied by a written statement by the nominee to the effect that he accepts the nomination and is willing to serve if elected. Such additional nominations shall be considered by the Nominating Committee of the Institute and, if found valid, shall be accepted by the Nominating Committee. It shall be the duty of the Chairman of the Nominating Committee to advise officially by letter any ten of the Corporate Members who have signed the petition of the acceptance or rejection of the petition. In case of rejection, the reasons for its invalidity shall be given.

57 VACANCIES IN THE LIST OF NOMINATIONS

After the approval of the report of the Nominating Committee by Council, vacancies in the list of nominees which may be caused by any circumstances which render a nominee ineligible for election or incapable of holding office, shall be filled by the Counci if, because of such circumstances, there remains no nominee for an office for which an election is to be held.

58 ELIGIBILITY FOR NOMINATION

Nominees for office shall, in addition to the qualifications referred to elsewhere in these By-laws, meet the following requirements.

All nominees must be Corporate Members of the Institute.

Nominees for the office of President and Vice-President shall have already served on the Council of the Institute, but this requirement shall not be mandatory for the first five elections to be held after the coming into force of these By-laws.

Nominees for the office of elected councillor shall not be members of the Council of their Participating Associations at the time of their nomination. They shall preferably have been a member of one of the following: Institute Boards and Committees, Branch Executive Committees, Branch Committees, Councils of Participating Associations, Committees of Participating Associations.

59 ELECTION BALLOT

Ballot forms for elections are prepared by the General Manager in accordance with the list of nominees finally approved by the Council. Separate ballot forms shall be so prepared: one for the office of President, one for the office of Vice-President and one for the office of Councillor in each province or territory concerned. No ballot form shall be prepared for election when there is only one nominee. Such a nominee shall be considered elected by acclamation and shall be so announced when the results of the election are made public at the Annual General Meeting.

The ballot forms prepared in accordance with the above shall be mailed as required to the voting membership not later than six weeks before the date of the Annual General Meeting. Each ballot shall be accompanied by a short biography of the nominees whose names appear on it.

The names of the nominees for each office shall be arranged alphabetically on the ballot form.

Members shall vote in favour of a nominee by marking an "x" in an appropriate space opposite the name of the nominee. No other mark shall be made on the ballot form. The election shall be conducted in accordance with the regulations provided for in these By-laws under the heading "Letter Ballots".

Election ballots shall be delivered to the General Manager before five o'clock in the afternoon twelve full days before the date of the Annual General Meeting. All ballots being delivered after that time shall be considered invalid. The ballots, as received, shall be handed to the Committee of Scrutineers on the day following the closing of the ballot.

The nominee receiving the highest number of votes for any office shall be declared elected to that office.

In the case of an equal number of votes being cast for two or more nominees for the same office, the voting Members resident in the province or territory for which that election is being held, and who are present at the Annual General Meeting, shall elect by secret ballot the officer or councillor from among these nominees. In the case of a further equality of votes, the presiding officer at the Annual General Meeting shall cast the deciding vote.

LETTER BALLOTS

60 CONDUCT OF LETTER BALLOTS

Letter ballots among the membership may be taken for the purpose of electing officers, councillors, and for other reasons as may be determined by Council. Such letter ballots are conducted under the supervision of the Council in accordance with the procedure outlined herein. The Council may, whenever possible, make arrangements with any of the Participating Associations to use their facilities for the taking of ballots among the members of the Institute residing in their territory.

61 PROCEDURE

(a) All letter ballots are prepared under the supervision of the General Manager and contain proper information for voting and returning the ballot forms. Ballot forms shall be returned by the members in three sealed envelopes. The inner envelope shall contain only the ballot form and shall bear only the inscription "Ballot Form of the . . . date . . . Scrutin du . . . date . . .". The intermediate envelope shall bear only the same inscription, the signature of the member voting and his name in block letters. The outer envelope shall bear the same inscription and the address of the General Manager.

(b) The Committee of Scrutineers shall receive from the General Manager all the sealed intermediate envelopes returned by the members within the time limits set by the Council or by these By-laws. They shall ascertain that the members voting are duly recorded voting Members, setting aside the envelopes of those who do not have the right to vote. They shall then open the intermediate and inner envelopes and count the ballots. They shall prepare a written and signed report to the Council, which they will deliver to the General Manager.

FINANCE

62 FISCAL YEAR

The Fiscal Year of the Institute commences on the first day of April of each year and ends on the 31st of March following. Financial records, reports and auditors' statements shall be prepared on that basis. Membership shall also be recorded on the same dates. A Fiscal Year is designated by the year in which it commences, for example, the "Fiscal Year 1962" for 1962-63.

63 OFFICIAL AUDITORS

Official auditors who shall be a firm of Chartered Accountants shall be appointed annually by the Council. These auditors shall report to the Council on all of the financial operations of the Institute at the close of each fiscal year, prior to the Annual General Meeting.

64 ADMINISTRATION OF FINANCE

The Council administers the funds of the Institute for the purposes of carrying out the objects of the Institute. In the discharge of this duty it is advised by the Finance Committee as provided for in these By-laws.

The funds to be administered by the Council of the Institute generally fall in one of the following four categories:

(a) **Annual Assessment:** Each Participating Association remits to the Institute annually an amount of money which represents the total of the annual assessment payable to the Institute. The basis for the establishment of this assessment is determined by the Council of the Institute after consultation with the Councils of the Participating Associations and is not subject to revision at intervals of less than three years.

(b) **Revenue from Publications:** Subscription rates and other revenues from publications of the Institute are determined by the Council.

(c) **Bequests, Donations and Trust Funds:** The Council is authorized and empowered on behalf of the Institute to receive by devise, bequest, donation or otherwise either real or personal property and to hold the same absolutely or in trust and to invest and manage the same and to apply said property and the income arising therefrom to the objects of the Institute or of the trust. The Council is authorized and empowered to appoint trustees of trust funds which it may agree to administer under the conditions of a deed of trust.

(d) **Other Revenues:** The Council is authorized and empowered to receive and administer all other revenues accruing from its operations and activities.

65 SIGNING OFFICERS

All monies, cheques and other negotiable instruments received on behalf of the Institute shall be deposited at such chartered bank or banks as the Council may direct, and only to the credit of the Institute by the signature of the Treasurer or the General Manager, or such employees who may be directed to perform this duty by the Council.

The following officers shall sign all cheques, bills of exchange and other negotiable instruments: the General Manager or his deputy, and one of the following: the President, the Treasurer and the Chairman of the Finance Committee.

66 BORROWING

The Council of the Institute may from time to time:

(a) Borrow money upon the credit of the Institute in such amounts and upon such terms as the Council may deem expedient;

(b) Mortgage, hypothecate, charge or pledge all or any of the real and personal property and rights of the Institute to secure any money borrowed or any other liability of the Institute;

(c) Delegate to such one or more of the officers and members of Council of the Institute, as may be designated by the Council, all or any of the powers conferred by the foregoing clauses of this by-law to such extent and in such manner as the Council shall determine at the time of each such delegation.

67 INDEMNIFICATION

Each of the officers, members of Council and members of any committee appointed pursuant to these by-laws, and his heirs, executors and administrators, shall be indemnified and saved harmless out of the funds of the Institute against all costs, charges and expenses that such officer, member of Council or member of a committee sustains or incurs by reason of any action, suit or proceeding that is brought against him in respect of any thing done or permitted by him, in or about the execution of his duties, and all other costs, charges and expenses that he sustains, or incurs, in connection therewith, except such costs, charges or expenses as are occasioned by his own wilful neglect or default.

CO-OPERATION WITH OTHER ORGANIZATIONS

68 The Institute may affiliate or co-operate with any international organization and with national organizations having objects similar to those of the Institute. In addition, divisions and branches of the Institute may, with the approval of Council, co-operate with other organizations in the joint sponsorship of projects in the interest of the profession. In all such cases, the Council of the Institute shall establish a policy designed to bring about full and friendly co-operation at the appropriate level.

DISCIPLINE

69 Disciplinary action against the members of the Institute may be taken by the Council, based on the following provisions:

(a) In all professional or business relations, the members of the Institute are governed by the Code of Ethics of the Association or Corporation of Professional Engineers of the Province or territory in which they are registered, recorded or licensed or, in the case of Technical Associates residing in one of the provinces of Canada or the Yukon Territory, by the Code of Ethics of the Association or Corporation of the province or territory in which they reside.

(b) The Council shall suspend or expel automatically any member of the Institute who has suffered such action by the Council of a Participating Association. The Council shall take such action immediately upon receipt of written notice to that effect from the Council of the Participating Association concerned.

(c) The Council has the right to censure, suspend or expel from the Institute any Technical Associate who is found guilty of a breach of the Code of Ethics by which he is governed or who may be convicted by a competent tribunal, of felony, embezzlement, larceny, or other offence which, in the opinion of the Council, renders him unfit to be a Technical Associate of the Institute.

(d) The Council also has the right to censure, suspend or expel from the Institute any Technical Associate residing outside a province of Canada or the Yukon Territory or any Corresponding Member who is, in the opinion of Council, guilty of a breach of ethics.

(e) All complaints received by the Institute relative to the conduct of a member registered or residing in a province of Canada or the Yukon Territory shall immediately be referred to the Provincial or Territorial Association or Corporation established in that province or territory.

(f) The procedure governing the hearing of cases of breach of ethics by a Technical Associate shall be that followed by the Participating Association established in the province or territory in which the Technical Associate concerned resides.

(g) All decisions on matters of discipline must be ratified by an affirmative vote of the absolute majority of the members of the Council.

AMENDMENTS TO BY-LAWS

70 PROPOSALS FROM THE MEMBERSHIP

Proposals to introduce new By-laws or to amend or to repeal existing By-laws shall be presented in writing to the Council, signed by at least one percent of the total Corporate Members. After having invited the opinion of the Participating Associations, the Council shall consider the proposals and the proposers shall be notified of the opinion of the Council in regard thereto, within three months of the receipt of their request. The proposals, if approved by Council, shall be submitted by letter ballot to the voting members of the Institute. The letter ballot shall be issued by the General Manager not later than three months after the approval of the proposals by Council.

The proposed amendments to the By-laws shall be considered as approved by the membership provided that at least thirty per cent of the total number of Corporate Members of the Institute have cast their letter ballot that at least two-thirds of the voters have recorded favourable replies.

Amendments to the By-laws which receive the required number of affirmative votes shall be considered approved forthwith. Changes affecting the tenure of office of an officer shall not take effect until the expiration of the term of office affected.

71 **PROPOSALS BY THE COUNCIL**

The Council may, at its discretion and after obtaining the opinion of the Participating Associations, prepare amendments to the By-laws. Such amendments shall be submitted by letter ballot to the voting membership of the Institute in accordance with the procedure described in the preceding section.

INTERPRETATION OF BY-LAWS

72 Any contingencies not provided for in these By-laws or any questions as to the meaning and intent of the By-laws are dealt with by Council.

TRANSITIONAL PROVISIONS

73 **PROVISIONAL COUNCIL**

Notwithstanding the provisions of by-law 16, during the period from the coming into force of these by-laws until the first regular Council composed as provided in by-law 16 has been elected and has assumed office, the Council of the Institute shall be a Provisional Council only. The Provisional Council shall be composed of members who have been appointed prior to the coming into force of these by-laws in the following manner:

(a) One President and two Vice-Presidents appointed jointly by the Council of the Engineering Institute of Canada holding office prior to the coming into force of these by-laws and by the Council of The Canadian Council of Professional Engineers.

(b) One member from each of Newfoundland, Prince Edward Island and Yukon Territory appointed in each case jointly by the Council of the provincial or territorial association and by the Councillors of the Engineering Institute of Canada representing the branches within each province or territory.

(c) Two members from each of Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Alberta and British Columbia, one of such members in each case being appointed by the Council of the provincial association and one member in each case being appointed by the Councillors representing the branches of the Engineering Institute of Canada in each province.

(d) Three members from Quebec, one of such members being appointed by the Council of the Corporation, one of such members being appointed by the Councillors representing the branches of The Engineering Institute of Canada in Quebec and one of such members being appointed jointly by the Council of the Corporation and by the Councillors representing the branches of the Engineering Institute of Canada in Quebec.

(e) Four members from Ontario, two being appointed by the Council of the provincial association and two members being appointed by the Councillors representing the branches of The Engineering Institute of Canada in Ontario.

The President and Vice-Presidents and Councillors of the Engineering Institute of Canada holding office prior to the coming into force of these by-laws shall cease to hold office and the Provisional Council shall assume office immediately on the coming into force of these by-laws.

The Provisional Council shall have all the powers and duties of the Council. Service on the Provisional Council shall not be interpreted as service on the Council of the Institute as mentioned in By-Laws 18 and 20.

74 **ELECTION OF FIRST REGULAR COUNCIL**

Notwithstanding the provisions of by-laws 53 to 59 inclusive, the Nominating Committee for the first election following the coming into force of these by-laws shall be appointed by the Provisional Council and such appointment need not comply with the provisions of by-law 54. The Nominating Committee and the Provisional Council shall comply with the provisions of by-laws 55, 56 and 57, subject to such variation from the provisions of these by-laws as may in their opinion be necessary and they shall have power to alter any of the times and time limits provided in these by-laws.

Notwithstanding the provisions of by-law 16, at the time of the election of the first regular Council after the coming into force of these by-laws, one Vice-President and a proportion of the Councillors shall be elected or appointed for a term of office of one year. The Provisional Council may make regulations before such election or appointment prescribing which offices of Vice-President and Councillor shall be filled for a one year term.

VALIDATION

75 When any act or thing under the provisions of these By-laws directed to be done within a limited time is not so done, or is not properly or effectually done, then anything actually done prior to such omission or improper of ineffectual act shall not be thereby vitiated, but shall remain in full effect and the Council either prior or subsequent to such act not properly or effectually done or omitted, may extend the time for completing or perfecting any such act or thing, which when completed or perfected, shall have the same effect as if done strictly in accordance with the provisions of these By-laws.

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PART 5: THE BUDGET

Part 1		
Salaries	$175,000	
Rental	14,000	
General Office Expense	35,000	
Mailing (Special	5,000	
Council Meetings	10,000	
Executive Committee Meetings	4,000	
Annual Meeting Deficit	3,000	
Staff Travel	17,000	
Travel — President and Vice-Presidents	6,000	
Travel — Councillors	8,000	
Travel & Meetings — Executive, Board, & Committees	20,000	
Membership, Conferences & Committees with other Societies	16,000	
Conference on Education	2,000	
Student activities	13,000	
Student prizes	1,000	
Pensions and Other Benefits	11,000	
Public Relations (Entertainment)	4,000	
Audit	1,000	
Depreciation (Office Furniture, equipment, etc.)	5,000	
Legal Expenses	1,000	
Miscellaneous special printing	15,000	
Miscellaneous services	4,000	
Contingencies	25,000	$395,000
Part 2		
Branch Rebates	60,000	
Membership Records	35,000	
Transactions	10,000	105,000
Grand Total		$500,000

The estimated total assessment per member become $12.50 — in addition to the fees payable to the provincial associations and corporation.

By way of comment — at the present time the provincial associations are assessed and paying to Canadian Council $1.35 per member, and also some associations are paying $1.00 or more toward branch organization or operation.

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PART 6: PROCEDURES FOR IMPLEMENTATION

6.1 The procedures necessary for the implementation of the confederation are fairly lengthy but if taken step by step are logical in their approach. With the benefit and assistance of legal counsel, the step by step procedures have been developed.

6.2 **SOLICITOR'S RECOMMENDATIONS AS TO PROCEDURE**

Proposed confederation of The Engineering Institute of Canada and The Canadian Council of Professional Engineers.

1. The officers of each of the Participating Associations and of the Engineering Institute should give assurance that the terms and form of each of the following documents have been agreed to by each of their respective councils and will be recommended to their members for approval, viz:

(a) The terms of the proposed bill to be submitted to Parliament to amend the charter of The Engineering Institute of Canada and change the name to "The Canadian Institute of Professional Engineers";

(b) The proposed by-laws of the Canadian Institute, referred to in the following paragraph 8;

(c) The "preliminary" agreement for confederation referred to in the following paragraph 6;

(d) The final agreement to be entered into after the proposed Private Act has come into force referred to in the following paragraph 9.

2. At this point it would be desirable that there should be prepared preliminary drafts of the petition which will be submitted to Parliament by the Engineering Institute requesting the enactment of the Private Act and of the supporting submission which may be presented by the Participating Associations and the Canadian Council of Professional Engineers. If The Engineers Confederation Commission is still functioning, it may be desirable for these drafts to be prepared by a committee of that Commission. Otherwise, presumably they would be prepared by The Engineering Institute of Canada and the Canadian Council of Professional Engineers in consultation with solicitors.

3. It also appears desirable that at this point, and before the terms of the proposed bill are submitted for formal approval by the Associations concerned, there should be an informal discussion with the Law Clerk of the Senate or some other appropriate law officer of Parliament in order, so far as possible, to ensure that there will be no objections to the form of the bill from the point of view of legislative draft-

manship. The draft bill could be submitted for this informal consideration either by solicitors or by the Secretary of The Engineering Institute of Canada or The Canadian Council of Professional Engineers.

4. The Engineering Institute should then submit to its members by letter ballot for approval:

(a) A by-law (or resolution) authorising the proposed application to Parliament for a Private Act, including the terms of the proposed Bill.

(b) The terms of the proposed by-laws of the Canadian Institute to become effective when the Private Act comes into force.

The form in which the foregoing are submitted to the members of the Engineering Institute and the procedure followed will be governed by the present by-laws of The Engineering Institute of Canada. On the basis of the provisions of Section 80 of the present by-laws, this would require the following:

i. The proposals should be mailed to corporate members of the Engineering Institute not less than 21 days before an annual general meeting.

ii. The proposals should be submitted for discussion at the next annual general meeting following the mailing.

iii. The proposals should then be submitted by letter ballot to the corporate membership of the Engineering Institute not later than two months after the annual general meeting, returnable not later than three months afer the annual general meeting.

iv. An affirmative vote of two-thirds of all valid ballots is necessary.

It is suggested that all these matters be submitted to the members of The Engineering Institute of Canada in the form of by-laws, or at least following the same procedure as is required for changes in by-laws, in order that it may be clear to the Parliamentary committees considering the bill that the application is properly authorised by the membership of the Engineering Institute.

5. The Councils of the Participating Associations should formally authorise each of the Participating Associations to enter into the "preliminary" agreement for confederation. This agreement together with the draft bill and by-laws may be submitted for approval to the members of each of the Participating Associations. Whether it is necessary for this to be done will depend upon the charter and by-laws of the individual association, but in any event the Councils of Participating Associations may consider it desirable that these matters be approved by their membership as a whole.

6. It is suggested that a "preliminary" agreement for confederation should be entered into by the Engineering Institute and each of the Participating Associations. This agreement would contain the following principal provisions:

(a) The Engineering Institute and the Participating Associations would agree upon the terms of the Private Act to be requested from Parliament.

(b) The Engineering Institute would undertake to make application to Parliament for a Private Act in the terms agreed upon.

(c) The Engineering Institute and the Participating Associations would agree upon the form of the new by-laws to come into force when the Private Act comes into force; these by-laws would be exactly the same as those approved by the membership of the Engineering Institute (see the foregoing paragraph 4) and as previously approved by each of the Associations (see the foregoing paragraph 5).

(d) The Engineering Institute and the Participating Associations would agree upon the terms of the "final" agreement to be entered into by each of the Participating Associations with the Canadian Institute after the Private Act comes into force, in accordance with the provisions of Section 5 of the proposed by-laws.

7. After approval by all concerned, the Engineering Institute would then present to Parliament its petition for a Private Bill. The following points may be considered in connection with this:

(a) It may be considered desirable that the petition of the Engineering Institute be accompanied by supporting submissions from each of the Participating Associations or from The Canadian Council of Professional Engineers.

(b) Normally Private Bills are introduced in the Senate.

(c) Petitions for Private Bills must be filed with the Clerk of the Senate within the first six weeks of the session of Parliament at which the Private Bill is to be presented.

(d) Notice of the application for a Private Bill must be published in the Canada Gazette at least once a week for a period of four consecutive weeks.

(e) It will be necessary to arrange for some member of the Senate to introduce the Bill and supervise its passage.

(f) It will also be necessary, of course, to ensure that proper support for the Bill will be forthcoming both in the Senate and in the House of Commons, and particularly in the committees which will consider the Bill.

(g) Presumably it will be desired that some committee shall be responsible for approving any changes in matters of detail in the Bill which may be required by Parliament when the Bill is considered in committee. While the consent of The Engineering Institute of Canada would probably be adequate for the purposes of the Parliamentary committee (since the petition for the Bill is the Engineering Institute's petition), from the point of view of the confederation plan, no doubt, it will be necessary for any such changes to be approved by a committee representing all the Participating Associations. If the Engineers' Confederation Commission is still functioning, presumably it would be suitable body for this purpose. Alternatively, a committee would probably be required representing all the Participating Associations and The Engineering Institute of Canada.

8. It is important to bear in mind that the "new" Canadian Institute (The Canadian Institute of Professional Engineers) will be the same corporation as The Engineering Institute of Canada and will really only be The Engineering Institute of Canada under a new name, with added powers and objects and new by-laws and membership. It is not possible, however, for the new by-laws to come into force before the new Private Act comes into force. It will be necessary, therefore, to take steps to ensure that the new by-laws come into force as soon as possible after the Private Act comes into force and without the necessity of having to submit these by-laws afterwards to the whole membership of the Institute. In order to accomplish this, a clause (Section 10) has been included in the draft bill approved by The Engineers' Confederation Commission providing as follows:

> "10. Upon the coming into force of this Act, the present by-laws of the Canadian Institute shall be repealed, and the by-laws of the Canadian Institute shall be the by-laws heretofore approved, subject to the condition that this Act shall come into force, by letter ballot by members of the Canadian Institute, until such by-laws are amended or repealed. The officers and members of council of the Canadian Institute holding office at the time of the coming into force of this Act shall continue to hold office until their successors have been appointed or elected in accordance with the provisions of the by-laws".

Some problem may arise if Parliament makes changes in the draft bill before it is passed. It is unlikely that these changes would affect the majority of the by-laws but they might affect By-law 1 (name) and By-law 2 (objects). Since the by-laws are all to be approved before the Act has been passed, it would be desirable to have some saving provision in any approval of the by-laws to ensure that the by-laws can be adapted to conform with the Act. Such a provision has been included in paragraph 11 (b) of the suggested "preliminary" agreement enclosed and it is suggested that in any submission of these by-laws to the members of The Engineering Institute of Canada language to the following effect be included in the formal approval:

> ". . . The by-laws of the Institute which shall come into force when the Private Act comes into force shall be the by-laws, the terms of which are set forth in Schedule A hereto, with such deletions, additions and/or amendments thereto as may in the opinion of the President of the Engineering Institute of Canada be necessary to ensure that the said by-laws conform to the provisions of the said Private Act, the opinion of the President to be conclusively evidenced by his certification thereof in writing."

9. If the sequence suggested in the preceding paragraphs is followed, then upon the bill being passed and the Private Act coming into force the new by-laws would come into force and thereupon each of the Participating Associations would sign an agreement with the Canadian Institute in the form already agreed upon (as referred to in the foregoing paragraph 6 (d)). A suggested draft for such a "final" agreement to be entered into between each Participating Association and the Canadian Institute is enclosed.

10. When all agreements with Participating Associations had been signed, "confederation" would be considered accomplished.

11. It is necessary to make some arrangements for the transition to the new by-laws particularly in order that a "Provisional Council" may be appointed to function during the period from the coming into force of the new Private Act and by-laws until the first election of the first regular Council of the Canadian Institute. Provision for such a Provisional Council has been made in the by-laws; if these provisions are followed, it will be necessary for the Participating Associations and the Engineering Institute of Canada, before the date when the Private Act comes into force, to appoint members to this Provisional Council.

To summarise the foregoing the suggested sequence would be as follows:

(a) Approval of the drafts prepared by The Engineers' Confederation Commission.

(b) Clearance with legislative counsel in Ottawa.

(c) Approval by the membership of The Engineering Institute of Canada.

(d) Formal approval by each of the provincial and territorial associations.

(e) Signing of a "preliminary" agreement for confederation by all the Participating Associations and The Engineering Institute of Canada.

(f) Application to Parliament for a Private Act.

(g) Coming into force of the Private Act and the new by-laws.

(h) Execution of "final" agreements between each of the Participating Associations and The Canadian Institute of Professional Engineers.

6.3 PRELIMINARY AGREEMENT FORM

The proposed preliminary agreement form as referred to in Section 6.2, para. 5 and 6, is shown drafted as Appendix "F".

6.4 FINAL AGREEMENT FORM
The proposed final agreement form as referred to in Section 6.2, para. 6d and 9, of this part, is shown as Appendix "G".

PART 7: OTHER RECOMMENDATIONS

7.1 LIBRARY
This commission recommends that the present library service as operated in Montreal by the Engineering Institute of Canada be **not** continued as a service of the new national organization since it serves a relatively local and limited number of members and is of limited value to the membership at large.
At the same time it is recognized that it is a technical library of high quality and historic value and should not be carelessly dispersed.
It is suggested that it could be given, intact, with full recognition in the terms of the gift, to one of the newer universities entering the field of engineering teaching or, alternatively, to the National Research Council as a section of the national technical library resources.

7.2 EMPLOYMENT SERVICE
This commission recommends that an employment service **not** be provided by CIPE. It will be recognized that a certain amount of day to day informal employment inquiries will be made of any national headquarters staff. However, any formal organization for employment services to be of effective value would be costly of time and money and would be in direct competition with the many effective agencies that are now available—such as placement offices of universities, certain provincial associations, National Employment Service, Technical Service Council, private placement companies, etc.

7.3 SPECIAL COMMITTEE
Part 6 of this report details the step by step procedure for implementation.
Attention is particularly drawn to Items 2 and 7 (g) of those procedures. wherein it is recommended that a special committee be appointed and authorized to "steer" the proposed bill through the Parliament of Canada, and also authorized to permit minor changes in detail as might be required by Parliamentary Committees prior to the final preparation and passage of the bill.
It is recommended that when the time comes for such appointments that the appointees be drawn from membership of this commission and that they be persons well informed in regard to the development and context of the proposed charter and by-laws.

7.4 TRANSITION TO THE NEW BY-LAWS
Provision has been made in the proposed Amendment Act to ensure that the proposed new by-laws would come into force without the necessity of having to re-submit them to the membership at large. There will, however, be an intertim period between the granting of the Amendment Act and the election of the first Council. A provisional set of officers and council **must be provided** for that period.
Provision has been made in the proposed By-Laws for the appointment to office and to the Council for this interim period.

7.5 THE ENGINEERS CONFEDERATION COMMISSION
With the presentation of this report, the duties of this Commission are concluded. The term of its appointment terminates in October, 1961. It is obvious that there will be many details which will require clarification or amplification for those who have not shared in this complete project.
The Commission, therefore, is prepared to remain on a standby basis until the term of its appointment is concluded.
Should all parties participating in this project wish to re-appoint the Commission for an additional period or term, the present Commission members are prepared to serve.

7.6 PROVISIONAL COUNCIL
Section 7.4 of this report makes reference to the need for a provisional Council. This Commission is prepared to serve as that provisional Council should it be the decision and desire of those participating in confederation.
The membership or the commission is consistent with by-law requirements provided one vice-president is added.

PART 8: ACKNOWLEDGMENTS

8.1 This report reflects the majority opinion of the commissioners. It will be realized that no project of this magnitude could at all times secure unanimous decision.
Minority opinions were recognized and, in the very few instances where these could not be resolved, majority decision was accepted.
During the meetings of the commission, of committees, and sub-committees, freedom of expression and opinion was given full play. An atmosphere of understanding and appreciation of the problems of geographic areas and groups, differing in backgrounds and interests, were at all times recognized and, if necessary, compromise decisions were made.
Your Commission has deemed it a great privilege to serve their various Canadian provincial and territorial associations and Corporation of Professional Engineers and the Engineering Institute of Canada all toward the common objective of a truly confederated organization of Professional Engineers which can speak with a unified voice on behalf of Professional Engineers in Canada.

8.2 Respectfully submitted on behalf of the Engineers Confederation Commission.

Signed ....
John H. Fox, P.Eng., M.E.I.C.,
Chairman.

Signed ....
J. E. Leo Roy, P.Eng., M.E.I.C.,
Vice-Chairman

April 15, 1961.

APPENDIX "A"
REPORT OF THE COMMITTEES ON CONFEDERATION
MARCH 18TH, 1959

THE PRESIDENT AND COUNCIL,
CANADIAN COUNCIL OF PROFESSIONAL ENGINEERS
and
THE PRESIDENT AND COUNCIL,
THE ENGINEERING INSTITUTE OF CANADA.

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 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 the requirement of presentation and implementation to the Council and members of The Engineering Institute of Canada.
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.
(signed) John H. Fox, P.Eng., M.E.I.C.
Chairman.
Respectfully submitted on behalf of
THE ENGINEERING INSTITUTE OF CANADA
Committee on Confederation.
(signed) Irving R. Tait, P.Eng., Hon. M.E.I.C.
Chairman.

PART "A"
REPORT OF COMMITTEES ON CONFEDERATION

As appointed by the Canadian Council of Professional Engineers and the Engineering Institute of Canada.

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 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	2 members	
Manitoba	2 members	
New Brunswick	2 members	
Nova Scotia	2 members	
Saskatchewan	2 members	
Newfoundland	1 member	(appointed)
Prince Edward Is.	1 member	
Yukon	1 member	
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 decisions 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.

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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 subcommittee 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 DATE

(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.

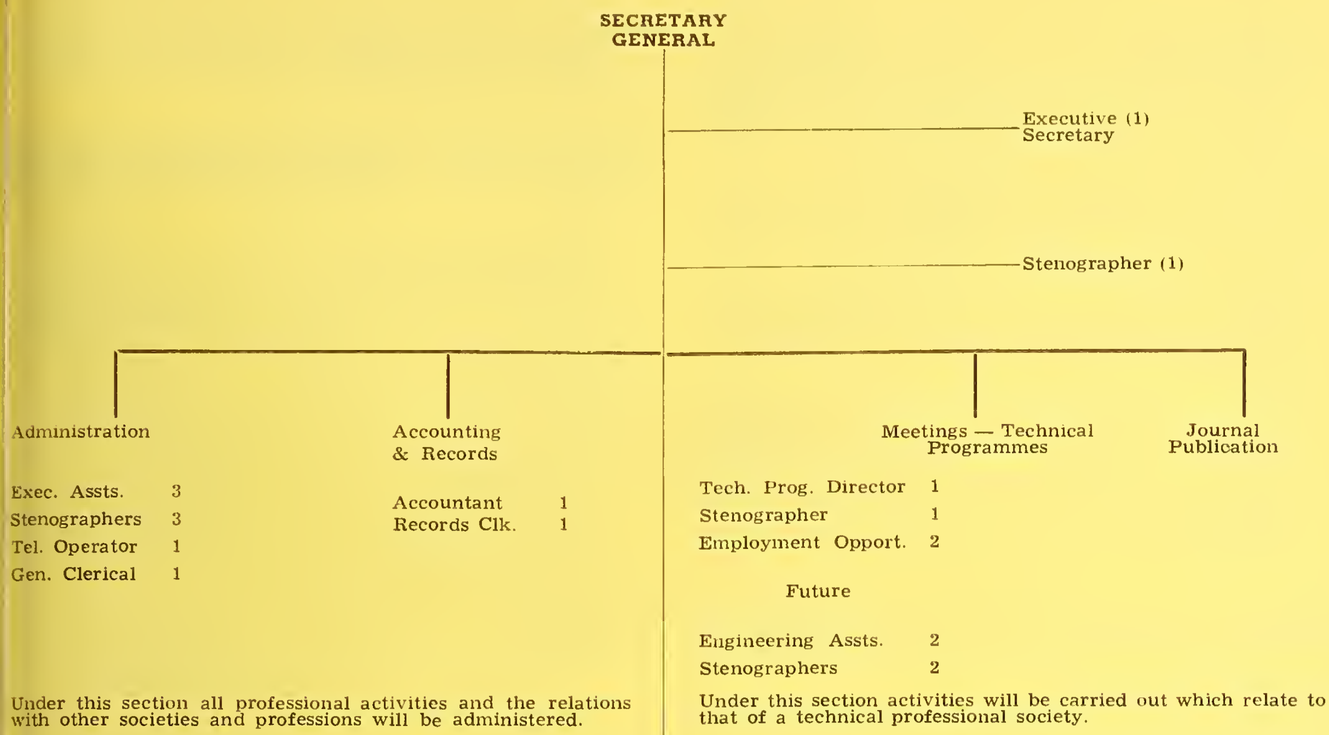
(e) Fee accounting and collection will be handled by the offices of the Provincial Bodies;—(where the provincial membership does not warrant the support of an office staff these services will be rendered by the office of the National Body with the cost charged to the province concerned).

(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.

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



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.

PART "C"

STATEMENTS OF INTERPRETATION IN REGARD TO CLAUSES 1 TO 8 OF THE REPORT ON CONFEDERATION, (PART "A")

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 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.

Clause 2. The significant word in this clause is "full" before the word "membership". In essence this means that to 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 over-balancing 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).

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 association 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 Association 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 Territory	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 75—Part "A", becomes redundant and unnecessary and should be disregarded.

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 Territory	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 75 — Part "A", becomes redundant and unnecessary and should be disregarded.

APPENDIX "B"

MEMBERSHIP OF COUNCIL

Based on membership of the participating associations and corporation as of January 1st, 1961, the Council of the Institute shall be composed as follows:

One President		elected
2 Vice-Presidents		elected
Alberta	2 members	1 appointed by each participating association and elected at large — not serving on provincial council.
British Columbia	2 members	
Manitoba	2 members	
New Brunswick	2 members	
Nova Scotia	2 members	
Saskatchewan	2 members	
Newfoundland	1 member	appointed by each participating association.
Prince Edward Island	1 member	
Yukon	1 member	

Quebec	3 members	1 appointed by participating corporation and 2 elected at large — not serving on provincial council
Ontario	4 members	1 appointed by participating association and 3 elected at large — not serving on provincial council

APPENDIX "C"

ROTATION OF TERMS OF OFFICE ON THE COUNCIL

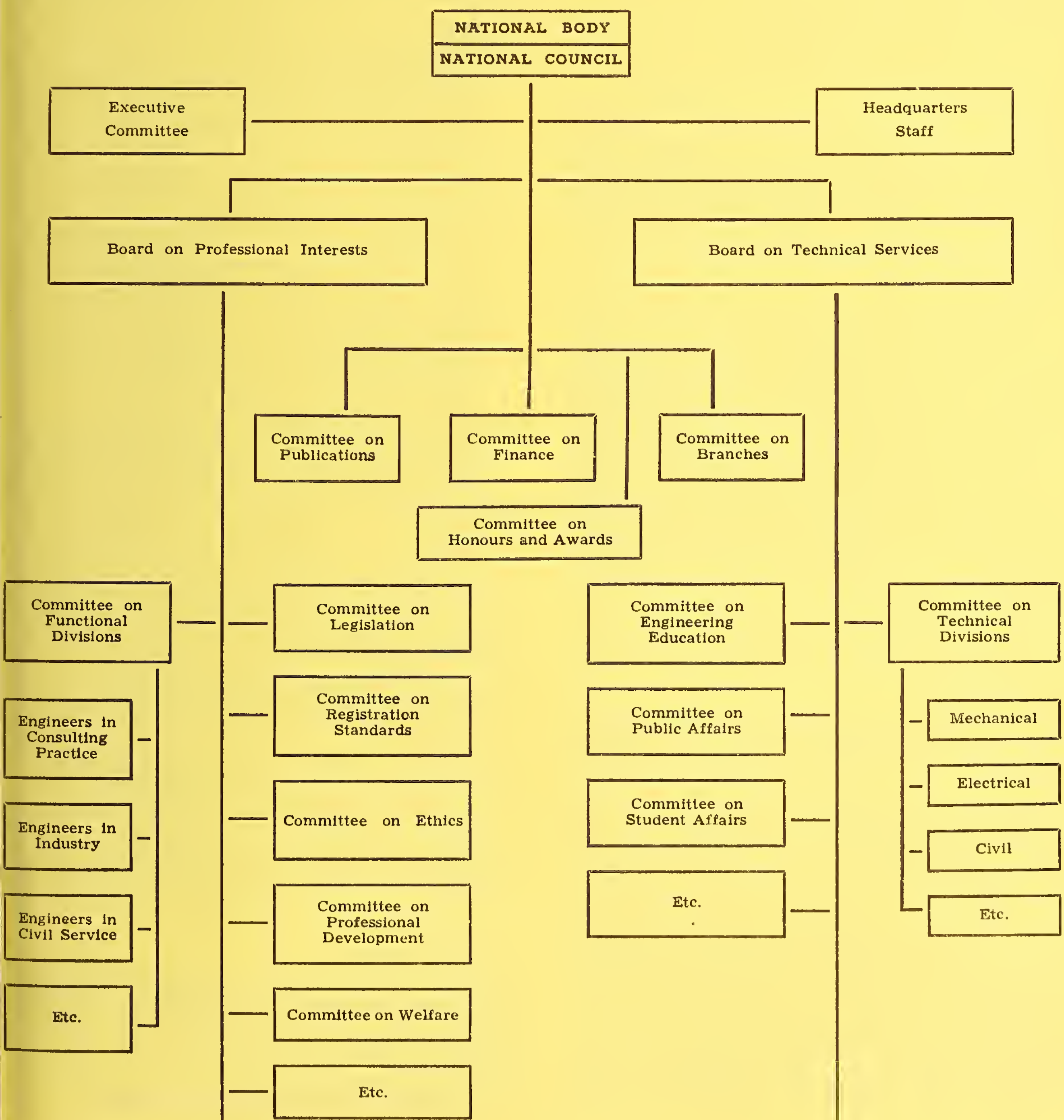
The terms of office of the first Councillors should be as follows: (See right hand column—ed.)

One year term Elected	One year term Appointed			Two year term Elected	Two year term Appointed
—	1	Alberta	(2)	1	—
1	—	British Columbia	(2)	—	1
—	1	Manitoba	(2)	1	—
1	—	New Brunswick	(2)	—	1
—	1	Nova Scotia	(2)	1	—
1	—	Saskatchewan	(2)	—	1
—	1	Newfoundland	(1)	—	—
—	—	Prince Edward Is.	(1)	—	1
—	1	Yukon	(1)	—	—
1	—	Quebec	(3)	1	1
2	—	Ontario	(4)	1	1
6	5			5	6

APPENDIX "D"

ENGINEERS' CONFEDERATION COMMISSION

PROPOSED ORGANIZATION CHART



APPENDIX "E"

PROPOSED BRANCH MODEL BY-LAWS

(Revised March 28, 1961 to conform to C.I.P.E. By-Laws)

"BY-LAWS OF THE .... BRANCH
OF THE
CANADIAN INSTITUTE OF PROFESSIONAL ENGINEERS"

1 NAME

The Branch shall be known as the .... Branch of the Canadian Institute of Professional Engineers.

2 DEFINITIONS

Where the word "Institute" appears, it shall be construed to mean the Canadian Institute of Professional Engineers.

Where the word "Association" appears, it shall be construed to mean the .... Association of Professional Engineers.

Where the word "Branch" appears, it shall be construed to mean the .... Branch of the Canadian Institute of Professional Engineers.

Where the words "National Council" appear, they shall be construed to mean the Council of the Canadian Institute of Professional Engineers.

Where the words "Provincial Council" appear, they shall be construed to mean the Council of the .... Association of Professional Engineers.

Where the words "Professional Engineer" appear, they shall be construed to mean a member of the .... Association of Professional Engineers.

3 OBJECTS

The objects of the .... Branch of the Institute shall be to promote the objects and interests of the engineering profession as defined by the Institute and by the Participating Associations. They shall encourage and facilitate the study, discussion and exchange of ideas and information among the members, on all questions of interest to them as professional engineers and as citizens. With the assistance and co-operation of the Institute and of the Participating Associations, branches shall extend their services to engineering students at universities and colleges, and also to high school students, to provide potential members with adequate information about the profession of engineering.

4 MEMBERSHIP

(a) Membership in the Branch shall be open to all members of the Institute who reside within the prescribed geographic limits, i.e. being the area bounded by .... etc., etc.

(b) At the option of the Executive Committee of the Branch, persons who are not members of the National Body may be admitted to participate in all Branch privileges other than the holding of office, or the discussion of, or voting on, **any matter concerned with the Branch or Branch Section,** or the policy of the Association or Institute. Such persons shall be styled Branch affiliates and shall pay to the Branch Treasurer such annual dues as determined by the Executive Committee.

A Branch affiliate shall be elected for one year by the vote of the Executive Committee upon nomination by two Members with supporting proof that they have an interest in common with the Engineering profession. Subject to annual review and approval by the Executive Committee, extensions of privileges may be granted to Branch affiliates without renomination.

5 BRANCH OFFICERS

The Officers of the Branch shall consist of:

Chairman
Vice-Chairman
Secretary
Treasurer

These officers shall hold office for one year and shall be elected according to the requirements of Section II following.

The Chairman shall be a Corporate member of the National Body. The positions of Secretary and Treasurer may be combined.

6 EXECUTIVE COMMITTEE

The affairs of the Branch shall be administered by an Executive Committee which shall consist of:

(a) Chairman
Vice-Chairman
Secretary
Treasurer

(b) The immediate past chairman and immediate past secretary of the Branch for a period of one year.

(c) One or more Branch members who shall be Corporate members of the Institute, elected annually for a term of office not exceeding two years.

(d) A member appointed by the Council of the Participating Association.

(e) Branch members who may be members of the Council of the Institute or of the Participating Association shall be ex-officio members of the Executive Committee.

Should a vacancy occur in the Executive Committee before the date set aside for the appointment of the Nominating Committee, a member may be appointed by the Executive Committee to the vacancy for the balance of the term.

Not less than 50% of the members of the Executive Committee shall constitute a quorum.

7 OTHER COMMITTEES

Other Committees may be appointed by the Executive from time to time for specific purposes. These Committees shall perform their duties under the supervision of the Executive Committee and shall report to the Executive Committee.

8 BRANCH SECTIONS

At the request of ten members of a Branch made in writing to the Secretary of the Branch, and approved by the Executive Committee, Technical Sections of the Branch shall be established, corresponding to the technical division organizations established by the Institute such as chemical, civil, electrical, mechanical, mining, etc. Similarly functional sections of the Branch may be established corresponding to the functional division organization established by the Institute and the Participating Associations.

Branch Sections shall operate in accordance with rules established by the Board on Technical Services or the Board on Professional Interests, whichever is applicable.

The Executive Committee shall appoint one of its members as an ex-officio member of each Branch Section committee.

The Branch may establish geographical sections for the purpose of serving members located in remote communities. These sections shall be governed by the Branch By-Laws.

9 BRANCH FUNDS AND PROPERTY

The Executive Committee shall control all funds and other property of the Branch.

(a) Immediately after installation, the Executive Committee shall cause to be prepared a budget respecting Branch finances for the ensuing year, and with this in view shall obtain applications for appropriations from the various Branch Sections whose activities will affect the funds of the Branch.

Following final formal approval by the Executive Committee of the budget and the allocations to the various Sections, each Section Committee shall be permitted to incur expenses up to the amount so allocated.

(b) All funds received on account of the Branch shall be deposited to the credit of the Branch in a chartered bank designated by the Branch Executive Committee.

(c) A motion of approval by the Executive Committee shall be required to authorize expense in respect to the operation of the Branch, and a motion of approval by a Section Committee shall be required to authorize expense in respect to the operation of the Section, in either case excepting individual petty cash disbursements. No expense not provided for in the budget shall be committed without prior approval by the Executive Officers.

The payment of every account in respect to the operation of any Branch Section shall be made by the Branch officers if the amount is within the budget allocation to the Section, or from the special funds of that Branch Section, provided the expense voucher bears the approval signatures of the Section Chairman or the Vice-Chairman, and the Section Secretary.

The payment of every account (except for petty cash disbursements) shall be made by cheque signed by the Treasurer, and countersigned by either the Branch Chairman or the Vice-Chairman.

(d) The financial accounts for the Branch as maintained by the Treasurer shall include a petty cash account complete with all debit and credit entries.

At each regular meeting of the Branch Executive Committee, the Treasurer shall submit for approval a statement of disbursements.

(e) The Treasurer shall maintain separately the account of each Section, also the account of any special funds.

(f) The financial year of the Branch and of every Section shall coincide with that of the Institute. Upon completion of the financial year, all accounts shall be closed out and the results of the year drawn up in Branch statements of revenue and expense. A balance sheet shall be prepared to set forth the assets and liabilities as on March 31st.

(g) Each year prior to the annual general meeting, the Executive Committee shall appoint one or more auditors competent to examine the vouchers and accounts of the Branch and Sections and to determine the correctness of assets and liabilities as shown on the balance sheet. The auditors' report shall be presented to the annual general meeting.

At any time the Executive Committee may order a special audit.

10 BRANCH DUES

Following formal approval of the budget, the Executive Committee may establish a fee (if required) to be paid by members for the ensuing year, in consultation with the Provincial Association who will collect the fee and forward the same to the Branch.

Branch affiliate dues shall be established and collected by the Branch.

11 NOMINATION AND ELECTION OF OFFICERS

The Executive Committee shall meet at least two months before the date set for the Annual Meeting and select at least two members, other than themselves, to act as a Nominating Committee to prepare and submit to the Executive Committee, accepted nominations for the vacant positions for the ensuing year.

In addition where possible, the Nominating Committee shall include the immediate past chairman of the Branch who shall be Chairman of the Nominating Committee.

At least six weeks before the date set for the Annual Meeting, the Secretary shall send to each member the names and addresses of those nominated by the Nominating Committee. At the same time he shall call attention to the following clause, and state the date, time and place of the Annual Meeting.

Further nominations may be made over the signatures of any four members of the Branch with the acceptance in writing of the nominee. Such nominations must be in the hands of the Secretary at least three weeks before the Annual Meeting.

The Secretary shall then send to each member at least two weeks before the Annual Meeting, the names and addresses of all those nominated with a ballot form to be returned not later than a specified time.

•The number of weeks notification are suggestions only and should be set by Branch requirements.

The Executive shall appoint scrutineers to tally the ballots and report the results at the Annual Meeting. Ballots should be destroyed on motion by the Annual Meeting.

12 ANNUAL MEETING

The Annual Meeting shall be held not later than ...., in .... Not less than ten days' prior notice of the time and place of the Annual Meeting, as determined by the Executive Committee, shall be given to all members.
.... members shall constitute a quorum.

13 ORDER OF BUSINESS OF ANNUAL MEETING

The order of business for the Annual Meeting shall be as follows:

(a) Reading of the notice calling the Meeting.
(b) Reading of the minutes of the previous Annual Meeting.
(c) Secretary's, Treasurer's, and Sub-Committee's reports and discussions thereon.
(d) Auditor's report.
(e) Chairman's Address.
(f) Installation of new Officers.
(g) Communications, new business, notices of motions, and discussions thereon.

14 ORDINARY MEETINGS

The holding of Regular Meetings and their order of business shall be decided upon by the Executive Committee.

15 SPECIAL MEETINGS

Special Meetings may be called on the request in writing, addressed to the Secretary, of .... members stating the objects of the meeting and a notice stating the objects of the meeting shall be mailed by the Secretary to all members at least five days before the meeting. The date of such meetings shall be determined by the Executive Committee and the quorum shall be .... members.

16 AMENDMENT TO BY-LAWS

Changes to the By-Laws may be requested by the Executive Committee or by a signed request from .... members to the Executive Committee. Notice of motion to alter the By-Laws shall be presented to the members at least two weeks prior to a regular or special meeting where the motion will be put to a vote of the members present. If a two-thirds majority is obtained, the motion will be submitted to all the members where a simple majority shall rule.

After approval by the Branch Members all alterations to the By-Laws must be approved by the Provincial Council and National Council.

17 INTERPRETATIONS

Other than being subject to appeal to Provincial Conucil, the interpretation of the Branch By-Laws by the Executive Committee shall be final.

18 GENERAL PROCEDURES

Where not otherwise provided for, the Branch shall conform in rules of order and general procedure, to the methods and rules adopted by the National Council.

DUTIES OF OFFICERS AND COMMITTEES

CHAIRMAN

The Chairman is responsible for the guidance and general supervision of the affairs of the Branch and is ex-officio a member of all Committees except the Nominating Committee. He presides at all meetings of the Branch or the Executive Committee. The Chairman instructs the Secretary when to call meetings of the Executive Committee and at least four meetings shall be held each year, at which meetings he presides and directs the order of business. The Chairman shall appoint scrutineers where ballots are to be counted.

VICE-CHAIRMAN

The Vice-Chairman acts for the Chairman in case of the Chairman's temporary inability to fulfil his duties.

SECRETARY

The Secretary, under the direction of the Chairman and Executive Committee, is the executive officer of the Branch: on instructions from the Chairman, he calls meetings of the Executive Committee at which he presents the business and keeps the records of the proceedings; keeps all records pertaining to the membership; etc., conducts the correspondence of the Branch and keeps records of same; attends to the printing and sending out of notices for all meetings; records minutes of all meetings of the Branch; prepares the Annual Reports of the Branch and performs other related activities commonly the responsibility of a Secretary.

TREASURER

The Treasurer has charge of the books and accounts and draws and signs cheques against the funds of the Branch for the payment of accounts after their payment has been authorized by the Executive Committee. The Treasurer shall record the receipt of all monies due to the Branch. He shall prepare the annual financial statement of the Branch. He shall collaborate with all sections and committees on all matters pertaining to finance and shall be responsible to the Executive Committee for a proper report covering such matters.

APPENDIX "F"

"Preliminary" or "Confederation" Agreement

DRAFT for agreement to be entered into by all Participating Associations and The Engineering Institute of Canada, before the application is made for new legislation.

MEMORANDUM OF AGREEMENT made the day of , 196 ,

BETWEEN:

THE ENGINEERING INSTITUTE OF CANADA, (hereinafter referred to as the "Engineering Institute"),

OF THE FIRST PART,

— and —

THE CANADIAN COUNCIL OF PROFESSIONAL ENGINEERS, (hereinafter referred to as the "Canadian Council"),

OF THE SECOND PART,

— and —

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF BRITISH COLUMBIA,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF MANITOBA,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF NEW BRUNSWICK,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF NEWFOUNDLAND,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF NOVA SCOTIA,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF PRINCE EDWARD ISLAND,
THE CORPORATION OF PROFESSIONAL ENGINEERS OF QUEBEC,
THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF SASKATCHEWAN, and THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE YUKON TERRITORY, (hereinafter individually referred to as a "Participating Association" and collectively referred to as the "Participating Associations"),

OF THE THIRD PART.

WHEREAS:

(a) The Participating Associations are each the governing bodies of the engineering profession in their respective provinces or territory; and

(b) The Engineering Institute is a corporation incorporated under the laws of Canada by Statutes of Canada 1887 50 Victoria Ch. 124 as amended by the Statutes of Canada 1918 — George V, Ch. 69; the said corporation as it may be constituted following the coming into force of the Private Act contemplated by the agreement is sometimes hereinafter called the "Canadian Institute"; and

(c) The Canadian Council is an unincorporated Association formed by the Participating Associations in February 1936; and

(d) Discussions have been taking place between the Canadian Council and the Engineering Institute with a view to confederation of the Canadian Council and the Engineering Institute, and the parties have agreed upon such confederation in accordance with the provisions and subject to the conditions hereinafter set forth; and

(e) A committee (hereinafter called the "Confederation Committee") has been established by the Canadian Council and the Engineering Institute, composed of members appointed by the Engineering Institute and the Participating Associations, to supervise the carrying out of this agreement for confederation and to perform the duties hereinafter set forth in this agreement.

NOW THEREFORE THIS AGREEMENT WITNESSETH that in consideration of the premises the parties agree as follows:

1. The Engineering Institute and the Canadian Council agree to confederation upon the terms hereinafter set forth, subject to the enactment by the Parliament of Canada of a Private Act amending the statutes incorporating the Engineering Institute as hereinafter provided.

2. The Engineering Institute agrees to make application to the Parliament of Canada at a date and time to be agreed upon by the Confederation Committee for a Private Act in the terms of the draft bill annexed hereto as **Schedule A.**

3. The parties agree that in the event that Parliament shall not see fit to pass the said bill in the form set out in Schedule A, but shall be prepared to pass the bill subject to certain amendments, the Confederation Committee shall have the power and authority to agree to such amendments and if such amendments are agreed to by the members of the Confederation Committee this agreement shall be binding upon the Participating Associations, the Engineering Institute and the Canadian Council as fully as though the said bill were passed in the form in which it appears in Schedule A.

4. The date which shall be requested as the date upon which the said Private Act shall come into force shall be determined by the Confederation Committee and may be provided for by an additional clause in the said bill in addition to the provisions appearing in the draft annexed as Schedule A or otherwise.

5 In the application to the Parliament of Canada it shall be indicated that the application is supported by each of the Participating Associations and by the Canadian Council and if so requested by the Confederation Committee each of the Participating Associations and the Canadian Council shall file submissions supporting the said application.

6. The parties agree that the first by-laws of the Canadian Institute after the coming into force of the said Private Act shall be in the same terms as draft by-laws annexed hereto as **Schedule B** to this agreement with such deletions, additions and/or amendments thereto as, in the opinion of the persons holding office as President of the Engineering Institute and as President of the Canadian Council immediately prior to the date when said Private Act comes into force, may be necessary to ensure that the said by-laws conform to the provisions of the said Private Act. The opinion of the President of the Canadian Council and the President of the Engineering Institute as aforesaid shall be conclusively evidenced by their certification thereof in writing filed with the Secretary of the Engineering Institute. The Engineering Institute agrees that the said by-laws, the terms of which are annexed as **Schedule B,** shall be the by-laws referred to in Section 10 of the draft Bill annexed as Schedule A.

7. The Engineering Institute and the Participating Associations agree that prior to the date upon which the said Private Act comes into force they will appoint members of the Provisional Council of the Canadian Institute as contemplated by By-law . . . of the draft by-laws annexed as Schedule B. The names of the persons appointed shall be notified to all other parties to this agreement not later than sixty days prior to the date upon which the said Private Act is to come into force.

8. The Confederation Committee shall have the following responsibilities:

(a) It shall approve the application to Parliament and all submissions to Parliament in connection therewith on behalf of the Engineering Institute, the Canadian Council and/or the Participating Associations.

(b) It shall be consulted on all changes in the proposed Bill proposed by Parliament or parliamentary committees and the (unanimous) consent of the members of the Confederation Committee shall be required before the Engineering Institute shall accede to any such changes.

(c) Following the coming into force of the said Special Act and the said by-laws, the Confederation Committee shall arrange for the execution by each of the Participating Associations of the agreements hereinafter mentioned.

(d) The Confederation Committee shall have such other duties as may be placed upon it by the Engineering Institute or the Canadian Council and generally shall be responsible for dealing with contingencies and resolving difficulties which may arise in connection with the carrying out of this agreement.

9. Immediately after the coming into force of the said by-laws, each of the Participating Associations hereby agrees to enter into an agreement with the Canadian Institute in the terms of the agreement annexed hereto as **Schedule C,** subject to modifications and variations, if any, which may be necessary by reason of the laws of any of the provinces in which a Participating Association is incorporated, and which may be recommended by the solicitors acting for the Participating Associations concerned and the solicitors acting for the Confederation Committee and agreed upon by the Confederation Committee.

10. All the agreements referred to in the foregoing paragraph 9 shall be executed within a period of not more than two months following the date of coming into force of the said Private Act.

11. The Engineering Institute hereby represents and warrants that the members of the Engineering Institute have by by-law duly enacted in accordance with the by-laws of the Engineering Institute and by a two-thirds majority on a letter ballot of the members of the Engineering Institute approved.

(a) The application to Parliament for a Private Bill in the terms annexed hereto as Schedule A.

(b) The terms of the draft by-laws annexed hereto as Schedule B as the by-laws of the Canadian Institute which, upon the coming into force of the said Private Act, shall thereupon come into force as the by-laws of the Canadian Institute, with such deletions, additions and/or amendments thereto as may in the opinion of the President of the Engineering Institute holding office immediately before the coming into force of the said Private Act be necessary to ensure that the said by-laws conform to the provisions of the said Private Act, the opinion of the President to be conclusively evidenced by his certification thereon in writing; and

(c) The making by the Engineering Institute of this agreement with the Participating Associations and the Canadian Council.

The Engineering Institute by execution of this agreement represents and warrants that it has the capacity and power at law to enter into this agreement.

12. Each of the Participating Associations by execution of this agreement represents and warrants that it has the capacity and power at law to enter into this agreement and that the execution of this agreement has been approved by the members of the said Association and/or that approval of this agreement and the execution thereof is within the powers of the Council of the said Association and has been approved by the Council of the said Association. Copies of the resolutions approving the execution of such agreement are annexed hereto as Schedule D. (?)

13. The Engineering Institute represents and warrants that there are and will be when the said Private Act comes into force no agreements or arrangements binding upon it or its members which are not set out in or contemplated by the draft by-laws annexed as Schedule B, and that the Engineering Institute has no liabilities other than those disclosed in its audited balance sheet as at ...., except liabilities incurred in the ordinary course of its operations.

14. In the event that the said bill is not enacted or does not come into force on or before the 31st day of December, 1964, this agreement, unless otherwise renewed by the consent of all parties, shall terminate and the parties shall be no longer bound thereby.

15. Upon the coming into force of the said Private Act the Canadian Council will be dissolved.

16. Each of the parties severally and jointly with the other parties agrees to take all steps within its capacity and power which may be reasonably necessary in order to ensure the carrying out of the purpose and intent of this agreement.

IN WITNESS WHEREOF the parties have hereunto affixed their corporate seals attested by the signatures of their officers duly authorised for such purpose.

THE ENGINEERING INSTITUTE OF CANADA

Per: ....

....

THE CANADIAN COUNCIL OF PROFESSIONAL ENGINEERS

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF ALBERTA

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF BRITISH COLUMBIA

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF MANITOBA

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF NEW BRUNSWICK

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF NEWFOUNDLAND

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF NOVA SCOTIA

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF ONTARIO

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF PRINCE EDWARD ISLAND

Per: ....

....

THE CORPORATION OF PROFESSIONAL ENGINEERS OF QUEBEC

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF SASKATCHEWAN

Per: ....

....

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE YUKON TERRITORY

Per: ....

....

APPENDIX "G"

Final Agreement

DRAFT for standard agreement to be entered into between Individual Participating Associations and The Canadian Institute of Professional Engineers as contemplated by By-law 5 of draft by-laws.

MEMORANDUM OF AGREEMENT made the day of , 196 ,

BETWEEN:

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF

....,

(hereinafter referred to as the "Association"),

OF THE FIRST PART,

— and —

THE CANADIAN INSTITUTE OF PROFESSIONAL ENGINEERS,

(hereinafter referred to as the "Canadian Institute"),

OF THE SECOND PART.

WHEREAS:

(a) The Association is a corporation constituted by or incorporated under ((reference to provincial statute)) and is the governing body of the engineering profession in the Province of ;

(b) The Canadian Institute is a corporation incorporated by Act of the Parliament of Canada, Statutes of Canada 1887, 50 Victoria Ch. 124, 1918 8-9 George V, Ch. 69 and The Canadian Institute of Professional Engineers Amendment Act, 196 , Elizabeth II, Ch. ;

(c) A copy of the by-laws of the Canadian Institute which came into force at the date upon which the Canadian Institute of Professional Engineers Amendment Act, 196 , came into force, pursuant to the provisions of Section 10 of the said Act, and which are in force at the date hereof is annexed as Schedule A to this agreement.

(d) In contemplation of the passing of The Canadian Institute of Professional Engineers Amendment Act, 196 , the Association and the Canadian Institute (under its then name The Engineering Institute of Canada) entered into an agreement (hereinafter called the "Confederation Agreement") dated the day of 196 , to which the parties were as follows:

The Association of Professional Engineers of Alberta

The Association of Professional Engineers of the Province of British Columbia

The Association of Professional Engineers of the Province of Manitoba

The Association of Professional Engineers of the Province of New Brunswick

The Association of Professional Engineers of the Province of Newfoundland

The Association of Professional Engineers of the Province of Nova Scotia

The Association of Professional Engineers of the Province of Ontario

The Association of Professional Engineers of the Province of Prince Edward Island

The Corporation of Professional Engineers of Quebec

The Association of Professional Engineers of Saskatchewan

The Association of Professional Engineers of the Yukon Territory;

(e) The Confederation Agreement providing that upon the coming into force of the said The Canadian Institute of Professional Engineers Amendment Act, 196 , the Association and the other Participating Associations referred to therein would execute agreements in the form of this agreement and this agreement is executed in pursuance of the said Confederation Agreement;

(f) The Association, subject to the execution of this agreement, has been accepted as a Participating Association by the Council of the Canadian Institute and by clause 5 of the annexed by-laws of the Canadian Institute annexed as Schedule A to this agreement, and the Association desires to enter into this agreement in order that it may participate in the Canadian Institute as a Participating Association.

(g) By execution of this agreement the Association represents that it has the capacity and power in law to enter into this agreement and that all necessary corporate action has been taken by the Associations to ensure that this agreement shall be binding upon the Association in accordance with its terms.

NOW THEREFORE THIS AGREEMENT WITNESSETH that in consideration of the premises and the mutual covenants hereinafter contained the parties agree as follows:

1. The Canadian Institute hereby agrees with the Association that, pursuant to the provisions of Section 5 of the by-laws of the Canadian Institute which came into force on the day of 196 , the Association shall be a Founder Participating Association of the Canadian Institute and entitled to all the rights and benefits provided for Participating Associations pursuant to the said The Canadian Institute of Professional Engineers Amendment Act 196 , and the by-laws of the Canadian Institute.

2. The Association consents to participate as a Participating Association of the Canadian Institute and agrees to be bound by the by-laws of the Canadian Institute and to perform all duties and functions required of it as a Participating Association pursuant to the provisions of the by-laws of the Canadian Institute, as such by-laws have now been enacted and annexed as Schedule A to this agreement, and as such by-laws may be hereafter varied, amended or supplemented.

3. The Association agrees that it will maintain a record of those of its members who are or may be members of the Canadian Institute pursuant to the provisions of Sections 8, 9 and 10 of the said by-laws. The Association agrees that it will, at the time of admission of any person to membership in the Association, request such member to designate that such member wishes to be a member of the Canadian Institute as well as a member of the Association and/or that it will otherwise take all such steps as may be within its capacity and power to arrange that its members shall also be members of the Canadian Institute by virtue of their membership in the Association.

4. (Other provisions may be inserted in this agreement if considered necessary to provide for specific services which the Participating Associations shall undertake in the interests of the Canadian Institute and for any financial arrangements not otherwise provided for in the by-laws; it may also be desirable to deal specifically with the participation in the Canadian Institute of existing Participating Association branches.)

5. The Association shall be bound by all the provisions of this agreement and the by-laws of the Canadian Institute to the full extent that it has the capacity and power to be so bound, provided that nothing contained in this agreement or in the by-laws of the Canadian Institute shall be deemed to require the Association to assume any commitments or do any act or thing contrary of the law of the province in which it is incorporated as aforesaid. Each of the obligations undertaken by the Association pursuant to this agreement and the by-laws referred to herein as the same may be varied, amended or supplemented shall be severable from each of the other obligations so undertaken and the lack of capacity and power in the Association to perform any part of this agreement or comply with any part of the said by-laws shall not affect the obligations of the Association in any other respect.

6. Notwithstanding any provisions of the said by-laws, the Association shall not withdraw from the Canadian Institute and its status as a Participating Association shall not be withdrawn by the Canadian Institute before the expiration of five years from the date hereof. This agreement shall extend for a period of five years from the date hereof and thereafter until terminated by the withdrawal of the Association from the Institute or by withdrawal by the Council of the Institute of the status of Participating Association from the Association in accordance with the provisions of Section 5 of the by-laws of the Canadian Institute and/or in accordance with the provisions of the by-laws of the Canadian Institute as the same may be hereafter amended, varied or supplemented.

7. This agreement shall be binding upon and enure to the benefit of the parties hereto, their successors and assigns.

IN WITNESS WHEREOF THE parties have hereunto affixed their corporate seals attested by the signatures of their officers duly authorized for such purpose.

THE ASSOCIATION OF PROFESSIONAL ENGINEERS OF THE PROVINCE OF

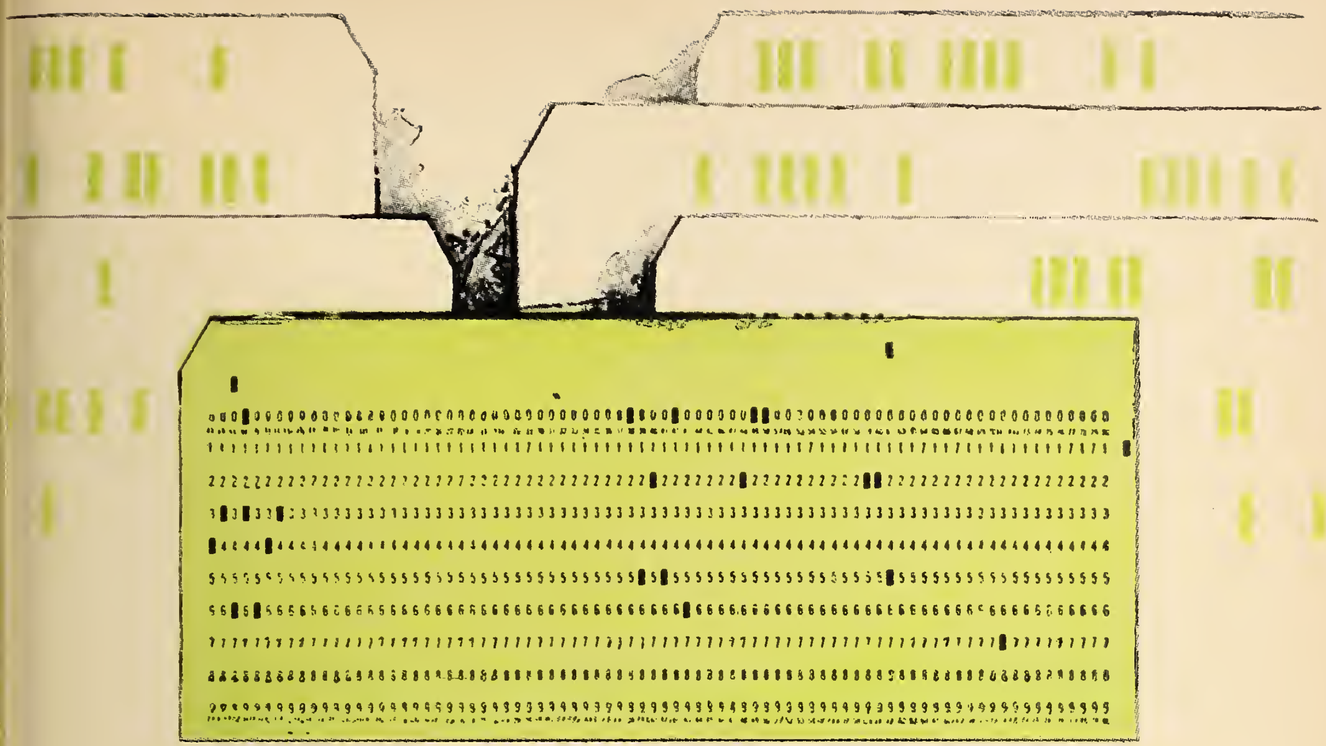
Per: ....

....

THE CANADIAN INSTITUTE OF PROFESSIONAL ENGINEERS

Per: ....

....



STOCKS WORTH MANY MILLIONS . . .

Our large inventories at principal distribution centres include over 10,000 items of stock. Immediate transmission of details of receipts and sales by our private wires enables us to maintain these stocks and so offer our customers, wherever they may be located, a high degree of service on a multiplicity of electrical products. For communications equipment, wires and cables, electrical supplies and apparatus, call *Northern Electric*

61-2 COMPANY LIMITED

(*Continued from page 102*)
could, in this case, be mercifully avoided.

The authors' ingenious solution for an equivalent hydrostatic loading of the model merits praise, and it is likely that neg'ator springs will now find general use for this work. It is unfortunate that even at a temperature as low as 300°F there is some reversion of the constant force spring toward conventional spring characteristics, although the force variation is still quite small. For the number of neg'ator springs used in this study it is possible that the usual "dead weight" loading, with fine wires, ball bearing pulleys, and calibrated weights would have been equally satisfactory, but the simplicity and portability of the neg'ator powered loading frame is very attractive.

The use of an eccentrically loaded pressure pad to simulate hydrostatic pressure variation is worthy of note and it would be of interest to know if tests were made to validate the assumption of linear pressure variation along the length of the pad.

The authors have given some useful information on handling techniques for Hysol 6000 OP, and the availability of this material in cast form provides welcome relief from the tedious procedure of making epoxy castings. There are also some low modulus members of the Hysol family, somewhat more difficult to machine, but perhaps capable of showing gravitational stresses for cases where these cannot be neglected.

Careful machining of models to preserve the sharp corners is always essential, particularly at drilled holes, but extreme care to avoid machining stresses does not seem necessary when followed by the stress freezing technique, since this heat treatment will usually erase any previous "frozen" stress pattern. The stress pattern produced in a model during drilling usually results from poor heat dissipation rather than from the cutting force itself, and, where no subsequent heat treatment will be applied to the model, unusual care must be given to cooling the drill and maintenance of the drill clearance.

Formation of the time-edge stresses is a more serious problem, as the authors have pointed out, since these are aggravated rather than remedied by the stress freezing cycle, and they appear at the surface of the model to superpose on the critical stresses under study. Dr. M. M. Leven of Westinghouse has shown that time edge stresses attain a peak value in epoxy resin models two or three days after stress freezing, but disappear completely after thirty days. In view of Professor Mantle's work on this problem (reference 5) one might hopefully provide a moist atmosphere in the stress freezing oven to prevent loss from the model during the heating cycle. For many years, while Fosterite was available as a model material, the time edge stress problem did not exist (EIC Journal, January, 1956), but having now returned (from the days when BT-61-893 was the only available material for stress freezing) further work should be done to establish suitable controls and preventive means.

The authors' method of finishing the surfaces of slices that have been removed from the model is very effective. For small slices we usually attach them to a piece of round material that has been chucked in the lathe and faced off to assure parallelism of the finished slice. In cases where it has been necessary to make a series of fringe pattern photographs, reducing the thickness of the slice between each photograph, the double faced adhesive method of holding the slice during the turning operation has been very satisfactory. We do no polishing of the slice after turning, but either coat the surfaces of the slice with a mixture of Halowax and Bayol, adjusted to have the same refractive index as the model, or we place the slice in a narrow glass tank filled with the liquid and mounted in the transmission polariscope. Figures 6 and 11 in the above reference are unpolished slices photographed in this way.

The stress distributions around the gallery openings shown in figures 11 and 12 are quite interesting and indicate clearly the concentration of stress at the corners. The pattern of figure 12, showing compression at the top and bottom and tension on the sides would perhaps not have been expected (a ring, for example, in vertical compression, has this pattern but with reversed signs) but no doubt it was welcomed in a structure of concrete. In regard to the authors' remark about missing zero fringes (col. 2, page 5) this is not an uncommon occurrence in this type of pattern; when the stress changes sign at the free boundary one is forced to assume the zero fringe is too small to be perceptible. In fact the boundary of any model usually produces a narrow band of indefinite fringe order which can be evaluated only by extrapolation of the fringes from within the boundary.

Regarding the authors' remarks on calibration of the model material (col. 3, page 2) it has been the experience of this writer that the fringe constant will vary somewhat with the stress freezing cycle and that a calibration beam must be included with each model when it is frozen. Rather than averaging results of the calibration specimens we are careful to apply the specific value to slices from the model associated with the particular calibration beam. Even in model material as standard as CR 39 we find the manufacturer's fringe coefficient quite inapplicable to a specific sheet of the material.

It is unfortunate that in preparing a paper for this purpose many points of interest must be omitted. For example what method was used to determine stress sign on the gallery walls, what thickness were the finished slices, what is the effect of Poisson's ratio in interpretation of results, etc.? However, in the space available, the authors have given a very clear and interesting account of how this project was carried out and it will provide encouragement and information for future attempts on problems of this type.

Authors' Reply

The discussions presented by Professors Rice, Richmond and Smith are very much appreciated and contribute materially to the paper.

Both Professors Richmond and Smith were concerned about the load distribution under the eccentrically loaded pads. Although no precise calibration was made during the present study, previous experience with this type of loading device by one of the authors[1] justified the assumption of linearity of load distribution.

Professor Richmond's remarks about the direction of slicing are pertinent. In the case of slice L, including the circular stairwell as a stress concentration, care was taken to insure that the slice was in the direction of a principal stress plane, particularly in the critical region. This was done by taking a vertical slice along the entire plane of symmetry of the dam and obtaining the isoclinics of the slice. From these the directions of principal stress were obtained and slices in a subsequent model were taken in the direction of one of these. Around the entrance and drainage galleries it was impractical to ascertain precise principal stress directions and it is conceded that some error is possible here, perhaps in the order of 10 or 15%. The reader is referred to work of Jessop[2] and Frocht[3] in which complete separation of stresses from an arbitrarily selected slice of a three-dimensional model is proposed.

Professor Smith's discussion is particularly comforting and contains valuable supplementary information. In regard to calibration the two values given were obtained from beams taken from different parts of the slab close to the model and subjected to temperature-time-load cycles corresponding to those undergone by the models. It was concluded that in a piece of material as large as that obtained (stock size 24" x 24" x 2") there would be variations in calibration through the slab and indeed in the model itself! It was assumed that an average of two representative samples could be taken as being reliable for the model. Slice thicknesses varied from 0.178 inches to 0.263 inches with the web itself being approximately 0.500 inches thick. Stress sign around the galleries was determined in three ways: (i) by applying external known loads to the slice and observing the photoelastic pattern changes, (ii) by using the Senarmont method[4] of fractional fringe determination and observing the direction of movement of fringes compared to that of a known specimen such as a calibration beam and (iii) by superimposing frozen stress patterns of known sign over the unknown area and observing the resulting combined fringe count at the point in question. No attempt was made to account for the difference in Poisson's ratio between the concrete structure and the model.

Professor Rice knows well the problems faced by workers in photoelasticity and the authors would hasten to assure him that the present project was not without its share of troubles. However, the main contributions to better techniques offered by this investigation appeared to be in the introduction of the clamps as loading devices and in the successful use of adhesives in constructing a photoelastically homogeneous model.

References

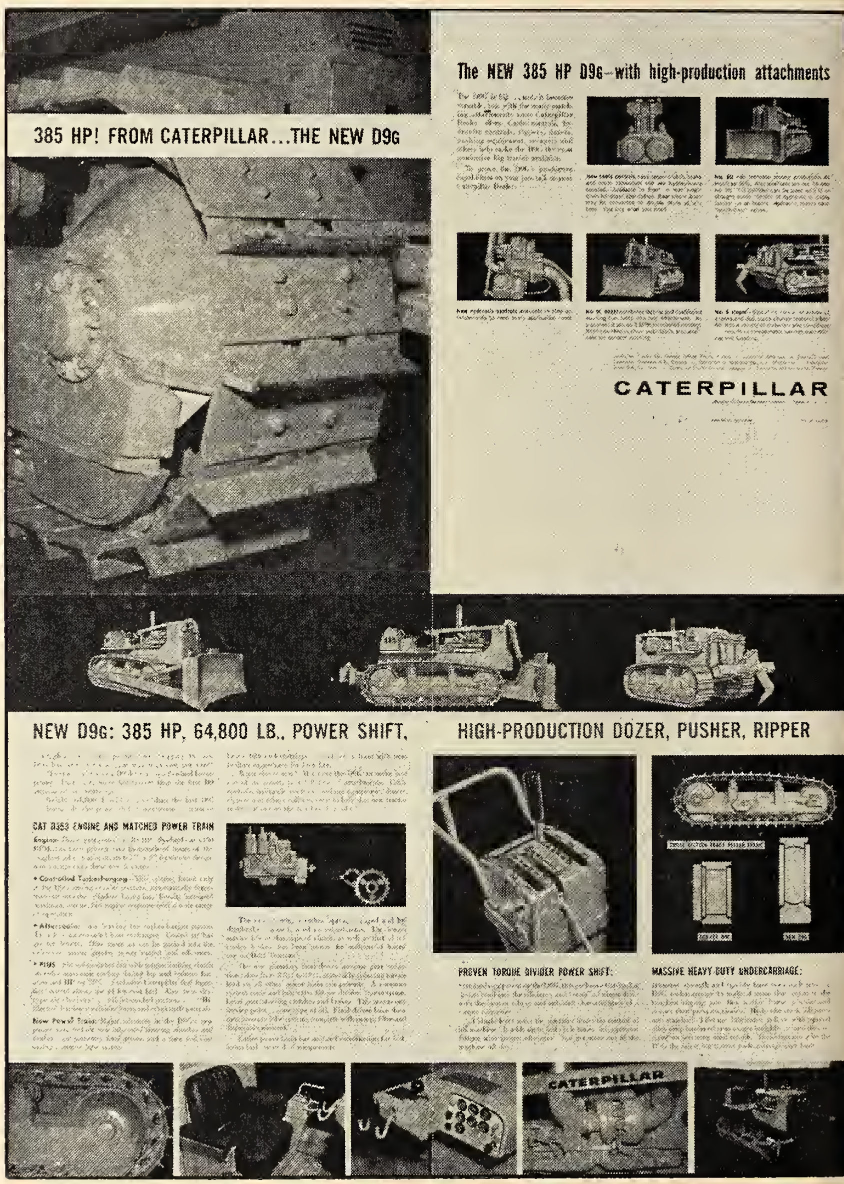
(1) Pant, B. and Mantle, J. B. "A Photoelastic Study of Multibarrel Conduits", **Proc. Society for Experimental Stress Analysis,** Vol. XII No. 1, 1954, p. 65.

(2) Jessop, H. T. — "A Tilting Stage Method of Three-Dimensional Photoelastic Investigation", **British Journal of Applied Physics,** Vol. 8, Jan. 1957, p. 30.

(3) Frocht, M. M.; Pih, Hai,; and Landsberg, D. — "The Use of Photometric Devices in the Solution of the General Three-Dimensional Photolastic Problem", **Proc. Society for Experimental Stress Analysis,** Vol. XII, No. 1, 1954, p. 181.

(4) Jerrard, H. G. — "Optical Compensators for the Measurement of Elliptical Polarization", **Journal of the Optical Society of America,** Vol. 38, 1948, p. 55.

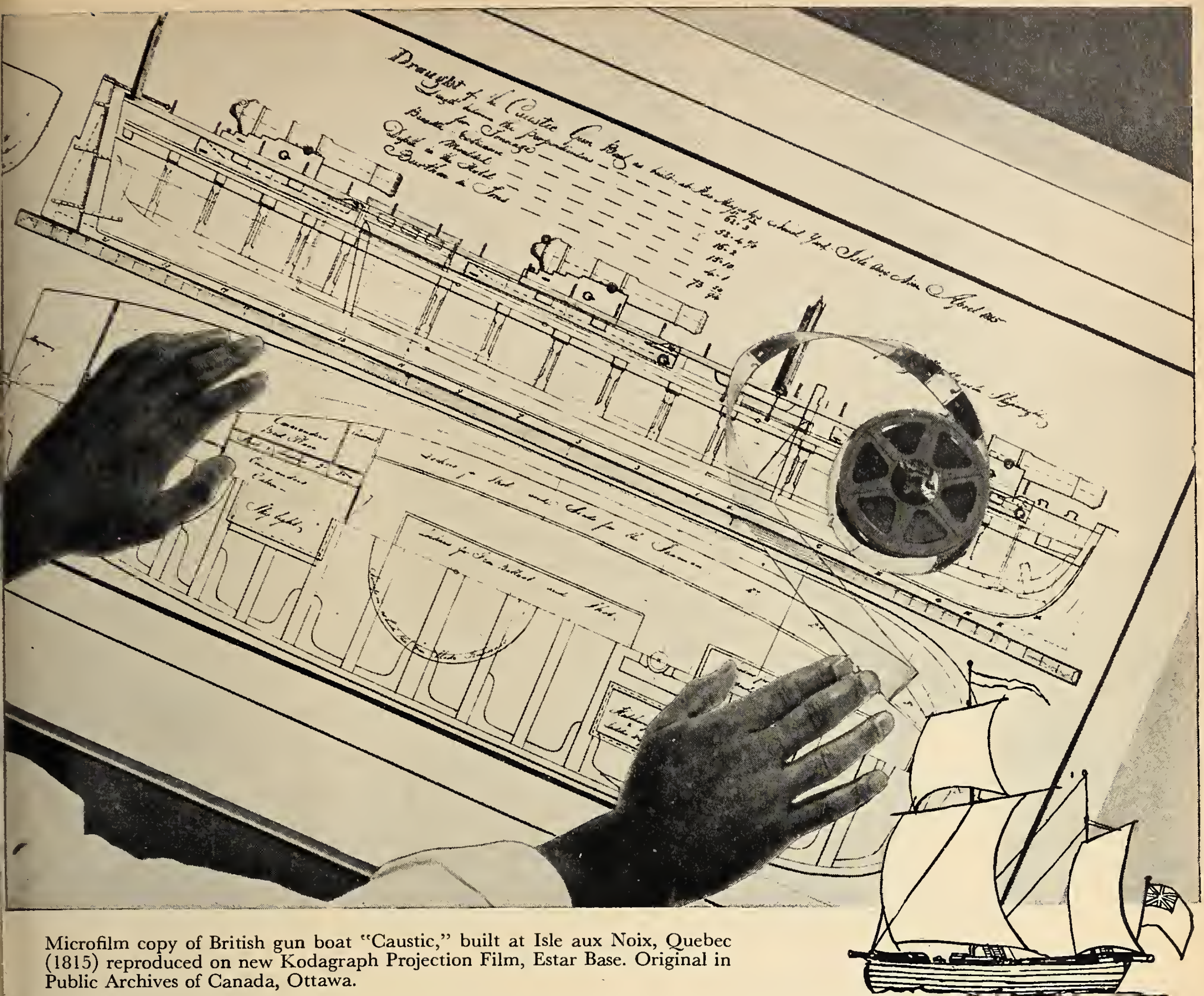
EIC CERTIFICATE OF ADVERTISING MERIT



For the second time this year, a striking 4-page, 4-colour Caterpillar Tractor Company insert has captured the Monthly Award as the best advertisement in The Engineering Journal. The first, in March, introduced new model "Cats", 630 and 631. The June winner introduces the new D9G, described as "385 hp, 64,800 lbs., power shift, high production dozer, pusher, ripper". High recognition is gained with a generous number of photos and illustrations in what might be termed "Caterpillar Yellow". Copy is chock full of reason-why facts.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

The Avertising Manager of Caterpillar Tractor Company is Mr. C. M. Adams who is located at the Company's Head Office in Peoria, Ill. The advertisement was prepared and placed by N. W. Ayer & Sons Inc.



Microfilm copy of British gun boat "Caustic," built at Isle aux Noix, Quebec (1815) reproduced on new Kodagraph Projection Film, Estar Base. Original in Public Archives of Canada, Ottawa.

Ship-shape drawings–any size!

New Kodagraph Projection Film, Estar Base, produces change-in-scale intermediates that will stand up under the heaviest use in drafting room or print-room.

Blowups from microfilm or reductions of drawings and maps are remarkably sharp and clean on a whiter base that has a "built-in" longer life.

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See this versatile new Kodagraph Film—and the others in the new *Estar Base line:* Kodagraph Contact Film; Kodagraph Autopositive Film.

All combine reliable Kodak emulsions on the new Estar Base—highly translucent, durable, and dimensionally stable, with excellent matte surface on both sides for easy drafting. Available in standard drawing sheet sizes and in rolls up to 52 inches wide. Call your local Kodagraph Dealer, or write Canadian Kodak Co., Limited, Toronto 15, Ontario.

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J. P. Fisher, M.E.I.C.

T. E. Harris, M.E.I.C.

C. T. Carson, M.E.I.C.

D. Scouler, M.E.I.C.

R. M. Dunton, M.E.I.C. (McGill '48) has been appointed to the new position of Manager of Engineering, Paper Division, Dominion Engineering Works Limited. **J. P. Fisher,** JR.E.I.C. (McGill '51) is Manager of Manufacturing, Standard Products. **T. E. Harris,** M.E.I.C., (McGill '50) has been named chief engineer of the P.M.R. Department, Industrial Division. All three appointments have been announced by R. J. Barrett, President of Dominion Engineering Works Limited.

C. T. Carson, M.E.I.C. (Tor. '23) has joined the consulting engineering staff of Smith, Hinchman and Grylls Associates (Canada) Ltd. and has been elected a vice-president of the Company. Mr. Carson will act as an engineering consultant and will assist in project development.

Daniel Scouler, M.E.I.C. (N.S.T.C. '48) has been appointed general manager of the Halifax Shipyards Limited.

Robert B. Nicolson, M.E.I.C. (Alta. '39) has joined Associated Engineering Services Ltd., Edmonton, N. A. Lawrence, president of the firm announced recently. A former assistant city engineer with the city of Edmonton, Mr. Nicolson has been a director of the Edmonton Branch of the E.I.C.

A. D. Margison, M.E.I.C. (McGill '51) has been elected a director of the Technical Service Council. The announcement of his election was made by C. B. C. Scott, President. Mr. Margison is president and general manager of A. D. Margison and Associates Limited, Toronto.

Obituaries

Samuel Blumenthal, M.E.I.C., a life member of the Institute died July 3, 1961. He was 77. A gold medallist, Mr. Blumenthal graduated from McGill University in 1904 with a B.Sc. degree. He was one of the youngest engineering students. He became an international authority on bridge structure during his 44 years with the CPR. For 30 years he was responsible for the preparation of Bridge Load Charts and for the rating of bridges. After retiring in 1948 he became a consulting engineer.

S. R. Speed, JR.E.I.C., died suddenly July 16, 1961. A graduate of the University of Manitoba, Mr. Speed received his B.Sc. degree in electrical engineering in 1947. He first joined the Institute as a student in 1956 and in 1947 became a Junior member of the E.I.C.

Robert Charles Wiren, M.E.I.C. professor of mechanical engineering at the University of Toronto died June 3, 1961. Professor Wiren was 65. A graduate of the University of Toronto, he received his degree in Mechanical Engineering in 1926. He first joined the Institute in 1929 as an Associate Member and in 1936 attained full membership status.

Other Societies

International Atomic Energy Agency

A symposium on the Programming and Utilization of Research Reactors will be held in Vienna Oct. 16-20. The program will be as follows:

I. Problems confronting new research centers
- (a) Organization of a research reactor center and its integration with other research efforts in the country;
- (b) Selection of a research reactor;
- (c) Support facilities and laboratories;
- (d) Technical staff requirements;
- (e) Planning a research program;
- (f) Reactor operation and safety.

II. Utilization of research reactors (up to 5 MWth) for training, basic experiments and research in
- (a) Reactor engineering;
- (b) Reactor physics;
- (c) Physics, especially nuclear and solid state;
- (d) Radiation chemistry, radio chemistry and reactor chemistry;
- (e) Chemical engineering and metallurgy;
- (f) Isotope production;
- (g) Agriculture, biology and medicine.

Suggested programs for low-cost research with a reactor in the above-mentioned fields will be considered.

III. Possibilities of collaboration of research reactor centers, especially between advanced and new laboratories.

The Metallurgical Society of A.I.M.E.

The Iron and Steel Institute of Great Britain will meet in the United States for the first time since 1910. The Society has planned a varied program with tour opportunities to interest the visitors.

During their three week stay they will attend the National Metal Congress and Exposition of the American Society for Metals which will be held in Detroit from Oct. 23-26. The Metallurgical Society will hold its Fall Meeting in conjunction with the Congress.

Points of interest in both Canada and the United States are on the tour agenda. The British delegates will have the opportunity to visit foundries and works in New York, Niagara Falls, N.Y., Welland, Ont., Hamilton, Ont., Tonawanda, N.Y., Cleveland, Pittsburgh, Akron, Massillon, Canton, Washington, D.C., Philadelphia and Cincinnati.

Ronald R. McNaughton, the first Canadian to become President of A.I.M.E. will greet the visitors on their arrival in New York. Recently the Institute elected Dr. Howard Biers an Honorary Vice President. Dr. Biers represented A.I.M.E. at the Institute's meeting in London.

Institute of Radio Engineers

The newly elected president of the Institute Dr. Lloyd V. Berkner, will be guest speaker at the Canadian Electronics Conference banquet in Toronto October 3. His address which will deal with one aspect of the Conference theme: "Progress Through Electronics", is considered to be one of the high points of the three day conference. Dr. Berkner, now President of Associated Universities, Inc., New York, served on national and international committees for the International Geophysical Year.

Canadian Good Roads Association

The winners of seven scholarships for postgraduate study in highway technology have been announced by the Association. The Scholarships of $2,000 each are to be used in the 1961-62 academic year. This is the tenth consecutive year that industry has made these scholarships available.

The seven winners are: James M. Main of Ottawa who will study at Yale University; D. W. Devenny, of Ottawa and R. I. Kingham of Victoria who will study at Purdue University; H. K. Walker of Edmonton and T. J. Bradshaw of Saskatoon who will study at the University of Alberta; D. J. MacQuarrie of Sydney, N.S. who will study at the University of Western Ontario and J. L. Simard of Quebec who will study at the University of Toronto.

Royal Architectural Institute of Canada

Three distinguished architects form the panel of judges who will select from the 315 entries, 100 outstanding buildings to be included in the Massey Medals Exhibition this Fall. On October 2 the judges will meet to select the winners of the Gold Medal Award and a maximum of 19 Silver Medal Awards. The Governor General will preside over the Awards Ceremony to be held November 2 at the National Gallery.

The Massey Medals Competition (five have been held since 1950) were inaugurated to recognize outstanding examples of Canadian achievement in architecture and to encourage interest both by members of the profession and the general public.

Members of the panel of judges for this competition are: Pietro Belluschi, Dean of the School of Architecture and Planning, M.I.T.; John Bland, Director of the School of Architecture, McGill University; and Peter Thornton of Vancouver.

The Associations and Corporation

C.P.E.Q.

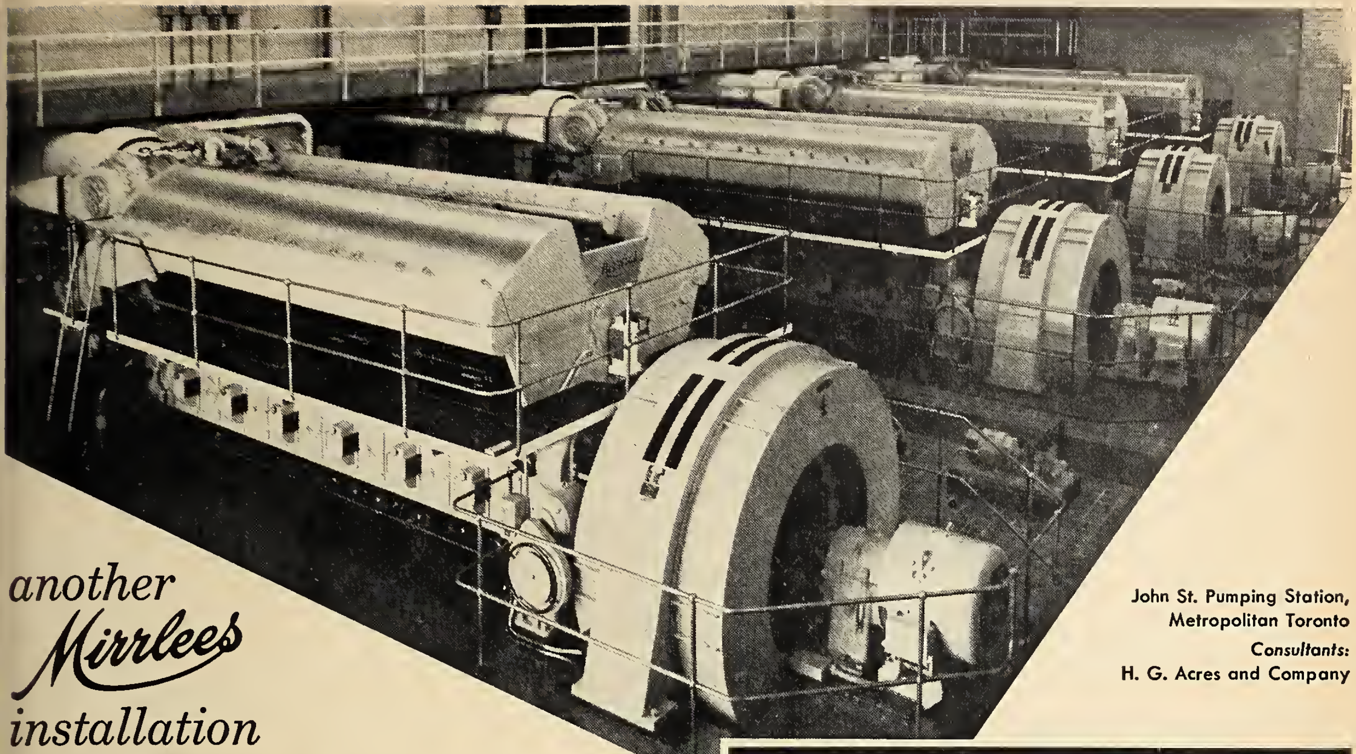
The Corporation presented a brief to Mr. René Levesque, Minister of Natural Resources. The brief, supported by eight monographs, was the first official contact between the Corporation and the Minister, and may be indicative of closer collaboration between the Quebec government and the C.P.E.Q. In the 200 page report the engineers urged the government to adopt definite policies to utilize the natural resources in the Province without waste. The development of renewable resources has become an important factor in the economy. An inventory of all natural resources is suggested followed by a fully planned five year plan for their development.

Some of the recommendations included in the report were concurrently considered by the Provincial Legislature. At the last session an anti-pollution board was appointed, and a law abolishing billboards along provincial roads was passed. Later the construction of a thermal-power plant on the South Shore was announced. The fact that some of the recommendations in the report were acted on independently of it gives an indication of the useful purpose it will serve.

A.P.E.B.C.

The Annual Convention of the Municipal Engineers Division will be held in Courtenay, from Sept. 21-23. Ten papers will be presented at the Convention and a discussion on laying underground pipe is also scheduled. A social program including a salmon derby and dance have been planned along with a complete program for the ladies.

(Continued on page 174)



John St. Pumping Station,
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Consultants:
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Although continuity of power is almost assured today, standby power must be available for essential public services to meet emergencies. Even when service is uninterrupted, operation of the standby equipment during periods of peak load can mean substantial reductions in operating costs. The performance record of the four Mirrlees-Brush 2200 KW units installed by the Municipality of Metropolitan Toronto in the John Street Water Works Pumping Station is a classic example of efficient use of essential standby equipment.

Mirrlees-Brush generating equipment is famous the world over for reliability and trouble-free, low cost operation. Now, in Canada, every installation is backed by the full resources of one of the nation's greatest industrial organizations.

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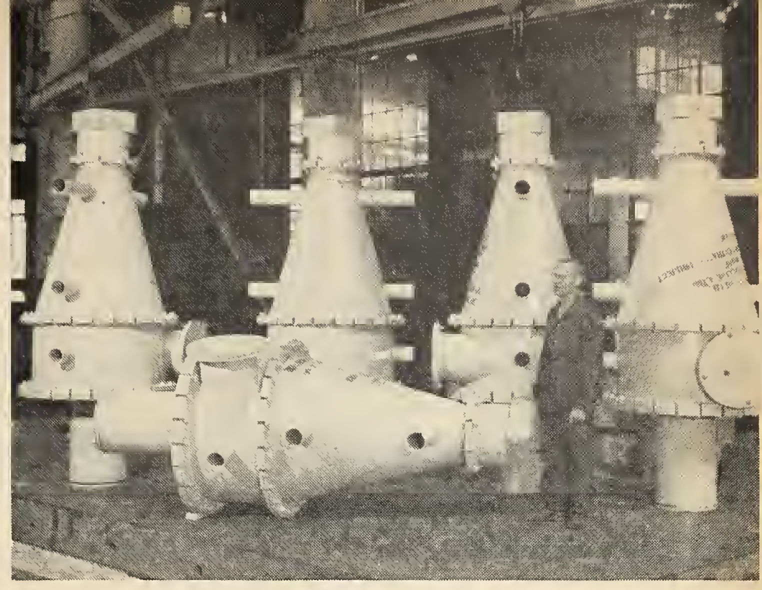
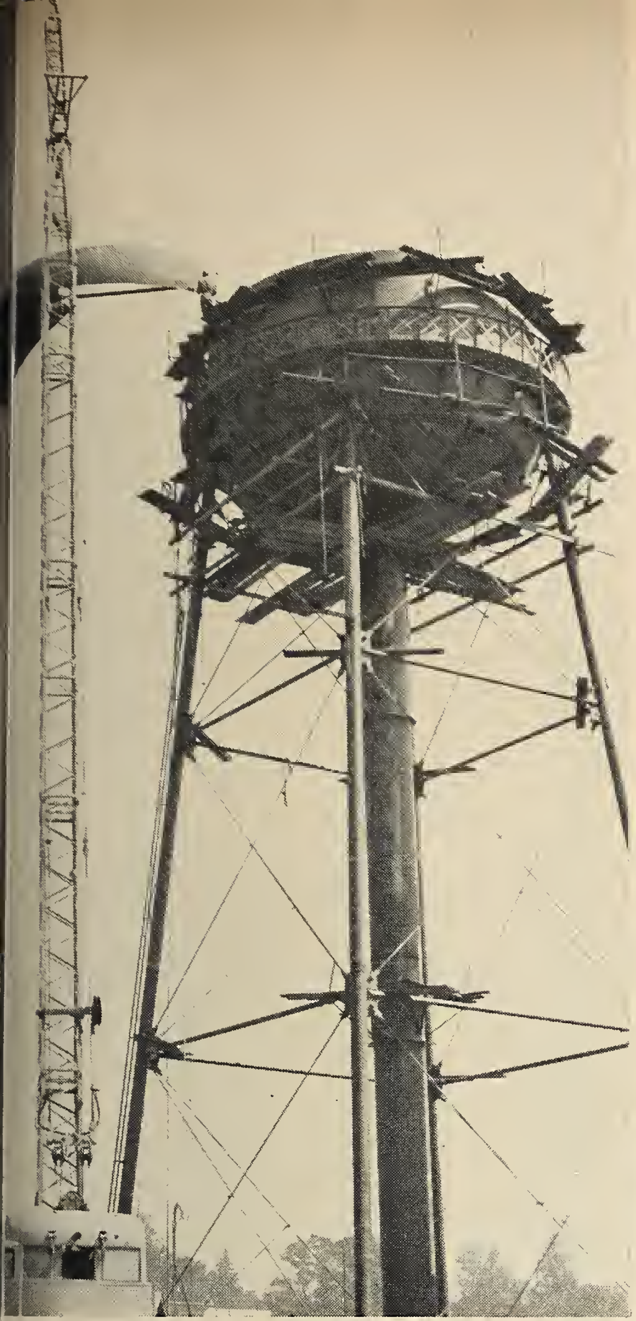
ORENDA... PRODUCTS FOR POWER

6021

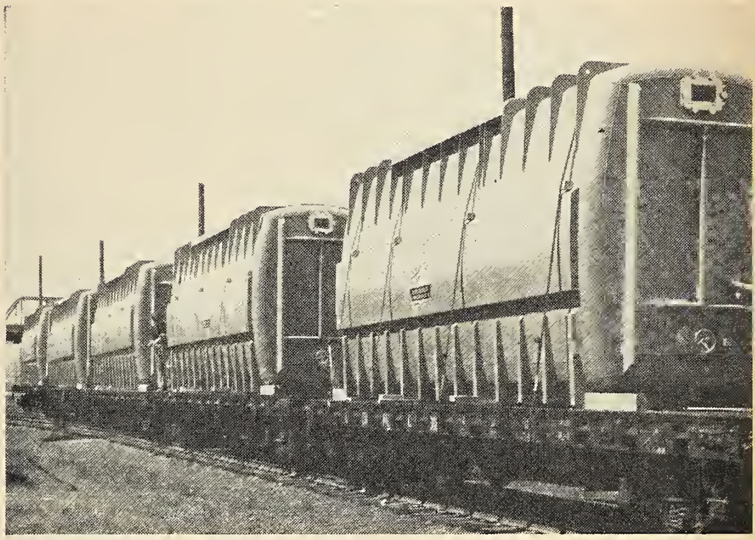
Fitting a ring casting to top cone section of blast furnace. Furnace shell is 76 ft. high ranging in diameter from 32 ft. at the bottom to 14 ft. 9 ins. at the top. It was made in Montreal.



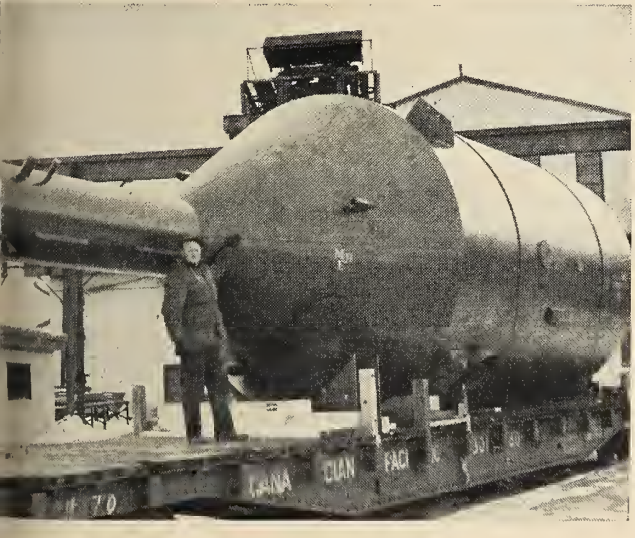
"Cyclone" thickeners for use in centrifugal separation of fine and coarse aggregates in the mining industry. Twenty-four of these 36″ diameter thickeners and 60 smaller 14″ diameter units were built in Montreal for Quebec Cartier Mining Company.



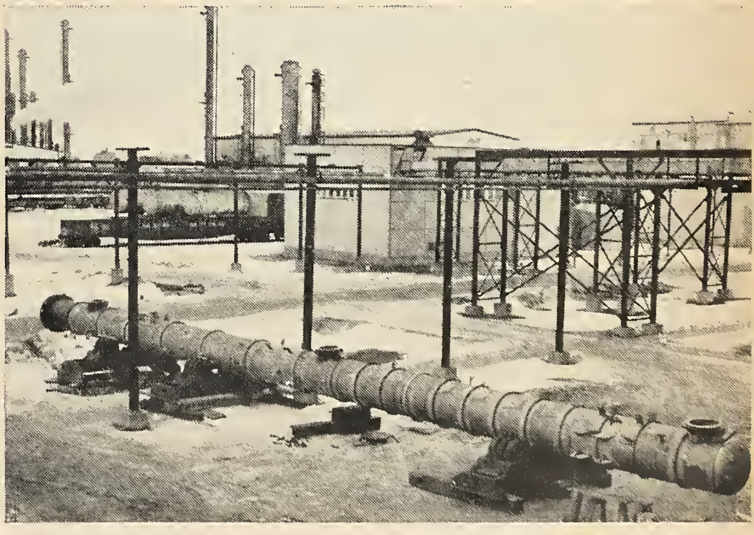
ion Bridge construction crews at our Vancouver hoist last segment of 100,000-gallon water tank. ver is 102 ft. high and 28 ft. 8 ins. in diameter.



Five of nine 340-barrel closed fermenting tanks fabricated at Manitoba Bridge in Winnipeg for Bishopric Products Company, Cincinnati. Each tank weighs 8 tons.



4 evaporators used in the salt industry leaving anitoba Bridge plant in Winnipeg. Each unit is n length and weighs 33 tons.



This 80-ft. long 36-inch diameter, stainless steel tower was fabricated in Edmonton for an Alberta petrochemical plant. Weight of the vessel is 22,000 pounds.

Library Notes

Prepared by the Library, The Engineering Institute of Canada

BOOK REVIEW

PROGRESS IN OPERATIONS RESEARCH, VOL. I.

According to the author's description, "This book inaugurates a series of review volumes which will inventory mathematical techniques and research methods available to operations researchers. These review volumes are designed to serve as basic reference works to which O.R. practitioners or students may turn for reliable up to date information on major O.R. techniques".

This review volume is an intelligent and critical guide to the already abundant literature in the field of O.R. It complements very effectively the author's well-known text "Introduction to Operations Research" and the excellent "Comprehensive bibliography on O.R." prepared by the O.R. group of the Case Institute of Technology.

In addition to its great practical value to the Operations researcher, this volume offers a very interesting general view of the present state of development of O.R.

The following are the headings of the main chapters: The meaning, scope, and methods of operations research; Decision and value theory; Survey of inventory theory from the operations research viewpoint; Mathematical programming-dynamic programming; Dynamics of operational systems; Markov and queueing processes; Sequencing theory; Replacement theory; Theory and application of simulation in operations research; Military gaming; Progress in operations research; Challenge of the future.

In this reviewer's opinion this book is one of the most important that has been published recently in this field. It should prove a useful addition to the library of every OR worker. (Ed. by R. L. Ackoff. New York, Wiley, 1961. 505p., $11.50.)

Reviewed by G. Cavadias, M.E.I.C.

*PRODUCTION FORECASTING PLANTING, AND CONTROL, 3RD. ED.

Intended primarily as a textbook, this description of basic principles and the manner of their application will be useful also to industrial management. The author concentrates on the techniques and principles of forecasting, planning and control, but also discusses the relationship to and application of other subjects in the practice of production engineering—such subjects as automation, electronic data processing and financial planning—and the relations of production engineering with other departments of industrial organizations. This third edition presents new material on sales forecasting, warehouse distribution and control, economic lot sizes, and military production planning and control, as well as general revision of repeated material. (E. H. MacNiece. New York, Wiley, 1961. 402p., $9.75.)

*ELECTRONIC SURVEYING AND MAPPING.

The author has collected, listed, and analyzed available material on the application of electronics to surveying and mapping, and has mixed in his own experiences as researcher and teacher, first at the Finland Institute of Technology, and later at Ohio State University. He has arranged the book so that it will be usable by geologists unfamiliar with electronics, and by electrical engineers unfamiliar with geodesy. Part I presents the basic principles of electricity, electronics, electronic surveying and its instruments. In Part II the electronic and magnetic features of various electronic surveying systems are analyzed, emphasizing those functions which primarily affect the accuracy of measurements. In Part III, reductions and corrections of the instrument data are derived so that information obtained from the electronic surveying instruments may be applied to the ellipsoid or the map projection plane. Written as a college text, this book also will be valuable to all interested in this subject. (S. Laurila. Columbus, Ohio State University Press, 1960. 294p., $6.00.)

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

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*UNDERWATER ACOUSTICS HANDBOOK

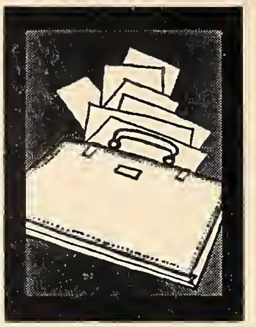
Despite its title, this book is more a detailed and careful study of sound transmission in sea water than a handbook, although the extensive table of contents and good index will make it also a valuable reference work. Part one discusses the nature of sound itself, and the units and reference standards of acoustics, briefly comparing underwater and air acoustics, and describing relevant physical characteristics of sea water, such as density, temperatures, salinity, marine organisms, and absorption and velocity of sound in sea water. Part two discusses the effects of these physical characteristics and other environmental factors such as rain and wind noise, thermal and depth variations, attenuation, reflection and refraction, upon sound transmission in this medium. Part three discusses methods and apparatus for underwater sound generation and detection, and part four deals with the techniques of underwater acoustic measurement and calibration. (V. M. Albers. Pennsylvania, State Univ. Press, 1960. 290p., $10.00.)

*RESEARCH ON THE ROLLING OF STRIP: A SYMPOSIUM OF SELECTED PAPERS, 1948-1958.

Seventeen papers selected from those published during the years 1948-1958, dealing with the mechanics of strip rolling. Full citations of source of original publication is given in each case. Topics covered include calculation of roll force and torque in cold strip rolling, cold rolling, and hot rolling; relations between roll force, torque, and tensions in strip rolling; cold rolling with strip tension; surface friction and lubrication in cold strip rolling; continuous gauge control in sheet and strip rolling; and effects of screw and speed-setting changes in gauge speed and tension in tandem mills. (London, British Iron and

(Continued on page 172)

Business and Industrial Briefs



Appointments and Transfers

The appointments of **Paul J. Kehoe** as director of personnel and of **William M. McCormack** as manager, public relations and assistant to the president, have been announced by J. L. Rapmund, president of Burroughs Business Machines Ltd.

Dr. J. W. Tomecko of Montreal was elected Chairman of the Industrial Advisory Council for the University of Waterloo at the recent annual meeting of the Council. He will serve a two-year term.

Dr. H. G. Thode, Vice President of McMaster University, has announced the appointment of **Dr. R. G. Ward** to the Steel Company of Canada's Chair of Metallurgy.

T. F. Bastet has been appointed assistant manager of Union Carbide Canada Limited's Chemicals and Plastics Division plant in Montreal.

Brig. J. P. Carriere, Executive Vice President of Franki of Canada Limited, announces the following appointments for the Eastern Division: **H. J. Vander Noot**, general manager; **J. G. Greene**, manager of engineering department; **T. Tatlock**, works manager.

R. L. Sears, manager of construction and industrial sales for Barnes Manufacturing Co., Mansfield, Ohio, has announced the appointment of **John B. Janusz** as special factory representative for Barnes pumps in eastern Canada.

The appointment of **M. B. Mairs** as general manager has been announced by H. K. Porter Company (Canada) Ltd.

Howard Smith Paper Mills Limited has announced the transfer of **A. L. Pomeroy**, general purchasing agent, from Cornwall, Ont., to its offices in Montreal.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A NEW BOOKLET published by Dexion (Canada) Ltd., illustrates the use of that company's "Speedframe" jig studs in structures which employ a series of repeated angles or frames. By making the first unit the "master-frame" or jig, and duplicating it by means of the patented studs, the company claims it is possible to effect 50% to 70% savings on labor, and to secure greater accuracy in construction, even with unskilled workmen.

A NEW SYSTEM for institutional use that effectively deaerates water to protect piping and pumps against corrosion and at the same time keeps the temperature low enough to render the water scald-proof for use in bathing, has been developed by The Permutit Division of Pfaudler Permutit Inc. The safety bonus for the hot-water system is achieved by operating a conventional steam deaerator at partial vacuum which permits the removal of corrosive gases at lower temperatures than those prevailing in pressure deaerators. The resulting hot water reaches the point of use at about 132° F., safely below the scalding point.

CANADIAN GENERAL ELECTRIC has announced the availability of a new, very efficient, general purpose, enclosed, area floodlight for small and medium sized areas and for mounting at medium distances. This incandescent flood-light has a concealed wiring slip-fitter mounting, smart appearance and is easy to install. It is available with or without visor and designed for use with 750 to 1500 watt lamps to provide various amounts of lighting dependent upon conditions and requirements.

RIPLEY AND ASSOCIATES, Engineering Consultants Ltd., have announced a change in the name of the firm to Ripley, Klohn & Leonoff Ltd. The firm, which was established in British Columbia in 1951, will continue to offer specialist consulting services in Soil Mechanics and Foundation Engineering. A new soil mechanics laboratory with all facilities has been constructed for the firm which is located at 1939 West Broadway. Vancouver 9, B.C.

A 20-PAGE, fully illustrated catalog has been published describing the complete Glass-tube Varea-meter line of Wallace & Tiernan Inc., Belleville, N.J. The catalog contains information on industrial applications of rotameters, features of the entire line, and details of the several tube and float types available. In addition, it lists selection and ordering data. The industrial user can quickly select the meter for his exact purpose by merely consulting the charts provided.

A NEW and economic process for base recovery from spent sulfite liquor was revealed by Abitibi Power and Paper Co. Ltd., and Pfaudler Permutit Inc. at the recent meeting of the Technical Section of the Canadian Pulp and Paper Association at Saranac Lake, N.Y. Unlike earlier ion exchange processes, none of which has won acceptance, the Abitibi-Permutit ion exchange process has been demonstrated in a one ton pulp per day pilot plant to be technically and economically successful.

A HIGH SPEED table model dry diazo whiteprinter is now available through the nation-wide sales and service facilities of Charles Bruning Company (Canada) Ltd. Called the Starlet 80, the machine has been completely field tested under actual use conditions, with excellent results.

CANADIAN Locomotive Company Limited, Kingston, has announced an agreement by the Canadian Fairbanks-Morse Company Limited of Montreal, and Fairbanks, Morse & Co., of Chicago, returning to the American company the ownership and use in Canada of the Fairbanks Morse name and trademark. Under terms of the new agreement, Canadian-Fairbanks Morse is taking the legal steps necessary to effect the change in its corporate name. The Canadian company will retain marketing rights for opposed piston diesel engines manufactured by the American company in Beloit, Wisc., and by its subsidiary in Kingston.

TWO CANADIAN firms have pooled their facilities for work on sewage, industrial waste and water treatment projects as municipalities step up action against pollution of water resources.

(Continued on page 185)

REACTOR PHYSICIST
FOR
CANADA'S ATOMIC ENERGY DEVELOPMENT PROGRAM TORONTO
ENGINEERING PHYSICS OR HONOURS PHYSICS GRADUATES

Minimum of three years' experience including at least two years' experience in experimental or analytical reactor physics, or postgraduate work in nuclear engineering.

Some experience in numerical analysis would be useful.

Benefits include: Superannuation, Group Insurance, Hospital, Medical-Surgical Plan, Vacation Plan.

File 7 C

ATOMIC ENERGY OF CANADA LIMITED
P.O. Box 905, Taranto 18, Ontario.

ENGINEER
APPLIED MECHANICS

Opportunity for a graduate engineer experience in the application of theoretical applied mechanics to the solution of practical problems. Will be required to plan and carry out theoretical studies and experimental work in stress and vibration analysis, thermodynamics and fluid mechanics. Toronto location. Write giving full details to—

Supervisor, Employment Services,
Ontoria Hydro,
620 University Avenue,
Toronto, Ontario
File No. 7316-V

ferred, or have the equivalent in engineering experience. Should have at least two years' experience as service operator in hydrolectric powerhouse. Working knowledge of plant equipment necessary. Complete responsibility for disassembly repairs and re-assembly of major equipment. Salary commensurate with ability. Living allowance and other fringe benefits. Eighteen to twenty-four month contract. Send complete detailed resume of experience and qualifications to Personnel Department. HARZA ENGINEERING COMPANY, 400 W. Madison St., Chicago 6, Illinois. File No. 7302-V.

MECHANICAL

GRADUATE MECHANICAL ENGINEER wanted between ages 30 and 35 to head up Plant Engineering Department of medium size, long-established Montreal Manufacturing Plant. The position involves the usual plant maintenance duties, but in addition, offers considerable scope in product design and development, and via this route offers a good opportunity to man wishing to work into a business rather than the pursuit of straight engineering duties. The company enjoys a good reputation in its field and has additional manufacturing plants across Canada. Successful applicant will be assured of the usual company benefits, such as Insurance, Retirement Plan, etc. In replying, please give full details as to education, experience, salary required, etc. File No. 7292-V.

MECHANICAL ENGINEER with 4 or 5 years' experience in design of plumbing, heating and air conditioning. Consulting firm in Ottawa. File No. 7311-V.

HEATING, PIPING, and VENTILATION DESIGN ENGINEERS WANTED

Applications are invited by the Consolidated Mining and Smelting Company of Conodo Limited at Trail, B.C. from Design Engineers in the heoting, piping, and ventilation field. Applicants should hove industrial bockground. Permonent positions with odvancement opportunities are availoble. Storting salory commensurate with experience. Excellent working conditions and employee benefits. Applications should be made in writing, giving full particulars of education and experience to the Supervisor, Stoff and Troining Department at Trail, B.C. Personol interviews can be arranged File No. 7318-V.

MISCELLANEOUS

ENGINEERS FOR SALES, PROJECT, design, research, development, control and management. Graduates of all types and ages required by clients of The Technical Service Council, a non-profit industry, sponsored placement service. Write 2 Homewood Avenue, Toronto 5, for an application. There is no charge for work done or your behalf. File No. 6648-V.

DIRECTOR OF INDUSTRIAL ENGINEERING — B.S. Degree in Mining, Mechanical or Industrial Engineering essential. M.S. Degree advantageous. Additional post graduate studies in field such as Business Administration, Industrial Psychology, Advanced Statistics, Human Relations, etc. Requires 10 years' experience in Industrial Engineering including 5 years in a supervisory position. Experience must cover Industrial Engineering techniques such as time and motion study, ratio delay, methods engineering, wage incentives, cost accounting, labor relations, job evaluation. Excellent opportunity—large copper company central Chilean area. Employment on contract basis in multiples of 2 years home leave vacation of 2 months at the end of 2 year contract. Transportation both ways and salary while travelling paid by Company. Provision also made to transport household effects. In reply give complete details and references. File No. 7270-V.

METALLURGICAL ENGINEER:—or mechanical engineer with knowledge of ferrous metal industry for production and development work in a plant in Quebec producing metal powders. Three to five years' plant experience required, some design and equipment layout experience desirable but not essential. File No. 7286-V.

INDUSTRIAL ENGINEER — Required by progressive bleached Sulphate pulp mill located on scenic North Shore of Lake Superior. Modern young community, on new Trans Canada Highway, with excellent recreational facilities. Experience in industrial engineering desirable but not essential. Necessary training will be provided. Will consider graduate from any engineering course at recognized University with one to five years' experience in any engineering field. Work is mainly on project basis in fields of work measurement, methods improvement, plant layout, economic evaluation and fact finding. Starting salary commensurate with experience. Please apply in own hand writing stating age, marital status, details of education and experience to—Personnel Superintendent, KIMBERLEY-CLARK PULP AND PAPER COMPANY LTD., Terrace Bay, Ont. File No. 7298-V.

MAINTENANCE ENGINEER Here is an opportunity for an experienced professional engineer to assume responsibility for all maintenance in a modern and expanding chemical plant. All trades will report to him through foremen. Location, Quebec Province, near a major city. Our client is a leading and well-financed manufacturer of industrial chemicals. Your enquiry will be kept in confidence and answered. TECHNICAL SERVICE COUNCIL, 2 HOMEWOOD AVENUE, TORONTO 5. File No. 7309-V.

OPERATIONS RESEARCH ENGINEER Progressive company with extensive interests in Canada and U.S. seeks aggressive Operations Research Engineer for their mining and refining installation in Saskatchewan. Applicant should have a college degree in Industrial Engineering, Operations Research or related fields with strong training and background in mathematics and statistics and familiarity with computer equipment in problem solving. Familiarity with linear programming, Monte Carlo theory, Queuing theory and other O.R. techniques highly desirable. Please submit resume and salary information to File No. 7321-V.

POST-DOCTORATE FELLOWSHIPS — A few are available in Biochemistry, Chem-

QUEEN'S UNIVERSITY
KINGSTON, ONTARIO
DEPARTMENT OF CIVIL ENGINEERING
Assistant Professor or Lecturer

QUALIFICATIONS: Ph.D., M.Sc., or equivalent, with specialization in soil mechanics, practical experience an advantage.
DUTIES: To instruct at graduate and undergraduate level in soil mechanics and other civil engineering subjects as required. To undertake research in problems involving theoretical and applied soil mechanics.
SALARY: The current salary range at Queen's for a lecturer is $5,200 to $6,800 and for an assistant professor is $6,700 to $8,700. In making an appointment consideration will be given to relevant teaching or research experience. Some additional remuneration for supervising research projects during the summer months is probable. Appointment to be effective January 1st, 1962 or earlier .

Application to be submitted to Dr. S. D. Lash, Head, Department of Civil Engineering, as soon as possible.

Steel Research Association, 1960. 216p., $3.00.)

*THEORIE DER SCHUTTGUTBEWEGUNG.

Based on a series of laboratory experiments in Czechoslovakia, this small book discusses the laws of motion of both fine and coarse bulk material in bunkers and silos. The observations include symmetric and asymmetric bunkers; bunkers with one and with several borrow areas; split bunkers; silos and grain elevators. The study aims to show that this basic experimental work has finally led to definitions and conclusions which will allow satisfactory bunker construction in the future. The appendix includes a list of German and English references. (R. Kvapil. Berlin, VEB Verlag Technik, 1959. 83p., DM 9.00.)

*BOOLEAN ALGEBRA AND ITS APPLICATIONS.

George Boole (1815-1864) developed the system of algebra now bearing his name as the first—and revolutionary—application of a tool of numerical calculation to the development of a system of logic. Boolean algebra now has two other important applications: in treatment of the combination of sets of elements under the operations of intersection and union of sets; and as the foundation for the theory of probability. This book, developed from notes for a course at Montana State College, is designed to introduce the subject on a level which will make it available even to those with rather limited mathematical background, and to examine each of the applications in enough detail so that the reader will gain an appreciation of the scope and usefulness of the subject. It can also serve as a background for specialized courses in any of the major areas of application, (J. E. Whitesitt. Reading, Addison-Wesley, 1961 182p., $6.75.)

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ENGINEERS-CONSTRUCTORS FOR THE METALLURGICAL, CHEMICAL, PETROCHEMICAL AND OIL REFINING INDUSTRIES

American Society for Quality Control

Quality Control Increases Productivity is the theme of the 50th annual all day Quality Control Forum to be held October 28 at the Ecole Polytechnique in Montreal. An attendance of over 250 delegates from beginner to expert is expected. Papers covering four sections of Statistical Quality Control; Basic Concepts, Practical Applications, Advanced Methods and Management Problems will be presented by speakers from Canada and the United States. The luncheon speaker is V. O. Marquez, Vice President of Northern Electric Co. Ltd. who will give a talk titled "Some Problems of Modern Day Competition".

A.S.M.E.

Professor Clifford H. Shumaker was named to serve as President of the Society at the Summer Annual Meeting of A.S.M.E. His term of office will begin in June 1962 following a mail ballot of the membership in the Fall. Six vice presidents and four directors were also nominated for terms to begin next June.

As president of A.S.M.E. Professor Shumaker will travel extensively for a year visiting sections and student sections all over the United States, Canada and Mexico and will attend as many of the national meetings and conferences of the Society as possible.

Chairman of the Department of Industrial Engineering of Southern Methodist University, Professor Shumaker is a Fellow of A.S.M.E. and has been both a vice president and member of the council. He has taken an active part in other activities of the Society, and holds the A.S.M.E. Certificate of Award.

American Society of Safety Engineers

The Annual Meeting of the Society will be held October 16 in Chicago. The national officers for the 1961-62 year will be installed and on October 17 the Annual Awards Luncheon will be held. At the luncheon achievement awards for contributions to the Society and the safety engineering profession will be presented to the chapters of the Society. Also the Technical Papers Awards for 1961 will be made then. These papers are to be published in the new Journal of the American Society of Safety Engineers which will appear for the first time in October. The Society is sponsoring 16 Special Subject Sessions at the National Safety Congress being held in Chicago October 16-20.

Scientific Society for Power Economy

The Second Conference on Industrial Power Economy will be held in Budapest from October 16-21. Co-operation on an international level and the exchange of knowledge and experience to economically use the power resources available is the purpose of the Conference. It was agreed at the first Conference on Industrial Economy held in Budapest in 1959 that there was much room for improvement in this field. Papers will be presented and discussed. An exhibition of new products, plans, photographs and brochures has been organized.

Brno International Trade Fair

The Fair, to be held in Prague from Sept. 10-24 will feature four international scientific and technical symposia on the following topics:

1) Compressors, turbo-compressors and turbo-blowers

2) Unwoven fabrics

3) Regulation of large power-engineering blocks

4) Steel and alloys for the chemical industry

Specialists Days to be held in the exhibition area will include the following topics: electric locomotives, agricultural machinery, rubber processing machines, plastic extruders, new developments in the chemical and engineering fields, labour safety measures, illumination techniques, industrial safety and others.

Three days will be devoted to scientific and technical meetings, two days will be reserved for visits to local institutions and factories and two days will be spent on the exhibition grounds.

Over 30 scientists from all parts of the world will join the same number of Czechoslovakian scientists for the Fair.

Institute of Chemical Engineers of Puerto Rico

The first Inter-American Congress of Chemical Engineering will be held in San Juan, Puerto Rico Oct. 23-28. The main purposes of the Congress are to create an Inter-American Society of Chemical Engineers and to contribute to the advancement in this field through the exchange of ideas, knowledge and experience. Technical papers will be presented and these will be complemented by a series of visits to industrial areas on the island of Puerto Rico. Eleven topics will be included in the technical sessions: Sugar Technology; Food Technology, Technology of Alcoholic Beverages, Nuclear Technology, Petroleum Technology, Sanitary Engineering (First Symposium—Industrial Wastes), Biochemical Engineering, Unit Operations, Pure Chemistry, Industrial and Engineering Chemistry (Second Symposium — Corrosion in Chemical Plants) and Chemical Engineering. An exposition of products and equipment used in industrial and experimental chemical operations will be held. Social activities have been planned for the delegates and their wives as well as a full program for the ladies.

British Institution of Radio Engineers

A Royal Charter was granted the Institution recently. This honour is a landmark in the Institution's 36 year history. The B. I. R. E. was founded in 1925.

This body was founded to help provide suitable technical training for future radio and electronic engineers. Its standards have been accepted as the yardstick of professional ability.

Regular meetings are held, along with conventions attended by engineers and scientists from all over the world.

A.I.M.E.—A.S.M.E.

The 24th Annual Joint Solid Fuels Conference will be held Oct. 5-7 in Birmingham, Ala. Sponsored by the Coal Division of the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers and the Fuels Division of the American Society of Mechanical Engineers, the purpose of the conference is to consider the accomplishments and problems facing the United States coal industry, from technical and economic standpoints. A two day meeting of the Southern Research Institute on "Future Coal Markets" immediately precedes the conference. Many nationally known experts in the coal industry will attend both programs.

Coming Events

Joint Meeting, American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., Canadian Institute of Mining and Metallurgy, Ottawa, Oct. 2-3.

Fifth Canadian Convention, Institute of Radio Engineers, Toronto, Oct. 2-4.

Seventh National Communications Symposium, Institute of Radio Engineers, Utica, N.Y., Oct. 2-4.

49th Annual Meeting, International Council for the Exploration of the Sea, Copenhagen, Denmark, Oct. 2-11.

Joint Solid Fuels Conference, A.S.M.E., A.I.M.E., Birmingham, Ala., Oct. 5-7.

36th Annual Fall Meeting, American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., Society of Petroleum Engineers, Dallas, Texas, Oct. 8-11.

National Electronics Conference, Institute of Radio Engineers, American Institute of Electrical Engineers, Chicago, Oct. 9-11.

16th Annual Meeting, American Rocket Society, New York, Oct. 9-13.

Seventh Convention, Prestressed Concrete Institute, Denver, Colo., Oct. 15-19.

International Conference on the Ionization of the Air, Philadelphia, Oct. 16-17.

Annual Convention, American Society of Civil Engineers, New York, Oct. 16-20.

Eighth Lubrication Conference, A.S.L.E., A.S.M.E., Chicago, Oct. 17-19.

33rd Annual Meeting, Gray Iron Founders' Society, Toronto, Oct. 18-20.

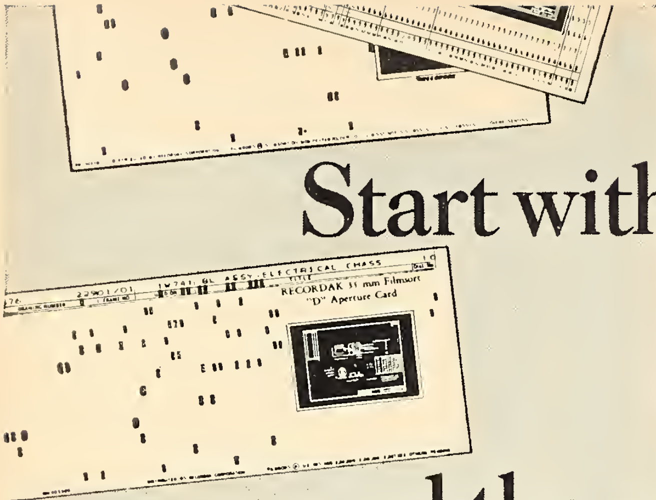
Joint Meeting, Canadian Aeronautical Institute, Institute of Aerospace Sciences, Ottawa, Oct. 23-24.

Ninth Weather Radar Conference, American Meteorological Society, Kansas City, Mo., Oct. 23-26.

International Symposium on Aerospace Nuclear Propulsion, Las Vegas, Nev., Oct. 23-26.

Symposium on Power Reactor Experiments, I.A.E.A., Vienna, Austria, Oct. 23-27.

International Symposium on Photoelasticity, Chicago, Oct. 29-31. EIC



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(Continued from page 172)

*STAHLMASTE FUR STARKSTROM-FREILEITUNGEN, 3RD. ED.

A study of steel towers for heavy-current overhead transmission, intended as a guide in planning new line systems and in calculating and manufacturing economic tower types. All examples are taken from recent designs comprising towers for high, low, and medium-voltage lines, such as structures for extra-high tension lines with operating voltage to 380 KW. The appendix includes tables in buckling values, cable cross-sections, sag calculations, and examples of insulator chains. (K. Fielitz and H. Mors. Berlin, Springer-Verlag, 1960. 164p., DM. 48.00.)

*SYNTHETIC RUBBER TECHNOLOGY, VOLUME I.

The author writes from many years of experience in industry, for technologists requiring a practical account of the compounding and processing of elastomers, without touching on their chemistry. The elastomers considered are SBR, high styrene resins, butyl, nitrile, and silicone rubber, neoprene, and Thiokol. The book describes the grades of synthetic rubber available, criteria for selection for particular uses, method of compounding in general and for special products, modern processing techniques, and current applications. Standard polymers with more or less crystallized techniques were selected for discussion in this volume; a subsequent volume will take up newer methods for which the techniques are less codified. (W. S. Penn. London, Maclaren, 1960. 325p., 50/-.)

*THE RADIO AMATEUR'S HANDBOOK, 1961, 38TH ED.

This annually-revised handbook by and for amateurs treats radio problems in terms of how-to-do-it rather than by abstract discussion. Its objective is to present the soundest and best aspects of current practice rather than the merely new and novel. It is a compendium of technical and trade information useful to all concerned with radio and its applications. (West Hartford, The American Radio Relay League, 1961. Various pagings. $3.50.)

*SELECTED PAPERS ON STRESS ANALYSIS.

Papers presented at the Institute of Physics, Stress Analysis Group Conference, Delft, 1959. The eighteen papers included deal with methods of stress analysis and their application. They are given in the form in which they were presented, in English, French, or German, together with summaries in the three languages of the conference. An English resume is given for thirty-three papers also given at the conference, but which are not included in the volume. (London, Chapman and Hall, 1961. 114p., 50/-.)

BASIC TRANSISTORS

A "pictured-text" introduction to the transistor, covering the p-n junction diode; transistor circuits; amplifiers; power transistors; transistor oscillators and the tetrode transistor, etc. (A. Schure. New York, Rider, 1961. 146p., $3.95.)

BASIC MATHEMATICS, VOL. I.

Really basic mathematics: addition, subtraction, ratios, fractions, etc., are covered in this "picture-book" text, intended both for students and those who never did obtain a firm grounding in, or understanding of, the subject. Other volumes will cover algebra, geometry, trigonometry and calculus. (N. H. Crowhurst. New York, Rider, 1961. 143p., $3.90.)

*WATER SUPPLY AND WASTE DISPOSAL

Insofar as possible, an integrated treatment is given of the fundamental principles and practices. This is followed by a detailed description of both the design and operation of systems for water supply and for waste disposal. A broad view of the subject is taken by the authors who take into account such problems as the growing populations coupled with rapid suburban development, the steadily increasing per capita rate of water use, and the increasing quantity of industrial waste products. (W. A. Hardenbergh and E. R. Rodie. Scranton, International Textbook, 1961. 503p., $11.00.)

*THE EXTRUSION OF METALS, 2ND ED.

This is a thoroughly updated edition of the 1944 presentation of extrusion practice relating to different classes of work and materials. The authors have added over 100 pages, including a completely new chapter on an evolved theory of flow which is seen as a valuable guide to industrial practice. New bibliographical references are also included. Recent trends and processes are discussed, but the emphasis is still on basic principles, accompanied by brief historical background information and attention to theoretical aspects. (C. E. Pearson and R. N. Parkins. London, Chapman and Hall, 1960. 336p., 45/-.)

SEWAGE TREATMENT: BASIC PRINCIPLES AND TRENDS

An introduction to the basic principles of sewage treatment processes, with emphasis on the chemistry of the subject. The topics covered include the nature of sewage and its chemical analysis; sewerage systems; preliminary treatment; primary sedimentation; aerobic biological treatment; sludge disposal; the various types of trade wastes and their effect; small sewage treatment plants; trends in sewage treatment. The authors are both with the Mersey River Board, England, and most of the references in the lengthy bibliography are to British publications. (R. L. Bolton and L. Klein. Toronto, Butterworth, 1961. 161p., $5.50.)

HEAT BIBLIOGRAPHY, 1958

Compiled by the Heat Division of the National Engineering Laboratory, this bibliography lists all the papers, reports, etc., noted by the Division during 1958. It is not an exhaustive bibliography for the year, and includes material which was published prior to that date. The articles are classified under 50 main subject headings, and a complete reference is given for each. (Ed. by D. E. Sexton. Toronto, U.K.I.S., 1960. 281p., $2.81.)

*ENERGY IN THE AMERICAN ECONOMY, 1850-1975.

A survey publication of Resources for the Future, Inc., which examines the sources, supply, and use of energy in the U.S. during the years 1850-1975, their place in the economic development of the country, and the future energy picture. Reversing the usual procedure, projections of the future are considered first, in the introductory section, which summarizes and evaluates the findings and conclusions of the other three sections of the book, and on this basis discusses the future. Part I then presents an historical analysis of the statistical record of energy supply and demand in the U.S. over the past 100 years. Parts 2 and 3 evaluate the future energy position of the U.S., both in terms of the country's growing needs, and of its ability to satisfy them from domestic resources. Extensive tables and graphs make this an excellent statistical source book in the energy field. (S. H. Schurr and B. C. Netschert. Baltimore, Johns Hopkins Press, Toronto, Burns and Mac Eachern, 1960. 774p., $15.75.)

(Continued on page 182)

SEMICONDUCTORS AND TRANSISTORS

A discussion of the theory and characteristics of these devices, commencing with fundamental concepts, and paying particular attention to atomic structure, the quantum theory, conductors and insulators. Design procedures in transistor amplifiers are also covered in detail. A useful basic introduction. (Ed. by A. Schure. New York, Rider, 1961. 138p., $2.90.)

ACHEMA JAHRBUCH 1959/61

This yearbook and catalogue of European chemical plant, apparatus and instruments is in two volumes, the first of which provides an introduction for those attending the 1961 ACHEMA Congress. It contains general information on various European chemical societies, reports from 106 research institutes in 12 European countries, on the work they are doing in the fields of chemical engineering and technology, and progress reports from 147 firms engaged in research in various fields: measurement, control and automation, structural materials engineering, works techniques, ancillary plant, and packaging.

The second volume contains an alphabetical list of manufacturing companies, and a classified buyers' guide in English, as well as a list of trade names. (Ed. by H. Bretschneider. Frankfurt, Dechema, 1960. 2 vols.)

HIGH-VOLTAGE A.C. CIRCUIT-BREAKERS

Written primarily for the user of circuit-breakers in high-voltage systems, this volume contains descriptions of obsolete apparatus as well as of new breakers, in order to complete the picture of the evolution of methods employed.

Basic components, types of circuit-breakers, breakers using oil insulation, and solid insulation, control and selection are all covered. There is a 21 page bibliography. (S. Gerszonowicz. Toronto, Longmans, Green, 1953. 454p., $12.60.)

*POLISSAGE ELETROLYTIQUE ET CHIMIQUE DES METAUX

Translated from the 2nd English edition, this volume is a survey of both metallurgical techniques and industrial finishing operations, describing the apparatus, methods and limitations of each process. This revision emphasizes laboratory work, but includes fuller discussion of the nature of mechanically prepared surfaces and of commercial electropolishing units. (W. J. McG. Tegart. Paris, Dunod, 1960. 170p., 23NF.)

ORGANISATION, 10. ED.

In the first volume, sub-titled Administration of the Company, the author considers general administrative principles, financial organization, accounting, commercial "politics" and agreements, such as trusts and cartels.

The second volume is concerned with the organization of work, work analysis, time study, programming, wages, and staff relations. The text is in French. (J. Chevalier. Paris, Dunod, 1961. v. 1, 295p., 22NF: v. 2, 263p., 22NF.)

INTRODUCTION A LA TREMPE

This introduction to the technique of steel tempering is translated from the German. The first, theoretical, section of the book covers the principles of heat treatment, heat treatment processes, thermo-chemical treatment, behaviour of steel during tempering, hardness testing. The second, more practical section, deals with tempering furnaces, temperature measurement, protective atmospheres, accident prevention. (W. Ordinanz. Paris, Dunod, 1961. 284p., 24NF.)

MANUEL DE BASE DE L'INGENIEUR, t.2.

This is a translation of the "Generalites" volume of a seven-volume Swedish engineers handbook. The first of the present two volumes dealt with mathematics and mechanics, and their application to fluid dynamics and strength of materials. This volume is concerned more with physics and physical chemistry, and covers the mechanics of vibrations; acoustics; optics; heat; combustion; the laws of physical chemistry; electricity and magnetism; the basis of atomic and nuclear physics; measurements in physics, electricity and magnetism. Many useful tables are included. (Ed. by S. H. Tidestrom. Paris, Dunod, 1961. 641p., 58NF.)

PROBLEMS IN ELECTRONICS WITH SOLUTIONS, 2ND ED.

In this enlarged edition, the sections on transients, waveform analysis and four-terminal networks have been expanded, and new problems have been added covering a variety of topics. Problems are included for all sections of

(Continued on page 183)

electronics, and although most are at an under-graduate level, more advanced ones are included. Both answers and the methods of solution are given. (F. A. Benson. London, Spon, 1961. 249p., 42/-.)

*DICTIONARY OF MECHANICAL ENGINEERING.

This is a one-man work defining terms in the fields of architecture, automatic controls, engineering mechanics, fuels and combustion, and power plants, as well as some related terms from the fields of electricity, mathematics, welding, and the heat treatment of metals. Most of the definitions are brief and quite general, and where the term is particularly pertinent to one field, this field is given in parenthesis after the term. A random sampling of the terms and their definitions would indicate that this dictionary is useful mainly on an elementary level, or to direct the searcher to the appropriate subject field and its particular reference books, for more complete definition. The last twenty-two pages contain a list of conversion factors for units of measurement. (A. Del Vecchio. New York, Philosophical, 1961. 346p., $6.00.)

EFFECT OF SURFACE ACTIVE MEDIA ON THE DEFORMATION OF METALS

Translated from the Russian, this volume presents the contributions of Soviet scientists in this field. Their research has led to the discovery of new effects resulting from the interaction between a deformed metal and the surrounding medium containing a surface active agent. The seven chapters cover: the growth methods and mechanical properties of single crystals: the rules governing the deformation of metal single crystals in the presence of surface active substances; creep of single crystals; effect of surface active media on the mechanical properties of polycrystalline metals; metal fatigue; principal mechanisms governing the adsorption fatigue of metals; physico-chemical effects during pressing and sintering metal powders. A bibliography containing 100 references is included. (V. I. Likhtman and others. New York, Chemical Publishing, 1960. 188p., $5.75.)

HANDBOOK OF CHEMISTRY AND PHYSICS, 42ND ED.

Constantly being revised, this new edition of this useful handbook contains revised and expanded data on many topics, including: atomic weights; plastics trade names; analytical reagents; properties of refractory materials. Many new tables have been added. The Handbook is divided into five sections: mathematical tables; properties and physical constants; general chemical tables; heat, hygrometry, sound, electricity and magnetism and light; quantities and units. The use of this Handbook is by no means confined to chemists and physicists — engineers will find it most useful. (Ed. by C. D. Hodgman. Cleveland, Chemical Rubber Co., 1960. 3481p., $12.50.)

(Continued on page 184)

*AN ENGINEERING APPROACH TO GYROSCOPIC INSTRUMENTS.

The authors are intimately connected with their subject, as executives in research divisions of General Precision, Inc., and United Aircraft Corporation, respectively. They write for engineers, at a level intermediate between elementary explanations of gyroscopic effects, and complicated mathematical derivations. In the first chapter, they discuss the fundamental principles of gyroscopic motion, and the basic elements of primary applications, such as the gimballed gyroscope. The remaining three chapters examine applications, in three separate categories: basic gyro configurations such as displacement, rate, and integrating gyros; special gyro designs such as floated, air and fluid bearing, vibrating rate and particle gyros, with details on magnetic and electrostatic suspension; and special instrument gyroscope applications — free, vertical, and directional gyros, and gyro platforms. "A comprehensive review of the principles and general features of existing instruments", according to Dr. C. S. Draper, of M.I.T. (E. J. Siff and C. L. Emmerich. New York, Robert Speller, 1960. 120p., $7.50.)

*AIRBORNE RADAR.

The eighth volume in the series "Principles of Guided Missile Design", this book presumes considerable prior knowledge of the basic principles of electronics and electromagnetic propagation, of the weapons systems employing airborne radar, and of associated language. This particular volume is primarly concerned with airborne radar, but is applicable also to surface radar. It is the work of 25 contributors representing U.S. industry and government organizations in this field. It provides an understanding of basic radar technology and its relation to overall weapons system design, with emphasis on the basic principles and systems analysis techniques, and how mathematical models may be developed to solve radar design problems. (D. J. Povejsil and others. Toronto, Van Nostrand, 1961. 823p., $19.00.)

*KINETICS, EQUILIBRIA AND PERFORMANCE OF HIGH TEMPERATURE SYSTEMS.

This volume constitutes the unclassified proceedings of the Conference on Kinetics, Equilibria, and Performance of High Temperature Systems held by the Western States Section of the Combustion Institute in Los Angeles, November, 1959. The papers discuss input and output thermodynamic data, computer programming for output thermodynamic data and for standard engine performance parameters, and special programs for combustor and exhaust nozzle design. (Ed. by G. S. Bahn and E. E. Zukoski. Toronto, Butterworth, 1960. 255p., $12.50.)

*AIR POLLUTION MANUAL, PART I: EVALUATION.

Prepared by a group of engineers, chemists, toxicologists, physicists, meteorologists, and others specializing in the field of industrial hygiene and air pollution, this book presents information needed for the intelligent appraisal of air pollution problems. It is a practical book, containing discussions of the methods, techniques, and instrumentation relevant to investigations of each problem, as well as literature references to proven sources of information. Volume 2 to follow, dealing with air pollution control. (Detroit, American Industrial Hygiene Association, 1960. 194p., $8.50.)

*THE STORY OF ENGINEERING.

An outstanding writer on the history of engineering presents here the history of the works of the master builders of the Western world, from the early Egyptians to the leaders of 20th century engineering. It is the account of the great construction works of man — bridges and roads, dams and canals, mines and machines — as well as the modern discoveries in such fields as electrical and chemical engineering, told in terms of individual engineers who contributed to these fields of endeavor. In the second part of the book, the emphasis is on events in the United States, with little reference to the achievements of engineers of other countries. (J. K. Finch. Toronto, Doubleday, 1960. 528p., $1.65.)

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L. J. McGowan, President, The Foundation Company of Canada Limited, and R. M. Robertson, President, Babcock-Wilcox and Goldie-McCulloch Limited have announced an agreement under which their two firms offer a manufacturing and construction package for sewage, waste and water facilities to municipalities and their consulting engineers.

CATALYTIC Construction of Canada Limited, of Sarnia, Ont., has been retained to handle the engineering design, procurement and construction of a polybutadiene plant in Sarnia for the Polymer Corporation Limited. The selection of this firm to carry forward this new project follows closely on the heels of the announcement of the licensing arrangements recently concluded with Goodrich-Gulf Chemicals and with Professor Karl Ziegler on the application of new and improved catalysts to the production of stereo-specific rubbers, of which polybutadiene is one.

THE PERMUTIT Company, a division of Pfaudler Permutit Inc., has released design and operating details of its new water-jet powered Precipitator, a simplified and economical solids-contact type water clarifier that has already demonstrated high efficiency in field tests carried out over the past eight months. Designated the type M Precipitator, the new clarifier is described as a sludge blanket type, in which the jet effect of water ejected from the tips of the agitator is the sole driving power required for the agitator unit.

CONTRACTS have been let for construction of new facilities to accommodate the electrical manufacturing operations of Canadian Allis-Chalmers Limited, which are being transferred from St. Thomas, Ont., to the main Lachine Works of the company. The electrical assembly operations will be housed in a building the main floor of which is 300 by 80 ft. and the second floor provides an additional 4200 sq. ft. of manufacturing space and 4000 sq. ft. of office accommodation.

A BALL BEARING in a flange-type iron housing is now available from United Steel Corporation Ltd. Of special application in the farm machinery and air-conditioning fields, the unit also meets the requirements of other machinery manufacturers. Known as the FLCT, this unit consists of a compact cast iron housing with a standard inner ring ball bearing and self-locking collar. The combination square and round bolt holes will accommodate carriage boits or standard machine bolts.

A REDESIGN of the elements in the conventional roller chain has led to the development of Jeffrey-Bowman Drive Chain, stronger than any other 2 in. pitch chain, requiring less adjustment and maintenance. With essentially the same amount of material, but more perfectly distributed, the results have exceeded expectations.

AS A RESULT of long-term agreements signed recently with two U.S. firms, John Inglis Co. Ltd., Toronto, will start early manufacture of heavy machinery

(Continued on page 186)

and replacement parts previously imported into Canada. The U.S. firms are Harnischfeger Corp., Milwaukee, manufacturers of power cranes and shovels for the mining and construction industries, and Nordberg Manufacturing Co., also of Milwaukee, which makes mining machinery for crushing ores. Both Harnischfeger, which has a wholly-owned Canadian subsidiary, and Nordberg will handle the sales and servicing of their respective products in Canada.

CANADIAN Ingersoll-Rand Co. Ltd. announce that they have acquired the patents and manufacturing rights on a system of air rinsing for material screening. Previously manufactured by Aussie Manufacturing Ltd., the unit carried the "Aussie" trademark. Canadian Ingersoll-Rand is marketing the unit under their trademark of "aIRinse".

COMPLETE illustrated information on brick floor installation featuring the preparation of corrosion-resistant and wear-resistant joints to reduce costly floor maintenance is included in The Master Builders Company publication, E-27b. This four-page bulletin also covers other money-saving procedures and techniques for proper installation of new brick floors and the repair of existing ones, using special, non-shrink grout.

IN PUBLISHING the schedule of courses for the next six months, June to December, 1961, DeVilbiss emphasizes that free classes at the Technical Training Centre are open to all owners or users of DeVilbiss equipment. Application for classes are available on request to DeVilbiss (Canada) Ltd., Barrie, Ont. Each course combines lectures, demonstrations and practical training.

DeVilbiss estimates that the knowledge of equipment, control, method and techniques imparted during the course would take students years of unguided experience to acquire.

A NEW line of four-inch chart Metagraphic pneumatic receivers has been announced by The Bristol Company of Canada Ltd. Built to a new design, these instruments, designated as the Series 670, are user oriented. Many new features, both standard and optional, combine to make the Series 670 easy to install, easy to use and easy to maintain. Nine models are presently available to meet any control requirement.

Canadian Sheet Steel Building Institute, Inc.

The newly formed Canadian Sheet & Steel Building Institute, Inc., has as its chief aim the encouragement of wider use of sheet steel in building construction. Among other things, the Institute will pay particular and constant attention to building codes and by-laws to ensure that designers will be free to use sheet steel when desired.

There are three categories of membership in the new Institute: Producer Members, comprising basic steel producers; Associate Members, suppliers to the basic mills; and Fabricator Members, who are qualified manufacturers of sheet metal or pre-engineered products.

Four technical committees have been formed to deal with the fields of: floor deck; roof deck; architectural and industrial cladding; and pre-engineered buildings.

Officers for the first year have been elected and the Institute's office is in Port Credit, Ontario. EIC

LIBRARY NOTES

(*Continued from page 184*)

*ELECTRONS AND PHONONS

Written for graduate students and research workers having an acquaintance with elementary wave mechanics, this treatise presents the theory of electrical and thermal conduction in metals, semiconductors, and insulators. The experimental facts and their theoretical explanation are developed for the basic ideas of lattice dynamics, electron zone structure, and transport theory, from first principles; formulae for the macroscopic coefficients are deduced by self-contained mathematical arguments. The emphasis is on chemical and structural effects to show they can be calculated and used as a tool for further investigation of individual solids. (J. M. Ziman. Toronto, Oxford, 1960. 554p., $13.45.)

APPLIED MECHANICS FOR ENGINEERS

An undergraduate text, written to present the fundamental principles which may be applied to engineering problems which cannot be solved by routine methods, and to illustrate these principles by examples. Statics, dynamics and the strength of materials are given an elementary, but detailed, treatment, and their inter-connection shown. Appendices cover vector quantities; graphical differentiation and integration; geometrical

(*Continued on page 193*)

properties of sections; Castigliano's theorem and theorems of reciprocal displacements. (J. C. Grassie. Toronto, Longmans, Green, 1960. 652p., $8.10.)

POSSIBILITES DU DECOLLETAGE AUTOMATIQUE SUR TOURS MULTIBROCHES.

As is pointed out in the preface, the more automatic a machine, the greater its value. In this book, the author discusses the possibilities of automatic screw-cutting on multi-spindled lathes, covering the machines involved, their selection and operation; working time; tempo of production; multiple operations; and actual and future possibilities. For the paper on which this book is based, the author won the 1959 prize of the Federation des Industries meeaniques et transformatrices des Metaux. (J. A. G. Granger. Paris, Dunod, 1961. 206p., 40 NF.)

LES DIELECTRIQUES ET LEURS APPLICATIONS.

Translated from the 1954 U.S. edition, this collcction of papers by 22 contributors is directed to the research worker, the manufaeturer, and the field engineer. The topics covered include dielectric theory; the methods and techniques for measuring permittivity and permcability; the use of such matcrials as liquids, plastics and ceramics; power, distribution and electronies equipment; rectifiers, magnetic and dielectric amplifiers and memory devices. (Ed. by A. R. Von Hippel. Paris, Dunod, 1961. 439p., 94 NF.)

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CONTENTS

THE IBM 1620

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IN THIS ISSUE

Concepts and Economics of Extra Long Distance Direct Current Transmission and System Interconnection by **H. L. Briggs**, M.E.I.C., is an economic feasability study of the place high voltage direct current transmission could have in the development of Canada's remote hydro power potential if commercially dependable high capacity DC conversion and control equipment were developed. The author concludes that there is a need for research into and the development of this equipment if Canada's power potential is to be fully realized. Mr. Briggs received his B.Sc. degree in Electrical Engineering from the University of Manitoba in 1928 and since that time has been; Chief Engineer and General Manager, Winnipeg Hydro Electric System, the position he held with the British Columbia Power Commission before he became a member of the National Energy Board in Ottawa.

Carillon Foundation Studies is not meant to be a profound discussion of the theories of soil mechanics or foundation design. The authors describe the methods used and the results obtained in performing in-situ shear tests on a particular altered shale bed at Carillon. The description of the tests may benefit engineers faced with similar problems at other locations. C. H. **Pigot**, M.E.I.C., received his B.Sc. in Civil Engineering from McGill University in 1926. He joined Quebec Hydro Electric Commission in 1944 and now is Assistant Chief Engineer, Power Development Division. **Ian D. MacKenzie**, M.E.I.C., is a geologist for the Shawinigan Engineering Company, Montreal, the post he has held since leaving Queens University in 1940 with a B.Sc. in geology and Minerology.

The three authors of *Economic Development of Hydro-Quebec Power Resources — System Studies Utilizing an IBM 704 Computer* describe in this paper how useful such a piece of equipment can be. To facilitate the planning of development of power sites by the Quebec Hydro-Electric Commission, a model of its expanding system was simulated on an IBM 704 computer. The paper describes the nature of the model and the methods of analysis used. **Joseph Bourbeau**, M.E.I.C., received a B.Sc.A. degree from the University of Montreal in 1947. He has been with the Quebec Hydro Electric Commission in a variety of positions since 1948. **Fritz H. Jonker** graduated from the Technological University in Delft in 1951. In 1953 he joined H. G. Acres & Company a year after coming to Canada. **J. G. S. Thompson**, a project engineer for H. G. Acres and Company Ltd. received his B.Sc. degree in Civil Engineering from the University of Glasgow in 1950. His work has taken him to all parts of the world.

C. Booy, author of *The Structural Design of the Tunnels for the South Saskatchewan River Dam*, is a design engineer for the South Saskatchewan River Project. A graduate of the Technical Institute in Delft in 1949, Mr. Booy came to Canada in 1951, and has been in his present position since 1959. His paper describes the five water diversion tunnels, which after the Project has been completed, will be used for power. The problems encountered in the design of these tunnels are discussed. The shale formation in which the tunnels are being laid is described along with the complications encountered. The design of portals and control shafts is briefly discussed.

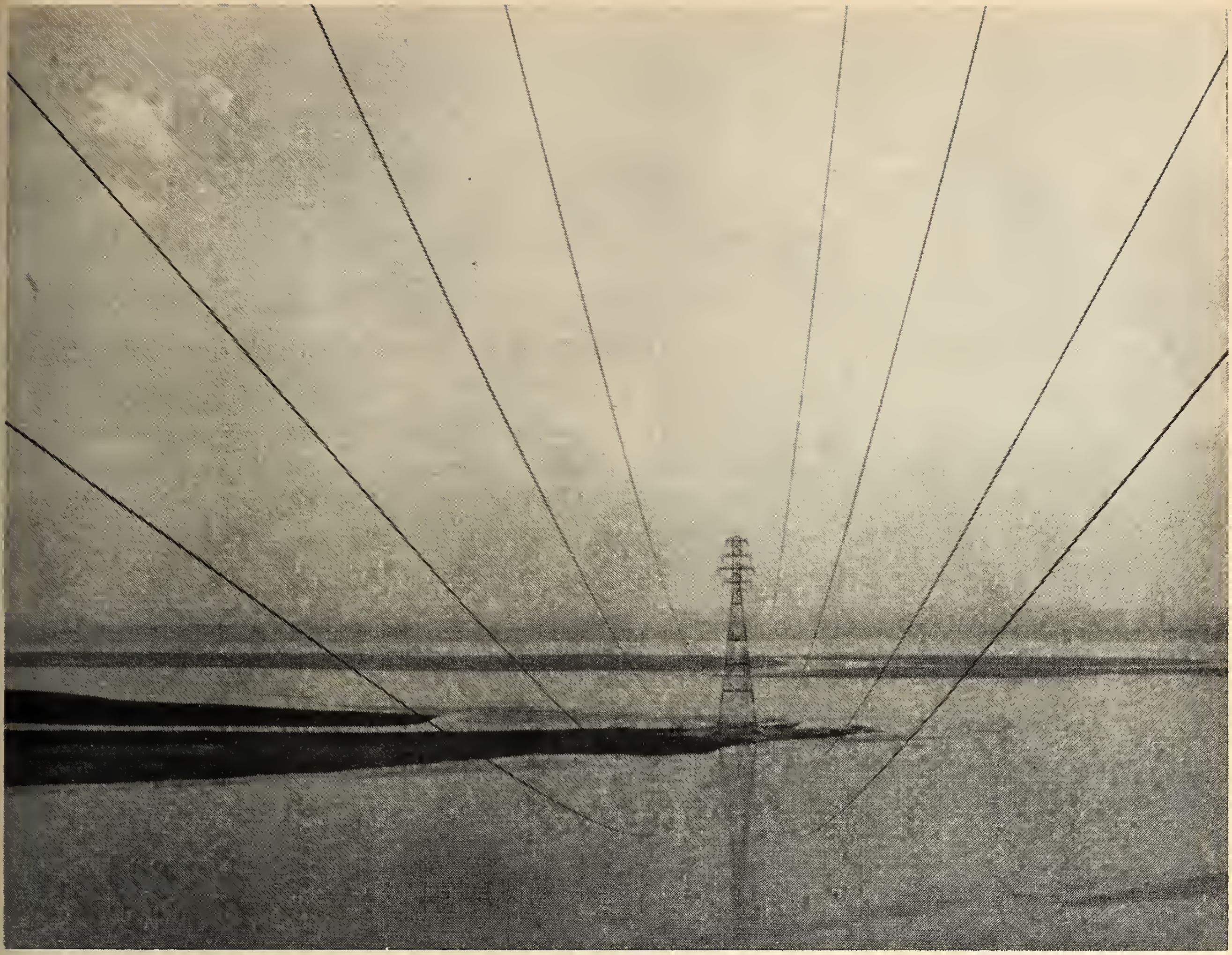
Speed Regulation for Hydraulic Turbines by **W. J. Smith**, M.E.I.C., and **J. L. Gordon**, JR.E.I.C., outlines a procedure for determining the frequency variations of hydro electric generating units operating in isolated systems which result in sudden load changes. The authors present data from tests which are a confirmation of theoretical computations. W. J. Smith, Chief Civil Engineer, Montreal Engineering Company received a B.Sc. (Honors) degree from Queen's University, and has been associated with that firm since 1946. J. L. Gordon, Supervising Engineer, Civil Engineer of the same firm received a B.Sc. (Honors) degree from Aberdeen University in 1952.

Extra high voltage transmission is reviewed in *The How's, Why's and Wherefore's of EHV Transmission* by C. M. Stairs. Particular emphasis is placed on its economic position in the power systems of the future. Technical content is kept to a minimum so that the economic facts can be outlined for all interested engineers. While the advent of EHV may not drastically influence the cost of power delivered to the consumer, considerable savings can be made in transmission lines, thus justifying further research. Colin Stairs graduated from McGill with a B.Sc. degree in 1948 after which he became a member of the engineering staff of Canadian General Electric Co. Ltd. He is specialist — power systems application engineering, apparatus dept. in Peterborough, Ont.

The co-authors of *Engineering Research on the Fish and Power Problem* are members of the Civil Engineering Department of the University of British Columbia. **J. F. M. Muir**, M.E.I.C., is Head of the Department. He graduated from the University of Manitoba in 1923 and joined the faculty of the University of British Columbia in 1939. Prof. Muir's colleague, **Eugen Ruus**, received a Dr. Engineer degree from Karlsruhe, Germany in 1957. He came to Canada in 1950 and in 1957 joined the faculty as an Assistant Professor. The development of the great rivers in British Columbia for fish, power and flood control is discussed. Fish passage facilities for a proposed dam and generating station on the Frazer River are described and the authors conclude with a recommended fisheries-engineering research program.

COVER ILLUSTRATION

Power is portrayed by the surge of water flowing through Cominco's Waneta Dam on the Pend-D'Oreille River near Trail, B.C. (Photo courtesy the Consolidated Mining and Smelting Company of Canada Limited)



POWER IN CANADA

ALTHOUGH THE rate of increase has slackened, production of power in Canada shows continued growth. During 1960 a net total of 1,741,820 hp of new hydro-electric capacity was added in Canada after allowing for 4,680 hp. which was dismantled or destroyed. Total installed hydro capacity now is listed by the Dominion Bureau of Statistics at 26,372,444 hp. At the end of 1960, installed thermal capacity totalled 4,257,788 hp., compared with 3,785,979 hp. at the comparable time in 1959.

The 1,176,500 hp. of new hydro capacity installed in Quebec during 1960 surpassed the combined total of the other provinces. Ranking second and third, respectively, were Manitoba and British Columbia, each of which added slightly more than 200,000 hp.

New thermal developments or extensions to existing installations were under construction in each of the 10 provinces and in the Yukon and

Northwest Territories. Significant increases in thermal installation were made in such provinces as Alberta, Saskatchewan, New Brunswick and Nova Scotia where the greater part of the total electric power requirements is derived from thermal plants, and also in British Columbia where the first major thermal installation started operation in 1958.

The greatest increase in thermal capacity, however, occurred in Ontario where the development of the principal hydro sites adjacent to present load centres has been largely completed. This growing tendency towards increased thermal generation in various provinces reflects not only the fulfilment of the rapidly-increasing energy demand but also the benefits of resource conservation which may be derived through the operation of an integrated power system supplied by both hydro-electric and thermal-electric plants.

While new hydro capacity to be installed in Canada during 1961 is limited to about 243,000 hp., construction is proceeding at other developments where 4,500,000 hp. is expected to be installed and where provision will be made for installation of an additional 1,000,000 hp. in later years.

Major installations during 1960 were made at the Chute-des-Passes generating station of the Aluminum Company of Canada Limited, where two units totalling 400,000 hp. started operation, and at Bersimis II and Beauharnois No. 3 developments of the Quebec Hydro-Electric Commission where 342,000 hp. and 368,-500 hp., respectively, were placed in service.

Of the total installed hydro capacity at the end of 1960, 77% was controlled by utilities, including companies, municipalities or individuals selling most of the power developed by them. Industries controlled the remainder, although it should be emphasized that in addition to power generated in their own plants, industries purchase large amounts of power from utilities.

Following is an outline of the main features of power in Canada, dealt with province by province.

BRITISH COLUMBIA

British Columbia ranks third in ininstalled capacity of hydro power with turbine capacity of 3,700,326 hp., and fourth in thermal power with an installed capacity of 402,238 hp. The west coast province is second in recorded available hydro resources, estimated at ordinary six months flow.

Last year, construction in British Columbia resulted in a net gain of 201,220 hp. in hydro capacity. This included 175,800 hp. of new equipment, an increase of 28,000 in existing equipment, and a loss by fire of 2,580 of older equipment. Additional capacity totalling 224,500 hp. is planned for development in later years. Not included in these totals are major developments planned for the Peace and Columbia Rivers.

Of major significance to the British Columbia Power Commission are plans for the development of storage in the Columbia River Basin by means of dams to be located at the outlets of Arrow and Duncan Lakes and at the Mica site, north of Revelstoke. These three projects will control approximately 20 million acre-feet of usable storage. According to a treaty negotiated between the governments of Canada and the United States, Canada would receive one half of the power benefits in the United States from the regulation of 15.5 million acre-feet of this storage, and one half of the value of the estimated flood damage prevented in the United States through flood control operation of these projects. It is estimated that Canada's initial share of the power benefits will total approximately 1,300,000 kw. of dependable capacity and approximately 7,750 million killowatt-hours of annual energy.

The Commission made no additions to its installed capacity during 1960. In the planning stage are the 51,500 hp. Kokish River development on Vancouver Island, and the Pyramid Mountain-Murtle River development which ultimately is expected to consist of four 43,000 hp. units.

Total development of British Columbia Electric Company Limited's Bridge No. 2 project was realized last year with the completion of Mission Dam and installation of the two remaining units in the powerhouse. It now has a total installed capacity of 328,000 hp. in four equal units. The increased head due to the construction of the Mission Dam will increase by 28,000 hp. the total turbine capacity at Bridge River No. 1 Powerhouse.

At Cranberry Creek the City of Revelstoke completed the initial phase of the development with the installation of one 5,800 hp. unit.

Northern British Columbia Power Company Limited doubled its installed capacity at Falls River with the installation of a second 6,000 hp. unit.

The Peace River Development Company continued its planning of the Peace River project. Preliminary plans indicate that the project will consist in part of a main storage dam where hydro-electric facilities under a maximum operating head of 600 feet will provide a generating capacity of about 2,500,000 kw. A second dam and hydro-electric plant is expected to be developed downstream from the main dam.

Northwest Power Industries Limited maintained an active interest in the Yukon power project in Yukon Territory and in the Nass River project in northern B.C.

In the thermal field the Commission completed the installation of new tri-fuel combustion units at Dawson Creek, Prince George and Quesnel. The generators for each unit are rated at 3,000 kw. at .8 power factor. Other capacities brought into service last year include: three units totalling 1,100 kw. added at Port Hardy; one 800 kw. unit installed and one 100 kw. unit dismantled at Burns Lake; three units totalling 2,100 kw. added at Fort Nelson; five units totalling 385 kw. installed at Valemount.

B.C. Electric continued construction of the Burrard thermal station at Ioco, where the first 211,000 hp. turbine connected to a 150,000 kw. generator is expected to be available for commercial service early in 1962. A second similar unit will be added in 1963 and the third and fourth units are scheduled for installation in the period 1964 to 1966. Provision is being made for two additional units, with all six having an ultimate rated capacity of 900,000 kw.

ALBERTA

Alberta ranks fifth in installed hydro capacity, with a total of 414,-455 hp., and is third in thermal power, with an installed capacity of 626,695. At ordinary six months flow Alberta is seventh in recorded available hydro resources.

New hydro capacity totalling 102,-000 hp. was brought into service last year in Alberta. All this work was done by Calgary Power Limited. In addition, 88,000 kw. of new thermal capacity was brought into service.

Total development was reached in 1960 at Calgary Power's Spray and Rundle plants on the Bow River. Capacity of the Spray plant was doubled with the installation of one 62,000 hp. unit. One 40,000 hp. unit was installed in the Rundle plant to raise its total capacity to 63,000 hp.

On the Brazeau River, construction continued for the installation late in 1964 of a single 200,000 hp. at Big Bend, about 15 miles upstream from the confluence with the North Saskatchewan River.

In the thermal field the company began installation of a new steam turbine of 150,000 kw. capacity at its Wabamun plant. This unit is scheduled to go into service in the autumn of 1962 and will be the third installed in the plant. The two units currently in operation are each rated at 66,000 kw.

The City of Edmonton brought into operation a new steam turbine of 75,000 kw. at its municipally-owned thermal plant. This addition increased the plant's capacity to 255,000 kw.

The City of Lethbridge installed a new 10,000 kw. gas turbine to raise the total plant capacity to 33,375 in five units.

Canadian Sugar Factories raised the total generating capacity of its Taber plant to 3,675 kw. with the installation of a 1,675 kw. unit. Northland Utilities installed a new 3,000 kw. gas diesel unit in its Fairview plant.

SASKATCHEWAN

The Wheat Province ranks ninth in installed hydro capacity with a total of 132,135 hp., and is second in thermal power with an installed capacity of 645,590 hp. At ordinary six months flow, Saskatchewan is eighth in recorded available hydro resources.

During 1960, new hydro capacity added in Saskatchewan was limited to a single unit rated at 3,300 hp. installed by the Consolidated Mining and Smelting Company of Canada at its Wellington Lake plant on the Charlot River.

Developments now under construction will provide up to 586,000 hp. of new hydro power. The bulk of this increase will come from the South Saskatchewan River project.

Although the project is being developed by the Prairie Farm Rehabilitation Administration, and is primarily for irrigation purposes, hydro facilities will be incorporated by Saskatchewan at the main dam.

The Saskatchewan Power Corporation, on behalf of the province, plans an initial development of three turbines of about 60,000 hp. eaeh, with the possibility of extending the development to five units with an ultimate capacity of about 300,000 hp.

Construction continued on the corporation's development in the Tobin Rapids-Squaw Rapids reach of the Saskatchewan River. When completed, this project will comprise six units of 46,000 hp. each. Four units should be installed in 1963 and the remaining two in 1964.

The Corporation, which now depends entirely on thermal installations, doubled the capacity in 1960 of its Boundary Dam plant with the addition of a 66,000 kw. steam unit. It closed its 1,000 kw. Kamsack plant and its 510 kw. Hudson Bay Junction unit. The 2,250 kw. Weyburn plant also was closed following its purchase from the City of Weyburn. The Corporation purchased and assumed operation of the 37,500 kw. Moosejaw plant, formerly owned by the National Light and Power Company.

MANITOBA

Manitoba ranks fourth in installed hydro capacity with a total of 988,900 hp., and is sixth in thermal power with an installed capacity of 269,710 hp. In recorded available hydro resources, Manitoba stands fourth.

Manitoba Hydro-Electric Board's Kelsey Generating Station on the Nelson River went into initial operation in 1960 when five units of 42,000 hp. each were placed in service. Provision has been made for a sixth unit of the same rating when the increase in demand warrants its installation.

At Grand Rapids on the Saskatchewan River the Board started construction on an initial installation of 450,000 hp. in three units of 150,000 hp. Two units are scheduled for service late in 1964, and the third the following year.

By the end of 1960, construction was nearly complete at the Board's Selkirk Generating Station on the Red River near Selkirk. One 66,000 unit was placed in service in the summer of 1960, and the second was added this year.

Also under construction or in the planning stage are several major terminal stations.

In 1960, the Manitoba Power Commission also carried out an extensive terminal and substation construction program. New capacities totalling 38,500 kva. were added at terminal stations, and 86,450 kva. at substations.

Major increases were 30,000 kva. at Kirkfield Park substation, and 15,000 kva. at Brandon East terminal station. Other completed construction included 12,000 kva. at University of Manitoba, 10,000 kva. at Boissevain and 8,500 kva. at Pilot Point.

The City of Winnipeg scheduled completion of one 20,000 kva. substation for the end of 1960 and another 15,000 kva. station for this year.

The International Nickel Company of Canada Limited eompleted construction of a 160,000 kva. main substation at its Thompson plant. Construction continued on five additional substations in the nickel refining section. On completion, one substation rated at 36,680 kva. will supply power for the electrolytic process while the four remaining substations, with a total capacity of 12,000 kva., will be used for general power requirements.

ONTARIO

Ontario ranks second in hydro electric capacity with a total installed capacity of 7,814,562 hp., and is first in the thermal field with an installed capacity of 1,509,836 hp. In recorded available hydro resources at ordinary six months flow, Ontario is third.

The Hydro-Electric Power Commission of Ontario was the only power producer to add new electrical capacity in 1960, or to advance construction of new capacity.

Last year, only 26,500 hp. of new hydro capacity was brought into service. This was at Red Rock Falls on the Mississagi River. A second unit of the same size was put into operation this year.

At Otter Rapids on the Abitibi River, rapid progress was made for an initial installation of four 60,000 hp. units. Provided for is an ultimate installation of eight 60,000 hp. units. Two units are scheduled for operation late this year, and two others in 1963.

Three plants are to be located on the Mattagami River on a 12-mile reach in the general location of the existing Smoky Falls hydro station. While engineering design for these stations is only in the preliminary stage, construction has begun at the Little Long plant where two of four 84,000 hp. units are tentatively scheduled for service in 1963. The Harmon and Kipling plants are expected to begin service in 1965 and 1966 respectively, and initially will comprise three units of 63,000 hp. Ultimate installation is expected to provide a total turbine capacity of 378,000 hp. in six units at the Harmon plant and 441,000 hp. in seven units at Kipling.

The Commission, banking heavily on thermal capacity for future needs, added two 200,000 kw. steam turbines at the Richard L. Hearn Generating Station. With the placing in service of the final 200,000 kw. unit this year the plant's capacity of 1,200,000 kw. in eight units will have been realized.

At the Lakeview Generating Station, the first 300,000 kw. steam turbine unit was scheduled for operation this year and similar units are to be placed in service in the three succeeding years. The site is planned to permit an eventual installed capacity of 1,800,000 kw.

Nuclear power developments are outlined later in this report.

QUEBEC

Quebec, Canada's power giant, is first in both installed hydro capacity with a total of 12,440,145 hp. and in recorded hydro resources. Her proved resources of 23,705,709 hp. is more than one third of Canada's total. Quebec ranks eighth in thermal power with an installed capacity of 111,200 hp., exceeding only Newfoundland, Prince Edward Island and the Northwest Territories.

A total of 1,176,500 hp. of new water power was added in Quebec last year, surpassing the combined total of all other provinces. Only 76,000 hp. of new capacity is expected to be added in 1961. Projects under construction or in active prospect are expected to provide an additional 6,700,000 hp. in later years.

At Quebec Hydro-Electric Commission's Bersimis II plant on the Bersimis River ultimate development was reached with the installation of two 171,000 hp. units, bringing the total capacity to 855,000 hp. in five units.

The third and final phase of the Commission's Beauharnois development on the St. Lawrence River was brought nearer completion with the addition of five 73,700 hp. units. A 10th unit was in operation this year and plans are being made for an 11th and final unit. Installation of this unit will bring the total installed capacity of the entire Beauharnois development to 2,234,700 hp. in 39 units.

At Carillon on the Ottawa River, construction was continued for the installation of 840,000 in 14 units. Operation of the first unit is planned for the autumn of 1962.

During the summer of 1960 the Commission announced plans for a project involving the harnessing of the headwaters of the Manicouagan and Outardes Rivers to provide nearly 6,000,000 hp. of new capacity at new and existing developments.

Early in 1960 the last two of five 200,000 hp. units were brought into operation at the Aluminum Company of Canada's project at Chute des Passes on the Peribonka River. Work was completed on the Bonnard River-Lake Manouan diversion, permitting the stored waters of Lake Manouan to be diverted into the Bonnard River, a tributary of the Peribonka above Passe Dangereuse.

On the Hart Jaune River, Quebec Cartier Mining Company completed construction on the installation of three 22,000 hp. units. The powerhouse, located 27 miles upstream from Big Manicouagan Lake, will operate by remote control.

The Office de l'Electrification Rurale started construction of a plant designed to house two 1,500 hp. units on the Magpie River near Magpie Village.

Water power investigation were continued by the Quebec Department of Hydraulic Resources in the following areas: Eastmain, Fort George, Great Whale and Nastapoca Rivers in the Hudson Bay watershed, on the Kaniapiskau, Whale and George Rivers in the Ungava Bay watershed, on the Chamouchouane, Mistassini and Mistassibi Rivers in the Lake St. John watershed, and the Mosie, Marguerite, Portneuf, Sault-au-Mouton and Escoumains river on the north shore of the lower St. Lawrence River.

In the thermal field, the Commission last year completed the installation of a 36,000 kw. gas turbine plant near the Gaspe village of Les Boules. The plant, which contains six 6,000 kw. units, will serve as a stand-by station in the event of breakdowns or failures in the submarine cable now supplying power to the Gaspe and lower St. Lawrence south shore regions.

The Commission is also building a substation in Montreal to replace the existing 41-year-old substation. It will contain six 48,000 kva. power transformers and 18 10,000 kva. power transformers as well as associated switching equipment.

NEW BRUNSWICK

With the exception of Newfoundland, the Maritimes generally are power poor. In installed hydro capacity, New Brunswick ranks seventh with a total of 354,258 hp., and is also seventh in thermal capacity with installations totalling 195,217 hp. In recorded available hydro resources, New Brunswick is 10th.

No new hydro capacity was brought into operation in New Brunswick last year and construction now in progress will add only 600 kw. of new capacity this year. This capacity, being built for Bernard Hargrove on the Monquart River near Bath, will consist of two units operating under a maximum head of 80 feet.

In the thermal field, the New Brunswick Electric Power Commission continued construction of a new steam plant at East St. John where the initial 50,000 kw. unit was to be added this year. The ultimate installation at this plant will be 250,000 kw.

NOVA SCOTIA

Nova Scotia ranks eighth in installed hydro capacity with a total of 184,538 hp., and is fifth in the thermal field with installed capacity totalling 383,940 hp. Ranking behind neighbouring New Brunswick, Nova Scotia stands 11th in recorded available hydro resources.

The Nova Scotia Power Commission continued construction of two new hydro developments on the Sissiboo River. The Weymouth Falls development will consist of a 12,000 hp. turbine driving a 9,000 kw. generator. The Sissiboo Falls development will have a single 8,000 hp. turbine connected to a 6,000 kw. generator. Unforeseen construction difficulties retarded the scheduled completion dates of these projects until this year.

In active prospect for the Commission is a third development on the Sissiboo River at Riverdale and another at Wreck Cove Brook at Wreck Cove with proposed capacities of about 10,800 hp. and 90,000 hp. respectively.

Two years ago the Nova Scotia Light and Power Company Limited began construction of a new hydro development at Lequille on the Lequille River. Completion date of the development, which will consist of a 7,500 hp. turbine connected to a 6,800 kw. generator, was retarded from 1961 until 1963 as a result of the interconnection between power systems. This interconnection temporarily set back the need for this development.

Expected to be finished in 1964 for the Company is a development on the Nictaux River at Alpina which will consist of a 6,500 hp. turbine and a 5,000 kw. generator.

In the thermal field, the Commission added a new 20,000 kw. unit at its Trenton steam plant. This increased installed capacity at the plant to 60,000 kw. in four units.

PRINCE EDWARD ISLAND

Prince Edward Island is in the most unenviable position of all the provinces regarding hydro electric power. It ranks last in installed capacity, with a total of 1,660 hp., and also stands at the bottom in recorded available hydro resources. Prince Edward Island has a total installed thermal capacity of 35,381 hp., to stand higher only than the Northwest Territories.

The Maritime Electric Company added a 10,000 kw. unit in December at its Charlottetown steam plant. The Company completed the construction of 22 miles of 34.5 kv. line between Summerside and Mount Pleasant and 20 miles of similar line from Elliotvale to Dingwell Mills. Rural distribution lines totalling 204.8 miles were constructed during the year, raising to 13,560 the number of farms being provided electrical service in the province.

NEWFOUNDLAND

Newfoundland ranks sixth in hydro power with a total installed capacity of 384,025 hp. and is ninth in the thermal field with capacity totalling 67,312 hp. Newfoundland is sixth also in recorded available hydro resources.

Both in Newfoundland and in Labrador last year there was significant progress in the construction of new electrical capacity. In these areas a net total of 13,100 hp. of new hydro capacity was brought into operation while an additional 710,500 hp. is planned or under construction for later years.

At Heart's Content on the Heart's Content River the United Towns Electric Company installed a single 3,200 hp. unit to replace two smaller units totalling 2,100 hp. in capacity which were dismantled.

The Iron Ore Company of Canada doubled the capacity of its plant at Menihek Rapids on the Ashuanipi River by adding one 12,000 hp. unit.

Southern Newfoundland Power and Development Limited is considering construction of a development with a total capacity of up to 350,000 hp. on the Salmon River at the head of Bay d'Espoir. Initial installation is expected to consist of two 38,500 units.

At Twin Falls on the Unknown River, construction proceeded for the installation in mid 1962 of two 60,000 hp. units as part of an ultimate development of 350,000 hp. for the Hamilton Falls Power Corporation Limited. This development is located on a tributary of the Hamilton River and is one of three subsidiary projects which may be built prior to construction of the main features included in the plan for Hamilton River development.

Bowater Power Company Limited proposes to install at Hinds Brook a 54,000 hp. development operating under a head of about 683 feet.

In the thermal field, Tilt Cove Power Corporation Limited completed the addition of a 5,000 kw. unit to increase to 9,600 kw. the total installed capacity of its Tilt Cove steam plant. A new steam plant containing two 2,100 kw. units is to be finished this year at Little Bay for the Atlantic Coast Copper Company Limited.

The Newfoundland Power Commission completed the construction last year of two small diesel plants, one with a generating capacity of 200 kw. in one unit at Happy Valley in Labrador and the other with a total capacity of 90 kw. in three units at Trepassy.

YUKON AND NORTHWEST TERRITORIES

The Territories rank 10th in hydro power with a total combined installed capacity of 60,440 hp. The Northwest Territory is last in the thermal field with an installed capacity of 10,669. In recorded available hydro resources, the Yukon is fifth and the Northwest Territory is ninth.

The only addition to hydro capacity was at Snare Falls, Snare River, N.W.T., where the Northern Canada Power Commission installed a single 9,200 hp. unit. The development can be extended, when required, to include a second similar unit.

At Frobisher Bay, the 1,000 kw. diesel plant which is operated by the Commission under lease from the Department of Transport, was extended by the Commission to include two other units totalling approximately 2,000 kw. Capacities of diesel plants at Inuvik and Fort Smith also were increased by the addition of single 1,000 kw. units at each location. At Fort Smith, two units totalling 250 kw. were removed from service following completion of the new 1,000 kw. unit.

At Fort Simpson, a 300 kw. unit was installed, replacing a smaller unit of 75 kw. The surplus units removed from Fort Simpson and Fort Smith have been transferred to Fort Resolution. At Fort McPherson, installation of a 150 kw. diesel unit has been completed.

The power requirements of Norman Wells now are being met by a small diesel plant which is owned by the Imperial Oil Company of Canada and designed mainly to supply the company's local refinery. As this plant is not adequate to supply the increasing power demand, the Commission is investigating the possibility of constructing a new diesel plant which will supply the total requirements for the area.

NUCLEAR POWER

Five years ago work began on the Nuclear Power Demonstration Project (NPD) on the Ottawa River near the Des Joachims Generating Station. Design changes forced a 10-month delay from early 1957 until August, 1958. The station, containing one 20,000 kw. unit, is being built by the Hydro-Electric Power Commission of Ontario in conjunction with Atomic Energy of Canada Limited and the Canadian General Electric Company Limited.

By the end of 1960, construction on the powerhouse and administration wing had been completed and work was proceeding on the installation of the turbine and generator and auxiliary equipment.

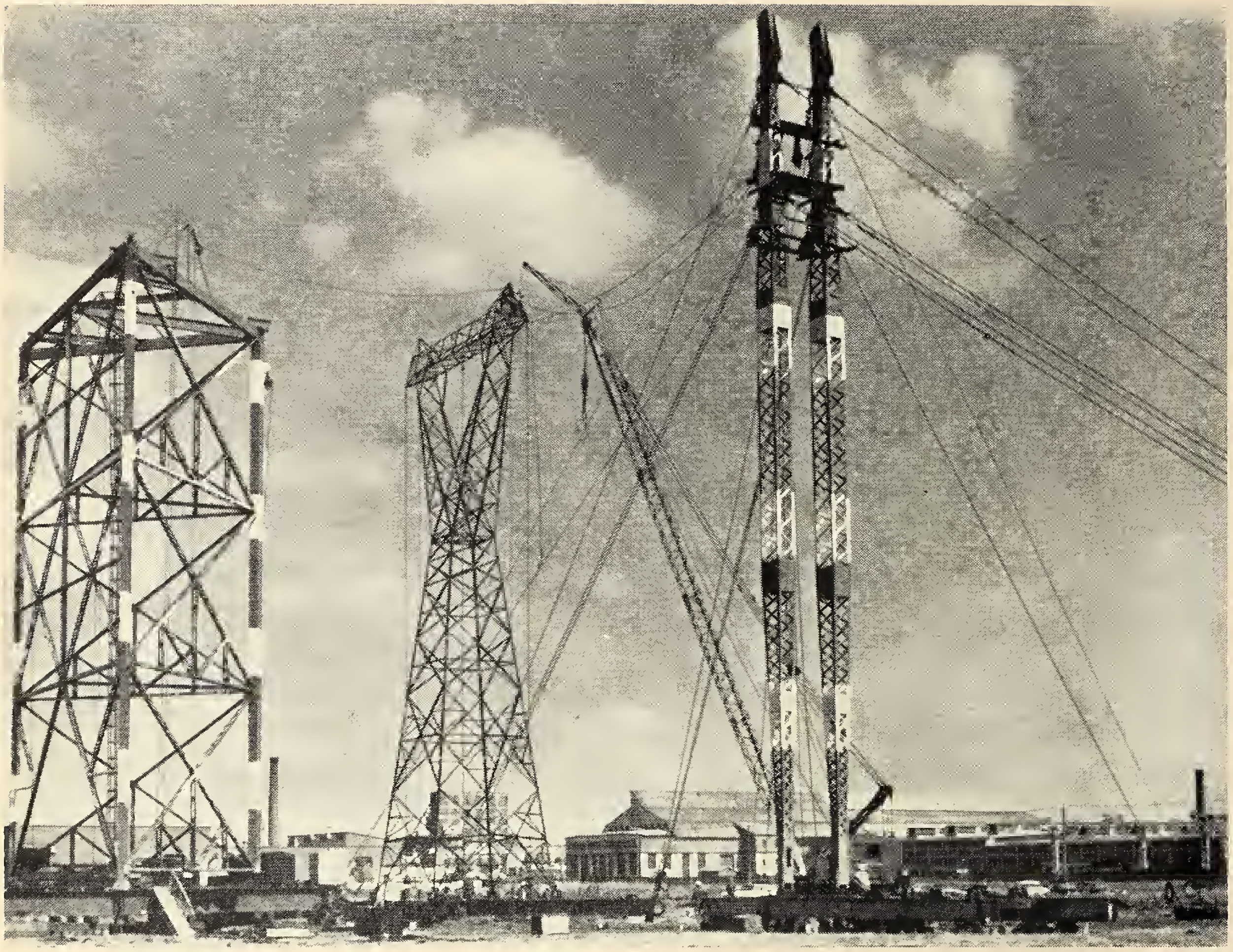
The reactor is expected to be critical late this year and full power operation is expected in the early summer of 1962.

Many of the technical aspects of the design will be demonstrated by this plant which also will be a test-bed for fuel performance of the full-scale reactors. It is too small to produce power on an economic basis and, since it is an engineering venture into a field requiring a very large amount of development effort, its capital cost is high.

In 1958 the Commission entered into an agreement with Atomic Energy of Canada Limited to participate in the development of a full-scale, uranium-fuelled heavy-water-moderated, nuclear-electric generating station. Under the agreement the Commission is supplying engineering, accounting, supply, research and construction services to complement the AECL organization. As part of the same agreement the Commission undertook to provide the site, to build a transmission line connecting the station with the southern Ontario network, to operate the station during the trial period, and, when its operating characteristices have proved suitable, to purchase the station at a price which will enable the energy output to be competitive in cost with that of a modern coal-fired station.

A 2,300 acre site was purchased in 1959 at Douglas Point on the shore of Lake Huron between Kincardine and Port Elgin. Last year work was begun on the site with the contruction of an access road, the erection of construction buildings and equipment, and the excavation of beach shingle for the powerhouse itself. The station, which will have a capacity of 200,000 kw., is expected to be in service late in 1964 or early in 1965.

Both the NPD and the Douglas Point plants use similar reactor concepts, except for size, and they are characterized as heavy water moderated and cooled, horizontal pressure tube reactors. This system is a Canadian development by Canadian engineers and scientists.



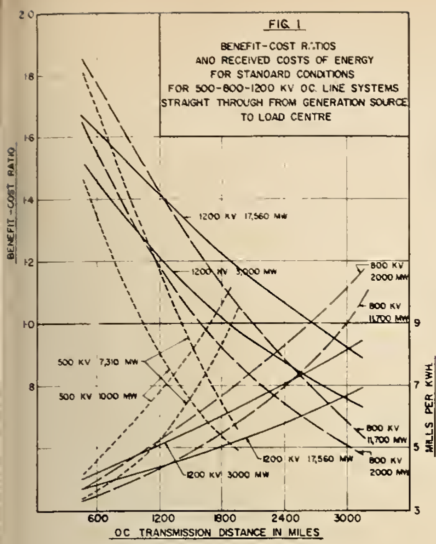
Extra Long Distance Direct Current Transmission and System Interconnection

CONCEPTS and ECONOMICS

H. L. Briggs, M.E.I.C.,
Member, National Energy Board

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

CERTAIN FUNDAMENTAL principles should guide a large modern electric utility which enjoys exclusive power distribution to the homes, commerce and industry within its service area. Perhaps the most



basic of these principles might be stated as follows:

1. To provide electric power in sufficient quantity to meet the sustained needs of the community at the time those needs arise;

2. To provide dependable electric power of a quality sufficient to meet present requirements and with flexibility adequate to cope with the changing character of the loads being served;

3. To provide electric power at the lowest reasonable price without sacrificing the principles already stated, this implying among other things an unrelenting effort to reduce costs.

While the long distance power transmission study being presented here is in substantial conformity with the first two principles, it is the third principle with which we are now to be chiefly concerned, namely the continuing effort to reduce the cost of electric power to the Canadian user.

Large potential sources of hydro power

The interest in extra long distance low cost transmission stems from the large capacity hydro sites in Northern Canada which are remote from present large power loads. A number of such sites are listed below. Some of these will never be used by present heavy power consuming areas unless made available to such areas by direct current transmission; using present AC transmission methods some of the closer sites will undoubtedly be used, but possibly at higher costs than if DC transmission were available.

Some considerations favoring DC

In the transmission of large blocks of electric power over distances of many hundreds of miles, for various technical reasons more economic use

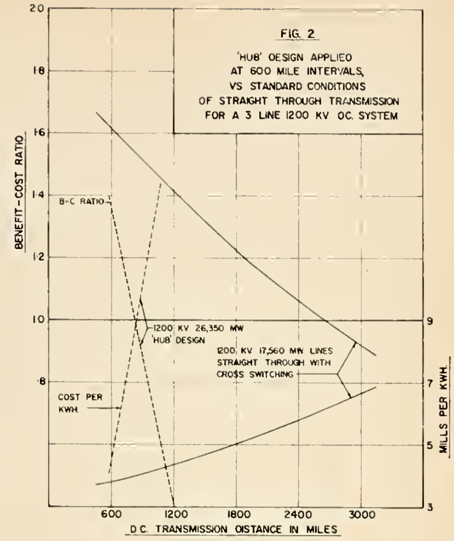


TABLE I

Case	*Power source*	*Possible load area*	*Order of transmission line length in miles*
1	Hamilton River, Labrador	Southern Ontario	1,000
2	Koksoak River, N. Que.	Montreal area	800
3	Lower Nelson River	Southern Manitoba	500
4	Lower Churchill River	Southern Manitoba	550
5	Peace River	Southwestern BC	550
6	Peace River	Southern Manitoba	1,200
7	Peace River	Southern Ontario	2,240
8	Nass River	Southwestern BC	600
9	Stikine River	Southwestern BC	800
10	Yukon River	Southwestern BC	1,300
11	Yukon River	Southern Alberta	1,300

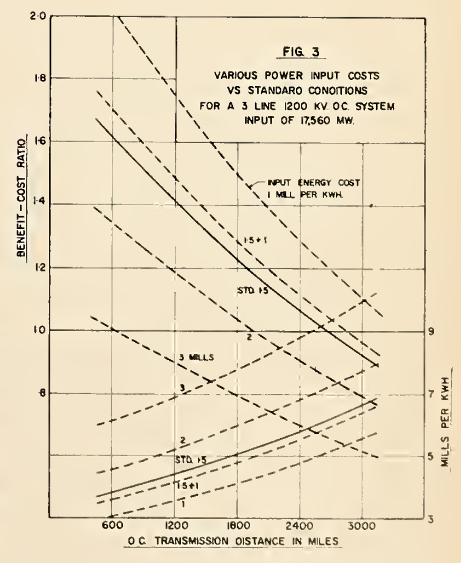
of the line insulation and of the conductivity of the wires may be achieved by the use of DC instead of AC. Electrical engineers who have designed and estimated such DC systems have, for example, stated that the distance beyond which it is more economical to transmit by DC overhead lines rather than by AC lines, is 500 to 800 miles. Russian engineers[1] now appear to lean towards decreasing the changeover distance above which the use of DC is favored.

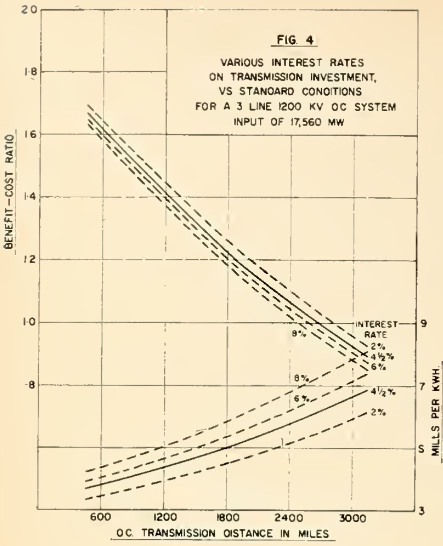
It is not proposed to discuss the distance beyond which DC should be selected. It is understood that for distances of the order of 1500 to 1800 miles, the unit costs of AC transmission are perhaps double those which result from the use of DC. It is proposed to examine DC transmission, its costs and possible application in relation to Canadian conditions and with particular reference to the distances which may be involved here, namely, up to 3000 miles. The least distance dealt with in this study is 600 miles. Attention has not been given to DC cables insulated for full line voltage, of interest for the transmission of large blocks of power for distances as short as 15 miles, under water or underground through congested urban areas.

Equipment use and comparisons

In modern practice, the generation of large quantities of electric power is performed in alternating current machines. This will no doubt continue to be the case, even though the output is intended for direct current transmission.

On this continent, the installed capital cost of a large AC power transformer is $2 to $5 per kva transformed. The annual maintenance cost for such a transformer is extremely low, efficiency of power transformation is high, and the economic life of the equipment is long, say 30 to 50 years. On the other hand, the capital cost of one stage of voltage transformation and rectification, in





order to convert low voltage AC power into high voltage DC, is relatively high (say $20 to $40 per kw. transformed), and the cost of one stage of inversion (DC to AC) is of the same order. Furthermore, provision is required for a source of reactive kva., if these are not otherwise available, at each transformation point and in comparable quantity to the kilowatts to be converted. The maintenance expense on such conversion equipment is relatively high. The economic life is much shorter than that of an AC power transformer.

EHV DC Transmission circuitry

This study should not be interpreted as a line design exercise. It is instead a broad approach by means of engineering economics to the problems of power supply which will be faced by some Canadian utilities within the next 10 or 15 years. If DC transmission line designs are to be produced, the designer himself must apply the most appropriate engineering principles carefully guided in his decisions by adequate economic studies.

The new flexible guyed tower designs developed by Canadian and European engineers give an entirely new complexion to transmission tower assembly and erection methods, and to capital costs per mile of line. In difficult terrain the tower, completely assembled, may be moved into place by helicopter. Furthermore, in such areas a substantial reduction in cable stringing cost now appears practicable by unreeling conductor directly from a helicopter. Such new concepts in line construction are significant because of the cost reductions implied.

This study reflects the economies resulting from use of flexible tower designs.

Circuit reliability

For the transmission of dependable or firm power, a long distance single circuit line has a reliability of zero.

The author is not prepared to concede that there is any significant degree of reliability to be accorded to a high voltage single circuit DC line which may under some circumstances remain in partial operation with one side conductor out of service. The likelihood of both conductors being involved by the cause of the trouble is too great.

Two 1500 mile parallel lines would have no reliability if each is continuous from end to end, that is, without cross-switching stations.

Two long separate single circuits, cross-switched as in accepted AC practice, are considered to have a degree of commercial dependability related to several matters including the number of line switching stations and the distance between them. These matters are in turn related to the basic criteria established for the transmission system, a problem of security policy, economics and probabilities.

Acceptable reliability

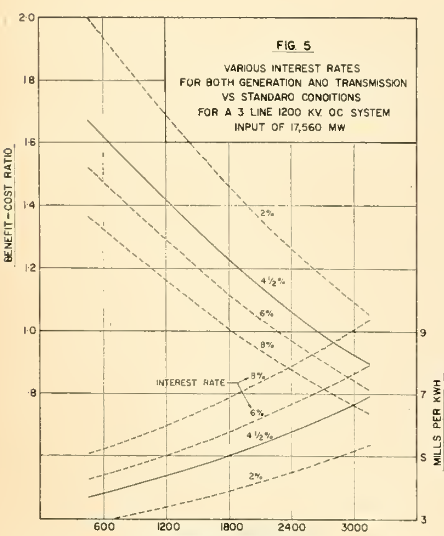
For estimating the transmission of dependable power, this study assumes that the design of the transmission system has been by fully knowledgeable transmission engineers, and that routine and special line maintenance is so well performed that only one of each 15 sections need be considered as not available for service at any one time. A two-circuit cross-switched transmission system is looked upon as the interim development of a three-circuit system. A three-circuit parallel system, well designed for security and cross-switched at proper intervals, has a high degree of commercial dependability, and will give closely the ultimate of economy in the unit costs of transmission. This development of parallel DC transmission circuits has not been proposed by others as far as is known, no doubt because of the present lack of DC switchgear, and because suitable controls to permit the parallel operation of conversion equipments and lines have not as yet been devised.

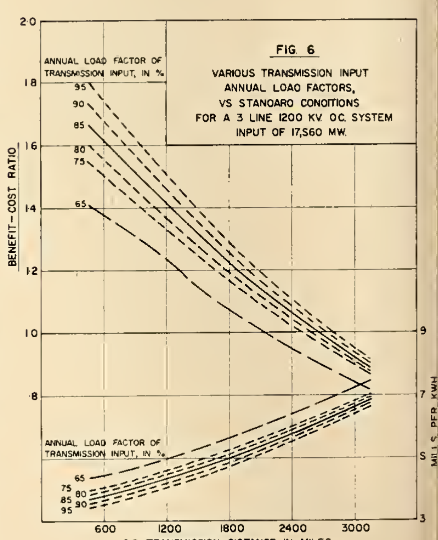
Special design precautions

By reason of the tremendous quantities of power which would flow over each individual circuit of the proposed transmission systems, many special precautions must be taken. The three circuits must fan in and fan out of each cross-switching station. The long cross-country runs must parallel each other with separations of say 25 miles wherever possible. There must be the least possible risk of multiple circuit involvement by such hazards as simultaneous lightning strokes, tornado damage, excessive icing of out-of-service or neutral conductors used as skywires, local whirlwinds carrying green hay or branches along the conductors until they accumulate at insulator strings, bush fires damaging conductors or towers, smudge or muskeg fires smoking up insulator strings, malicious damage by persons, damage by aircraft and the many other possibilities which can occur with such widespread exposure of these circuits through both uninhabited and thickly settled sections of the country.

Conductor loadings

When considering the whole of a DC conversion-transmission system, the most economic loadings, that is, those loadings giving the lowest unit





transmission costs, tend to approach those loadings which represent the thermal limit of transmission as imposed by conductor temperature. This is not entirely the case however.

A transmission system designed to permit the removal of individual line sections either under fault conditions or for maintenance purposes must of course continue to carry its full power throughput on two circuits in a three-circuit system. It is this sectional pair of circuits which, being loaded to 150% of normal, establishes the thermal limit to the throughput of dependable power. It would appear to be the case that for relatively short line systems (under 1000 miles) the most economic loading is near the thermal limit of these conductors, for still longer line systems, the most economic loadings decrease by varying percentage amounts. Accordingly, it became desirable to express these sectional emergency loadings as a percentage of conductor ampacity at the thermal limit.

Likewise, it became desirable to establish carefully and on a monthly basis the maximum ambient temperatures such as are available across Canada, and to establish the conductor ampacity for each ambient. The approaches to the conductor temperature problem have been those proposed by Earl Hazan.[2]

Diversity and related gains

Prior to considering the effect of area diversity gains which may become available through long distance interconnections across Canada, let us examine the circumstances which justify the bulk transmission of power to any area load centre. In order to justify such transmission, with some exception each kwh on the average must end up at the area load centre at a lower cost than would be available from other bulk sources of supply, including local generation. If a local steam turbine plant could have produced the energy for six mills per kwh., then the energy transmitted from remote sources will certainly have to be made available at six mills or less. If generation at the remote source costs two mills, then transmission costs, whether these result from transporting the energy 100 or 3000 miles, cannot exceed four mills and retain any hope of being selected.

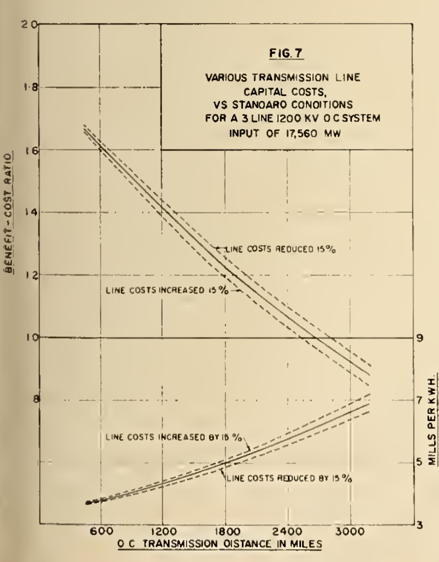


FIG. 7
VARIOUS TRANSMISSION LINE CAPITAL COSTS, VS STANDARD CONDITIONS FOR A 3 LINE 1200 KV D.C. SYSTEM INPUT OF 17,560 MW

Economic studies demonstrate that if no subsidy is intended, power loads transmitted over long distances must be transmitted more or less continuously. If they are transmitted over extra long distances, they must be transmitted continuously, otherwise excessive cost will be borne by each kwh. A corollary statement is that long distance transmission facilities (i.e. over several hundred miles in length) will not pay off when used only for occasional, intermittent, or variable low load factor power transfers. Therefore as transmission distance increases, maximum loads must be carried continuously, and as the distance further increases only continuous high value (e.g. firm power) loads are able to make the line pay off.

When one accepts the fact that a heavy flow of high value power with a relatively continuous (24 hour 365 day) loading schedule is a necessary condition for economic justification of an extra long distance transmission system, and that this must be continued throughout the entire line investment writeoff life, then many incidental and relatively transient possible benefits which some have claimed to accrue to a cross-country long distance power transmission backbone, are recognized to be impractical. The transient benefits referred to include standby service between regions (if subject to frequent call), stepped generation extension programs, economy energy displacements and the like. On the other hand, generation standby service such as is called upon but very few hours per annum, or the gain which can be achieved from load diversity when the diversity transfer kilowatts are less than perhaps 25% of the main power throughput may be advantageous under some circumstances. A restatement in somewhat different terms is that since generation standby service and diversity gain are sometimes premium services, as such they can perhaps be incorporated advantageously when scheduling the loadings of an extra long distance transmission system.

The essentiality of ensuring continuous loads for long distance lines

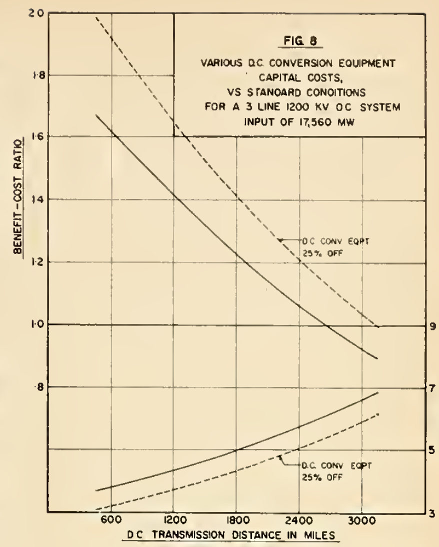


FIG. 8
VARIOUS D.C. CONVERSION EQUIPMENT CAPITAL COSTS, VS STANDARD CONDITIONS FOR A 3 LINE 1200 KV D.C. SYSTEM INPUT OF 17,560 MW

is so fundamental that a still different approach to it will be put forward. In the following, the connotation 'high unit value' refers to power at the load end which has a value equal to or higher than that of firm power; the connotation 'low unit value' refers to power at the load end which has a value less than that of firm power.

First, let us consider the case of a relatively short tie line interconnecting two adjacent electrical utilities. Such a tie line can have two valuable attributes:

(1) a high benefit-cost ratio — perhaps 3, 5 or 10.

(2) a power transfer capacity much larger than will normally be used, but always available if it can be utilized for fluctuating and intermittent service. This excess carrying capacity will permit both parties to pick up all the major (i.e. the high unit value) benefits of interconnection, and additionally, the incidental (i.e. the low unit value) benefits. Thus in general, and assuming a mutually co-operative attitude by both utilities, the relatively short tie line is able to pick up all the significant benefits.

Secondly, when one examines longer and still longer transmission systems it becomes evident that with a constant power input, the output of both firm and secondary power which results at the receiver end decreases with distance. At the same time, the increase of annual cost with increase of distance raises the transmission cost which must be assigned to each kwh. In general terms, the benefit-cost ratio decreases rapidly as distance increases. As this ratio decreases to approach the value of 1.00, special efforts along the following lines will be required if the project is to remain economically sound:

(1) to secure the minimal cost

of energy supplied to the input end of the transmission system;

(2) to secure the highest possible annual load factor, continued year after year for the full writeoff period of the investment;

(3) to ensure as far as possible the exclusive transmission of power with the highest value at the receiver load centre, meaning firm energy or better, which may or may not include diversity or standby generation capacity infrequently called upon;

(4) the circumstances call for the rigorous exclusion of:

—'if, as and when' use of these high cost transmission facilities,
—low value uses,
—low marginal uses,
—intermittent uses in respect of time,
—partial use in respect of distance.

(5) a highly reluctant attitude will be taken to the investment of the millions of dollars required for each intermediate station connection to the DC system, if proposed for the purpose of picking up relatively small power inputs, relatively small loads, or minor diversity gains.

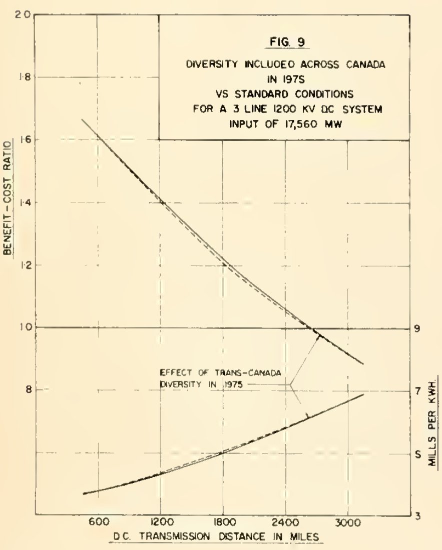
Attitude to problem

Unless the reader gains an appreciation of the attitude of the author to the problem, he may perhaps be inclined to scorn the scale of the operations which are to be considered.

In the first place, it is assumed that the many technical and developmental problems relating to DC transmission and which are later enumerated, can with adequate attention be overcome.

In the second place, it is fully intended to look carefully at the ultimate scale of DC transmission as a problem in electrical performance but perhaps even more so as a problem in deriving in good measure the ultimate costs and benefits which may be within grasp. If these ultimate benefits are insufficient to warrant the further study of this form of power transmission, it should be forgotten. If on the other hand they hold promise of being sufficiently substantial to warrant the effort and expense required to gain them, the course of action which should be taken becomes quite clear.

A further point is that if the ultimate possibilities of a proposal are known, then any interim or partial installation which may later be extended to encompass the ultimate benefits, may at the outset be compared with and judged by the ultimate benefit possible.



Approach to problem

The approach to this cost study was to compute for each case, each line station and each voltage the electrical characteristics between the main low voltage AC bus at the power source and the main high voltage AC bus at the load centre; to estimate the capital costs involved in such conversions and transmissions; to estimate the fixed and operational costs involved in such conversions and transmissions; to include the acquirement cost of power at the load source; to tailor the power received at the load centre to the firm load curve of the load centre; to include the values of any diversity gains throughout the length of the line where applicable; to credit excess or secondary energy taken out at the receiver load centre at its replacement value; thereby to end up at the receiver load centre with the annual cost of each quantity of firm power and energy such as would fit the load curve of the firm power demand.

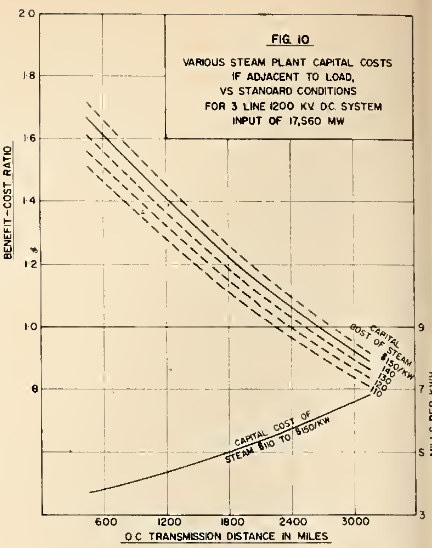
The next part of the study had to do with the computation of power costs such as otherwise would apply to local generation at the receiver load centre, by an alternative source producing power in the same quantity, under the same load conditions and delivered to the same high voltage AC bus.

Benefit-cost ratio, as the term is herein used, is the ratio of the total annual cost of the local alternative power source to the total annual cost of power as transmitted from the remote source, in the same numerical quantities, both being in terms of firm power and energy fitted to the annual firm load curve applicable to the area load centre.

Assumptions, conditions and definitions

The basic assumptions of these engineering and economic analyses, other conditions and definitions, are:

(1) the technical problems enumerated in appendix "A" hereto will be solved;



(2) 1960 price levels for materials and equipment were assumed;

(3) development costs for new DC equipments have not been included and are presumed to be offset by unit cost reductions below present prices as a result of the large quantities which would require manufacture;

(4) various economic lives and various maintenance rates for various components are assumed, commensurate with present information;

(5) transmission line designs and conductor fittings will be improved to the point of avoiding significant power losses from corona;

(6) power losses in conversion equipments, transformers and transmission circuits are fully accounted for;

(7) the cost of the power input at the transmitting end has been included;

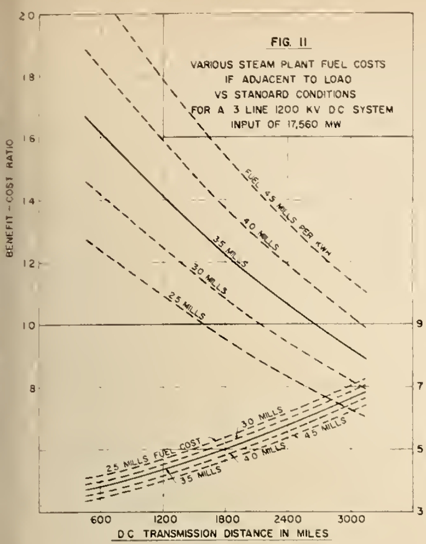
(8) interconnection benefits, to the extent these are estimated to exist, have been included where so stated;

(9) except as otherwise noted, money is valued at 4.5% per annum; level debt service for the economic life of the equipment is provided; no profit above interest and no corporation income taxes are included on the expense side;

(10) credit is allowed for secondary (excess above firm) energy available at the receiver end of the system at its thermal replacement value;

(11) the costs of transmitted power, as reported in the accompanying figures, relate to firm power on the high voltage AC bus at the area load centre at the receiver end of the transmission system;

(12) a benefit-cost ratio is the ratio of the annual cost of the most economical alternative, to the annual



cost of the proposal under consideration;

(13) the 'alternative' cost is assumed to be the cost of power from high efficiency very large steam turbine generating units under circumstances such as those which apply in Southern Ontario, where coal fuel costs as received have been taken at 32 cents per million btu. Atomic fission energy costs are as noted; for these, a range of costs has been assumed with plant capital ranging between $400 and $300 per kilowatt of capacity, and with nuclear fuel ranging between 1.1 mills and 0.7 mills per kwh. The possible reduction in secondary energy credits allowable as a result of a combination of coal and nuclear generation, has not been computed in this series;

(14) the bulk of the study has been conducted on the basis of a maximum of 50°C rise in the transmission conductors employed. However, the study proceeds later to incorporate the ambients which are available across Canada in association with line loadings such as will result in a maximum transmission conductor temperature of 75°C;

(15) no inclusion has been made for any financial loss which might occur during the early years of operation prior to full build-up of transmission system loadings which in an economic sense are most desirable;

(16) conductor bundles of all two-circuit lines consist of 4-795,000 c.m. ACSR bare cables; conductor bundles of all three-circuit lines consist of 6-1,192,500 c.m. ACSR bare cables. Each line of the two-circuit system is provided with two neutral skywires of 795,000 c.m. ACSR, and each line of the three-circuit system is provided with two neutral skywires of 1,192,500 c.m. ACSR. The conductor size for the two-circuit system has been selected in the possibility of it providing, perhaps with expanded conductors, a corona-free system; the size for the three-circuit system because smaller conductor sizes gave higher unit transmission costs, and larger sizes and bundles seemed to the author to be verging on impracticability of design and of electric loadings.

Circumstances and variations examined

The theme 'system' around which this study is oriented has its performance shown in Fig. 1, entitled "Benefit-cost ratios and received costs of energy for 'standard' conditions for 500-800-1200 kv. DC lines straight through from generation source to load centre". The curves originating at the upper left are the benefit-cost ratio curves, those originating at the lower left indicate the delivered cost of energy at the load centre.

Two of the 500 kv. curves relate to the most economical throughput of the three-circuit transmission system, namely, 7,310,000 kw., while the other two 500 kv. curves apply to an interim or initial two-circuit system, transmitting only one million kw. Thus for a 600 mile two-circuit 500 kv. system transmitting 1000 Mw. the benefit-cost ratio is 1.34, the delivered cost of energy is 4.6 mills. The curves for each of the two other voltages are on a similar basis, on the one hand they show the results from transmission of closely the most economical load for a three-circuit system, and on the other hand the results of a lesser initial load for an interim two-circuit system.

The 17,560 Mw. 1200 kv. benefit-cost curve and the per kwh. cost curve shown in this Fig. 1 are reproduced in many of the succeeding figures as standards of comparison.

The component assumptions used to derive these standard curves include:

A 1.5 mill price for AC energy fed into the system at the generation source;

Allowance of an extra 5% of the total value of the power input as a suitable margin of spare generation capacity to ensure a fully dependable input;

A 10% installed capacity margin for all DC conversion and power factor correction equipments;

An 85% annual load factor for the transmission system, based upon maximum power throughput;

A 65% annual load factor for the firm power output;

Firm power output has been computed with not less than one line section out of service for each 15 line sections in use;

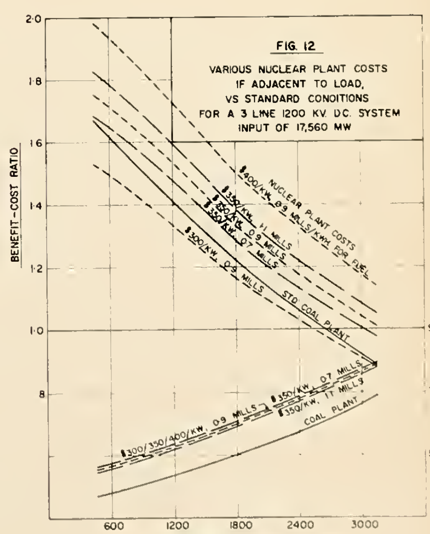
Secondary energy surplus at the receiver end has been credited at 3.5 mills per kwh.;

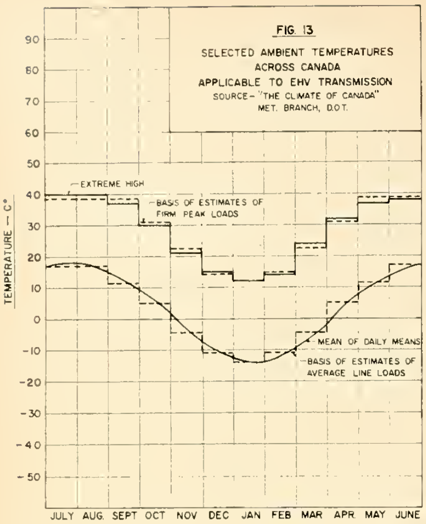
The alternative source power considered to have been avoided is a coal fired source. with an investment of $140 per kw. at the 230 kv. bus, fixed charges (including 10% spare capacity) of $14.99 per kilowatt per annum, and energy charges of 3.5 mills per kwh.

Fig. 2 "Hub design applied at 600 mile intervals, versus standard conditions of 'straight through' from generating source to load centre", has been included to show the economic effects of the hub system in the matter of transmission costs. By the hub system is meant the reconversion of all the power to AC at each hub point, where it is tied in with the regional AC lines, then the through power is rectified again for DC transmission to the next hub point. Conversion costs are much too great to make this plan a serious consideration.

Fig. 3 shows the economic effects of several different costs of power input when this component of cost is varied from the selected 'standard' of 1.5 mills per kwh. The curves show clearly that very long distance transmission, to be economic, must have a very low cost of input power. For all except the shorter distances, steam plant input is ruled out, it costs too much.

Fig. 4 shows the importance which attaches to the cost of money, that is, the interest rate. Note that this series of curves assumes a constant power input cost at the 'standard' basis of 1.5 mills per kwh. The interest rate variation is applied to conversion and tranmission costs. In addition, it is applied to the investment in the alternative power source at the receiver end, which inclusion has substantially affected the resulting benefit-cost





ratio curves by reducing the impact of the interest variation.

In Fig. 5 it is assumed that the 1.5 mill cost of input power would apply only to an 85% load factor input and to an interest rate of 4½%. This relationship is now disturbed, and power input costs are now varied so that these, too, change in proper relation to the interest rate. The cost changes in relation to the interest rate upon the investment in conversion, transmission and alternative power source equipments are included exactly as in the Fig. 4 data. Very obviously, high interest rates have the effect of reducing, and low interest rates the effect of extending, the economic transmission distance.

Fig. 6 shows the economic effects of increasing and decreasing the annual load factor at which the transmission system operates.

Fig. 7 shows the economic effects of varying transmission line construction costs either above or below the line costs which were estimated to apply in the 'standard' case.

Fig. 8 indicates the importance which should attach to efforts to reduce the capital costs of AC-DC and DC-AC conversion equipments below presently indicated prices. If large quantities of these equipments are to be manufactured, even those quantities which apply to a single multiple line transmission system, then some reduction from present costs is surely possible.

Fig. 9 data has incorporated the kilowatt diversity gains across Canada, estimated for 1975 power quantities. These diversity gain estimates were based upon what diversity gains would have been available in 1960, when 472 mw. of peak capacity would have been avoided by an interconnection extending from Ontario to British Columbia. However, the cost of extra terminal conversion equipment and the high cost of making DC-AC tapoff connections to each province nullify the dollar value of the diversity gain in the examples. The conclusion is that no advantage is clearly apparent to justify the construction of a trans-Canada grid system. The data presented give full credit to the transmission system for all interconnection benefits; in fact, the local utilities will no doubt require some portion of these benefits, hence taps become unattractive to the transmission system itself. With taps, hourly system operation would become more complicated and difficult.

In Fig. 10, the economic effects of varying the capital cost per kilowatt of the alternative steam plant at the load centre are shown. The results reflected in the transmission costs are indirect, since only the basis of the comparison of these costs is changed, not the transmission costs themselves. Fig. 11 is similar, except that the cost of the fuel consumed per kwh. is varied in the alternative power source plant, whose 'standard' capital investment remains unchanged at $140 per kw.

Fig. 12 shows the economic effects of introducing as the alternative source, nuclear power at various capital costs per kilowatt of plant and at various fuel costs per kwh. delivered. Here again, the effect on transmission costs is indirect, since only the basis of comparison of the transmission costs is changed.

Fig. 13 sets forth the ambient temperatures in which transmission line conductors may be expected to operate in the case of a line extending from central northern B.C. through Edmonton, Saskatoon, Winnipeg, North Bay and Ottawa. With slight adjustments from recorded data, the curves show month by month the extreme upper limits of temperature in degrees centigrade, also the mean daily temperatures. These data were derived from information contained in "The Climate of Canada", published by the Meteorological Branch of the Department of Transport, Canada.

Fig. 14 shows one family of curves dealing with conductor temperatures. It became necessary to derive several of these. The calculations were done according to Earl Hazan.[2] Other curves, not shown, were derived for the relationships of DC resistances for wide ranges of conductor temperatures.

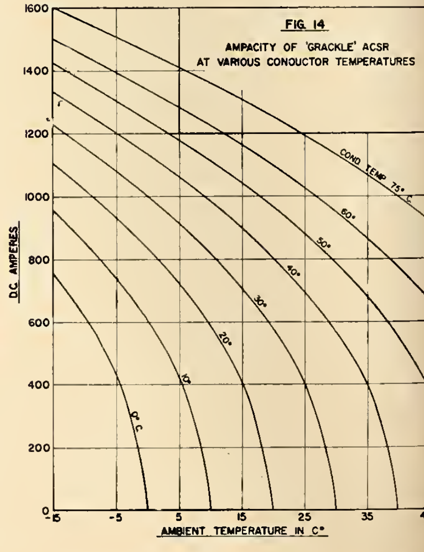
In Fig. 15, in addition to the dependable power throughput, month-by-month calculations were employed to determine the effect of surcharging the transmission system with whatever secondary power quantities were required to maintain the conductor temperature always at 75°C. The object was to obtain a substantial increase in energy deliveries, and therefore lower transmission cost per kwh. However, the cost of so much conversion equipment capacity is great, and since this equipment would be in part-time use only, the net effect on the resulting firm power costs is seen to be detrimental.

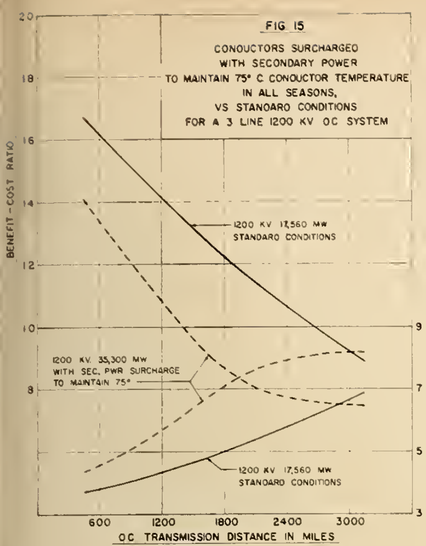
Having moved as a result of the above experience into the subject of loading conductors in accordance with temperature, Fig. 16 has been developed to compare the '50°C rise' concept as used for the conditions represented in Figs. 1 to 12, with the same 1200 kv. three-line system, but with conductors 'temperature loaded' for trans-Canada ambients to a 75°C maximum under emergent conditions.

In Fig. 17 and the remaining figures, temperature limit loading has replaced 50°C rise loading. Fig. 17 indicates the economic effects throughout the year of loading the transmission system at various percentages of the thermal limit, that is, the percentage of the limiting load which under emergent conditions would take the in service conductors to 75°C.

Fig. 18 shows during a 12 month period the economic effects of loading the two-circuit interim 1200 kv. transmission system at various percentages of the thermal limit of the conductors.

Fig. 19 shows for each line voltage the combined and simultaneous effects of several reasonably possible means of improving the economic performance of these long distance transmission systems, over and above the 'standard' conditions from which the curves of Fig. 1 were produced. For the figure 19 series, line loadings





which correspond to 70% of the thermal limit of the conductors were used, a maximum ambient of 3°C for the month of January was assumed, the mean daily temperature throughout the year was likewise taken at 3°C, the annual load factor of the transmission system was raised to 92.5%, no line tapoffs were included, and the interest rate as before was taken at 4.5%. No capital nor operating cost was assumed less than the 'standard' values previously used.

The transmission cost performances indicated by the Fig. 19 curve series, are considered to be of great interest in relation to the large future power requirements of particular areas of Canada and the large potential sources of hydro power which still remain undeveloped in this country.

Conclusions

Long distance high voltage direct current transmission appears to be distinctly advantageous in some circumstances. The greatest possibilities are those involving the development of a large power source, whose output is transmitted straight through without intermediate interconnections to a large power consuming area.

A commercially dependable trans-Canada power grid from Southern Ontario to B.C., integrated with the various local utilities through which it passes, is not a serious consideration in the foreseeable future. This statement is made however solely from the viewpoint of transmission economics. No weight has been given to monetary allowances for benefits which others may consider reasonable, for example the benefits of substantial reduction in the need for foreign exchange by the substitution of hydroelectric energy for energy produced in turbo-electric plants in central Canada fired with imported coal.

Similarly, a transmission grid system interconnecting major power resources across Northern Canada, built with tapoff connections taken southward at intervals for the purpose of supplying large power consuming areas, is for economic reasons of no interest.

It is the author's opinion that the cost of nuclear power must be reduced significantly below the costs presently achieved, before remote Canadian hydroelectric resources are rendered unattractive. Canada more than any other single country, with the possible exception of the U.S.S.R., possesses remotely located hydroelectric resources which may be developable at costs well below the prospective costs of nuclear power and indeed sufficiently low to warrant extra-long distance DC transmission, even though the competitive source at the receiving end may be nuclear. Furthermore, the high annual load factor type of plant which would be required at the hydro sites is most favorable in respect of the lower unit cost of energy resulting from this type of installation.

Canada would appear well advised to begin at an early date to devote intensive efforts toward the development of direct current transmission.

Appendix 'A' tabulates 20 major items requiring research and development prior to the establishment of a reliable system of parallel circuit EHV DC transmission. This assumes that the requirements of Appendix item 14, related to the degree of maintenance of DC voltages under fault conditions can be met. There is no known reason why research and inventive ingenuity should not resolve these matters. At the same time it should be realized that years of time will be required to provide progressively better solutions to the problems involved. There is good reason why active studies should be begun at once. There is no single quick solution to these matters.

The extent, volume and importance of the research and development work which must first be done in respect of DC transmission equipment make it virtually pointless to be concerned with the delineation of DC equipment standards at this time.

During the next two decades a power consuming area very likely to have good use for large quantities of bulk power is the Southern Ontario region. If about 1970 plans were in course of preparation for new generation capacity for the next few years in the amount of say 5000 mw., the annual cost of this power if generated locally in fossil fuel plants or perhaps even in nuclear plants and at 1960 price levels would be about $175 million for each year after construction. If a remote low-cost hydro source were available and if DC transmission had been developed to permit a benefit-cost ratio of 1.2, this same quantity of power could be carried perhaps more than 2000 miles and be injected into the bulk distribution system at the same point which the local plant would have used, but at a cost of about $146 million each year. A potential saving of some $29 million per annum thereafter is indeed of consequence.

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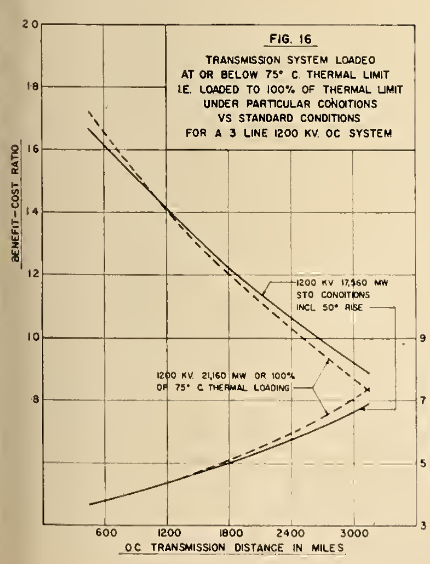

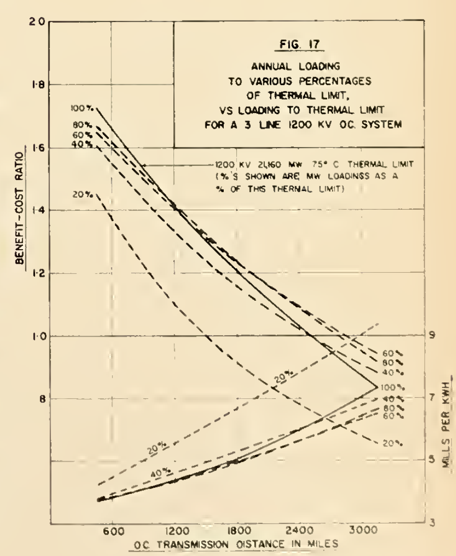

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APPENDIX "A"

A Tabulation of Some Major Items Requiring Research and Development Prior to the Establishment of a Parallel Circuit System of Extra High Voltage Direct Current Transmission Lines

The studies made on extra long distance high voltage direct current transmission have made clearly evident that research and/or development are required in respect of the following matters. For convenience these are divided into two groups as follows:

Group I—*Those problems which probably could be solved by incisive theoretical and design analyses, combined with comprehensive experimental studies and inventive development.*

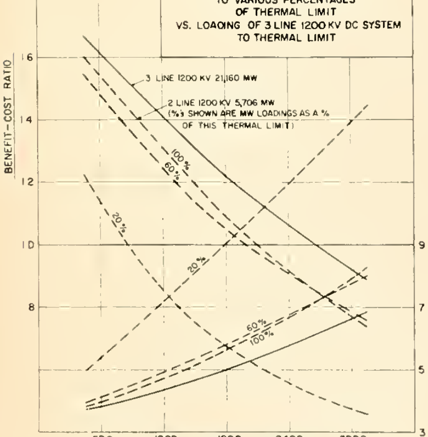
1. Exhaustive expression of the phenomenon of DC corona through experimental data and mathematical analyses.

2. The development of commercially corona-free (power-loss, telephone or radio interference) DC extra high voltage lines, equipment and fittings.

3. Examination of the implications of the magnetie fields from stray or return transient DC currents, and of magnetic fields from steady state currents of the order of 15,000 amperes carried by a parallel system of high voltage DC transmission lines.

4. Examination of the implications of DC leakage currents with particular reference to switching station and transmission line structures and to protective coatings such as zinc on steel.

5. Examination of short-circuit currents, their magnitude, behavior and implications, on EHV parallel circuit DC transmission systems.



6. Analysis of those means by which fault current discharges from EHV lines or equipments which have been switched off at both ends may be killed instantly. Otherwise, condenser discharge will continue along the normal exponential discharge curve, burning off conductors or destroying flashed bushings or insulator strings.

7. Examination of the problems created by EHV DC line energizing and de-energizing transients and other travelling voltage and current waves.

8. Examination of the problems created by lightning transients whether due to direct strokes or to the release of bound charges by cloud discharges.

9. Examination of the problems created by static buildup on EHV DC transmission line eonductors whether due to precipitated or wind carried particles of snow, ice crystals, rain, smoke, sand, dust or other particles or whether due to bound charges on passing clouds.

10. Examination of the problems created by aurora borealis and unusual sunspot activity.

11. Design and development either of self-cleaning DC insulator strings and bushings, or designs which will eliminate or nullify the plating out of atmospheric dirt on the insulator surface such as occurs in an electrostatic air cleaner.

12. The development of effective systems of metering and of fully reliable automatic control of the EHV direct current voltages and currents and of the AC voltages and currents, particularly through rectifier or inversion equipments with two or many units operating on parallel.

13. The development of effective systems of fully reliable selective instantaneous automatic protective relaying of faulty equipment and lines.

14. The successful development of a system of automatic voltage control on the DC output side of the rectifier equipment units, such as will tend to *maintain* the DC output voltage when fault conditions are imposed, in place of tending to *collapse* the DC output voltage, is deemed essential to the basis of power system design which has been used. Otherwise, the entire plan requires reconsideration.

15. An examination of the means of securing, and of the benefits to be achieved from, half line (i.e., single pole) switching applied to one side of a DC transmission circuit.

16. An analysis of the suitability or otherwise of the 3:1 ratio of conductivity of phase conductor to ground wire, as has been assumed.

Group II — *Those problems which must be solved by a combination of theoretical analyses, experimental development, the construction and testing of prototypes, reduced scale and full scale models.*

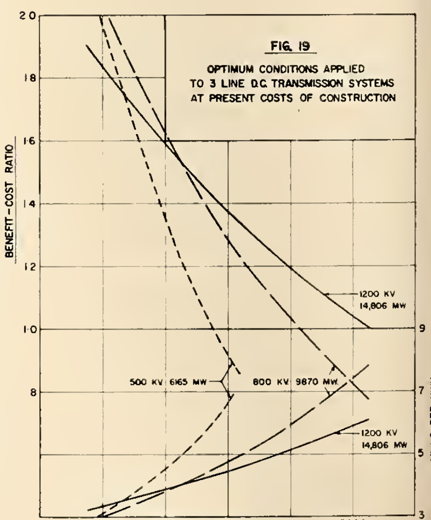
17. The development of fully reliable high speed high voltage high current high rupturing duty direct current circuit breakers.

18. The development of reliable lightning, surge or static discharge arresters suitable for use on EHV DC systems.

19. The development of ultra-high capacity high reliability low inherent power loss designs of high voltage rectification and inversion equipments, with particular attention to stability and similarity of characteristics when operating in parallel with another or many units, and with particular attention to flashback performance.

20. Consistent with fully adequate performance and reliability, a rigorous cost reduction program will be required for all major equipment items. Apart from the construction costs of the transmission lines themselves, by far the most fruitful field for reduction of manufacturing costs is in the equipment unit designs and layouts of the rectification and of the inversion equipment assemblies.

Without doubt other matters of similar or lesser consequence will appear upon further examination of the items above mentioned.



POWER IN CANADA

C. H. Pigot, M.E.I.C.,
*Assistant Chief Engineer,
Power Development Division,
Quebec Hydro-Electric Commission,
Montreal*

I. D. MacKenzie, M.E.I.C.,
*Geologist,
The Shawinigan Engineering Company Limited,
Montreal*

CARILLON FOUNDATION STUDIES

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

TO VERIFY assumptions used in the design of the Carillon Hydro-Electric Power Development, an in-situ shear test was carried out during the fall of 1960 on a particular shale bed which had been identified as the weakest in the area. This bed was located stratigraphically some 10 to 20 feet above the foundations of the sluiceways. A 36 in. diam. calyx drill, a wire saw, and hand labour were used so that the test blocks, five in all, could be exposed with a minimum of disturbance to the shale bed. A hydraulic jack assembly, consisting of a hand-operated jack, a ball and socket joint, and a roller path, was used, acting against a reaction beam, to apply pre-determined vertical loads. The horizontal load was applied by large diameter twin hydraulic jacks arranged so that their extremely slow rate of travel was identical and independent of the resisting force encountered. In four out of five of the tests, primary consolidation was completed prior to the application of the shearing force; in Test 5, the horizontal load was applied immediately after application of the vertical load.

In the four tests where primary consolidation had taken place, it was found that a peak value of shear strength occurred during a deformation of 0.02 to 0.05 in. There was then a reduction, after which the shear strength remained at a more or less uniform value to the end of the test at a minimum deformation of 3 in.

Using the initial maximum, the shear strength of the shale can be expressed as:

$S = 5.85 + 0.26\ N$ p.s.i.

where

S = Shear strength in the plane of the bed (p.s.i.)

N = Unit force normal to the bed (p.s.i.)

At a deformation of 0.05 inch this becomes

$S = 6.42 + 0.25\ N$ p.s.i.

and at a deformation of 2.0 inches

$S = 3.1 + 0.31$ p.s.i.

The time required for the tests was fifteen weeks.

This paper is not intended to be a profound discussion on the theories of soil mechanics or foundation design but rather a description of the methods used and the results obtained in performing in-situ shear tests on a particular altered shale bed in the bedrock at Carillon. It is hoped that this description of the tests will be of help to engineers confronted with similar problems at other locations even though the shear strength values obtained at Carillon may not necessarily be applicable.

Introduction

The Quebec Hydro-Electric Commission is presently building a power development on the Ottawa River, some 35 miles upstream from Montreal. Scheduled to commence delivery of power to the Commission's distribution grid in the autumn of 1962, the plant will have an installed capacity of 840,000 hp. consisting of fourteen 60,000 hp. adjustable blade propeller type turbines operating at a head of 62 ft. As well as the powerhouse, the development will include a concrete sluice section with twelve 50 ft. vertical gates, a navigation lock, bulkhead sections, and more than four miles of earth dikes.

The bedrock at the site consists primarily of horizontal or gently dipping dolomitic and calcareous beds with lesser shale horizons. The rock is of Beekmantown age and has been previously identified as the March and Oxford formations.[1]

During extensive preliminary core drilling in the area, it was found that the beds were quite thin, beds more than 5 ft. thick being uncommon. It also showed that there were extensive zones where the bedrock had been altered or weathered to a varying degree. Intrusive dikes and sills, both fresh and altered, were identified. A large mass of severely altered intrusive rock was outlined some 1200 ft. downstream from the site that was finally chosen. Artesian horizons were found at various elevations, and testing disclosed porous zones in the bedrock. During the drilling, sections from a few inches to more than 2 ft. were encountered where there was no core recovery.

After an appraisal of this preliminary information, the design developed for the structures was quite conservative. A very extensive program of consolidation and curtain or cut-off grouting was also anticipated.

In the early stages of the excavation, soft altered zones that had not been identified during the preliminary drilling were exposed in the shale beds. These altered zones, while thin, were found to extend over relatively large areas.

While research in the laboratory and in the field has been carried out on structurally weak horizons in bedrock foundations, it was not known to what degree these findings were applicable to the conditions at Carillon.[2-5] It was therefore deemed advisable to carry out an in-situ shear test in order to substantiate the design assumptions that had been made.

It was not considered necessary to conduct the test on an altered shale bed under the structures themselves but rather to test what was identified as the weakest bed in the area. The shale bed finally chosen was stratigraphically 10 to 20 ft. higher than the foundation surfaces under the sluice section. The test location was near the south bank of the river downstream from the sluiceways at a spot where there would be a minimum interference from the construction activity.

The tests were patterned on similar tests made by the U.S. Corps of Engineers at the Harlan County Dam in Nebraska but differed in that, with the procedures used at Carillon, a constant rate of deformation was more easily obtained during a test, thereby facilitating the interpretation of the data obtained.

Description of Shale Bed

The bed tested was more uniform than most of the others in the area; its thickness was approximately 6 in. and its dip was quite consistent. The contacts with the dolomitic beds above and below were smooth with only occasional ripple marks and other irregularities. The surface of the shale plates was not glossy; the plates were irregular in detail, and the major cleavage was parallel to the bedding planes. The unaltered shale of this bed was dense and compact; the altered zone was quite consistent with a thickness in the order of ⅜ in. The consistency of this soft black material can best be described as resembling that of soft plasticine.

While the bulk of the material in this zone was soft and cohesive, there were also numerous small plates of unaltered shale scattered through the matrix. At the location of the tests, the shale was topped by a massive dolomitic bed some 4½ ft. thick that was suitable for the cutting of the test blocks.

Test Requirements

To carry out the tests, it was essential that the shale bed be undisturbed prior to the actual testing. As well as guarding the test blocks from mechanical shock, it was also necessary to maintain the water content in the shale at its original value.

The theory as developed by Coulomb for the shearing resistance of a substance is made up of two parts —cohesion, which is the resistance encountered when there is a no-load condition on the plane of shear, and additional resistance due to friction when a force is applied along the shear plane. This can be expressed as

$$S = C + N \tan \phi$$

where

S = Total shearing strength

C = Cohesion or shearing strength under a no-load condition

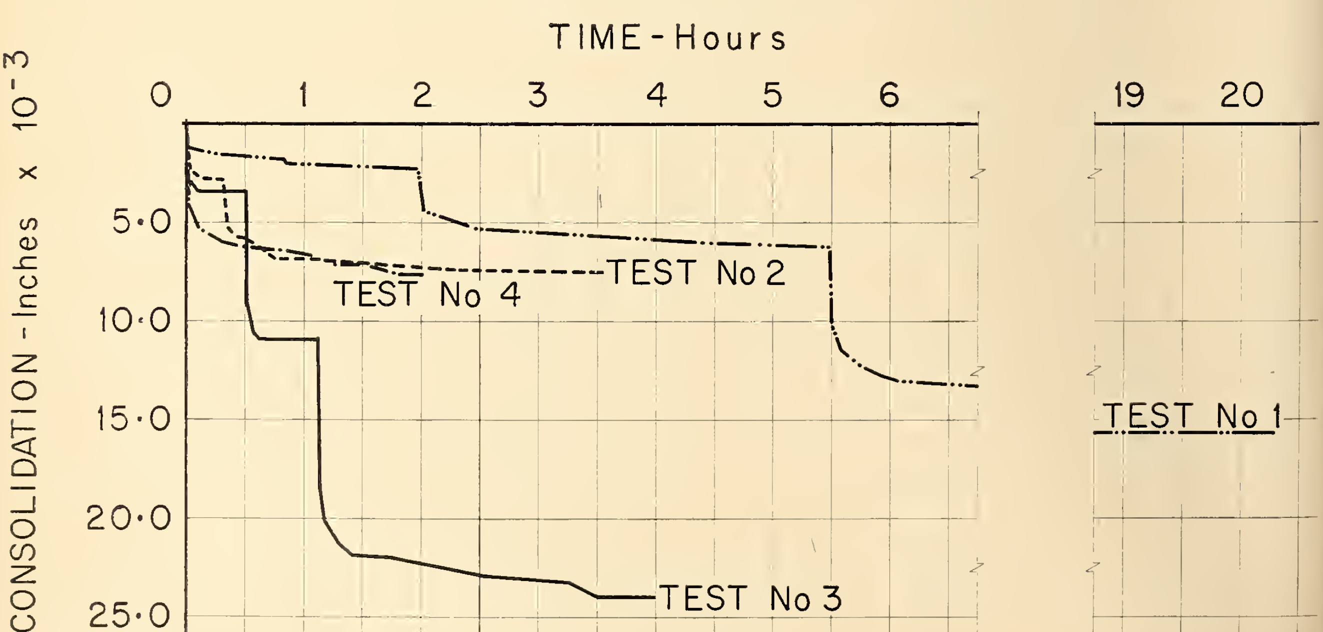
N = Load normal to the shear plane

$\tan \phi$ = Tangent of the angle of friction.

Therefore, the application of the horizontal force during this test presented a rather special problem. The resisting force, i.e., the shear strength of the bed being tested, being a function of the rate of forward motion or deformation, it follows that a series of tests carried out at different rates of deformation would result in a series of different stress-strain curves. Similarly, if the rate of deformation were allowed to vary during a test, a number of values would be obtained having no clear relationship to one another and belonging to a number of stress-strain curves, thus making the evaluation of the results obtained most difficult if not impossible.

It was, therefore, imperative to set up the test so that the rate of deformation could be maintained constant despite variations in the magnitude of the resisting force. To obtain results that would be indicative of conditions as they will exist under the dam, a very slow rate of deformation was required. A third condition was that during the movement of the test block under this horizontal force there be no skewing or twisting of the block. The application of the vertical load to the test blocks would have to cover a range from well below to well above the calculated loads which the structures would impose on the foundations so that extrapolation of the test results would be unneces-

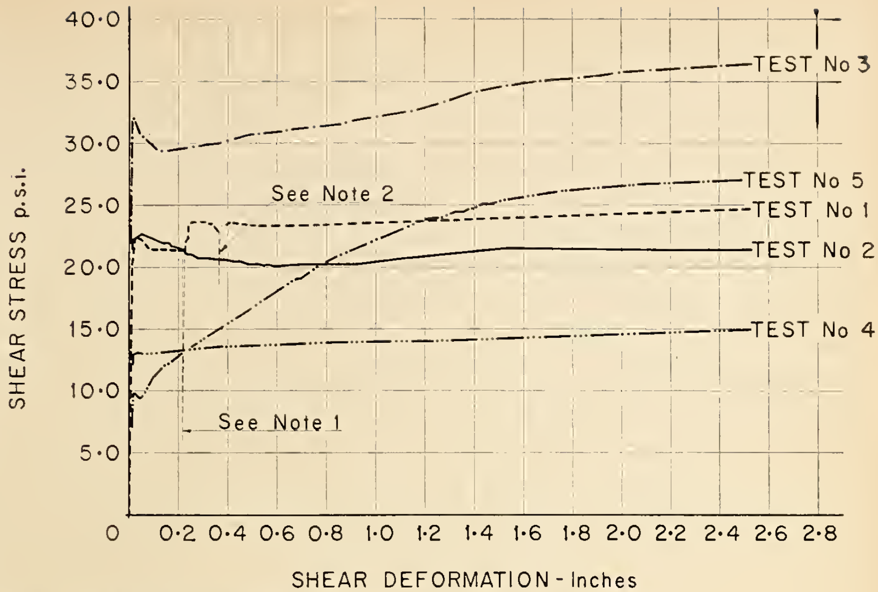
Fig. 1. Primary Consolidation Versus Time.



sary. Eccentricity during the application of the vertical load and friction developed between the load and the test block were required to be a minimum to facilitate interpretation of the test data.

Instrumentation to measure both horizontal and vertical movements of the block under test had to be such that all movements could be measured to 0.001 in. and in the case of the forward movement of the block due to the horizontal force applied, this accuracy was required over a range of 4 in. For the measurement of both horizontal and vertical forces applied during the test, a minimum accuracy of 0.25% was necessary. A further requirement for the instrumentation was that dials showing both force and movement could be centralized on one panel to permit simultaneous photographic recording.

It was decided to carry out tests on five blocks. The dimensions of the blocks were fixed at 30 in. in plan. To facilitate interpetation of the data obtained, all five blocks had to have the same orientation relative to the dip and strike of the shale bed to be tested. Field conditions were such that it was more convenient to carry out the tests down dip.



Notes: 1. 2 hr. cessation of test (Air pressure system breakdown)
2. Temporarily inadequate air supply to pump.

Fig. 3. Stress-Deformation Curves.

Test Block Preparation

Bedrock was carefully removed down to the top of the massive dolmitic bed overlying the shale. A series of carefully positioned 36 in. diam. calyx drill holes were then put down to below the elevation of the shale bed. The purpose of these holes was threefold: first, to establish accurately the dip and strike of the shale and hence orient the test blocks; second, to provide access for the wire sawing equipment to free the blocks; third, to provide sumps for the removal of water.

A series of carefully oriented cuts were then made with wire saw to form the vertical faces of the test blocks and to permit removal of sufficient rock from around them to provide the required working area. Immediately on completion of a saw cut, this ¼ in. groove was filled with a bentonite slurry to minimize migration of water. As soon as the sawing was complete on the side of a test block or blocks, hand labor was employed to carefully remove the adjacent rock. The exposed face of the shale was then painted with a bituminous compound to maintain the water content in the shale. Soil cement was carefully tamped into place to support the exposed face of the test block during the remainder of the sawing and rock excavation. This work was so scheduled that only one face of any test block was left unsupported at one time. The wire sawing equipment produced smooth faces that were plumb and true to line.

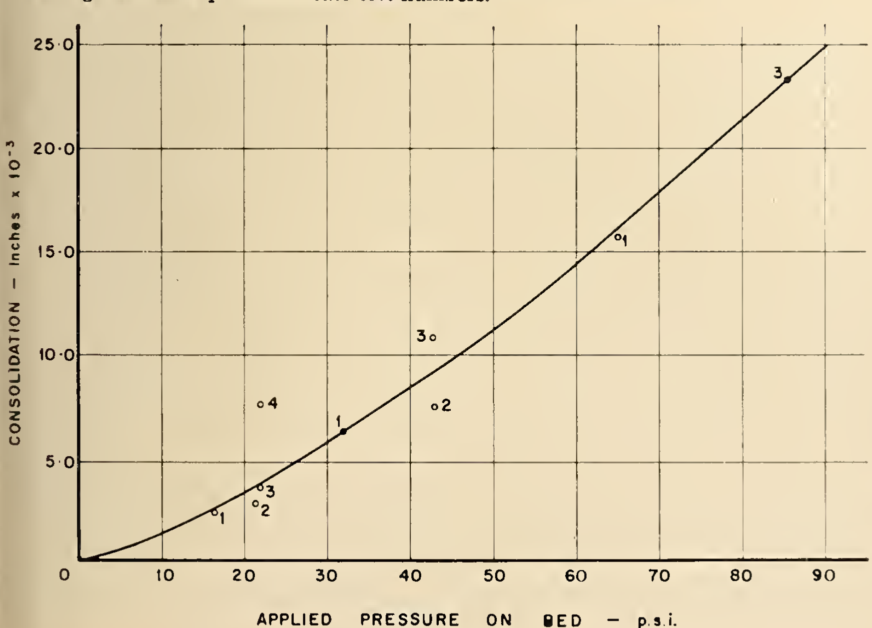
On completion of the sawing and excavation of rock, the soil cement was carefully removed, hand labor again being used. A reinforced concrete corset and a cap 6 in. in thickness were then cast to enclose the test blocks. Vibrators were not used during the placing of this concrete which was carried down the sides of the blocks to within 1 in. of the top of the shale bed. Anchors for the installation of instrumentation and equipment were carefully positioned.

The concrete encasement was kept moist until cylinders cured at the site indicated strength of over 3500 p.s.i.

A weatherproof shelter was erected over the test area with an annex on one side that served as an instrument room for the recording of data. During this period, assembling and testing of equipment and instrumentation were carried out, and dummy tests were run on a concrete block resting on a bentonite-coated rock surface as a final check on equipment and to

Fig. 2. Primary Consolidation Versus Applied Pressure.

Note: Figures beside points indicate test numbers.



familiarize personnel with the test procedure.

The preparatory work required 14 weeks with long working days being the rule rather than the exception.

Test Equipment

The equipment for the application of the horizontal force consisted of two 12 in. double-acting hydraulic jacks rigidly supported in a horizontally parallel position on the up-dip side of the blocks. These jacks contacted a heavy machined plate aligned and set in plaster of Paris against the face of the concrete encasement. The centre of application of this load was 5 in. above the top of the shale bed, and the direction was at right angles to the strike of the shale bed. The jacks reacted against an oriented concrete pad cast against the rear wall of the trench.

The jacks were driven by an air-operated pump through a precision flow control valve. This valve had a constant flow characteristic, and working with the pump, these two pieces of equipment produced a constant flow of a high order. The flow control valve was sized to give a very low rate of flow and this, coupled with the large diameter of the jacks, produced a rate of forward movement in the order of 0.025 in. per minute. The double-acting jacks were so arranged that the oil output from the first jack became the oil input to the second jack; hence the forward movement of the two jacks was identical irrespective of the resistance encountered by either jack. In this way, skewing of the blocks was prevented.

A hand-operated hydraulic jack working against a long, heavy reaction beam through a polished ball and socket joint was used for the vertical loading. The ends of the reaction beam were attached to rods grouted into rock, arranged to provide vertical anchorage and to prevent lateral movement. The load was transmitted to the test blocks through a heavy bearing plate assembly. The bearing plate set on the blocks was levelled, using a five second machinist's level, and set in plaster of Paris. A polished roller path set on top of this plate allowed for a horizontal movement of 5 in.

Instruments to measure all movements were mounted on a rigid steel cage that was set over the test blocks. This cage was independent from the test blocks themselves and it was securely braced to the sides of the trench. The instruments consisted of a rack and pinion arrangement that actuated a gear box coupled to an electrical transmitter. The probe end of the racks was in contact with polished steel plates set on the surface of the test blocks. The transmitters were coupled to receivers that actuated dial gauges mounted on the instrument panel. The dials were graduated so that observations accurate to 0.001 in. could be obtained. For the instruments to measure the forward movement of the blocks, two transmitters, two receivers, and two dials were installed so that the movement could be recorded over a range of 4 in.

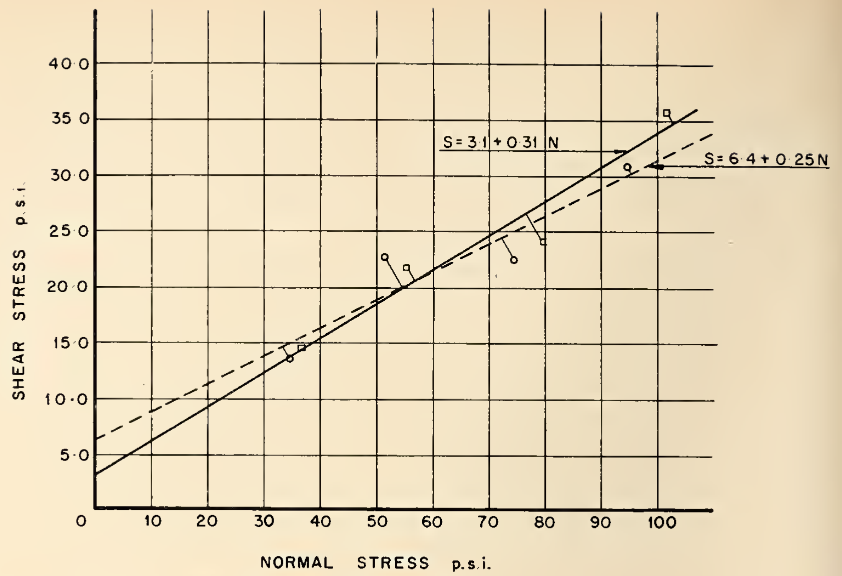
Three instruments were mounted to measure the movement of the top of the block under vertical load. Two instruments were set near one side that was parallel to the direction of the horizontal movement, one being near the up-dip corner and the other near the down-dip corner. The third instrument was installed near the opposite face at the mid point.

Two instruments were installed on the side of the block to measure skew and lateral movements. The two instruments to measure the forward motion of the block were set on the down-dip end diametrically opposite the horizontal jacks.

Gauges to show the pressures on the jacks were also mounted on the instrument panel.

An electrical and a mechanical clock together with a manually-operated counter completed the equipment installed on the instrument panel.

An emergency power supply was installed so that a power failure would



Notes: □ — Shear stress at 2 in. deformation
○ — Shear stress at .05 in. deformation.

Fig. 4. Shear Stress Versus Normal Stress

Fig. 5. Wire Saw Operating in 36 in. diam. Calyx Hole.

cause only a momentary interruption during a test.

The data was recorded photographically. A 4 in. by 5 in. filmpack camera was the main unit, and it was supported by two 35 mm. cameras. The maximum rate achieved using this equipment was one exposure every 15 sec. A 16 mm. movie camera operating on single frame at 1 sec. intervals was used during the early part of each test.

The clocks on the instrument panel were required for the photography, and they permitted a running check to be made during a test. The time indicated and the counter served to identify the photographs.

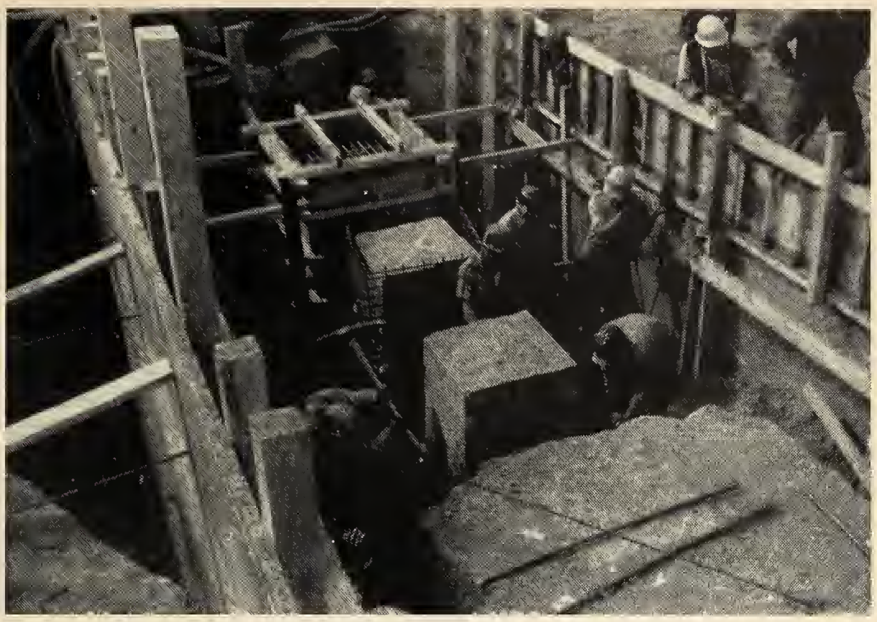


Fig. 6. Four Test Blocks in Progressive Stages of Final Preparation.

Test Procedure

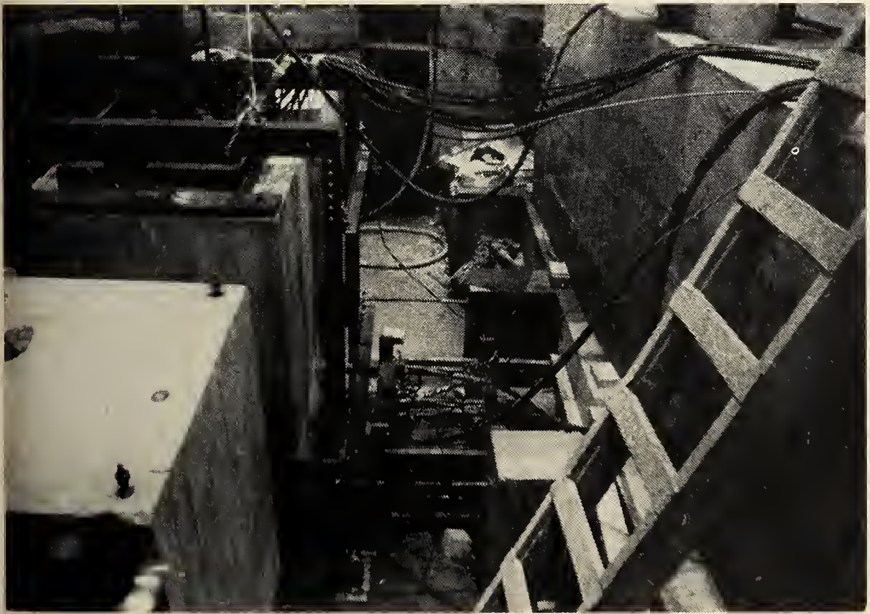
On Test Blocks 1 to 4 inclusive, the vertical loads were applied in predetermined increments. The final intensity of pressure varied from 34.2 p.s.i. in Test 4 (one increment) to 94.5 p.s.i. in Test 3 (three load increments).

The total period of application of the vertical load prior to the application of the horizontal load varied from 20 hr. and 17 min. on Test 1 to 1 hr. and 47 min. on Test 4. On Test 1, it was found that the primary consolidation was essentially complete within 30 min. after the application of a load increment. On Tests 2 to 4 inclusive, additional load increments were applied, or in the case of the final load increment, the horizontal load was applied after no measurable consolidation was observed for a minimum period of 30 min. On Test 5, the horizontal load was applied immediately after the application of the vertical load of 69.2 p.s.i.

As well as recording the consolidation photographically, a manual plot was made to determine the time when an increment of vertical load should be added or when the horizontal loading could be started.

During the application of the horizontal load, the vertical load was maintained constant. The horizontal force was applied so that there was a constant rate of deformation during each test. The rate of deformation varied between 0.024 in. per minute for Test 2 and 0.032 in. per minute for Test 4. A test was continued until a minimum horizontal movement of 3 in. was obtained. Here again, the photographic record was supplemented by a running plot of significant dial readings to follow the progress of the test.

Fig. 7. Test in Progress. Horizontal Jacks in Right Foreground.



Immediately a test was completed, the equipment was removed and the block was lifted vertically and laid on its side. Jacks, one at each corner, were used to lift the blocks the first few inches to ensure verticality of movement. The two sheared surfaces were examined and photographs were taken.

The time required to carry out the actual tests was one week. On completion of the tests, all components were returned to the laboratory foi calibration.

The photographic record of the test data consisted of 2400 8 in. by 10 in. prints. From these prints, more than 33,000 individual observations were made, and this data was tabulated and plotted. The 16 mm. movie film record was also examined to ensure that there had been no minor irregularities of short duration that had been missed by the manual camera.

Test Results

A plot of the primary consolidation against time is shown in Fig. 1. Consolidation took place almost immediately after the application of a load increment. In Test 1, on application of the final increment which increased the unit vertical load from 31.7 to 65.1 p.s.i., a consolidation of 0.007 in. took place in the first 30 min., and during the ensuing 13 hr. the consolidation was 0.002 in. In the ensuing 2 hr. and 57 min., no measurable settlement occurred. A part of the consolidation after the first 30 min. of this load application was due to difficulties experienced in this first test. In Test 2, where more accurate control of loading was achieved, no measurable settlement occurred after the first 30 min. of the second and final load increment although this load was maintained for an additional 3 hr.

In Fig. 2, primary consolidation has been plotted against applied pressure. The applied pressure in this case is only that due to the vertical jack, as primary consolidation due to the weight of concrete encasement was assumed to have taken place prior to the actual test.

During the horizontal movement an attempt was made to correlate the observed vertical movement of the block with the calculated vertical movement due to the dip of the shale bed. There was no clear indication of further consolidation. There was a slight indication that the vertical movement of the forward end of the block was greater than that due to dip, and the movement of the rear end was less. Differences in observed and calculated amounts of movement were of such a nature that no definite interpretation was possible.

Shear deformation plotted against shear stress for the five tests is shown in Fig. 3. During the derivation of these curves, it was necessary to make corrections to the observed data for

1. The weight of the test block and vertical jack assembly resting on the shale bed;
2. The effect of the dip of the bed;
3. The effect of reduction of the shearing plane area during the tests;
4. The frictional resistance of the roller train used in the application of the vertical load;
5. The difference between indicated and actual pressures on the horizontal and vertical jacking systems.

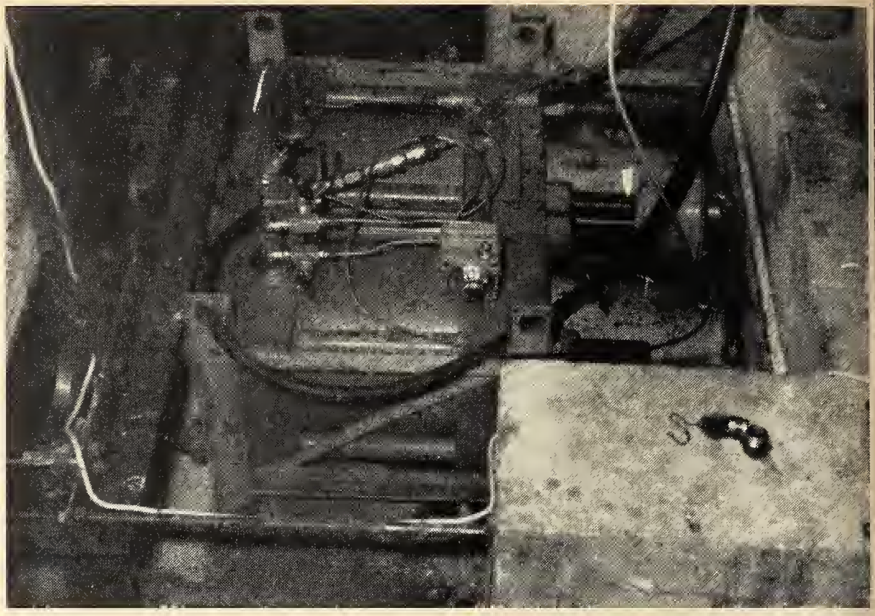


Fig. 8. Horizontal Jack Assembly in Position. Test Block on Left.

In Tests 1 to 4, the application of the horizontal load resulted in a rapid rise in the shear stress to a peak value at a shear deformation of between 0.02 and 0.05 in. From this high point, the shear stress then fell away to a more or less uniform value. In Test 5 where there had been no primary consolidation, the shear stress increased after this initial peak and continued to rise throughout the test, finally attaining a value similar to that of Test 1 which had had a similar consolidation load applied.

The first irregularity in the curve for Test 1 was due to a failure of a component in the pumping system for the horizontal jacks. The vertical load remained constant during this 2 hr. interruption. On recommencing the horizontal movement, an increase in shear stress was found. The second irregularity of a momentary nature was due to a power failure that affected only the horizontal jacks.

True values of the shear and normal stresses acting on the shear plane during the tests were calculated at three significant points on the stress-deformation curves. These were at the point of initial maximum shearing strength, at a deformation of 0.05 in., and at a deformation of 2.0 in.

Values of shear stress plotted against corresponding values of normal stress at deformations of 0.05 in. and 2.0 in. are shown in Fig. 4.

Fig. 9. Vertical Jack Assembly in Position. Connections for Instrumentation on Left.

Conclusions

At the point of initial maximum shearing strength, the strength of the shale bed can be expressed as

$S = 5.85 + 0.26\ N$ p.s.i.

where

S = Shear strength in the shear plane

N = Pressure acting normal to the shear plane.

At a deformation of 0.05 in. its shearing strength can be expressed as

$S = 6.42 + 0.25\ N$ p.s.i.

and at a deformation of 2.0 in. as

$S = 3.1 + 0.31\ N$ p.s.i.

Interpretation of Results

The values of shear strength given have been obtained from only four tests, Test 5 not being considered as there was no primary consolidation prior to the application of the shearing force. The equation for the line of best fit was found by the method of least squares. As assumed by Coulomb, this implies a linear relation-

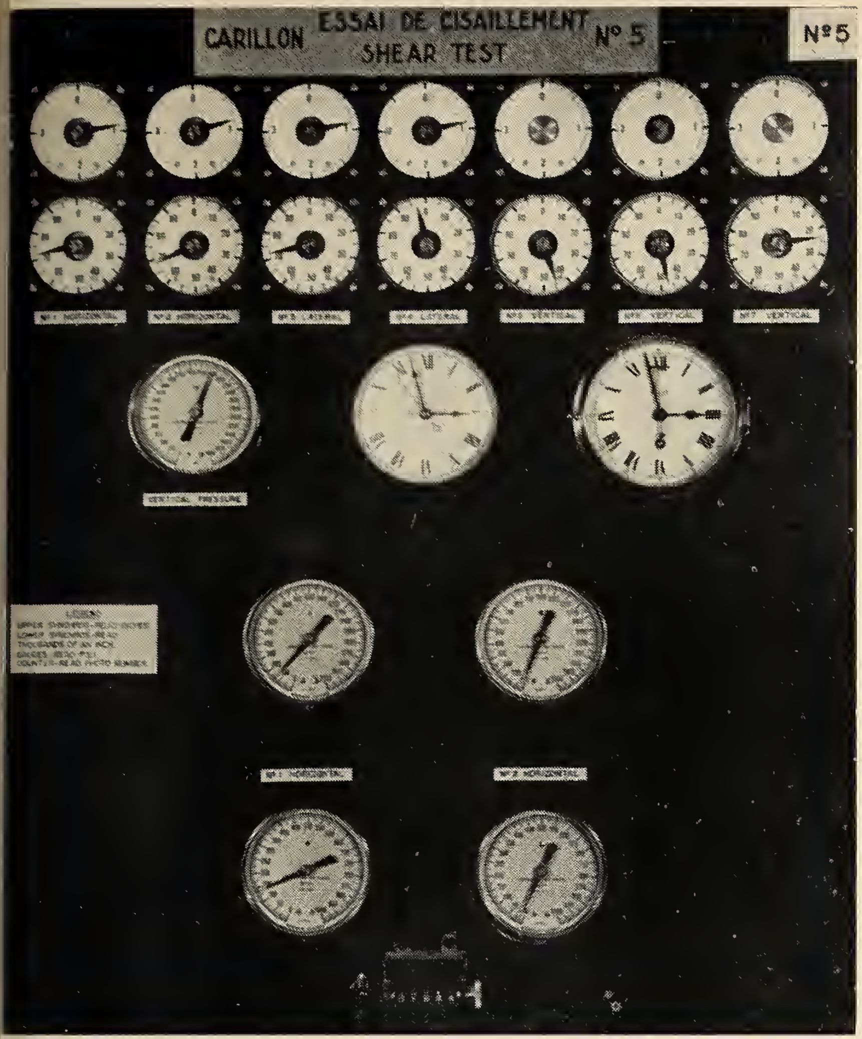


Fig. 10. Instrument Panel.

ship between shear and normal forces. While this may not be absolutely true, it was not considered advisable to attempt to derive any other relationship due to the scatter of the tests' results which may have been due to

a) Variation in thickness of the altered layer in the shale (⅜ in. to ⅝ in. as measured)

b) Variation in degree of decomposition of the shale in the altered layer

c) Variations in moisture content in the layer

d) Variation in rate of deformation from test to test

e) The effect of secondary consolidation during deformation

f) Unintentional and unknown disturbance of the test blocks prior to testing

It can be considered remarkable, in view of these possible sources of error, that the results have been this consistent.

Description of Sheared Surfaces

In all cases, failure occurred in the altered zone located near the mid point of the shale bed and not at the contacts with underlying or overlying dolomite. The failure occurred on a series of surfaces rather than along a single plane. In plan, these shear surfaces were irregularly distributed over the area, and the offsets between them were in the order of ¼ in. or less. Slickensides parallel to the direction of shear were irregularly developed and in all cases they were parallel to the direction of shear.

Six samples of the altered zone taken immediately after the shear tests yielded the following data:

Water content from 5.6 to 14.2%
Liquid limit 23.2 to 27.7%
Plastic limit 14.1 to 15.3%

Small plates and fragments of unaltered shale were distributed through this soft altered zone so that undisturbed samples for further laboratory testing were unobtainable.

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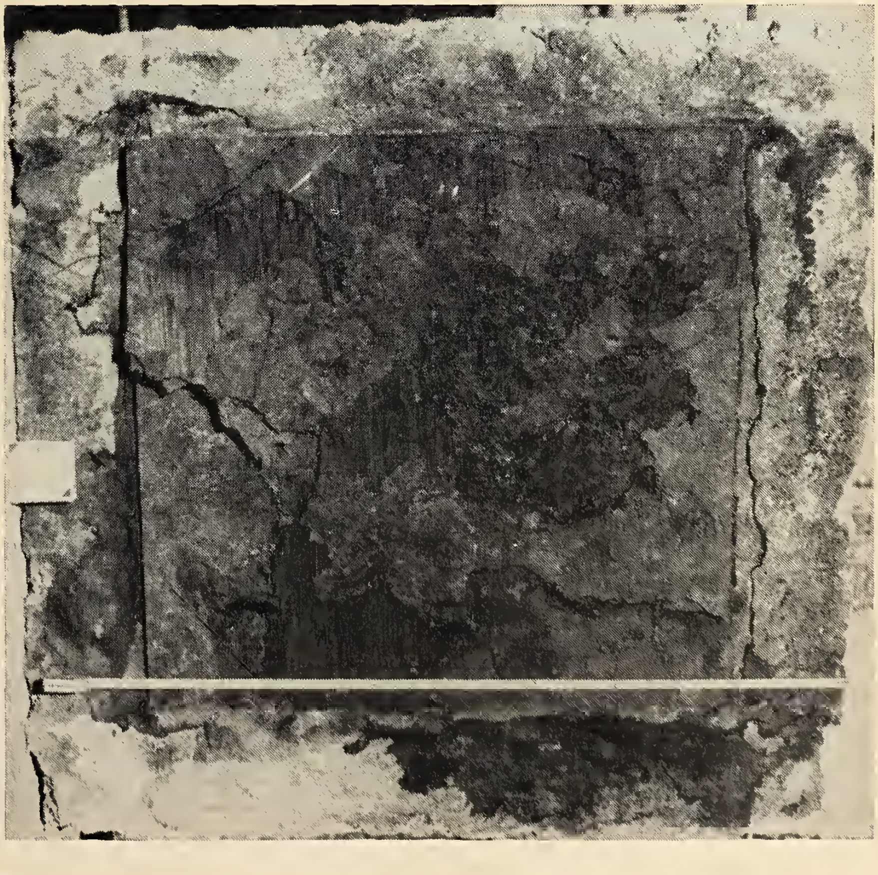
Fig. 11. Face of Block after Test. Surface Damaged in Handling but Slickensides Apparent.



System Studies Utilizing an IBM 704 Computer

ECONOMIC DEVELOPMENT OF HYDRO-QUEBEC POWER RESOURCES

J. Bourbeau, M.E.I.C.,
Quebec Hydro-Electric Commission

F. H. Jonker,
J. G. S. Thomson,
H. G. Acres & Company Limited

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DEVELOPMENT of the most economic hydro power sites in areas close to Montreal, Quebec's principal load centre, is now nearly completed and, to meet the continuing and increasing load growth of the Province, the Commission has looked towards the eastern rivers to provide power over the next 15 year period of development. Already, the Bersimis River has been fully developed, but immediately beyond lie the relatively undeveloped Outardes and Manicouagan Rivers.

The average energy potential of these rivers is about 3,300 Mw. years per year. The sites at which this energy potential can most economically be harnessed have already been selected on the basis of field investigations and general engineering studies. The locations of these sites and their base outputs are shown in Fig. 1.

The problem which faces the Commission is the determination of the most economic sequence of development which will have, at all times, sufficient flexibility to meet changes in anticipated load growth, and yet maintain inherent reserves to meet adverse conditions of river flow. The phases of development must be such that the progressive installation of capacity at the various new plants will be properly integrated into both the existing and expanding system, and the whole development must be in keeping with a practicable overall construction schedule.

As the plants on the eastern rivers will be somewhat remote from the present principal load centre, the proper integration and development of the transmission network, and the selection of voltage levels, are also major factors affecting overall planning. The economic advantages that may be gained through the use of long transmission lines must also be weighed in relation to overall system reliability.

Associated with this, consideration of the benefits obtainable by installing peaking capacity close to the load centre is also included in the scope of the studies. Such peaking capacity could be provided by gas turbine installations, by a thermal installatio or by a pumped storage developmen

Anticipated Load Characteristics

A peak load and energy forecast f the Commission's system is shown Fig. 2. Existing plants on the syster and plants already under constructi close to Montreal, will be able to me power demands until the fall of 196 and energy demands to the end 1965. Thereafter, the annual incr ment in load demand to be met b new plants increases from about 4(Mw. per year to about 600 Mw. p year by the end of the 15 year peric of development. It is of interest note that, in the period of develo ment under consideration, the i stalled capacity on the Commissior system will be almost trebled.

While such a general load foreca defines, for the purposes of overa planning, the total amounts of pea ing capacity and energy requiremen for each year, the monthly deman reflecting the distribution of ener demand throughout each year are equal significance. From a study he Commission's records, it has been possible to establish consistent ratios of monthly peak to annual peak demand, and to evolve a typical dimensionless or normalized monthly load duration curve as shown in Fig. 3. The whole character of future loads can therefore, for study purposes, be simply defined by correlating the normalized load duration curve, the monthly ratios of peak load, the monthly and annual load factors, and the annual rate of load growth.

Characteristics of Existing Plants

The present interconnected system is virtually composed entirely of hydro plants, and comprises two principal groups of plants which are located in separate parts of the province. The first group is constituted by plants in the vicinity of Montreal, the principal load centre. There are three plants in this group; Beauharnois, Cedars, and Back River, and these are all run-of-river plants. Beauharnois, the principal one, is located on the St. Lawrence River and has an installed capacity of 2,140,000 hp. It is designed to utilize practically all of the St. Lawrence River flow. In wintertime, however, it is frequently necessary to reduce output in order to form or to preserve an ice cover in the intake canal. It is unfortunate that this reduction is coincident with the time of peak load. Some of the water not utilized by Beauharnois may be routed through the Cedars plant which has an installed capacity of 218,000 hp. The third plant of this group, Back River, is located on the Rivieres des Prairies. This small plant has an installation of 60,000 hp.

The second group of plants is on the Bersimis River, some 360 miles from the load centre. Bersimis No. 1 has an installed capacity of 1.2 million hp. and Bersimis No. 2 has an installed capacity of 855,000 hp. Long-term regulation of river flows is possible at these plants because of the large storage volumes in the reservoirs created at both sites. The capacity factor of Bersimis No. 1 is of the order of 65% and of Bersimis No. 2 is of the order of 50%.

Characteristics of Plant Under Construction

With the completion of ultimate installation at Bersimis No. 2 in 1960 and at Beauharnois in 1961, the only plant under construction for the Commission's system is that at Carillon. This plant, which is located on the Ottawa River, will have an installed capacity of about 840,000 hp. which will be completed by 1964. In summer, it will be a run-of-river plant; in winter, with pondage, it will be a peak plant.

Characteristics of New Plants

The next group of plants to be constructed will be on the Outardes and Manicouagan Rivers, and the characteristics of these plants may generally be seen by reference to Fig. 1. On the Outardes River, principal storage will be provided at Outardes Mile 58. At Outardes Mile 45 and Outardes Falls, the reservoirs will be very small, and hence the capacity factors of the three plants must be made very similar if spillage and excessive drawdown are to be avoided.

On the Manicouagan River, the principal storage will be at Manicouagan 5. This reservoir, when constructed, will, in storage volume, be the third largest in the world. Aldeadavilla in Spain, and Kariba in Rhodesia, will be about 25% and 15% larger, respectively. It will take from seven to ten years to fill, depending upon inflow and water demand, and will become the regulating or controlling reservoir for the interconnected system as a whole.

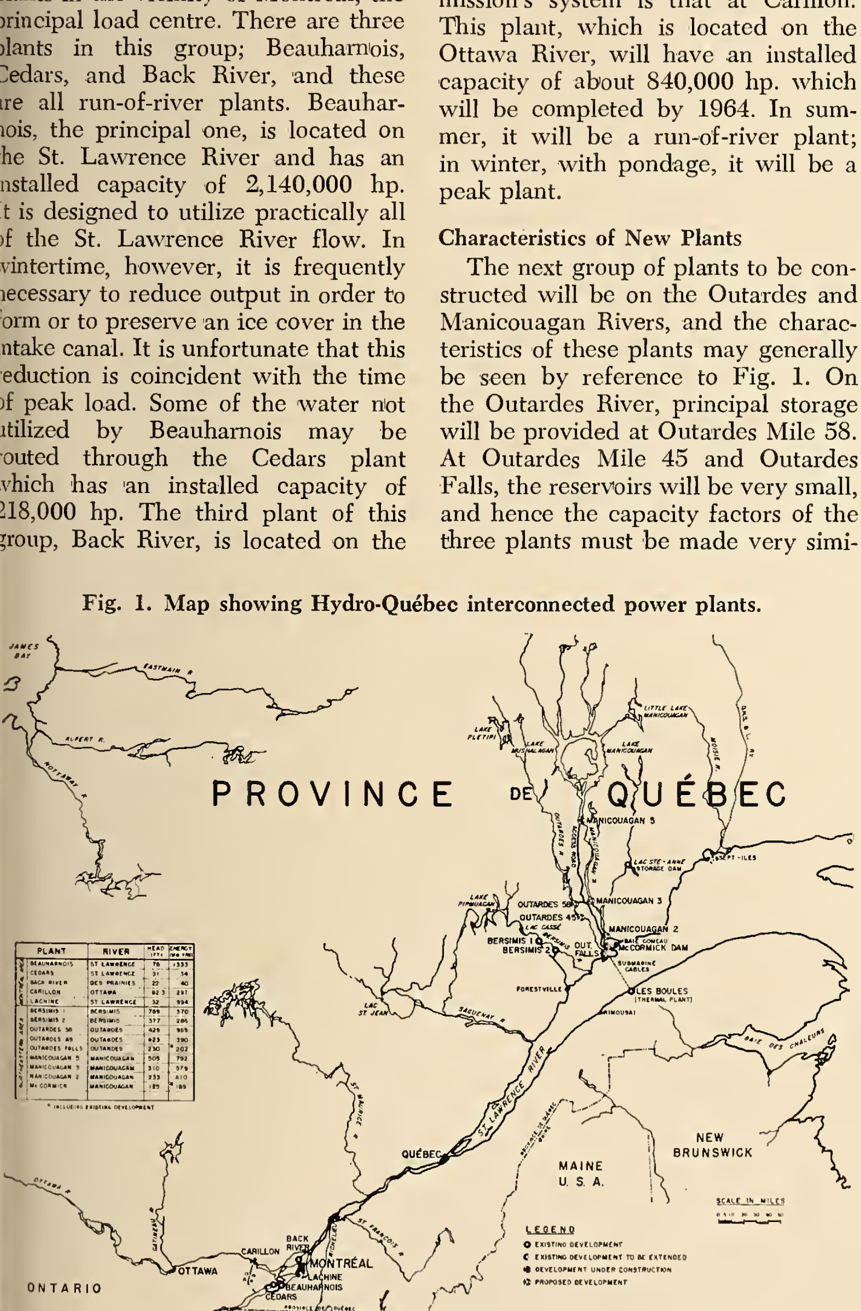
Below Manicouagan 5, the available head of the river will be fully developed, and sizable reservoirs will be created at Manicouagan 3 and Manicouagan 2. The fill-up of these two reservoirs could be arranged to be completed in about one year, but the actual time will depend on the sequence of development selected. Below Manicouagan 2, the existing reservoir at McCormick is very small and it will, therefore, be necessary as before, to have the capacity factors of Manicouagan 2 and the completed McCormick plant made closely similar.

Some storage has already been developed at the storage reservoir at Lake St. Anne. This storage provides regulation for the existing plant at McCormick during wintertime and will continue to provide some regulation for Manicouagan 2 and the completely developed plant at McCormick.

At all of the new sites, the Commission has considerable freedom of choice of capacity factors. Generally, it is economic to provide peaking capacity at high-head stations; however, in the case of these two rivers, the high-head stations are further away from the load centre than the lower-head stations. The associated incremental costs of transmission therefore diminish this economic advantage. Additionally, installed capacities at all stations must be great enough to permit full water utilization and regulation to plants downstream.

The advantages of providing alternative peaking capacity closer to the load centre must also be considered from many points of view. As stated before, such peaking capacity could be provided by gas turbine plants, by a thermal plant, or by a pumped storage development. Economically, the cost of these plants must be compared with the cost of providing peaking capacity in the plants on the Manicouagan and Outardes Rivers, together with the incremental cost of transmission from the Manicouagan area to the load centre. Other considerations,

Fig. 1. Map showing Hydro-Québec interconnected power plants.



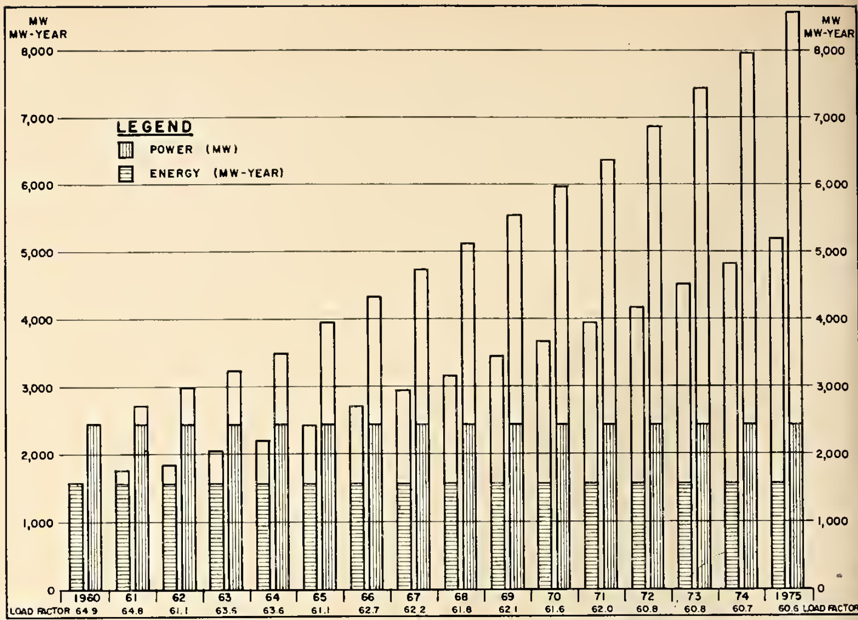


Fig. 2. Forecast of Load and Energy Demand.

such as system stability and reliability, must be taken into account, both from the immediate and long-term points of view. These aspects require particular study. For instance, a gas turbine or thermal peaking plant may quite economically meet the system peak demand but, if either is required to generate for an appreciable period of time, the cost of fuel and maintenance can become very high. On the other hand, a pumped storage peaking plant can normally only provide standby capacity for a relatively short time unless additional expenditure is made to provide extra storage. Several suitable sites for pumped storage peaking plants exist within reasonable distance from the load centre.

Principal Variables

The proper development of sites requires study of the system development as a whole. In system studies, the effects of a very large number of variables can be taken into account. Some variables are, however, of second order importance initially, in that they do not affect the relative economics of sequences of development or the selection of the capacities to be installed at each site. The principal variables are those which do affect initial selection. For the Commission's system, the following have been considered as principal variables:

Variation in Load Demand: For study purposes, a range of load forecasts typified by that shown in Fig. 2 has been made.

Variation in Energy Demand: Also as typified in Fig. 2, various energy demands have been compiled, and a range of relationships between annual and monthly energy demands has been selected.

Variation in River Flows: Long-term flows in the St. Lawrence River are known and the range of flows is relatively small. This is, of course, due to the amount of regulation provided by the Great Lakes. Three typical sets of flow conditions were therefore compiled for use in the studies as follows—

- Monthly flows in an average year;
- Monthly flows in a low-flow year;
- Monthly flows in a high-flow year;

These conditions set the range of monthly outputs of the existing plants on the St. Lawrence River.

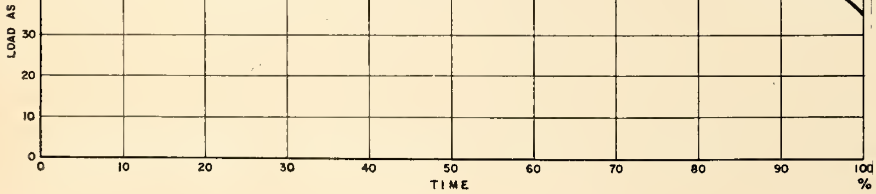
For the new Carillon plant located on the Ottawa River, flow records do not extend over a very long period. However, similar estimates of monthly flows for average, low, and high-flow years were also compiled.

For the Bersimis, Outardes, and Manicouagan Rivers, which are in adjacent watersheds, only records of the Outardes River extend over a reasonable period of time. Flows in the Outardes River were therefore analyzed and transposed through the use of area and runoff factors to provide records of flow in the other two rivers. The drainage areas above each site were treated separately. Since the commencement of the studies, checks on the actual proportionate flows from the various drainage areas have been initiated.

Variations in Installed Capacity: As discussed previously, there is great freedom of choice of installed capacity at each and every site, but the effects of variation are not easily determinable because of such factors as transmission requirements, schedule of construction and interest charges during construction. However, in the trial selection of a sequence, integration of the various plants must not only meet the developing load and energy demand, but the whole pattern of installation must provide adequate system reliability and balance towards the end of the period of development. Hence, the widest possible range of installations must be tried. The range includes the installation of various peaking capacities near the load centre.

Variation in Sequence of Construction: In theory, the range of trial sequences is limited only by the possible permutations of the number of sites to be considered. Practical considerations, such as impounding times and limitations of construction schedules, however, diminish the feasible range of sequences. Additionally, the range may be further diminished by avoidance of excessive overlap of construction at several sites, since this would undoubtedly result in unduly high rates of capital expenditure with

Fig. 3. Typical normalized monthly load duration curve.



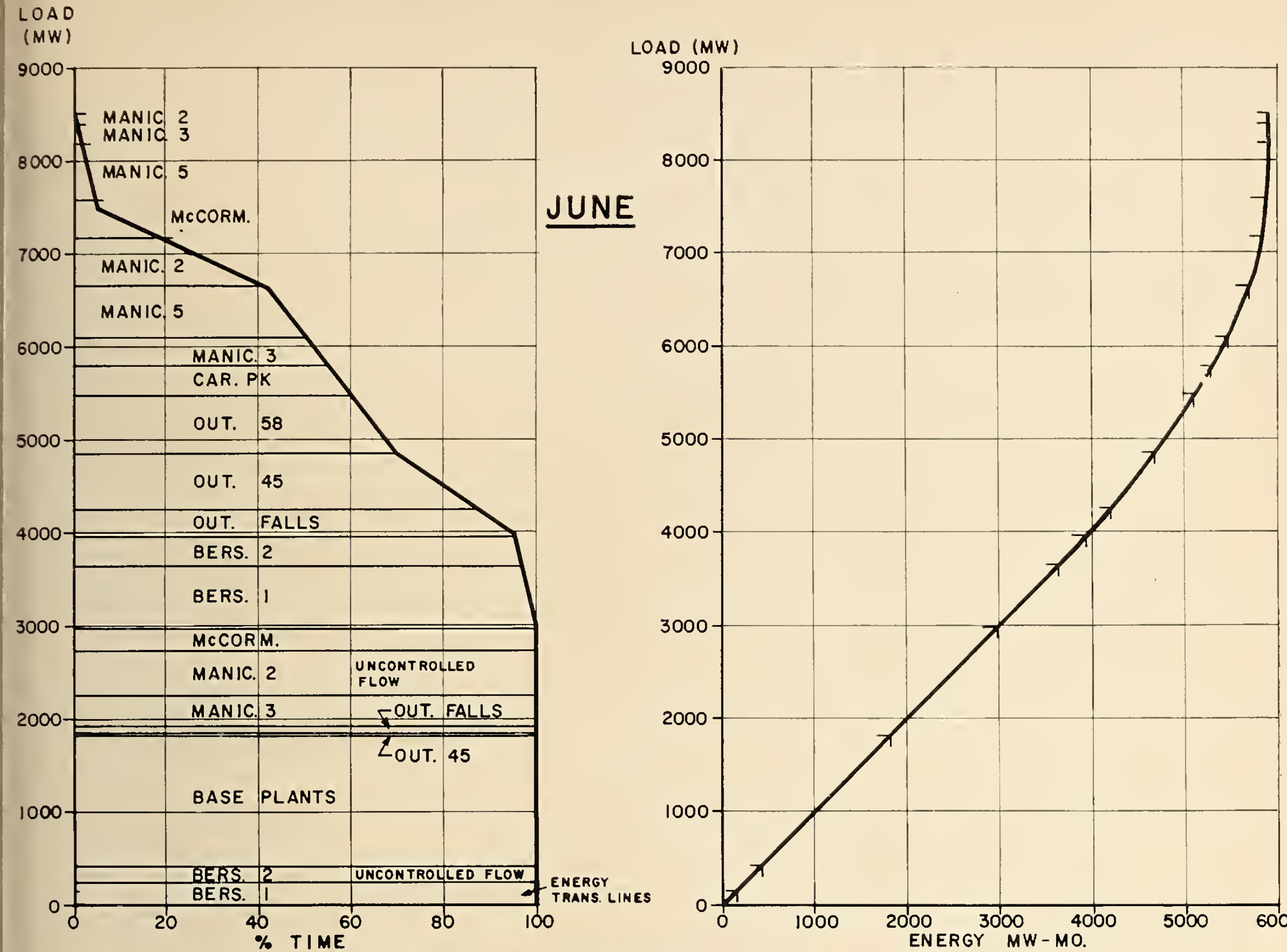


Fig. 4. Simplified load duration curves for December & June showing plant stacking.

resultant high annual charges during the period of development.

Secondary Variables

As discussed above, variables which do not affect the relative economics of sequences of development or the selection of installed capacity may be classified as secondary variables. In initial studies, appropriate values may be selected for these. The secondary variables and their evaluation are as follows.

Design Characteristics of Equipment: In choosing the size and characteristics of units to be installed at the various sites, it has been assumed that all units will be of the maximum size possible, subject only to limitations imposed by manufacturing capacity, experience, and techniques. It has been further assumed that all units will have efficiencies at or near the maximum values possible at the present time. In the cases of the gas turbine and thermal peaking plants, unit sizes of 30 Mw. and 250 Mw. have been considered, respectively.

Fuel Costs for Thermal Plants: It has already been generally established that thermal base plants would not be economically attractive on the Quebec system within the development period under consideration. The economics and other benefits of thermal peaking plants are, however, of interest. At such plants, the amount of fuel consumed would be very small and variations in fuel cost would, therefore, have a negligible effect on system costs. For present purposes, it was assumed that Bunker C oil at a cost of 35 cents per one million B.t.u.'s would be used.

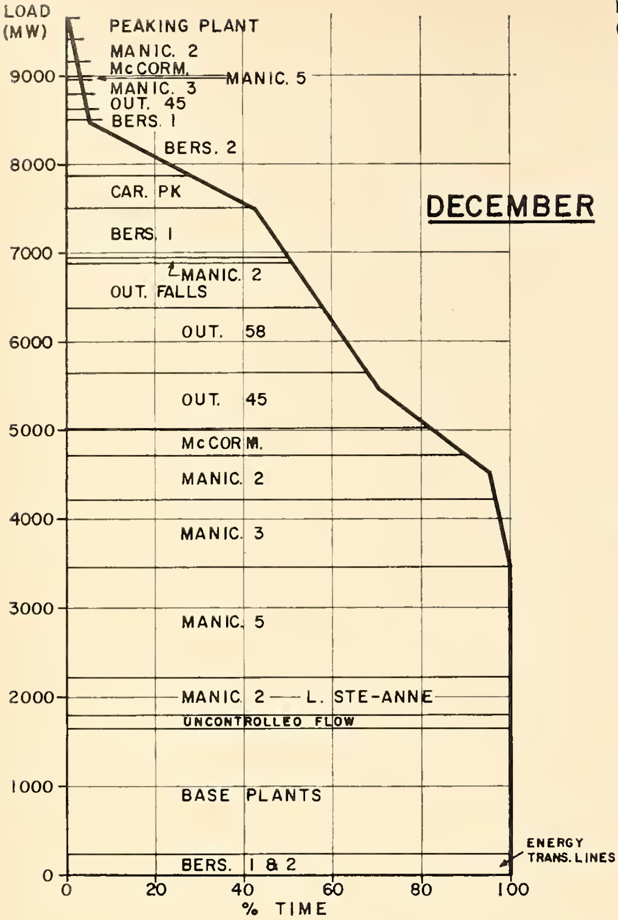
Transmission Losses: It has been assumed that the losses in the long transmission lines from plants on the Outardes and Manicouagan Rivers would have an aggregate of about 3% of peak power transmitted. This would not include transformation losses at the generation end which were included with the unit efficiencies. The transmission losses are added to the net load curve.

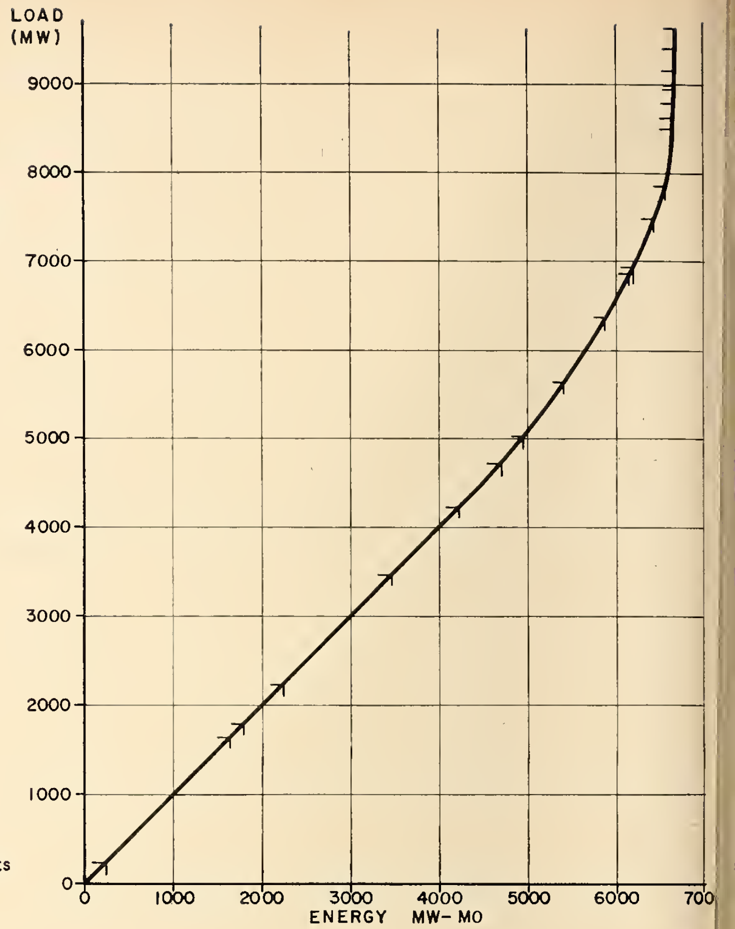
Storage Control Techniques: Rule curve methods of operation, as described later in this paper, were adopted for the various reservoirs. The particular curves for each reservoir were first assumed and thereafter checked by trial and error methods which indicated that the curves were generally close to the optimum.

Design Levels for Reservoirs: Preliminary calculations indicated that the normal controlled elevations for Manicouagan 5 and Outardes Mile 58 reservoirs should be at elevations 1180 and 1150, respectively. These values were therefore selected for use in the studies. After general selection of the economic sequence of development has been made, these levels will be checked.

Construction Cost, Interest Rate, Methods of Bookkeeping, and Annual Charges: In comparative studies, it is of particular importance that costs be standardized so that anomalous results will not occur. For this purpose, the Commission's engineers embarked on a very thorough study of costs for all sites. Wherever possible, equipment costs were standardized in curve form, and thereafter costs were compiled for schemes with capacity factors of 100%. These therefore represented the costs of base energy production. Additional units were added to these installations and the incremental costs were derived. Costs of transmission lines and switching stations were similarly treated.

Construction schedules were established, and the rates of annual ex-





penditure during the construction periods were selected following analysis of expenditure patterns for previous similar types of construction.

Interest rates, methods of bookkeeping, and annual charges were selected in accordance with the Commission's practices.

System Operation Criteria

In a system of the type described, wherein there is virtually no thermal generation, the primary criterion for economic operation is the prevention or minimizing of spillage. To accomplish this, it is necessary to have adequate storage developments. On the three eastern rivers very large reservoirs will be in operation, and these will also provide protection against low-flow periods. As has been stated, there will be at Manicouagan 5 on the Manicouagan River the third largest reservoir in the world, and major storage reservoir at Bersimis No. 1 and at Outardes Mile 58. Short-term regulation will also be provided by the pondages at Bersimis No. 2, Manicouagan 3, Manicouagan 2, and Lake St. Anne. The problem of minimizing spillage becomes, therefore, one of correctly integrating plant utilization to meet the varying conditions of load and energy demand. This is achieved by proper "stacking" of the various installations on the load duration curve as indicated graphically in Fig. 4. The order of "stacking" is determined by the relationship between the flow available at a specific time and the installed, or more exactly, the flow capacity of the plant at that time. Fully developed run-of-river plants will always be stacked at the bottom of the load duration curve so that the maximum amount of their energy potential can be used. Higher on the load duration curve, plants with storage are stacked because generally their capacity or stacking factors are of a lower order. Finally, peaking plants are located at the top of the load duration curve. It should be noted that the "stacking" procedure is a continuing and varying operation which may be done hourly, daily, weekly, and monthly, depending upon the degrees of flexibility of the system. Generally, for study purposes, where plentiful storage is available, monthly "stacking" of the plants is adequate. An understanding of the "stacking" procedure provides the best understanding of the nature of the various plants which should be integrated into the system. Since the "stacking" procedure, in practice, is a continuing operation, it follows that in the integration of new plants there will be many types of conditions to be satisfied.

Proper methods of storage control also contribute significantly towards minimizing of spillage. Control should among other things, take account of the second criterion for economic operation which is that the head at each plant should be kept to maximum or optimum. To achieve the necessary degree of control, rule curve operation is adopted. A rule curve is made for each principal reservoir. Each rule curve is a plot of reservoi elevation against calendar month in which the elevations for each month represent the levels to which an operator may draw down his reservoir if demand exists, but beyond which he may not reduce water level except in emergency, since he mus maintain an adequate amount of storage until the following spring flood The rule curves also take into accoun the maintenance of best head at th plant which will allow some storag for incoming flood flows without sacrifice of head. Rule curves are mad first by approximate methods and ar thereafter established, in relation t best system operation, by trial an error. They may be changed from tim to time to meet change of condition if this is necessary.

Where the amount of storage o more truly, pondage, at a plant limited, operation must be such th excessive drawdown is not necessar This is best accomplished by ensurin that in the planning or allocation of installed capacities, the capacity factors of the stations immediately below and above the pond are made closely similar. These stations would, therefore, be stacked adjacently on the load duration curve.

During the period of development, it will be necessary to plan the filling of each reservoir. Particularly in the case of Manicouagan 5 where the fill-up period will be several years, the planning of water usage must be very carefully considered. Operating procedure must take into account the necessity of filling this and other reservoirs without unduly requiring the prior construction of additional plants.

The day-to-day requirements of the system, such as allocation of minimum charging currents to transmission lines, must also be met, and adequate amounts of spare capacity must always be set aside to preserve system reliability.

Computer Program

To incorporate and set in perspective all of the characteristics of the existing system, the characteristics of the new plants, the variables to be studied, and the system operating criteria to be met would require a substantial planning period and numerous engineers if normal calculation methods were adopted. The benefits of using high-speed electronic digital computers in economic studies of this type are now being recognized to an increasing extent by modern, expanding electrie utilities. The establishment of a realistic model of the system in a computer provides the means of quickly observing the effects of the variables described above, and the computer results provide compact documentary evidence on which to base decisions which will affect long-term planning and operation.

Once established, the system model can be used by operation personnel to determine the best methods of operation for various sets of conditions from month to month and from year to year. Changes in conditions can be rapidly incorporated in the computer program and new results obtained.

The Quebec Hydro-Electric Commission therefore required the preparation of a system model with a scope large enough to serve both their present planning purposes and future operational requirements. The model is at present set up for use on an IBM 704 computer located in Toronto. The program is designed so that it can be eventually transferred to a computer of a different type once the present series of studies has been completed.

The computer program may be considered as being comprised of three particular phases as described below.

Input Data: The first phase of the program is made up of input data which is in two separate parts; firstly, information which is stored in the memory of the computer, and secondly, additional principal variables to be studied. The stored information is divided into the following categories which have been discussed in some detail above:

System load characteristics;
Plant characteristics;
River flows;
Operating criteria;
Reservoir characteristics;
Cost data.

This information which includes all of the secondary variables described above, and additionally contains the ranges of load forecast and river flow data which are principal variables, is initially in numerical form and is thereafter translated into computer language for storing in the machine. It is of interest to note that the IBM 704 computer has a basic memory of 8,000 "words" and that the present program utilizes the whole of this memory.

The second part of input data comprises the additional principal variables which are to be studied, such as various installed capacities at the different plants and various sequences of development. For each sequence of development to be tried, the principal variables are selected and assembled for insertion as input data. Additionally, the particular load and flow data to be used are identified so that they will be called forward from the computer memory. In this way, it is possible to determine the relative costs of each sequence, and its ability to meet particular loads under different conditions of flow.

Output Data: The output data obtained for each sequence tried is printed separately for system simulation and cost simulation. The data for system simulation may be printed for an annual basis or a monthly basis depending upon the amount of detail which is required for the purpose of the particular study. This data is arranged as follows:

Repeat of salient input data.

For each plant on the Bersimis, Manicouagan and Outardes Rivers:

The usable energy.
The flood spillage.
The saleable spillage.
The demand spillage.

Note: Saleable spillage is water which could have been used for generation within the limits of installed capacity.
Demand spillage is water released from storage for generation at plants downstream.

For the combination of the base plants at Beauharnois, Cedars, Back River, and Carillon, and for Lachine if this is included:

The usable energy.
The spillage energy.

For any thermal or pumped storage peaking plant:

The usable energy.

The maximum and minimum water levels at the following reservoirs:

Bersimis No. 1.
Outardes Mile 58.
Manicouagan 5.
Manicouagan 3.
Lake St. Anne.

The total outflow from Manicouagan 5 reservoir.

The cost data is printed out under the following headings:

Repeat of salient input cost data.

The following total costs for all stations excluding Manicouagan 5:

Annual capital expenditure.
Accumulated capital expenditure, including interest during construction.
Annual charges.

Similar data for Manicouagan 5.

Similar data for transmission and switching costs.

Grand totals for the cost items above with an additional total including the effect of compounding annual charges at five per cent interest.

Order of Computation: The third phase of the program, by which the computer simulates river flows, energy generation, and spillage; adopts the operating criteria described above; computes water levels, energy outputs, and reservoir outflows, and calculates the various costs, is shown in the simplified flow sheet contained in the Appendix. The system simulation calculation shown is typical for one month and this calculation is repeated for each month of the period of development. Cost calculations are only made at the end of each run.

It is of interest to note that for the system simulation for one sequence extending over the 15-year period of development, the computer performs from ten to twenty million separate operations. The time taken for each system simulation, excluding print-out time, is about 15 minutes. Print-out takes additionally about 30 minutes, and the cost computations take about three minutes.

From examination of the simplified flow sheet in the Appendix, it may be seen that the computer functions exactly as a model of the system in that flows are utilized and regulated, and plants are stacked on the load duration curve and brought into service in accordance with requirement. If insufficient capacity is installed to meet the peak demand, or if all reservoirs are drawn down to minimum levels and the energy demand is not met, the computer stops. From the print out data, it is possible to determine the cause of the stoppage and the necessary adjustment of sequence or installation can be made.

Normally, whenever a run has been completed, key sections of the output data are checked by inspection. Subsequently, other arithmetic checks are made manually, to ensure that the program has functioned correctly in every way.

Methods of Analysis

The method of analysis is essentially one of trial and error. Problems of prime importance to the Commission, at the present time, are the choice of an economic sequence of development of the various sites, and the determination of the economic capacity to be installed at these sites. Each trial sequence of development is therefore tested on the computer with average conditions of river flow and selected dates of impounding of reservoirs to ascertain that it will meet the load and energy demand. The resultant costs of the various elements are then analyzed. If the sequence has not been successful in meeting the load and energy demand, or if reservoir elevations are unsatisfactorily low, it is adjusted until it is acceptable. Thereafter, each sequence is tested for more rigorous conditions of flow, impounding, and load increase. The water levels in all reservoirs are carefully observed, and the amounts of flood and demand spillage at each site are scrutinized. If it is found that the sequence can be improved by adjustment of installed capacity between the various sites, thereby saving more water in the reservoirs, then this adjustment is made and the sequence is retested.

Once all trial sequences have met the load forecast under the various selected conditions of flow and impounding, the accumulated annual charges for each sequence are converted to mill rates and these are used as indicators of the economics of the sequences.

APPENDIX

Simplified Computer Flow Sheet for Typical Monthly Calculation

System Simulation

Read in input data.

Calculate monthly capacity and energy requirements.

Store load duration curve in memory of computer.

Find flow requirements of stations which charge transmission lines. Subtract the station output equivalent to the minimum flow requirements from the bottom of the load duration curve.

Subtract the output of the base load stations (Back River, Beauharnois, Cedars, and base portion of Carillon) from the bottom of load duration curve. Calculate used energy and secondary energy.

Subtract the output of Lachine generating station, if existing, from the bottom of the remaining load curve. Calculate used energy and secondary energy.

Check if capacity of remaining stations in the system is sufficient to meet peak demand.

If insufficient — If sufficient

- If insufficient: Place peaking plant of preselected capacity at top of load curve.
- If sufficient: Subtract the output of the peaking portion of Carillon plant from the now remaining load curve in such a manner that the secondary energy is at a minimum while using the full capacity.

Draw Bersimis No. 1 reservoir down to the rule curve. Calculate discharge at Bersimis No. 1 and Bersimis No. 2. Calculate energy generated at both stations and stack the stations on the load curve so that spillage is a minimum while using the full capacity of both stations.

Calculate the uncontrolled flow at all other stations in the system. Calculate the energy at all stations and check whether this uncontrolled flow is sufficient to meet the remaining capacity and energy requirements.

If insufficient — If sufficient

- If insufficient: Draw Outardes Mile 58 down to rule curve. Calculate discharge and energy output at Mile 58, Mile 45, and Outardes Falls. Stack stations on remaining load curve so that spillage is at a minimum while using the full capacity of all stations.
- If sufficient: Calculate and print out:
  - Water levels in all reservoirs.
  - Used and spilled energy at all stations.
  - Outflow from Manicouagan 5 reservoir.
  - Capacity factors at all stations.
  - Used energy at peaking plant, if installed.

If end of sequence calculate cost — If not, repeat for next month

Draw Lake St. Anne down to rule curve and calculate the uncontrolled flows at Manicouagan 5 and Manicouagan 3, and controlled flows at Manicouagan 2 and McCormick. Calculate energy generated at all Manicouagan stations and calculate stacking factors.

Place stations on residual load curve, derived from above, in order of decreasing stacking factors. Calculate used and spilled energy at all stations. Check if energy and capacity requirements are met.

If insufficient — If sufficient

Release additional flow from Manicouagan 5 reservoir. Calculate flows and energy generated at the Manicouagan stations and calculate stacking factors.

Place stations on residual load curve, in order of decreasing stacking factors. Calculate used and spilled energy at all stations. Check if energy and capacity requirements are met

If insufficient — If sufficient

Calculate and print out:
Water levels in all reservoirs.
Used and spilled energy at all stations.
Outflow from Manicouagan 5 reservoir.
Capacity factors at all stations.
Used energy at peaking plant, if installed.

If end of sequence calculate cost — If not, repeat for next month

Cost Calculations

Read in input data for cost calculation for all sites.

Calculate accumulated capital expenditure and annual charges for Mile 58, Mile 45, Outardes Falls, Manicouagan 3, Manicouagan 2, McCormick, Lachine, and Peaking Plant.

Calculate accumulated capital expenditure and annual charges for Manicouagan 5.

Calculate accumulated capital expenditure and annual charges for transmission system.

Add all accumulated capital expenditures for each year and print out.

Add all accumulated charges for each year and add annual charge for Lake St. Anne, and print out total.

Accumulate annual charges and print out.

From the tests of sequences which have been made to date, the relative effects on cost of the different variables have become clear. Minimum costs are not, however, the governing factors in selection of a sequence, but differential costs are used as indicators to show where savings can be made by proper planning. The principal factor in the assessment of a sequence is the preservation of flexibility to meet change in load growth and various conditions of river flow without incurring unnecessary expenditure.

Benefits to be Obtained From the Computer Model

The principal benefit to be derived from the establishment of a model, such as has been described above, is of course the saving of time and man power, and hence of cost in a program which permits such a very broad study of all aspects of system planning. The effects of change in load growth, in river flows, in new designs, and in cost data, can be very rapidly determined. Secondary advantages may also be derived. For instance, financial schedules can also be quickly obtained for each site, and the required diversion and bypass capacities can be obtained for various flow conditions.

The model may also be used to determine the most economic criteria for operation of the system as it exists or will exist in the future. Such operational planning could be done quite easily on a monthly basis, and the cost of using a computer for this purpose would be negligible compared with the value of savings in water usage which could be obtained.

Acknowledgements

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The Hows, Whys and Wherefores of EHV Transmission

C. M. Stairs, *Systems Application Engineering, Canadian General Electric Co. Ltd.*

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

ONE OF the subjects in the electrical power field which has been receiving a great deal of attention in the last few years is that which is described as EHV, or extra high voltage transmission. In the thoughts of many, this appears to be an area of "technological break through" which will result in the imminent development of Canada's vast northern hydro power resources and guarantee cheap power to all her citizens. Unfortunately, as in the case of all such dreams, this panacea is subject to the hard laws of economics and cannot fully live up to the hopes of its proponents.

Purpose

The purpose of this paper is to try to outline the story of EHV, without any glamour treatment, so that its main economic and technical advantages and disadvantages can be understood by those who are not closely associated with the electric power transmission field. It is hoped that this will contribute to a better appreciation of the position which EHV is likely to occupy in the future of the power business in Canada.

At this point it should be stated that it is not the purpose of the paper to delve deeply into the technical aspects of the subject and, indeed, many simplifications are used to achieve the primary aim.

Definition

Having outlined the purpose of the paper, it would seem to be advisable to start at the beginning by defining the scope of extra high voltage transmission. This undoubtedly includes transmission lines and terminal equipment which are operated at voltages that are greater than those which have been used in the past. Beyond this point the definition is not clear, since no quantitative boundaries have been agreed upon. At present, some people consider 275 kv. to be the lower limit of EHV while others feel that nothing below 345 kv. should be dignified by being included in this classification.

In general, as more operating experience is gained at any voltage level, it tends to become accepted as being a normal transmission system voltage and loses its aura. Ten years from now it is probable that EHV will not include anything below 460 kv. and, as the years go by, it is likely to be reserved for higher and higher voltages, with no limit as yet being indicated.

History of Transmission Voltages

Fig. 1[1] shows how the maximum operating transmission line voltage in the world has increased since the beginning of this century. Reflection on this graph will show that there have always been regions of pioneering in the field of EHV, even though, at the beginning, the levels concerned were less than 100 kv. The economic and technical problems involved in venturing into the unknown were, proportionately, just as great in 1900 as they are today. One major difference seems to be that the term "EHV" has only recently been added to the public vocabulary and subjected to the forces of mass advertising.

The Reason for the Historical Increase of Transmission Voltages

The steady rise of transmission voltages which is illustrated in Fig. 1 has, primarily, been the result of the continuing struggle of the electric utilities to supply their rapidly increasing loads as cheaply as possible.

Fundamentally the initial cost of a transmission line varies roughly as the first power of the voltage while its maximum power carrying capability, as limited by stability considerations, is approximately proportional to the square of the voltage. These basic relationships together with the requirements of system reliability, the availability, suitability and cost of real estate and the expected load growth pattern, essentially determine the most economical number of lines and their approximate voltage.

The most economical voltage actually varies with many other things, and each of these must be considered when making a final system evaluation. Among these variables are:

(a) The effects of line length, series capacitor installations, conductor arrangements and the terminal systems on the power carrying capability of the transmission system;

(b) The actual costs of each piece of equipment;

(c) An evaluation of the losses for different conductor sizes and arrangements;

(d) The effect of the expected load factor at which the line will operate;

(e) The interest rates which must be used in comparing various alternatives;

(f) Standard voltage levels in neighboring areas.

It has been the evaluation of transmission system economics in the light of all these factors which has determined the optimum transmission voltage for each application. The same general method has been used for many years, although the numbers have varied considerably as time has gone by. However, it should be noted that technical limitations have never held up the use of higher voltages for more than a relatively short time. The increase of transmission voltages has been determined by existing economic, and sometimes political, factors alone.

Further Comments on the Relative Economics of Different Transmission Voltages

As mentioned previously, there is an optimum voltage for each transmission project, this being a function of a large number of variables. Some of these variables, such as the apparatus and line conductor costs are well defined, but others, like the future load growth pattern and inflation of the dollar, can only be evaluated on the basis of informed judgment. This being the case, the apparent optimum economic solution can only be considered as a best estimate and not as an exact solution.

Fig. 2[2] has been derived from the results of a general economic evaluation, based on a particular set of assumptions, of the optimum voltages for transmission systems which are needed to carry various maximum loads over a range of distances. The most important things to note from this figure are:

(a) As the line length increases the optimum voltage for a given power increases, e.g. the optimum voltage for carrying 1000 Mw. of power over 50 miles is 270 kv. or over 300 miles is 390 kv.;

(b) If the total load is large, the cost of carrying it over one pair of transmission lines is only a little different from that when it is carried over two pairs of lines. For example, for the assumptions of the study, 1500 Mw carried 300 miles over one pair of lines would require 475 kv. and would cost 2.0 mils per kwh., while with two pairs of lines the optimum voltage would be 340 kv. and the cost would be 2.2 mils per kwh.

(c) Since the cost curves are quite flat, a small error in the initial assumptions could possibly result in a wide deviation in the "optimum" voltage for the conditions assumed in this study.

In general it can be said that only in those cases where some factor, such as real estate availability or cost, is truly outstanding does the optimum voltage become clearly enough defined to override the economic unknowns. Because of this, the final selection of the voltage for a transmission system is often made after a consideration of factors which are other than either technical or economic.

Technical Problem Areas

In the preceding sections of this paper, an attempt has been made to emphasize that economic and political factors have dictated when increased transmission voltages should be applied and that technical difficulties have caused only temporary road blocks. This does not mean that technical problems have been lacking but rather that, although it has always been possible to design transmission systems and equipment which would operate satisfactorily at any required voltage level, the costs involved in developing higher voltage systems have often been such as to make their application uneconomical. The major technical problems of EHV transmission have therefore been associated primarily with cost reductions.

At present, some of the technical regions which are receiving a considerable amount of engineering attention, in the interests of improving ultimate system economics, are:

(a) Tower mechanical design safety margins and construction methods;

(b) Line and terminal equipment electrical insulation margins;

(c) Ways of improving protection against lightning, switching surge and abnormal operating overvoltages;

(d) Methods of increasing maximum line loadings by series capacitor applications and improved generator excitation systems:

(e) Reduction of line corona losses and radio noise interference;

(f) Design improvements in all components.

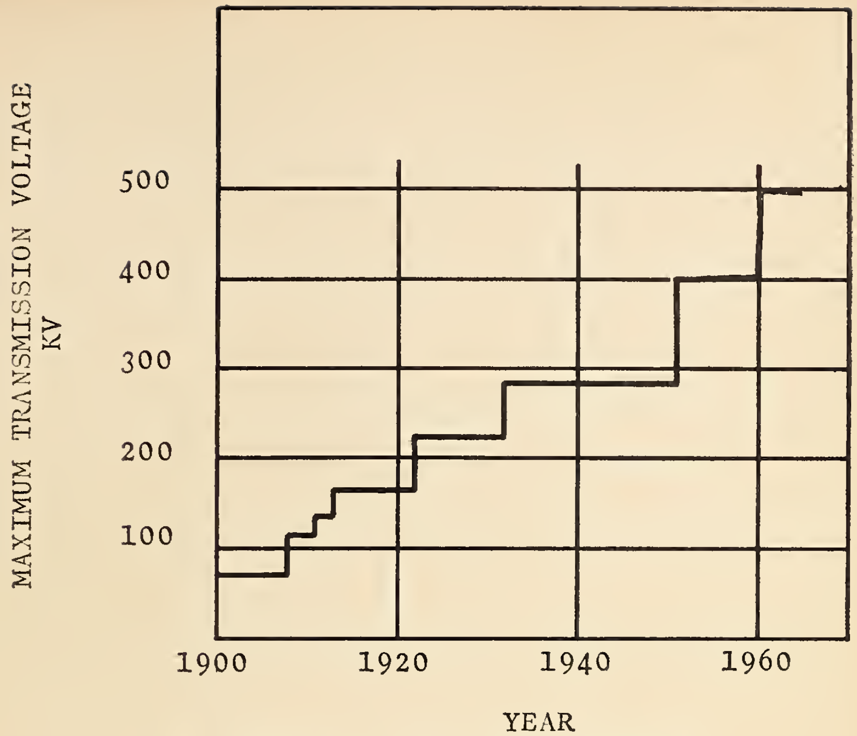

Fig. 1. Historical Growth of Transmission Voltages.

Each of these areas is undergoing extensive theoretical investigation, together with model and field testing, and, as a result of this effort, a large amount of basic knowledge is being accumulated. This will undoubtedly allow lower cost transmission systems to be built in the future.

Since only a relatively small amount of experience has been obtained to date in the EHV area, as compared to the more usual HV regions, it is to be expected that the engineering effort which is now being expended will tend to lower the cost of the higher voltage systems more than that of the lower voltage ones. However the state of engineering refinement at the present time is such that it is doubtful if future transmission systems will cost less than 80% of those which are being constructed today, this 80% figure referring to very long lines with very heavy loadings.

The meaning of this 80% cost figure can be more easily understood if it is expressed in terms of capital cost savings, and the resulting power bill rate reductions which these will allow. In rough figures, the capital cost savings on a 500 mile, 500 kv. two circuit transmission system, capable of carrying about 1800 Mw., might be $30 million. This transmission system saving would allow a rate reduction of only about .04c kwh. to the ultimate user. This indicates that the reduction in power bills which may result from improvements in high voltage techniques cannot be expected to be a major one. However, the capital savings which are possible can easily justify the very substantial research program which is now being undertaken.

D. C. Transmission

Up to this point, only transmission systems which employ high voltage alternating current have been considered, since this is the only type of transmission which has, as yet, been used for other than a very limited number of submarine cables and experimental overhead lines. However, the apparent advantages of direct current over alternating current for transmission purposes has kept D.C. in the foreground of the technical discussions on most recent large transmission projects. The three major advantages of D.C. over A.C. are:

(a) It is a two conductor system rather than a three conductor one and therefore its line costs are substantially lower;

(b) It provides an asynchronous transmission link and hence is not subject to the stability limitations which define the maximum power carrying capability of an A.C. line;

(c) It is not confronted with the line charging problems which introduce serious difficulties into A.C. systems with cables or long high voltage lines.

Unfortunately D.C. transmission has two big disadvantages when compared with A.C. These disadvantages are:

(a) It requires expensive and complicated converter equipment at its terminals to connect it into the sending and receiving end A.C. systems;

(b) High voltage D.C. switchgear, which would allow a D.C. system to be sectionalized for reliability, has not been fully developed as yet.

The latter disadvantage could be solved without too much difficulty if the first did not limit the economic desirability of the D.C. system. It appears at present, however, that D.C. cannot compete with A.C. except where cable links of over 20 miles, or very long overhead lines are to be used.

Thus, again, it can be seen that economic considerations dictate the choice of the transmission system which is to be used. This being the case, the only real hope for D.C. transmission is that its cost will be reduced more than will the cost of comparable A.C. facilities. This is, perhaps, not a forlorn hope since A.C. technology is now much more refined than is D.C. However it should be realized that even if D.C. transmission does become more economical than A.C., it is not probable that the amount of saving will be sufficient to allow any major reduction in the cost of power delivered to the ultimate user.

Conclusions

Some interesting general conclusions can be drawn from an outline analysis of the sort which has been presented in this paper. These are:

1. Economic evaluations will determine the details of the transmission systems of the future, as they did for those of the past. These evaluations decide between A.C. and D.C. systems and will indicate the optimum transmission voltage for each system;
2. If economic factors indicate the need for technical developments these will be forthcoming;
3. Because of increasing system loads the maximum transmission voltage will probably rise steadily;
4. Technical improvements which will provide transmission system savings will, most probably, not greatly reduce the cost of power to the ultimate user.

Future Expectations

As the years go by the electric utilities will be faced with the problem of supplying ever increasing amounts of power to their load areas at minimum cost. To do this, they will have to explore all the possible types and locations of generating plant, and evaluate the cost of the power which can be obtained from each. These evaluations will include not only the generating plants and their necessary hydraulic and civil works, but also the associated transmission systems, since the economic comparisons must be made on the basis of delivered power. Only those plants which can prove their economy will be used. Thus the cost of the required transmission system may prevent the construction of an apparently desirable remote generating plant while indicating that one nearby should be developed. Since extra high voltage transmission systems are not very much lower in cost than are conventional high voltage ones, the advent of EHV will not affect these economic comparisons to a very marked extent. Certainly EHV will not automatically justify carrying power from very distant sites.

Similarly the coming of EHV will not in itself justify the construction of a Canadian grid. This grid will be of economic worth only if each section will result in a saving, in the total cost of power delivered to the users, which is greater than its cost. At present this economic balance appears to be negative, but changing conditions, associated mainly with the magnitude of system generating requirements, could reverse this situation at any time. Therefore, it will be necessary to continually re-evaluate the benefits which would result from the construction of each piece of the grid in order to know when such construction becomes economically feasible.

The development of Canada's remote hydro resources, and the transmission of their power to the load areas, falls into the same category as does the Canadian grid. Some of these sites may never be attractive, on an economic power basis, when compared with generating plants nearer the load areas. Again, in the case of such presently uneconomic sites, a continual re-evaluation of their worth will be necessary to take care of changing conditions, such as system size and load characteristics.

It is hoped that this paper has accomplished its purpose of bringing the significance of EHV into better perspective for those who are not intimately connected with this field of endeavour. If it is desired to investigate the many aspects of this fascinating technical subject in more detail, the list of articles in reference 3 are recommended.

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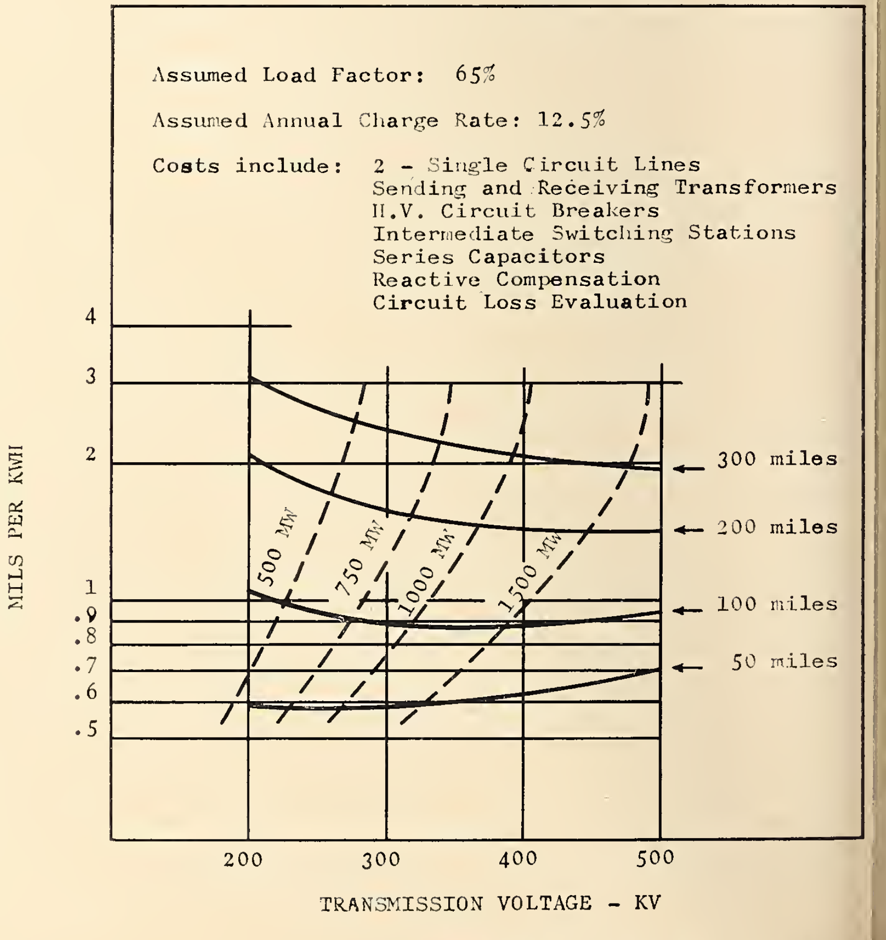
Fig. 2. Electric Energy Transmission Cost vs Voltage.



Structural Design of Tunnels for SOUTH SASKATCHEWAN RIVER DAM

C. Booy, Design Engineer, Prairie Farm Rehabilitation Administration

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THE South Saskatchewan River Dam is an earth fill dam, presently under construction near the town of Outlook in central Saskatchewan, where it will create a large reservoir with a total capacity of 8 million acre-feet. The height of the dam will be 210 ft. and its total volume over 64 million cu. yd. When completed, it will be one of the largest earth dams in the world. The project is being proceeded with under the provisions of an agreement between Canada and the Province of Saskatchewan entered into in July, 1958. The project has been described in general terms by MacKenzie.[1]

At the damsite the river is about 2,000 ft. wide. The irregular valley banks rise at a slope averaging 10 to 1 to the nearly level prairie, which is incised by many creeks and coulees that drain into the river. One of these, Coteau Creek, has formed a deep valley on the west side. The main dam has been located just upstream from this valley so that the proposed chute spillway can discharge into it as is shown on the general plan on Fig. 1. Another depression farther upstream will be used as the spillway approach channel. The spillway itself could thus be located approximately 5,500 ft. away from the river. In the area between the spillway and the river the tunnels are being built, their design is the subject of this paper.

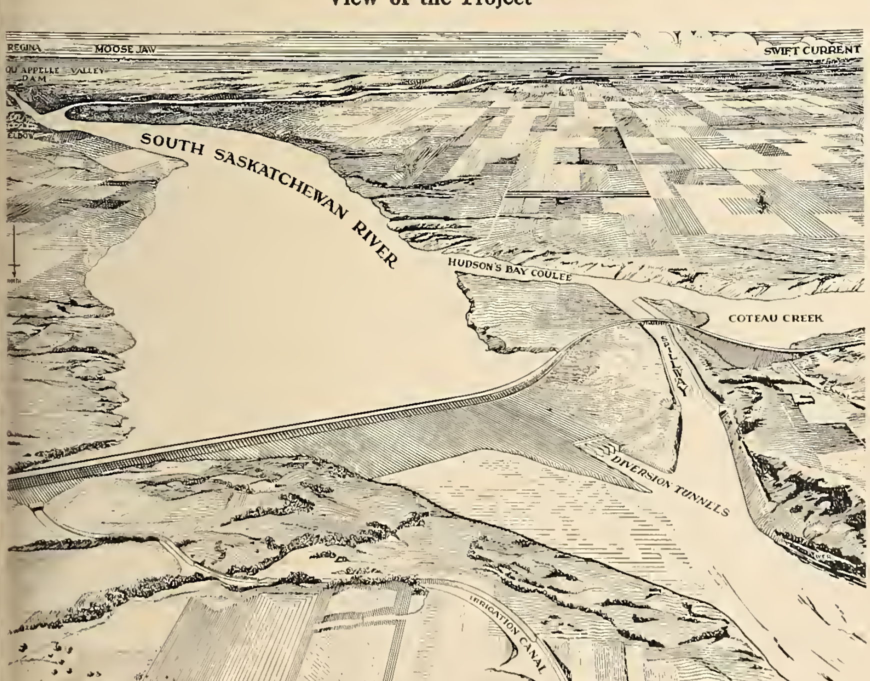
River diversion is planned for the summer of 1963 after the June rise of the river has subsided. Five tunnels, each with a finished diameter of 20 ft. are required to handle the diversion flow. Each has a diversion capacity of 14,000 c.f.s. so that a total outflow of 70,000 c.f.s. can be provided. The tunnels are spaced 100 ft. on centres and average approximately 4,300 ft. in length. All will be equipped with elevated inlets and control gates so that the tunnels will be available for power in 1965 after the diversion period is over. Three will be developed immediately, the other two at a future date as power demands require. The design of the powerhouse and the connecting penstocks will be carried out by the Saskatchewan Power Corporation. This paper will, therefore, deal with the tunnels as diversion structures only.

The use of tunnels as a means of diverting the river during construction of the main embankment seemed at one time a rather natural choice. Bedrock consists of shale which in places outcrops at river level. At the site the river curves somewhat to the west which reduces the required length of tunneling. Tunnels were, therefore, proposed in the earliest stages of the over-all design. Yet, as the investigations and the subsurface explorations developed, more and more difficulties arose until the point was reached where the feasibility of tunnels at this location was seriously doubted.

A description of these problems requires a brief discussion of the geological conditions treated in more detail by Peterson[2, 3] and presented in a companion paper by Pollock.[4]

Bedrock generally consists of Bearpaw shale. In preglacial times this material has been consolidated by sediments over 2,000 ft. thick and in glacial times by ice. The maximum pressure was estimated to be 100 to 150 tons per sq. ft. Under these pressures it became a uniform hard material. Chunks can be broken in the hands but only with difficulty. After the preconsolidation loads were removed rebound action took place. Part of the rebound occurred immediately as an elastic reaction upon the reduction of the load. The remainder, however, is a non-elastic process of volume increase which is characterized by an absorption of water and a softening of the shale to the point where it turns into a highly plastic clay which can easily be remoulded by finger pressure. This is an extremely slow process extending at an ever decreasing rate over thousands of years until at every level an equilibrium is reached between the water content of the shale and its pressure conditions. Possibly this equilibrium is now nearly reached. As a result, the shale beneath the glacial overburden shows a pronounced decrease of water content with depth. The upper layers are soft; they contain slickensides and closely spaced joint planes along which little shear strength exists. The deeper layers become progressively firmer; slickensides and joint planes become less

View of the Project



frequent, and the cohesive strength increases to maximum values of the order of 200 p.s.i. As physical properties of the shale can thus be closely related to the water content an arbitrary division into soft, medium and hard shale, to be used for design purposes, was established on the basis of chosen limits in water content.

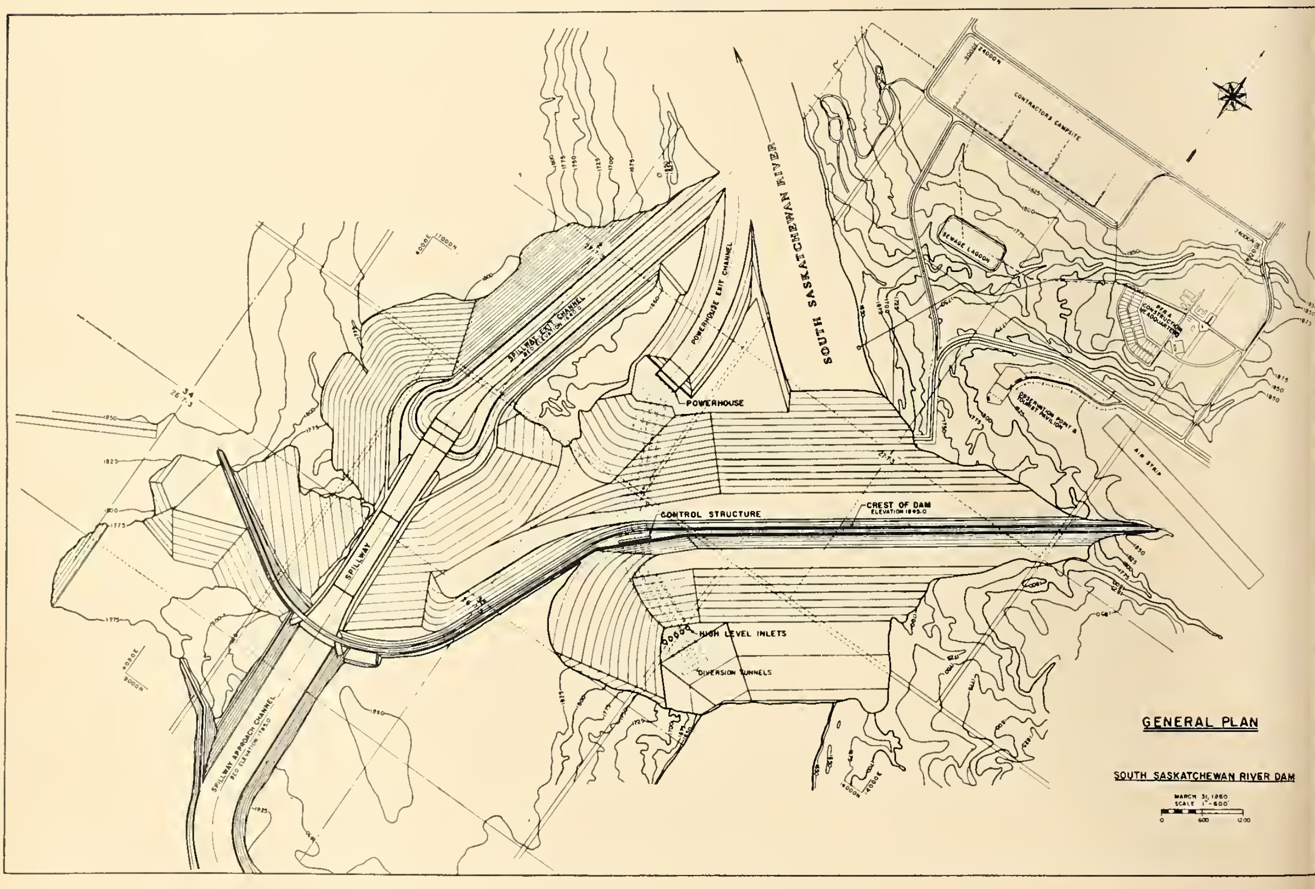
The tendency of the shale to swell after removal of load holds the key to many design and construction problems experienced at this project. In the horizontal layers, away from the river valley, rebound could cause movement in a vertical direction only. The valley, however, provided also a possibility for expansion in a horizontal direction. The consequences of this possibility were twofold. Firstly, the additional expansion caused the layer of soft shale to be thicker at the valley banks than at some distance away from the river as can be seen from the typical geological profile on Fig. 2. Secondly, the movement of the shale towards the river in the form of a slow creep was responsible, according to Terzaghi[5] for the typical slump topography of the valley banks which break away sharply from the nearly level prairie and show numerous troughs and ridges in the overburden mantel and many indications of old slides. Fig. 3 shows typical bank topography. The slides have occurred in the soft shale and have presumably created zones along which very little resistance to sliding exists even at the present time so that any disturbance of the present condition may cause additional movement. This may account for the fact that it was found impossible to predict from laboratory strength tests of the material whether or not excavated slopes would be stable. Instead, a study of existing slopes and field experience had to be used to obtain design slopes for the tunnel portals. It was found that extremely flat slopes of the order of 12 to 1 would be required to ensure stability, particularly where they would pass through thick layers of soft shale. Fairly steep slopes could be used for temporary excavations in the firmer shale. For the final grades, however, it was considered necessary to use flat slopes throughout because of the tendency of the hard shale to soften after unloading.

To evaluate the problems associated with tunneling in this material a 6 ft. wide, 8 ft. high horizontal test drift was excavated about 300 ft. into the valley bank in 1950. It passed through the soft, medium and hard shale to a point where the cover depth was about 65 ft. The drift was braced with heavy timbers except at the end where a special test section was constructed in hard shale for the purpose of measuring soil pressures. The sides, the roof and the bottom of this section were lined with rectangular reinforced concrete slabs. These were braced against each other by means of steel pipe jacks provided with strain gauge measuring points, so that the horizontal and vertical pressures on the slabs could be determined.

Two facts stood out in the experience gained through the test drift. Firstly, it was found that the shale has a tendency to squeeze, especially the soft shale. It moved in between the heavy timbers supporting the sides and the roof and built up pressures that caused them to fail. The total inward movement of both sides in the soft shale zone was as much as 20 in. In the hard shale zone the inward movement was of the order of 2 to 3 in. Secondly, it was found from the test section in the hard shale that, while the vertical pressure corresponded to the overburden load, the horizontal pressure exceeded this by as much as 50%.

The tunnel design was further complicated by the vertical movement associated with the rebound upon unloading by excavation at the portals. Based on laboratory tests and field observations, here and at other locations, it was estimated that initial rates of rebound up to 0.1 ft. per

Fig. 1. General Plan



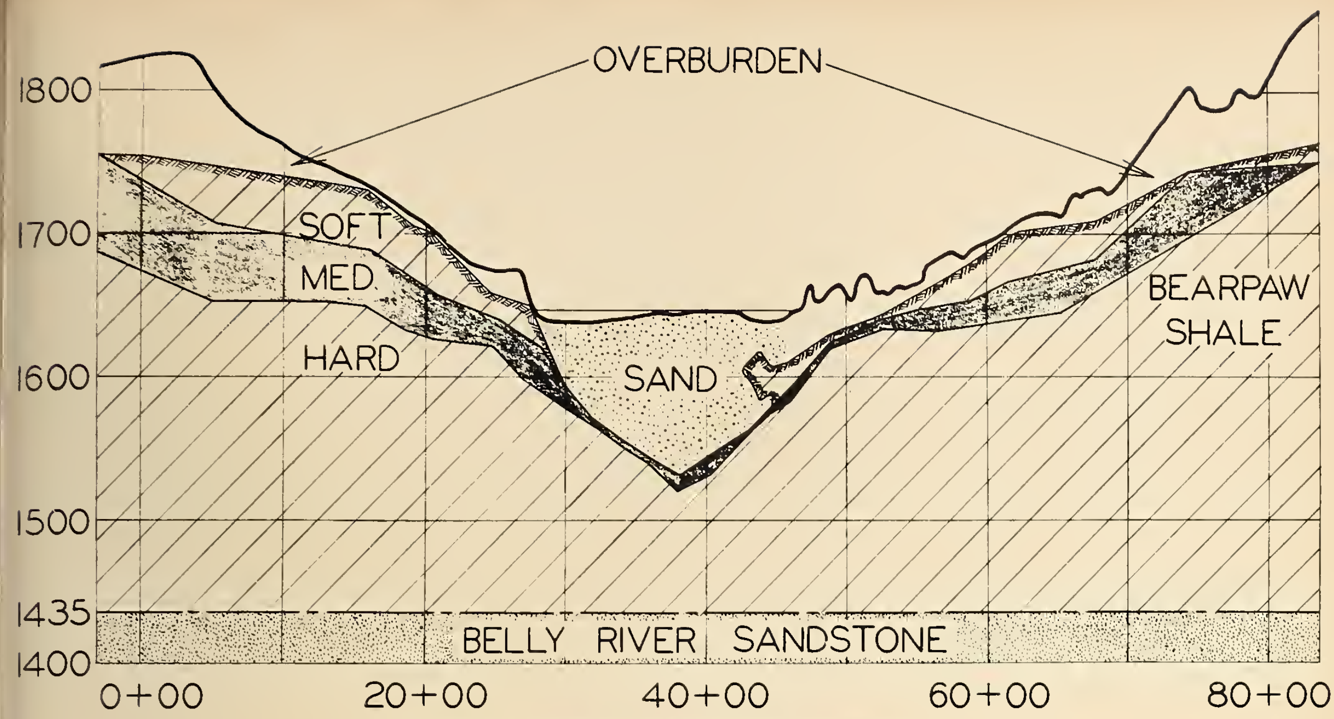


Fig. 2. Typical Geological Profile at Damsite

year might occur in the portal excavations. This created a difficult problem at the downstream end where power penstocks are to be connected to the tunnels after the diversion period is over.

In summary, the situation was thus as follows. The inherent instability of the valley banks made it necessary to avoid deep approach cuts and to use very flat slopes above the firm shale. In addition, as the soft shale was expected to be a very undesirable tunneling medium, the tunnels had to be routed through the hard zones which resulted in much longer tunnels. Furthermore, the occurrence of lateral pressures in excess of the vertical pressures was to be expected and finally, prounounced rebound tendencies near the portals had to be provided for.

In view of these obstacles to the tunnel design, P.F.R.A. started simultaneous investigations on cut-and-cover conduits as possible alternatives. Two types of conduits were investigated: massive 45 ft. high reinforced concrete structures with four 25 ft. diam. circular openings as one alternative, and 20 ft. diam. flexible steel pipes as another. Workable solutions were developed for both types but during their design it became apparent that the ultimate behaviour of such structures, unique with respect to size and loading conditions, could only be determined during or after construction. A consideration of major importance, especially in the design of the rigid conduits, was the expected settlement and the accompanying longitudinal stretch of the foundation under the weight of embankment. The huge dimensions of the dam would make this weight felt at considerable depth so that deep layers would participate in the consolidation and contribute to the resulting settlement and the stretch. While the vertical settlement could be dealt with in various ways, the estimated maximum joint opening of 6 in. caused considerable concern in view of the necessity to keep all joints watertight. Flexible steel conduits would be more suitable in this respect but steel pipes of this size and under such loading conditions meant a considerable departure from anything built so far. In addition, they would not provide permanent outlets for power development.

While these investigations were underway two main developments occurred in the tunnel design. Firstly, it was realized that the tunnels could be excavated in hard shale over their entire length by depressing them below the river level. Secondly, at the Oahe project on the Missouri River where tunnels of approximately the same size were built in more or less comparable soft rock, considerable success had been encountered with a tunneling machine which continuously excavates a full circular bore and enables supporting steel ribs to be placed close to the excavated face. Recent experience there showed a progress of over 140 ft. of tunneling per day under optimum conditions. With such a machine the great length of tunnels did not seem to be as objectionable as before.

The final decision regarding the type of diversion structure was made with the realization that three workable schemes were available, each with a number of unknowns. With tunnels it was felt that these unknowns were mostly associated with their construction, so that a trouble-free structure would be available afterwards. With conduits it was feared that unforeseen maintenance problems might come up at a later date. Economic comparisons did not favor conduits sufficiently to offset this advantage so that the final choice fell on tunnels.

Over-all Layout of the Works

The general design and especially the hydraulic requirements of the tunnels will not be discussed in detail as this paper is limited to the main structural aspects. Fig. 4 shows the layout and a centreline section.

As was explained before, the presence of extensive soft shale layers requires the tunnels to be depressed below river level. The invert elevation was chosen to be 1610, about 30 ft. below the bottom of the river. At the upstream and downstream portals the tunnels rise at a 10 to 1 slope to the required inlet and outlet elevations.

The portal excavations were planned in two stages. The first formed part of an over-all trim on the west abutment to slopes of about 12 to 1, locally steepened at the portals to 5 to 1 and 7 to 1 slopes. In these steeper slopes the actual tunnel portals are cut just prior to construction. The choice of the portal cut location and the necessity to avoid soft shale required the total length of the five tunnels to be 21,600 ft.

At the downstream side a nose in the shale contours permitted the soft and medium shale to be removed in the general area of the portal structures. After construction and backfilling of the stilling basins the final slopes will be very flat so that no future instability should occur on this side.

On the upstream side the tunnel entry structures are located in an extensive excavation in the valley bank which at a future date might cause trouble, especially since not all the soft and medium shale could be removed in this area. For this reason separate permanent intake shafts, to be used later as power intakes, are located approximately 500 ft. downstream from the entry structures. These high level intake structures have their inlet openings 70 ft. above river level, at elevation 1715. This arrangement permits the upstream 500 ft. of the tunnels to be abandoned after the diversion period is over so that the upstream portal excavation can then be backfilled completely to approximately the original ground lines.

The control gates of the tunnels will be placed in central shafts which are located near the dam centreline. Earlier studies have considered the use of upstream gate towers as an alternative. However, the flat slopes made the access problem difficult and the danger of damage by ice ruled this alternative out in favor of central shafts.

The structural design of the various components will be discussed in more detail in the following sections.

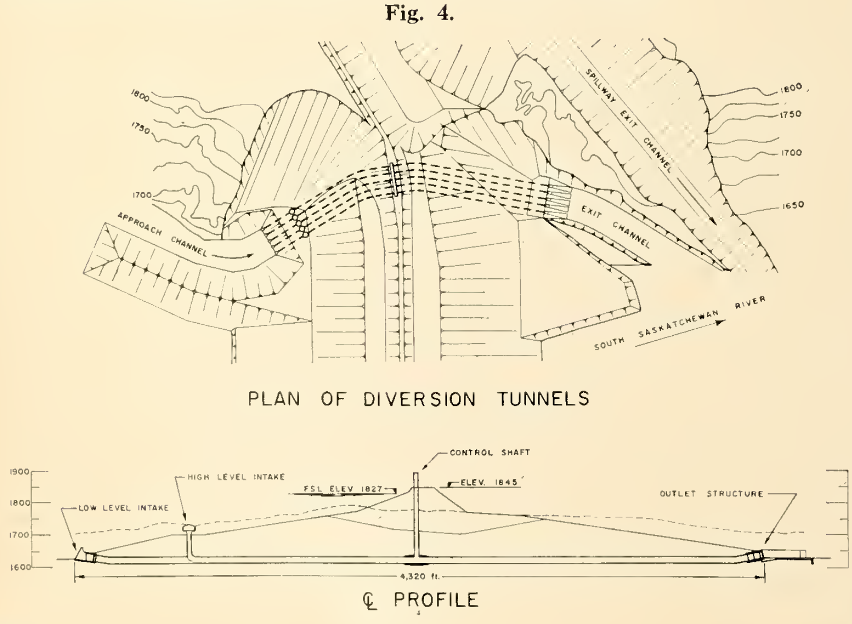
Design of the Tunnels

The design of the tunnels was approached on the threefold basis of empirical knowledge, judgment and calculations. The following account of the design may give the erroneous impression that the principal features were determined mainly from calculations, which is due to the fact that little justice can be done to the other factors in the limited scope of this paper. Actually, throughout the entire design the experience gained in the tunnels of the large Missouri dams and the judgment of our consultants have guided and influenced its evolution to a considerable degree.

Fig. 3. Typical River Bank Topography

From the beginning it was obvious that the shape of the tunnels had to be circular since large lateral pressures might develop on the reinforced concrete lining. In addition, circular steel ring beams could then be used for the temporary ground support, which offer the most efficient shape to resist any squeezing tendencies of the shale. It was decided that the three tunnels adjacent to the river, which would be used for power immediately after completion of the works, would be steel-lined downstream from the central control shafts.

Fig. 4.



The loading conditions for the temporary bracing and the reinforced concrete lining were difficult to determine. The firm shale has the appearance of a soft rock which stands up very well in vertical cuts and shafts if fallouts along joint planes and weathering are prevented. This would suggest that the type of load acting on the tunnel would be a fall-out load. Its magnitude would then depend upon the blockiness of the shale and be lineally proportional to the tunnel diameter. Experience with the test drift, however, indicated that even the hard shale might tend to squeeze into an opening and that horizontal pressures in excess of the overburden weight might gradually build up against a fairly rigid concrete lining. A further indication of this tendency was found in the laboratory where sustained loading tests on laboratory samples of the shale have shown that the shearing strength is substantially smaller for long term loads than for loads of short duration so that a gradual creep toward the tunnel lining may occur. These factors point to the possibility that eventually the pressures on the lining might be related to the local soil stresses as they existed before tunneling rather than to the dimensions of a possible fall-out cone. In other words, the ultimate external pressures might be proportional to the depth of overburden rather than to the bore diameter.

The vertical earth pressure would not likely become more than the weight of overburden including the weight of the reservoir water and of the added fill. This was taken as the vertical design pressure.

The only guidance for the horizontal pressure was the measured value of 1.5 times the overburden pressure which had developed in the experimental section of the test drift. It was realized that this ratio might not apply at the tunneling level where the overburden depth is more than twice the depth at which the test drift observations were made. In addition, considerable relief of locked-in horizontal stresses can be expected where a row of five tunnels will be built, 100 ft. on centres. On the other hand, the evidence of a horizontal pressure considerably in excess of the vertical pressure could not be ignored. It was decided, therefore, to arbitrarily set the ultimate external horizontal design pressure at 1.4 times the weight of overburden at the tunneling level.

For the computation of the vertical pressure the depth of overburden after trimming of the slopes was taken, while for the horizontal pressure the average depth before and after trimming was used. This allows somewhat for the probability that unloading would affect the horizontal pressures less than the vertical. The weight of the reservoir water and the weight of any fill were added to both pressures. Internal hydrostatic pressures were added where this would result in a more unfavorable condition.

It was apparent from the outset that these loading assumptions were very severe and would have required a heavy concrete lining up to 48 in. thick if applied without modification.

It was realized that the design pressures, assuming that they would occur as soil pressures at some distance from the tunnels, would be modified in two ways when transmitted to the lining. In the first place, a ring of shale unloaded in a radial direction by the excavation will be compressed tangentially as the surrounding shale tends to move in toward the lining. It will thus resist, to some extent, the build up of pressure on the lining. In the second place, the tunnel lining will deform somewhat if the pressure in one direction exceeds the other. This deformation will also be resisted by the shale. Where the lining moves outward the deflection will cause the shale pressure to increase and where it moves inward the deflection will cause a similar pressure decrease.

The second type of pressure modification incorporated in the analysis, justified to some extent a welcome reduction of the large differential in horizontal and vertical design pressures. Since the bending moments in the lining are directly proportional to the pressure differential a reduction in lining thickness could thus be obtained. It was found that the effect was appreciable, even though for the shale reaction a conservative value of 60 p.s.i. per inch of deformation was used at every point on the lining circumference. The resulting reduction in lining thickness started something like a chain reaction in that the external diameter and thus the loads could be reduced. In addition, the thinner and more flexible lining increased the effectiveness of the shale resistance to deformation. Thus a lining thickness of 30 in. was found to be adequate. It may be mentioned that the shale reaction of 60 p.s.i. per inch of deformation was applied only in the centre portion of the tunnels; toward the portals where the overburden is less this value was gradually decreased to zero. In the design computations the effect of the shale reaction could be incorporated in a simple way. While keeping the average pressure the same, the pressure difference was reduced by a percentage — which depends on the ratio between the shale reaction modulus and the lining thickness. The modified pressures were then used instead of the original design pressures.

On the basis of the assumptions explained above the required concrete thickness and the reinforcing were determined. It was decided to use a constant concrete thickness throughout and to vary the hoop steel reinforcing in accordance with loading conditions. This would obviously simplify the tunnel construction.

An important question in the dimensioning of the cross-section was what factor of safety, or what unit stresses should be used to compensate for the uncertainties in design and construction. It was decided to use a limit load analysis to determine for a number of cross-sections the range of horizontal and vertical pressures that could be borne without failure of either the reinforcing steel or the concrete. A set of load factors could then be used to express the margin of safety separately for various combinations of loads and to allow for deficiencies in strength of the structure. Thus to some extent consideration could be given to the probability of occurrence of these contingencies.

Fig. 5 shows a typical example of the results of such a limit load analysis in the form of a graph that defines for one section the combinations of horizontal and vertical pressures which would cause failure. After

Fig. 5.

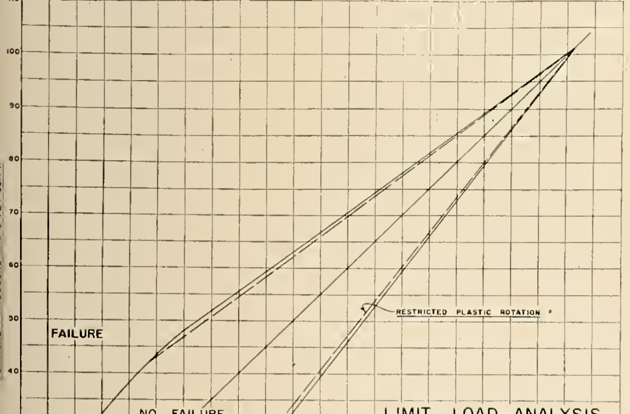
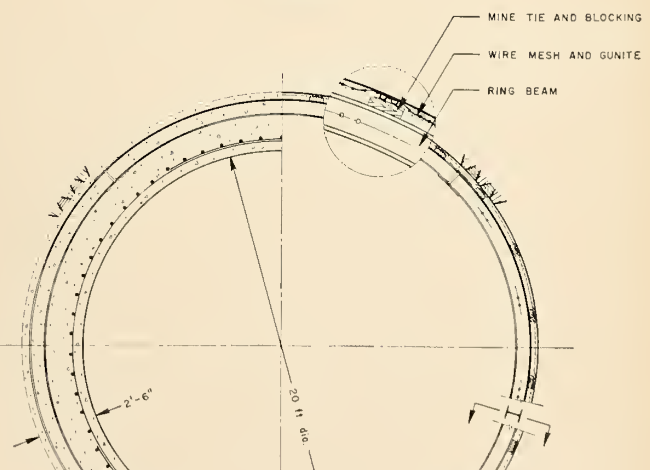
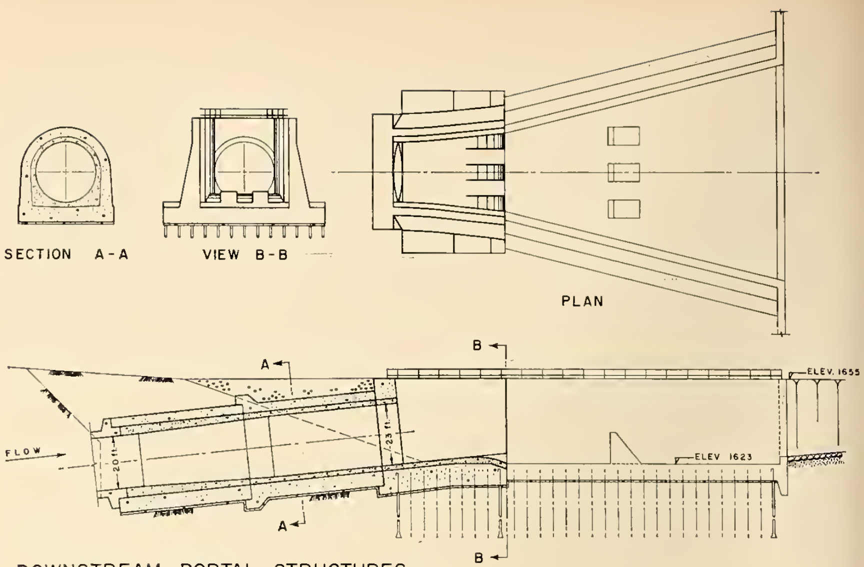


Fig. 6.





DOWNSTREAM PORTAL STRUCTURES

Fig. 7.

multiplying the horizontal and the vertical design pressures on that section with certain load factors which will be discussed below, the point representing the loading condition should fall within the graph.

It may be mentioned that the definition of failure is necessarily somewhat arbitrary. In general, failure occurs when the cross-section yields in four points, at the crown, the invert and at the two sides. Usually yielding does not start in these four points simultaneously. If, for instance, the yield point is reached first in the crown and the invert, the load can still be increased until the sides also start to yield. This process involves a redistribution of the bending moments and rotation in the two plastic hinges in the crown and in the invert. When dealing with the redistribution of the bending moments, two cases were considered. The first case occurred when the plastic rotation caused yielding of the tensile reinforcing without the compressive strength of the concrete being exceeded. In that case some increase in load was permitted. If no restriction were placed on the amount of plastic rotation, the failure load would be reached when a second pair of hinges would form. However, it was considered necessary to limit the amount of cracking associated with the redistribution of the bending moments. The plastic rotation was, therefore, restricted to a maximum of 0.0025 radians. It was estimated that any cracks caused by this rotation would be acceptable under limiting conditions of stress. The second case occurred if the first pair of hinges was formed by plastic deformation of the concrete before the steel reinforcing was stressed to its yield point. In that case the danger of spalling of the concrete and subsequent deterioration of the section necessitated that no further plastic rotation be permitted in that hinge to redistribute the bending moments. Fig. 5 shows the effect of these restrictions placed on the plastic rotation in the form of a broken line which replaces the original solid graph.

It was found after a few trials that a lining thickness of 30 in. would give acceptable amounts of hoop reinforcing steel. With this thickness a number of limiting graphs were computed for various amounts of reinforcing steel after which the distribution of the hoop reinforcing along the length of the tunnels could be determined.

Regarding the load factors, it was considered that the function of a load factor is twofold. Firstly, it ensures that the structure will be adequate in spite of uncertainties in design and construction such as variations in material strengths, approximations and simplifications used in the analysis or adverse conditions during construction. For this reason it was specified that a load factor of 2.0 be applied to the horizontal and the vertical pressures both. Each loading condition was then checked to ensure that the loads multiplied with the load factor would fall within the limits designated by the limit load analysis at every tunnel cross-section. A second function of a load factor is to provide some insurance against unforeseen loading conditions that are more severe than the design loads. In this regard it was considered that the horizontal loads are much more uncertain than the vertical loads. It was decided, therefore, to separately apply a second load factor to the horizontal pressure only. This is a rather severe condition since the greater pressure differential causes the stresses due to bending moments to increase rapidly. A value of 1.5 was considered adequate for the second load factor.

On the basis of the foregoing, it was found that with a lining thickness of 30 in. the maximum hoop reinforcing at the inside face had to be No. 18 bars at 10 in. This maximum reinforcing is required over a short length in one tunnel only. The ring beams for temporary ground support, which will be discussed below, formed sufficient reinforcing for the outside face. The hoop reinforcing was theoretically not required over the full circumference. It is not certain, however, that the direction of the principal stresses on the tunnels will be horizontal and vertical. In addition, it was considered the vertical load may be larger than the horizontal load at some locations, especially during the process of building up stresses on the lining. For this reason the same reinforcing was carried around the entire circumference at any one section.

The temporary ground support consists of primary and secondary bracing. The primary bracing is formed by circular steel ring beams fabricated from W.F. sections. The ring beams will have to support the shale for a relatively short time. It was, therefore, considered that their maximum load would be a function of the bore diameter rather than of the depth of overburden as it would have the character of a fall-out load, increased possibly by the squeezing tendency of the shale. The spacing was tentatively set at 3 ft. A larger spacing will be used if this proves to be feasible during construction. For the purpose of designing the rings a spacing of 3 ft. was assumed. The load on the bracing was taken as the weight of a column of shale two tunnel diameters high, and applied as a uniform pressure all around the circumference. This is a conservative assumption since a fall-out load of that magnitude would be very unusual. However, it takes into consideration the fact that some squeezing of the shale may occur and also that the load will actually be transmitted to the rings via timber blocking. No allowance was made for bending moments which occur between the blocking points. It also provides some margin of safety if the ring beam spacing would be increased to 4 ft. The design requirements were met with an 8 in. W.F. section, weighing 40 lb. per lineal ft.

The ring beams have been fabricated in four segments. Splices have been designed for the full strength of the beams in tension so that the internal hydrostatic pressure could be resisted by the combination of hoop reinforcing and ring beams without having to rely on the external shale pressure to balance the load. For this severe design condition high stresses were permitted on the rings and reinforcing. In addition, the full strength splices make the ring fully available as concrete reinforcing if the direction of the external pressures would cause the maximum bending moments to occur at other points than at the horizontal and vertical diameters. The ring beams will be connected laterally by means of one inch diameter threaded spreader bars provided with nuts on either side, and spaced close enough to exclude the possibility of lateral buckling of the ring if loaded to capacity.

The secondary bracing between the ring beams consists of steel lagging, wire mesh and mortar. In cross-section the lagging resembles a steel mine tie. It weighs about 4 lb. per lineal ft. Wire mesh will be placed behind the lagging. The shale between the ring beams will be covered with pnuematically-applied mortar. The combination of mortar and wire mesh serves the double purpose of preventing fall-out and protecting the shale against deterioration due to drying.

Regarding the construction methods, it should be mentioned that the tunnels will be excavated in sequence starting from the most landward tunnel. The specifications provide that no concrete shall be placed in any tunnel before the adjacent tunnel has been excavated far enough to prevent extra stresses to be transmitted to the concrete due to the arching and doming actions in the shale which accompany the excavation of a tunnel. In tunnels 1, 2 and 3 the steel lining will serve as an interior form downstream from the central shaft. Removable steel forms are prescribed for the remainder. Construction joints are provided every 24 ft. The longitudinal steel will be continuous through these joints.

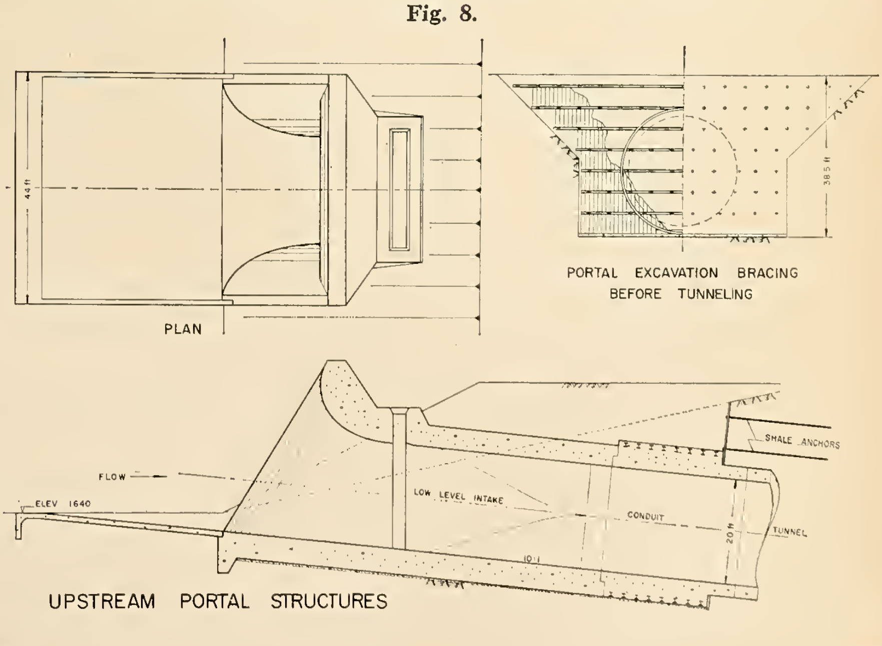
The construction of the tunnels proper has been divided into two contracts. The first covers the downstream tunnels up to the control shafts; the second, the upstream tunnels including the high level intake structures. The downstream tunnel contract was awarded early in 1960. The portal structures have been built and tunneling has started in tunnel No. 5. At the time this paper was written the upstream tunnel contract was not yet awarded.

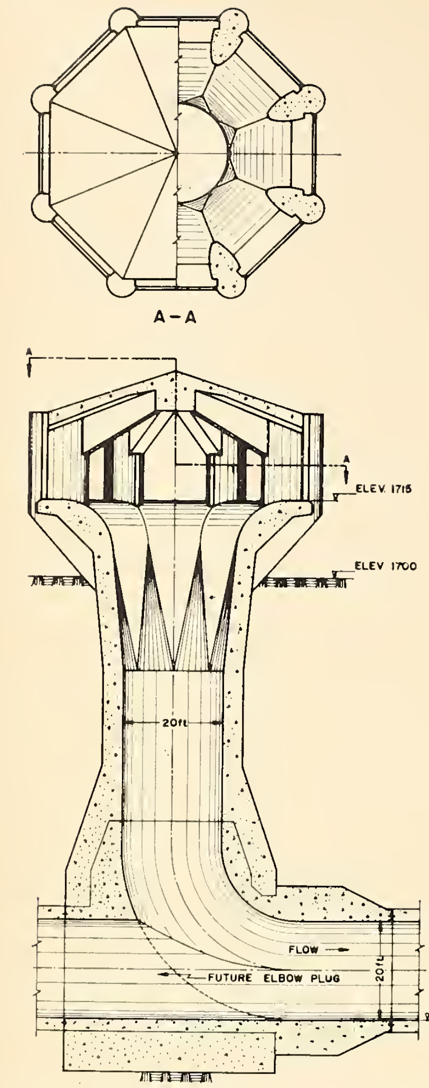
Design of the Downstream Portal Structures

The rebound which is expected to follow the portal excavation has influenced the design of the portal structure to a considerable degree especially since the movement will probably continue over a very long time. Some attempt was made to estimate the rate of rebound and the ultimate magnitude which it may attain. An estimate of the rate was obtained by comparing observed rates of rebound for various depths of excavation at other P.F.R.A. projects on similar foundation materials. It was found that a rate of the order of 0.1 ft. per year might occur in the first years if no counteracting measures are taken. An estimate of the ultimate magnitude of the rebound was obtained from vertical water content profiles of the shale in the following manner. These profiles, taken at various points, show a marked similarity in the way the water content decreases with depth. It was assumed that the average water content profile represents equilibrium conditions and that after excavation the underlying foundation material will tend to absorb water until the equilibrium condition between the pressure and the water content is established again at every point. The entire water content profile would then be displaced vertically downward over a depth equal to the depth of excavation. The total rebound could thus be estimated from the resulting volume increase in the successive layers. No great accuracy can be expected from such a procedure. It indicated, however, that the ultimate rebound might be of the order of magnitude of several feet. As migration of water in the shale is extremely slow the rebound process will take a very long period and extend far beyond the life of the project. The ultimate magnitude was, therefore, of importance only in that it confirmed that rebound would likely be a serious problem. The most troublesome consequence might be that irregular movement might occur. This might take the form of differential movement between blocks of shale bounded by fault planes which would cause abrupt discontinuities. In addition, substantial differential movement would be unavoidable near boundaries of excavation.

For these reasons: to prevent abrupt differential movement, to reduce the rate of rebound, and also, to possibly reduce its ultimate magnitude, it was decided to install 20 ft. hold-down piles below the portal structures and the stilling basins. These hold-down piles will knit a substantial block of shale together and reduce the rate of water absorption in the upper strata by counteracting the swelling. The hold-down piles consist of 1½ in. smooth steel bars placed in 6 in. diam. holes, drilled 5 ft. on centres. The holes are belled out at the bottom and grouted full. The bars are anchored in the bell and in the floor slab of the structure, but asphalt coated through the stem in between. This coating is considered to be necessary. The swelling pressures of the shale, if totally restrained, are too large to be resisted by the anchor bars. The anchor bars are, therefore, expected to be stressed beyond the yield point of the steel. Recent field tests in which hold-down piles were installed and anchored to a concrete slab, have shown that this occurs fairly rapidly. The bars must thus be able to stretch sufficiently to allow some swelling to occur. Field tests have also indicated that the

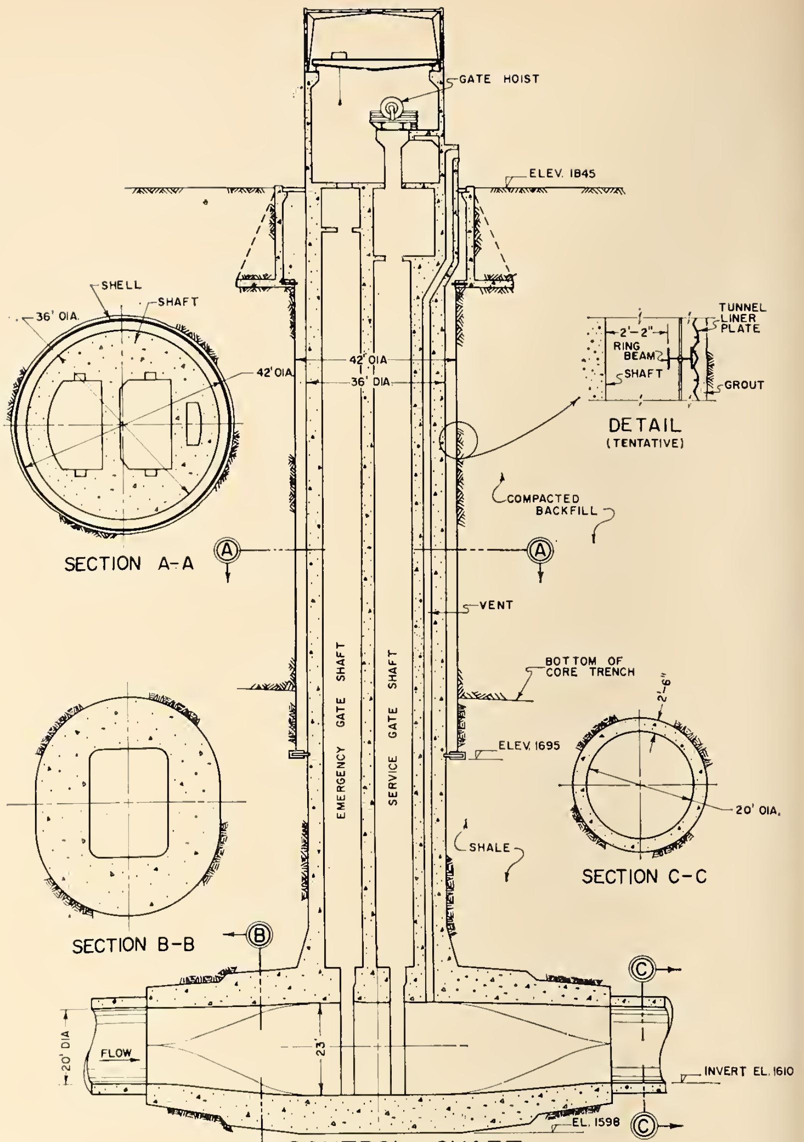
Fig. 8.





HIGH LEVEL INTAKE STRUCTURE

Fig. 9.



CONTROL SHAFT

Fig. 10.

coated bars will stretch more than 10% of their total length before failure. This will be ample to prevent the bars from breaking since the swelling pressure of the shale decreases rapidly with increased moisture content. If the bars were not coated, the bond stresses would cause the yielding of the steel to be restricted to a small length of the bar. The total stretch before failure would then be much less.

Anchor bars are thus expected to reduce the rate of rebound and to make it more gradual. They cannot completely prevent it. Additional measures are necessary to prevent difficulties at the junction of the steel tunnel linings with the free-standing penstocks that connect the tunnels to the powerhouse. The rebound presumably decreases fairly rapidly inside the tunnels. It was decided, therefore, to provide an enlarged section about 100 ft. long near the end of the tunnels in which free-standing penstocks can be installed. These will be placed on cradles that are adjustable in height and are provided with expansion joints to allow some differential movement. The connection with the tunnel lining is thus removed from the area where the greatest differential rebound is expected to occur. The enlarged section, which is built as a cut-and-cover conduit, offers an additional advantage of considerable value. During the diversion period it permits the tunnel exits to be flared to a 23 ft. diam. opening by means of temporary concrete placed in the conduit. This reduces the exit velocity and permits considerable saving on the stilling basin design. In addition, each cut-and-cover conduit provides an excellent tunnel entry structure. Fig. 7 shows a sketch of the downstream portal structures.

The stilling basins at the downstream end of the conduits are of a temporary nature. After the construction period is over they will be partially demolished to make room for the penstocks. These connect the tunnels to the powerhouse, which will be set at an angle with the tunnels and over to one side. Construction of the powerhouse can thus start before the end of the diversion period. One stilling basin may be retained to provide a low level outlet but this has not yet been worked out in detail.

A 50 ft. deep cut into firm shale was required for the construction of each conduit structure. These cuts were excavated over half their height to a 1 to 1 slope; for the remaining part the excavation was vertical. The vertical portions were braced with timber lagging between H-beams that were placed vertically in holes drilled in the shale. The H-beams were tied back at the top to a row of deadmen. In the middle they were supported by a row of shale anchors, 20 ft. long and 5 ft. on centres. These shale anchors consist of 1½ in. diam. steel rods placed in 3⅜ in. holes that were grouted full with an expansive grout mixture. The holes were drilled with an air-driven auger; the use of water was not permitted to avoid softening of the shale in the holes. Load tests on the anchors up to 80 kips showed that 20 ft. bars thus installed will yield and break rather than being pulled out.

Design of the Upstream Portal Structures

Each upstream portal structure consists of a low level intake structure and a tunnel entrance conduit as is shown on Fig. 8. The low level intake structure provides a bell mouth opening which reduces the hydraulic entrance losses, a bulkhead gate slot for closure and a transition section between the square bulkhead section and the circular tunnels. Immediately downstream from this structure a 20 ft. long conduit will be built of steel ring beams 30 ft. in diameter and 3 ft. on centres with steel lagging welded side by side on the perimeter. This conduit terminates against a shale face excavated perpendicular to the tunnel axis in which the tunnel excavation is to start. The conduit and the intake structure will be backfilled prior to tunneling. The purpose of the tunnel entry conduit is to permit a tunneling machine to be assembled behind the intake structure which will have an inside diameter of only 20 ft.

The shale face in which tunneling is to start will be nearly vertical and excavated to a depth of 38½ ft. It will pass through medium and hard shale. To prevent fall-out, the face will be braced with horizontal H-beams and vertical timber lagging that will follow the excavation. The H-beams will be tied back with shale anchors 5 ft. on centres. Collaring will be done in a manner which will allow the shale around the tunnel bore to remain tied back with bracing and shale anchors over the first 20 ft. It is expected that overbreak will thus be minimized and the operation of collaring the tunnel hole simplified.

Design of the High Level Intake Structures

The high level intake structures are thus named to distinguish them from the low level intake structures at river level. Actually the mouth of the high level intake structures is 117 ft. below full supply level and about 80 ft. below the lowest reservoir level anticipated. Fig. 9 shows the general outline of the structures.

Each structure consists of a shaft with a rounded elbow connection to the tunnels at the bottom, and a bell mouth entrance at the top. Over the entrance a roof will be built, supported on piers. This permits trash-racks to be placed at the entrance and bulkheads if necessary. The elbow to the tunnels must, of course, be open to the upstream side during the first year of river diversion. It is expected that the low level intakes in the first four tunnels will be plugged in the second year of diversion. Then the high level intake structures must be able to pass the diversion flow. The fifth low level inlet will be plugged later so that a small riparian flow can be maintained in the river while the reservoir fills up to the high level inlets. The dimensioning of the structures was governed mainly by the necessity of passing the diversion flow, which per tunnel may be twice as large as the maximum power discharge.

The high level intake structures will be built in the following manner. First the shafts will be excavated down to the required depth. They will be braced with ring beams having a maximum diameter of 42 ft. at the bottom. The shafts will then be concreted except for openings and block-outs in the area where the tunnels will be connected. A rigid concrete frame will thus be formed at the bottom of the shafts. This permits the shaft ring beams, that are in the way of the tunneling process, to be cut. The following step is the excavation and concreting of the tunnels up to and past the shaft. The concreting will be completed as far as is required for the first period of low level diversion. Finally, before the switch over from low level to high level diversion, closure blocks must be placed which complete the elbow section. In the first stage of construction block-outs, filled with temporary concrete, are required to prevent feather edging when the closure blocks are poured. The base of the structure has been designed for each stage of construction, using arbitrary loading assumptions that increase in severity. This is in accordance with the probability that the external pressures will build up slowly. Due to the complicated shape several simplifying assumptions had to be made to make even a rough analysis possible.

The superstructure was designed for the possibility that at some time the necessity might arise to dewater the tunnels completely. The intakes would then be bulkheaded by a diver. This would subject the roof and the bulkheads to a water pressure of about 100 ft. Since the roof spans a 55 ft. diam. opening this loading condition required a heavily reinforced structure. The roof was designed as a system of concrete ribs and plates.

Design of the Central Control Shafts

The central control shafts will house the gates required for emergency closure of the power tunnels and the bulkhead gates which are needed to allow inspection and repair. Not all aspects of the gating problems have been finalized so that only the design of the concrete substructure will be discussed here. Fig. 10 shows a sketch of the proposed shafts.

Each shaft will have two compartments: one for the emergency gate and one for the bulkhead gate. In addition, there is the air vent which for gates of this size must be substantial. The shafts reach from the top of the dam at elevation 1845 down to elevation 1598. Extensive excavation and backfill operations have been performed in the general location of the shafts in order to build a cutoff trench for the dam and also to remove soft shale that would endanger the stability of the embankment. In addition, an embankment height of 50 ft. will eventually be added to the original ground surface. In order to accommodate any settlement and horizontal movement in the material surrounding the shafts a flexible steel shell has been provided around each shaft. The space between the shafts and the shells will be approximately 2 ft. wide; thus the shells can follow any movement in the surrounding soil without affecting the concrete structure. It is thought that the space in between be filled with either concrete or sand after a period of 10 or 20 years. The flexible steel shells will extend down to the firm shale, where no appreciable movement is expected to originate. The steel shells will probably be constructed of tunnel liner plate and circular ring beams. The construction procedure will likely be similar to the one described for the high level intake shafts.

Acknowledgements

It has been the author's privilege to describe the design of the tunnels which has been developed gradually and which reflects the thoughts and work of many engineers in the employ of the Prairie Farm Rehabilitation Administration. The author wishes to gratefully acknowledge the liberal assistance offered by the author's colleagues in preparing this paper.

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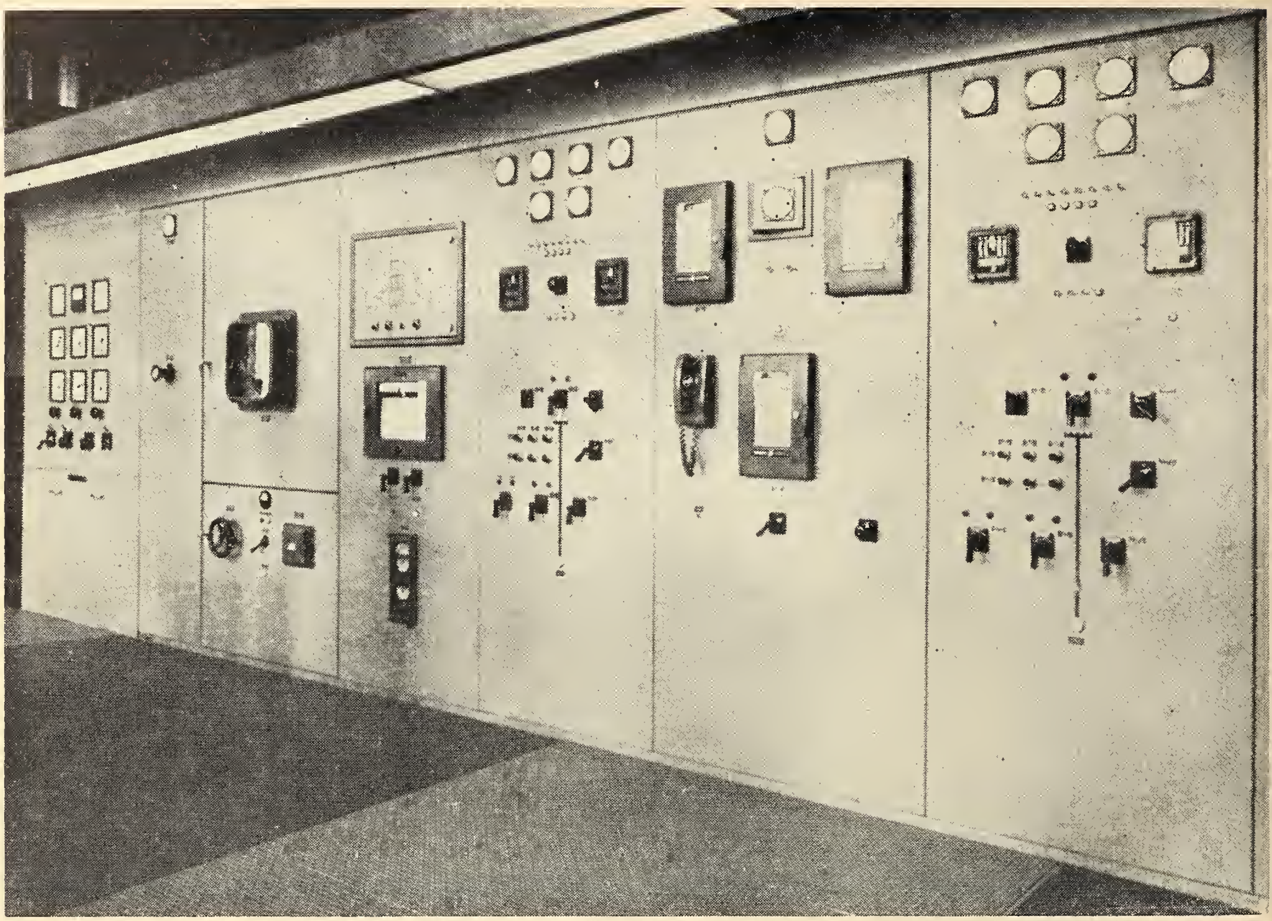

SPEED REGULATION FOR HYDRAULIC TURBINES

J. L. Gordon, JR.E.I.C.,
Supervising Engineer, Civil Section, Montreal Engineering Co. Ltd.

W. J. Smith, M.E.I.C.,
Chief Civil Engineer, Montreal Engineering Co. Ltd.

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IN THE ANNALS of technical publications available to the engineering profession, there are many and varied papers dealing with specific aspects of speed regulation, selection of inertia constants for machines, power surges and the like. The authors have felt the need of a concise summary of the approach to this phase of hydroelectric station design. It is recognized, and indeed emphasized, that the use of unfamiliar formulae and graphs may be dangerous, if not used or supervised by those experienced in such design. However, it is essential that there be a standard approach in order to instruct engineers, facilitate checking and provide an orderly method of recording design tests and experience. The authors make no pretense at having developed new theories; rather have they condensed known methods of calculations in a form which can readily be used without lengthy and laborious calculations.

Nomenclature

H = rated head of turbine
L = length of water conduit
L_p = length of penstock
L_s = 1/2 length of scroll case
L_r = length of surge tank riser
T'_c = time required for wicket gates to reach new gate position, excluding the governor dead time.
T = $T'c + 0.25$ seconds dead time
T_c = total governor time
T_g = $T_c + 0.25$ seconds dead time
T_e = effective governor time
h = waterhammer, expressed as a fraction of the net turbine head
N_0 = Normal r.p.m.
N_2 = max. or min. transient r.p.m.
WR_2 = inertia of rotating parts in foot pound units
T_s = start-up time of the unit $= WR^2N^2/1.6 \times 10^6 \times HP$
n_s = unit specific speed
T_p = start-up time of pipeline $= LV/gH$
V = average water velocity in conduit
ϕ_1 = initial load on unit expressed as a fraction of full load
ϕ_2 = final load on unit expressed as a fraction of full load

Assumptions

The formulae used in this paper are based on certain assumptions which are listed below

(a) Isolated units.

(b) Step load changes of a sustained nature.

(c) Purely resistive loads.

(d) Governors with compensating dashpots.

(e) Constant turbine efficiency during load change.

(f) Constant power output independent of speed.

The last two assumptions are only true for very small load changes. Where there is a substantial variation in efficiency or output characteristics during the load change, corrective factors must be introduced to allow for these changes. These factors are summarized later.

Also for the first part of this paper only reaction and propeller type turbines are considered. For impulse type units, certain modifications have to be made in the design procedures which are covered later.

General Formulae

When the load on a unit is suddenly reduced from an initial load of ϕ_1 to ϕ_2, during which time the speed rises from N_0 to N_2 then the increase in kinetic energy of the rotating parts will be

$$WR^2(N_2^2 - N_0^2)/5870$$

the power surplus from the turbine will be:

$$= 550T\,\text{HP}\,\frac{(\phi_1 + \phi_2)}{2}\,(1 + h)^{3/2}$$

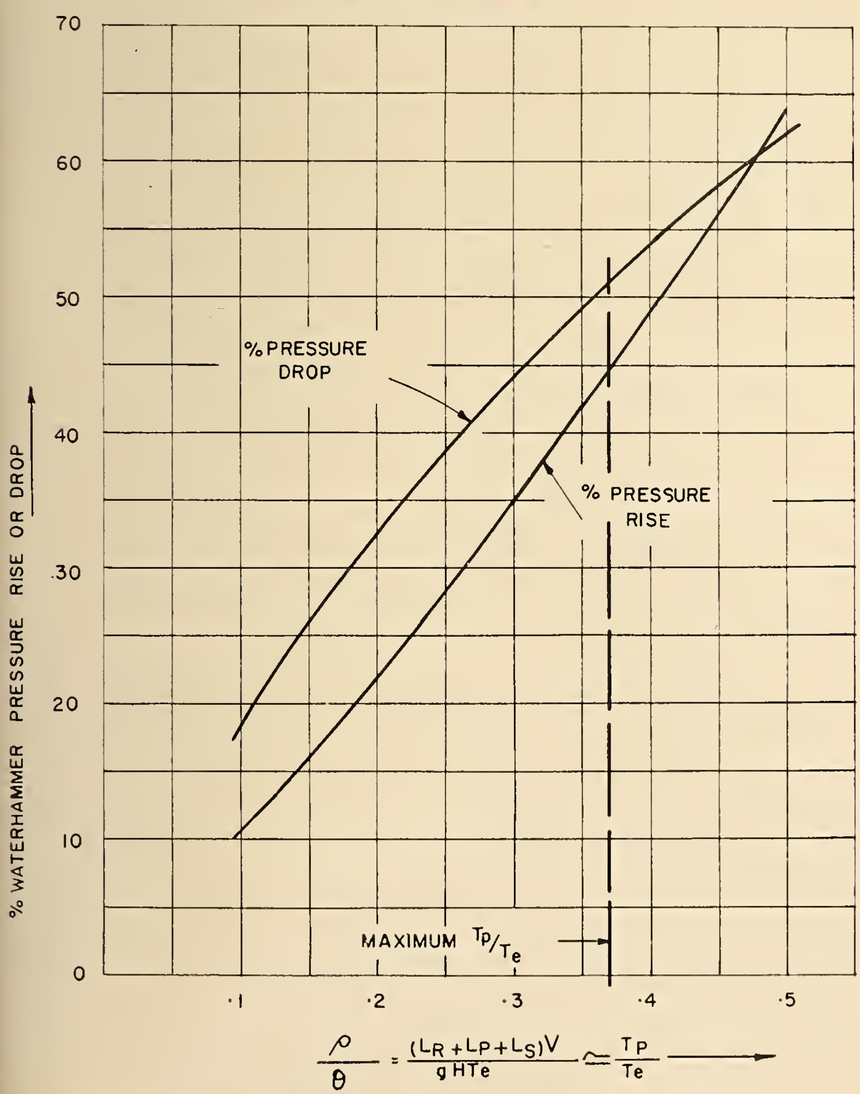
Equating and reducing

$$\left(\frac{N_2}{N_0}\right)^2 = 1 + \frac{T}{T_s} \times \left\{(\phi_1+\phi_2)(1+h)^{3/2} - 2\phi_2\right\}$$

Similarly for load on

$$\left(\frac{N_2}{N_0}\right)^2 = 1 - \frac{T}{T_s} \times \left\{2\phi_2 - (\phi_1+\phi_2)(1-h)^{3/2}\right\}$$

Fig. 1. Waterhammer



The use of these formulae require a study of the water hammer factor (h) and the fractional governor time (T).

Waterhammer Factor — Full Load Rejection or Acceptance

The waterhammer under full load changes from or to zero can be determined from Allievi charts. Where these are unavailable, Fig. 1 may be used. In using this figure, it should be pointed out that the simplification of using T_p divided by T_e foregoes the calculation of the wave velocity (a). This is accurate for normal governor closing time.

When using the Allievi charts, two penstock characteristics are used namely, ΣLV and $\Sigma L/a$. The former is the summation of LV in the complete conduit to the draft tube exit. The latter is the summation of L/a in the conduit to the wicket gates where the waterhammer wave originates. Accordingly, in using Fig. 1 the factor V is the average water velocity to the draft tube exit and the L is the length of the conduit to the wicket gates.

The governor time used is the effective governor time representing the most rapid rate of change of the wicket gate opening. The relationship between effective and total governor time depends on the cushioning at the end of the closing stroke and the effect of the dashpot. These factors are almost constant for a particular unit and accordingly their effect is more pronounced with fast governor settings than for slow. The relationship between effective and total times can be obtained from Fig. 2, if no more precise information is available from the manufacturer of the particular turbine under question. The graph is based on general information received from manufacturers combined with results from one actual test. The results using the chart are considered to be much more accurate than those obtained using the effective time =60% of total time as is often recommended.

Waterhammer Factor — Partial Load Changes

For part load changes the waterhammer will be somewhat less than that for full load changes. For small load changes the wicket gate movement is under the control of the governor dashpot and the maximum rate of movement will not be attained. Thus for small load changes, the waterhammer may only be 10% or 20% of the full load waterhammer. As the load change increases, the dashpot will eventually bypass allowing the wicket gates to move at maximum rate of travel. This produces a waterhammer equal to that on full load change. However, the average waterhammer which applies over the load change is somewhat less than the full load waterhammer.

To study the waterhammer for partial load changes, it is necessary to know the time of wicket gate movement for the partial load changes. This time is made up of two components

1. The dead time of about 0.25 seconds required for the governor flyballs to initiate movement of the gates;
2. The time of travel of the gates to the new load position.

Fig. 3 shows the relationship between the time of travel of the gates and the percent load change for various total governor times. These curves are based on load changes to and from zero load and have been derived from information supplied by the Woodward Governor Company. The value of the term T may be read from Fig. 3. For example, a unit with a 5-second governor time (total), will take 2.1 + 0.25 (dead time) = 2.35 seconds to reach the new load position on a 25% load change.

The dotted line shown on Fig. 3 gives the approximate average waterhammer for such part load changes, expressed as a percentage of a waterhammer under full load change. For example the average waterhammer that would occur during the same 25% load change on a unit with a five-second total governor time would be 60% of the waterhammer attained under full load change.

For load changes other than those to or from zero, the waterhammer will differ from the values given in Fig. 3. This is because the time factor will be different. In the upper ranges of load changes, the dashpot effect will be similar but the servomotor cushioning effect will be absent. However, use of Fig. 3 will give reasonably accurate results since a change in time has compensating effects i.e., shorter time produces higher waterhammer but less speed change and vice versa.

The importance of the foregoing is that there is a marked reduction in waterhammer for a part load change when compared to that for a full load change. Failure to take this into account when computing the transient speed due to small load changes can lead to erroneous results.

Speed Rise on Full Load Rejection

It is recommended that for calculations of speed rise for full load rejection, the method outlined in the USBR Engineering Monograph No. 20 be used. For handy reference this procedure is reproduced below

(a) Determine $K = (T_g/T_s)$

(b) Determine S_r from Fig. 4 using n_s and K where S_R is the speed rise in percent of normal speed for full gate load thrown off to zero with no waterhammer.

(c) $T_p = (LV/gH)$ = start-up time of pipeline

(d) $k = (T_p/T_c)$

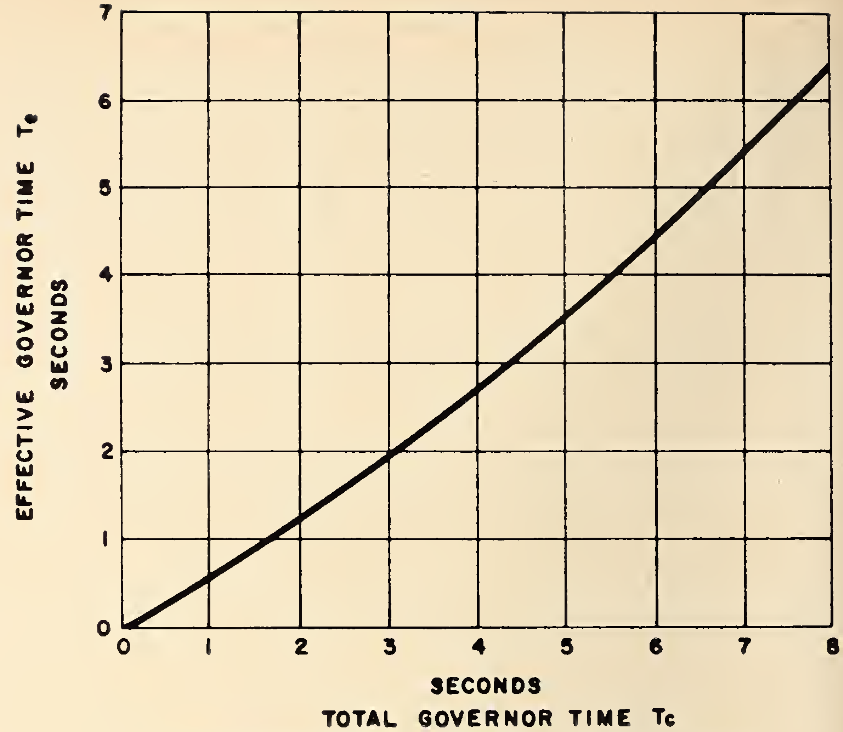


Fig. 2. Relationship between total and effective governor times

(c) $S'_R = S_R(1 + k)$ – speed rise including effect of waterhammer for full load thrown off to zero.

Speed Variation Due to Partial Load Change

The general formulae presented earlier in the paper can be used for calculating speed changes for partial load changes using the information in the charts.

It should be noted here that for 50% load on from zero the general formula reduces to

$$\left(\frac{N_2}{N_0}\right)^2 = 1 - R\frac{T}{T_s}$$

where $R = 1 - 0.5(1 - h)^{3/2}$

Since this calculation is frequently referred to in general appraisals of speed regulation, a plot of R versus waterhammer h has been prepared and is shown on Fig. 5.

Application of Charts

(a) *General Considerations:* In the early stages of hydroelectric plant design, the designer is faced with a study of a number of elements which are interdependent. Many of these centre around the subject of speed regulation including penstock design, surge tank design, waterhammer, governor operating times, selection of generator inertia and a study of load characteristics.

To have a direct approach to these problems, certain assumptions based on experience are necessary. The basic variables which enter into the calculations are waterhammer, surge and allowable speed variation. It has been found that satisfactory performance will be attained if the pressure and speed variations are not excessive as outlined by the following conditions

(1) *Pressure*—A turbine governor will function correctly if the pressure changes at the spiral case do not exceed 50% of the gross turbine head. A 50% pressure change is defined as follows

(i) For plants with surge tank

$$H_s + H_w \ngtr 0.5H_G$$

where H_s = rise in surge tank above normal operating level.

H_w = waterhammer surge.

H_G = Gross head on turbine measured from normal operating level in surge tank to tailwater level.

(ii) For plants with no surge tank

$H_w \ngtr 0.5H_G$

where H_w = waterhammer surge.

H_G = Gross head on turbine measured from forebay level to tailwater level.

This condition must be satisfied for both high and low reservoir levels. In general, it is sufficient to check for full reservoir only, except in the case of low head plants with a surge tank, when the surge rise H_s represents an appreciable proportion of the total allowable pressure change.

(2) *Speed*—This condition depends on the characteristics of the system. If the machine is the only unit supplying

power to an isolated load, it must be able to accommodate large load changes. This calls for a greater inertia than if the unit were supplying power to a system where a large load change would be distributed among all the units on the system. Accordingly, the allowable speed fluctuation for a load change on an isolated unit is smaller than that for the same load change on a system unit with calculations based on isolated operation.

An isolated unit may be defined as one in a system of not more than two units, or where the unit represents more than 40% of the total system capacity.

It is recommended that speed variations be kept within the following limits:

(i) Speed rise on 100% load-off should not exceed 40% for independent units, 45% for system units.

(ii) Speed drop on 50% load-on should not exceed 25% for independent units, 40% for system units.

Where a unit will be interconnected with a very large system, and is intended to operate on base load only, the above conditions do not necessarily apply.

(b) *Design Procedures:* The following step-by-step procedure for designing the main elements of a hydroelectric station satisfies the general conditions described above and results in the most satisfactory and economic combination of the variables:

(i) Determine economical penstock diameter, size of surge tank, etc.;

(ii) Where there is surge tank, determine the surge height H_s for 100% load rejection;

(iii) Assume several effective governor times and determine the waterhammer (by Allievi or otherwise) for each case;

PART LOAD GOVERNOR TIMES AND WATERHAMMER

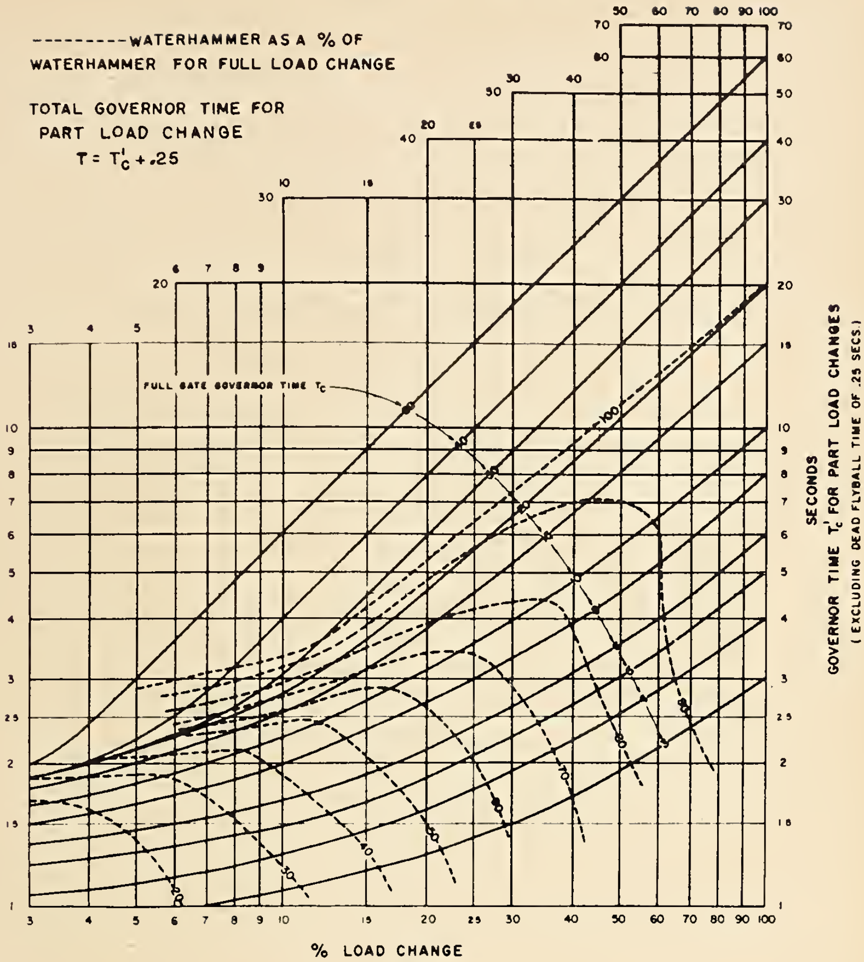
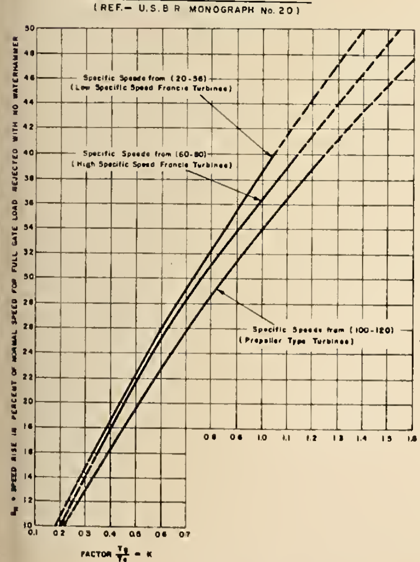


Fig. 3.

Fig. 4.

REACTION TURBINES
SPEED RISE ON 100% LOAD OFF
(REF.— U.S.B.R. MONOGRAPH No. 20)



(iv) Draw a graph of waterhammer plus surge for plants with a surge tank, or for waterhammer only for plants without a surge tank, against the effective governor time;

(v) From the graph select the effective governor time to suit the allowable pressure rise;

(vi) Assume several generator WR^2, and determine the speed rise for 100% load rejection as outlined above;

(vii) Draw a graph of generator WR^2 against speed rise;

(viii) From graph select WR^2 which suits allowable speed rise;

(ix) From the Allievi charts determine the negative waterhammer for full load on in the governor time (similar calculation to "iii" above). Under this condition the negative waterhammer surge line must safely clear the conduit, if vacuum relief valves are not used. This may require a governor opening time different from the closing time.

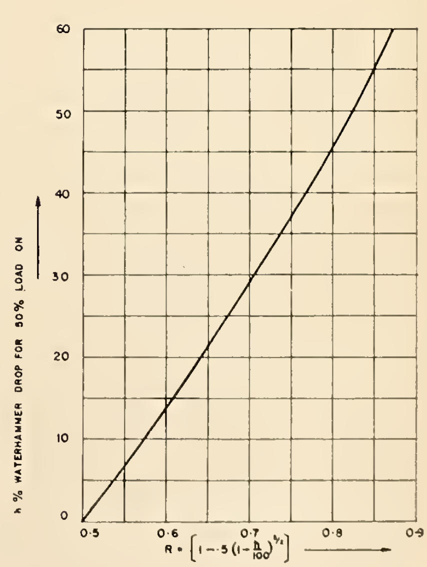
(x) Determine the speed drop for a 50% load on as outlined above;

(xi) Check against allowable speed drop.

In some cases it will be found impractical to obtain the allowable speed variations with the economic diameter of penstock selected. In such cases an

Fig. 5.

50 % LOAD-ON CHARACTERISTIC "R"



economic study must be undertaken to select the necessary change in penstock diameter and/or generator inertia.

In the check of item (ix) above, the negative waterhammer gradient must be applied below the level of minimum drawdown in the surge tank.

If the surge tank is designed for a part load acceptance, say 25%, and if the unit is not limited in the amount of load which can be suddenly applied, the tank could be emptied with possible damage to the pipeline and penstock (depending on the profile). If a check indicates that such damage is possible, protective devices must be added to the plant control to keep the load acceptance within the surge tank limitation.

Correction Factors

In the development of the general formulae for speed regulation, it was assumed that turbine torque and efficiency did not change during the transient state. This assumption is essentially correct for load changes less than 10%. For larger part load changes a correction factor may be necessary. The following consideration of these factors only accounts for the turbine variables; other variables external to the unit, such as variation in load torque with frequency, are not considered in this paper.

Fig. 6 illustrates a typical relationship between speed, torque and power. This curve shows that the power output decreases if the speed deviates up or down from synchronous. Accordingly, the variation in torque decreases transient speed rises and increases transient speed drops.

Fig. 7 shows typical efficiency curves which show efficiency increasing with load except near full load (at which point a unit is normally not regulating large load changes). The effect of efficiency variation thus reduces the transient speed changes in either direction.

If the turbine is a Kaplan type the correction for efficiency is further complicated because of the two methods of control by blade and wicket gate adjustment. Normally, the runner blades are timed to move at the same rate of travel as the wicket gates on gate opening. Thus during a load increase the unit will always be operating at its peak efficiency. However, on gate closing, the runner blades are timed to move at about one fifth to one sixth the rate of travel of the wicket gates. Hence on a load rejection a Kaplan unit will momentarily behave like a fixed blade propeller, having a large temporary reduction in efficiency which contributes towards reduction of the speed rise.

The transient speed variation may be expressed as follows:

$$N^2 = N_0 \pm \Delta N$$

where ΔN is the change in speed as previously calculated.

Introducing the correction factors, for a load rejection, with consequent rise in speed.

$$N^2 = N_0 + \Delta N C_e C_t$$

where C_e = average efficiency during the load change, expressed as a fraction of the peak efficiency during the load change.

C_t = average power output during the speed drop expressed as a fraction of the synchronous speed power.

Similarly for a load-on with consequent speed drop:

$$N_2 = N_0 - \Delta N C_e / C_t$$

Notice that on a load rejection, the effects of torque and efficiency characteristics combine to reduce the speed rise, whereas on a load-on, the effects of torque and efficiency characteristics tend to cancel each other out.

The correction factors are included in the USBR curves (Fig. 4) for full load rejection.

Impulse Units

The foregoing discussion applies to reaction and propeller turbines. For Impulse units the theory still applies with certain modifications. The authors have not completed the assembly of test data which it is hoped will confirm a theoretical approach to the calculations for Impulse units. Accordingly, this paper only refers to the modifications to the formula that must be considered.

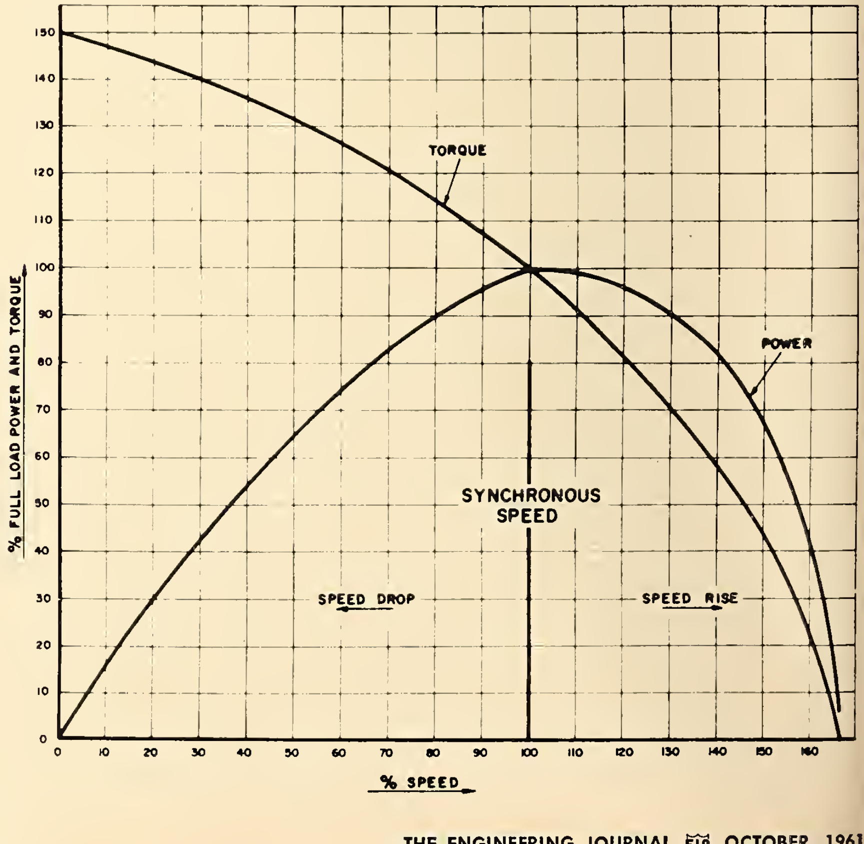
The speed of an Impulse unit is controlled both by the deflector which intercepts the jet, and by the needle valve. The action of the deflector is extremely fast, being capable of cutting off the jet in about two seconds. The action of the needle valve is comparatively slow on closure (about 20 to 30 sec.), to minimize the waterhammer, but relatively fast on opening to reduce the speed drop on a load-on condition.

In the general equations for speed regulation, the governor time should be a proportion of the deflector time for load-off and of the needle valve time for load-on.

As far as waterhammer considerations are concerned, the effect is probably negligible on load rejection since the needle valve has barely started to move by the time the deflector has cut the jet. On load acceptance, the negative waterhammer effect has the same relation as it has with Francis and propeller wheels.

On load acceptance, the calculations are further complicated by the fact that the discharge through a needle valve is not linearly proportioned to the stroke as is approximately the case for wicket gates. There is a rapid rate of change of flow with stroke at the beginning of the opening of the needle valve, and the

Fig. 6. Speed-torque-power relationship



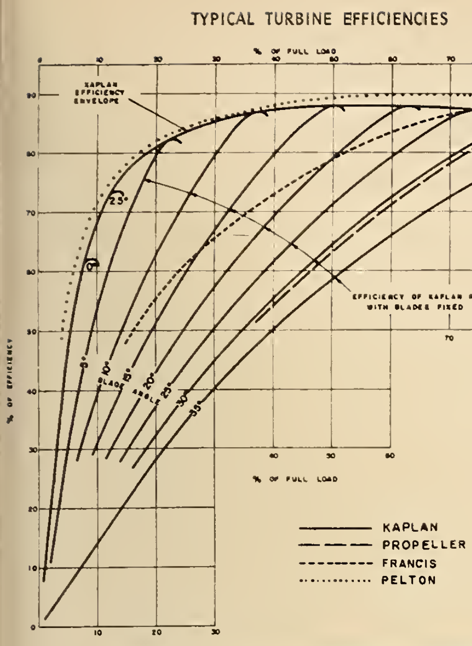


Fig. 7. Typical turbine efficiencies

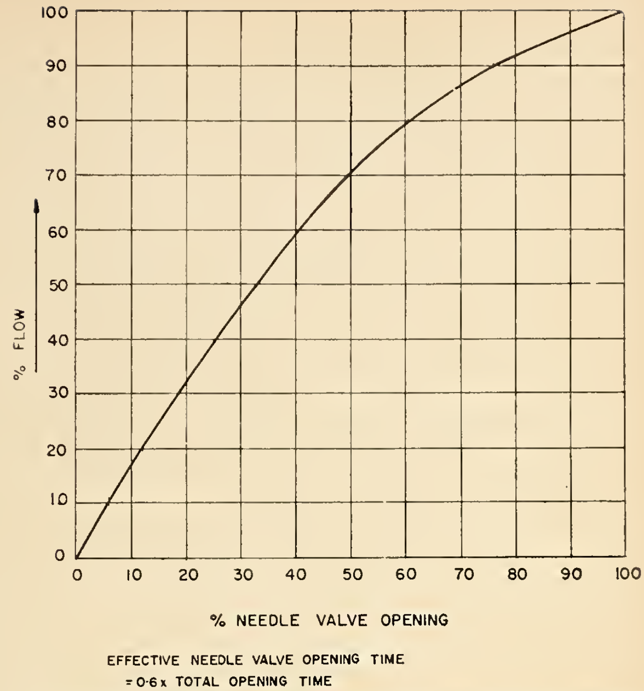


Fig. 8. Impulse Turbines needle valves flow—stroke relationship

rate of change of flow decreases as the needle valve is further opened. This effect is illustrated in Fig. 8 which shows a plot of flow against opening as measured by needle stroke. Thus if the needle valve is timed from 25% open to 75% open at say five seconds, to give a total opening time of ten seconds, the effective time as far as waterhammer is concerned will be 60% of the total time or six seconds. Also the maximum effect of waterhammer will be felt at the beginning of the stroke with this effect being progressively smaller for loads-on from higher needle valve openings.

The other factor that should be taken into account with Impulse wheels is the windage effect. The speed change obtained from the formula should be modified by a windage correction factor.

When test information is available for the above factors, it should be possible to modify the general equations for calculation of speed regulation for Impulse turbines.

Conclusions

The calculations of speed regulation for hydraulic turbines can be readily assumed by the use of simple formulae and charts as indicated in Appendix I.

A design procedure is outlined which enables the engineer to consider in their proper perspective all of the interrelated factors that must be studied in connection with speed regulation. Since these factors represent the main elements of hydro electric station design a proper appraisal is of the utmost importance.

Criteria necessary for the design procedure are presented. These criteria are based on an analysis of over forty hydro electric developments engineered by the authors' company.

There is apparently very little test data on speed regulation available to the engineering profession. The test information given in Appendix I, although admittedly not precise, is encouraging and tends to confirm the theoretical analysis. It is the authors' belief that owners should be persuaded to carry out similar tests and make it available to those concerned with this important and interesting aspect of hydro electric design.

APPENDIX I

Test Results

Unit—vertical Kaplan rated at 7500 h.p. at 300 r.p.m.

Total governor time 5.4 seconds.

$$T_s = 5.6 \qquad (T_p/T_e) = 0.372$$

Determine the minimum transient speed when the load on one unit is reduced to 500 kw. from 2600 kw.

$$\phi_1 = 0.482 \quad \phi_2 = 0.093 \quad \Delta\phi = 0.389$$

From Fig. 3

$$T = 2.85 + 0.25 = 3.10$$

$$H = 0.75 \times 0.45 = 34\%$$

Substituting in the formula for load-off

$$\left(\frac{N_2}{N_0}\right)^2 = 1 + \frac{3.1}{5.6} \times \left\{(0.482 + 0.093)(1 + 0.34)^{1\cdot5} - 2 \times 0.093\right\}$$

Solving $N_2 = (1 + 0.179)N_0$

Applying the corrections and bearing in mind that a Kaplan unit momentarily behaves as a fixed blade propeller on load rejection.

Torque correction $C_t = 0.97$

Efficiency correction $C_e = 0.71$

$$N_2 = (1 + 0.79 \times 0.97 \times 0.71)N_0 = 1.122N_0$$

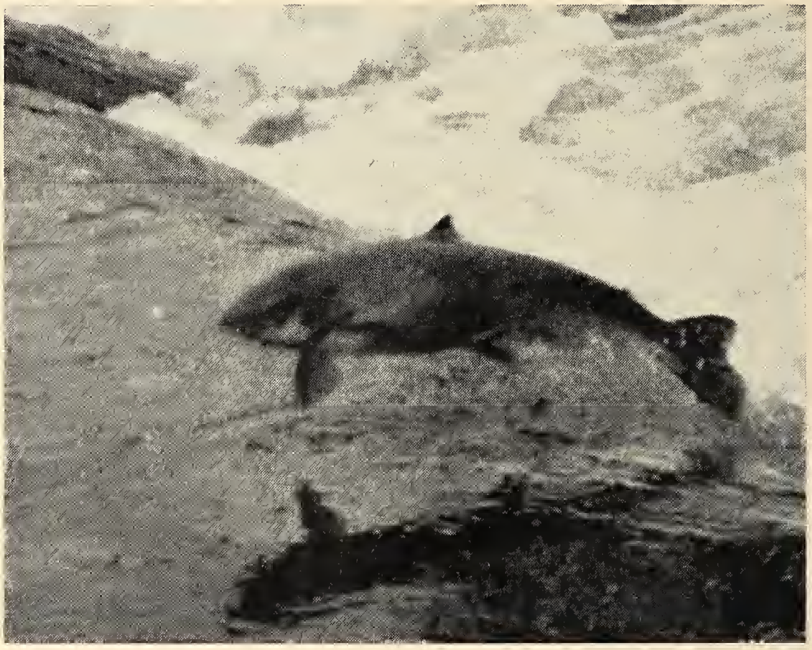
= 336 r.p.m. Test result 327 r.p.m.

The following tabulation shows the calculated and test results for other load changes.

kw. ϕ_1	ϕ_2	*r.p.m.* Test	Theoretical
1200	2400	262	268
1250	3000	240	241
1000	2600	237	252
500	1900	247	268
1500	0	315	317
2000	0	324	325
3150	400	335	351
2600	500	327	336

It should be pointed out that these tests were run primarily to check on the performance of the unit with certain block load changes. The load readings were taken from the standard switchboard instruments which are not particularly accurate at the lower end of the scale. This could account for some of the discrepancy between calculated and test results.

ENGINEERING RESEARCH ON THE FISH AND POWER PROBLEM



J. F. Muir, M.E.I.C.,

Head, Department of Civil Engineering, University of British Columbia, Vancouver.

Eugen Ruus,

Assistant Professor, Civil Engineering Dept., University of British Columbia.

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THE development of the great rivers of British Columbia for fish and power, flood control, irrigation, and recreational facilities is a major economic problem demanding the initiation of a co-ordinated research program without delay.

The Fraser River system (Fig. 1) is the largest source of water power in the province. Recent studies by the Fraser River board[1] indicate a reasonable expectation of more than 10 million hp. as the potential of the river and its tributaries. The cost of electrical energy per kwh. from water power development of the Fraser should be substantially less than the cost per kwh. of thermal or atomic energy.

Periodic floods in the Fraser River valley have caused extensive damage to homes and property, particularly in the region of Hope to Vancouver. Upstream reservoirs to regulate stream flow would permit dual-purpose development of the river for flood control and power. Without power dams on the lower and intermediate reaches of the river, flood control by means of upstream storage would be uneconomic.

Future irrigation projects would not entail substantial water power development relative to the Fraser River potential. Nevertheless, estimates indicate that pumped irrigation could require a billion kwh. per year, equivalent to 626,000 hp. in use for an average of 3¼ months.[2] This estimate is based on potentially irrigable areas and envisages development of benches bordering the Fraser River, the North and South Thompson Rivers, the Thompson River, and the Okanagan and Kettle Valleys.

Construction of power dams on the Fraser has been opposed by fisheries organizations wishing to reserve the river for migration and spawning of anadromous fish. They fear that power dams might destroy the salmon species.

During the past decade, significant progress has been made in fisheries-engineering research devoted to assuring safe passage of anadromous fish past dams of low and intermediate heads. Most of the important discoveries have come from a $3.5 million research program initiated in 1951 by the Corps of U.S. Army Engineers and participated in by all the major fisheries organizations in the Pacific Northwestern States. This research has already paid handsome dividends. A wealth of data has been published giving criteria for the safe passage of fish past dams.[3, 4, 5] It is very likely that this program and further research will show that the Fraser and other rivers of British Columbia can be developed for multi-purposes including the preservation of anadromous fish.

The authors believe that at least one dam can be constructed on the Fraser with a minimum of interference with the migration of young and adult fish. A 100 ft. head dam located near Spuzzum (120 miles from Vancouver) would permit a hydro-electric development of 700,000 hp. The reservoir created by the dam would raise the water level in Hell's Gate Canyon and eliminate the obstruction to migration of adult fish through this difficult stretch of the river. The Black Canyon and Scuzzy rapids would be inundated in the reservoir. Fish ladders in the Spuzzum dam would replace the Hell's Gate fishway which now assists the migration of adult fish through the rapids at Hell's Gate Canyon.

Young fish migrating downstream to the sea would pass over the spillways or through the turbines at the Spuzzum dam. Recent research has shown that the spillways and power house could be designed and operated in a manner assuring a very low mortality among the young fish passing the dam.

The 11 mile long reservoir created by the dam would not flood important spawning grounds. The impoundment of water in the reservoir would have a negligible effect on water temperatures in the river. The velocity of water flowing through the reservoir would be substantially greater than the low velocities in Columbia River reservoirs created by the construction of dams at Bonneville, the Dalles, and McNary. Migrating salmon pass through these reservoirs on the Columbia. Velocities in the Spuzzum reservoir would be greater than those in existing long reaches of the Fraser, downstream from Spuzzum, through which migrating young and adult salmon of all species indigenous to the river and its tributaries must pass. Velocities in the reservoir would be very much greater than those in lakes on the Fraser River tributaries, upstream from Spuzzum, through which young and adult sockeye salmon pass.

The Spuzzum dam should contain full-scale experimental fish-passage facilities similar to but more extensive than those now existing at the Bonneville dam on the Columbia River. These facilities would be invaluable in further research on the safe passage of fish past additional dams on the Fraser and other rivers of British Columbia.

This paper describes the results of some of the most important fisheries-engineering research recently undertaken in the United States and Canada and shows the application of these findings to the proposed dam at Spuzzum. The paper is composed of five parts: (1) Passage of adult fish past dams; (2) Passage of young fish past dams; (3) Passage of young and adult fish through the reservoirs created by the dams; (4) The proposed Spuzzum dam; (5) A proposed fisheries-engineering research program.

Passage of Adult Fish Past Dams

The Columbia River system (Fig. 1) provides a spectacular example of the fish passage problem. Four low head dams at Bonneville, the Dalles, McNary, and Rock Island have been constructed on the main branch of the river with passage facilities for migrating adult fish incorporated in them. Many additional dams are either under construction or are planned for the Columbia and Snake Rivers and for most of the tributaries. Two major Columbia River dams, Grand Coulee and Chief Joseph, without fish passage facilities, cut off more than 1,000 miles of stream that were formerly available to salmon.

At the time of the construction of the 350 ft. head dam at Grand Coulee it was thought that an economic solution of the problem of fish passage over high head dams was impossible. If another Grand Coulee were planned today very serious consideration would undoubtedly be given to the problem of fish passage over the dam.

Recent research has caused a drastic revision of concepts that have prevailed during the past 30 years on the fish passage problem especially on the exhaustion of adult fish caused by steepness and height of ladders. It now appears that fish passage through ladders can be made relatively easy and that the major problem associated with the passage of fish over dams may be the attracting of adult fish without delay from the stream into the collection channels and ladders.

The fish collection system associated with a fish ladder at a Columbia River dam is usually a channel with one end connected to the fish entrance of the ladder. The channel is buried in the power house at tailwater elevation and water flows in it horizontally, usually at right angles to the river flow, and away from the ladder. The water discharges into the river from a series of underwater orifices through which fish may enter the channel. Water is supplied to the channel by low head pumps or by discharge from turbines so that the water flows in the channel and issues from the orifices at a velocity that will attract fish from the river into the channel and along it to the ladder. Water is also discharged into the river from the fish entrance to the ladder. The fish may either enter the ladder directly or from the collection channel.

At the McNary dam (Fig. 2) a ladder 30 ft. wide, on a grade of 5%, is located on each shore. The collection channel extends across the face of the power house and attracts the fish to the ladder on the Oregon shore. Special facilities at each end of the spillway attract fish to the two ladders.

To minimize delay in adult fish migration at a dam, the collection system must operate efficiently at all stages of river flow during the migration period. This entails an ample number of submerged orifice ports and means to control the flow so that downstream conditions attract the fish to the channel.

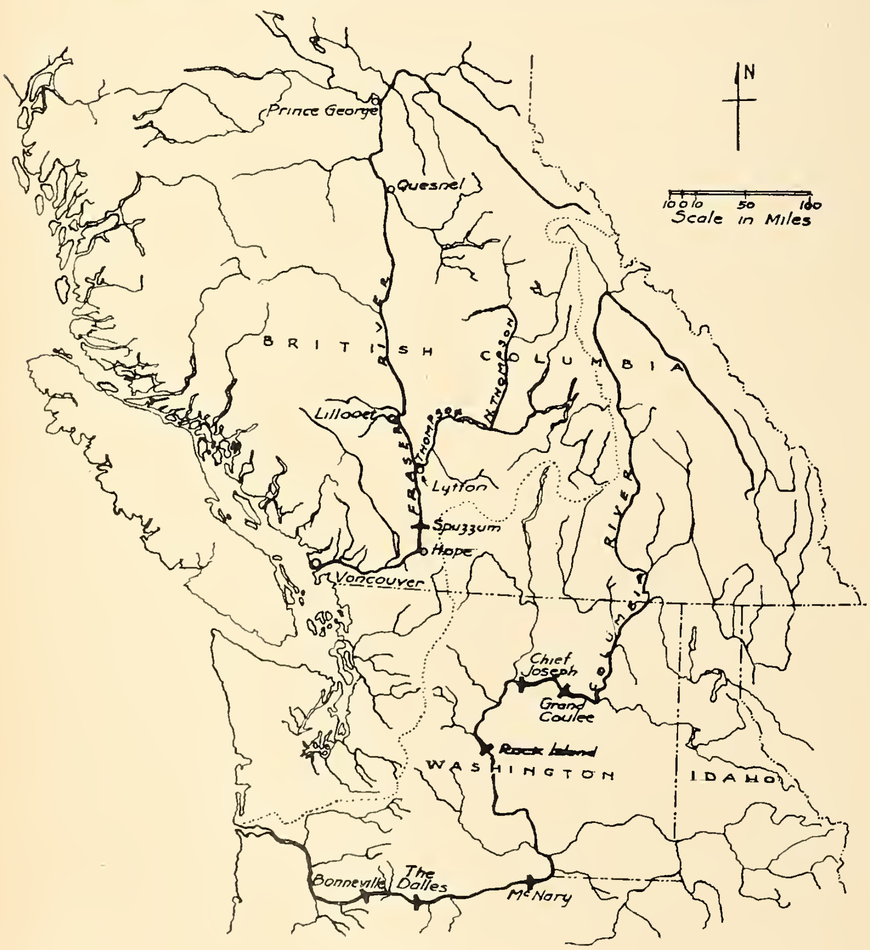
The overflow weir and submerged orifices type of ladder, used at present by the Corps of Engineers, evolved from the Bonneville design which has proved effective for fish passage. This ladder is an inclined channel in which water flows from the forebay into the tailwater pool. A ladder usually curves around the end of a dam, the downstream entrance being readily accessible to the fish. Partitions are installed at intervals across the ladder, the crest of one partition being placed one foot above the preceding one. Two square orifices are located near the bottom of the partitions. Water flows over the partitions or weirs and through the orifices to form a series of pools. The velocity is so adjusted that fish are induced to swim upstream through the orifices or over the weirs. Most of the fish swim through the orifices without rising to the water surface.

Other types of fish ladders have been successfully employed. A vertical slot ladder was installed in 1946 on the Fraser River at Hell's Gate.[6] The Denil ladder has been used extensively in Europe. The first Denil ladder on this continent was built in 1949 at the Dryden Dam on the Wenatchee River, Wash.[7] Fig. 3 shows an isometric view of the Bonneville, vertical slot, and Denil ladders.

As a part of the Corps of Engineers fisheries - engineering research program, a special auxiliary fish ladder has been installed on the Washington shore fishway at the Bonneville dam. A five year period of full-scale operation of the ladder by the U.S. Fish and Wildlife Service produced significant information about the behaviour and performance of adult fish.[4] The work of Collins[8] and Elling[9] has been outstanding.

One of the most important Bonneville fishway experiments produced data for estimating the space required by fish in a ladder. During a 48-hour period, large numbers of fish were collected and then released in one hour into a pool-type ladder, only 4 ft. wide, with a slope of 1:16. Three thousand fish per hour passed through the ladder without any indication that its capacity had been reached.

Fig. 1. Map of a portion of the Fraser and Columbia River Basins.



Other experiments gave valuable information on the behaviour of fish swimming through long ladders. Two ladders, at slopes of 1:8 and 1:16, each having a 180° turn, were made endless by connecting the highest pools to the lowest pools by locks. When a fish reached the highest pool the water was lowered to the elevation of the lowest pool so that the fish could ascend again.

During a five day test, one blueback salmon ascended through 6,600 pools, a height of more than a mile. The conclusion drawn from this and similar tests is that a fish exerts only moderate swimming effort in ascending a properly designed fishway.

Experiments with pool-type ladders on slopes of 1:8 and 1:16 showed that if the hydraulic conditions maintain a suitable pool flow pattern, crowding and delay of fish will not occur in the upper end of a long fishway.

Experiments have been made by the Corps of Engineers[4] at the Bonneville dam to determine the type of inlet preferred by migrating adult fish swimming from the river into the power house collection channels (Fig. 4). The inlets consisted of overflow weirs and submerged orifice ports discharging water from the collection channels into the stream. In two sets of experiments in 1952 and 1954 it was observed that fish preferred the submerged orifices. More than 60% of the fish passed through the orifices, the remainder over the weirs. Then, orifices located at shallow (2.5 ft.-6.5 ft.), medium (14.8 ft. ave.), and deep (30 ft.) submergence were tested. By far the greatest proportion of the fish chose the orifice with shallow submergence. The best range of submergence for orifice ports was shown to be two to eight feet.

Delay in Migration of Adult Fish

There may be a delay in migration of adult fish past a dam and through the reservoir created by the dam. This problem is of major concern to biologists because prolonged delay will deplete the energy reserves of fish proceeding toward the spawning grounds. The delay problem is illustrated in Fig. 5. What is the length of the time interval for fish to traverse the distance from A to C before construction of a dam and what are the lengths of the time intervals for fish to traverse the distances from A to B and from B to C after construction of the dam?

A sufficient amount of research has not been done to enable one to draw definite conclusions regarding the extent of delay, if any, in the passage of migrating adult fish, resulting from a dam in which fish passage facilities conform to the most recent design practice.

In 1948, Schoning and Johnson[10] of the Fish Commission of Oregon studied the extent of delay in the migration of adult Chinook salmon at the Bonneville dam. One group of fish was tagged and released into the river at Oneonta, downstream from the dam. These fish had to swim 6.7 miles to the dam, locate the fishway openings, and ascend the ladders to gain access to the forebay above the dam. Another group of fish was released into the Washington shore ladder. These fish merely had to ascend about 50 yards of ladder to enter the forebay. Representative samples of both groups of fish were caught between the dam and Celilo Falls located about 48 miles upstream from Bonneville. Allowance was made for the extra 6.7 miles travelled by the first group of fish. The anaylsis of the test results gave an estimated average delay of 2.6 to 3.0 days at the dam.

It is of interest to note that during the delay tests of 1948, the inlets to the collection channels at the Bonneville dam were overflow weirs. The 1952-54 experiments of the Corps of Engineers showed that fish prefer submerged orifice ports. The design and operating characteristics of fish collection systems have been progressively improved as each new dam is constructed on the Columbia. It is the general opinion among operating personnel that the fish collection complex at the recently constructed Dalles dam is the best on the river.

A test program was undertaken in 1956-57 by the Oregon Fish Commission[4] to measure changes in adult fish migration rates resulting from construction of the Dalles dam. This dam is between the Bonneville and McNary dams about 47 miles upstream from Bonneville and 98 miles downstream from McNary.

Groups of summer and fall Chinook salmon and blueback salmon were tagged and released at Bonneville and recovered at McNary. The study extended over a two-year period — in 1956 before completion and in 1957 after completion of the Dalles dam. The study showed a reduction from .3 to 3.3 days in the time of travel in 1957. However, these results were considered inconclusive for a number of reasons such as adverse hydraulic conditions resulting from turbidity and high rates of flow in the river in 1956 and the inundation of Celilo rapids. Prior to 1957, the Celilo rapids may or may not have had an adverse effect on the migration of adult fish.

A number of studies have been made of the delay in migration of adult fish caused by a rock slide that constricted the Fraser River at Hell's Gate canyon in 1913. Construction of the Hell's Gate Fishway in 1946 eased the passage of fish through this difficult stretch of the river, although the delay is not completely eliminated.

Killick[11] of the International Pacific Salmon Fisheries Commission discusses a delay in migration of the Adams River run through the Hell's Gate fishway in 1954. In that year, the pattern of the run was unique; instead of passing a cross-section of the river near the mouth during a normal period of about 30 days, some 2 million sockeye made a mass movement into the river in a period of 2½ days from September 17th to 19th. At Hell's Gate, congestion developed when hundreds of thousands of sockeye were forced into the limited passageways. The time of passage was extended to 6 days compared with 2½ days at the mouth of the river. The period of the run was further extended to 14 days of passage at the Thompson Rapids, 10 miles above Lytton, where the fish were congested in the swiftly flowing water. The final period of the run extended over 22 days as a result of consecutive delays caused by the congestion resulting from a very large run migrating in a short period of time.

It does not follow from the unusual situation at Hell's Gate in 1954 that the normal delay at the fishway is about 3½ days. Additional studies are required for a thorough analysis of the delay problem especially at locations where dams may be built in future years. The information needed has been discussed under Fig. 5. The lengths of the time intervals for fish to traverse the distances shown in this figure should be determined for a number of years, before and after construction of each dam. Otherwise, it will be impossible to assess the extent of cumulative delay, if any, resulting from the construction of a series of dams on the Fraser River and its tributaries.

Passage of Young Fish Past Dams

At a typical low-head dam on the Columbia, young fish migrating seaward are, in general, carried by the river flow over the spillways or through the turbines. There is now encouraging evidence to show that fish passage by either of these two exits can be made relatively safe.

The percentages of fish utilizing the spillway or turbine exits at Columbia River dams are not well defined at present. If it is assumed that the fish are distributed in proportion to the rates of flow, somewhat more than one-half of the fish pass over the spillways. In the future, with optimum control at storage dams, more fish would pass through the turbines and fewer over the spillways.

Passage Over Spillways

Recent experiments by the Washington Department of Fisheries have shown that mortality among fish passing over or through the spillways of two relatively low head dams on the Columbia River system is minor. High free-fall spillways discharging into a plunge pool also appear to provide relatively safe passage.

Tests at the 92 ft. head dam at McNary in 1955 and 1956 gave an estimated survival rate of 100% among Chinook fingerlings and yearling salmon passing over the spillways.[4] Other tests were made in 1957 at the Big Cliff dam on the Santiam River where the physical features of the dam that might be related to fish mortality are similar to those at McNary. The combined results for the McNary and Big Cliff tests gave an estimated survival rate of 98% with a 95% confidence interval from 96 to 100%.

The spillway at the McNary dam is of the ogee type. Split-leaf vertical gates control the discharge over the crest. The gates are constructed to permit the upper portion or the whole gate to be moved at one time.

During the McNary tests, the spillway gate openings were set to simulate, as closely as possible, conditions which would normally exist during the late spring months when downstream migration is at its peak. This was done by opening spillway gates on three adjacent spillway sections, just above the crest of the ogee (Fig. 6a). A similar test was conducted using split-gates with water discharged through the gate approximately 25 ft. above the top of the ogee (Fig. 6b). Mortality was not indicated in either case.

Two other experiments conducted recently in Washington indicate that spillways can be designed to assure relatively safe passage of young fish through heights greater than 100 ft. At the Glines dam on the Elwha River the spill falls 180 ft. from the spillway crest through the atmosphere into a pool at the base of the dam. At Glines, Shoeneman and Junge[12] found no significant mortality among fingerlings during tests in which the spillway gate opening varied from 0 to 8 ft.

At the University of Washington, fingerlings have been dropped various heights from a helicopter into a pool.[13] The speed of descent apparently increases for the first 100 ft. or so to a maximum velocity of about 40 m.p.h. Thereafter air resistance prevents further increase in velocity. The mortality among the fingerlings in these tests is reported to be negligible.

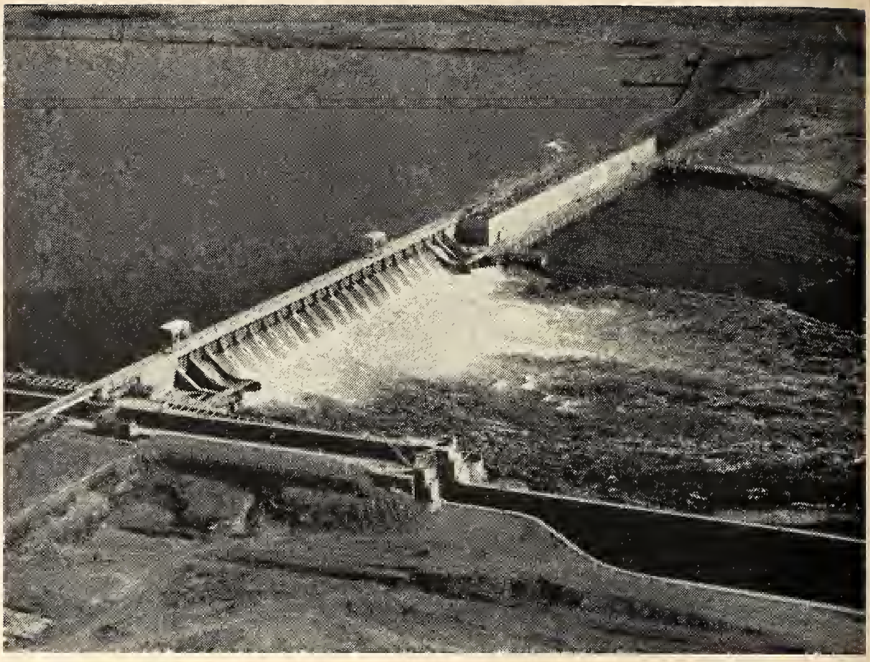


Fig. 2. The McNary Dam, Washington and Oregon.

Passage Through Turbines

Recent research has given promising evidence that successful passage of young fish through turbines can be achieved through hydraulic heads of several hundred feet and that the hydraulic characteristics of the turbine water passages are far more significant than heights of dams.[18]

In a three year series of tests by the Washington Department of Fisheries[4] in 1955-6-7 at the McNary and Big Cliff dams, the average survival rate among fingerlings and yearling salmon passing through the turbines was estimated to be 89%. The 95% confidence interval on this estimated survival rate was from 87 to 91%. In other mortality tests at the lower Elwha dam on the Elwha River, where the head on the dam is 104 ft., the survival rate among fingerlings passing through the turbines was estimated to be 100%.[12]

It is of interest to discuss the mysterious reasons why 11% of the fish passing through the McNary turbines were killed; while at the Elwha dam, where the head is about 13% higher, the fish passed through the turbines without significant losses.

The Elwha turbines are small, 15 bladed Francis wheels about 5 ft. 6 in. in diameter at the outlet, each of 5,000 hp., rotating at 300 r.p.m. Here, the fish pass through very narrow openings, the minimum clearance between adjacent blades being only 3 in. The McNary turbines are Kaplan, six bladed, adjustable-pitch propeller wheels, 23 ft. 4 in. in diameter, each of 114,300 hp. rotating at 85.7 r.p.m. The McNary turbines are similar to those in the Dalles power plant (Fig. 7). The blade clearances are very much greater than those at Elwha.

Among the various factors that research workers have thought might be involved in the problem of fingerling mortality in turbines are the following: injury from impact or abrasion resulting from collision with a turbine blade; abrupt reduction in water pressure; degree of partial vacuum in the water passages; time of exposure to the vacuum; and cavitation.

At the Bonneville laboratory in 1955, fingerlings were placed in an injector connected to a 20 in. pipe from which water issued through a nozzle at a velocity of 45.6 f.p.s.[4] A steel baffle plate was placed so that the 8 in. jet impinged directly on it at 90° and also at 45° angle. Of 1,000 fish used in the impact test against the plate set at the 45° angle, the mortality rate was only 1.7%; while the corresponding mortality rate for the 90° impact test was 3%.

Fig. 8a is a pressure vs. time diagram showing qualitatively the variations in pressure to which fish may be exposed in passing through a Francis or propeller turbine. The pressure at the entrance to the penstock is shown by the ordinate at A. As the fish approach the leading edges of the turbine blades, the pressure increases to a maximum at B. After a brief interval of time T, of the order of a fraction of a second, when the fish pass the trailing edges of the blades, the pressure decreases to K.

Some of the fish may pass through regions of low pressure in the turbine. In these local regions, the pressure-time diagram of Fig. 8a may be modified as indicated in Fig. 8b. (Note the change in the abscissae scale of the latter diagram.)

Fish may encounter a partial vacuum if they pass close to the leading edge of a turbine blade. This wave of pressure is shown in Fig. 8b as a trough-shaped wave to the right of B. Some fish may encounter another similar wave downstream from the trailing edge of a blade: this wave is shown to the right of F. If the pressure at the bottom of the troughs decreases to the vapor pressure of the water, vapor pockets or bubbles form in the regions of low pressure in the turbine. When the bubbles are carried downstream into regions of higher pressure, they collapse. Local pressure intensities of high magnitude then occur. These pressures would appear as a series of sharp, jagged peaks and valleys in the diagram at E and K. If the pressure at the bottom of the troughs does not decrease to the vapor pressure of the water, the vibrations at E and K would be much less pronounced.

The effects on fish of waves of pressure of the type shown in Figs. 8a and 8b have been determined by various investigators. Rowley[14] showed that fish can withstand pressure changes of substantial amounts providing that the pressure does not decrease below atmospheric. He subjected rainbow trout contained in water in a lucite tube to gauge pressures up to 200 p.s.i. He then lowered the pressure abruptly to atmospheric. He observed no detrimental effects on the fish during a two week period.

In a series of experiments in 1957 and 1958 at the University of British Columbia, Muir[15] investigated the effects on Coho fingerlings of abrupt changes in pressure, degree of partial vacuum, time of exposure to the vacuum, and cavitation. A water-filled plastic tube was used to subject some 200 fingerlings, one at a time, to trough-shaped waves similar to those shown in Fig. 8b. In one set of tests, the fish were exposed to a reduction in pressure from 110 p.s.i. gauge to a partial vacuum of approximately 29 in. hg. in about 1/125 second. This vacuum was maintained for about one second before the pressure was increased to atmospheric. In general, the swim-bladders were deflated by such vacuum waves and the fish were momentarily stunned. They recovered quickly and showed no ill effects during a one week period.

Fish exposed to a high degree of vacuum for more than three or four seconds suffered from the bends. No fish exposed to a vacuum for a short period equivalent to the time of passage through a turbine showed symptoms of the bends.

Exposure to an extremely high degree of vacuum (equal to the vapor pressure of the water) for periods equivalent to the time of passage through a turbine resulted in negligible mortality.

Fish were then exposed to cavitation shock waves resulting from collapse of a vapor pocket induced in the vessel containing the fish. Mortalities of about 60% among the fish were observed.

The conclusion drawn from the U.B.C. tests is that cavitation is a major cause of mortality among fish passing through turbines.

Cavitation in turbines can be reduced by several means.[15] These include (1) increasing the number of turbine blades; (2) increasing the surface area of each blade; (3) shaping the blades to minimize cavitation; (4) avoiding turbine operation at low efficiency; (5) reducing the partial vacuum in the water passages by placing the turbine at a lower elevation with respect to tailwater level; (6) injecting air in the draft tube near the runner exit.

The control of tailwater level with respect to turbine setting provides a convenient way for conducting field tests to determine relationships between cavitation and fish mortality.

The Thoma criterion of cavitation, sigma (σ), is calculated by means of the formula

$$\sigma = \frac{H_b - H_s}{H}$$

in which H_b is the height of the barometric water column in ft.; H_s is the elevation in feet, at which the turbine is placed above the tailwater level; and H is the head in feet under which the turbine operates.

As a result of years of experience of turbine manufacturers, considerable information is available on the allowable values of sigma. These enable one to select suitable values of H_s for Francis and propeller turbines so that loss in efficiency and excessive pitting of the turbine blades from cavitation will not occur. For a dam of fixed head, sigma may be increased and cavitation (and the danger of injury to fish) lessened by placing the turbine at a lower elevation with respect to tailwater level.

In a series of experiments by the Corps of Engineers[16, 18] in 1959-60, fish were passed through a 12 in. diameter model of the McNary turbines, also a 12 in. diameter Francis turbine, at the Allis-Chalmers Co. laboratory at York, Pa. The head varied from 5 to 45 ft. and the speed from 95 to 1,400 r.p.m. The tests were performed at a given net head and turbine speed with the runner set at various elevations in relation to tailwater level. Von Gunten[18] reports that the tests appeared quite conclusive with respect to the following:

(1) With a model turbine, 12 in. in diameter, wide variations in survival could be achieved, depending on speed and tailwater elevation.

(2) Extremely high mortality occurred where adverse hydraulic conditions resulted in cavitation.

These model tests were followed by a spectacular full-scale test in which some 40,000 young fish were passed through a Francis turbine operating under a 450 ft. head at the Cushman II dam, Wash.[17, 18] The Cushman turbine runner is 76 in. in diameter, developing 37,500 hp. at 330 r.p.m. The runner has 15 blades with blade clearances varying from about 3 to 3½ in. at the runner discharge side. The draft tube is vertical, discharging into a rectangular chamber containing a hydraucone. The tailrace discharges into the ocean where tailwater level is controlled by the tide which normally has a daily variation of 5 to 9 ft. At high tide, the tailwater level is about 1 ft. below the turbine runner.

The fingerling test specimens were collected by a large net, at the draft tube exit, which screened the entire turbine discharge. About 90% of the fish placed in the penstock were caught in the net.

Fish mortality in the Cushman tests was found to be strongly dependent on (1) turbine output; (2) elevation of tailwater. Under the most unfavourable conditions of partial loading and low tide, the survival rate was only 45%. Under the more favourable tailwater conditions at high tide and with normal turbine operation at best efficiency, the survival rate was over 75%.

The hydraulic conditions in the water passages of the Cushman turbines are far from ideal for safe passage of fish. The power plant was built without consideration of the problem of fish passage through the turbines. Even at high tide the tailwater level is about 1 ft. below the turbines. In a future plant similar to Cushman, sigma could be increased more than 50% by lowering the turbines about 20 ft. An improvement in fish survival rates could undoubtedly be achieved with such a substantial increase in the value of sigma. Further research should be directed toward achieving the ideal conditions at the Elwha dam where fingerlings pass through the turbines without significant losses.

Referring to the Corps of Engineers' test program at the Allis-Chalmers Co. laboratory and at the Cushman II dam, Von Gunten[18] says, ". . . the research gives much promise that passage through turbines may be made relatively safe. The investigations in the future should be aimed at three problem areas:

(1) Structural design of turbines to reduce mechanical injury.

(2) Physical setting of the runner in relationship to tailwater conditions to reduce negative pressures.

(3) Scheduling of turbine operation to obtain optimum hydraulic conditions throughout the water passages."

The Corps of Engineers plans to conduct additional laboratory model tests at York, and full scale tests at the Cushman II dam during 1961.

Passage of Young and Adult Fish Through Reservoirs Created by Dams

On the Columbia River, anadromous fish pass through a series of four reservoirs created by the construction of the Bonneville, Dalles, McNary, and Rock Island dams. The authors believe that fish passage through the Spuzzum reservoir would be easier than the passage through any of these Columbia River reservoirs. The Spuzzum dam would affect river temperature and velocity to a lesser degree because the Fraser at Spuzzum is narrower than the Columbia between Bonneville and Rock Island. Construction of the dam would result in inundation of the Hell's Gate, Black Canyon and Scuzzy Rapids. Passage of adult fish would then be eased through an 11 mile length of the river.

Fish migration through reservoirs may be affected by (1) changes in water temperature caused by impoundment; (2) temperature gradient resulting from stratification of water in the reservoir; (3) reduction in water velocity caused by the reservoir; (4) delay in passage of adult fish past the dam and through the reservoir.

At the University of British Columbia in 1958-9 Ruus[19] studied the problem of passage of anadromous fish through the proposed Spuzzum reservoir. These studies were based on (1) research done in the United States on water quality in reservoirs on the Columbia River system and (2) analysis of recorded flow of the Fraser River near Spuzzum.

In 1958, the U.S. Fish and Wildlife Service published a report of studies by Sylvester[20] of water quality of the Columbia River basin. Among the components studied was that of water temperature in a number of reservoirs including those created by

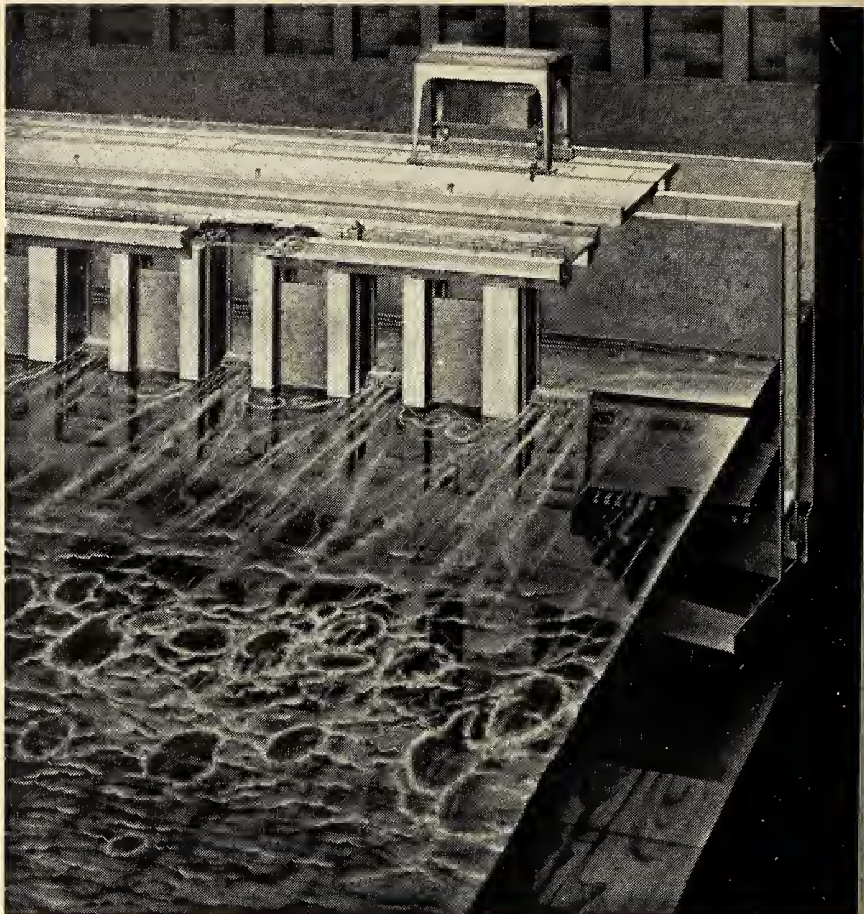
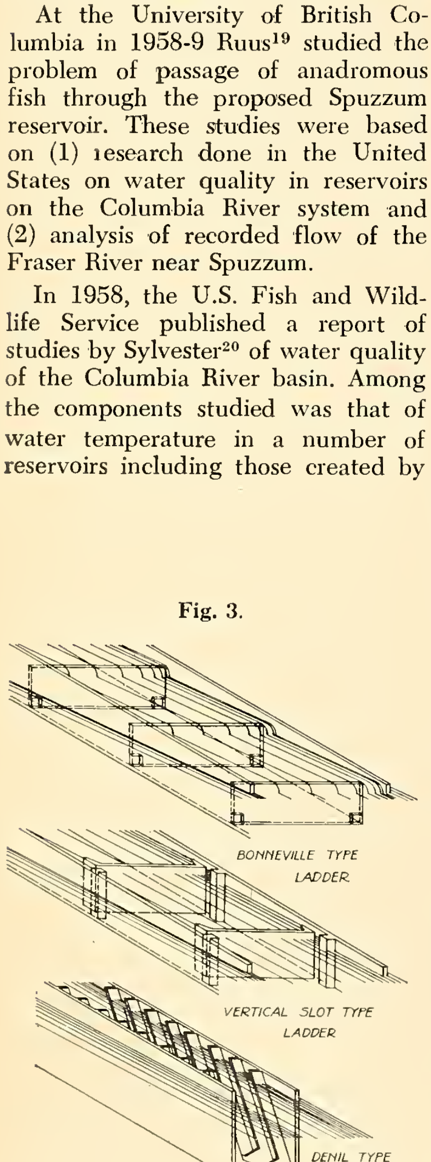


Fig. 4. Fish collection channel showing overflow weir entrances.

Fig. 3.



the construction of the Bonneville and McNary dams. The lengths of these two reservoirs are about 45 and 60 miles respectively. The detention periods are about one and two days, based on the average flow during a two year period. The studies showed that the impoundment in the McNary reservoir produced a net cooling effect (0.1 to 1.5°F.) in winter and spring, and a warming effect (0.1 to 0.5°F.) in the late summer and fall, on the water in the lower Columbia. The water temperature changes resulting from the impoundment in the Bonneville reservoir were even smaller than those in the McNary reservoir, the greatest change occurring in December when a cooling effect of 0.5°F. was noted.

The studies also indicated the extent of the temperature gradient resulting from stratification of water in the reservoirs. Degree of stratifieation depends on a number of variables. It will increase with an increase in the detention period and decrease with an increase in velocity and turbulent mixing of the water. Wind action on surface layers is also an important factor. Only a slight temperature gradient resulting from stratifica tion was noted across the reservoir a the McNary dam.

The length of the proposed Spu zum reservoir would be only 11 mile The detention period would be le and the water velocity and degree turbulent mixing greater than tho in either the McNary or Bonnevil reservoirs. The following conclusio were therefore drawn from the U. Fish and Wildlife Service studies:

1. The Spuzzum reservoir wou have a negligible effect on wat temperatures in the river.

2. There would be no appreciab temperature gradient resulting fro stratification of the water in the rese voir.

Velocity of stream flow is co sidered to be one of the influenc that assist in the orienting of a fi during the migration period. T reservoir created by the Spuzzu dam would cause a reduction velocity in an 11 mile reach of t river. The velocity in the reserv would, however, be greater than t velocity in some other portions of t

TABLE I

Velocities in Proposed Spuzzum Reservoir

Month	47 year minimum velocity in ft. per sec.	47 year average velocity in ft. per sec.	47 year maximum velocity in ft. per sec.
Mar.	0.16	0.30	0.81
Apr.	0.20	0.66	3.68
May	0.41	2.17	6.70
June	1.44	2.81	6.63
July	1.38	2.20	5.06
Aug.	0.81	1.37	3.35
Sept.	0.41	0.96	2.75
Oct.	0.37	0.78	2.42
Nov.	0.19	0.65	1.78
Dec.	0.17	0.46	1.42
Jan.	0.15	0.35	0.92
Feb.	0.19	0.30	1.28

Fraser River system, upstream and downstream from Spuzzum, through which migrating young and adult fish must pass.

Fig. 9 shows the hydrographs of maximum, average, and minimum flows of the Fraser River at Hope (20 miles downstream from Spuzzum) during a 47 year period from 1912 to 1959. The hydrographs are not plotted in chronological order. For example, the minimum flow for the first day of May is the lowest recorded daily average rate of flow for that date in any one of the years during the 47 year period. Superimposed on the hydrograph are graphs showing the estimated relative abundance of adult salmon of different species passing Spuzzum during various periods of the average year.[21] An ordinate of 1.0 on this graph gives the time of peak migration of fish of the species indicated.

The estimated mean velocities at a typical cross-section through the Spuzzum reservoir forebay are given in Table 1. These velocities are computed on the following basis:

1. The minimum velocity corresponds to the minimum ordinate on the hydrograph, Fig. 9, for each month listed in the table.

2. The average velocity corresponds to the average discharge for each month.

3. The maximum velocity corresponds to the maximum ordinate for each month.

The 47 year minimum velocity in the Spuzzum reservoir at the time of peak migration of adult fish in September would be about 0.41 f.p.s. This and other velocities in Table 1 are much greater than corresponding velocities in the Bonneville, Dalles, and McNary reservoirs.

From a preliminary topographic map of the Spuzzum site, the cross-sectional area of the waterway in the reservoir forebay is estimated to be approximately 80,000 sq. ft. There are long reaches of the Fraser, near the mouth, where the cross-sectional area of the river is greater than 80,000 sq. ft. Velocities here are subject to tidal influences which increase the velocity at low tide and decrease it at high tide. It is known that the triggering of migration of very large numbers of adult sockeye salmon into the mouth of the Fraser occurs at high tide.[22] This means that this phenomenon occurs when the velocity at the mouth of the river is at or near its diurnal minimum. This minimum velocity is less than the estimated minimum velocity in the proposed reservoir at Spuzzum.

Upstream from tidal influences, there are a number of lakes, e.g. Harrison, Kamloops, Adams, and Shuswap Lakes in which the velocity is very much lower than the estimated velocity in the Spuzzum reservoir. Sockeye salmon travel through these lakes. For example, migrating young and adult sockeye travel about 20 miles through Kamloops Lake and 40 miles through Adams Lake.

The Proposed Spuzzum Dam

Fisheries-engineering research in British Columbia could be expedited if full-scale experimental fish passage facilities were available in a low head

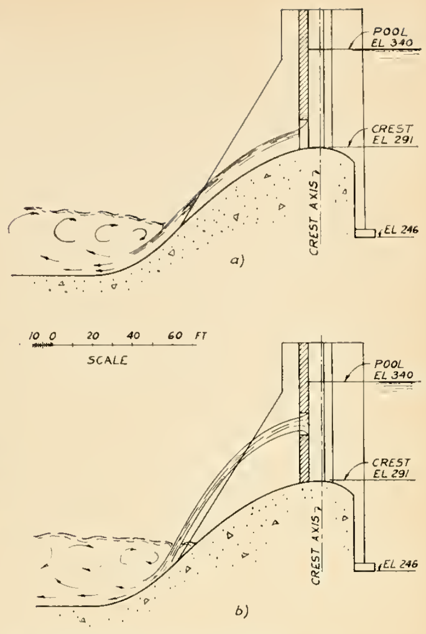


Fig. 6. McNary Spillway gate settings for fingerling mortality tests.

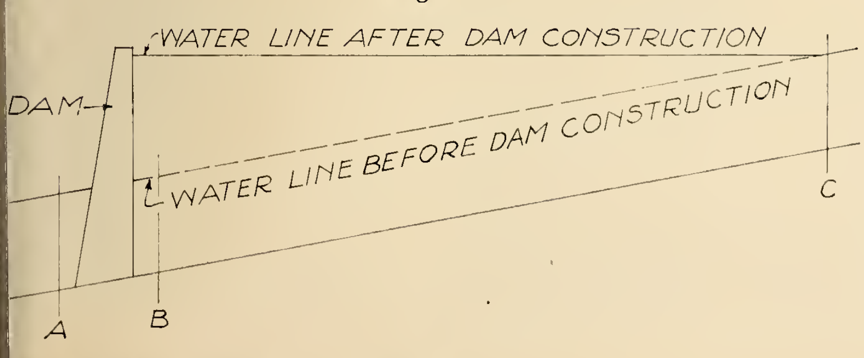
dam on the Fraser River system. Among a number of possible sites for such a dam, two appear to be particularly suitable — one located near Lillooet, the other near Spuzzum.

Additional topographic data and sub-surface exploration at the Lillooet site would be required before the design of suitable fish passage facilities for this dam could be undertaken. Some of the advantages of the other site near Spuzzum have already been discussed in this paper.

A preliminary design of a dam for the Spuzzum site has been prepared by the engineers of the Fraser River Board.[1] A number of ingenious and economical features have been incorporated in this plan. The influence of recent European practice is apparent in the design of the structure. Practically the whole of the length of the dam crest is used for a spillway. This provides for large flood flows through the relatively narrow Fraser River canyon. The turbines and generators are shown buried in the spillway section.

The authors have modified this design to incorporate fish passage facilities that appear particularly well suited to conditions on the Fraser. Fig. 10 shows a plan and cross-section of the proposed Spuzzum dam. Six turbines, each of 100,000 hp. are shown for the initial stage of construction and provision is made for one additional turbine of the same capacity for future expansion, if and

Fig. 5.



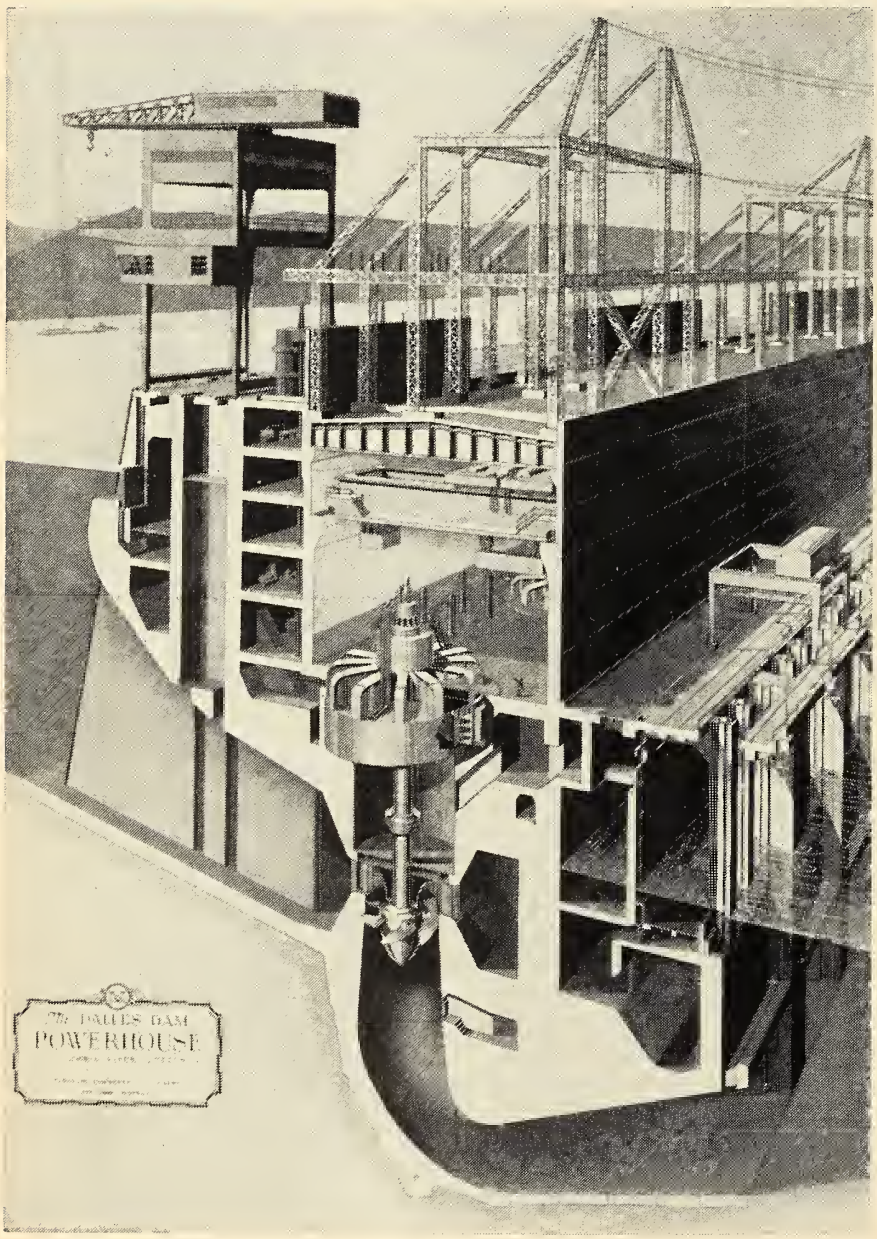
when upstream storage becomes available.

The fish collection system at the base of the spillway extends for the full length of the dam and is connected to fish ladders on both shores. For the period of peak migration of adult fish, the authors propose that the flood flow be discharged over the mid-portion of the spillway. This would result in turbulent flow in the middle of the river below this portion of the spillway and divert the fish toward the collection channel and fish ladders on each side. The ratio of fish collection channel length to river width as proposed for the Spuzzum dam is much greater than the corresponding ratio at Columbia River dams. This feature would make the collection system at Spuzzum readily accessible to the fish. The collection system would be designed to pass 750,000 fish per day.

It is not usual to extend a fish collection channel across the spillway section of a dam. When portions of the spillway are inoperative, slack water regions may be created in the tailwater pool below these portions of the spillway. Because of the low velocities in these slack water regions, some adult fish may be delayed in their search for the entrance ports leading to the collection channels on each side of the spillway.

Two features of the proposed fish collection complex at Spuzzum should minimize the delay in migration of adult fish past the dam. Discharge from the draft tube exits underneath the spillway would minimize the extent of slack water regions in the tailwater pool. Submerged orifice ports leading to the collection channel would be available to fish at uniform distances for the full length of the spillway.

Fig. 7. The Dalles Dam powerhouse. The six-bladed Kaplan turbines, each of 105,000 hp., rotate at 85.7 r.p.m.



The curve of the spillway of the proposed Spuzzum dam is similar to the upper part of the ogee curve of the McNary dam where mortality among young fish passing over the spillway is known to be negligible. A deep pool would be available at the base of the spillway to ensure that fish mortality resulting from impact with masonry or rock would be negligible.

Relative to tailwater level, the turbines are shown at an elevation substantially lower than usual. This would increase the turbine cavitation parameter, sigma, to a value higher than usual for a dam of 100 ft. head. The increase in sigma would be accompanied by a reduction in mortality rates among young fish passing through the turbines and also a reduction in pitting of turbine blades from cavitation. A study of the Corps of Engineers current research work on modification of mechanical features of turbines should be made and additional model tests undertaken before a decision is reached on the most suitable type of turbine.

The low setting of the turbines, relative to tailwater level, requires a deep submergence of the draft tube exits. These are shown more than 50 ft. below minimum tailwater level. It is unlikely that many adult fish would descend to this depth in a futile search for an exit from the tailwater pool through the draft tubes and turbines to the reservoir forebay.

Two important points are to be emphasized relative to the migration of young fish past the Spuzzum dam:

1. During the period of peak migration of young fish, an average of approximately one-half of the river flow would be discharged over the spillways, the remainder through the turbines. If it is assumed that the fish are distributed in proportion to the rates of flow, approximately one-half of the fish would pass over the spillways where the survival rate would very likely be close to 100%.

2. The authors are confident that the 89% survival rate among fish passing through the McNary turbines could be substantially improved upon at Spuzzum. Evidence of the possibility of such an improvement is furnished by the conditions at the Elwha dam where fish pass through

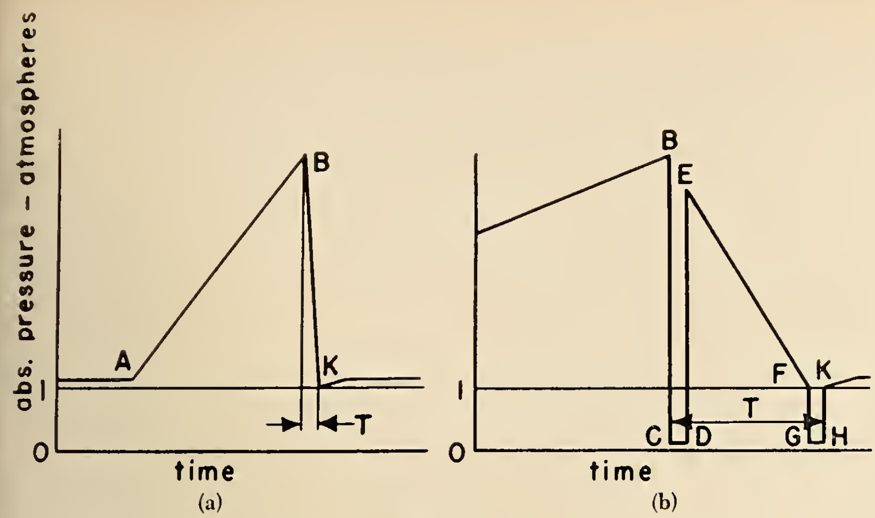


Fig. 8.

the turbines without significant losses. If a completely satisfactory improvement in survival rates were not achieved at Spuzzum, there is another factor of safety for the fish. Some or all of the turbines could be shut down during the period of peak migration. At that time, a surplus of water is available at other power plants serving the lower mainland area. A temporary extra load of 700,000 hp. could be taken care of by these interconnected power plants. Migrating young fish at Spuzzum would then pass over the spillways.

A Proposed Fisheries-Engineering Research Program

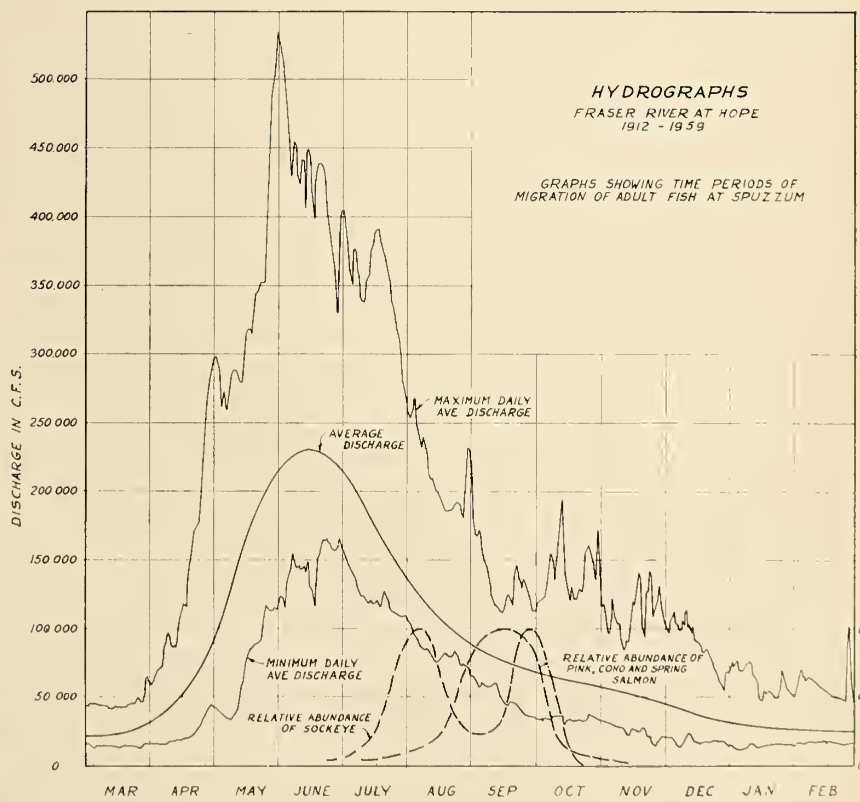
The Canadian research effort on the fish and power problem has been sporadic. This is in marked contrast to the coordinated, long range research program embarked on by the crown corporation, Atomic Energy of Canada, Ltd. Over $219 million has been spent on research by the AECL since its inception in 1943. Expenditures for the fiscal year 1959-60 are estimated to be over $31 million.[23]

Relative to the AECL program, expenditures on fisheries-engineering research on the problem of assuring safe passage of anadromous fish past proposed dams on the great rivers of British Columbia have been infinitesimal. Yet, because the province is richly endowed with water power sites, it is generally conceded by persons well informed about the economics of electric power production that British Columbia will very likely be the last province in which atomic power plants are built. Many of these water power sites can be developed to produce hydro-electric energy at costs per kwh. substantially less than the costs per kwh. of atomic energy.

Agreement between the U.S. and Canadian governments to proceed with development of additional Columbia River power would not relieve the need for an immediate start on a research program on the fish, power, and flood control problems of other British Columbia rivers. Development of the Fraser River system is a logical next step in providing additional large blocks of power that will be needed in the future for industrial expansion in the province. A long period of time for research should be allowed because of the number and complexity of the problems. It would be a very short sighted policy to neglect the research that could eventually result in a $2 billion project for optimum multi-purpose development of the Fraser River system.

The authors suggest that the first steps in a fisheries-engineering research program should be the preparation of a topographic map and sub-surface exploration of the site of the proposed first dam to be constructed on the Fraser. This should be followed by a preliminary design of the principal engineering features of the spillways and power plant. Then a hydraulic model of the project should be built and tested. Planning of the spillways, turbines, fish ladders, and fish collection system at all stages of construction and at all stages of river discharge would be facilitated by careful measurement of flow through the model. Model tests of the conditions at the fish entrances are particularly important to ensure that these would be readily accessible to the fish. Other problems requiring study include location and sizes of structures, river discharge and upstream storage characteristics, variations in forebay and tailwater elevations, velocities in the draft tubes and below the spillways,

Fig. 9.



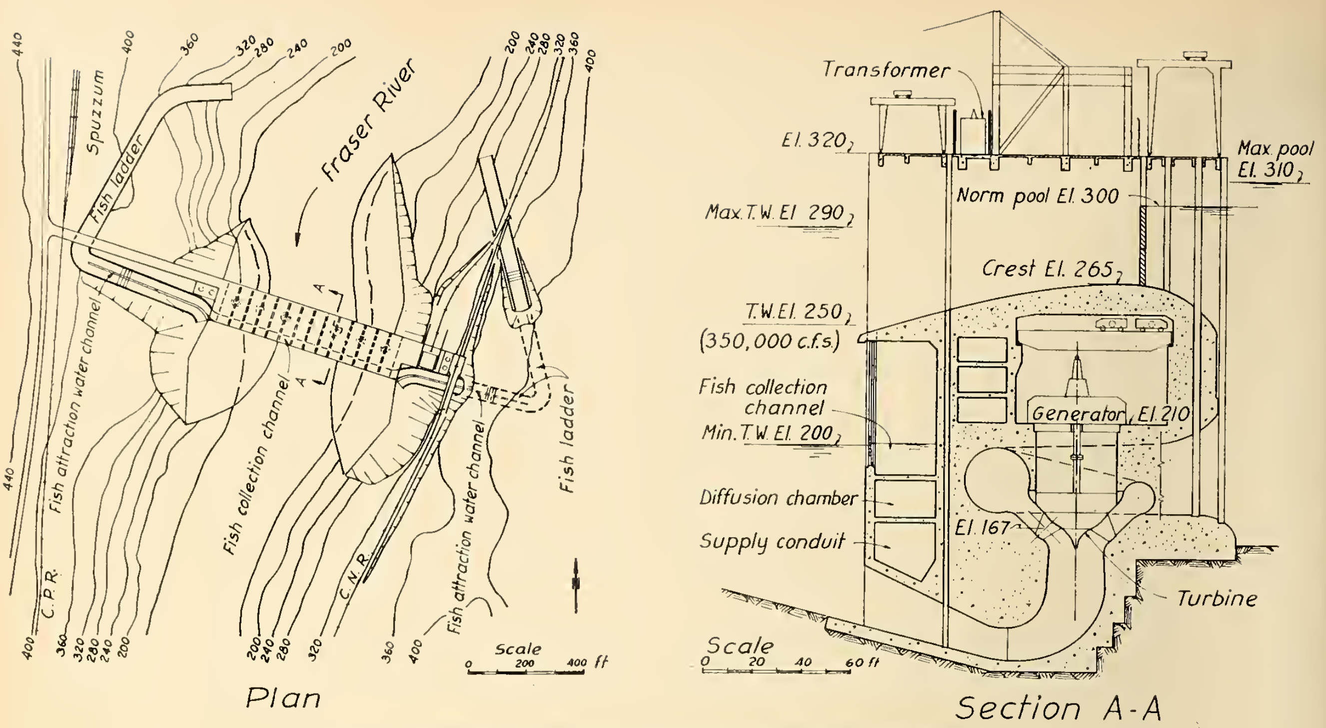


Fig. 10. Plan and cross section of the proposed Spuzzum Dam.

and the planning for future expansion. The valuable information gained from these tests would make it possible to build a dam over which anadromous fish could safely pass.

If and when the first low head dam is constructed on the Fraser, it is suggested that an auxiliary channel be placed adjacent to one of the fish ladders. Various types of ladders could thus be investigated for fish passage efficiency. The information gained from these tests could very likely be usefully employed in planning improved fish ladders for future dams.

It is suggested that facilities be provided in the power plant for testing models of turbine runners to determine the relationships between various turbine characteristics and fish mortality. This research would be helpful to turbine designers in planning improved turbine runners for future power plants.

Coupled with the fish and power problems at the proposed first dam are other problems of upstream storage for flood control and for the additional power which could be developed by a series of dams on the Fraser River system. These problems constitute a fertile field for research on dam and reservoir locations, dam heights, and improvement of channels and control of flow through streams used by spawning fish. Solution of these problems would permit the development of the Fraser and other rivers of British Columbia for the maximum benefit to the people of this province.

Acknowledgment

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Canadian Developments

Port Cartier Now Open to Traffic

Port Cartier, the largest man made harbor of its kind in the world was opened this summer with the arrival of the first ore carrier.

This deep water harbor, virtually carved out of solid rock, is unusual in that it was constructed artificially almost completely within the confines of land. Because of its location and the purpose for which it was intended, Port Cartier presented many interesting and unusual engineering problems. The harbor is situated on an exposed part of the coast on the north shore and at the mouth of the St. Lawrence River. Adequate protection against extreme weather and sea conditions is imperative. This ruled out the normal port design consisting of a dock beyond the shoreline and a breakwater.

The final shape of the harbor facilities was evolved through many preliminary design stages. To a large degree it was developed from the results of interpretations of weather and sea conditions in that area for the past 50 years. The National Research Council built a model of the port design to scale. This was tested under simulated wave conditions. The underwater topography had been reproduced as exactly as possible so as to ensure that results of the tests would be as accurate as possible. In order to overcome any design problems encountered in the tests moveable concrete sections were used in the construction of the model harbor. A variety of designs and improvements were thus easily tested. The end result is a harbor which meets the needs for which it was intended.

The shipping terminal at Port Cartier was specifically designed to handle ore being transported from the Quebec Cartier Mining Company. Everything has been built to facilitate the entrance and exit of the large ore carriers. The harbor has a total frontage of 5,350 ft. which includes 4,600 ft. of loading and mooring dock. There are 2,850 ft. of graded beaches mainly at the northeast, east and west sides of the harbor. These are in line with the approach channel. Minimum depth of the port is 50 ft. at low tide.

An aerial photograph of the harbor facilities at Port Cartier

The integration of docks and beaches allow for maximum berthing space. One of the outstanding features of the harbor is the use of sloping beaches which absorb and dissipate wave action. Excessive surging in the harbor is thus prevented. Though the port facilities have been built in a protected area, the harbor is located on an exposed part of the coast.

Port Cartier will provide shipping facilities the year round. While equipped to handle only eight million long tons of iron ore concentrate annually at present, plans are for an eventual increase in all facilities at the port to 30 million long tons. Giant ore carriers of the future up to 950 ft. in length and with a capacity of up to 100,000 tons can be accommodated at the port. These ships can enter or leave the harbor bow first.

The ore handling facilities were the primary consideration in the overall design of the shipping terminal. An automatic system which is capable of loading 6,370 long tons an hour either direct from train to ship or from a storage shed or a combination of the two is a feature of the harbor. This makes use of a huge ship loader, one of the largest in the world. The storage shed is not small either. It can hold up to 400,000 long tons of ore concentrate. Another feature of the port is a special cargo dock specifically designed to receive freight and petroleum products.

The opening of this harbor with its giant ore handling facilities is the culmination of a multimillion dollar mining and ore processing project which was formally initiated by the Quebec Cartier Mining Company at its inception in 1957.

Though the port is open productively, work on it is not complete. The port facilities there will be expanded while the harbor in its present state is in use.

Consulting engineering services for this project were provided by the C. D. Howe Company Limited. Extensive studies were made after which the firm designed the harbor as well as the ore loading facilities. At this company's suggestion the harbor was excavated on shore and made as sheltered as possible. And normal port design was ruled out as being uneconomical for the location and the specific purpose of the harbor.

The newly built harbor facilities at Port Cartier are the result of four years of work and are an excellent example of engineering skill in adapting a natural location for a desired purpose. EIC

International News

First Stage of Netherlands "Delta Plan" Completed

A concrete caisson dam over the 1¾ mile wide Verse Gat estuary which has just been completed represents another victory in Holland's constant fight against the North Sea. Part of the "Delta Plan", a long term flood control program to protect coastal and inland waters from the inundation caused by dangerous sea tides, the new dam is the first part of the "Delta Plan" to be completed. Final completion of the whole program is scheduled for 1978.

First a temporary harbor for the contractors' fleets and a storage base were constructed near the dam site. Then a dam joining the sea defenees then in existenee was built into the Veer Gat estuary from the two opposite sides. The body of the dam was coated with sand and the channel dredged to a depth of 50 ft. To keep the sand on the dam from shifting around the outside face was covered with nylon mat which had been coated with asphalt.

At the end of 1960 a gap of only 354 yds. remained between the two sections of the dam. The gap was closed with seven water-passing caissons. First it was narrowed at each end with normal caissons which were 203 ft. long, 62 ft. wide and 59 ft. high. These formed vertical abutments to which the water passing caissons could be readily joined.

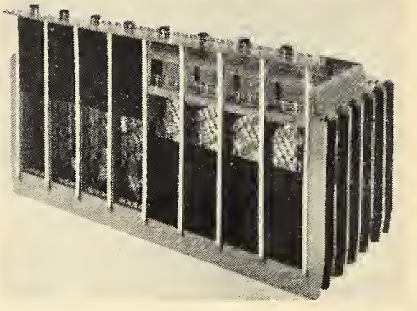


Fig. 2 Model of one of the water passing caissons

The water-passing caissons were constructed close to where they were to be joined in a 5½ acre dock which had been specially excavated. When the caissons were ready the building dock was filled with water and a channel dredged to link it with the Veerse Gat. The caissons reached the dam site towed by tugs. Measuring 149 ft. long, 65½ ft. wide and 65½ ft. high the caissons were constructed mainly of concrete. The end faces of each caisson have seven concrete ribs which project out about 39 in. Eight openings were made in one side of every caisson, each opening being 16½ ft. wide. Two steel gates, each 16½ ft. high were installed one above the other in each opening. Two gates rather than just one insure safety and manageability. These gates, of which there are a total of 56 on the lower level and 56 on the upper level, were operated from a platform on the caissons by winches. Electric motors are used to raise and lower the gates. In the raised position the gates allowed water to flow through the caissons. When all of the caissons were in position the gates were closed to stop the flow of water.

Fig. 1 The Final stage in closing the Veerse Gat estuary

Mounted on top of each caisson is a concrete bin, 10 ft. in height. These bins were filled with sand when the caissons were placed in position to keep them from shifting.

Before the caissons were sunk in the gap between the two sections of the dam, the bed of the estuary was dredged to a depth of 46 ft. below sea level. A sill 10 ft. high was built up with gravel and rubble.

After the ballast bins on the caissons were filled with sand the winches were removed. Then the caissons were pumped with almost five million cu. yds. of sand. When the body of the dam is completely finished off an inner berm to carry a highway will be built along the entire length of the dam.

Because the gates in the caissons offer only slight protection in the Veerse Gat and are not able or intended to withstand strong currents a massive dike is being built in front of and behind the caissons.

The method used for closing the Veerse Gat estuary is an entirely new one. Had the customary watertight caissons been built and sunk in the gap the velocity of the current would have become too high thus hindering operations. So the sides were left open and the top and bottom surfaces of reinforced concrete were joined by a network of diagonal steel bars.

The closing of the Veerse Gat has shortened the coastline of Holland by 31 miles. When the dike was completed across the estuary the link between Walchern, South Beveland and North Beveland islands was completed, forming an inland lake of 3,954 acres between the three islands. EIC

1961 Annual General Meeting

Minutes of the Seventy-Fifth Annual General Meeting of The Engineering Institute of Canada held on Wednesday, May 31st, 1961, at the Hotel Vancouver, Vancouver, B.C. between the hours of nine a.m. and twelve noon, presided over by the President George McK. Dick, Sherbrooke, Quebec.

QUORUM, CALL TO ORDER AND NOTICE OF MEETING

The President established that there was a quorum of members present. The president then called the Seventy-Fifth Annual General Meeting of The Engineering Institute of Canada to order at 9:00 a.m. The General Secretary read the official notice of the meeting which in accordance with Section 52 of the By-Laws has been mailed to corporate members twenty-one days before the date of the meeting.

PRESIDENT'S OPENING REMARKS

President Dick extended a sincere welcome to those present and said he was very pleased to see such a large and representative attendance. He acknowledged with appreciation the work of Dean Myers and the members of the 1961 Annual Meeting Committee which had enabled this successful meeting to be held in Vancouver. Referring to the agenda for the meeting, he stated that because of the large number of items on the agenda, and the fact that the Final Report of the Engineers Confederation Commission would be received at this meeting, the Executive Committee of Council had deemed it necessary to impose a time limit on each item. In this way it was hoped that the maximum opportunity will be given to members to discuss the various items of business within the overall time available for the meeting.

CONFIRMATION OF MINUTES

It was moved by Mr. A. F. Brooks, seconded by Mr. Ernest Mason, and carried unanimously, that the minutes of the Seventy-fourth Annual General Meeting of the Institute held in Winnipeg, Manitoba, on Wednesday, May 25, 1960, be taken as read and adopted.

REPORT OF COUNCIL, REPORT OF OFFICIAL AUDITORS, TREASURER'S REPORT, AND REPORT OF FINANCE COMMITTEE

The President stated that the Report of Council for the year 1960 was incorporated in the Annual Report for 1960, which was circulated to the membership in the April, 1961, issue of The Engineering Journal.

The treasurer, Mr. E. D. Gray-Donald, stated that the Report of the Official Auditors and Financial Statements, the Treasurer's Report and the Report of the Finance Committee are incorporated in the Annual Report for 1960. He read the auditor's report to the meeting. He summarized the Treasurer's Report by saying that the most significant factor in the year's operation was the deficit of approximately $56,000. He pointed out that this amount is almost the equivalent to the loss of revenue by not charging for The Engineering Journal.

Mr. Gray-Donald said that unfortunately the Chairman of the Finance Committee, Mr. F. L. Lawton, was abroad and unable to be at the meeting, and had therefore asked him to present the Report of the Finance Committee which is also contained in the Annual Report, and supported by a number of graphs. Mr. Gray-Donald said that the important features of the Finance Committe report are the changeover, late in the year, from a cash basis of accounting to an accrued basis. The financial outcome of the year's activities was a deficit of $56,000—this resulted from a budgetary provision for a deficit, a decrease in the amount of income due to the remission of the Journal subscription, and the late decision in 1959 to change the Journal distribution policy, which meant that the advertising sales staff could not secure the anticipated increase in advertising sales. In addition, there was a far larger circulation list for The Engineering Journal, under the new distribution policy, than had originally been anticipated. According to the 1961 budget there should be a surplus of about $20,000: unfortunately, due to a number of circumstances, the advertising revenue was down during March and April, and the predicted surplus may not be achieved.

The Finance Committee reports that the total membership on December 31, 1960, stood at 21,536. There have been changes in the proportion of memberships, and these are well illustrated in the charts printed in the Annual Report. The Institute's membership has been growing substantially, and it is hoped that it will continue to do so. The Institute's obligations are also growing rapidly because in order to properly carry out its functions there is an increasing demand for additional services. The Finance Committee hopes that it will be possible to provide the funds necessary for these services and for continuing and improving existing services.

It was moved by Mr. Gray-Donald, seconded by Mr. N. S. Bubbis, that the Report of Council, Report of Official Auditors, Treasurer's Report, and Report of the Finance Committee be adopted.

Colonel L. F. Grant asked if the present publications' policy had been examined recently, and a decision arrived at as to whether or not it is justified.

Mr. Gray-Donald said that the statements of revenue and expenditure are examined every month by the Finance Committee, and the matter is therefore constantly before that Committee and Council. He pointed out that the Institute has been going through two very difficult situations in this respect. One was the disruption of the selling of advertising caused by the demise of the late Mr. Blandford, and the other is the great curtailment of advertising budgets. The closest answer which can be given to Colonel Grant's question is that the Finance Committee thinks the ultimate outcome will be satisfactory.

The motion to approve the Report of Council, Report of Official Auditors, Treasurer's Report, and the Report of the Finance Committee was approved.

APPOINTMENT OF OFFICIAL AUDITORS FOR 1961

It was moved by Mr. Gray-Donald, seconded by Professor J. B. Mantle, and carried unanimously that the firm of Peat, Marwick, Mitchell and Company, Chartered Accountants of Montreal, be appointed the official auditors for the Institute for the year 1961.

REPORT OF COMMITTEE ON BRANCH OPERATIONS

Mr. J. R. Rettie, Vice-Chairman of the Committee, said that the report of the Committee to December 31 is contained in the 1960 Annual Report. Since that time the Committee has been busy further organizing its effort. Replies to the Branch Questionnaire mailed on December 20, 1960, which brought a 94.6% return, have been analyzed and the findings and recommendations submitted to Council. Two meetings of the Committee have been held, the most recent being the previous day's meeting which was held jointly with a meeting of Branch Officers. The Committee will continue to address itself to problems associated with Branch Operations and endeavour to give all assistance to both the Branches and Headquarters. Mr. Rettie said that the Committee's meeting on the previous day indicated that the principal and most urgent job of C.B.O. is to try and improve communications between Branches and Headquarters and remove some of the misunderstandings which are prevelant.

It was moved by Mr. Rettie, seconded by Mr. Chandler, and carried that the report of the Committee on Branch Operations be adopted.

REPORT OF THE COMMITTEE ON TECHNICAL OPERATIONS

Dr. Ballard said that the Committee on Technical Operations was increasingly active during the year and an article giving a breakdown of the work of the Committee was published in the March, 1961, issue of the Journal. Action has been taken to classify every member by his field of technical interest, so that the membership at large may participate more fully in the activities of the Institute and the ten technical divisions. This is particularly important to the Committee on Technical Operations so that it may assess the overall interest of the Institute. A manual of technical operations has been prepared for the guidance of technical division committee members, branch officers, and the staff. Through the C.T.O. the Institute supports and assists many agencies of the Government, sister societies in Canada and international organizations. The 1960 Report of the Committee is contained in the Annual Report.

It was moved by Dr. Ballard, seconded by Mr. Mullins, and carried that the Report of the Committee on Technical Operations be adopted.

REPORT OF COMMITTEE ON MEMBERSHIP

Mr. C. L. Fisher, a member of the Committee, presented the Report in the absence of Mr. S. B. Cassidy, Chairman of the Committee. Mr. Fisher said that membership activity within the Institute has been intensive during the years since the last Annual Meeting, and was divided into two stages. First, during the summer and early fall, the Ad Hoc Committee on Membership Procedures was formed, and held a series of meetings, under the chairmanship of Hugh C. Brown, M.E.I.C., in Ottawa. Under terms of reference from Council this Committee examined, and where necessary, recommended the overhaul, of almost every detail of E.I.C. membership policy and procedure. Much improvement and streamlining were accomplished, and some important changes are reflected in By-Law amendments now under consideration.

Second, during the late fall, as recommended by the Ad Hoc Committee, the national Committee on Membership was reactivated with new terms of reference, under the chairmanship of Stan B. Cassidy, M.E.I.C. of Fredericton, N.B. The principal task of this committee was to launch, and promote in every way, a full scale membership promotion drive at the Branches, in close co-operation with headquarters staff. Well-attended meetings were held in November and February, and a program was planned and carried out under which the Branches received help, suggestions and encouragement through special mailings, visits by staff and committe members, and the use of The Engineering Journal. The results of this work, although by no means finished, have been very encouraging.

In terms of statistics, the membership total has risen in the twelve months' period from 20,260 to the latest count of 21,690 including applications on hand. This represents a net increase of just over 7 per cent. It is interesting to note that during the same period the increase of membership in full Member grade, through both admissions and transfers, was 11.5 per cent.

In conclusion, while it is realized that this work must be continued with full vigor, and with every possible new approach, any Canadian organization which has accomplished a 7 per cent growth during the economic conditions of the past year, has made a creditable showing.

The President said that he has been particularly interested in the work of the Committee on Membership, and he wished to thank all those who had helped in any way to achieve the results which had been attained.

It was moved by Mr. Fisher, seconded by Mr. J. T. Henderson, and carried that the Report of the Committee on Membership be adopted.

REPORTS OF OTHER COMMITTEES, REPORTS OF REPRESENTATIVES, REPORTS OF BRANCHES, AND THE ONTARIO PROVINCIAL DIVISION

Mr. R. A. Phillips, Chairman of the Publications Committee, added to the report of the committee by saying that he believed it to be particularly important that he pay tribute to the work done by the Editor and publications' staff under the very difficult circumstances which the Treasurer described. Mr. Phillips said that, in connection with the decision to establish a broader circulation of The Engineering Journal, he understood that one of Council's primary objectives had been to stimulate membership growth, and he noted that in the Report of the Committe on Membership acknowledgement has been to the effect that the increased circulation has had on membership growth. Mr. Phillips said that the excellent job done by the staff in planning content and selling advertising space in The Engineering Journal had done much to offset the increase in distribution costs brought about by the wider circulation.

It was moved by Mr. R. A. Phillips, seconded by Mr. Leo Hammerschmidt, and carried that the reports of other committees, reports of Representatives, and reports of Branches and the Ontario Provincial Division, be adopted.

NOMINATING COMMITTEE 1961

The General Secretary reported that one member from each Branch has been appointed to serve on the Nominating Committee for 1961, with Mr. R. F. Legget of Ottawa as Chairman. The complete list appears in the 1960 Annual Report.

OTHER BUSINESS

ANNUAL MEETING OF COUNCIL MAY 30, 1961

The General Secretary reported that the only item referred to the Annual General Meeting by the Annual Meeting of Council was The Report of the Engineers Confederation Commission, which would be received later in the meeting.

PROPOSED AMENDMENTS TO E.I.C. BY-LAWS

The President said that for some years it has been apparent that certain changes to the Institute By-Laws are necessary to bring them in line with current practice, as approved by Council. Accordingly, Council requested the Committee on By-Laws with Mr. J. S. Waddington of Brockville as Chairman, and Messrs. Janitsch and Dolphin of Belleville and Kingston, members, to prepare appropriate amendments to the By-Laws, and to review amendments that had been proposed by the membership in accordance with the By-Laws. Those proposals were approved by Council for consideration at the Annual Meeting and were mailed to corporate members not less than 21 days before the Annual General Meeting as required by Section 80 of the By-Laws.

These proposals are now before the membership for discussion: the members here present may propose an amendment or amendments thereto, and all proposals together with such amendment or amendments as are approved by the Annual General Meeting shall be printed on a letter ballot to be submitted to the corporate membership of the Institute. The General Secretary shall issue the letter ballot not later than two months after this Annual General Meeting. An affirmative vote of two-thirds of all valid ballots shall be necessary for the amendment or repeal of existing By-Laws, or for the adoption of new By-Laws.

A general review of membership procedures was made by a committee of Council during the Summer of 1960. Council approved its recommendations, including one to change the class of Junior membership to Associate Member, at its October 1960 meeting, Minute 60/597-9 and Appendix "F". In addition, the Honorary membership class and the establishment of a Fellow class of membership have been under study by Council for some time. Action was taken at the January '61 meeting, Minute 61/71-74 to recommend By-Law changes. A petition dated September 22, 1960, from the required number of corporate members proposed an increase in fees. This petition, at the suggestion of Council, was amended by its proposers to the form which is now given in the proposed By-Law amendments. Council Minutes 60/619-20 and Appendix "K", 60/689-91, and 60/798 refer to this petition. At its October 1960 meeting, Minute 60/594, the Council assigned responsibility for co-ordination of Regional Technical Conferences to the Committee on Technical Operations. The Publications Committee proposed new terms of reference, based on an up-to-date concept of the Committee's duties, to Council in October 1960. The Council approved these terms of reference. Minute 60/583-5 and Appendix "I". Council agreed that the Finance Committee would conduct its business with greater facility if the Treasurer were ex-officio Vice-Chairman of that Committee. This proposal was approved by Council at its October 1960 meeting, Minute 60/622.

It is proposed that the first and second sentences of this Section be written as follows:

Present Wording:

The membership of the Institute shall consist of Honorary Members, Members, Juniors, Students and Affiliates. Members, Juniors, and Honorary Members who have previously been corporate members shall be styled corporate members.

Proposed Wording:

The membership of the Institute shall consist of Honorary Mmbers, Fellows, Members, Associate Members, Students and Affiliates. Fellows, Members, Associate Members, and Honorary Members who have previously been corporate members shall be styled corporate members.

Dr. L. Austin Wright, said that the proposed changes had not been well considered, not only because in several instances I feel the proposals are not in the best interests of the members, but also because there is conflict between some of the proposals. Further, it appears that the Council of the Institute has abandoned any idea of getting Confederation because some of the proposed changes are in conflict with the proposals made by the Confederation Commission.

Some of the proposals appear to me to be worthy of support, but others are wrong and should not be approved.

With reference to the conflict between some of these proposals and the proposals for Confederation; as regards Honorary Member and Fellow—the Confederation Report proposes that Fellow "will be the highest grade of membership", whereas the By-Law changes would make them equal.

The Confederation Report proposed that the classes of membership shall be Fellow, Honorary Member, Member, Junior and Student, whereas the Institute proposal has Associate Members instead of Juniors, and with entirely different requirements. Why not withhold this change in membership nomenclature until the fate of the Confederation proposal is settled?

The Confederation proposals, as recommended by the original joint committee stated that the annual fee to the National Body would be $6.25. If this thinking is to be approved, why change the Institute's schedule of fees now, only to have to change them again later? None of the changes proposed is sufficiently important to be proceeded with now, unless, of course, Council has already abandoned any hope of Confederation.

Dr. Ballard said that it is felt that there are two distinct types of honours that are necessary, one for those who are not eligible as engineers for an honour, and another for those who are engineers. He asked why Dr. Wright concludes that one has a higher status than the other. Dr. Wright referred to the Confederation report which, in his opinion, indicates the difference in status between these two classes of honour, and suggested unless the E.I.C. has given up the idea of Confederation, these proposals are out of place. It was moved by Dr. Ballard, seconded by Professor S. D. Lash, and carried, with 15 votes in opposition, that this Annual General Meeting approves the amendment to Section 3, Classes of Members, for submission by letter ballot to the corporate membership.

Section 4—Titles: It is proposed that Section 4 read as follows:

Present Wording:

Any Honorary Member, Member, Junior, Student or Affiliate having occasion to designate himself as belonging to the Institute, shall state the class to which he belongs according to the following abbreviated forms: Hon. M.E.I.C., M.E.I.C., Jr., E.I.C., S.E.I.C. Affiliate E.I.C.

Proposed Wording:

Any Honorary Member, Fellow, Member, Associate Member, Student or Affiliate, having occasion to designate himself as belonging to the Institute, shall state the class to which he belongs according to the following abbreviated forms: Hon. M.E.I.C., Fellow E.I.C., M.E.I.C., A.M.E.I.C., S.E.I.C., Affiliate E.I.C.

It was moved by Mr. C. L. Fisher, seconded by Professor A. C. Davidson, and carried with one vote in opposition, that this Annual General Meeting approves the amendment to Section 4 "Titles", for submission by letter ballot to the corporate membership.

SECTION 6 — HONORARY MEMBERS

It is proposed that Section 6 be written as follows:

Present Wording:

Honorary Members shall be chosen from those who have become eminent in engineering or kindred sciences.

Proposed Wording:

Honorary Members shall be elected from corporate members of the Institute who have achieved outstanding distinction in fields other than engineering or from non-membrs of the Institute who have achieved outstanding distinction in the engineering field.

Dr. L. Austin Wright said that this is a most unusual and unreasonable proposal. It is almost the universal practice of societies such as ours to make Honorary Membership their highest award. Just why The Engineering Institute of Canada would endeavour to raise a new class of Fellow to greater heights is more than I can understand, and that the Institute will never get recognition among engineers and particularly among engineering organizations, to Fellowship being superior to Honorary Membership.

It seems unreasonable that a Member of the Institute cannot be given Honorary Membership because he has achieved distinction in the engineering profession, but a non-member can. It seems unreasonable to reward the engineer who has never seen fit to join the Institute, when you won't give the similar honour to the engineer who has supported the Institute probably all his professional life.

The classification of Fellow in engineering societies generally is just a super class for Members. As far as I can discover every engineering organization that has a Fellow classification still ranks Honorary Membership above it.

A further consideration is that the present holders of Honorary Membership were awarded this distinction on the basis that it was the highest honour the Institute could bestow. The present proposal would demote all these people.

In Section 8 there is a statement that the Honorary Member and the Fellow are to be considered equivalent grades. If they are only equivalent, why bother with two?

I feel this proposal should not be approved inasmuch as it is unfair, unwise, and unproductive of any advantages to the Institute or the membership."

It was moved by Cmdr. P. F. Fairfull, seconded by Professor W. G. Heslop, and carried with three votes in opposition that this Annual General Meeting approves the amendment to Section 6, Honorary Members, for submission by letter ballot to the corporate membership.

SECTION 6 (A) — FELLOWS

It is proposed that Section 6(A) be written as follows:

Proposed Wording:

Fellows shall be elected from those corporate members who have achieved outstanding distinction in the engineering profession within the Institute. Fellows shall be at least forty years of age.

It was moved by Mr. R. J. Harvey, seconded by Mr. H. R. Hatfield, and carried with two votes in opposition that this Annual General Meeting approves the new Section 6 (A)—Fellows, for submission by letter ballot to the corporate membership.

SECTION 8 — CHANGE OF MEMBERSHIP CLASS

It is proposed that the Section be written as follows:

Present Wording:

Upon the adoption of these By-laws, all Associate Members of the Institute shall ipso facto become Members, and the present class of "Associate Member" is hereby abolished (Effective May 1940).

Proposed Wording:

On Sept. 1st, 1961, all Juniors shall ipso facto become Associate Members. The Honorary Member class and the Fellow class of membership are considered to be equivalent to each other in recognition of achievement in fields of of non-engineering and engineering endeavour.

It was moved by Dean H. G. Conn, seconded by Professor A. C. Davidson, and carried with one vote in opposition, that this Annual General Meeting approves the amendment to Section 8, Change of Membership Class, of the By-Laws:

SECTION 9 — JUNIORS

It is proposed that this section be headed "Associate Member" and be written as follows:

Present Wording:

A Junior shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year, if the candidate for election has graduated from a school of engineering recognized by the council, in which case he shall not remain in the class of Junior beyond the end of the eighth year after graduation.

Every candidate who has not passed the examinations of the third year in a school of engineering recognized by council shall be required to pass an examination in engineering science as prescribed by council. He shall not remain in the class of Junior beyond age thirty.

A Junior may be transferred to Member without payment of transfer fee providing he makes application before the end of the seventh year after graduation or if a non-graduate, before attaining age twenty-nine and his application is approved by council.

Council may extend the above limits if in its opinion special circumstances warrant such extension.

Proposed Wording:

An Associate Member shall have been engaged in some branch of engineering for at least four years. This period may be reduced to one year, if the candidate for election has graduated from a school of engineering recognized by the council.

Every candidate who has not passed the examinations of the third year in a school of engineering recognized by council shall be required to pass an examination in engineering science as prescribed by council.

An Associate Member shall be transferred to Member automatically without payment of transfer fee at the end of the fifth year after graduation or if a non-graduate, before attaining age twenty-nine. He may apply for transfer to Member any time after a two-year period.

Council may extend the above limits if in its opinion special circumstances warrant such extension.

It was moved by Mr. H. A. Mullins, seconded by Mr. A. J. Groleau, and carried, with one vote in opposition, that this Annual General Meeting approves the amendment to Section 9, Juniors for submission by letter ballot to the corporate membership.

SECTION 10 (A) — STUDENT

It is proposed that Section 10 (A) be written as follows:

Present Wording:

Present Students pursuing a course of instruction in a school of engineering recognized by the council, in which case he shall be transferred to Junior automatically without payment of transfer fee in the second January after graduation.

Proposed Wording:

Proposed Students pursuing a course of instruction in a school of engineering recognized by the council, in which case he shall be transferred to Associate Member automatically without payment of transfer fee in the first January after graduation.

It was moved by Professor A. C. Davidson, seconded by Mr. R. N. Boyd, and carried with one vote in opposition, that this Annual General Meeting approves the amendment to Section 10 (A)—STUDENTS, for submission by letter ballot to the corporate membership.

SECTION 12 — HONORARY MEMBERS

It is proposed that this section now be headed "Honorary Members or Fellows" and be written as follows:

Present Wording:

Honorary Members shall be elected by unanimous vote of the council given by letter ballot, one month's notice having been given to the members of the council of the names of the nominees, and of the meeting at which it is proposed to canvass the ballot.

The general secretary shall write the Honorary Member advising him of his election and shall request him to notify the Institute by letter of his acceptance, within three months. Failing such acceptance, his election shall be void.

Proposed Wording:

The number of Fellows to be nominated each year shall not exceed one per 5,000 or fraction thereof, corporate members.

The number of new Honorary Members to be nominated each year shall not exceed two.

Council shall adopt procedures, from time to time, for the nomination and election of new Honorary Members or Fellows.

On the election of an Honorary Member the general secretary shall write the Honorary Member advising him of his election, and shall request him to notify the Institute by letter of his acceptance within three months. Failing such acceptance, his election shall be void.

It was moved by Mr. R. B. Chandler, seconded by Mr. R. A. Phillips, and carried with one vote in opposition that this Annual General Meeting approves the amendment to Section 12—Honorary Members, for submission by letter ballot to the corporate membership.

SECTION 13 — APPLICATION FOR ADMISSION OR FOR TRANSFER

It is proposed that the first sentence of this section of the By-Laws be written as follows:

Present Wording:

Applications for admission to the Institute, or for transfer from one class to another, shall be made upon forms approved by the council and shall contain a statement, over the applicant's signature, of his age, residence, the record of his engineering experience, and an undertaking to conform to the by-laws and regulations of the Institute it elected or transferred.

Proposed Wording:

For classes of membership other than Honorary Member or Fellow, applications for admission to the Institute, or for transfer from one class to another, shall be made upon forms approved by the council and shall contain a statement over the applicant's signature, of his age, residence, the record of his engineering experience, and an undertaking to conform to the by-laws and regulations of the Institute if elected or transferred.

It was moved by Mr. R. J. Rettie, seconded by Dean H. G. Conn, and carried with one vote in opposition, that this Annual General Meeting approves the amendment to Section 13—Applications for Admission or for Transfer, for submission by letter ballot to the corporate membership.

SECTION 20 — ENTRANCE FEES

It is proposed that this section be written as follows:

Present Wording:

The entrance fees, payable at the time of application for admission to the Institute shall be as follows:

Members	$10.00
Juniors	5.00
Affiliates	10.00

Honorary Members and Students shall be exempt from entrance fees.

Proposed Wording:

The entrance fees, payable at the time of application for admission to the Institute shall be as follows:

Members	$10.00
Associate Members	5.00
Affiliates	10.00

Honorary Members and Students shall be exempt from entrance fees.

It was moved by Mr. J. H. Budden, seconded by Mr. R. A. Phillips, and carried with one vote in opposition, that this Annual General Meeting approves of the amendment to Section 20—Entrance Fees, for submission by letter ballot to the corporate membership.

SECTION 21 — ANNUAL FEES — TABLE OF FEES

It was moved by Professor A. C. Davidson, and seconded by Mr. R. Harvey Self, that the Institute fees be increased to the proposed new rates given below: It is proposed that this section be written as follows:

Present Wording:

Montreal Branch Residents	All other Branch Residents	Branch Non-Residents and Non-Residents
	Members	
$20.00	$18.00	$16.00
	Juniors	
9.00	7.00	6.00
	Students	
2.00	2.00	2.00
	Affiliates	
21.00	19.00	17.00

Proposed Wording:

Montreal Branch Residents	All Other Branch Residents	Branch Non-Residents and Non-Residents
	Fellows	
$27.00	$25.00	$23.00
	Members	
27.00	25.00	23.00
	Assoc. Members	
12.00	10.00	8.00
	Students	
3.00	3.00	3.00
	Affiliates	
22.00	20.00	18.00

Dr. L. Austin Wright said that he did not believe the heavy increase in fees justified. This increase, as far as a Member is concerned, is almost thirty-five per cent. I would be surprised if the members would vote themselves into this additional expense. While it is recognized that the cost of doing business is steadily increasing, it must be recognized also that the selling price for advertising is increasing at least proportionately. While it is true that the Institute has been operating under a deficit for some time, and a particularly heavy one last year, the members should not be asked to put hands into their pockets to make it up.

A study of the present operations of the Institute would reveal economies which could be effected without reducing the service to the members. With advertising revenue up $108,000.00, why was the Institute in the red last year to the colossal sum of $56,000.00?"

Professor A. C. Davidson emphasized that this By-Law change is up for consideration because of the petition from the required number of corporate members in Toronto, and has nothing whatever to do with the Toronto Branch. He also stated that there is no reflection intended on the principal officers of the Institute.

Referring to the 1960 Annual Report, he pointed out that a deficit of $56,000.00 developed in 1960, and he also commented particularly on Charts 9 and 10 on page 12 of the Report. As a Councillor, he said that he has information available to him which is not ordinarily available to the average member, but is available to them through their Councillors. If Councillors examine their statements of revenue and expenditure they will note that for the three months ended March 31, 1961, there was a defiicit of $9,560.00 on the publications and for the four months ended April 30, a deficit of $11,239.00.

The reports of the C.B.O., C.T.O., and Publications Committee definitely show that these committees need money to operate on. The Institute is undergoing a period of expansion and must have funds to support this. Councillors need some financial assistance to attend meetings of Council. Students and international activities also need support. Many of these aspects are not apparent to members at large, but if the Institute is to retain its "image" and a good working organization it must take the necessary steps now to do so.

Professor Davidson said that the effect of many of the economies made recently has not yet been felt, but it undoubtedly will be in time. He said that the petition to increase the fees had been put forward only after a very careful examination of the 1969 financial statements, and the petitioners based their thinking on these results.

Mr. Gray-Donald said that he had discussed this matter very fully the previous day at the meeting of the Committee on Branch Operations. He said there is no question that the Institute needs more money for its ordinary operations: the ordinary operations expenditure is not met by the fees and miscellaneous revenue, which is quite small. He said the Institute should not be dependent on financing the Institute from the profits of the Journal. In any case, at the present time, these profits are pretty nebulous and it hoped that they will improve. If the Journal should become a profitable enterprise, it cannot be relied upon because it is dependent on economic conditions. It should also be noted that although greater revenue is being received from the Journal due to higher advertising rates, there is a much higher expense due to the greatly increased circulation. In addition, the membership is constantly demanding greater coverage of Institute activities in the Journal and, unfortunately, economic circumstances have been such that it has been possible to do this because at the present time a certain ratio between advertising and editorial content must be maintained. Mr. Gray-Donald said the Institute should try to set up its operation so that the revenue from fees is equal or will meet fully the operating requirements. These operating requirements are increasing very rapidly for three reasons:

1) Over the past few years the cost of doing business in any field has greatly increased.
2) Increased membership requires great services.
3) The greatly augmented activities of the Institute which have increased at a startling rate over the past two or three years require more money.

Mr. Gray-Donald said there is no extravagance in the Institute's operations; the budgets are very carefully scrutinized, and at present, reduced to the point where the EIC is not able to give the service it would like to. The membership now has a larger and more active Institute, with a higher level of doing business, which must be faced. The last increase in fees was in 1954 and in 1960 there was a drop in fee of $4.00 per member due to the elimination of the charge for the Journal.

It has been asked by quite a number of people how this particular suggestion for increased fees related to the additional services and other expenses which are foreseen. This has not been done in any great detail, as Professor Davidson said, but it is a pretty good estimate. The C.B.O. was very concerned that the membership at large would not understand these matters and has asked that if this proposal is approved to go to ballot that it should be accompanied by a carefully prepared statement explaining the needs for the increased fees, and how the money will be spent. I can assure you that if this proposal is approved by this meeting, the ballot will have with it a detailed statement showing why the money is needed, and what it will be used for.

Mr. Gray-Donald said he thinks the basic reason for the proposal to increase the fees is just that the Institute is an active association, and the members are trying to make more active. This cannot be done on a shoestring. If the Institute wants to achieve its object of becoming the best engineering society in the world, it must expect to pay at least a reasonable fee. E.I.C. fees, even on the increased schedule, will be much lower than most United States and British Institutions. Mr. Gray-Donald said it is not a large amount of money per individual, and he thought the proposal should be approved.

Dr. I. R. Tait asked if the Treasurer had made an estimate of the number of members which the Institute may lose with the increased fees.

Mr. Gray-Donald said an estimate has not been made, and he is inclined to think that the loss will not be very great. Certainly those that pay the additional fees will be active members.

Mr. W. B. Pennock said that discussing this matter fully at this time might be just a waste of time because, if approved, the proposal could not take effect until 1962. To see where it is going the Institute needs to know the financial results of 1961.

Mr. Durrant pointed out that because of the joint agreement between E.I.C. and the A.P.E.N.S., members in Saskatchewan will not know what sort of fee increase they are voting for.

Mr. Edgar A. Cross spoke in favour of increasing the fees. He pointed out that the increase represented about ten to fifteen cents per week for each member, and thought that engineers can well afford that amount. By the same token, students who earn about $5,000 on graduation, should be able to pay a fee of $3.00 per year. He maintained that the membership fees should pay the cost of membership expenses and operating expenses which is unlikely to happen this year with a budgeted deficit.

Mr. Thom said he had no objection to the fees being raised but he did object strongly to what he considered to be an absurd fee for Associate Members. He moved an amendment that the Associate Member fee be three quarters of the full membership fee.

Mr. G. W. Chorley seconded the amendment moved by Mr. Thom.

Mr. J. E. Harris said he did not intend to speak in favour of or against the proposal, but emphasized the necessity and the responsibility of keeping the members informed of the financial state of the Institute, and in particular of making sure that a detailed statement, embodying the remarks of the Treasurer, is sent to the membership with the ballot. If this is properly handled, the affirmative vote will be achieved and there will be little loss in membership to the Institute.

Mr. Mason said there appears to be a conflict between the Finance Committee and those who wish to have more income from membership fees. The Finance Committee's annual report for 1960 predicts a surplus of approximately $23,000 for 1961.

Mr. Gray-Donald said this estimate was predicted on certain revenue subsidies, from the Journal. The experience of the Journal in the last two months had not been a happy one, and it now seems likely that there will be a deficit. The Institute is operating on a reduced budget and every possible economy is being effected. The forecast made in the Finance Committee's report was the best estimate which could be made at that time, but present indications are that it will not be achieved by a substantial amount.

Mr. Mason said he understood this but considered the Committee must have had ample time to prepare a statement.

Mr. Gray-Donald said that the Committee's estimate was based on a budget made up in November 1960.

Mr. Monaghan spoke in favour of Mr. Thom's amendment that the fees for Associate Members be increased, and moved an amendment to the first amendment that Associate Member fees be increased as follows:

Montreal	—	17.00
Others	—	15.00
Branch Non-residents	—	10.00

Mr. A. C. Davidson seconded the second amendment. The second amendment, and motion were carried with ten votes in opposition and it was therefore resolved that the amendment to Section 21, Annual Fees —Table of Fees, with amendments above, be approved for submission by letter ballot to the corporate membership.

SECTION 28 — COMPOUNDING OF FEES

It is proposed that Section 28 be written as follows:

Present Wording:

A Montreal Branch Member in good standing may compound all his future annual fees by a single payment in accordance with the following schedule:

Age of member at time of compounding	Amount
25	$415
30	395
35	375
40	345
45	310
50	270
55	220
60	160
65	90

All other branch residents may compound future annual fees by paying 90% of the amounts shown. Branch non-residents or non-residents may compound all future annual fees by paying 80% of the amounts shown. For intermediate years direct interpolation will apply.

In the event of discontinuance of membership for any cause there shall be a refund of compounded fees in the amount of 90% of the unused portion, with age 70 taken as the reference year for such calculation.

Payment received for compounding of fees shall be kept in a separate fund during the period of membership of the compounder, and only the interest used for the current expenses of the Institute and the rebates to the branches.

Proposed Wording:

A Montreal Branch Member or Fellow in good standing may compound all his future annual fees by a single payment in accordance with the following schedule:

Age of member at time of compounding	Amount
25	$560
30	535
35	505
40	465
45	420
50	365
55	297
60	215
65	120

All other branch residents may compound future annual fees by paying 92.5% of the amounts shown. Branch non-residents or non-residents may compound all future annual fees by paying 80% of the amount shown. For intermediate years direct interpolation will apply.

In the event of discontinuance of membership for any cause there shall be a refund of compounded fees in the amount of 90% of the unused portion, with age 70 taken as the reference year for such calculation.

Payment received for compounding of fees shall be kept in a separate fund during the period of membership of the compounder, and only the interest used for the current expenses of the Institute and the rebates to the branches.

It was moved by Mr. R. Monaghan, and seconded by Mr. R. J. Harvey, that this amendment be approved. An amendment to the motion was moved by Mr. A. F. Brooks, seconded by Mr. C. G. Rogers, that the words "and over" be inserted after age 65 in the second paragraph, and the words "to age 65" inserted at the end of the third paragraph after the words ". . . direct interpolation will apply".

The amendment and motion were carried that this Annual General Meeting approves the amendment to Section 28—Compounding of Fees, with additional amendments proposed above for submission by letter ballot to the corporate membership.

SECTION 35 — THE TREASURER

It was proposed that Section 35 be written as follows:

Present Wording:

"The treasurer shall be a Member of the Institute."

Proposed Wording:

"The treasurer shall be a Member or a Fellow of the Institute."

It was moved by R. B. Chandler, seconded by Professor A. C. Davidson, and carried unanimously that this Annual General Meeting approves the amendment to Section 35—The Treasurer, for submission by letter ballot to the corporate membership.

SECTION 45 — THE TREASURER

It was proposed that a second sentence be added, as follows:

"The treasurer shall be ex officio vice-chairman of the finance committee."

Dr. Wright said: "It seems to me to be quite improper to make the Treasurer, Vice-Chairman of the Finance Committee. He is not an elected officer and therefore should not be put into such a strong position." It was moved by Mr. C. L. Fisher, seconded by Professor A. C. Davidson, and carried with two votes in opposition, subject to approval by the Institute's legal counsel, that this Annual General Meeting approves the amendment to Section 45, Treasurer, for submission by letter ballot to the corporate membership.

SECTION 48 — COMMITTEE ON TECHNICAL OPERATIONS

It was proposed that Section 48 be written as follows:

Present Wording:

Gives terms of Reference of Committee on technical operations.

Proposed Wording:

Add, prior to the present last paragraph a new paragraph reading—"It shall consider requests for regional technical conferences, and when it deems advisable, recommend to council that council grant approval to hold such conferences."

It was moved by Mr. T. N. Davidson, seconded by Dean H. G. Conn, and carried that this Annual General Meeting approves the amendment to Section 48—"Committee on Technical Operations", for submission by letter ballot to the corporate membership.

SECTION 49 — PUBLICATION COMMITTEE

It was proposed that Section 49 be headed "Publications Committee' and be written as follows:

Present Wording:

The publication committee shall be composed of members representative of the principal branches of the engineering profession. The committee shall decide whether papers submitted to it, either by the author directly, or through any of the branches, and the discussions thereon, shall be printed for advance circulation or published. It shall also advise the general secretary in the editing of the publications of the Institute.

An appeal from the decisions of the committee may be made to the council upon the signed application of five corporate members.

The right of prior publication of all papers accepted to be read at a branch or professional meeting is reserved by the Institute. Any such paper not accepted for publication shall be returned promptly to the author.

No paper shall be considered eligible for any of the prizes of the Institute, which has been published elsewhere prior to its publication by the Institute, unless so published with the consent and approval of the publication committee officially-transmitted by the general secretary.

Proposed Wording:

The publications committee shall be composed of seven corporate members representative of the major areas of engineering specialization. It shall study and make recommendations to the council concerning the publication policy of the Institute with regard to technical journals, transactions, directories, books and related media. It shall consult with and advise the general secretary concerning policy and practice for all publications of the Institute. Suggestions from the membership concerning all matters of publication shall be received and examined by the publications committee.

The committee shall, with the approval of council, appoint editorial review boards to advise the committee on all technical content of any of the Institute's publications. The committee will approve, reject or request modification of technical papers submitted to the Institute for possible publication. The committee shall determine in which, if any, publication of the Institute technical papers will appear.

The publications committee shall advise and assist the finance committee in matters of financial policy concerning the publications of the Institute.

The publications committee shall maintain the closest possible liaison with the committee on technical operations."

It was moved by Mr. R. A. Phillips, seconded by Dean H. G. Conn, and carried that this Annual General Meeting approves the amendment to Section 49, Publication Committee, for submission by letter ballot to the corporate membership.

SECTION 63 — SECTIONS OF BRANCHES

It is proposed that the second paragraph of this section be written as follows:

Present Wording:

"Student or Junior sections may likewise be established . . ."

Proposed Wording:

"Students or Associate Member sections may likewise be established . . ."

It was moved by Professor A. C. Davidson, seconded by Mr. J. R. Rettie, and carried that this Annual General Meeting approves the amendment to Section 63—Sections of Branches, for submission by letter ballot to the corporate membership.

CANADIAN RESEARCH

Mr. L. A. Broddy said he wished to congratulate the Institute on the choice of the theme for this Annual Meeting—"Canadian Design for Canadian Products". He said that one of the reasons we have not got a distinctive Canadian design, although Canada is carrying out some very worthwhile research in some fields, is due to lack of funds. The United States spends large amounts in research, and Europe, with it lower standard of living, spends approximately four times as much as Canada. If the matter is looked at more closely it would be found that actually Canada spends more than this on research but the work is carried on outside Canada. Canadian subsidiaries have to pay for research done by parent companies and they have to pay for the research rights. It has also been stated that if Canadian Graduates were withdrawn from one of the largest United States chemical companies, the concern would have to close down.

Mr. Broddy believed the Institute should take the strongest stand in this matter. It was moved by Mr. Broddy, seconded by Mr. C. L. Fisher, and carried unanimously that the Institute take appropriate steps to urge the Government of Canada and industry to increase research in Canada.

The President said he was entirely in accord with Mr. Broddy. The matter is an important one, and also a very complex one and he said that the motion which had just been approved would help the Institute to get some action taken.

HONOURS, MEDALS AND PRIZES

The President said that the Council of the Institute has unanimously voted that certain Honours, Awards and Medals be bestowed by the Institute, as follows:

HONORARY MEMBERSHIP

"Chosen from those who have become eminent in engineering of kindred sciences, and elected by unanimous vote of Council".

Robert John Beaumont,
Honorary Chairman and Consultant
The Shawinigan Water & Power Company,
Montreal, Que.

Albert Edward Berry,
General Manager and Chief Engineer,
The Ontario Water Resources Commission,
Toronto, Ont.

Robert MacDonald Hardy,
Consulting Engineer,
(Formerly Dean of the Faculty of Enginering, University of Alberta)
Edmonton, Alberta.

Hubert Ryerson Sills,
Design Engineer—Waterwheel Generators,
Canadian General Electric Company,
Peterborough, Ont.

Kenneth Franklin Tupper
President,
Ewbank & Partners (Canada) Ltd.,
Toronto, Ont.

SIR JOHN KENNEDY MEDAL (1960)

"As a recognition of outstanding merit in the engineering profession and of noteworthy contribution to the science of engineering".

Hubert Ryerson Sills,
Design Engineer—Waterwheel Generators,
Canadian General Electric Company,
Peterborough, Ont.

JULIAN C. SMITH MEDAL (1960)

"For achievement in the development of Canada".

Arthur Duperron,
Formerly, Chairman and General Manager,
The Montreal Transportation Commission,
Montreal, Que.

THE GZOWSKI MEDAL (1960)

"For the best paper of the medal year on a civil engineering subject".

Carson Howard Templeton,
Senior Partner,
Templeton Engineering Company,
Winnipeg, Manitoba.
For his paper:
"Benefit Cost Analysis of Greater Winnipeg Floodway"

THE LEONARD MEDAL (1960)

"For papers on mining subjects"

John A. Hall, M.C.I.M.
Mines Superintendent,
Gaspe Copper Mines Limited,
Murdochville, Que.
For his paper:
"Trackless Mining at Gaspe Copper"

THE PLUMMER MEDAL (1960)

"For papers on chemical and metallurgical subjects"

Robert Norman Boyd,
Supervising Engineer—Design Services,
DuPont Company of Canada Limited
and
Vladimir Joseph Bakanowski,
Principal Computation Engineer,
DuPont of Canada Limited,
Montreal, Que.
For their paper:
"Electronic Computation in the Chemical Industry"

THE DUGGAN MEDAL AND PRIZE (1960)

"For the best paper dealing with the use of metals for structural and mechanical purposes"

Stanley Dale Lash,
Head, Department of Civil Engineering,
Queen's University,
Kingston, Ont.
and
Brian B. Hope,
Research Assistant,
Queen's University,
Kingston, Ont.
For their paper:
"Structural Behaviour of Highway Decks"

THE R. A. ROSS MEDAL (1960)

"For papers on electrical engineering subjects"

Lindsay Mansur Hovey,
Consulting Engineer,
The Manitoba Hydro-Electric Board,
Winnipeg, Man.
For his paper:
"Optimum Adjustment of Governors in Hydro Generating Stations"

THE ROBERT W. ANGUS MEDAL (1960)

"For the best paper on a mechanical engineering subject"

John Bemister Bryce,
Hydraulic Engineer,
Hydro Electric Power Commission of Ontario,
Toronto, Ont.
For his paper:
"Head-Loss Co-efficients for Niagara Water Supply Tunnels"

SIR GEORGE NELSON AWARD

No award

JUNIOR PRIZES

JOHN B. GALBRAITH PRIZE

Roger Hugh Wilkins,
Standards Engineer—Manufacturing Department,
British American Oil Company,
Toronto, Ont.
For his paper:
"Sewage Treatment Plant for the City of Belleville"

REPORT ON ELECTION OF NEW OFFICERS

Report—

The President said that a new President, three Vice-Presidents, and the appropriate number of Councillors were elected at the December 1960 meeting of Council in accordance with the By-Laws, as follows:

(1) Extract from Minutes of January 28, 1961, meeting of Council:

PRESIDENT, 1961

61/94 Mr. John Budden, Montreal, Chairman of the 1960 Nominating Committee presented, for the approval of Council, the nomination for the E.I.C. presidency for the year 1961. The Nominating Committee nominates Bristow Guy Ballard of Ottawa, Ontario as E.I.C. President for 1961/62.

RESOLVED unanimously, and by acclamation, that Bristow Guy Ballard, Ottawa, Ontario, be named President of The Engineering Institute of Canada for the year 1961/62, to take office at the 1961 Annual Meeting in Vancouver."

(2) Extract from Minutes of December 19, 1960, meeting of Council:
Officers and Councillors
60/806 It was noted that the 1960 Nominating Committee reports that only one nomination has been received, with the exception of the Border Cities Branch, for each vacancy on the Council of the Institute for the year 1961, and that these nominations were accepted by the Executive Committee of Council on September 9, 1960, and were published in October 1960 issue of The Engineering Journal for scrutiny by the membership.
60/807 It was:
RESOLVED unanimously that, in accordance with Section 42 of the By-laws, the following officers be declared elected by acclamation and asked to take office at the Annual General Meeting of the Institute to be held at the Hotel Vancouver, Vancouver, B.C., on May 31, 1961:
Vice-Presidents
One to be elected for two years
Zone "A" (Western Provinces)
F. M. Cazalet, Vancouver, B.C.
Zone "B" (Province of Ontario)
Paul E. Buss, Thorold, Ont.
Zone "C" (Province of Quebec)
G. N. Martin, Montreal, Que.
COUNCILLORS
Two to be elected for three years

Montreal	T. A. Monti
	R. J. Harvey

One to be elected for three years

Ottawa	Hugh C. Brown
Toronto	A. M. Toye

One to be elected for two years

Vancouver	C. Peter Jones
Vancouver Island	L. C. Johnson
Edmonton	J. Longworth
Saskatchewan	F. W. Catterall
Winnipeg	G. Flavell
Yukon	G. B. Starr
Central B.C.	H. R. Hatfield
Kootenay	L. Williams
Belleville	T. E. Flinn
Border Cities	J. E. Dykeman
Brockville	R. H. Wallace
Chalk River	C. E. L. Hunt
Kingston	S. D. Lash
Lakehead	D. B. McKillop
London	D. M. Jenkins
Nipissing & Upper Ottawa	J. F. Chantler
Port Hope	H. A. Gadd
Sudbury	W. B. Ibbotson
Baie Comeau	Emil Bodmer
Eastern Townships	A. S. Mitchell
Lower St. Lawrence	J. R. Menard
North Shore Lower St. Lawrence	R. W. Pryer
Saguenay	C. C. Louttit
St. Maurice Valley	J. U. Moreau
Fredericton	S. B. Cassidy
Saint John	J. W. G. Scott
Amherst	J. W. Wilson
Prince Edward Island	L. A. Coles
Corner Brook	H. B. Carter
Newfoundland	V. A. Ainsworth

(3) Niagara Peninsula Branch Councillor
61/366 To complete the remainder of Mr. Paul E. Buss's term of office as Councillor for the Niagara Peninsula Branch on his election to the Vice-Presidency, the Branch has nominated Mr. F. R. Denham, M.E.I.C.
It was:
RESOLVED unanimously that Mr. F. R. Denham be elected Councillor representing the Niagara Peninsula Branch to take office at the 1961 Annual Meeting and to complete the remainder of Mr. Buss's term of office, until June 1962.

Induction of New Officers

The President reported that the new officers will be formerly introduced and inducted at the Annual Banquet on June 2, with the exception of the incoming President who would be inducted at Dinner on May 31st. The President took the opportunity of introducing to the meeting, Dr. Bristow Guy Ballard of Ottawa, the Institute's new President for 1961-62, and the three incoming Vice-Presidents, Mr. Paul Buss, Mr. G. N. Martin, and Mr. F. M. Cazalet.

Dr. Ballard said he was sure he could speak for the new Vice-Presidents and the members of the 1961 Council how much they appreciate the confidence which has been placed in them. They can foresee an extremely heavy responsibility before them during the ensuing year and realize that they will have very serious decisions to make. He said they would endeavour to meet their responsibilities to the best of their ability and he knew that they could count on the support of the membership. He said that they would do everything they could to ensure that the Institute continues to expand and improve.

REPORT OF ENGINEERS CONFEDERATION COMMISSION

The President stated that at the 1960 Annual Meeting in Winnipeg it was indicated that The Engineers Confederation Commission would prepare detailed proposals for Confederation of The Council of Professional Engineers and The Engineering Institute of Canada, based on the joint Report of the C.C.P.E. and E.I.C. Committees on Confederation.

He said that on May 30, the Council received officially the Final Report of The Engineers Confederation Commission and statements regarding the Report from Mr. John H. Fox and Mr. Leo Roy, Chairman and Vice-Chairman, respectively of the Commission. He said that in view of the importance of this matter he had invited these gentlemen to be present at the Annual General Meeting and to present to the meeting these statements for the information of the membership.

Before presenting the report, Mr. Fox, the Chairman of the Engineers Confederation Commission, expressed his appreciation to the engineering profession for charging him, together with the members of the Commission, with the responsibility of bringing down a report on the proposed Confederation of The Engineering Institute of Canada and the Canadian Council of Professional Engineers. He paid tribute to the members of the Commission with whom it had been his privilege to work on this important project. He acknowledged the tremendous amount of time devoted by individual members of the Commission to the project over and above the meetings of the Commission and said that this had been possible only because of the generosity of the organizations with which the members of the Commission are associated. Mr. Roy, Vice-Chairman of the Commission, said that it was a great pleasure for him as the Institute's representative to be able to comment briefly on a subject which has been in the minds of engineers for a number of years. He stressed that the Commission was not asked to comment on the advantages and disadvantages of Confederation: it was asked to draw up a Constitution and By-Laws for the Confederation of The Engineering Institute of Canada and the Canadian Council of Professional Engineers in conformity with the eight basic clauses previously approved by these two organizations.

Mr. Fox and Mr. Roy then highlighted sections of the report as follows:

PART 1 — Introduction
1.1 History and Background
1.2 Authority and Terms of Reference
1.3 Composition of the Commission
1.4 Summary of Operation

In presenting this section of the report, Mr. Roy paid particular tribute to the very active participation by members of the Commission in the past in the affairs of The Engineering Institute of Canada, and said it would be hard to find a more qualified group of engineers to undertake the work carried out by the Commission.

PART 2 — Summary of Proposals
2.1. Preamble
2.2. Charter
2.3. Name
2.4. Headquarters

Mr. Fox commented in regard to the Charter that in addition to the obvious advantages of retaining the present Charter of The Engineering Institute of Canada, looking at the historical background there is also the feeling that the engineering profession would like to retain a Charter that is so broad it its scope and which has been in existence for a long period of time. The Charter had been reviewed by a corporation lawyer and the Commission is assured that it is in a form which can be presented to the Senate.

Mr. Fox emphasized that Headquarters, according to the By-Laws, can be located anywhere that future councils may wish, but for the purpose of drawing up the Charter, it is necessary that it be stated definitely where the Headquarters will be and it is recommended that they be located in the City of Ottawa.

2.5. Objects

Mr. Roy drew Council's attention to the statement in the report that throughout all the deliberations an effort was made to ensure that the original "objects" of the two parties to Confederation would be retained.

2.6. Participating Associations
2.7. Rights of Provincial Associations
2.8. Membership:
—Classes of Membership
—Corporate and Voting Membership
—Protection of Rights of Present Membership

Mr. Fox commented that there has been an omnibus clause drawn up concerning participating associations whereby provision is made within the proposed Charter and By-Laws for the affiliation or agreement with any body or society having objects similar or comparable to the proposed new national organization. Future councils have therefore the power to develop association with other groups of professional engineers. In connection with classes of membership, Mr. Fox said that legally the new organizations must make provision for all of the present membership of the participating organizations. The proposed By-Laws have taken this into account and Mr. Fox read to the meeting the conditions governing the various classes of membership.

2.9. Organization and Management
—Council
—Boards
—Committees

Mr. Roy summarized the proposed organization and management of C.I.P.E. and emphasized that the principal areas of activity of the national organization would be divided into two parts, the Board on Professional Interests and the Board on Technical Services.

2.10. Branches
2.11. Regional Branch Conferences
2.12. Student Chapters

Mr. Fox stated that the By-Laws are extremely detailed concerning the development and operation of branches within C.I.P.E., the method of co-operation with the provincial associations, and the services and assistance that may be given to branches by the national organization. He said that the Commission went slightly beyond its terms of reference in that it took upon itself to develop model By-Laws. It is visualized that the members of two or more neighbouring branches may wish to meet together to discuss mutual professional or technical problems and the By-Laws therefore provide for the development of Regional Branch Conferences if so desired. The Commission would like to see the development of Student Chapters on the university campuses where there are engineering schools and provision has been made accordingly for the continuance or formation of these chapters.

2.13. Finances

Mr. Roy said that a complete survey of the financial needs was made in the light of today's conditions and costs, an initial program combining the essential activities of both the Canadian Council and the E.I.C. and an anticipated membership of 40,000. He referred in detail to the budget contained on page 64 of the report and said that the Commission has budgeted for half a million dollars a year which includes Branch rebates of $60,000.

The estimated total assessment per member becomes $12.50 per annum of which approximately $9.90 is directly applicable to the national organization. It is proposed that the fiscal year of the Institute commence on the first day of April of each year and end on the 31st of March following. Subscription rates for publications are determined by the Council. It is recommended that the Library and Employment Services be discontinued and no budget provision appears for these items.

2.14. Discipline

Mr. Fox said that provision has been made for disciplinary action of C.I.P.E. within the proposed Charter and By-Laws insofar as membership in the national body is concerned and direct disciplinary action is provided for special classes of members who are not governed by provincial associations.

2.15. Library and Employment Services

Mr. Fox said that there was not a member of the Commission who was not familiar with the traditions of the E.I.C. library and the matter was given very serious consideration. It was however decided that it be not continued as a service of the new national organization since it served a relatively local and limited number of members and is an extremely expensive operation to run as it is at the present time. The Commission recognizes that it is a technical library of high quality and historic value and should not be carelessly dispersed. Mr. Fox said that the Commission is of the opinion that any formal organization for employment services to be of effective value would be costly of time and money and would be in direct competition with the many effective agencies that are now available and the Commission therefore recommends that an Employment Service not be provided by the C.I.P.E.

PART 4 — The By-Laws

Mr. Fox paid tribute to the fine work done by Dean Henri Gaudefroy and the members of his By-Laws Committee who had been responsible for the tremendous job of drawing up the proposed By-Laws. Mr. Fox quoted from the report as follows: "The proposed By-Laws have been prepared to conform with the terms of the proposed Charter. Legal counsel advises that these By-Laws will protect the interests of all parties to any agreement and the membership from the legal point of view.

"The basic intent of the proposed By-Laws is to provide for permissive action and not to restrict a broadening of activities, should such seem desirable, in the opinion of the Council or the Membership".

Mr. Fox drew attention to the Transitional Provisions laid down in the By-Laws. He said that it is recognized that there will be a transitional period during which some interim group has to be empowered to act and it is proposed that a provisional council be formed.

PART 6 — Procedures for Implementation

Part 6, together with Appendices "F" and "G", outline the solicitor's recommendations as to procedures necessary for the implementation of the Confederation. Mr. Fox emphasized that the procedure is fairly lengthy but is a logical approach if taken step by step. Mr. Fox noted that some problem may arise if parliament makes changes to the draft bill before it is passed. It is unlikely that these changes would affect the majority of the By-Laws but they might affect By-Law 1 (Name) and By-Law 2 (Objects). To make provision for such an eventuality, it has been suggested that in any submission of the By-Laws to the members of the E.I.C. it be made clear that the By-Laws of the Institute which will come into force when the private act comes into force shall be the By-Laws.

A summary of the suggested sequence for implementation appears in the report.

PART 7 — Other Recommendations

Mr. Fox outlined the other recommendations made by the Commission, particularly in respect to the suggestion that a special committee be appointed and authorized to "steer" the proposed bill through parliament of Canada and noted that the Commission recommends that when the time comes for such appointments that the appointees be drawn from the membership of the Commission and that they be persons well informed in regard to the development and context of the proposed Charter and By-Laws. He also noted that in the interim period between the granting of the amendment act and the election of the first Council, a provisional set of officers and Council must be provided for that period and provision has been made in the proposed By-Laws for the appointment to office and to the Council for this interim period.

Mr. Fox said that with the presentation of this report the duties of the Commission are concluded and the term of its appointment ends in October 1961. Since there will be many details which will require clarification or amplification for those who have not shared in the complete project, the Commission is prepared to remain on a standby basis until the term of its appointment is concluded. Should all parties participating in the project wish to reappoint the Commission for an additional period or term the present Commission is prepared to serve. Mr. Fox also stated that the Commission is prepared to serve as the proposed provisional Council of C.I.P.E. should it be the decision and desire of those participating in Confederation.

The President thanked Mr. Fox and Mr. Roy on behalf of those present for presenting to the Annual General Meeting the Final Report of The Engineers Confederation Commission. He asked that they convey to the members of The Commission the appreciation of this Annual General Meeting for the great amount of work rendered in preparing the Report.

The President said that Council on May 30 took action to appoint the Executive Committee to study the Report and recommend regarding the method of presentation of the Report to the membership as well as to make any Comment it wishes to the Council regarding the Report. All of this is to be done prior to November 1, 1961. He stated that due to the short time that the Report had been in the hands of Council, and since it had only been sent to Councillors and Branch Chairmen, the Council is of the opinion that it would serve no useful purpose to discuss the contents of the Report at this time, pending thorough and complete study. He invited the meetings' attention to the note which accompanied the notice of the Annual General Meeting as follows:

"To provide an opportunity for members who may wish to speak to Item 6, "Report of the Engineers Confederation Commission", members may be requested to speak only once to this subject on the floor. Members who will wish to speak on this subject are invited to advise the General Secretary prior to 9.00 a.m. on May 31, 1961. They will be called on to speak in the order in which their names are received, following which, in the time remaining, members who desire to speak but have not so indicated will be invited to speak from the floor."

He said that in view of this he was imposing a time limit of three minutes for each member who wished to speak on this subject once. He said it would be appreciated if discussion at this meeting was confined to questions directed to Mr. Fox and Mr. Roy.

He said that as Chairman, he had ruled that any motion to accept or reject this Report at this Annual Meeting will be ruled out of order. He stressed however that ample opportunity for discussion of the Report through the normal E.I.C. channels will be provided in the ensuing months.

Dr. I. R. Tait said that his approach to this subject is one of caution. He realized that it is a big step to take and just wanted to say he was not speaking to the meeting as an Honorary Member or a Life Member, but as an ordinary member who has taken an interest in the welfare of the Institute for many years. He said that in the last few years his efforts had been directed towards whether it is possible to achieve a satisfactory Confederation. He still hoped it would be possible but only under conditions which will make it a happy and lasting one. He said he was sure that everyone appreciated the talks given by Mr. Fox and Mr. Roy. They had cleared up some of his worries and created others. However, he said that everyone realized, especially the members who had been serving on committees concerned with this matter, as he had done until the Commission was formed, what a big step it is. He said that this is realized even more after listening to Mr. Fox and Mr. Roy, that it is not an easy job and that we must make haste slowly. He said a good job had been done in preparing the Report, and he could understand the great amount of work and trouble that this had entailed.

He said the Commission had deviated from its terms of reference. He knew that the Commission had to overcome many troubles and he was hoping that when the membership has a chance to read the Final Report that it will see that these have been overcome. He said he had had a chance to analyze the progress report issued at the close of the year and he judged from this that the matter will have to be gone into in very great detail. He said he was glad that the Executive Committee is examining the report and that the Committee would be very wise to note any suggestions which are made. He thought it unfortunate that the report was not published before the Annual General Meeting.

Dr. L. Austin Wright presented a memorandum regarding the report of the Confederation Commission from Dr. I. R. Tait and himself dated May 31, 1961 as follows:

(Note: The full text of Dr. Wright's quoted remarks is with the original of these minutes)

Dr. Wright stated that one of the worst features of the proposal is changing the Institute's name and introducing the word "professional", which does not seem to add anything significant. He stressed the important heritage and recognition of the Institute's name and noted that this recognition extends throughout the world.

He went on to point out the high cost of the mechanical changes that would be required if the name were changed.

He suggested that the Commission had not adhered to the specific terms of reference which it was given and questioned the validity of the report on this basis.

Dr. Wright deplored that there is no provision in the report for continuing the class of life member, nor for membership of persons who are not required by law to be registered, or could not be registered because of lack of Canadian citizenship. He noted that in terms of reference provision was made for the members of the Institute to elect their own representatives to the governing Council, but that the report proposes that a certain number of the Councillors will be appointed by the Councils of the Associations and the balance elected by the members of the Associations, thus disenfranchising the entire membership of the Institute and creating the situation whereby the members of one organization elect the officers of another.

Dr. Wright questioned what will happen to the Institute's assets and noted that this is not covered in the report and that if the report is approved the Associations will have control of the Institute's assets.

He regretted having to criticize the work of the Commission, but considered that the proposal is badly put together and relegates the national body to an inferior position controlled by the professional associations.

Colonel L. F. Grant spoke strongly against the report and the manner in which the matter was being handled by Council and at this Annual General Meeting. Referring in detail to the report, he said that the proposed new organization is not a truly Canadian national organization because it is secondary to the provincial bodies. The attitude appears to be that one may not be a Canadian engineer until one has become a provincial engineer. This means that you will not have a voluntary organization but an entirely "conscriptive" one. You do not become a member because you wish to, but because the law says you must.

Colonel Grant said he regretted deeply that the report was not presented in time to be properly discussed at the Annual General Meeting.

Mr. Fox said that there would be ample opportunity to discuss the Report as it is now printed and he said that if members wished to write to him direct, or through their elected officers, that would be in order.

Mr. Ernest Mason said he had sat in on the original meeting of the Committee on Confederation, and went on record at the time, in 1954, that he did not think Confederation will be accomplished before he retired in 1960. He said there were members at that time in Quebec who recommended that the Commission report in September of that year so that Confederation could be voted on. He said the meeting had listened today to some of the troubles the Commission has had. It could be quite easy to find fault with the Commission, but it is regrettable that such an important subject as Confederation has been kept away from the membership at large and information not available to them. He expressed regret that it had not been possible to devote more time to an active discussion of this extremely important matter and said he thought it to be essential that such a general discussion should take place between the membership on the subject of Confederation.

Mr. Fox said he was certain that every member will have an opportunity for detailed discussion regarding the Report. Each member of the Commission will be available to any branch, group, or body that wishes to discuss the Report.

Professor Black said he would support the senior members who have urged that the Institute proceed slowly with this matter.

Mr. Monaghan said he failed to see how anybody who has not had an opportunity to fully study the Final Report of The Engineers Confederation Commission can print objections to it. He moved that a vote of confidence be expressed in the action which had been taken by the Institute so far concerning the Report.

VOTE OF THANKS

It was moved by Vice-President Edgar A. Cross, seconded by Dean H. G. Conn, and carried with acclamation that a hearty vote of thanks be accorded to the retiring President, Vice-Presidents and Members of Council in appreciation of the work they have done for the Institute during the past year.

MOTION OF ADJOURNMENT

It was moved by Mr. C. G. Southmayd, seconded by Mr. J. G. Frost, and carried that the 75th Annual General Meeting of The Engineering Institute of Canada be adjourned.

The Meeting adjourned at twelve Noon.

GEORGE McK. DICK M.E.I.C.,
President, 1960-1961.

GARNET T. PAGE, M.E.I.C.,
General Secretary.

2050 Mansfield Street,
Montreal 2, Quebec.
(Date) July 11, 1961.

NOMINATIONS FOR OFFICERS, 1962

The report of the Nominating Committee, as accepted by Council at its meeting held on September 23, 1961, in Charlottetown, P.E.I., is published for the information of all corporate members as required by Sections 19 and 40 of its By-Laws.

VICE-PRESIDENTS

One to be elected for two years

Zone A (Western Provinces)	M. L. Wade, Kamloops, B.C. J. B. Mantle, Saskatoon, Sask.
Zone B (Province of Ontario)	T. Foulkes, Ottawa, Ont. J. E. Harris, Sarnia, Ont. G. E. Humphries, London, Ont. S. Sillitoe, Belleville, Ont. J. S. Waddington, Brockville, Ont.
Zone C (Province of Quebec)	Gaétan J. Côté, Rouyn, Que. Georges Demers, Quebec City, P.Q. B. M. Monaghan, Seven Islands, P.Q. J. J. Rowan, Montreal, P.Q.
Zone D (Maritime Provinces)	G. F. Bennett, Halifax, N.S. S. J. Carew, St. John's, Nfld. C. N. Murray, Sydney, N.S. R. E. Tweedale, Fredericton, N.B.

COUNCILLORS

Three to be elected for three years

Montreal	Marc Benoit Redmond Kane Harrison A. Mullin
Toronto	W. Leslie Hutchiso
Ottawa	G. B. Williams

One to be elected for two years

Vancouver	J. H. Swerdfeger
Calgary	F. L. Perry
Edmonton	A. Sandilands
Lethbridge	R. D. Hall
Saskatchewan	Roy Ludwig
Winnipeg	L. A. Bateman
Cornwall	B. T. Yates
Hamilton	W. A. Wheten
Huronia	F. Alport
Kitchener	J. Runge
Niagara Penninsula	George H. Milne
Peterborough	D. A. Lamont
Sarnia	H. V. Page
Sault Ste. Marie	W. M. Hogg
Quebec	P. A. Dupuis
Cape Breton	V. Palmer
Halifax	H. A. Marshall
Moncton	W. M. Steeves
Northern New Brunswick	No nominee
Northern Nova Scotia	No nominee

E.I.C. ELECTIONS AND TRANSFERS

A number of applications were presented for consideration and on the recommendation of the Admission Committee, the following elections and transfers were effected at a meeting of council on August 18, 1961.

MANITOBA

Junior to Member: F. W. Bergman, G. R. Kilgour.

NOVA SCOTIA

Junior to Member: J. D. Fitch, P. D. Murphy.

STUDENTS ADMITTED

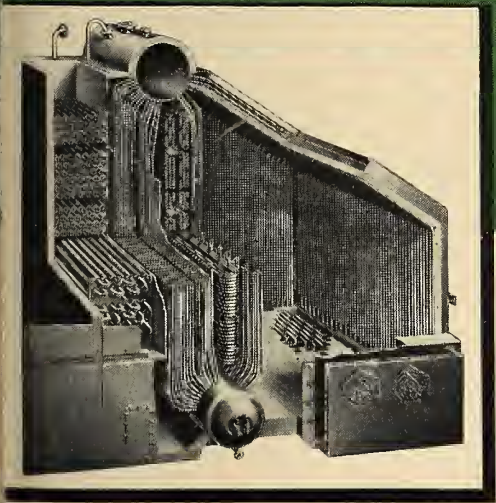
McGill University: E. Bercel, M. Tuchner.
University of British Columbia: K. T. Gustafson.
University of Manitoba: D. R. G. Melville, B.Sc, (Elec.) 1961.

Applications through Associations

By virtue of the co-operative agreements between the Institute and the Associations the following elections and transfers became effective August 18, 19

ALBERTA

Junior: P. B. Hussey.
Junior to Member: E. J. Arnold, R. Matthews, A. Smerek, D. B. Smith, A. Stodalks.



Steam for the main propulsion units of the latest addition to Canada Steamship Lines' ever growing fleet, is again supplied by Foster Wheeler Marine Steam Generators. Each of these D-type Marine Boilers have a normal capacity of 40,000 lbs. per hr. with peaks of 50,000 lbs. at 525 PSIG and 765°F at the superheater outlet.

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STANDARDIZATION IN CANADA

by B. G. Ballard, M.E.I.C.

Vice-President Scientific and Director
Radio and Electrical Engineering Division,
National Research Council, Ottawa

STANDARDIZATION in Canada has developed remarkably in recent years, not only because of an increasing application within industry, in the growing demand by government departments and the public for standard specifications, but also through Canada's participation in international standards through the International Organization for Standardization and the International Electrotechnical Commission.

The two main standardization bodies in Canada are the Canadian Standards Association, dealing mainly with requests from industry, and the Canadian Government Specifications Board, dealing with the needs of the government. While the CGSB is concerned primarily with government purchasing specifications, some of these find general use by the public. Both organizations operate in a similar manner, their standard specifications being prepared by voluntary committees. On each, both industry and government are generally represented.

There exists an operating agreement between the two organizations designed to avoid overlapping of effort and to integrate their work as far as possible. This liaison is further assisted by the membership of government staff members on CSA boards and committees.

There are several other standardizing bodies which operate independently of the above two organizations, but which are responsible for the preparation of important specifications in rather restricted fields. These include several federal government departments with special requirements, the Canadian National Railways, the Hydro-Electric Power Commission of Ontario, and many of the trade associations which have formed standards committees dealing with matters of special interest to their membership. In some cases, such as the Canadian Electrical Manufacturers' Association, there is a very close liaison with the Canadian Standards Association, and if, in the opinion of the latter, standards prepared by the former are of broad interest, the Canadian Standards Association will assume responsibility for the standard and publish it, with any amendments which may be necessary, as a CSA standard.

A brief description of the major standardization bodies of more general interest follows.

The Canadian Standards Association

The original committee of what was to become the Canadian Engineering Standards Association was formed in 1917, at the suggestion of the British Engineering Standards Association, by members of the Canadian Society of Civil Engineers (now the Engineering Institute of Canada). This committee immediately began standardization work on certain materials required for war purposes.

In 1919, the committee was incorporated by Letters Patent of the Secretary of State as the "Canadian Engineering Standards Association", with the right to promote the establishment and general adoption of engineering standards in Canada. In 1944, because of the apparent need for extending its activities beyond the engineering field, the name of the Association was changed to "Canadian Standards Association" and its scope broadened accordingly. It was reorganized in 1952 with a new set of Bylaws and a new form of operation. Its affairs are now directed by a Board of Directors of 18 elected members and one ex offici member, the President of the National Researcl Council.

The Association is a private, non-profit organizatio comprising members from industry, government, an technical and scientific institutions. The President o the Association is elected by the Board of Director from among its members, and holds office for tw years. The Board of Directors appoints from amon its members an Executive Committee which ad ministers the affairs of the Association when the Boar is not in session, and discharges responsibilities as signed to it by the Board. The President is Chairma of the Executive Committee.

Created under the authority of the Board o Directors is a Technical Council consisting of member nominated by professional organizations, industrial an trade associations, public utilities, and government de partments. The Chairmanship of the Technical Counci is held by the immediate Past-President of the As sociation. The Council is the final authority for th approval of standards prior to publication.

Sectional Committees are established by the Boar to co-ordinate the standards interests of related se tions of industry. Specifications committees operat under the sectional committees and have the task o drafting the standards required. Chairmen of section and specifications committees are appointed by th Board of Directors and arrange the membership o their committees subject to approval by the Board.

Before publication, draft standards require lette ballot approval of the Specifications Committee, rel vant Sectional Committee, and, finally, of the Tec nical Council.

The Association is financed by money fro membership dues, sale of publications, and an annu government grant. The annual budget for the standard division of the Association totals about $130,00 exclusive of office space and certain services. The sta numbers about 18, and the annual output of standard is about 40. The total number of standards on issue about 636. Distribution of copies of standards tota over 90,000 annually.

Subsidiary divisions of the Association are th CSA Testing Laboratories and the Canadian Weldin Bureau. The former provides a testing service f applianees, devices and materials subject to the r quirements of the Canadian Electrical Code and pertinent CSA specifications, with particular referen to reduction of safety hazards in connection with su equipment. The C. E. Code has been adopted by th provinces, and while the CSA itself has no mandato authority, the provinces have demanded that electric equipment used in the area under their jurisdiction shall comply with the requirements of the C.E. Code. On satisfactory evidence that the equipment and materials comply with the C.E. Code requirements, the use of the CSA Monogram on such equipment is authorized. Adoption of the C.E. Code by the provinces has made possible a highly satisfactory degree of standardization, and manufacturers can now market equipment which is acceptable by all provinces from coast to coast.

The Canadian Welding Bureau is a service organization devoted to sound and safe practices in welding operations through conformance with codes and standards that are under the jurisdiction of the CSA Sectional Committee on Welding. The Bureau operates an educational and certification service certifying the competence of operators, and also certifying the compliance of certain welding materials with the CSA standards. Again, the CSA has no mandatory authority, but several municipalities require that welded structures erected within those municipalities shall be welded in conformance with the appropriate CSA standards, and that the work shall have been done by welders certified by the Bureau.

These two divisions are self-supporting and receive no financial assistance from the Association. They derive their operating funds from fees and, in the case of the Welding Bureau, some additional revenue from sustaining memberships, which are held by organizations interested in maintaining high welding standards. This operation has been particularly successful, and has received very favourable comment from various sources.

The Canadian Government Specifications Board

In 1934, the Royal Commission on Price Spreads requested the National Research Council to determine the extent to which specifications were being used by federal government departments in purchasing. This investigation showed that valuable economies could be achievel through the use of specifications. On the recommendation of an interdepartmental conference, the Canadian Government Purchasing Standards Committee was formed on June 13, 1934, under the auspices of the National Research Council, with the responsibility of preparing specifications for government purchasing purposes.

Originally, the technical and secretarial work of the Committee was assigned to the Codes and Specifications Section of the Division of Research Information of the National Research Council. Changes in organization later caused this group to be administered within the Division of Building Research of the Council. On September 1, 1948, the name of the Committee was changed to "Canadian Government Specifications Board".

The Board is a government financed and operated organization with the purpose of preparing specifications at the request and for the use of government departments and agencies. The Board is made up of deputy heads of government departments and ageneies. Its specification activities are carried on by a Secretariat that operates as a section of the Division of Building Research. The staff of the Secretariat numbers 16, and the yearly budget is about $130,000, exclusive of the cost of office space and certain administrative services.

The immediate control of the Board's activities is in the hands of an Executive Committee made up of representatives appointed by the Board members. The Committee meets at least once a year to receive reports on work done, to make recommendations, and to act as a general advisory body.

The technical work of drafting and revising specifications is handled by committees that are appointed for each commodity field in which the preparation of specifications is undertaken. These committees include representation from interested government agencies and industry, and their activities are organized and guided by Committee Secretaries from the staff of the Specifications Section. Specific aspects of specification work are generally dealt with by technical subcommittees and panels appointed by the committees. When a specification has been developed to the stage where the collaborators are in substantial agreement, it is submitted to letter-ballot of the Board for ratification and issue. The present output of specifications is about 150 per year.

The total number of specifications on issue at the end of 1960 was 1,011. Distribution of copies of these specifications now totals well over 250,000 annually.

International Standardization

International Organiation for Standardization (ISO)

The International Organization for Standardization is a world-recognized agency established "to promote the development of standards throughout the world with a view to facilitating international exchange of goods and services and to developing mutual cooperation in the sphere of intellectual, scientific, technological and economic activity." It is supported in its work by 44 countries, including the USSR. It operates through the usual medium of technical committees, the secretariats for these being located in one of the interested countries. Eighteen of the secretariats are held by Great Britain, and eight by the United States.

Canada has maintained membership in the ISO since 1947. The Canadian Standards Association, as the Canadian member of ISO, now pays an annual subscription of $3,960, a modest investment from the national point of view. (Canada holds corresponding membership in the International Electro-technical Commission (IEC), a body similar to ISO but with a longer history, although working in a much more limited field.)

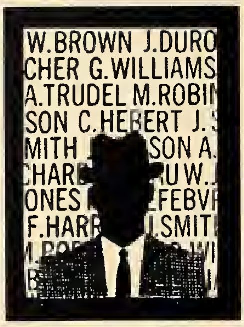
Canada plays an active part in fourteen of the Technical Committees of ISO. Arrangements for most of these are made through CSA, for some jointly by CSA and CGSB, and for one which is partieularly active (Textiles) directly through CGSB.

The Board of Directors of CSA appointed a special committee in 1955 to review the entire matter of Canada's participation in ISO. This committee rendered a unanimous report in May 1957, recommending that CSA should establish a standing committee on ISO which would be responsible for all Canadian liaison with ISO technical committees in which Canada is interested. The report was adopted by the CSA Board of Directors, and an ISO Committee has been created.

The International Electrotechnical Commission (IEC)

The International Electrotechnical Commission is one of the oldest international standardizing bodies, and was formed originally in 1904. As the name implies, its interests were confined entirely to electrical units and equipment, and through its efforts a worldwide standardization of units was achieved, and the Commission is exercising a continuing influence in achieving standardization of equipment. It operates

(Cont'd on page 187)



Personals

W. C. Moffatt, JR.E.I.C. (M.I.T. '61) has been appointed assistant professor in the Department of Mechanical Engineering at M.I.T., where he was engaged in research prior to receiving his Sc.D. degree this year. Dr. Moffat's research was done in engineering magnetohydrodynamics and high temperature gas properties.

Donald J. MacQuarrie, M.E.I.C. (N.S.T.C. '49) has been awarded a post graduate scholarship by the Canadian Good Roads Association. Mr. MacQuarrie will use the $2000. scholarship to study at the University of Western Ontario.

William F. Dawson, M.E.I.C. (McGill '45) has been made president of Douglas Bremner Contractors & Builders Ltd. Formerly vice president of the organization, Mr. Dawson's new appointment was announced by Douglas Bremner, chairman of the board.

Lech S. Brzezinski, S.E.I.C. (McGill '60) has received a Master's degree in Soil Mechanics and Foundation Engineering at the University of Illinois where he is continuing his studies under Dr. R. B. Peck.

Lt. F. J. Wawrychuk, JR.E.I.C. (Tor. '58) has been attached to the United States Army Corps, of Engineers, Ballistic Missile Construction Office, at Malmstrom Air Force Base, Great Falls, Montana. He has been assigned to the Montana Minuteman I.C.B.M. project.

Edward A. Silver, JR.E.I.C. (McGill '59) has returned to M.I.T. to continue studies towards a Ph.D. degree in Operations Research after working in the San Francisco Research Department of the Matson Navigation Company during the summer.

W. A. Wyszkowski, M.E.I.C. (Politech Warsaw '30) has joined Ewbank & Partners (Canada) Limited, Toronto, as chief civil and structural engineer and deputy head of the civil engineering division. Mr. Wyszkowski brings to the firm 35 years of experience in civil engineering.

Frank R. Pope, M.E.I.C. (McGill '35) has been appointed general manager of Westclox Canada Limited. Mr. Pope was previously assistant general manager. A mechanical engineer, Mr. Pope joined Westclox in 1938.

Roy E. Young, M.E.I.C. has been made chief engineer of Alberta Government Telephones. Mr. Young joined in 1926 and the following year was transferred to the engineering department as a draftsman. After being appointed apprentice engineer in 1936 he rose through the engineering department to the post of assistant chief engineer, which he held until his appointment as chief engineer became effective.

H. M. Hay, M.E.I.C. (Aberdeen Univ. '47) has been transferred from the Quality Control to the Sales Department of the Asbestos Fibre Division of Canadian Johns-Manville Co. Limited. His new title is Technical Sales Engineer.

David R. Morrison, M.E.I.C. (Sask. '42) has been appointed director of the patent department of Shawinigan Chemicals P. W. Blaylock, vice-president, research and development announced recently. Mr. Morrison, a native of Saskatoon, Sask., succeeds Dr. A. H. Heatley who has retired.

William L. Todd, M.E.I.C. (McGill '41) has been elected vice president and director of Stadler Hurter International Ltd. Mr. Todd's election was announced by A. T. Hurter, president of the firm.

Rod Bradley, M.E.I.C. (N.S.T.C. '48) was appointed assistant superintendent of mills at the Sydney works of Dominion Steel & Coal Corp. Ltd. The announcement was made by assistant works manager, J. F. Miles.

Karl E. Gustafson, M.E.I.C. (McGill '40) has returned to India to continue as mining consultant to the World Bank on the loan to the Indian Coal Industry. Mr. Gustafson is chief mining engineer, Pierce Management Corporation, Scranton, Pa.

D. F. Griffiths, M.E.I.C. (U.B.C. '45) was appointed assistant superintendent of the refining department of the Consolidated Mining and Smelting Company. R. R. McNaughton, manager of th Metallurgical Division made the an nouncement.

S. C. Roberts, M.E.I.C. (U.B.C. '43) ha been appointed Product Manager Power Switching Equipment, Easter Power Devices Division of ITE Circu Breaker (Canada) Limited.

F. James Cameron, JR.E.I.C. (McGill '52 an associate engineer with Martey Plant Ltd., Civil Engineering and Build ing Contractors, Kingston, Jamaica, ha been elected a director of the firm. M Cameron has been with the compan since 1957.

Edgar D'Souza, M.E.I.C (Syracuse '50 has left Quebec-Telephone where h was supervising engineer, constructio program and plant extension at the head office in Rimouski to join th Montreal office of K C S (Quebec) Ltd

Willard A. Jackson, M.E.I.C. (Queen '39) a mining and construction enginee is president and managing director of th new firm Consul Construction Consult ants, Toronto. Before starting this fir Mr. Jackson was general superintende for North Shore Construction Compan Ltd., Montreal.

M. P. Whelen, M.E.I.C. (McGill '21, To '22) has retired from the Toronto Hydr after more than 39 years of service. M Whelen will act as a consultant on pub lic utility problems. He is a forme councillor of the Institute.

Capt. C. A. Leech, JR.E.I.C. (Man. '53 has been selected to attend the 1961-6 course at the Canadian Army Staff Col lege, Fort Frontenac, Kingston, Ont. Th course commenced in September.

William J. Swanson, M.E.I.C. (U.B.C '51) has formed a consulting engineer ing firm, Swanson and Associates. Spe ializing in design as well as constru tion methods, the firm will work o reinforced concrete structures, marin and underwater structures, structures i permafrost and studies and reports o construction planning and methods.

(Continued on page 148)

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Other Societies

Canada's Power Show

The first Power Engineering Seminar of its kind to be held in Canada will be held with Canada's Power Show in Toronto from December 7-9, 1961. The aim of the seminar is to improve the job skill and increase the delegate's understanding of the entire power field. Technical papers will be presented by experts in the Canadian and U.S. power industry including the latest engineering developments and maintenance techniques.

The main speaker, Hon. Robert Macaulay, Canadian Minister of energy resources and vice chairman of Ontario Hydro Commission will forecast the development of all energy sources in Canada.

The Power Show, largest of its kind in Canada, has been held in alternate years since 1945. This is the first year that a Power Engineering Seminar has been added.

American Society for Testing Materials

A symposium on Cleaning and Materials Processing for Electronics and Space Apparatus will be held during the Fourth Pacific Area National Meeting of the A.S.T.M. in Los Angeles, Cal. from September 30 to October 5, 1962.

Abstracts from authors wishing to present papers may be submitted to Dr. D. E. Koontz, Bell Telephone Laboratories, Inc., Murray Hill, N.J. not later than January 1, 1962.

The subjects to be discussed at the Symposium fall into four major categories:

1) Examination of device materials
2) Treatment and examination of specific components
3) Processing facilities, such as chemical agents, processing liquids and ambients, including dust and lint control
4) Device experience with ultraclean conditions.

As many contamination and processing techniques, to say nothing of material problems, are common to other industries it is hoped that many of the topics will interest people from industries such as pharmaceuticals, optics and aircraft.

The Institution of Electrical Engineers

The Measurement and Control Section of the Institution has arranged a symposium on Nuclear Electronics to take place from November 30 to December 1, 1961, to be held at the Institution's headquarters at Savoy Place, London, W.C.2. It is to be a follow-up conference on the same subject as the one held by the International Atomic Energy Agency in Belgrade in May.

The Belgrade Conference, attended by delegates from more than 30 countries, was the largest and most successful international conference on Nuclear Electronics which has been held to date.

The Symposium will consist of three sessions dealing respectively with "Radiation Detectors", "Electronic Circuits and Techniques" and "Radiation Monitors and Instruments". At each session a report will be given on the relevant papers presented at Belgrade.

C.I.C.

A highlight of the Chemical Engineering Conference sponsored by the Chemical Engineering Division of the Institute to be held from Nov. 6-8 in Toronto will be the presentation of the R. S. Jane Memorial Lecture.

Special sessions will be held on digital computers, chemical engineering aspects of nuclear engineering, the kinetics of catalytic reactions and a featured topic will be process design dealing with typically Canadian problems such as scaling-down of prototype plants, batch plants and multi-purpose plants. A session on miscellaneous technical papers is also scheduled. The panel discussion on graduate research in Canadian Chemical Engineering Schools will be moderated by A. I. Johnson, McMaster University, Hamilton, Ont.

Plant visits include the HF unit of British American Oil Co. Limited at Clarkson, Molson's Brewery (Ontario) Limited, and the new refinery of Canada and Dominion Sugar Co. Limited. There will be a luncheon at the O'Keefe Centre where V. L. Henderson will describe the Centre's special acoustics.

International Federation of Automatic Control

Authors are invited to present papers at the Second Congress of I.F.A.C. on Automatic Control to be held in Basle, Switzerland in September 1963. There are four eategories under which the papers should deal.

1) Theory which includes:
   Discrete Systems
   Stochastic Systems
   Optimal Systems
   Learning Systems
   Systems Reliability
2) Applications which include:
   Process Dynamics
   Computer Studies of Applications, on or off line
   Optimizing or Adaptive Control Applications
3) Components which include:
   New and effective devices
   Measurement of the reliability of components
4) General

The length of each paper should not exceed 30,000 symbols (letters and spaces) corresponding to about 20 typewritten pages with 20 lines of 60 symbols per line including drawings and tables.

An abstract of not more than 200 words in the original lanugage as well as in English or Russian (or in both if possible) should summarize the paper. However, an introduction eannot be used as an abstract.

The Associations and Corporations

A.P.E.O.—Professional Engineers' Wives Association

The Toronto Branch has presented bursaries valued at $500 each to three first year students at the University of Toronto. Recipients of the bursaries were Camillo Mancini, 19, Laurie Hiivalo, 18, and John Giecko, 18. All three have enrolled in electrical engineering.

This is the first year that the Association has been able to present three bursaries in one year. Over $5,000 in bursaries have been given by the Association to worthy high school graduates who were planning to enroll in engineering courses, since the project was started in 1956.

Started originally as a club for the wives of U. of T. engineering graduates from the classes of 1950-51, the Association expanded to take in all wives of members of the A.P.E.O. Funds for the bursaries are raised by holding special events.

(Continued on page 152)

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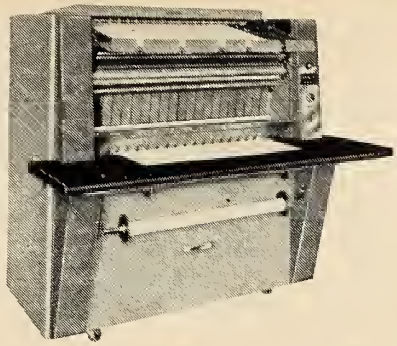

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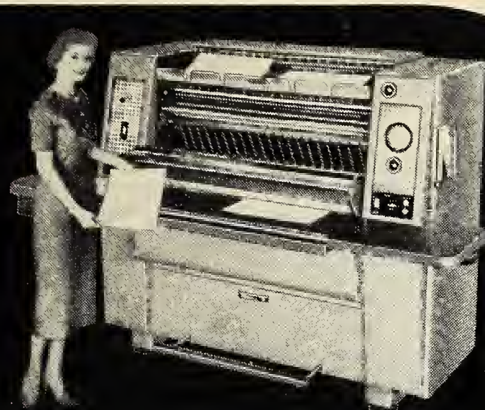

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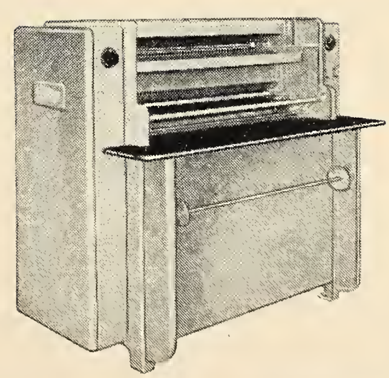

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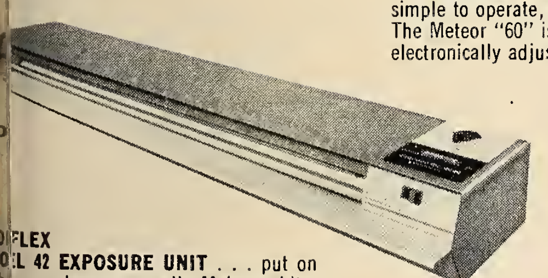

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News of the Branches

Baie Comeau

G. W. Scott, M.E.I.C.
Correspondent

Thirty-six members went on the field trip to the Cargill Grain Company's installation at Baie Comeau May 20. Grain loading and unloading operations were in progress. Norman Williams, local manager of the grain elevator system, explained the layout of the Baie Comeau installation and the various types of material handled. He described the sampling methods and analyses carried out on the different cargoes and the method of weighing during loading and unloading. He also reviewed the storage and handling conditions essential for the successful preservation of the various cargoes dealt with.

Members of the visiting party were then permitted to inspect the conveyor system and the dock installation which was in operation during the visit.

Current grain storage capacity at Baie Comeau is just short of 12 million bushels. The Cargill handling equipment is comprised of two bucket elevator type marine towers on the receiving berth and a combined unloading capacity of 60,000 bushels per hour (approximately 2,000 tons per hour) and a conveyor belt of equivalent capacity running at 850 ft. per minute transports the grain to storage. Reshipment from the storage silos is via a conveyor belt system running in concrete reclaiming tunnels. The grain is then elevated, weighed and loaded on two shipping conveyor belts, each capable of carrying 96,000 bushels per hour. At the shipping dock 12 shipping spouts, six to each berth, feed the grain into the vessels. The flow may be directed on either side or to both sides simultaneously and the rate of discharge through any spout can be adjusted over a wide range by an operator at the main control room.

J. E. Hayes, chief engineer of the Canadian Broadcasting Corporation was guest of honor at the Annual Dinner-Dance held in the Manoir Comeau June 8. One hundred members and guests attended.

Mr. Hayes, deputizing for R. I. Dunsmore who had been called away on business, read Mr. Dunsmore's address which he enlivened with amusing anecdotes from his own experience. The speech concisely summarized the functions of the C.B.C. and the success achieved in fulfilling the functions as assessed by the numerous Parliamentary Committees and Royal Commissions appointed from time to time. Mr. Dunsmore described his impressions of the C.B.C. based on the two and a half years he has been with the Corporation. The second part of his speech dealt specifically with the production, distribution and broadcasting of the over 100,000 programs produced each year for both the radio and television networks. These include 30 radio and 25 television stations owned by the C.B.C. together with 102 affiliated private radio and 77 affiliated private television stations. In fulfilling its mandate under the Canadian Broadcasting Act, the Corporation has covered 98% of Canada's population by radio and 96% by television.

At the conclusion of the address Mr. Hayes invited questions and the ensuing discussion dealt mainly with additional broadcasting developments on the North Shore of the St. Lawrence.

Mr. Hayes was introduced by S. J. Simons, Branch Chairman and thanked by G. W. Scott.

At the invitation of the Quebec Cartier Mining Company the Branch went on a field trip to Port Cartier July 22. On arrival at Port Cartier representatives of the Company met the party. Jean Paul Drolet gave a description of the activities of the company in the boardroom which was followed by a tour of the new office building.

At lunch the members met Lloyd J. Severson, president who introduced them to his staff and their wives.

A conducted tour of the new townsite, rail installation and the harbour filled the afternoon.

Trains loaded with ore concentrate from the Lac Jeannine plant 193 miles to the north pull directly into the dumper building at Port Cartier. An entire train of 125 cars, containing 12,500 tons of ore, can be dumped in 2 hrs. and 45 min. after which the ore goes through a rotary crusher and to a storage shed from which it can be loaded easily onto a ship.

Estevan Section

O. P. Lesiuk, M.E.I.C.
Correspondent

The Secretary - Treasurer of the S.A.P.E., R. Bing-Wo was the speaker at the June 5 meeting of the Section. His topic was "the New Engineering Act". Mr. Bing-Wo briefly outlined the history of engineering in Saskatchewan before discussing the Engineering Act passed in 1930. By 1959 this Act had become rather obsolete so a committee of seven engineers was formed to present recommendations regarding a new act to the legislature. In 1961 the Legislature passed Bill 58 and the new Engineering Act came into effect July 1. To conclude his talk the speaker summarized the new act. Gary Ursenback thanked Mr. Bing-Wo on behalf of the Branch.

Ted Huta gave a talk on engineering to the high school students at Broadview.

The Golf Tournament and barbecue were held June 26.

London

E. T. Skelton, M.E.I.C.,
Correspondent

"Ground Water Resources" was the title of the speech given at the September 19th meeting by A. K. Watt, Director of Water Resources, Ontario Water Resources Commission. Ground water is not an unlimited resource, regardless of its quality, though ground water of high quality is scarce in some regions of Ontario. Mr. Watt described the work his Department is doing to control the excessive use of ground water which lowers the water table. The province of Ontario is introducing a system of permits for users of ground water. Each permit will be issued only after the Department is satisfied that the required amount of water is available. James Lefler of Woodstock chaired the meeting which was attended by engineers from both London and Woodstock. George Chorley, chairman of the London branch, thanked Mr. Watt, whose speech was followed by a lively question and answer period.

The Branch has organized a Professional Development Program in conjunction with the University of Western Ontario. This year the course will be on Law and will consist of ten two-hour lectures. The University stated that 60 people could take the course, and then upped the number to 75 (allowing for absenteeism). However though, 75 have been enrolled 12 had to be refused. While disappointing to those refused, the interest was gratifying to the committee.

(Continued on page 158)

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.

*DESIGN OF PRESTRESSED CONCRETE BEAMS.

Presents tables and design methods intended to reduce the amount of trial and error usually encountered in determining the cross-section of simply supported prestressed concrete beams. The tables are not limited to members of any particular proportions or dimensions, and are applicable to I-beams, T-beams, long-span members, and composite sections. The major emphasis in the methods presented is on the elastic design for bending, but attention is also given to prestress losses, shear, and ultimate flexural strength. (W. H. Connolly. New York, Dodge, 1960. 252p., $11.50.)

*COMPUTER ENGINEERING.

This translation from the Russian contains papers discussing the power supply of the high-speed electronic computer of the Academy of Sciences of the USSR; new elements and units for computers; a method of control of the arithmetic unit; a method of electing the required word from the dictionary in machine translation; and present-day computer technology. The original publication was drawn up by specialists in the design and operation of electronic computers. (Ed. by S. A. Lebedev. New York, Pergamon, 1960. 184p., $10.00.)

*CENTRIFUGAL PUMPS.

A guide, for the centrifugal pump user, to the most satisfactory combination of system design and equipment selection, and to achievement of maximum service with minimum maintenance and unscheduled outage for installed equipment. Structural details, component parts, construction materials and such aspects as conditions of service and performance characteristics are given in general for centrifugal pumps, and also in particular for such specific types as vertical, regenerative and self-priming pumps. Detailed attention is given to pump controls. A general data section presents valuable data required for engineering pumping installations and for analysing the performance of existing units. Complex technical explanations and theoretical discussions have been avoided in the interests of providing useful and practical information on all aspects of the use of centrifugal pumps. (Igor Karassik and Roy Carter. New York, Dodge, 1960. 488p., $15.75.)

*FEUERFESTKUNDE.

This extensive treatise on refractories is divided into sections by the major types: silica, fireclay, alumina, basic and neutral, etc. Within each section are given the basic physical, chemical, and mineralogical characteristics, raw materials and their origin, manufacture, properties of the fabricated materials, applications. Certain other insulating materials such as asbestos and vermiculite are also briefly treated. An appendix contains phase diagrams and detailed indexes. (Friedrich Harders and Sigismund Kienow. Berlin, Springer-Verlag, 1960. 981p., DM 126.00.)

*ESSENTIALS OF DIELECTROMAGNETIC ENGINEERING.

This book is written for the inquisitive electronics engineer and the advanced engineering student looking for facts about the possibilities and limits inherent in magnetically soft ferrites and high-permittivity dielectrics. Chapter 1 examines relations in electric, magnetic and electromagnetic fields in materials with large but constant material parameters — a theoretical investigation and review of idealized dielectromagnetics. Chapter II discusses underlying physical principles, and then describes the frequency, amplitude, and temperature dependencies of ferrites and high-permittivity dielectrics, thus demonstrating how much actual dielectromagnetic ceramics deviate from the simplifying assumptions made in the first chapter. The last three chapters are concerned with application principles of dielectromagnetics — lumped reactive circuit elements in conventional and unconventional uses; elimination and utilization of macroscopic electromagnetic resonance phenomena; and selected classes of unique applications such as nonlinearity, nonrecprocity, and utilization of losses. (H. M. Schlicke. New York, Wiley, 1961. 242p., $9.50.)

*POLYSTYRENE.

A semi-technical book for all practical people in plastics. The chemistry of polymerization and several commercial procedures for the manufacture of polystyrene are discussed, as well as fabrication processes such as injection, compression, and blow molding, extrusion, sheet forming by pressure or by mechanical means, and casting. Emphasis is given however to commercial applications, in household appliances, electronics, building construction, packaging and other general uses, in the form of foam, and in special forms such as latex and beads. The final chapter surveys future prospects for polystyrene. (W. C. Teach and G. C. Kiessling. New York, Reinhold, 1960. 176p., $5.00.)

*DESIGN OF WORM AND SPIRAL GEARS.

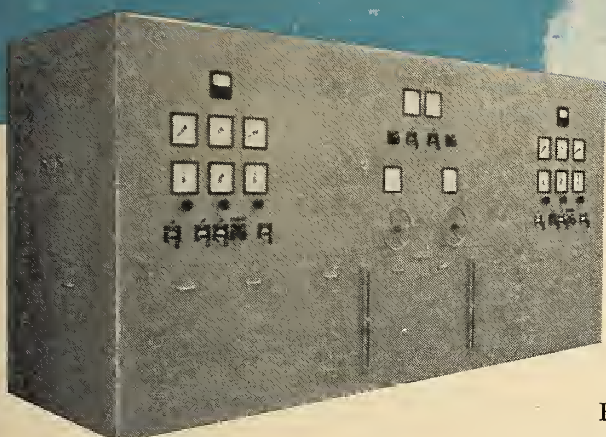
Intended to demonstrate the value of all-recess-action design principles, this book provides a step-by-step guide to the design of worm and spiral gear drives with all-recess action, pointing out how all-recess action design concepts can improve load-carrying and life capacity, and the other benefits of improved design. Also presented are certain basic principles and practices which enter the successful design and manufacture of all types of gears and gear drives. (Earle Buckingham and Henry H. Ryffel. New York, Industrial Press, 1960. 450p., $15.00.)

(Continued on page 162)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.



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(Continued from page 128)

Ross C. Norgrove, M.E.I.C. (Tor. '50) has been appointed to the Toronto sales division of James Howden & Co. of Canada Ltd. Mr. Norgrove was formerly with Canadian-Brazilian Services Ltd.

Walter Maslowski, JR.E.I.C. (McGill '59) has been appointed to the Montreal sales division of James Howden & Co. of Canada Ltd.

L. F. Morrison, M.E.I.C. (Alta. '43) has been appointed chief civil engineer of the newly formed corporation, Pacific Coast Pipe Limited, Vancouver.

A. H. Heatley, M.E.I.C. (Tor. '22) has joined the faculty of the University of Waterloo as a professor of Chemical Engineering. Dr. Heatley, a well known chemist and chemical engineer, was formerly director of patents for Shawinigan Chemicals Ltd.

ERRATA

In the September issue of the Engineering Journal it was erroneously reported that Dr. Heatley was to remain part-time with Shawinigan Chemicals. The Journal regrets its error and any embarrassment it may have caused Dr. Heatley.

Obituaries

Kenneth MacKenzie Cameron, M.E.I.C., died July 2, 1961. He was 80. Dr. Cameron was elected president of the Institute in 1943. Born at Strathroy, Ont. he graduated with honours from the Royal Military College, Kingston in 1901. The following year he received the degree of B.Sc. in civil engineering from McGill University. His post graduate work was done in hydraulics and he received the degree of M.Sc. from McGill University in 1903. He was the second graduate of Royal Military College to become President of the Institute, the first was Lieut-Col. R. W. Leonard. Dr. Cameron joined the E.I.C. while a student at McGill in 1901. He was the recipient of one of the four inaugural awards of student prizes established by Council in 1902. The subject of his paper was "The Practical Use of Extensometers".

After spending the 1905-06 year at McGill University as a lecturer in surveying and geodesy, Dr. Cameron went to the United States where he took a variety of jobs to gain experience. He returned to Canada in 1908 and worked for a consulting engineering firm before joining the Department of Public Works of Canada. In 1912 he went to Ottawa as senior assistant in the Dredging Branch. In 1918 he became assistant chief engineer and in 1923 he succeeded Arthur St. Laurent as chief engineer of the Department. Dr. Cameron was Chairman of the Ottawa Branch of the Institute in 1922 and was a councillor of the Branch in 1924-25. In 1941 and 1942 he was vice-president of the Institute for Ontario. Dr. Cameron was the recipient of two honorary degrees in 1944. He was awarded an honorary D.Sc. degree from Laval University, and an Honorary D.Sc. degree from McGill University in the same year. He was made a life member of the E.I.C. in 1945.

Walter St. John Miller, M.E.I.C. died while vacationing at the home of his son in Victoria, B.C. He was 81. He served in the Transvaal Horse Artillery Volunteers in the Zulu uprising of 1906 and was a member of the R.A.F. during World War I, and a captain in the veteran's volunteer reserve during World War II. A well known patent attorney he made his home in Calgary. Mr. Miller received a degree from London Polytechnical Institute in 1901. He was awarded a life membership in the Institute in 1951.

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(Continued from page 148)

Col. Hugh A. McKay, M.E.I.C., president of McKay Cocker Construction Ltd. died in London, Ontario on July 29th at the age of 64. Awarded the Order of the British Empire in 1944, Col. McKay was responsible for the construction of all coastal defence and anti-aircraft batteries on Canada's east and west coasts. A graduate in civil engineering he received his degree from the University of Toronto, and specialized in construction work prior to World War II.

Robert James Askin, M.E.I.C., died July 1, 1961 in Montreal at the age of 62. Well known in his field, Mr. Askin was executive vice-president (development, engineering) and services with the Abitibi Power and Paper Co. Ltd. He joined the Institute in 1922 while a student at Queen's University from which he graduated in 1923. Mr. Askin was awarded a life membership in January 1961.

Sumer Wolf, M.E.I.C. died suddenly July 2, 1961. He was 48. Mr. Wolf, a member of the engineering and development staff of Montreal Locomotive Works Limited, received his education in Europe. In 1935 he received the degree of Ingenieur Diploma from the German Technical University in Bruenn, Czechoslovakia.

Geoffroy M. Demarque, M.E.I.C., a civil engineer with the Dominion Bridge Company died April 9, 1961 in Montreal. He was 55. A graduate of the Ecole Nationale des Ponts et Chausses in Paris, Mr. Demarque came to Canada with his family in 1947. He has been a member of the Institute since 1947.

Bernard Cain, M.E.I.C., Dean of the school of engineering at Acadia University died May 26. He was 49. He graduated from Nova Scotia Technical College in 1935 with a B.Eng. degree in electrical engineering. In 1937 he joined the faculty of Acadia University as an instructor. Later he became a professor. Since 1952 he had been dean of the school of engineering at Acadia University.

A. V. Tracy-Gould, M.E.I.C. died in Moncton May 27. He was 82. Born in Northfolk, England, he obtained all of his education in Europe. From 1901 to 1908 he practiced engineering in the United States. In 1908 he first came to Canada and for the past 40 years had been a resident of Newcastle, N.B.

Frank S. Small, M.E.I.C. died in St. John, N.B. in May. He was 83. Mr. Small graduated with honours from McGill University in 1914 with a B.Sc. degree in Civil Engineering. He joined the Institute in 1909 as a student. In 1950 he was awarded a life membership. He was awarded the Gzowski gold medal in 1951. EIC

The Engineering Institute of Canada Quebec Regional Technical Conference

November 2, 3, 4, 1961

Chateau Frontenac — Quebec City

PROGRAM

Thursday, November 2

2-10 p.m. —Registration

6.30 p.m. —Informal dinner for delegates to Regional Branch Officers Conference

8.00 p.m. —Regional Branch Officers Conference

8.30 p.m. —Informal reception for early arrivals

Friday, November 3

9.30 a.m.-Noon —*"Trends in Engineering Education in Quebec"*
Dean H. Gaudefroy, Ecole Polytechnique
Dean D. L. Mordell, McGill University
Dr. A. Cholette, Université Laval
Prof. G. Denis, Université de Sherbrooke

12-12.30 p.m. —Muriel's Room

12.30-2 p.m. —Luncheon

2-3 p.m. —*"Engineering Aspects of Space Technology"*
Part I—L. A. Dickenson, CARDE, Valcartier, Que.
Part II—F. Ward, CARDE Valcartier, Que.

3-4 p.m. —*"A New Approach to Building Highways Over Muskeg"*
J. Jacques Paré, Université de Sherbrooke

4-5 p.m. —*"First High Voltage Pipe Type Cable in Eastern Canada"*
Gaston Galibois, Quebec Power Company, Quebec

6.30-7 p.m. —Muriel's Room

7-9 p.m. —Buffet Dinner, Informal

10 p.m.-2 a.m. —Dance, Informal

Saturday, November 4

10-11 a.m. —*"Introduction to a New Iron Ore Development in the Province of Quebec — Quebec Cartier Mining Company"*
Jean-Paul Drolet, Quebec Cartier Mining Company, Port Cartier, Quebec

11 a.m.-Noon —*"Foam Asphalt"*
Armand Beaupré, Quebec Roads Department, Quebec

Noon-12.30 p.m.—Muriel's Room

12.30-2 p.m. —Luncheon

3-6 p.m. —Visit to New Faculty of Science, and Reception, Université Laval

Ladies' Program

Ladies are cordially invited to all meals and social functions.

There will be a special fashion show and tea on the afternoon of Friday, November 3, presenting "The Wardrobe of an Engineer's Wife for Different Occasions" by John Kelly.

(Continued from page 138)

Papers may be submitted in English, Russian, French or German. Prospective authors are requested to state the field of interest, and to inform the Associate Committee on Automatic Control, National Research Council, Ottawa 2, as well as the I.F.A.C. Secretary, of their intention to present a paper.

Further information may be requested from Dr. Ing. G. Ruppel, Secretary, I.F.A.C. Postfach, 10250, Dusseldorf 10, Germany.

I.A.E.A.

The first international scientific meeting devoted entirely to work in the field of plasma physics began September 4 in Salzburg, Austria. The Conference on Plasma Physics and Controlled Nuclear Fusion Research was opened almost three years to the day after the opening of the Second Geneva Conference of the Peaceful Uses of Atomic Energy in 1958.

The understanding of the basic phenomena underlying controlled nuclear fusion is imperative before the goal of controlled fusion can be reached. A great deal of basic research has been done in recent years on the behaviour of plasmas. Because this research is complex and costly, international co-operation and free exchange of information is vital.

A.I.M.E.

The Metallurgical Society of the Institute has formed a Fellow membership classification. This is a special recognition to be bestowed on selected members of the Society who have won recognition for outstanding or notable contributions in some phase of metallurgy. To be so named, a member "must have attained distinction as an eminent authority in some aspect of the broad field of metallurgy." A candidate must have been a member of the Society for at least five years.

The Society's Board of Directors will elect the Fellows. This year 20 will be elected after which no more than five will be elected in any given year. A maximum of 100 living Fellows has been set, and they will establish their own procedures for the administration of their affairs.

The Society has recently established a Geological Engineering Unit Committee of the Mining and Exploration Division to provide a base for geological engineers within the structure of the Society.

Prof. Shirley A. Linch is Chairman of the new committee which it is hoped will grow to become a division of the Society in its own right.

A session of highly significant technical papers will be presented by the Committee at the 91st Annual Meeting of A.I.M.E. to be held in New York, February 18-22, 1962.

A.S.M.E.

A committee to bring engineering skills to bear on problems of air pollution and refuse disposal through burning was formed by the Society. The organizational meeting, held June 26th in New York, was attended by 50 engineers.

Greater emphasis has been placed on the problem of air pollution control and many towns and cities may soon be compelled to construct incinerator plants. The orderly planning of such installations is imperative as some incinerator plants built in the past were constructed without regard to the control of air pollution.

In addition to the main committee, seven subcommittees have been established to deal with; design, stokers, materials handling equipment, refractories, auxiliary equipment, operation and air pollution control.

A full schedule of meetings is planned for 1962.

First International Congress on Chemical Machinery, Engineering and Automation

September 3-8, 1962 has been set as the date for the Congress which will be held in Brno, Czechoslovakia, and will precede the Fourth International Brno Trade Fair.

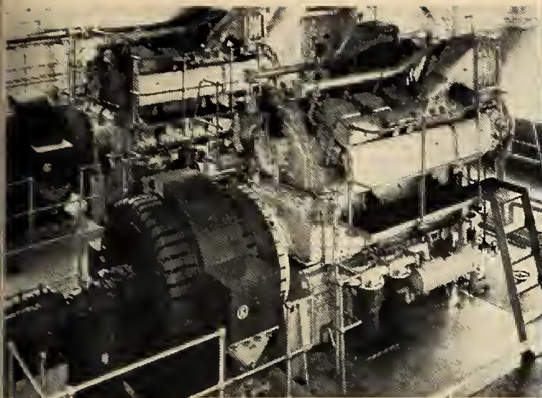
The Congress will be divided into three specialized sections:

- Chemical Machinery Design and Manufacture
- Chemical Engineering (unit operations and chemical reactors)
- Regulation and Automation in the Chemical Industry.

Original scientific contributions are welcomed. Simultaneous translation in English, German and Russian will be provided at the Congress.

Arrangements have been made for

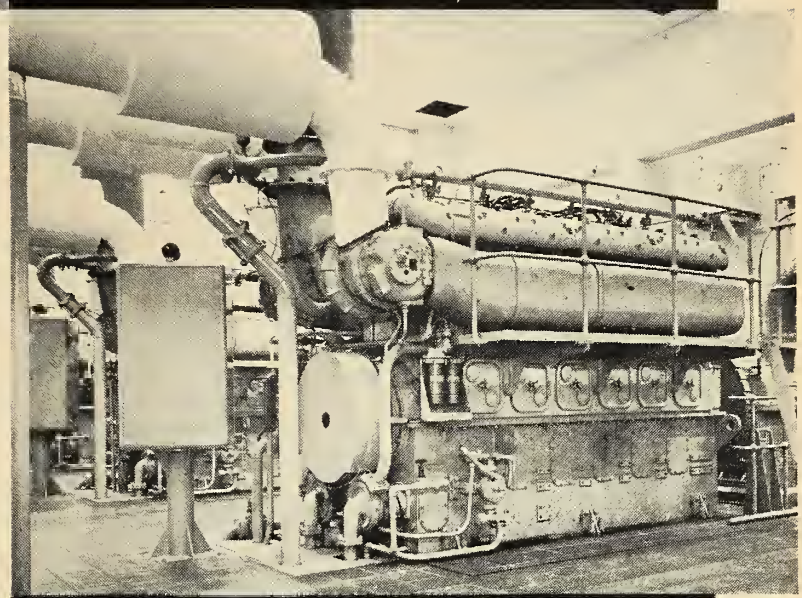
(Continued on page 156)



Paxman Emergency Power Installation at Centre Island Filtration and Water Treatment Plant. H. G. Acres & Co. Ltd., Consulting Engineers.

Metro Toronto Chooses

PAXMAN POWER



Paxman Power Installation for Pumping at John Street Pumping Station. H. G. Acres & Co. Ltd., Consulting Engineers.

At Metro's John Street Pumping Station, three Paxman '12 YLX' diesels supply power to a unique, separate high pressure watermain system used to fight dangerous fires. And at Toronto's Centre Island, two Paxman '8YLC' diesel generating sets are the standby emergency power for the city's main filtration and water treatment plant. These two installations are typical of thousands all over the world supplying reliable emergency power. That's why it pays to *specify* Paxman power . . . backed by coast-to-coast service, second-to-none.

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delegates to visit points of interest in Czechoslovakia. Tours of chemical plants have been arranged, and each delegate will be specially invited to the opening day of the Fourth International Brno Trade Fair on September 8, 1962.

Canadian Good Roads Association

The International Road Federation has extended a formal invitation to members of the Association to attend the Fourth World Highway Congress to be held in Madrid, Spain, in October 1962. It is hoped that the C.G.R.A. will be able to charter an aircraft to take the Canadian delegation there.

The world meeting, being organized by I.R.E., will start on Oct. 14, two weeks after the C.G.R.A. annual convention in Quebec City.

In addition to discussions on international highway networks in Europe, Africa, Asia, North, Central and South America, subjects to be covered at the meeting include:

United Nations activity in transport development
International financial assistance for road development
Economic justification for road development in underdeveloped countries
Need for long-term road planning
Progress in research—technical and economic.
Technical assistance

In addition to the technical sessions which will be held Mondays through Fridays there will be an inspection tour of highways and testing laboratories. Delegates will also be able to attend a Spanish fiesta and tour Toledo and the monastery-palace at El Escorial. Free passes on Spanish railways, buses and the Madrid Metro will be given delegates during the month of October.

1st European Symposium on "Fresh Water From the Sea"

The symposium, to be held in Athens (Greece) from May 31 to June 3, 1962 is expected to attract specialists from many countries. It is open to all professional men engaged in scientific and technical developments in the production of fresh water from the sea.

The main themes to be discussed are:
Evaporation processes
Electro-dialytic processes
Desalting of brackish water

The sessions will consist of principal lectures and short papers followed by discussion. There will be four principal lectures and the short papers will be scheduled so as to avoid parallel sessions.

The deadline for applications to present papers is October 31, 1961. The application should include the proposed title of the paper and a short abstract. Papers can be written and presented in English, French or German. The manuscript, ready for printing (including all illustrations) should be sent to the Secretariat of the Symposium, P.O.B. 1199, Omonia, Athens, Greece before December 31, 1961. Further information on the Symposium can be obtained from the Secretariat or from DECHEMA, Frankfurt (Main), Germany.

1962 Materials Handling in Canada Conference

"Build Profits Through Better Materials Handling" is the theme for the Conference sponsored by the combined Canadian Chapters of the American Material Handling Society, Inc. The Conference will be held October 16-18, 1962 at Exhibition Park in Toronto while the 1962 Materials Handling in Canada Exposition is being held.

Directed to higher management as well as technical people involved in materials handling problems, the Conference will pursue the basic purpose of A.M.H.S. which is to promote education and understanding and will also provide management with practical tools of measurement in this increasingly important industrial area.

Lecturers, being selected by the Conference Committee will be men who are outstanding in their respective fields. The HOW of building better profits through better materials handling will be stressed throughout the conference program. As equipment will be the basic topic the areas covered will be; selection, financing, application, maintenance and replacement and the final session will cover realistic approaches to the actual measurement of cost and profits using applications of principles used in the previous sessions.

1962 Nuclear Congress and Atomic Exposition

Public aspects in the use of nuclear energy along with engineering and operational problems within the nuclear industry will be the basis of discussions of the Congress and Exposition to be held June 4-6, 1962 in the New York Coliseum.

Under the sponsorship of the Engineers Joint Council, the Congress will deal with nine major areas into which the technical sessions will be divided. They are: Public Aspects of Nuclear Use, Problems of Advanced Reactors, Nuclear Education for Engineers, Computational Problems in the Nuclear Industry, Application of Atomic Physics for Tests of Materials, Instrumentation, Testing Methods, Radiochemical Separation, Fuel Cycling and Nuclear Safety.

Following the all-day General Session which opens the Congress at which the topic "Operating Experience with Power Reactors" will be discussed, the nine technical sessions will run concurrently.

Effluent & Water Treatment Exhibition and Convention

The Second Exhibition and Convention to be held at Seymour Hall, London, from October 31 to November 3 has attracted delegates from France, Belgium, Germany, The United States, Italy and the United Kingdom.

A feature of the Convention will be a paper presented by a leading Russian water treatment scientist, Oleg Lenchevsky who recently sought political asylum in the U.K.

The increasingly severe restriction

imposed by river authorities control the type of effluent that can be discharged. The increasing volume of water required for industry cannot always be provided economically from available sources and the recovery of used water is of prime importance. These subjects will be represented at the Exhibition via new designs and techniques.

European Federation of Chemical Engineers

The Third Congress of the Federation will be held at Olympia, London, from June 20-28 1962. It is being held concurrently with the second Chemical and Petroleum Engineering Exhibition which will take place at Olympia, London, from June 20-30 inclusive.

The schedule for the Congress itself is as follows:
June 20: Meeting on "Process Optimisation"; June 21-23 inclusive: Meeting on "Interaction between Fluids and Particles"; June 25: Symposium on "The Handling of Solids"; June 26-28 inclusive: Symposium on "The Physics and Chemistry of High Pressures. Further information can be obtained from:

The General Secretary,
Society of Chemical Industry,
14 Belgrave Square,
London, S.W.1, England.

Coming Events

Radio Fall Meeting, Institute of Radio Engineers, Syracuse, N.Y., Oct. 30-31.

International Conference on High Magnetic Fields, Cambridge, Mass., Nov. 1-3.

First International Congress on Experimental Mechanics, held in conjunction with the Fall Meeting of the Society for Experimental Stress Analysis, New York, Nov. 1-3.

Quebec City Regional Conference, Engineering Institute of Canada, Quebec City, Nov. 2-4.

Non-Linear Magnetics Conference, American Institute of Electrical Engineers, Institute of Radio Engineers, Los Angeles, Nov. 6-8.

Chemical Engineering Division, Chemical Insitute of Canada, Toronto, Nov. 6-8.

National Fuels and Lubricants Meeting, Society of Automotive Engineers Inc., Houston, Texas, Nov. 9-10.

15th Canadian Soil Mechanics Conference, Montreal, Nov. 9-11.

Seventh Annual Conference on Magnetism and Magnetic Materials, American Institute of Electrical Engineers, Institute of Radio Engineers, American Institute of Physics, American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., Detroit, Nov. 13-16.

Annual Meeting, Sociey of Naval Architects and Marine Engineers, New York, Nov. 15-18.

Winter Annual Meeting, American Society of Mechanical Engineers, New York, Nov. 26-Dec. 1. EIC

(Continued from page 142)

Next year the Branch members will be asked well in advance so that the committee can make plans to run more than one course if necessary.

Niagara Peninsula

W. I. Marshall, JR.E.I.C.
Correspondent

The Eighth Annual Professional Engineers' Ball was held at the Sheraton Brock Hotel in Niagara Falls on September 29. Bob Ward and his orchestra provided the music for dancing, while there was a piano interlude during cocktails and the smorgasbord dinner.

North Shore Lower St. Lawrence

L. Fisher, M.E.I.C.
Correspondent

Track laying was the topic considered by the Branch members at the June 2 meeting. J. Hority, a construction engineer with the Quebec North Shore and Labrador Railway Company, gave a talk illustrated with a film. The film illustrated the plant setup in Seven Islands. The rail is made ready for welding and transporting to the rail and tie plant so that the tie plates can be attached to the ties. The placing of ties and laying rail was also shown in the film. A panel of engineers involved in this work answered questions. Two meetings on this topic were held, one in Seven Islands and the other in Port Cartier.

Vancouver

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

The E.I.C. Salmon Derby held June 3 was an entertaining but unsuccessful fishing expedition. The Howe Sound salmon were conspicuous by their absence. Contestants bravely fought aboard a variety of sea life that gave the judges much concern as to the relative merits of the catches.

The Silver Cup for First Prize was awarded to Mrs. W. G. Sharpe of Calgary, Alberta. Mrs. Sharpe's rock cod which weighed in at over 2½ pounds was the heaviest edible fish.

The Second Prize, a Fisherman's rule and bottle opener, went to Professor J. S. Campbell of Kingston,Ont. for the most unusual denizen of the deep. Dr. Campbell's trophy was a half-inch diameter clam caught when dredging the bottom in 40 feet of water.

Wilson Phillips of Winnipeg took Third Prize with an 18 inch dogfish weighing about two pounds. Mr. Phillips' prize was a "stick of dynamite" inscribed "Better Luck Next Time".

The Booby Prize, a "crying towel" was won by D. R. Bakewell of Vancouver for the smallest rock cod (four and a half inches long) that could possibly be hooked on salmon gear.

The local members had such a wonderful time that another Derby is planned for September.

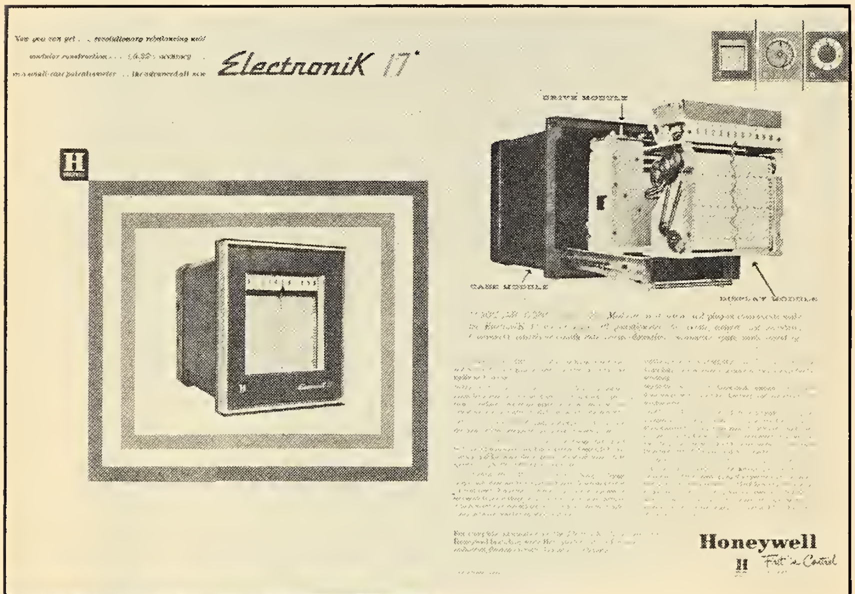
Engineers' Wives Associations

The **Winnipeg Association** held a successful Wind-Up evening in May at which husbands were special guests. The Bridge group presented a skit using large playing cards, the Social Group presented a take-off on "Romper Room", the Music Group arranged a Sing-Song and piano interludes between acts, the French Conversation Group gave a hat show, the Speakers' Group demonstrated meeting procedure and the Drama Group presented a one-act play entitled "Five to Five-Thirty". In June fifty members attended a luncheon and nine-hole golf tournament. Seventy members of the **Toronto Auxiliary** attended a luncheon on June 15 at St. Andrews Golf Club. Both bridge and putting competitions followed.

The **Windsor Auxiliary** held its Spring Dance at the Lakewood Golf and Country Club. The highlight of the evening was a floorshow which consisted of a dance review, choreographed by the members, followed by a novelty number.

EIC CERTIFICATE OF ADVERTISING MERIT

For the second time in two and a half years, two companies tied as winners of the Monthly Award for the best advertisement in The Engineering Journal. Winners for the July issue were The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ont. and Honeywell Controls Limited, Toronto.



The Algoma advertisement announces the Canadian production of wide flange beams in the Company's new Universal Beam Mill, "fully competitive with imports". The illustration is a striking 4-colour photograph of the rolling mill in action.

The advertising manager of The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ont. is L. F. Mason-Tulby, and the advertisement was prepared and placed by Cockfield, Brown & Company, Toronto. Account Executive, F. D. Adams.

The Honeywell advertisement took the form of a page-and-a-half-size, 3-colour insert, printed on both sides, with the extra half sheet folded in. Purpose was to introduce the Company's new ElectroniK 17 potentiometers. Copy emphasized the many new features built in to the ElectroniK 17 line, claiming them to be the "easiest of all potentiometers to operate, convert and maintain". This is, incidentally, the fifth time Honeywell Controls has captured the Monthly Award.

The advertising manager of Honeywell Controls Limited is K. K. Warne, and the winning insert was prepared and placed by Cockfield, Brown & Company, Toronto. Account Executive, G. V. Forster.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.

(Continued from page 144)

*INTRODUCTION TO THE KINEMATIC GEOMETRY OF GEAR TEETH.

The author has been actively engaged in the development of modern gear-cutting machines and tools for more than forty years. In this book he draws on his experience to discuss the theory of the transmission of motion by gear teeth, and applications of principles. He limits his treatment to contact between profile curves in cross sections of gear teeth, employing two-dimensional geometry, a treatment which applies mainly to gears on parallel axes. General principles, and general ideas of tooth design are covered first. Then the author carefully examines spur gears, fillet curves, and involute curves, devoting most space to the last. In each case he covers layout and construction of profiles, cutting and generating of teeth, and other such pertinent matter. The final two chapters deal with profile errors, modification and variations and with involute approximations. (A. H. Candee. Philadelphia, Chilton, 1961. 204p., $12.50).

*PROBLEMS IN BASIC OPERATIONS RESEARCH METHODS FOR MANAGEMENT.

The exercises and problems in this book were developed for graduate courses in operations research methods at the University of Virginia. The topics covered include mathematical programming methods, inventory models, sequencing models, queuing problems, problems requiring Monte Carlo analysis, replacement and assignment problems, and problems in the design of experiments and the analysis of variants. In terms of numerical complexity and required level of mathematics, most of the problems are simple — elementary knowledge of differential and integral calculus, probability and sampling theory, and exponential distributions will be helpful, but is not prereouisite. (R. W. Cabell and Almarin Phillips. New York, Wiley, 1961. 110p., $3.95.)

*COBALT; ITS CHEMISTRY, METALLURGY, AND USES.

Designated A.C.S. Monograph no. 149, this work replaces Monograph no. 108, "Cobalt", written by Mr. Young, who, as editor of this new monograph, contributes sections dealing with history, occurrences, extractive metallurgy, chemical and physical properties, compounds, metallurgical applications, and biology and biochemistry of cobalt. Other sections, written also by specialists, summarize the newer developments in cobalt technology, and discuss such topics as coordination compounds, phase diagrams, catalytic behavior, magnetic, electrical and electronic applications, radioactive cobalt, and cobalt alloys in high-temperature, high-strength service. (Ed. by R. S. Young. New York, Reinhold, 1960. 424p., $15.00.)

PROCEEDINGS OF THE SECOND CONFERENCE ON ELECTRONIC COMPUTATION.

Sponsored by the Structural Division and the Pittsburgh Section of the A.S.C.E., the Conference was concerned with the use of computers in civil engineering. This volume contains the thirty-two technical papers presented, dealing with such topics as: design of transmission towers; design by systematic synthesis; matrix structural analysis; frame analysis; beam vibrations; vessel foundation design; retaining wall design, etc. (New York, American Society of Civil Engineers, 1960. 673p., $13.00.)

°ELECTRONIC EQUIPMENT RELIABILITY.

The authors present a conspectus of current knowledge on the subject of reliability in electronic equipment, a task suited to their affiliation with the Royal Radar Establishment. They first discuss the reliability problem in general, and then devote several chapters to failure rates, faults, and the effects of environmental conditions and constructional techniques in electronic equipment. Other chapters deal with circuit reliability and standard circuits, designing for maximum reliability, testing for, predicting, and calculating reliability, and the future outlook. A chapter on human engineering examines the problem of successful design of electronic equipment for human use. There is an extensive classified bibliography. (G. W. A. Dummer and N. Griffin. Toronto, Pitman, 1960. 274p., 45/-.)

°WAREHOUSE OPERATIONS PLANNING AND MANAGEMENT.

A step-by-step description of the various stages — planning, organization, management and operation — in the layout or modernization of warehouse operations. It discusses in detail initial study of the problem, fact gathering and analysis, floor plans and space charts, pallets, pallet racks, and bins, the particular tools and materials handling equipment suited to the job in mind, storage aids, conveyors, stock location systems, and finally operating procedures and practices, and management reports and statistics. (A. J. Briggs. New York, Wiley, 1960. 303p., $8.50.)

°MODERN MATERIALS, VOLUME 2.

This is the second volume in a series whose object is to gather together periodically in the form of authoritative review articles, the more important developments in specific materials or classes of materials. It contains seven chapters written by experts in their fields, dealing with: polymer modified papers, plastic-coated papers, laminates and synthetic fibre papers; flame-sprayed ceramic coatings in metallurgy; ceramic cutting tools; borides; titanium; and the joining of materials by welding and soldering. (Ed. by H. H. Hausner. New York, Academic, 1960. 413p., $12.50.)

THE MAJOR ACHIEVEMENTS OF SCIENCE.

A history of scientific ideas, intended primarily for advanced high school students whose chief interest is in the humanities, this book will be of interest to a much wider audience. The author covers the developments of the last 350 years, relating them to their historical background, and emphasizing the role of the scientists involved. Some of the topics with which he deals include air pressure, the circulation of the blood, the creation of modern chemistry, theory, and cosmogony. A second volume contains extracts from scientific writings, related to the topics covered in the first volume. (A. E. E. Mackenzie. Toronto, Macmillan, 1960. vol. 1, $3.40: vol. 2, $2.15.)

NUCLEAR SHIP PROPULSION.

The author has tried to include those elements of nuclear technology necessary to an understanding of nuclear ship propulsion, and although his primary interest is in merchant ships, many of the technical concepts and safety principles apply equally to naval vessels. He discusses the commercial advantages of nuclear ships; the various fuel forms and calculations; heat removal; the reactors in the N. S. Savannah; other types of reactor; shielding; refueling; safety precautions. A useful bibliography is included. (H. F. Crouch, Cambridge, Md., Cornell Maritime Press, Toronto, General, 1960. 347p., $11.50.)

(Continued on page 167)

Employment Service

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 advertisement should be addressed to the file number, Employment Service, 2050 Mansfield Street, Montreal. Interviews with the Employment Service may be arranged by calling VI 2-8121 at the above address.

SITUATIONS WANTED

ELECTRICAL ENGINEER, M.E.I.C., Age 35, graduate 1950. Sound knowledge of general electrical controls, heavy electrical machinery, plant power distribution, pneumatic and electronic process instrumentation, plant services equipment, administration of project engineering, construction and maintenance. Desires responsible senior position requiring a matured man with diversified experience. Will consider any location. File No. 5962-W.

CHEMICAL ENGINEER, M.E.I.C., B.Sc., Queen's University 1948, age 36, married, bilingual, wide experience in mechanical engineering, production development work, all phases of plant maintenance, some industrial engineering background, powerhouse operation and supervision, construction experience. One year in the welding industry. File No. 6006-W.

CIVIL ENGINEER, P. Eng., A.M.E.I.C., 1959 University of Manitoba. Age 27, married. Experience Highway Department Province of Manitoba in bituminous surfacing construction, designing, estimating, field and laboratory testing. Some experience in municipal street paving, drainage, sewerage, also in the earth moving field. Seeks employment in Canada or abroad. Located Prairie Province. File No. 6140-W.

ELECTRICAL ENGINEER, B.Sc.E.E., 1957, A.M.E.I.C., Mem. I.R.E. Four years' experience in transmission engineering dept. of telephone company. Seeking a position with challenge and opportunity for learning in communications or electronics fields. Single, age 26, willing to consider any location. File No. 6206-W.

ELECTRICAL ENGINEER, M.E.I.C., graduated in Electrical Engineering from London in 1956. Age 30 years, married, widely travelled, immigrant in Canada. Having 4 years' experience in dealing with switchgears, transformers, instruments, motors etc. Seeks position in Sales or Manufacturing. File No. 6303-W.

ELECTRICAL ENGINEER, M.E.I.C., P. Eng., naturalized Canadian with 12 years of diversified experience in electrical machines, controls, drives, Navy orders, steam and diesel generating plants, consulting and field work. Presently on assignment in the Far North. Preferable location Montreal. File No. 6306-W.

MECANICAL ENGINEER, M.E.I.C., P. Eng., B.Eng 1950. Seven years design, layout and construction experience in Plant facilities including steam, water, air, heating and process. Three years' consulting office design and layout of air conditioning and plant equipment with one year as resident engineer. Prefer Montreal and vicinity, present location. File No. 6335-W.

CIVIL ENGINEER, M.E.I.C., P.Eng., Ont. and Alta. B.Sc. M.Sc. (Soils and Concrete) U. of Alberta 1949, 1952. Married with family. 12 years' field and office experience in all aspects of contract supervision and administration. Post Graduate studies and 3 years' experience in soils and concrete. Desires responsible position with advancement opportunities and security. Full resume on request. Now located Central Canada. Available on usual notice. File No. 6347-W.

CIVIL ENGINEER, A.M.E.I.C., P. Eng. (Quebec), B.Sc. Loyola '58, B.Eng. McGill '61, age 24. Single, summer experience in soil, surveying and construction. Would like position in construction, municipal or other interesting work. Full resume given on request. Prefer Montreal area but would move. File No. 6350-W.

CIVIL ENGINEER, A.M.E.I.C., P. Eng. (Ont.) U.N.B. 1959. Age 26, married. Two years' experience in design and inspection of bridges, also some experience in design and construction of highways, airstrips, wharves and drainage problems. Presently employed in Central Canada. Desires challenging position with consulting firm, municipality or industry. Preferred location Maritimes or Quebec, but this is not a prime consideration. File No. 6356-W.

CIVIL ENGINEER, B.E., A.M.E.I.C., Sask. 1961. Age 22, single. Employed since graduation in soils engineering and construction. Undergraduate experience consists of soils construction and supervision. Desires a position in the structural design field with a progressive company. Presently located Prairie Province. Willing to relocate. File No. 6362-W.

PROFESSIONAL ENGINEER, P. Eng., (Que.) A.M.E.I.C., B.Sc. Civil, Polytechnique 1950, age 35, married, bilingual, experience includes two years' municipal work, three years' field supervision on construction projects and five years' construction office administration including quantity take-offs and estimating costs. Seeks responsible position in small or medium sized company. Available on reasonable notice. File No. 6370-W.

CIVIL ENGINEER, A.M.E.I.C., P.Eng., Que. B.A., B.A.Sc., Laval 1955. Bilingual, age 32, married. Diversified experience; public works, wharf construction, dredging; public utility, traffic, planning, Operation Supervision, cost and results; Road and Highways, traffic engineering, geometric design. Full resume on request. Desire position in management capacity with small or medium size firm. Located in Central Canada. File No. 6377-W.

CIVIL ENGINEER, A.M.E.I.C. P. Eng. (Ont.) U.N.B. 53, age 31, married, present location Central Canada—experience includes 2 years structural steel design; 4 years municipal engineering (3 in senior position) in large Canadian city; approximately 2½ years with large consulting engineering firm involved in defence projects. Desires responsible, challenging position with opportunity to advance. File No. 6379-W.

ELECTRICAL ENGINEER, S.E.I.C., B.E. 1961, University of Saskatchewan. Seeks a position with a firm in the medical engineering field. Willing to relocate if such a position is available. File No. 6384-W.

CIVIL ENGINEER; A.M.E.I.C., P. Eng. (Quebec) B. Eng. (McGill) Age 26, single. Four years experience in the materials aspect of construction including design, testing, field supervision and quality control of bituminous and concrete mixes. Additional experience in highway design and construction. Desires position with municipal, technical, construction or consulting engineering firm in a similar field. File No. 6385-W.

SENIOR CONTRACT ENGINEER P. Eng., M.E.I.C., offers Professional Liaison Service in Ottawa with Federal Government Departments and Crown Companies to gather information on anticipated works contracts, drawing and specifications for select few Consulting Engineers, Architects, Contractors, or Construction Equipment Manufacturers. Retiring early after long experience as engineer in Civil Service, good knowledge of Government procedures and extensive acquaintance with Government engineers, architects, specification writers and chief purchasing agents. File No. 6386-W.

CIVIL ENGINEER, P. Eng. Alta. M.E.I.C., 6 years experience (overseas) in conducting soil and engineering surveys, town planning; 5 years in transportation engineering (in Canada) design, estimates, construction and maintenance. Also some work in tunnel construction. Age 31. Married with family, speaks 3 languages. More details on request. Prefers position in research or teaching, will accept any responsible position with future in S. Ont. Alta. or West Coast or Overseas. File No. 6387-W.

CIVIL ENGINEER, A.M.E.I.C., B.Sc. Loyola College (55), B.Eng. McGill (57) bilingual, age 28, married. One year experience in design and construction of bulk plants and marine terminal plants for a major oil company. Three years of experience in market research, product promotion, and technical development in small industrial, institutional and housing construction for a leading Canadian lumber manufacturer. Requesting work involving direct selling preferably. Also interested in design work in timber, steel or concrete, or field supervision work. File No. 6388-W.

CIVIL ENGINEER, B.Sc. 1949 P. Eng. (Ontario) M.E.I.C., aged 38, married. Experience 3 years reinforced concrete design, 4 yrs construction supervision of thermal power stations of which 2 yrs were as resident engineer 4 yrs highway and bridge construction as R.E. Requires position either on site or in office. Present location Toronto. File No. 6389-W.

CIVIL ENGINEER, A.M.E.I.C., B. Eng., P.Eng., Age 29, single, English speaking with six years field and design (steel and reinforced concrete) experience seeks responsible position with Consulting Engineer in Montreal Area, leading to possible partnership. Limited investment possible. File No. 6391-W.

MECANICAL ENGINEER, A.M.I. Mech.E., P.Eng., M.E.I.C., 16 years experience oil, gas and steam turbines and engines, and associated equipment electrical and mechanical, also works services, in Britain, Middle East, Far East, Canada. Strong in contract work, inspection, acceptance tests, trouble shooting, maintenance. Any province or country considered. Consultants or industry preferred. File No. 6392-W.

PROFESSIONAL ENGINEER, M.E.I.C., desires position with consulting firm or company as a project engineer or in heading a design group, co-ordinating and lead-

(Continued from page 163)

°SPECIFICATIONS, 2nd. ed.

This is an introductory text in the writing of architects' specifications. The good and bad points in the selection of words and phrases, the logic behind the grouping and arrangement of sentences, paragraphs and sections, and the methods involved in the assembling of the facts and their organization, are presented herein, along with enough technical information to illustrate the entire procedure of specification writing. Part 1 deals with the general aspects of specification writing, which have changed relatively little since the first edition (1953); hence the revisions here are more in the form of alterations and improvements on the original text, plus new revised contract forms, and other revised forms and documents. Part 2 deals with the general conditions during construction and specific trades involved in construction, as related to specifications writing for non-fireproof types of construction, and revisions here are more extensive, to embrace materials and methods developed since 1953. (H. G. Edwards. Toronto, Van Nostrand, 1961. 372p. $8.75.)

°PROGRESS IN SEMICONDUCTORS, Volume 5.

The present state of knowledge in semiconductors is critically reviewed, with some emphasis on the optical properties of semiconductors. The subjects covered include the electrical properties of semiconductor surfaces, the absorption edge spectrum of semiconductors, the chemical bond in semiconductors, indium antimonide, thermal conductivity of semiconductors, magneto-optical phenomena in semiconductors, and the band structure and electronic properties of graphite crystals. (A. F. Gibson. New York, Wiley, 1960. 316p., $11.00.)

°BRITISH NUCLEAR POWER STATIONS.

In the first three chapters the author outlines the British Nuclear Power program for the next twenty years, and presents a general discussion of the design of nuclear power stations and the special problems of nuclear power. The remaining chapters give the stories of specific British nuclear power stations — Calder Hall, Hinkley Point, Berkeley, and Hunterston — discuss electrical control and switchgear, and give accounts of research in thermonuclear power, and with the Dounreay Sphere. Coordination of nuclear and conventional power plants to meet the fuel shortage expected about 1970 is also discussed. (Rolt Hammond, London, Macdonald, 1961. 182p. 25/-.)

°INTERNATIONAL ASSOCIATION FOR BRIDGE AND STRUCTURAL ENGINEERING, MEMOIRS. Volume 20.

This 20th compilation contains 18 papers, 12 of which are in English. Approximately half of the papers deal with analysis of structural frames or with shell structures. Other topics include calculation of pile groups, vibration of foundations, bridge loadings, and relaxation of steel wires. English, French, and German summaries are provided for each paper. (Zurich, The Association, 1960. 414p., Sw Fr.45.)

°SEQUENTIAL DECODING.

The electrical communications problem of coding and decoding is considered from the probabalistic point of view, and a data-communication procedure is presented for which the average computational complexity grows only algebraically with delay. This decoding scheme, called sequential decoding, is considered in detail with respect to binary symmetric channel. Its extension to more general channels is discussed briefly. (J. M. Wozencraft and B. Reiffen. New York, Wiley, 1961. 74p. $3.75.)

°FLUE GAS CORROSION IN BOILER PLANTS.

Report no. 38 of the Flue Gas Corrosion Research Committee of the Danish Academy of Sciences, this is concerned with flue gas corrosion in boiler plants. The major part of the report deals with low-temperature corrosion, discussing in detail the formation of sulphur trioxide, and the formation, corrosive action, and methods of control, of sulphuric acid. There is also a short section on high-temperature corrosion, and a chapter describing other aspects of the Committee's work in relation to such topics as corroded welds, dolomite injection, and oil analyses. A thirty-page final section presents abstracts of literature from 1929 to date, selected for particular pertinency to this report. References also are given to complete surveys and summaries of literature on the subject of flue gas corrosion. (Danish Technical Press, Copenhagen, Denmark, 1960. No price given.)

(Continued on page 168)

*STABILITY OF COASTAL INLETS.

This is a report on current efforts towards effecting engineering control of the problems of coastal inlets-shore protection, stabilization of navigable channels, and maintaining and increasing their depth. The authors are affiliated with the Coastal Engineering Laboratory of the University of Florida. After introductory chapters giving background, origin, and natural "behaviour" of tidal inlets, the authors discuss tidal hydraulics and its effects; such inlet stability factors as flow, shape, bottom soil conditions, sediment load, and littoral drift; the analysis of actual inlet data; and the design of tidal inlets for maximum operating efficiency. (P. Bruun and F. Gerritsen. Amsterdam, North-Holland Publishing Co., 1960. 123p., $3.00.)

*RARE METALS HANDBOOK, 2nd. ed.

A revised and expanded edition of a handbook that presents currently available data on 55 of the less-common metals. In this edition six essentially new metals are added. A new format facilitates reference to such aspects as occurrence, production statistics, economies, latest methods of production from ores or other raw materials, chemical and physical properties, alloys, fabrication techniques, and present and potential uses. Comparisons between metals are shown in convenient tabular form. (C. A. Hampel. New York, Reinhold, 1961. 715p. $20.00.)

*TRANSMISSION OF INFORMATION.

This text is devoted to that aspect of communication theory originating from Shannon's work. It provides an up-to-date treatment of coding theory that emphasizes those formulations and mathematical techniques that have proved to be of greatest engineering significance. Aspects discussed include measure of information, simple message ensembles, discrete stochastic sources, transmission channels, channel encoding and decoding, encoding for binary symmetric channels, and encoding for discrete, constant channels. (R. M. Fano. New York, Wiley, 1961. $7.50. 389p.)

*MANUAL ON INDUSTRIAL WATER AND INDUSTRIAL WASTE WATER, 2nd. ed.

This manual consists of two parts. The first discusses the general uses and problems of sampling and analysis of industrial water, while the second includes the ASTM standards on industrial water and waste water. This edition differs from the first in that it takes cognizance of the increased interest in the potential effects of certain waste waters on downstream uses. (Philadelphia, American Society for Testing Materials, 1960. 658p., $11.00.) (s.t.p. 148-E.)

3. COLLOQUE DE METALLURGIE SUR LA CORROSION.

The third of a series of symposiums on metallurgy, organized under the auspices of the French Atomic Energy Commission, this 1959 meeting was concerned with corrosion, both aqueous and gaseous. Two of the papers are in English, the remaining 16 being in French, with very brief English summaries. The topics covered include: recent ideas on the oxidation of metals; diffusion mechanisms and gaseous corrosion; alloys which resist corrosion at high temperatures; oxidation films morphology; corrosion of stainless steels in aqueous solutions; influence of hydrogen on the corrosion of zirconium in high temperature water; the IRSID seawater corrosion testing station; the corrosion of steels by hydrogen sulphide, etc. (Amsterdam, North Holland Publishing, 1960. 239p., $10.00.)

(Continued on page 178)


COMMUNICATIONS

Business and Industrial Briefs

Appointments and Transfers

At a recent meeting of the Board of Directors of Canada Cement Company Ltd., **M. Roger Letourneau, Q.C.**, was elected a Director.

C. H. McInnis has relinquished his position of president of C. H. McInnis Co. Ltd. to become Chairman of the Board of Directors. The new president is **Albert Reilingh.**

W. D. Fallis has been named General Manager at Manitoba Hydro.

The appointment of **Alex McPhail** as production superintendent has been announced by Omark Industries Ltd., Guelph, Ont. Another announcement by Omark Industries is the appointment of **William Sansom** as metallurgical engineer.

A. I. O. Davies, Director of Sales, Collins Radio Company of Canada, Ltd., has announced the appointment of **W. L. Murray Binions** as Sales Manager.

Lewis J. Burger has been named president of LeTourneau-Westinghouse Company. He will succeed Merle R. Yontz.

R. W. Faulk, vice president, manufacturing Shell Oil Company of Canada, Ltd., has announced the appointment of **J. E. Nichol** as manager of chemical development operations.

The appointment of **John Kenneth Irwin** as Manager of the Hoist Division has been announced by D. A. Burris, General Sales Manager, Canadian-Ingersoll-Rand Co. Ltd.

Herman G. Klemm has announced the appointment of **Lee E. Elfes** as director, engineering North America, Massey-Ferguson Limited, Toronto.

J. Charles Honey, F.C.I.C., has been elected president of the Canadian Cleaners and Launderers Allied Trades Association.

At a recent meeting of the board of directors of Northern Electric Company, Ltd., **R. Holley Keefler** was elected president of the company.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

A BROCHURE outlining the "FLYGT" system of pre-dewatering with flygt electric submersible pumps has been prepared. The six page brochure outlines the method used and compares it to conventional wall point systems, and illustrates its points in two case histories. One deals with the Toronto subway and the other describes work done on expanding sewage treatment facilities at Leaside, Ontario.

A RADICALLY new type of incineration process has been developed by Canadian Thermal Industries Co. The new range of incinerators named "The Phoenix" has burning capacities of 100, 150, 250 and 350 lbs. per hour. It meets the requirements of the Air Pollution Board and is designed to operate within a compact clean-lined outer casing.

NEGOTIATIONS have been completed and B-I-F Industries announces that it is now a division of the New York Air Brake Company. This consolidation is a major step in the growth of B-I-F and is consistent with the continuing program of diversification and expansion of The New York Air Brake Company, thus further broadening its over-all capabilities in the growing field of systems engineering.

A NEW 16-PAGE Buyers Guide, of interest to industries handling process liquids or gases is now available from Pfaudler Permutit Canada Ltd. This Buyer's Guide for 1962 is divided into two main sections, one dealing with Pfaudler products and the other with Permutit products. Each section contains concise engineering data in chart or tabular form and tables are used to provide physical specifications and process characteristics of the equipment described.

AUTOMATIC exposure control and automatic light meter return are new conveniences built into the Dea-Graph Planetary Microfilm Camera equipment now available from Charles Bruning Company (Canada) Ltd. A warning buzzer and signal light tell the operator when the last exposure has been made and the unit swings the light meter into center board position to determine light values for illumination of the next original. The light meter return can also be activated manually by depressing a control button on the illumination unit or the automatic control panel.

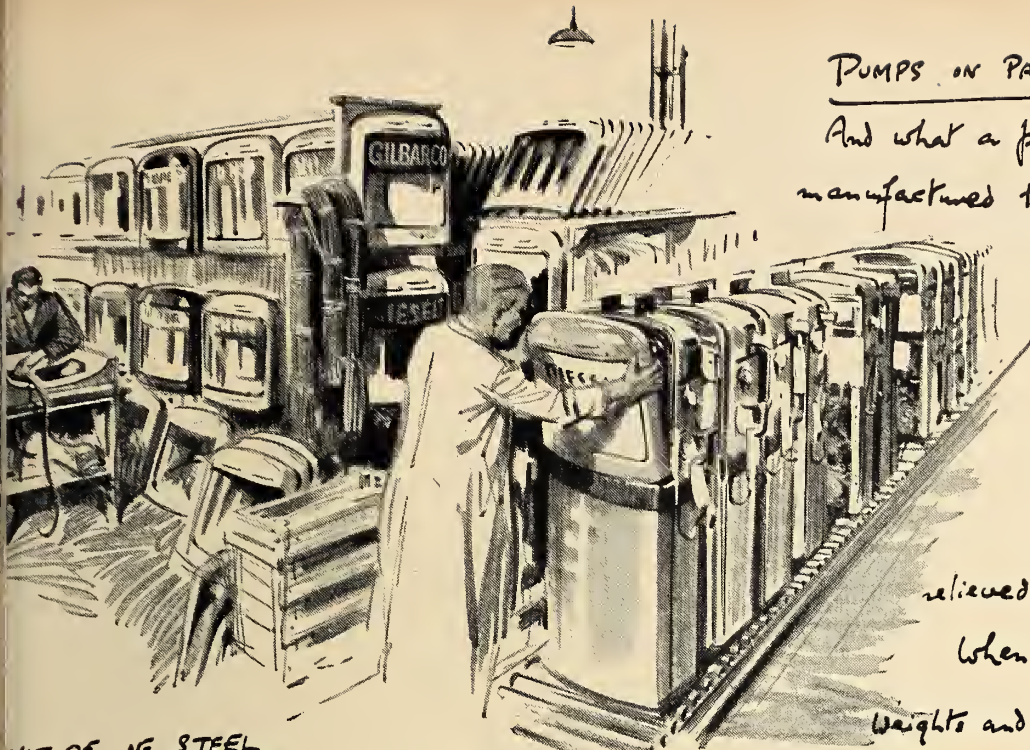
HIGHER YIELD strength steel is now available from the Algoma Steel Corporation, Limited. Algoma is prepared to supply steel to specification CSA G40.8 with guaranteed yields, 4,000 p.s.i. higher than called for in the specification. Now a steel with up to 33 percent higher yield can be supplied without any corresponding increase in price.

A HUGE shiploader has been built by the Mechanical Division of Dominion Bridge Company Limited for the Quebec Cartier Mining Company's facilities at Port Cartier. The loader has the capacity of 100 tons of ore per minute and two-directional mobility.

BULLETIN 13-17C describes in detail the Type 12A Pneumatic Temperature Transmitter developed by the Foxboro Company, Foxboro, Mass. The 12-page bulletin includes detailed specifications, descriptions of operating principles, table of temperature ranges and data on related accessories.

APPROVED concrete cylinder casting procedures including selection of molds; correct sample taking and filling, handling and curing of cylinders are outlined in a new Master Builders Company publication. It has been prepared to be distributed as a service to all concerned with the accurate testing of concrete.

(Continued on page 176)



PUMPS ON PARADE

And what a parade! Crayford have manufactured thousands of Petrol Pumps since 1946 — & have sent them to many countries of the world.

As my car only does 15 to the gallon I was relieved to hear the following:— When a pump is checked the Weights and Measures Dept. of the Board of Trade only allow a tolerance of minus nothing plus one fluid ounce on one gallon.

NITURE OF STEEL

impressive row of Vickers built Press Brakes shaping components for steel office furniture
150 tonner in the
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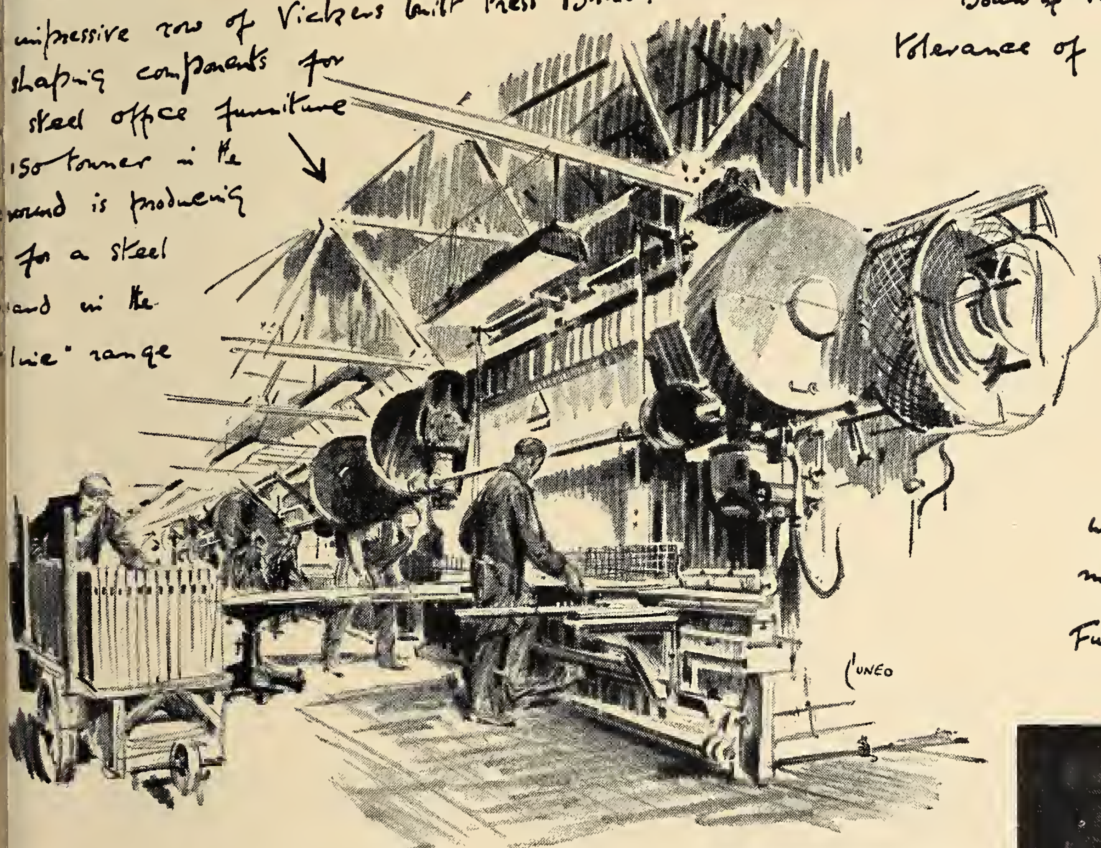

The Dartford works have been manufacturing Steel Furniture since 1931

Next Commission:
VICKERS - ARMSTRONGS (Engineers) Ltd
BARROW.

Office equipment and furniture for industry's administration, fuel pumps for industry's transport. These are typical of the contributions made by the Crayford and Dartford Works to the resources of the Vickers Group to meet the ever increasing and diverse demands of industry all over the world.

TGAOV74

 (Continued from page 170)

A FOUR-PAGE publication put out by the Canadian General Electric Company explains how to prepare an economic study on heat processing furnaces. Included in the booklet are sections on where to obtain data, how to make the study, a table showing items to consider in the studies, and three typical examples.

ONE OF THE many precautions being implemented by Shell Oil Company of Canada, Limited to prevent air pollution from their new manufacturing plant at Pincher Creek, Alta., is a 375 ft. waste gas disposal chimney. To be completed at the end of the year the sulphur recovery facilities, with a design capacity of 1,500 long tons per day, will be the largest in North America producing sulphur from natural gas.

A LOW BOILING petroleum solvent vapour is being used by Canadian Westinghouse under a controlled vacuum system to dry high-voltage electrical equipment. The process called Vapotherm, is particularly suited to drying high-voltage transformers in which very large amounts of water-retaining cellulose insulation are arranged in an extremely inaccessible form.

A COMPLETE line of industrial gas manifolds has been described in a comprehensive 12-page catalogue now available from Union Carbide Canada Limited, Linde Gases Division. Included in the catalogue are 21 stationary manifolds designed for use with oxygen, acetylene, argon, nitrogen, hydrogen, methane propane, helium, butane and other gases used in industry.

THE MAJOR feature of the Kodak Retina Reflex III is a two-way automatic exposure control system which allows the user to make exposure settings either by looking througth the viewfinder or by viewing a small opening at the top of the camera. In the viewfinder the exposure meter needle appears in the lower left corner while at the top of the camera the meter window permits settings to be made by simply lining up a needle between two fixed reference pointers.

A HANDY POCKET booklet on drill steel equipment has been published for distribution in Canada by Atlas Copco Canada Ltd. Types of drill steel equipment are listed with corresponding dimension catalogue numbers and thread sizes. Detachable bits are illustrated with front-view and cut-away diagrams. Tools for use in connection with drill steels are also included.

CONSTRUCTION has begun on a $7 million extension to the international dam on the upper Niagara River. A joint venture of Ontario Hydro and the Power Authority of the State of New York it will add to the present structure which will be inadequate by the end of 1962. Five 100-foot wide sluices and gates will be added to the dam to maintain the required Pool levels and permit the safe passage of ice on the Canadian side. Two guide walls will be built parallel to the Canadian shore. The flow of water over the Falls will not be affected.

DISTILLATION facilities are being constructed at the Imperial Oil Limited refinery in Sarnia to raise its capacity by 16,000 barrels a day. Present capacity there is 94,000 barrels a day.

THE SECOND revision of the Honeywell Scientific and Test Instruments condensed catalogue, No. G-10b, is now available. The 48 page catalogue has 100 illustrations describing Honeywell instruments and systems used in the field of scientific measurement, recording and testing. Among the items described are amplifiers, components, data handling systems, lab and calibration instruments, magnetic tape instrumentation and nuclear instrumentation.

ACCOUPLEMENTS, JOINTS DE CARDAN, ENCLIQUETAGES.

A practical treatment of the transmission of a rotating movement from one shaft to another. In each chapter, an explanation of the theory is followed by a description of practical applications, and all illustrations are schematic. More than thirteen types of drive are covered. (Jean Brondel. Paris, Dunod, 1961. 449p., 64 NF.)

LES SYSTEMES LINEAIRES. t.1 ANALYSE FREQUENTIELLE

The first in a series to be published on applied mathematics, intended for those who, whilst primarily interested in the applications of mathematics in engineering, are also interested in mathematical theory. This volume is concerned with elementary linear systems, governed by linear differential equations; with constant coefficients. The topics covered include the theory of complex numbers; linear differential equations; sinusoidal systems; Fourier series and integral; graphical representation; matrix calculus. (J. Garsoux. Paris, Dunod, 1961. 346p., 39 NF.)

LES RECEPTEURS DE TELEVISION, t.2.

Translated from the English, this second volume of a theoretical text on television receivers is concerned with sound channels, antennas, video amplification, television by projection, etc. The first volume covered television signals, cathode ray tubes, and receiver circuits. (W. T. Cocking. Paris, Dunod, 1961. 308p., 35 NF.)

LANDSCAPE ARCHITECTURE

"Modern man", states the author, "thinks with his bulldozer, plans with his thirty-yard carryall." He shows the many unhappy effects of this on the modern city. The author then presents his analysis of landscape and site-planning, from the selection of the site to the completed project. The topics covered include: the site; the organization and use of space; visual aspects of plan arrangement; circulation; the relation of the structure to the landscape; regional planning. This is a very well produced and illustrated volume, of interest to all those concerned, however remotely, with the development of the modern city. (J. O. Simonds. New York, Dodge, 1961. 244p., $12.75.)

*CHIPLESS MACHINING.

This book describes production processes for the cold working of steel, the essential steps in making parts by these methods, the design of equipment and tooling necessary for the use of the processes, typical applications, and the economies of moving metal rather than removing it. Working data is included on such processes as spline and gear rolling, radial forging, power spinning, cold extrusion, and explosive and other high-energy-rate forming. (C. H. Wick. New York, Industrial Press, 1960. 502p., $10.00.)

STANDARDS RECEIVED

AIEE standards. American Institute of Electrical Engineers, 33 West 39th Street, New York 18, N.Y.

No. 43 — 1961 — Recommended guide for testing insulation resistance of rotating machinery.

No. 85 — 1960 — Proposed test procedure for noise measurements on rotating electric machinery.

No. 86 — 1961 — Definitions of basic per unit quantities for alternating-current rotating machines.

ASTM standards. American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

Copper and copper alloys (with related information). 18th ed., 1960. $9.25.

Petroleum products and lubricants (with related 37th ed., 1960. $7.50.

ASA standards. American Standards Association, Inc., 10 East 40th Street, New York 16, N.Y.

C37.7 — 1960 — Interrupting rating factors for reclosing service on power circuit breakers.

Y14.15 — 1960 — American drafting standards manual — section 15, electrical diagrams. $1.50.

BSI standards. British Standards Institution, British Standards House, 2 Park Street, London, W.1.

B.S. 1134 — 1961 — Centre-line-average height method for the assessment of surface texture. 8/6.

B.S. 1296 — 1961 — Specification for butt-welded, single point cutting tools and blanks. 6/-.

B.S. 2789 — 1961 — Specification for iron castings with spheroidal or nodular graphite. 5/-.

CSA standards. Canadian Standards Association, 235 Montreal Road, Ottawa 2.

A93 — 1961 — Aluminum vents for housing. $1.25.

B159.13 — 1961 — Gas-fired gravity and forced air central furnaces. $4.50.

C22.2, no. 3 — 1961 — Electrical features of fuel-burning equipment (gas and oil). $2.25.

C22.2, no. 47 — 1961 — Air-cooled transformers (dry type). $1.00.

C22.2, no. 56 — 1961 — Construction and test of flexible metallic conduit and liquid-tight flexible metal conduit. $1.75.

0116 — 1961 — The physical properties of power and communication wood cross-arms. $1.50.

EIC

(Standardization in Canada continued from page 127)

in very much the same manner as the ISO, and actually is a constituent component of that organization. Because of its long and important contribution, it has retained its own identity and continues to operate in a relatively independent manner.

Canada has maintained a membership in the IEC since 1908, and the Canadian National Committee of IEC is now a committee of the Canadian Standards Association. Canada has played a modest part in the work of the IEC, and presently is represented on the Committee of Action which is the governing body of the Commission. She holds the secretariat for one committee (TC 7) and has maintained an interest in many of the technical committees.

It should be noted that the IEC does not in itself prepare standards, but does make formal recommendations which the Commission hopes will be adopted as national standards by the participating countries.

A B C

World War II emphasized in an almost tragic way the hazards which can be created by lack of international standardization. At a time when the very closest collaboration was needed between the allies during the war, the lack of interchangeability of parts and machinery created grave problems. The absence of standardization on screw threads was a major difficulty, but differences in expressing limits and fits and also conventional differences in drawing office practice created confusion of a serious kind.

Arising out of these difficulties, the United States, Great Britain and Canada undertook a standardization scheme to overcome them. The organization was called the ABC, standing for America, Britain and Canada, and it was dedicated to the principle of international standardization among the three countries, with special reference to the fields previously mentioned. The Canadian participant is the Canadian Standards Association, and already a substantial degree of agreement has been achieved in screw threads, drawing office practice, and in tolerances and methods of denoting limits and fits. The now well-known unified screw thread has emerged from this work, and while there is still much to be desired in the adoption of these standards, the work is continuing and there is a growing recognition of their need.

The National Trade Mark and True Labelling Act and its Implications

The National Trade Mark and True Labelling Act, as its title implies, was enacted to provide a means of indicating, by the use of a national mark, "Canada Standard", that any particular article is manufactured to meet the requirements of an established specification, and to establish regulations for the accurate labelling of commodities.

The operating procedure is simple. Upon a request to the Department of Trade and Commerce for permission to use the national mark for a particular product, a decision would be made as to the desirability, necessity, or otherwise of taking further action. If it should be decided to proceed, a committee, such as a specification committee of the CGSB, composed of representatives of interested organizations and groups, would be established to settle the required specification. This done, the specification would be incorporated in a regulation. At this stage, any manufacturer wishing to use the national mark would apply to the Department with an undertaking to comply in all respects with the requirements of the regulations. If the product was produced in accordance with the regulation, he would be entitled to mark it with the national mark. Provision is made for withdrawal for breach of the regulation, and also for legal action against the offender.

There has been no great demand as yet for the use of the National mark. The one big project in hand is for standards of size in children's and women's garments. If this is completed successfully, other requests may be forthcoming. Although it is true that initially the Act was designed to cover the commodity field, there is no reason why it could not be of general application. It has been the hope that one or two items could be covered for a trial period to give some experience in the scope of the work from the point of view of enforcement.

Conclusion

Canada has a proud tradition in standardization, dating from the time of Sir Sandford Fleming's standard time zones in 1884. Despite two major cultures and a rather unique system of government in which ten provinces with varying environments and needs possess extensive powers, a very gratifying degree of standardization has been achieved. Indeed, the Canadian Electrical Code and our Welding Bureau (as mentioned previously) have been the envy of several other countries.

As yet, there has been little demand for standardization of consumer products, and it remains to be seen whether this demand will develop, but industry and public have benefited by a rather wide-scale standardization. The various standardizing bodies are continuing their work with ever-increasing effort. EIC

INDEX TO ADVERTISERS

OCTOBER 1961

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Indexed in
The Engineering Index
The Applied Science and Technology Index

CONTENTS

IN THIS ISSUE

"The Inspection, Repair and Maintenance of Highway Bridges in the City of London, Ontario", deals with certain problems and design faults encountered during a thorough inspection of London's bridges. It makes certain recommendations in connection with inspection routine and future new construction. The investigations described in this paper revealed that the condition of many of the bridges was worse than might have been expected. The cause in part is attributed to the increasing use of de-icing chemicals. **Richard M. Dillon**, M.E.I.C., Dean, Faculty of Engineering Science, University of Western Ontario, is a director of M. M. Dillon & Co. Ltd., consulting engineers. In 1948 he graduated from U.W.O. with a B.A. degree in maths. and physics. He then joined M. M. Dillon & Co. in the capacity of structural designer. From 1949-1950 Mr. Dillon did post graduate study, and then joined Dominion Bridge, Toronto, for a year, as a design engineer. From 1951 to 1960 he was again with the M. M. Dillon firm first as a partner and later a director. In 1960 Mr. Dillon joined the staff of U.W.O. **Paul Harper, D. Edwards**, structural design and project engineer at M. M. Dillon & Co. was born in Wangami, New Zealand and received his engineering education at Wellington Technical College and the University of New Zealand (Canterbury College). After five years with the Ministry of Works, New Zealand he joined W. G. Morrison & Associates, Bridge, Building and Highway Projects. In 1957 Mr. Edwards joined a Vancouver firm, A. C. Smith & Associates and in 1958 became associated with the M. M. Dillon & Co. Ltd. firm.

Val Gwyther, author of *Watershed Resource Value — The Associated Development of Fish and Power*, received most of his education in Vancouver where he graduated from the University of British Columbia in 1924 with a B.A.Sc. degree in Civil Engineering. He is Chief Engineer of the consulting firm he formed in 1951. Mr. Gwyther's experience has been mainly in hydroelectric power, harbor works and heavy industry. The necessity of conserving the salmon resources has retarded the development of hydro electric power the author states. His paper discusses salmon production in large quantities jointly with power. With this joint development of water shed value, many large lake areas which exist or are impounded produce a less valuable hydro electric power "yield" than the salmon yield.

A. Hrennikoff, M.E.I.C., professor of civil engineering, University of British Columbia, was born in Moscow and completed his studies at the Moscow Institute of Engineers of Communication (Civil Engineering). From 1920-1925 he was employed as a junior engineer by firms in Russia and Manchuria. Dr. Hrennikoff came to Canada in 1925 and in 1930 received an M.A. Sc. from the University of British Columbia. From 1933-1940 he was with the Dominion Bridge Co., Vancouver, and in 1940 received a Sc.D. in structural engineering from the Massachusetts Institute of Technology. Dr. Hrennikoff has been associated with the University of British Columbia from 1933 to date. He has won awards from ASCE for papers published. In his paper, *"Weakness of the Theory of Plastic Design"*, Dr. Hrennikoff, a dissenter of the theory of plastic design of steel structures, gives a comprehensive study of the subject.

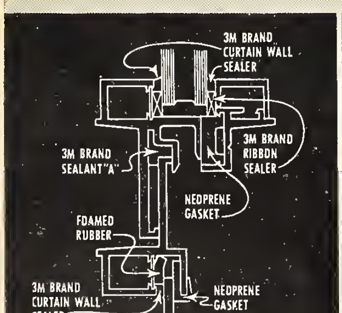
Erman A. **Pearson**, professor of sanitary engineering, University of California, Berkley, author of *"Marine Waste Disposal"* received a BS CE (Cum Laude) from the University of Washington, and a SM and Sc.D. from the Institute of Technology, Mass., 1949. For five years he was with Boeing Aircraft Co. Since graduation to date he has been associated with the University of California. Dr. Pearson acts in a consulting capacity to more than 30 industries and 10 governmental organizations, including the City of Rio de Janeiro. He is the author of 30 scientific and technical publications and more than 20 engineering reports. In his paper, the author discusses the significant oceanographic factors affecting the design of coastal dispersion systems, and particular attention is given quantitation of nearshore circulation systems, current structure, density-temperature structure, and eddy diffusivity coefficients.

"A Simulation of the Economy of British Columbia — A Guide to Industrial Development" examines the feasibility of using the Leontief Input-Output Analysis as a means of evaluating a proposed industrial development program for British Columbia. Several industrial development questions are presented along with preliminary results to indicate the usefulness of the simulation. The author, **Ralph E. Boston**, JR.E.I.C. is assistant professor, Department of Mechanical Engineering, University of B.C. In 1951 he graduated, with honors, from the University of Toronto with a B.A.Sc and obtained a M. Comm. from the same university in 1954. He has been associated with U.B.C. since graduation, and has held a number of engineering positions. For more than a year he taught and studied at the University of Michigan.

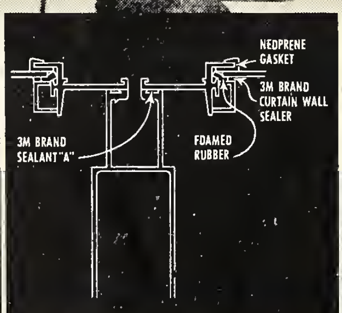
The use of a small, nine-element electronic analog computer, which can be used for analyzing dynamic problems encountered in power systems which involve the solution of differential equations, is described by **L. M. Hovey**, M.E.I.C. *"The Use of an Electronic Analog Computer for Determining Optimum Settings of Speed Governors for Hydro Generating Units"* dealing with the general principles of the computer are described with examples of how the units are connected up to solve certain well known equations. The author is with The Manitoba Hydro-Electric Board. He graduated from McGill in 1925 with a B.Sc. in electrical enginneering. After graduation he joined the Engineering Department of Winnipeg Electric Co. as draughtsman and junior engineer on the first extension to The Great Falls Development. In 1929 he was promoted to assistant electrical engineer, and in 1938 became electrical enginneer. In 1953, when the Manitoba Hydro-Electric Board took over ownership and operation of Winnipeg Electric Co., Mr. Hovey was appointed to his present position of Assistant to the General Manager of the Planning Department, with the responsibility of general long-range system planning.

COVER ILLUSTRATION

Part of the gas treating section is shown in this partial view of the largest capacity natural gas processing plant in Western Canada, at Rimbey, Alta. Hydrogen sulphide and carbon monoxide are removed at these amine contactor towers. (Photo courtesy British American Oil Company Limited)



SEALING DETAIL WINDOW & PANEL



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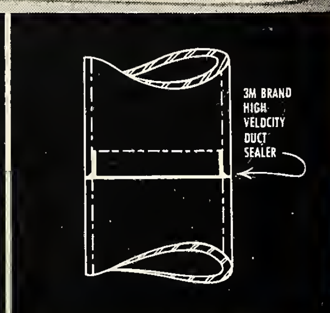

AIR CONDITIONING DUCT JOINT DETAIL

Speed, economy and quality are vital in construction of buildings like the new Sun Life Head Office in Toronto. This is the reason 3M Brand Adhesives, Coatings and Sealers were selected for this project. And that's why more and more progressive planners specify these modern *quality* products. There's a complete line—for further information get in touch with your nearest 3M office.

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The Inspection, Repair and Maintenance of Highway Bridges in LONDON, ONTARIO

R. M. Dillon, M.E.I.C.,
Consultant

P. H. D. Edwards,
Senior Structural Engineer
M. M. Dillon & Company Limited, Consulting Engineers

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

IN THE FALL of 1959, a section of deck collapsed on the Dundas Street Bridge in the City of London, Ont. Fortunately no one was injured and in a few hours the damage was temporarily repaired and traffic was back to normal. The next day the authors' consulting firm was retained to make a detailed report which ultimately lead to a comprehensive inspection of most of the bridges in the city, and recommendations for a reconstruction program which will eventually cost almost $250,000. The investigations described in this paper revealed that the condition of many of the bridges was worse than might have been expected. The cause in part is attributed to the increasing use of de-icing chemicals. It is hoped that this story will be of interest to those who share responsibility for the thousands of municipal bridges in Canada today.

London is situated at the confluence of the two main branches of the Thames River and has always been faced with the construction and maintenance of a relatively large number of bridges. Before surrounding suburban areas were annexed to the City in January, 1961, there were 10 major crossings over the Thames in addition to several overhead and subway structures at railways and other minor river crossings. Of these, five were built or extensively rebuilt during the period 1926-1937. One, a wrought-iron truss has been in continuous service since 1875. All these older structures are through-type steel truss bridges, supported on stone or concrete masonry substructures, while most of the newer bridges are deck-type, reinforced concrete construction throughout. Data describing these bridges which will be referred to by name throughout this paper are tabulated at Fig. 1. General views of two typical bridges are shown in Fig. 2.

The initial investigation at Dundas Street revealed that the concrete deck and steel floor system were badly deteriorated and that extensive repairs would be necessary. Faced with the possibility that several structures might be found in similar condition and that the City would soon be responsible for additional bridges located in areas to be annexed, the

Fig. 1.

SUMMARY — BRIDGES OVER THAMES RIVER INSPECTED

Bridge	*Date Built*	*Spans*	*Description*	*Defects Revealed*	*Est. cost of Reconstruction*
Richmond St. South	Rebuilt 1933	Single 160′	Through truss. Concrete deck on steel stringers.	Unstable abutments. Bearings frozen. Some floor beams overstressed.	$53,000
Dundas St.	1929	Three 105′—105′—105′	Through truss. Concrete deck on steel stringers.	Deck concrete deteriorated. Steelwork under deck corroded.	$94,000
Ridout St.	1926	Two 110′—110′	Through truss. Concrete deck on steel stringers 45 skew.	Deck concrete deteriorated.	$35,000
York St.	1937	Single 160′	Through truss. Asphalt filled Steel grid and plate deck on steel stringers.	Grid deck failing and leaking. Deck steelwork not adequate for H20-S16 loading.	$35,000
Wellington St.	1937	Two 110′—110′	Through truss. Concrete deck on steel stringers.	Abutment sliding. Bearings frozen. Deck concrete deteriorating in gutters.	$28,000
Adelaide St.	1946	Three 78′—108′—78′	Continuous reinforced-concrete box girder.	Abutment bridge seats deteriorating. Deck concrete deteriorating in gutters. Asphalt paving badly cracked.	$ 6,000
Oxford St.	1954	Four 85′—125′ —125′—85′	Continuous reinforced-concrete box girder.	Some pavement cracks.	$ 400
Blackfriars	1875	Single 216′	Wrought iron bowstring through truss. Timber deck on steel stringers.	Truss steelwork slightly damaged by traffic. Bearings frozen.	$ 1,500

City Engineer ordered a comprehensive program of inspection covering all the major structures under his jurisdiction. He decided that on the basis of these inspections, necessary repairs should be assessed and placed in order of priority with estimated costs. At the same time he directed that a system of future inspection and maintenance should be recommended. In all, 12 structures were examined and reported on. To date, repairs of a major nature have been carried out at three sites and it is estimated that a period of five years will be required to complete all the work recommended.

Inspection Program

Preliminary Investigations: To initiate the projected program the City Engineer asked for a proposal outlining the scope of the work and its overall cost. To prepare this a cursory examination of each structure was carried out and sufficient information gathered on which to plan the individual inspections. It was agreed that City personnel and equipment would be used wherever possible and this co-operation resulted in considerable savings. Equipment such as ladders, small boats and scaffolding was made available and the City Works Department personnel assisted in taking soundings and breaking out existing work to facilitate inspection of otherwise inaccessible members.

For each bridge, all available drawings, records and previous reports were collected and studied. The Consultants were fortunate that in nearly every case complete shop drawings for the steelwork were available. In addition they were able to use a series of reports on substructures made by a contracting firm in 1956. These reports were based on exploratory diamond drilling which gave valuable information about the condition of the concrete and thickness of abutments and retaining walls. All this information was most valuable in simplifying and narrowing the scope of the inspection procedure.

Fig. 2. Typical Bridges: Wellington St. & Blackfriars St.

Inspection of River Channels: In most cases the river bed and both banks were carefully surveyed for a distance of at least 200 ft. upstream and downstream. Special care was taken in the vicinity of piers and abutments to check for evidence of scour. A plan of the channel and river bed was prepared from the survey data which was used as a basis for designing and recommending additional bank protection.

Inspection of Substructures: By far the most difficult element of bridge structures to investigate and evaluate, having regard to reasonable cost, is the substructure. The exact conformation and condition of abutments, wingwalls and piers and their foundations must be determined with some certainty if a rational analysis is to be attempted. Fortunately some plans and the 1956 reports already mentioned were available, thus allowing the consultants to proceed with reasonable confidence.

Visual inspection by a qualified structural engineer provided probably the most important single source of information. Abutments and piers were carefully examined for evidence of movement, settlement and cracking and where damage of this type was evident, further exploratory work was carried out. This consisted usually of hand excavation to the base of the footings to ensure they were properly founded but at the Richmond Street Bridge soil borings were called for when it was discovered that the footings had been constructed on a silt layer.

Inspection of Superstructures: The inspection of superstructures involved considerable detail. Pavements were examined for signs of wear and cracking. An examination was made of the deck and sidewalk concrete and where there was any doubt as to its soundness, cores were removed and tested. This procedure was adopted in several instances, cores being removed from representative locations, distributed from the gutters to the centreline of roadway. Bearings were checked for general condition and, in the case of expansion bearings, for freedom of movement. Expansion details were likewise checked and the condition and safety of all handrails was noted. On the steel bridges, trusses, floorbeams, stringers and all connections were examined for evidence of wear and corrosion. Most of the trusses had no top chord bracing system, therefore, special care was taken to check the vertical and horizontal alignment since misalignment can seriously affect the load carrying capacity of laterally unsupported compression chord members. In many cases, truss members were found in direct contact with sidewalk concrete and these were examined for corrosion at their intersection with the concrete surface.

A meticulous inspection of steelwork below the deck of a river bridge involves erection of scaffolding, an expensive and time consuming operation. In most cases it was judged from the preliminary examination that such a close inspection was unnecessary, sufficient information being obtained by observation from the tops of abutments and piers and from below the bridge using field glasses.

The preliminary investigation of the Dundas Street Bridge, however, showed that much of the steelwork was very badly corroded and extensive repairs appeared urgent. Since Dundas Street is a busy arterial street, it was imperative that the period during which the bridge was closed for repairs be kept to a minimum. This required the preparation of detailed plans and specifications to allow fabrication of new steelwork to start ahead of the removal of the old deck so that once the bridge was closed, reconstruction could proceed without interruption. Scaffolding was therefore erected to provide access to every member of the truss and floor system and each was thoroughly examined. City workmen chipped away scale to enable an accurate estimate of load carying capacity to be made. On this basis, the plans and specifications were prepared and while the scope of repairs was later modified to a small extent, it was found that the initial assessment was remarkably accurate. Construction time was saved, the structure being reopened to traffic two and a half months after the Contractor moved on the job.

Photographs: Extensive use was made of photographs which proved valuable in many ways. Initially, they were useful in assessing the extent and seriousness of damage and later in the planning of remedial work and in illustrating the reports. It was found that detailed photographs saved considerable time in the office, especially in the comparative study of "as built" details with working drawings.

Structural Analysis: Before compiling written reports and deciding on final recommendations a considerable amount of analysis, based on field observation and study of other available data, was considered necessary. Abutments were analysed for stability. In two of the bridges, Richmond Street and Wellington Street, these investigations indicated the need for reconstruction, and preliminary designs and estimates were prepared. For each of the steel bridges the superstructure, trusses and floor system, was completely analysed. In determining the load carrying capacity, careful consideration was given to the corroded condition of some of the members.

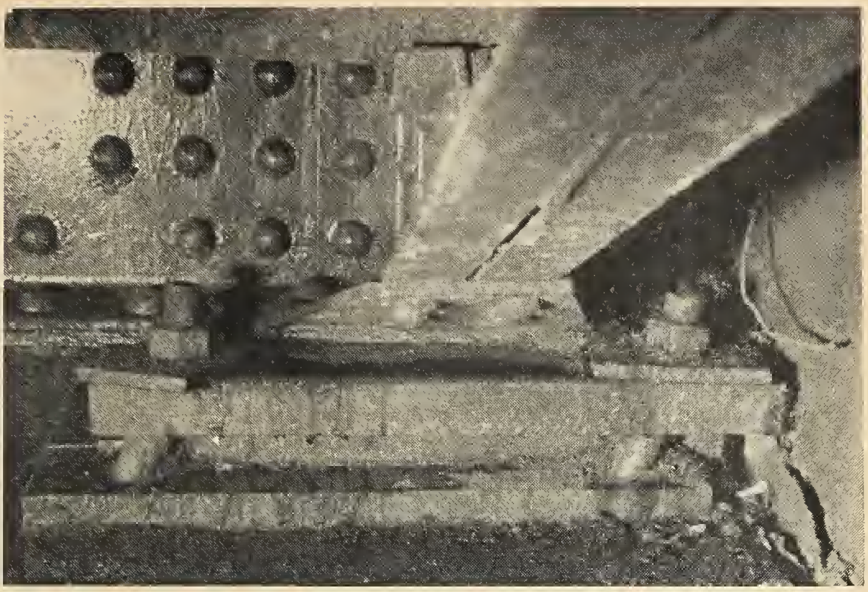


Fig. 3. Expansion Bearing Approaching Failure — Wellington St. Bridge.

Preparation of Reports: Those structures which required urgent repairs were dealt with first and separate reports were issued as soon as they were completed, so that remedial work could proceed. At the conclusion of the inspection programme, a consolidated report, covering all structures inspected, was prepared for the City Engineer.

Individual reports included a summary of findings and recommendations together with results of structural analyses and estimated costs of recommended reconstruction.

The final consolidated report included a summary and schedule of recommended repairs covering all structures. These were set out in tabular form showing the general details and cost of the work which was programmed over a five-year period, the most important being recommended during the first and second years of the program. Also included were detailed recommendations for the routine inspection and maintenance of all the structures covered by the individual reports. These will be discussed later in greater detail.

The Sections following describe some of the defects encountered in the inspections, and the remedial work recommended.

Bridge Bearings

Much of the damage uncovered during the investigation could be attributed in some measure to malfunctioning expansion bearings. Four different types had been used on the bridges inspected:

Nests of 3 in. diam. rollers surmounted by spherical rockers;

Machined sliding plates—bronze on steel—with spherical rockers;

Single rollers. These were about 12 in. diam. and consisted of high strength steel cylinders filled with expanding grout;

Modern type rocker bearings.

Bearings of the first two types were used on all the truss bridges. Both tend to "freeze" in time, and none appeared to be functioning freely. Roller nests had become mis-aligned and consequently had suffered extensive damage due to temperature movement. Of the bearings examined the only types which appeared to be functioning satisfactorily were the modern type rocker and the single large diameter roller.

For several of the bridges, bearings will have to be repaired or replaced. Consideration is at present being given to the use of rubber bearings or rubber laminated with steel, a type recently developed, which promises greater simplicity and better resistance to corrosion. For economic reasons work carried out to date has involved the repair and re-use of existing bearings.

Abutments

Examination of the Richmond Street and Wellington Street bridges revealed that inward movement of the abutments had occurred. There were several indications of this, such as a partial separation of the wingfalls from the main abutment, but the situation was dramatically shown by the condition of the expansion bearings.

At the Richmond Street Bridge the bearings consisted of nests of 3 in. diam. rollers surmounted by spherical rocker plates. The Wellington Street Bridge expansion bearings were a simple sliding type, again surmounted by spherical rockers. In both cases, movement which had exceeded the limits of travel allowed by the slotted holes had occurred seriously bending the anchor bolts. Except at one abutment on the Wellington Street Bridge, the superstructure at the time of inspection was bearing against the abutment backwall at each expansion bearing. The photograph Fig. 3 illustrates the typical condition.

Observations were made during cold weather when the superstructure was at its minimum length. Since no room was left for expansion, it was obvious that very considerable forces would be exerted on the backwalls during the thermal expansion occurring in the summer. Considerable backwall cracking which can be observed in Fig. 3 had already occurred and serious concern was felt for the safety of the structures, particularly the Richmond Street Bridge.

After investigation to determine the depths of the footings and the bearing capacity of the soil, stability analyses were carried out. At the Richmond Street Bridge this study established that under normal pressures from granular backfill, an unstable abutment condition existed. There was satisfactory resistance to sliding but the abutments were unstable against overturning. The Wellington Street Bridge abutments on the other hand, were found to be stable against overturning but, being supported on vertical timber piles with little resistance to horizontal movement, were subject to translation without rotation.

In the authors' opinion the resistance to free movement building up in the bearing as it became "frozen" was the primary cause of failure in these two structures. The friction force gradually increased to the point where it was sufficient to pull the abutment away from the approach fill as the superstructure contracted during cold weather. This caused transverse cracking in the approach fill and pavement immediately behind the abutment. In warmer weather when the deck expanded these cracks had been completely or partially closed under the action of heavy traffic and therefore the abutment was prevented from moving back to its original position. The forces exerted through the bearing are in this case, very great and the

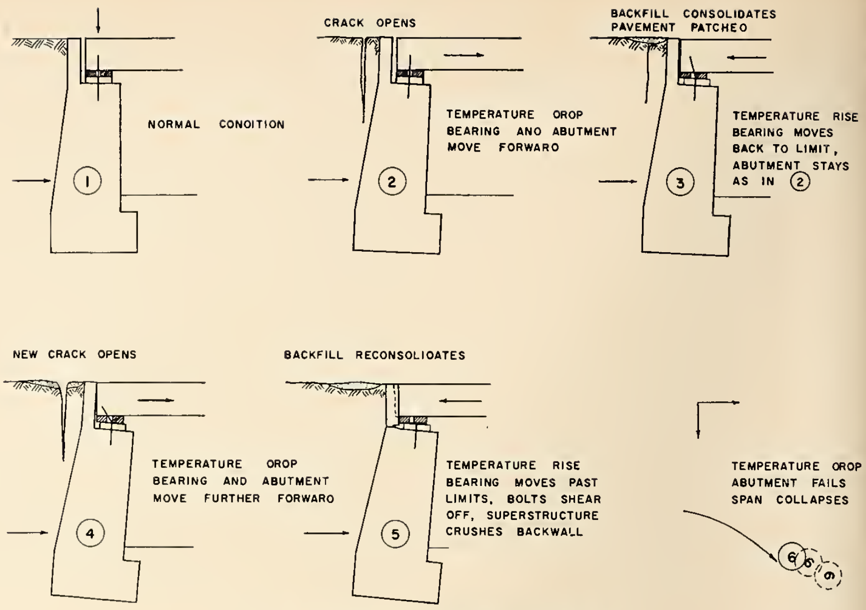


Fig. 4. Cycle of Abutment Collapse.

bearing is forced to move to accommodate them. Repetition of the cycle results in the bending and finally the failure of the anchor bolts, and serious damage to the backwall of the abutment. If remedial measures are not taken the backwall would eventually be sheared away from the abutment and total collapse might ensue. The nature of this failure is illustrated in Fig. 4.

Evidence supporting this theory of failure was obtained by observation one morning after a sudden temperature drop of 30°. Fresh cracks had opened up as wide as ⅜ in. on the approach side of the backwalls at each end of both bridges. It was learned from the City Works Department that similar cracks had been appearing every winter and that patching had taken place twice a year. Fig. 6 illustrates the cracking at the Richmond Street Bridge.

The consultants recommended that the abutments be stabilized and the bearings repaired on both bridges and proposed methods for carrying this out. Since the Richmond Street case was considered critical, work was planned and initiated without delay. Fig. 5 reproduced from the report, illustrates the method by which abutments were stabilized. The completed job is shown in Fig. 7.

Abutments on other bridges using similar types of bearings showed little or no signs of movement. Most of these were massively constructed and proved to be stable under increased horizontal forces developed by the bearings during expansion and contraction of the deck.

Expansion Joints

Expansion joints encountered were of two basic types, sliding plates and finger plates. The sliding plate type has not proved satisfactory as plates have become damaged and loose under passage of traffic. The finger plate type of joint is superior in this respect but has one disadvantage that it allows leakage and accumulation of dust and debris on the bridge seat below. Salt-laden moisture retained by this matter quickly attacks the bearings and concrete of the bridge seat. Fig 8 shows the abutment of the Adelaide Street bridge and the extent of damage which has occurred over a 14 year period. Where expansion is not too great, say up to plus or minus ⅝ in. a third type of joint can be used, consisting of a polyvinyl-chloride expansion type water stop set between the concrete of the deck and backwall about two inches below the pavement surface. The gap above the water stop is filled with a rubberized caulking compound. In the reconstruction of the Dundas Street and Ridout Street bridges, the existing sliding plate expansion joints were replaced with this third type.

There is need for development of a satisfactory non-leaking type of expansion joint suitable for longer spans. One answer to this problem may be the use of precompressed rubber which can be laminated with a series of vertical steel plates to reduce bulging above the deck surface during maximum compression of the rubber. In this type of joint the difficulty is to work out a simple system of precompressing the rubber when constructing the joint.

In some cases it proved difficult to determine whether abutment movement was in fact taking place. Even if an examination of the bearings shows the anchor bolts at the limit of the slotted holes, one cannot always be sure that this is not a result of improper construction. When the Oxford Street Bridge was constructed in 1954, a series of punch marks was made on both sides of the finger plate expansion joints and records kept of the distance between them related to temperature. By checking this relationship periodically, abutment movement can be detected at an early stage. Keeping records of this type could well be adopted more frequently, field observation being part of the routine inspection program.

Deck Concrete

By far the most serious situation revealed was the deteriorated condition of the deck concrete and steelwork in several of the bridges. Those most affected were the Dundas Street and Ridout Street structures.

The authors are of the opinion that the primary cause of this deterioration is the use of de-icing salts, which was started in London on a systematic basis in 1950. At first a salt and sand mixture was applied only after serious storms—but public demand has resulted in a steadily increasing frequency of application. The possibility that the type of aggregate might be at fault was considered but examination proved that the aggregate was still sound.

Although research is proceeding, little has been written on the manner in which salt affects concrete. Most experts seem to agree that the action is physical rather than chemical in nature, and is related to the increased frequency of freeze-thaw cycles caused by regular salt applications, but the authors are not convinced that some form of chemical action is not taking place as well. Future research may reveal the exact nature of the action and lead to a better solution but in the meantime certain protective measures which may be taken in the preparation and surface sealing of concrete are known and tested. These are discussed in the next section.

The investigations of the Dundas Street and Ridout Street bridges revealed a much greater degree of deterioration than was originally expected. Diamond drilling was carried out in an attempt to obtain cores for testing. Only one core was recovered since in all other cases the concrete disintegrated under the action of the drill. This one core was placed on a table indoors and after two hours in the warmer atmosphere it had crumbled to a heap of sand and gravel. Some idea of the concrete condition is given by the two photographs shown in Fig. 9. Stalactites on the underside of the Dundas Street deck gave evidence of heavy and widespread leakage through the concrete. The case of the Ridout Street Bridge particularly demonstrated the rapid rate which deterioration had proceeded over the past few years. During extensive substructure repairs in 1956, a small section of deck concrete was replaced at the south end and condition of the existing concrete was noted to be reasonably good. Yet by 1960, deterioration was such that most of the concrete would crumble under the impact of a hammer. Over the years the asphalt pavement on both bridges had accumulated to a thickness of nearly 4 in. and it became apparent that general failure had been averted mainly by the asphalt layer spreading wheel loads to adjacent stringers which were spaced at approximately 3 ft. centres.

The reconstruction of the deck was carried out for the Dundas Street Bridge during the summer of 1960. The work cost $90,000 and took 2½ months to complete. This operation resulted in considerable disruption to summer traffic and it was, therefore, decided to postpone similar repairs to Ridout Street until after Dundas Street had been reopened. Since this plan left little time for the Ridout Street job before the onset of winter, every effort had to be made to

Fig. 5. Stabilization proposed for Richmond St. Bridge Abutments.

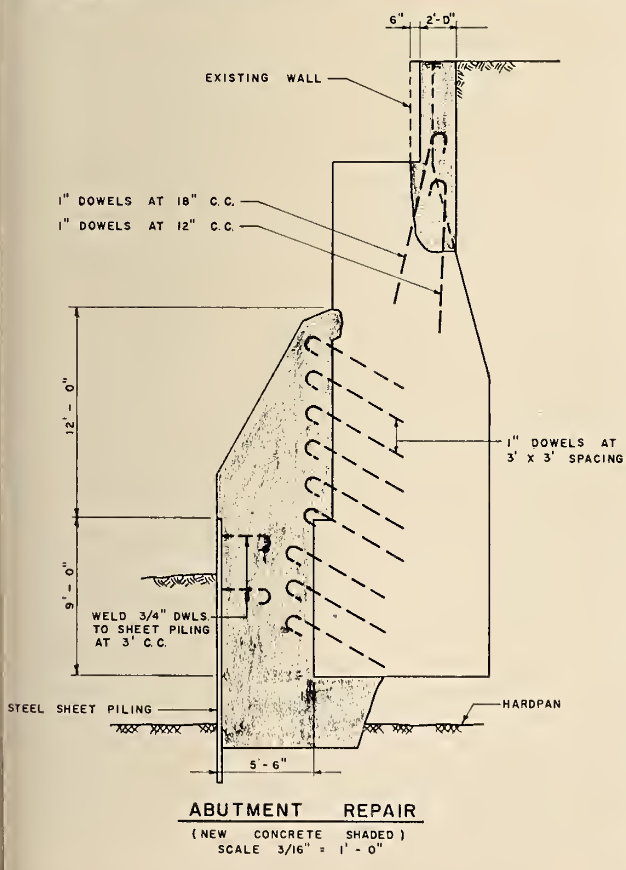


Fig. 6. Crack behind Richmond St. Bridge Abutment after 30 deg. temperature drop.

shorten the construction time. To this end corrugated steel framework was used, this being left in place obviating the use of wood forming. Repairs were thus completed except for painting by the end of November 1960.

Careful investigation of the deck concrete was also made in other bridges inspected. In most cases the cores removed from the deck in and adjacent to the gutters near the curbs showed that the concrete below the asphalt had deteriorated to a depth of about 2 in. but that the concrete below this was sound. No significant deterioration had taken place near the centre line.

The future maintenance program for these bridges calls for stripping off the asphalt paving, repairing the deteriorated areas and applying a sealer to the concrete before replacing the asphalt.

This work is considered by the authors to be of vital importance especially as it pertains to the newer reinforced concrete structures in which the slab constitutes a vital structural element. Deterioration in this case if allowed to develop to the degree found at Dundas and Ridout Street Bridges would result in total collapse. Hundreds of bridges of this type have been constructed in recent years due in part to the fact that they were considered cheaper to maintain. In most cases, deck slabs have not been adequately protected and are therefore subject to progressive damage which is hidden from casual view by asphalt paving.

Fig. 7. Complete stabilization of South abutment of Richmond Street Bridge.

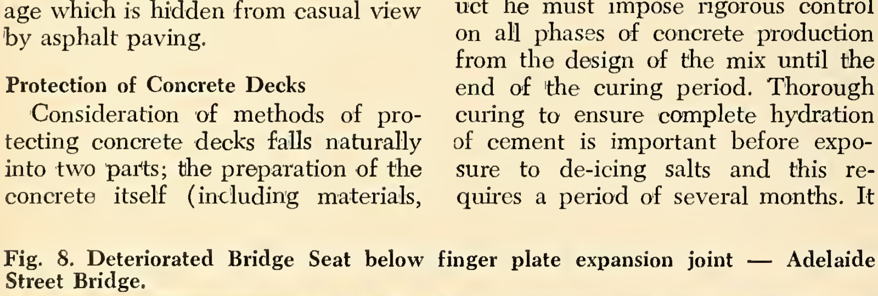
Protection of Concrete Decks

Consideration of methods of protecting concrete decks falls naturally into two parts; the preparation of the concrete itself (including materials, admixtures, mixing, placing and curing) and the application of protective surface coats.

It is very difficult to control the quality of concrete because so many factors are dependent on the judgement and care of the individual operator. The various measures to be taken in producing a good concrete are well known and will not be reviewed here in detail, but several points are worth emphasizing. The engineer must never forget that if he is to be assured of a satisfactory product he must impose rigorous control on all phases of concrete production from the design of the mix until the end of the curing period. Thorough curing to ensure complete hydration of cement is important before exposure to de-icing salts and this requires a period of several months. It is considered a wise precaution to delay exposure of new concrete decks to salts until after the first winter. This is not completely effective, however, since it must be remembered that salt laden ice and snow is carried by traffic onto the deck from nearby treated pavements.

The value of air entrainment, in increasing the resistance of concrete to scaling under freeze-thaw cycles, is now well established and is constantly being stressed in current engineering literature. Several investigators have suggested that by increasing the design strength of the concrete, its resistance to scaling is improved. For exposed areas they have recommended a design strength of 4000 or even 5000 p.s.i. rather than the customary 3000 p.s.i. at 28 days. The authors consider this to be a wise measure and for the Ridout Street and Dundas Street bridges specified a concrete strength of 3750 p.s.i. at 28 days.

Fig. 8. Deteriorated Bridge Seat below finger plate expansion joint — Adelaide Street Bridge.



A sound concrete produced with careful attention to the points set out above will have more inherent resistance to attack from salt than a concrete of inferior quality, but even the best concrete is not perfectly resistant, therefore consideration should always be given to surface sealing.

Ordinary asphalt paving is not by itself an adequate protection for concrete decks against attack by salt. Indeed its use may be more harmful than beneficial since it prevents the evaporation of salt laden moisture trapped beneath it, thereby increasing the deleterious effect on the underlying concrete. If asphalt is used, some method of sealing off the

Fig. 9. (a) Crumbling Curb Concrete

concrete should be employed before it is applied.

In the search for an effective sealer the consultant's attention was drawn to the epoxy-resin compounds which in recent years have gained widespread use in combatting corrosive agents. Several U.S. authorities were consulted who reported generally favourable results with epoxy resin road surfaces laid down experimentally. In most cases investigated, nonskid wearing surfaces subjected to very high traffic volumes were being tested. The longest trial period was only two years but there was enough evidence in favour of the material to lead to a decision to try it experimentally on the Dundas Street and Ridout Street Bridge decks. These applications will be carefully observed over the next few years to determine efficiency both as a sealer and as a wearing surface.

Two different applications were used. On the Dundas Street Bridge, an epoxy resin "skin" with a wearing surface of silica chips was applied directly to the concrete slab, curbs and sidewalks. The surface was first thoroughly cleaned by etching with 15% hydrochloric acid solution and the application made within the specified temperature range (60° to 105°F.). Considerable skill is required to ensure satisfactory application and the work was carried out under the strict control of the suppliers. The finished surface seal of epoxy resin and chips is approximately ⅛ in. thick.

For the Ridout Street Bridge a less permanent type of seal was used, partly for a comparison of performance and partly because this bridge is slated for replacement in the next 10 to 15 years. The concrete deck slab was made 8 in. thick rather than the original 6 in. plus 2 in. of asphalt. An epoxy resin diluted with equal parts of Toluol was applied to the broomed concrete and no additional wearing surface was added. This application is primarily for the purpose of sealing off the concrete from the effect of salts for at least the first winter to enable the concrete to develop its full natural resistance.

The one reservation apart from the cost, in the use of an epoxy resin seal of the type used on the Dundas Street bridge is that the seal may break above shrinkage cracks forming in the concrete. To minimize this danger, application was delayed until three weeks after the deck was poured. This was the minimum curing time acceptable. An examination will be made after the winter and any visible cracks will be repaired with a new application of the material.

The authors considered several other sealers which were eventually discarded in favour of the epoxy-resin. Some of these are reviewed below and for purposes of comparison approximate costs are given.

Silicone Solution—applied directly to the concrete before paving this material seems to be losing favour, possibly because of a relatively short effective life, which limits its usefulness under a pavement (70 cents per sq. yd.)

Boiled Linseed Oil—applied hot in two coats (15 cents per sq. yd.)

Hot Applied Bitumen Cutback—has been used extensively in the past. The difficulty is to achieve perfectly continuous coverage (50 cents per sq. yd.)

Rubberized Mastic Asphalt Membrane — a compound of powdered limestone, asphalt and 2% rubber crumb, mixed at a temperature of 350° to 450° F., it is applied hot in a ⅜ in. layer over a bituminous tack coat and then covered with asphalt. Its proponents claim it is waterproof, elastic and if not exposed to air has a long life. Probably one of the most promising sealers developed to date. ($2 per sq. yd.)

Epoxy Resins—a skin coat using silica chips described above costs $5 per sq. yd. while the diluted sealer used on Ridout Street Bridge costs $1 per sq. yd.

It should be noted that when a 3 in. asphalt pavement is called for on top of the sealer, the cost is approximately $1.50 per sq. yd.

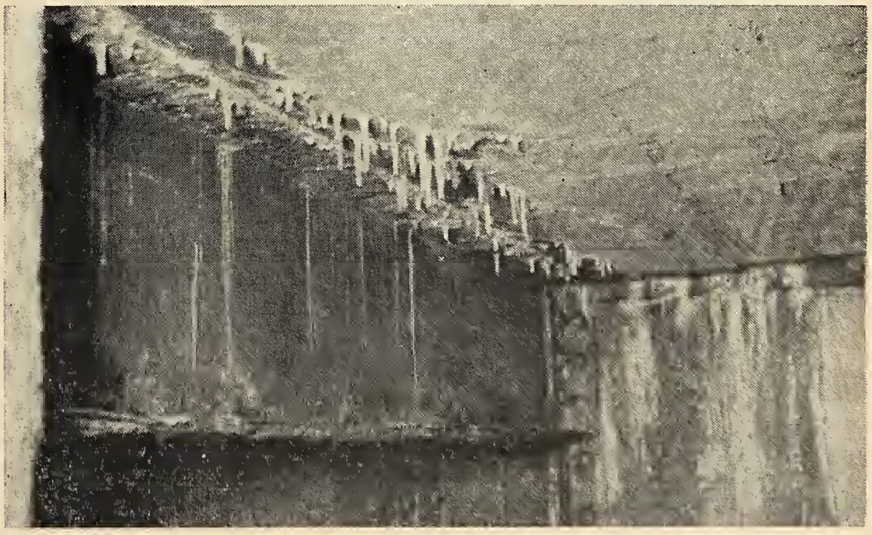
Regardless of the sealing agent used, particular care must be taken to achieve a perfect seal at the gutters. One proposal for effecting this has been to use epoxy resin on the curb and an adjacent 12 in. strip of deck over-lapped by rubberized mastic asphalt on the deck. This method should result in a satisfactory job at a reasonable cost.

Corrosion of Structural Steelwork

Little need be said to thousands of today's motorists about the deleterious effects of de-icing salt on steel. A set of observations made in Lagos, Nigeria showed that the rate of corrosion of mild carbon steel in a salt laden atmosphere was nearly 20 times that in a relatively salt-free atmosphere. There is little wonder then that the use of de-icing salts spells added trouble insofar as maintenance of steel bridges is concerned.

At the Dundas Street bridge where salt-laden water was percolating freely through the disintegrated deck slabs, extensive corrosion was found

Fig. 9. (b) Stalactites showing Leakage under Dundas Street Bridge.



in many of the steel stringers, particularly in those just below the curbs where leakage was at its worst. The bottom chords of the trusses and the webs of some floor beams were also seriously affected. In some places, flanges and webs were completely corroded and connections broken away. Fig. 10 illustrates the conditions encountered. Since the steelwork had been painted only four years previously, it is reasonable to assume that much of the damage had occurred very rapidly.

It was fortunate that damage was progressively less towards the centre line of the roadway under which were heavy girders originally designed for street railway traffic. This fact allowed continued use of the centre portion of the deck during the planning and reconstruction; the reduced roadway width being defined by wooden barricades.

The contract for reconstruction specified the removal and replacement of 67 of the 231 stringers and extensive repairs to floor beams and bottom chords of trusses.

In the Ridout Street Bridge evidence of active corrosion was observed. Chipping of scale from the top flanges revealed numerous bright patches of corrosion which indicated that a condition similar to that found at Dundas Street was rapidly developing although, fortunately, damage had not proceeded to the point where major repairs were considered necessary. At other bridges where deck concrete was found to be relatively sound, no serious corrosion was encountered, thus the condition of the Dundas and Ridout Street Bridges in particular emphasizes the startling rapidity with which serious damage due to salt action can develop.

Another common point of weakness was observed where web members of trusses pass through the sidewalk concrete. Corrosion in these members invariably took place at and just below the surface of the concrete. To overcome this at the Dundas Street Bridge, truss members were coated with a bituminous paint and then wrapped with bituminous fibre to isolate them from the concrete. The sidewalk surface adjacent to the member was built up slightly to prevent ponding and trapping of moisture. Fig. 11 illustrates the procedure. The strip of foam rubber shown was removed after the pour, thus leaving a deep groove which was filled with a caulking compound.

Protection of Steelwork

Faced with the problem of specifying suitable protective coatings for steelwork, the engineer has so many to choose from that he is in somewhat of a dilemma. On one point, however, he may be sure: the effectiveness of any painting system depends largely on surface preparation. It is due to inadequate surface preparation rather than the quality of the paint itself that many premature paint failures occur, although naturally, it is still important to choose good quality paint and exercise care in application technique.

Of the four main methods of preparing steel surfaces — hand cleaning, flame cleaning, pickling and blast cleaning, the latter is certainly the most effective. The higher cost of blast cleaning is justified since it increases the effective life of the paint. An experiment supporting this argument has been carried out by the conultants at the Highbury Avenue Overhead at the Canadian Pacific Railway crossing in London. When the structure was erected in 1956, several members in the lower bracing were sandblasted prior to shop painting while the remainder of the steelwork was hand cleaned under normal shop conditions. The work has been carefully observed and to date the sand blasted members are still in near-perfect condition while the remainder of the steelwork is rapidly reaching the point where repainting is necessary.

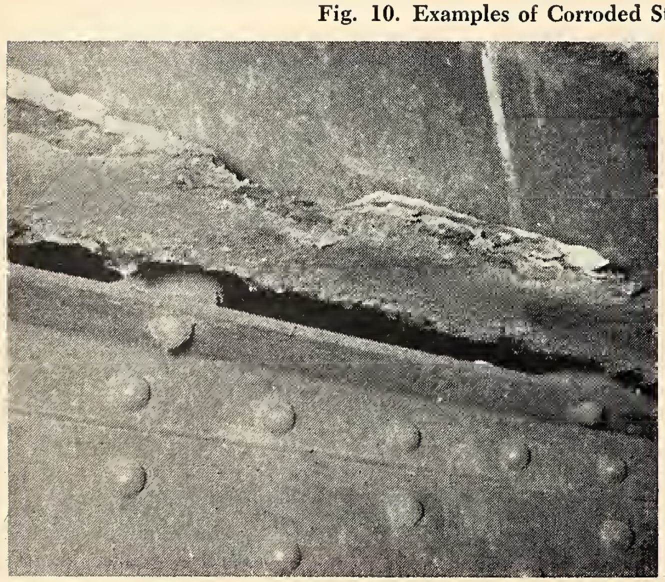
Recently many of the better fabricating shops have installed special equipment for cleaning which should tend to reduce the cost and blast cleaning is becoming an accepted practice. In the authors' opinion it should be specified for all new bridge work.

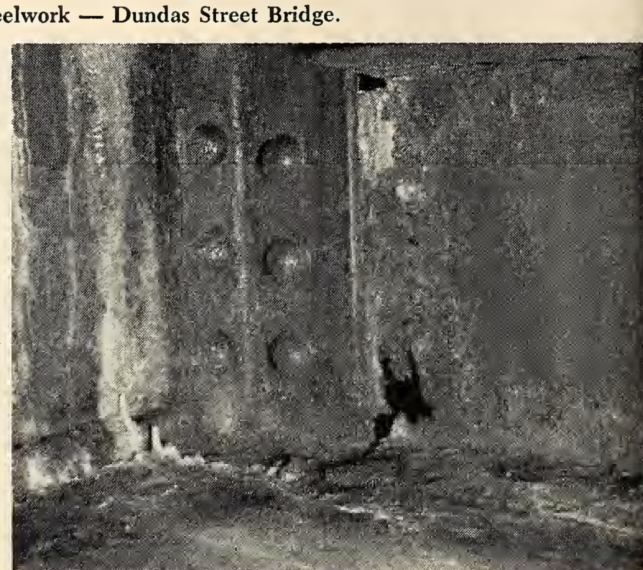
Blast cleaning in the field is, however, still a relatively difficult and expensive operation. In spite of this, at the Dundas Street Bridge it was specified for the steelwork below deck which was in particularly poor condition. The paint work above the deck was in fair condition and hand cleaning including a thorough washing to remove salt film was considered adequate prior to repainting.

The paint used most commonly for structural steel in the past two or three decades has been the oil-alkyd type. It is relatively inexpensive and has the advantage of being more tolerant of imperfectly clean surfaces than some of the more recently developed products. Paints in phenolic-resin media have also been in use for a considerable time. These have superior resistance to dampness, chemicals and generally severe atmospheric conditions, but they require perfect cleaning of steelwork and in several respects more rigid control in application.

Many more recent types including vinyl, epoxy-resin, lead-chromate and coal tar paints have excellent qualities for use on bridge steelwork. Most

Fig. 10. Examples of Corroded Steelwork — Dundas Street Bridge.





of these also require special application techniques and meticulous care in surface preparation, which to date have limited their acceptance on a wide scale. Many of these products are expensive—but should they provide more permanent protection, they may be in the long run more economical.

Sprayed metal coatings using zinc and aluminum may in future provide an effective answer to the problem.

Careful consideration was given to specifying the paint for the reconstruction at Dundas Street and Ridout Street bridges. Since time was limited and there was relatively little chance to control the weather conditions during application, it was decided to use an oil-alkyd type paint. Good surface preparation was achieved and satisfactory service is expected.

Rating Bridges

Mention has already been made that in most of the steel truss bridges, a complete superstructure analysis was carried out for rating purposes. With some execptions, trusses were found to be capable of carrying H20 loading. The Richmond Street bridge trusses were in general, good for only H15 loads and some web members weakened by corrosion were not adequate even for this. Some web members of the Wellington Street bridge trusses similarly limited the load capacity otherwise good for an H20 loading. In nearly every case, however, the limiting feature was the capacity of the stringers.

In the Dundas Street Bridge the stringers were brought up to H20-S16-44 Standard by redesigning them to act compositely with the new concrete deck slab. Nelson Stud shear connectors were installed in the field. At Richmond Street where the deck did not need replacing certain deck members will be reinforced to increase the capacity of the structure to H15-S12-44, which rating was in this case considered adequate.

In rating existing bridges, it is not considered necessary to be governed entirely by the specifications for allowable design stresses. In the design of new bridges, the factors of safety upon which our specifications are based, are such that a substantial reserve of strength is built into the structure. This is a wise measure as witnessed by the hundreds of older bridges designed for lower loadings yet still carrying the heavier loads of modern times. Therefore, in analysing the safe carrying capacity of existing bridges it is reasonable to take into account a portion of these reserves of strength. This is recognized in the A.A.S.H.O. specifications on rating.

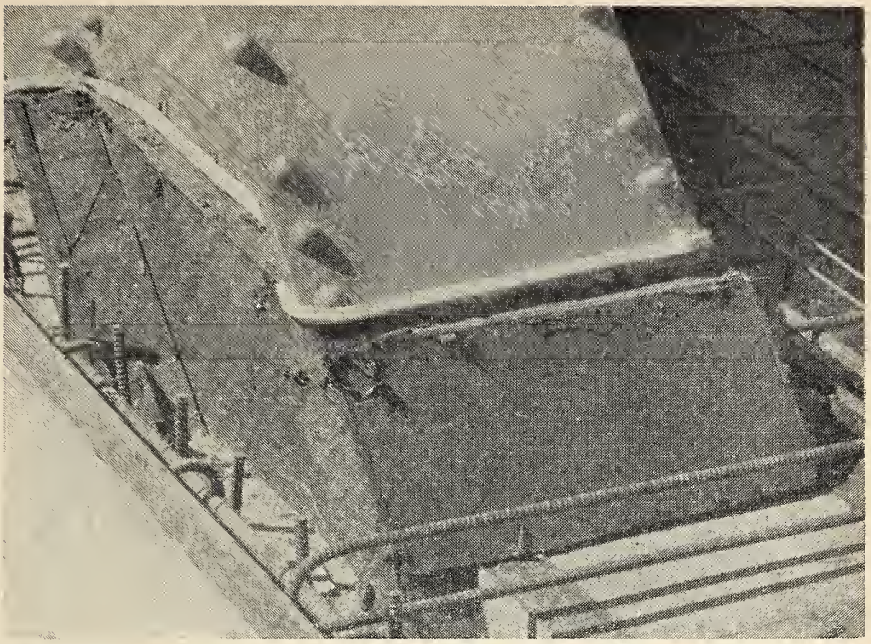


Fig. 11. Bituminous Fibre to Isolate Truss Member from Concrete. White strip is foam rubber forming caulking groove.

D. T. Wright in his Reports No. 1 and 2 of the Ontario Joint Highway Research Programme points out the inconsistency in applying a factor of safety on yield strength for a combination of dead load and live load stresses. The ratio of dead to live load may vary from 0.1 or less in the case of stringers to 3 or more in the case of heavy long-span girders.

Thus if the overall factor of safety defined by the ratio of yield stress to design stress is taken as 33/18 = 1.83, and a factor of safety of unity is assumed for the dead load, the actual factor of safety applying to the live load varies from about 1.9 to over 4.3. For rating purposes, Wright proposes the use of separate factors of safety for dead loads and live loads as set out in the expression

$$1.10\ W_D + 1.25\ W_L = C$$

Where

W_D = dead load
W_L = live load
C = maximum load capacity of member based on yield stress for steel and other criteria for concrete and timber.

Thus some of the reserve strength of a structure is used to carry additional live load. The factor of safety of 1.1 for the dead load takes into consideration construction tolerances and other inaccuracies and 1.25 is the proposed factor of safety for the rated live load plus 30% impact.

It would not be wise to use as low a factor of safety as 1.25 for live load on structures which are intended to be kept in use for a long period, but it could be allowed on bridges scheduled for early replacement and on which frequent inspection was carried out. Wright is careful to point this out in his reports stating that the matter is subject to the judgment of the engineer. In rating the London bridges all of which are to be kept in service for a number of years, some increase in allowable design stress was accepted but the factor of safety on live load in all cases was kept above that proposed in the formula.

Planning and Economic Aspects

Final recommendations dealing with repairs to old bridges must not be made without consideration of the plans for future development of the road system. Before a decision is made to spend money on a particular structure, its useful life from a traffic point of view as reflected in the overall plan should be established. If replacement by a larger or realigned structure is called for in a few years it may be considered expedient to limit the immediate work and to allow continued use under a reduced load limit. This course was recommended in the case of the Richmond Street bridge.

On the other hand, consideration of future plans might point to the advisability of constructing, some years ahead of time, a new bridge designed to satisfy future requirements, rather than spending money on an old structure which in the interests of public safety demands immediate attention.

In the fall of 1959, the City of London received a long-awaited Traffic Study and Report which contained recommendations for the development of roads in the area over the next 20 year period. Information contained therein dealing with future bridge construction was of great value in arriving at sound recommendations covering repairs to existing bridges.

As a result of the comprehensive inspection program, the City of London found itself with several structures which needed more or less costly repairs. These could not all be carried out simultaneously nor even in the same year, first because disruption to traffic would be intolerable, and secondly because of the considerable cost involved.

The program of reconstruction recommended called for all work to be completed in a five year period. Priorities were based on the relative seriousness of damage encountered, considerations of public safety and overall reconstruction plans.

Setting up a Maintenance Schedule

There is no doubt that an effective program of inspection and maintenance can go a long way in reducing costs. Preservation of protective systems prevents deterioration and repair of minor damage obviates the necessity of major reconstruction. Such a program was proposed to the City of London.

It was recommended that each structure should receive an annual inspection, the results of which would be recorded on an Annual Report Form especially tailored for that particular bridge and listing the salient points to which the inspector should give attention. The scope of this annual inspection was quite comprehensive, although for steel bridges a detailed investigation of steelwork below deck was thought unnecessary. Careful measurements would be taken to detect early evidence of abutment movement.

Maintenance measures would generally follow from the findings of the inspection, but it was recommended that each year after the winter the paint work above the deck be touched up and that any damage to concrete or wearing surface be patched and sealed.

At approximately five year intervals, a major inspection of the complete superstructure would be carried out, probably in connection with repainting.

In addition to the report form and again for each structure a Bridge Record Sheet was proposed. This recorded load capacity, and structural data, some of which was depicted by a plan, elevation and typical cross section of the structure. Space was provided to record the annual inspections and to summarize repairs.

The chief value of properly organized well maintained records is that regardless of changes in the inspection staff—minor damage of a progressive nature can be detected early so that remedial action can be taken before major damage occurs.

Conclusion

These investigations and the planning and supervision of the remedial work served to bring out several lessons. There is nothing particularly new contained in them, but their importance was brought into sharp focus.

The more important ones are worthwhile repeating.

The design of abutments and piers should make adequate provision for friction forces developed in expansion bearings. This is particularly important for structures using sliding plate bearings which tend to freeze.

Design of foundations should take full account of the possibility of scour and bank erosion.

There is need for development of a satisfactory non-leaking type of expansion joint suitable for longer spans.

Gauge marks on expansion joints and on bearing plates are useful in early detection of abutment movement.

Control of concrete production at all stages is more important than ever where structures are exposed to de-icing agents. This is of prime importance in modern concrete bridges where the deck acts as a structural element of the superstructure.

Asphalt pavement will not protect concrete from salt attack. An efficient sealer is necessary.

Steel painting specifications must be prepared with care, particular attention being given to steel surface preparation and paint application. Field control is important.

And finally, it is hoped that this description of the investigations carried out in London has clearly established the importance of careful periodic inspection and a co-ordinated maintenance program. Those charged with responsibility for the thousands of bridges in Canada's municipalities could learn much from the railways — which have for years realized that good bridge maintenance makes good sense.

Most of the serious damage observed occurred in structures which were constructed between the two wars. With relatively little maintenance they have stood up well for about 25 years, but under heavier and heavier loads, more and more traffic and finally under increasing attack from de-icing chemicals, they are deteriorating at a rapid rate.

Without prompt positive action the situation will quickly become even more serious. Today bridges are being built at a faster rate than at any time in our history. It appears that without adequate care in construction and maintenance, this new construction may be attacked by de-icing salts in a remarkably short time. All these structures, the new and the old, represent an investment which is increasing concurrently with the rapid development of our Canadian road system.

Surely then, we who are charged with the responsibility must do everything possible to protect this investment — by getting the maximum useful life from our old and new bridges through inspection and maintenance — and by increasing the life of our future bridges through better design and construction.

Author's Footnote

The application of spoxy resin and chips to the Dundas Street Bridge deck has not been entirely successful. In the spring of 1961, some six months after application, areas of bare concrete were showing. These areas continued to increase in relation to the amount of wear on the deck.

The deterioration in this application was attributed to the following:

(a) Uneven distribution of the apoxy material due to application by brooming.
(b) Uneven distribution of grit due to application by scattering from shovel.
(c) Application at low temperature (60° or lower).
(d) Insufficient quantity of epoxy applied (2 lbs. per sq. yd.).
(e) Silica grit was used.

While this protective system has for some time been used with success in the U.S.A., its use in Canada is relatively new. Practical applications for use under all conditions, to be inspected over several years are still required in this country to ensure that the initial comparatively large capital outlay is justified.

The deck to the Dundas Street Bridge, being under manufacturer's guarantee was resurfaced by the manufacturer and his applicator. The method of application was drastically revised in an attempt to produce a more durable wearing surface.

(a) The spoxy was sprayed onto the deck.
(b) The grit was sprayed on the spoxy using a modified grit blaster.
(c) No application was attempted unless the weather was dry and the temperature was 60°F and rising and would remain so for several hours after application.
(d) 50% more epoxy was used.
(e) Only trap rock grit was used.

It can be seen that the application of this material requires experience and a great deal of care. However, it is possible to train a crew specialized in this work* and obtain optimum results when large areas are to be surfaced. Applications to small areas at intermittent periods could prove costly.

The application of rubberized mastic asphalt has so far only been made as a membrane underlying a hot laid asphalt wearing course. It is of interest to note that the Ontario Department of Highways have made a trial application of this material to some 2000 sq. ft. of bridge deck. The mastic was sprayed with grit and thus forms a waterproofing membrane and wearing surface. It will be of interest to discover how durable this proves to be.

*"Corrective Measures Employing Epoxies on Concrete Bridge Decks on New Jersey's Garden State Parkway" by Harold W. Goldberger. Published by New Jersey Highway Authority for New Garden State Parkway.

WATERSHED RESOURCE VALUE

The Associated Development of Fish and Power

Val Gwyther, M.E.I.C.,
Val Gwyther & Co. Ltd., Consulting Engineers, Vancouver

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THE necessity to conserve the salmon resource in the many watersheds of British Columbia which these fish inhabit, or could inhabit, has retarded the development of other resources, primarily hydro electric power. This is due only to our present inability to ensure present production of salmon by natural spawning and rearing in fresh water. This condition exists today even though we are unable to affix a definite yearly value to salmon production due to variations in climate and other influences of nature. To conserve and increase production of the salmon resource in a watershed, from which we wish to obtain the benefits of power, we must provide means to protect these fish in their fresh water life. This paper discusses matters vital to proper understanding of salmon production in large quantities jointly with power. With this joint development of watershed value, where large lake areas exist or are impounded, the value of the salmon resource may well exceed that of power.

Salmon Species—Survival—Management

Commercial production relies on five species of salmon: sockeye, pinks, chums, cohoe and spring. The first three species, throughout their free swimming lives are dependent mostly on plankton for food while the last two species as they increase in size become fish eaters. The cohoe and springs are the main sporting fish while the steelhead, a trout, is valuable in both sports and commercial fishery in the sea and sports fishery in fresh water.

In this paper I have used the sockeye species as an example as they contribute the greatest value to our commercial fishery and they require added protection in rearing areas.

In natural spawning, a tremendous loss of life is caused by: under and over seeding of spawning areas; incomplete spawning of females; inefficient fertilization of eggs; flash floods; varying river levels caused by fluctuation of power plants; temperatures too warm or too cold; pollution; drying up of river beds; sedimentation; lack of food; predatory birds; animals and fishes; the inability of salmon to bury their eggs; frost; unsanitary conditions in nests during incubation; and delays in passing dams which have not been properly designed for fish passage. With these heavy losses, if one-tenth of one percent of the eggs live to grow and return as adults, the runs are maintained.

By artificial fertilization and incubation in hatcheries, successful means have been developed in bringing to life 80 to 90% of the salmon eggs produced by all five species. In hatcheries, eggs are taken from salmon ready to spawn and placed in incubation trays. From this point on they are kept free of all natural hazards until they become free swimming fry. With properly prepared rearing areas they are protected from predators until they migrate to the sea. We then may have a survival rate of 80% of all eggs prior to migration from rearing areas. Again, if we are able to eliminate predatory fish in migration routes to the sea, at least in part, we are able to reduce mortality.

The predatory fish problem is one of the major problems that must be solved. We are advised "It has been shown that after sockeye fry are liberated in Cultus Lake a mortality of from 94 to 97% occurs. This, it may be presupposed, exists irrespective of whether the fry are reared naturally or in hatcheries and therefore presents, perhaps the most urgent problem facing fish culturists".[2] This is in the rearing areas.

In migrating streams and rivers in a 10 mile reach of Minto Creek we are advised. "Stream mortalities on various lots of 500 to 585,000 fingerlings planted under five months of age ran from 87.5 to 98.2%. Stream losses on lots from 3,000 to 53,000 planted at six months of age were 74 to 83%. At nine months of age losses in plantings of 3,000 to 33,000 were 53 to 67%. At 12 months plantings of 5,000 to 70,000 showed stream losses of 17 to 43%. While plantings of 14 month old fish in two lots of 30,000 and 98,000 showed only 16 and 12 percentage respectively. While stream factor loss was far less on 14 month old planted fish, it was evident from high marine mortality, that young silvers (cohoe) held that long, were unable to cope with conditions in salt water. Thus on the face of present knowledge ultra long rearing term is not the answer."[3]

If we investigate the life history of those species of fish which are predators on salmon, either by devouring the small fishes or devouring the food in the streams, rivers and rearing areas that could support salmon, we find that some of the species migrate from the sea to fresh water spawning grounds and some are totally fresh water fish. However the latter migrate from the lakes to incoming streams to spawn. These species then, all appear to migrate, deposit their eggs in the same gravels as do salmon and the small migrants return to the sea or lakes to continue their lives. There may be some species whose total life is spent in lakes, in which cases lake poisoning may be necessary. It appears that control of all migrating predatory fishes can be accomplished if we are able to extract these fishes in the migration routes.

Our present policy of propagation of salmon by natural spawning, in the numerous watersheds of British Columbia, from which the salmon harvest is produced, is certainly not beneficial to the industry as yield is progressively reducing. This was realized before the turn of the century when a hatchery program was commenced. A number of hatcheries were built in later years but production did not appear to be increasing. In 1936 all hatcheries were closed after a study was made as to the respective indices of incubation in the three methods of propagation namely, natural spawning, planting of free swimming fry (hatcheries) and planting of eyed eggs.

The results of this investigation are available to us[4] and the conclusions and their interpretation are of extreme importance in our proper understanding of present policy[15-17] in sockeye salmon propagation and therefore must be reviewed.

Conclusions 1, 2 and 3 show the relative efficiencies of natural spawning, hatcheries and plantings of eyed eggs. Conclusion 4 is: "During the year's residence in the lake from 94 to 97% of the fry liberated therein perish. The loss has been attributed largely to predatory fish—squaw fish, char, trout and sculpins. Tests are now being undertaken to determine the benefits accruing from destruction of predators." The conclusions continue — "The above data may appear to show an appreciable benefit to be obtained from artificial propagation. On the contrary, however, due consideration of ranges of variation in percentages of efficiency for each of the three methods indicates that the differences which seem to exist between the methods are not significant. They do not portray any distinct advantage for any one of the three methods tested.

On the basis, therefore, of the above results, it may be concluded that in an area such as Cultus Lake where the natural run of sockeye occurs with reasonable expectancy of successful spawning, artificial spawning for the purposes of continuing the run to that area is unnecesary, and if producing any additional results over natural spawning, these would not appear to be in any way commensurate with the cost."

Conclusions 1, 2 and 3 indicate that there is a slight increase in production of fingerlings both in hatchery propagation and artificial spawning in the amount of perhaps only 75%. If higher efficiencies had been obtained in fertilization of eggs, in natural spawning by higher percentages of returning males, this increase by artificial means may even be nullified. Conclusion 4 is the most important of the bulletin, and, in my opinion limits the validity of conclusions 1, 2 and 3. Greater success in artificial spawning would have been obtained if predator control had been carried out.

What then do these conclusions mean? Is the increase recorded in hatchery propagation based on 4.5% of survival? Records of escapement returns of later years appear to indicate this meaning. Or does it mean that as greater quantities of hatchery produced fish were placed in the lake, the predators were better fed, grew larger and fatter and more numerous and continued to devour the salmon fingerlings in quantity, at a rate per unit of fish which is slightly less than that in natural spawning? With this prime factor of destruction of salmon fingerlings by predators, have we any indication of the comparable indices of production in the various methods of propagation?

Hatcheries were closed at the end of 1936. The International Pacific Salmon Fisheries Commission report results from 1939 to date.[5] The returning races of 1935 and 1936, four years later, which were assisted by hatchery propagation report escapement to Cultus Lake in quantities of 73,189 and 74,121 respectively. All future reports of these two races up to 1956, after they received no assistance from hatcheries varies from 8,898 to 26,000 or an average of about 15,000 adults. This then is an increase in escapement of about 500% when runs were assisted by hatcheries even though 95.5% of all fry, liberated in the lake were devoured by predators.

Certainly then, our present appreciation of efficiency in the various methods of propagation requires adjustment.

Reservoir Management

The quality of water that is discharged from impounded reservoirs or natural lakes is of primary importance to survival of salmon during migration and their existence in river channels. Unsatisfactory control of reservoirs in all seasons tends to retard migration of adults and pollute river channels below the reservoir. In all reservoirs stratification exists with depth in all items of water quality. However, thermal stratification has a tendency to alter chemical and physical quality due to seasonal variations of climate, temperature of inflow and quality, outflow its quantity and depth of discharge from the reservoir. In such items as turbidity, color, odor, biochemical oxygen demand (B.O.D.), dissolved oxygen, free carbon dioxide and nitrogen are concerned, those waters near the surface are more beneficial than those of some depth. Surface waters may however be too high in dissolved oxygen and temperature which is detrimental.

As far as chemical quality is concerned in these waters, the decay of organic matter tends to use the dissolved oxygen and form carbon dioxide. This biochemical oxygen demand is defined by the American Public Health Association as the oxygen in parts per million (p.p.m.) required during stabilization of the decomposed organic matter by acrobic bacterial action. Complete stabilization requires extended periods of time therefore for practical indices B.O.D. requirements for a five day period at 20° C is used.

While this decay of organic matter is using up dissolved oxygen the small plant life of the water, (algae, water plants, diatoms, etc.) by photosynthesis, takes in carbon dioxide and gives out oxygen. As an example of the variations of B.O.D. dissolved oxygen and carbon dioxide with reservoir depth, at the bottom of a 77 ft. reservoir, decomposition had used up all dissolved oxygen and had put 12.2 p.p.m. of carbon dioxide into the water. At 40 ft. the carbon dioxide was 8.5 p.p.m. and dissolved oxygen had risen to 31 percentage of saturation (too low for fish life). At 20 ft. the carbon dioxide had diminished to 1.5 p.p.m. and the dissolved oxygen had risen to 90% of saturation (satisfactory for fish). At the surface, carbon dioxide had decreased to 0.5 p.p.m. while the dissolved oxygen had increased 6% beyond the saturation point (oxygen high for fish). The water at the surface being slightly supersaturated with dissolved oxygen. Fig. 1.

Obviously since the process of photosynthesis is dependent on light there are differences in the amount of oxygen in a lake or reservoir, in the day and in the night or even in sunny or cloudy days. There is also some retardation in reservoirs carrying heavy sediment, as light does not penetrate this water as readily as it does clear water.

Both decay and plant growth are faster in warm weather than in cold, but even in winter under the ice both processes are taking place, although at much slower rates than during summer conditions.[6]

With regard to physical behavior, the maximum density (specific gravity) of a unit of volume of pure (distilled) water, is at a temperature of 4° C. As the temperature decreases the density progressively decreases, or it occupies greater volume, until it reaches 0° C, where it changes its physical state from liquid to solid, with abstraction of heat. There is an increase in volume in water at 0° C to ice at 0° C. As the temperature lowers beyond this point the ice increases in density. Again as the temperature of water rises from 4° C to 100° C there is a progressive decrease in density. With acceptance of heat at 100° C the water changes to steam.

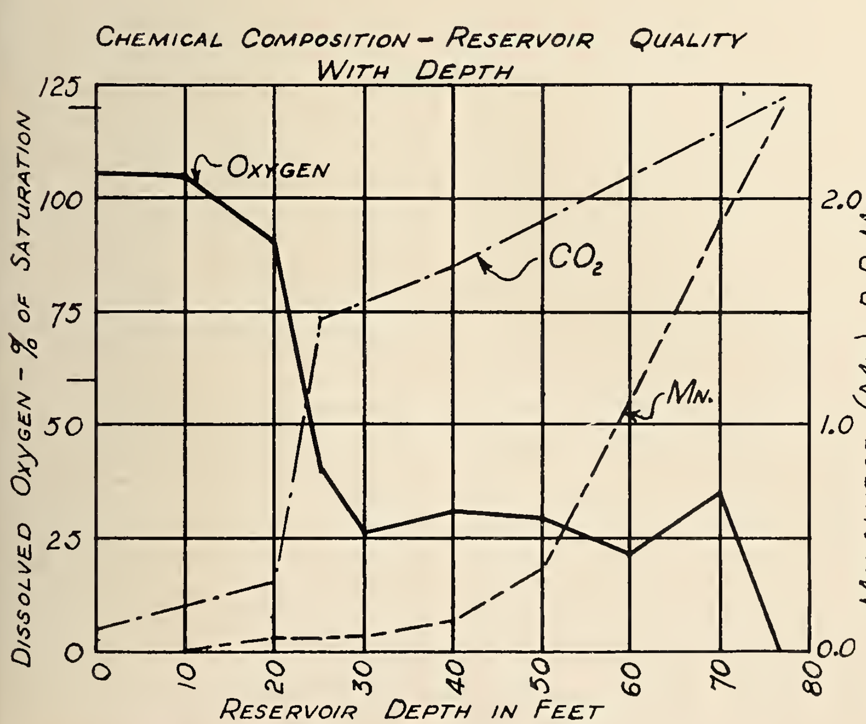
The acceptance of hardness by water whether it be in solution or suspension, will increase the density of water. This density will be increased in proportion to the amount of hardness and also in relation to its chemical composition as designated by its molecular weight, volumes being the same.

The erosion of the geological formations by precipitation and its related forces provides inorganic sediment and the decay of vegetable growth provides organic sediment. These two types of sediment have different specific gravities which on the average may be in the ratio of about 2.65 to 1.2.[7]

Water has the ability to transport sediment in suspension and this ability varies as the 2.56 power of the velocity.[7] Water also has the ability of moving sediment along the bottom of a relatively shallow water course and this ability appears to be in the relationship of the sixth power of the bottom velocity.[7] With climatic variations in precipitation and temperature we are provided with varying velocities in river discharge with its accompanying ability to transport larger particle size and in greater quantity.

Each particle of suspended sediment will settle in a still reservoir of pure water, due to its higher density and the inorganic sediment will settle out at a more rapid pace than organic sediment, particle size being the same. As an example a particle of 1 mm. diameter in 10° C water has a settling velocity of 100 mm. per second for inorganic material and 12 mm. for organic matter. Continuing down the scale in particle size, a particle with a diameter of 0.001 mm. will settle out at a velocity rate of 0.000,015 mm. per sec. for inorganic material and 0.000,00084 for its equivalent in particle size of organic material.[8] These settling velocities in fine particle size materials are very small. They will be decreased by water hardness and particles may be retained in suspension with vertical oscillations of water due to temperatures.

Fig. 1. (Compiled from Table 26, p. 69 — "Water Treatment", Eskel Nordel).



These then, with effects due to chemical changes in the reservoir, local currents and wave motion, are the influences which nature provides and which must prevail in any reservoir.

If we examine a reservoir in the interior of British Columbia, with the varying temperatures of inflow water and amosphere we will readily appreciate that in winter months the surface water is colder than the lower waters and the opposite occurs in the summer period. Then there is a complete turnover of the surface strata twice per year. In this turnover, waters of maximum density pass to the lower reservoir and may remain there for generations. The same occurs in coastal areas provided at some time the atmosphere is lower than 4° C.

With heavy inflow, gradually building to heavy outflow, as lake storage is developed, we may have some disturbance of these lower waters especially in relatively shallow reservoirs, as density currents will form due to temperature difference.

Then in the interior of British Columbia during the winter months we may expect a thermocline from the bottom of the ice to some depth, varying from 0° C to 4° C and the remaining depth of 4° water. In summer during heavy discharge, we may expect a pool of warm water floating in the density current and underlain by the dead waters at 4° C. The coastal area is somewhat the same except that the density currents occur in the winter months due to heavy discharges and these may travel on the surface at this time.

In reservoir management there are some other influences which we must consider. These bodies of water in their ability to retain water for a period of time, not only level out variations of hardness but allow purification of these waters. We then can expect larger variations at the upstream end of the reservoir and increased hardness with depth.

How then are we to manage the discharges from power reservoirs, whether it be turbine drawoff or flood discharge, to ensure satisfactory quality at all times and all stages of operation throughout the year accompanied by the drawdown of storage. Obviously we must regulate the discharges from those zones of reservoir depth, which are satisfactory for fish. In order to accomplish this we must insure a stable reservoir condition from which we are able to extract known water.

In this appreciation we cannot use the bottom dead waters at any time of the year due to lack of oxygen, and pollution and we should not use surface waters as they are supersaturated with oxygen and may have unsatisfactory temperatures at some times of the year. We then must abstract all waters from below the surface to a point of some depth above the relatively dead waters in the reservoir bottom. It is beneficial to be able to mix these strata for satisfactory fish migration.

Rearing Areas

How must we approach this problem of economic production in the salmon species in quantity with assurance that other benefit resource value of the watershed can be jointly obtained at the same time or some future time? Alternatively, if other resource values are developed prior to salmon, will this potential resource value be retained for future development?

Our present index of the value of the salmon resource, namely the ability to incubate salmon by natural spawning and rearing in bodies of water in their natural state is far removed from the potential value from production in these species.

The potential value of salmon production in any watershed is only dictated by the rearing capacity and what may be accomplished to improve these rearing areas for optimum yield. Spawning of salmon and the incubation of eggs, whatever method is used, must keep pace with the ability to produce in rearing areas. Furthermore incubation must keep pace with productivity in rearing areas as we continue to increase the fertility of these areas and reduce predation losses.

We are advised that "Fish of all kinds respond tremendously within their proper environment to the right kind of fertilizer in the water whether it is organic or inorganic. The reason is simple. The fertilizer stimulates growth of vegetable plankton. This produces more food for tiny free swimming plankton and small crustacea which graze upon the vegetable matter. With adequate food and favorable water temperature, animal plankton multiplies phenomenally. Larger insect larvae and nymphs, as well as fish fry feed on the lesser plankton and thrive. The fingerlings and adults gorge on both larger inhabitants as well as on the myriads of amphipods, those many-legged little creatures which swarm the waters of good fish producing areas. Break this chain of production anywhere along the line, or overload it, and the water can become barren of desirable fish."[9]

"Mineral requirements for the continued survival of fish in both fresh and salt water include a minimum of 50 parts per million of calcium and traces of phosphorous, nitrogen, iodine, sulphur, cobalt and magnesium. Other minerals may be desirable. Of great importance, therefore, to good fish growth is the quality of water itself, which must contain the desired elements to foster the growth of all links in the vegetable and animal chain essential to desirable productivity. If these elements are not available in natural water selected for a production program, then means must be found of introducing them artificially to achieve best results."[10]

Every acre foot of water in our lakes of British Columbia contains some soluble hardness which is dissolved by water as precipitation erodes and transports the geological formations in each and every watershed. This hardness through the chain of production is the food of small salmon fish. The food which exists under an acre of lake surface, in that zone of depth which fish are able to inhabit, is the index of fertility of the area. As hardness increases and oxygen decreases with depth (Fig. 1) small fishes are unable to obtain the benefits of the majority of food which is acquired by water during erosion of the watershed. This very large storage of dissolved hardness at lower depths is a potential storage for fertilization of the upper zone which the fish occupy.

The hardness of our waters varies considerably depending on the geological formations of the watersheds and the ability of runoff water to dissolve chemical ingredients from these formations. The waters that are collected in and discharged from the Coast Range have a tendency to be slightly acid and are low in calcium hardness. As we proceed easterly in the Cascades they carry higher quantities of dissolved solids. Those waters which are collected and flow through the Rocky Mountains are relatively high in dissolved hardness and of a calcium base.

There is also a variation in water hardness (p.p.m.) due to seasonal climate especially in those streams and rivers which have no regulation of flow by lakes. These lake reservoirs tend to average out the variations in water quality between inflow and outflow water.

This then means that the lakes in the interior of British Columbia have greater capacities for rearing fish per acre foot than those in the coastal areas and probably in proportion to the dissolved solids they contain, which water plants require and are able to assimilate.

In natural conditions, adult salmon

migrate upstream, deposit their eggs, and die. In the nutriments derived from the decaying of these carcasses, the waters of the streams, rivers and lakes are fertilized prior to the removal of adult salmon by the industry at sea. In our present management of taking 80% of adults at sea and allowing 20% to escape, we are interfering with nature's method of fertilization and thereby depleting the rearing areas in their ability to produce fish in size and quantity. Regardless of how inefficient nature's method of fertilization may be, there is little doubt, that with this practice over a period of years the rearing areas will be seriously affected and we will of necessity have to artificially supply food to maintain production. Of course, this is dependent on the ability of watershed runoff to acquire dissolved hardness.

The present practice in the planting of cohoe fry in predator free lakes of western Washington, which is relative to our coastal area in fertility, is 5,000 fry to the acre of surface area,[11] without feeding. As these fish, at the migration to sea age of about one year may run about 45 to the pound, this then is a rate of planting of 111 lb. fish to the acre, and appears conservative.

As an indication of rearing capacity increase with intensive feeding such as now practised in hatchery pools, we are advised that the capacity of these pools is 22,000 lb. of fish per surface acre with intensive feeding as against 200 lb. of fish per acre in open lakes without feeding.[12] This then is the ratio of 990,000 to 9,000 fish or an increase that can be obtained by intensive feeding of 110 times. Then any feeding in our predator free lakes above that which may be necessary to maintain present fertility will increase the capabilities of the lake in producing fish.

The above capacities are predicated on predator free lakes, which prior to preparation for rearing of salmon in quantity or even in our present policy of management are heavily inhabited with predatory fish. These predators migrate from the sea, where they can be abstracted in the migration routes. Some of these predators migrate from the lakes to incoming streams to spawn and they may be removed during this migration. We may however have some species that remain in the lakes for their entire life and these will have to be removed by poisoning of the lake waters.

We then have a definite index of value, namely per acre of rearing capacity, which we are able to add to any overall watershed value for the salmon resource. There appears no other index which we can use in assessing this potential value with assurance in yearly production.

Upstream Migration

Satisfactory facilities for upstream adult migration requires the concentration of all migrating fishes in some area of water or conveyance where they can be readily sorted into species as desired. It requires sufficient controlled ponded area to be able to accept large quantities of fish in short durational migration surges, which occur in nature and average these surges over such periods as secondary conveyance requires. It requires, in these facilities assurance that excessive fish energy is not dissipated and that delays in migration are reduced to a minimum. Economy also requires that those fish extracted from the desired species be put to useful use. The ideal facilities must be satifactory for processing of all waste.

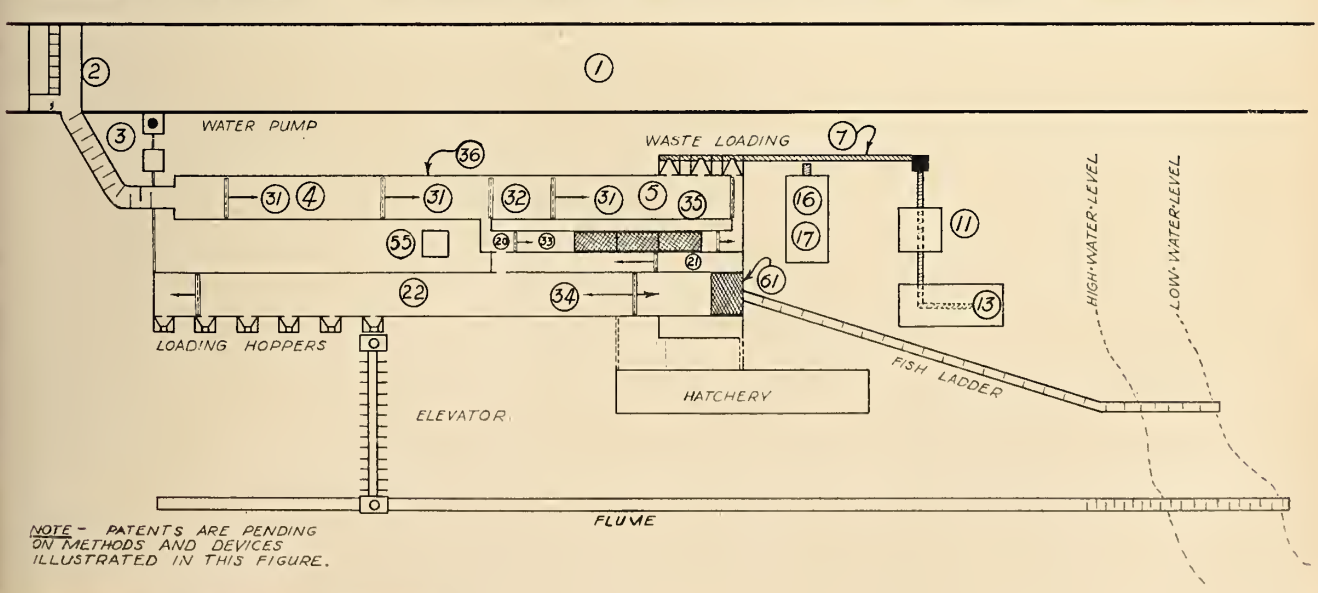
There is no difficulty in obstructing a stream or river to eliminate the passage of all migrating fish, and this must be done. Our present fish ladders are satisfactory in lifting salmon to some height in their passage over dams but they are also satisfactory in lifting predators and passing these fish over the same dams. This direct connection from tailrace to head pond, while beneficial to salmon migration is a definite detriment to the production of this specie.

However, to concentrate all fishes for sorting, it is necessary to remove them from the turbulent rivers into areas, where they may readily be controlled. Fig. 2 is a diagrammatic sketch showing a plant layout for the extraction of all predation and processing this waste flesh for useful use. The plant also levels out natural quantity migration surges to capacity of secondary transportation and allows for hatchery propagation when desired.

The process is simple. As the fish are restricted from migrating further up the river channel by a barrier, all species pass up a fish ladder to pool 4. This lift only needs to be slightly above high water of the river. Screen 32, of large mesh sufficient to retain only the salmon species desired is fixed in place. Then as pool 4 is

Patents by Val Gwyther, inventor, are pending on methods and devices illustrated in Figs. 2 and 3.

Fig. 2. Diagrammatic Layout — upstream migration plant. Predator elimination — quantity — surge control.



occupied by some fish, screen 31 is placed near the upper end of the fish ladder, to stop return of the fish to the river, and it is moved slowly towards 32. With this progressive reduction of tank volume and allowance for escapement of smaller fish, only salmon and those predators of like or larger size are retained except perhaps some smaller fish which have not escaped. A small mesh screen 31 is placed immediately upstream from 32 and the predators in pool 5 are moved to batching hoppers for delivery to conveyor where they may be sorted for market processing or reduced to fish meal or both. In the fish meal we have some fertilizer for rearing areas.

The larger fish between 31 and 32 are then allowed to escape through gate 36 as they are moved along quietly by reducing volume between 31 and 32. They move into pool 20 over trays 35 separated by vertical screens. These trays with large mesh bottoms are raised to allow only about 6 in. of water on the tray bottom, allowing sorting by inspection and removal of large predators to pool 5. The trays are then tilted, the side of tray adjacent to pool 21 dropped and those fish that pass to this pool are only the desired salmon. The trays are then lifted clear of the water and separating screens are lifted to allow screen 33 to clear the tank of all remaining smaller fishes, which have passed through the tray bottoms. The continuous operation in all tanks by batching in pool 4 is then normal operation.

The salmon are then passed to pond 22, which has large capacity for holding fish and therefore levels out the hourly migration surges of the main fish ladder and loads to secondary transportation by truck, elevator inclined or otherwise or fish ladder. The size of pool 20 is dependent on type of secondary transportation and its relative capacity to natural migration surges. All operating tanks in the circuit assist in this surge regulation.

The plant also allows for processing in hatchery propagation in part or total. In this operation pool 22, or part of it, is a ripening pool to retain the adults until such time as they are ready to spawn. They are then, as required, moved over tray 61, lifted to allow only shallow water in the tray bottom. Those ready for spawning are taken, stripped of their eggs, fertilized and placed in hatchery trays, where they are incubated to the free swimming stage. As this may take from 60 to 90 days depending on water temperature, pool 22 has no remaining adults. It is then again used for holding these tiny fish by loading to rearing areas.

This plant then allows the extraction of all predatory fishes in their routes of migration and processing this waste fish flesh to useful use. It allows for regulation to secondary transportation, whatever it may be. It allows for hatchery incubation if this is desirable and it definitely allows sorting by size even of salmon, to obtain better stock for breeding or what we generally call selective breeding. Furthermore it allows for extraction of those predators, such as trout, from rearing areas of salmon, as these fish migrate from lakes to incoming streams to spawn.

Downstream Migration

Downstream migration facilities are more difficult than those previously discussed. We must provide for collection of all fish at all stages of reservoir drawdown prior to turbines and also those migrants which may pass in free overflowing spillage. In addition satisfactory quality water for fish must be made available in the upstream reservoir and downstream river channel at all stages of reservoir drawdown to ensure no pollution of waters during fish migration.

It must be remembered that salmon in such a river as the Fraser start to migrate in early April when reservoir levels are at a minimum, and the migration continues to June, when this river is in flood. In our coastal rivers the fish migrate at about the same time of the year but are decreasing in flowage as migration proceeds.

In the passage of these migrants we must allow for natural quantity surges as in adult migration. More than six million yearlings migrated from Chilco Lake in seven hours or at an average rate of about one million per hour. The intensity at any particular time may have been much higher and mixing of other races, in the main stem of a large river may also occur. This suggests that all works for the passage of yearlings should have a capacity of many times this quantity. Assuming, then, that this rate of migration may be six million per hour over many continuous hours, and using an index of fish saturation in water of one pound of fish (45 to pound) to one U.S. gallon of water, which is the trucking index, we require about 5.3 c.f.s. of water to contain these fish, satisfactorily. Larger quantities of water in this rate of migration will of course be beneficial.

Fig. 3 shows a general layout of a hypothetical hydro electric power development which may occur on any river. The dam is shown as a large sectional area for earth or rock fill but any type of dam may be used. The free flow spillway is shown on the left with skijump profile to reduce mortality of downstream migrants to a minimum and a series of collectors for these migrants are shown on the right. All turbine waters pass through the collectors and thence to the forebay from which it may be accepted by the turbines in many ways. As this water passes through the collectors, carrying with it migrating fish, the fish are abstracted over the end of the screen and thence to the river below the dam, being earefully husbanded in the entire operation.

To ensure proper quality water at all times, a curtain wall or membrane is supplied to restrict lower water from passing to the forebay and another curtain wall is supplied to restrict upper lake waters. The opening to the forebay is then in a comparatively shallow entranee conforming with that strata of water which is satisfactory for fish. The entire collector works between the retaining piers, is buoyancy controlled and the sectional parts of the curtain wall are self-supporting, with the exception of a slight residual load. Hoist and hydraulic pins are allowed for emergency. Then only known quality water is passed through the screens for proper migration downstream. The screens are provided with adjustable cover, mechanical and hydraulic eleaning which may be automatically controlled to provide the necessary differential head for water passage through the screens between screen bay and forebay water levels. The fish are collected in a flume and passed to a fish pump, or other means, which elevates these fish in water to a flume and thence through the forebay wall, from which they are passed to the river channel by fish ladder lowerater and pipe line or other means.

Watershed Value

We are then able to control and protect from hazard the upstream and downstream migration of the salmon species. We are able to eliminate all predatory fish from the migration routes and we are able to prepare rearing areas for these fish with some fertilization above what nature annually provides in their zone of habitat. With these known facts we are able to forecast with assurance the value of salmon in a watershed and therefore with power and other resources, the watershed value for optimum development.

What then is the value of a watershed jointly developed for fish and power? As an example let us take the Clearwater watershed which is a tributary of the North Thompson River, whose waters pass via the Thompson and Fraser Rivers to the sea.

The Fraser River Board[13] advises that the total annual value of this watershed to hydroelectric power is $33,401,000 of which $3,093,000 is applicable to downstream benefits in power. There are other benefits such as flood control, navigation and agriculture which I do not intend to go into at this time.

The salmon species has not been able to inhabit this extensive rearing area due to physical obstructions in the river channel. However it appears some steelhead may use at least part of the watershed for propagation. The value of this watershed to the salmon resource, in our present thinking is zero, neglecting the steelhead which are predators.

With our present incorrect approach to the potential fish value in the Clearwater we can then discard this watershed as a producer of fish and it can be used as a single purpose watershed for the development of power only. How false this statement must be!

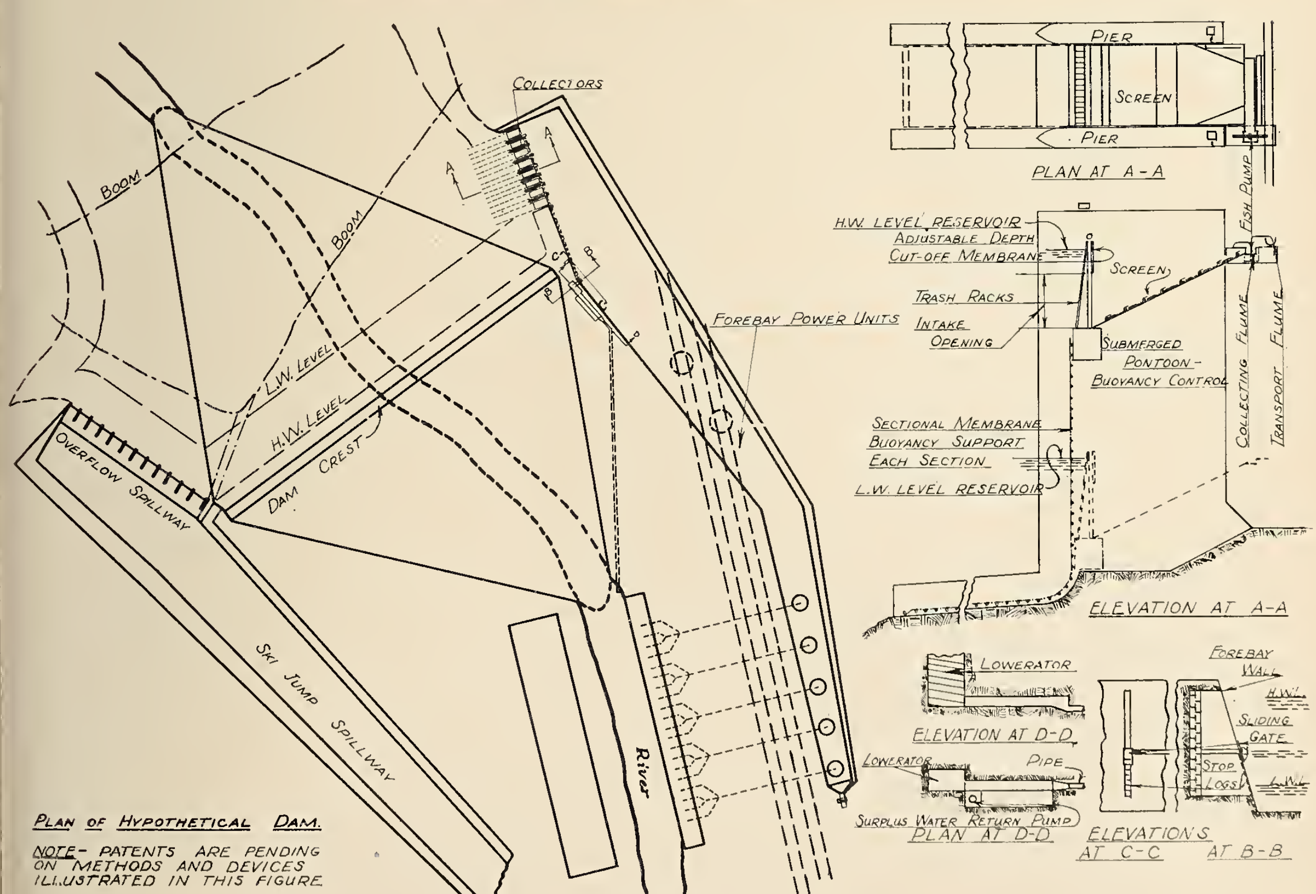
Races of salmon appear to thrive more abundantly in physical conditions common to their native habitat. As there are at present no salmon in the Clearwater area, it will be necessary to plant this race from other areas where physical conditions are somewhat similar. The major portion of the Clearwater Lake areas lie between 2,000 and 2,700 ft. in elevation while Myrtle Lake lies at an elevation of about 4,000 ft. It will certainly be desirable to plant only one race of fish in the Clearwater area for proper management and some difficulties may be encountered with this race in rearing in the higher elevation of Myrtle Lake. However it is assumed that one race can be planted in the total 70,000 acres of the lakes in the Clearwater watershed.

This watershed lies in the interior of British Columbia where the hardness of lake waters is probably higher than in Coastal areas. The potential rearing capacity of Coastal lakes is 9,000 per acre. This figure on first appearance appears high but when broken down, it shows that each fish is supplied with the production of plankton from 4.8 cu. ft. of water for every foot of depth of reservoir it is able to inhabit.

To be very conservative, let us then assume that the fertility of the Clearwater lakes, without feeding, is sufficient to support 3,000 reared yearlings per surface acre. Then with 70,000 acres we will produce a yearly migration to the sea of 210 million small fish. With a mortality of 20% in hatcheries and the predator free rearing areas we require 262 million eggs. Also with 10% survival in the sea life of these fishes, we will obtain a return of 21 million adult salmon each and every year, for production and escapement to perpetuate the species.

The female sockeye of the Cultus Lake race varies in egg content of about 4,500 in most years, but only about 3,800 was recorded in 1933.[14] Assuming then, that a female salmon will produce an average of 4,000 eggs, at hatchery, the number of adult females required is 65,500. While the sperm from one male is sufficient to fertilize the eggs of many females at hatchery, it does not appear possible at this remote distance from the sea, to segregate the males at some downstream point and we

Fig. 3. Layout and details — downstream migration works (Hypothetical dam).



must therefore allow natural migration, which may be in equal number of males and females. Then with allowances of 25% for losses during migration, it will be necessary to protect in all facilities in the entire migration route from sea to hatchery diversion at least 163,750 adult sockeye salmon.

The net yield to the fishery at the sea is then 20,832,250 adults yearly from the Clearwater or at 7 lb. per fish is about 145 million pounds of sockeye salmon fish flesh yearly, which can readily be assessed in primary wholesale value of raw fish flesh.

However, there are some problems in upstream migration. In a watershed such as the Fraser, upstream migration occurs from June to November, but the migration of any race such as the Clearwater will take place in much lesser time. While this migration will be over a month or so, the majority of fish will migrate over a few days and in high surges over a few hours. In the Lower Fraser from Yale to the confluence of the Thompson and in the Thompson from this point to Kamloops Lake, we may at some time in the future, have multiple dams in these two 60-mile reaches of the rivers. Assuming we collect the adult requirements of the Clearwater at Yale and transport by mechanical transport to the upper reservoir on the Lower Fraser and again collect these fish at the lower dam on the Thompson and transport to Kamloops Lake, what is the extent of this transport?

With an adult fish weighing 7 lb. and the index of water requirements at 1 U.S. gal. per pound of fish, we must transport a load of 65.5 lb. for each fish or a yearly load of 5,425 tons in each reach. If this migration occurs over 15 days, the average load per 24 hours is 362 tons. Trucks will make this return trip, 60 miles, in less than 4 hours or 6 trips per day. We then require four 15-ton water conditioning trailers with motive power, in each reach of these rivers. Perhaps for emergencies double this quantity is advisable.

In transport of fry from hatcheries to rearing areas this same transport is satisfactory but capacities are much less. The Clearwater requires planting of incubation from 262 million eggs. Neglecting hatchery loss and assuming the fry weigh 2,000 per lb., we then require transport for about 500 tons per year which one of these trailers can readily handle.

It must be appreciated that motive transport may not be necessary for fish passage, over high dams such as Moran. The fish can be passed to elevators and thence to flume for passage to reservoir. The actual loss in migration time in either of these transportation systems and the dissipation of fish energy can be much less than the time which is now being consumed in natural migration as this rate of passage appears to be from 20 to 30 miles per day, and may not vary, with water velocities encountered.

Economy

The value of raw sockeye fish flesh at boat has greatly increased in price in the past few years. In 1959 this price was 30 cents per lb. and in 1960 the price per lb. was 33 cents. It is doubtful if large quantity sales of end product, in regular yearly markets can be maintained at this price level. It may, then, be beneficial to the industry to purchase raw fish at a much reduced price, with large quantity production. Assuming then that the price at boat is 15 cents a pound for all sockeye fish developed from the Clearwater area, where none exists at present, the yearly value received by fishermen for raw fish harvested at boat is $21,874,000.

We can, then, conservatively assess the salmon resource value of the Clearwater watershed at a yearly value of about $22 million which when combined with the related primary wholesale value of hydro electric power ($30 million) indicates a total watershed value in these two resources of $52 million yearly.

In past experience, in hydroelectric power developments where it has been necessary, to maintain the present populations of the salmon species, the cost of power development has been increased to provide facilities for this purpose. These additional costs appear to be in the ratio of from 5 to 10% of power development cost and have been higher in smaller projects. With proper facilities for production of salmon in quantity it appears that these additional expenditures may not be much greater than past experience, even though such additional work as hatcheries and preparation of rearing areas are necessary. Then with an additional expense of perhaps 10 to 20% we may greatly increase the value of the watershed.

Conclusions

There is no doubt we can now produce the salmon species in great quantities, jointly with other resource values and with economy. We are now able to protect the upstream and downstream migrating fish in their routes of migration. We are able to extract migrating predators in these routes of migration, thereby eliminating these species. We are able to eliminate predation from rearing areas and we are able to control discharge from reservoirs to ensure satisfactory water quality for migration of both upstream and downstream migrants of the salmon species.

The rearing capacity of our natural and impounded lakes is greatly in excess of the yield by incubation from natural spawning grounds. Incubation of eggs must be provided in such quantities as are necessary for the rearing capacity of the lakes and such increases in the rearing capacities as we may wish and are able to make, in time to come.

The present policy of retardation of power developments in a watershed, due to our inability to produce the answer to beneficial fish migration is in the past and these watersheds are now open to development of both fish and power.

As each and every drop of water and flake of snow falls in a watershed and is collected in storage reservoirs for regulation at sites where height of fall is available, we obtain the benefits of hydro electric power. This same drop of water and flake of snow as it erodes the geological formations of the watershed accepts chemical hardness and transports this hardness to the same storage reservoirs as the food for fishes. Then, in the development of the numerous drops of water and flakes of snow we obtain the associated development of fish and power, or we obtain, optimum watershed resource value.

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WEAKNESSES OF THE THEORY OF PLASTIC DESIGN

A. Hrennikoff, M.E.I.C.,
Professor of Civil Engineering,
University of British Columbia, Vancouver

Advocates of the plastic theory argue its superiority to the elastic theory in simplicity of design, more realistic factor of safety and better economy. The author says, that with some qualifications, the assertion may be conceded in applications on simple types of structures if instability is not involved.

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THE Theory of Plastic Design of steel structures has been occupying the foremost place in structural engineering literature in the last 10 years. The great majority of authors praised the theory highly, seeing in it a new departure destined to supersede the conventional elastic theory. As time went on, national engineering societies like the American Society of Civil Engineers, the American Institute of Steel Construction and the Welding Research Council, took steps to sponsor the plastic theory further and make it available for practical design. At the same time, some dissenting voices became heard, disagreeing with the majority and pointing to the weaknesses of the theory. The author of this paper was one of the dissenters who took part in the discussion of the recently published paper by the foremost authority on the theory, Professor J. F. Baker.[1] The author will attempt to develop his thoughts on the subject more fully in the present paper. His principal sources of information on the plastic theory, apart from the paper just mentioned, are the book by Professor Baker[2] and The Commentary on Plastic Design in Steel.[3]

General Plastic Theory vs. Rigid Plastic Theory

The basic principles of the plastic theory may be presented in the following manner. A statically indeterminate frame is acted upon by a number of loads increasing gradually in intensity while keeping a constant ratio among themselves. With progress of loading several sections of the structure reach, one after the other, the limits of their carrying capacities at the level of yield stress, forming what is known as plastic hinges. When the number of the latter becomes one greater than the number of static unknowns (and sometimes at a smaller number) the structure becomes a mechanism and begins to deflect catastrophically with no further increase in load. This is the failure condition and the load intensity corresponding to it is the failure load. The ratio of the failure load to the working load is the load factor or the true factor of safety.

Determination of the value of failure load as outlined here is very simple and may be carried out by statics alone, in spite of the possible high indeterminacy of the structure in the elastic range. However, the situation is not quite as simple as presented, because the solution in this form makes no allowance for the all-important matter of instability of the members. Before the structure develops the mechanism condition characterized by several plastic hinges, or even before the formation of the first hinge, it is liable to fail by the buckling of some of its members. It is here that the principal difficulties of the plastic theory lie.

Instability of Members in the Elastic and Plastic Theories

Problems of instability are very complex even in the elastic range. Solutions have been found only in simplest cases involving single members with well defined loads and conditions of restraint. Mathematical difficulties become great when several interconnected members assist each other before failure. In the plastic theory the situation is even more complicated. The loads used in the plastic theory exceed the working loads, employed in the elastic design, by the load factor normally as great as 1.75. Since the structure should be barely above the failure level under the action of the factored loads and since the failure is partly determined by the formation of plastic hinges, the instability of the members becomes transferred into the plastic range with virtually insuperable mathematical difficulties.

A complete review of the stability derivations used in the plastic theory is out of the question here because of their highly technical nature and complexity, but a discussion of their broader aspects is desirable because it will serve to demonstrate the methods and the degree of exactitude of these derivations.

Plastic Instability of Beams by Professor Baker

Professor Baker analyzes in his book, among other subjects, the stability of an I-beam bent about its strong axis by a constant moment.[4] With some explanations Professor Baker sets up a number of very complicated equations, then leaves them in an unfinished form, asserting that they represent one case out of four which have to be considered. Further on, a formula for the critical length is stated (without derivation) purporting to be a sufficiently close approximation derived from the unfinished equations. Later, a different formula for the critical slenderness ratio in relation to the minor axis is stated without making clear whether or not it is derived by further approximations of the previous formula.

Buckling of a simply supported beam, loaded with a concentrated load at the centre, merits only six lines of text and no formula.

Two theoretical aspects of the subject make the writer even more dubious of these manipulations:

a) Professor Baker's analysis is based on von Karman's theory of inelastic buckling which, by a pretty general concensus of opinion, has been superseded by Shanley's theory. Von Karman visualizes buckling as commencing suddenly from a condition of unstable equilibrium, so that one side of the beam compresses further while the other side undergoes a rebound. According to Shanley, buckling is a gradual development of deformations arising from minute irregularities of shape with no rebound. Shanley's theory, being the more conservative of the two, would make Professor Baker's derivations unsafe.

b) The research conducted by the Lehigh University team[5] demonstrated that rolled sections always carry high residual stresses produced by rolling operations. At the edges of flanges, these stresses are compressive and their intensity is as high as 30% of the yield stress. These stresses are ignored by Professor Baker. While in the elastic design these stresses are normally of no consequence, they become vital under the conditions of plastic buckling.

Plastic Instability of Beams in the Commentary

In the Commentary[6] the problem of instability of a beam is approached through the differential equation applied to a beam which is bent about its strong axis by unequal end moments, at least one of which projects beyond the elastic range. The aim of the theory is the derivation of an expression for the unsupported length in buckling about the weak axis.

In setting up the equation which would allow for co-existence of the elastic and inelastic states of stress, two questionable assumptions are made:

a) The material of the beam passes through the plastic or yielding stage in such a way that each element deforms all by itself, suddenly, the full width of the plastic range before the other elements follow suit. This is alleged to signify that all material must necessarily be either in the elastic or in the strain hardening range, both of which are endowed with definite moduli of elasticity. The writer accepts the premise but does not agree with the conclusion. The stress at the beginning of strain hardening is always lower than the upper yield point terminating the elastic range. To the author, this signifies that when the strain extends beyond the upper yield point the elastic stage is passed and the individual elements of the material must necessarily be either in the strain hardening or in the plastic ranges, the latter characterized by the zero value of the modulus of elasticity, making the beam more unstable than what is implied in the derivation.

b) The material of the beam is idealized in such a way that all elements in each cross-section are present only in one state of stress, either the elastic or strain hardening. This assumption contradicts the generally recognized view that the unit strains in a beam are distributed linearly over the cross-section, forcing the stresses into different stress ranges. It also disagrees with the presentation accepted by the proponents of plastic design, on the manner of distribution of plastic stress over the cross-section in the process of formation of plastic hinges.

These two assumptions are unrealistic and unsafe but they are needed by the authors of the Commentary for the solution of the differential equation which, without them, could not be integrated.

Difficulties and uncertainties of the derivation are not limited to these two assumptions. Many others are found on practically every page of this particular chapter. Here are some of them:

i) The authority for the theory is

contained in a student's thesis presented at Lehigh University in 1956 but still unpublished. It is felt that an authorization of this kind is scarcely sufficient.

ii) The solution of the differential equation in conditions of constant moment for a beam with simply supported ends is claimed to result in the following simple expression for the critical value of the slenderness ratio

$$\frac{L_{cr}}{r_y} = 18 \qquad (1)$$

The constant moment used in the derivation of this equation seems to have been assumed of the fully plastic intensity. In contradiction to this formula, the unsupported length under the same conditions, according to Professor Baker's theory discussed earlier, is zero.

Derived under the assumptions discussed here, Equation (1) appears to the author as nothing more than an empirical formula, but can this formula be justified experimentally? For most standard I-beams the minor radius of gyration equals approximately 1/5 or 1/4.5 of the width of the flange b. Then Eq. (1) expressed in terms of b becomes approximately

$$\frac{L_{cr}}{b} = 3.5 \text{ or } 4.$$

The writer does not see how a test for stability of a beam of such short length, under a fully plastic moment about the strong axis, could be rigged up without creating unintentional restraints.

iii) In the general case of unequal end moments Eq. (1) is superseded by a much more complicated equation in which the coefficient 18 on the right hand side is multiplied by a string of coefficients correcting the expression for a number of factors, such as the moment variation and the end fixity, some of these factors being interrelated in a complicated manner. The new expression seems to be purely empirical. By a number of assumptions and simplifications, which seem quite arbitrary, a simple and allegedly conservative expression for the critical slenderness ratio is derived in terms only of the ratio of the end moments. Confusing and unexplained manipulations of complicated expressions, which in the end result in a simple formula, inspire no confidence in the reader.

iv) The application of the theory is illustrated on several examples. In Example 1, when solving the problem by method one, the critical unsupported length comes out 46.6 in., which is satisfactory under the conditions of the problem. Solving the same problem by a different method, in a more refined manner, the critical unsupported length is found to be 112.5 in. A question arises: what should one think of the first method if it underestimates the critical length two and a half times?

In Example 2, girts are placed every 5 ft. on the tension (outer) flange of a rigid frame. The stability of the frame is analyzed, assuming its members to be fully restrained at the girts. The author refuses to accept the view that a girt placed on the tension flange constitutes an adeqate restraint of the compression flange of a beam against buckling.

Column Theory of Professor Baker

The analysis and design of columns in the elastic range is complicated but possible. It requires some trial and error procedure involving moment distribution, stress analysis and occasionally investigation of elastic instability. In the plastic theory the difficulties are magnified out of all proportion. Professor Baker and his team made an excellent study of the conditions under which columns fail by buckling in the plastic range. Three kinds of conditions on the ends of the columns are distinguished:

Plastic: if the ends of the members framing into the column have developed plastic hinges before the column; or if the column itself has developed a plastic hinge on one end before becoming unstable. In this condition the magnitude of the end moment in the column is fixed ir-

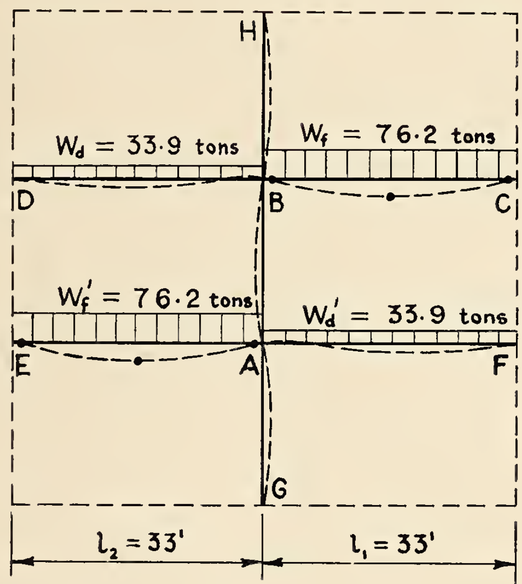

FIG. 1

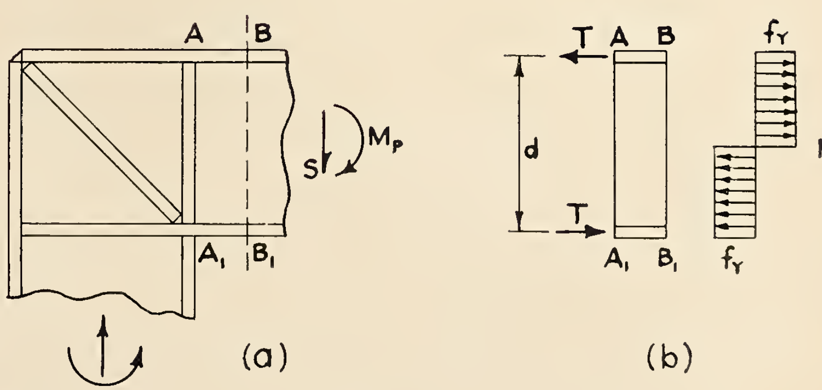

FIG. 2

respective of its angle deformation.

Elastic: if plastic hinges in the ends of the adjoining members have not yet developed by the time the column approaches failure. The column end moments under these conditions would vary depending on its angle deformation.

Zero moment condition: if the adjoining members are in effect hinged to the column.

These three conditions, designated P, E and O, may develop both with regard to bending about the major principal axis X and the minor axis Y. Assuming the same type of loading conditions as, for example, P_xO_y, on both ends of the column, nine distinct loading cases are identified. A great amount of thought and effort has gone into the study of these cases. For most of them design solutions have been attained, although the writer has questioned some aspects of these solutions.[7] Two or three cases had been adjudged by Professor Baker as intractable.

The difficulty with these solutions is not only that they are quite complicated but also that their form is different from case to case: sometimes the solution presents itself as a stress calculated by a certain formula and then compared with some other formula or graph; sometimes it appears as a slenderness ratio or an unsupported length. Different approaches are thus required in different cases.

The available solutions of the column problems discussed here are the design solutions leading to determination of the sizes of members. As to the analysis solutions or check designs required to determine the failure intensity of loads for a structure already designed, i.e., a structure with known sizes of members—such solutions seem to be unavailable. While in the course of designing columns by plastic theory the engineer is justified in assuming the same loading cases on both ends of the column and thus wrestling with only nine different cases; in the problem of analysis, the conditions on the two ends may be different, giving rise to 45 distinct cases of loading, not counting subcases. Whether 45 or nine cases, the problem confronting the designer is staggering in its complexity.

As if all these difficulties were not enough, the presentation of the subject is by no means lucid and the author does not see how Professor Baker's book could be of much practical help in a designing office.

Column Theory in the Commentary

The authors of the Commentary approach the column problem in a much more restricted manner than Professor Baker. The column is assumed to be bent only about its strong axis and fully restrained against buckling about the minor axis. The solution in the form of interaction curves between the maximum moment and the maximum thrust for different values of slenderness ratio seems rigourous but restricted in the following respects:

a) It is admitted that the maximum predicted strength may not be fully realized if the slenderness ratio for buckling about the minor axes is excessive. It is suggested that the unsupported length be checked by the theory of buckling of beams discussed earlier. The author questions this suggestion not only because the beam theory appears to him unreliable, but also because he feels that a member like a column containing more than half a section under compression should require closer spacing of restraints than a beam containing only half a section under compression.

b) The rotation capacity required to be developed on the end of the column in order to create a plastic hinge may be inadequate. A theory for the analysis of this type of column action is not yet available.

c) The theory is developed for two types of moment loading only: a constant moment over the whole length or a moment varying in a straight line from zero at one end to a maximum at the other.

Effect of Creep

The formulae of plastic theory are supported, although not always conclusively, by a long array of experimental evidence. The writer is not in a position to go effectively into the interpretation of the test results which often depend on the details of the procedure and apparatus, but he wishes to refer to one particular aspect which has been left unmentioned in the description of the tests and received no recognition in the derivations of the formulae. It is the question of creep.

Creep is a deformation developing with time. It is negligible in the elastic range and need not be considered in the elastic design. It is, however, large and significant beyond the elastic range. Yielding may be presented as a manifestation of creep. The stress following the drop from the upper yield point adjusts itself in such a way that the rate of creep equals the speed of the testing machine. If the machine is slowed the stress decreases in order to reduce the rate of creep. Thus the lower yield point stress is variable depending, not only on factors related to the crystalline structure of the metal, but also on the speed of the testing machine. If a member strained beyond the upper yield point is kept under a constant strain, its stress decreases on account of creep. The curves of the moment vs. the angle change given in the Commentary actually depend on time or the speed of testing: the longer the time the greater the angle change for a given moment.

Buckling in the plastic range is likely to be strongly affected by creep. In highly stressed members the effects of curvature and shape irregularities will in time be magnified by creep and will lead to a premature failure. Thus it is vital that creep should be recognized in the plastic theory, and allowance be made for it in the buckling formulae. Once the stress conditions are extended into the plastic range all the consequences of this action must be accepted by the plastic theory, including creep as a part of the new environment.

Frame Instability

When approaching the failure condition characterized by the development of an appropriate number of plastic hinges the frame may become deformed so significantly that its geometry will be altered and it will fail prematurely, unless it is stabilized by bracing or by an attachment to a rigid structure. The structure may also collapse by instability as a unit rather than piecemeal through its individual members. No workable methods have yet been devised for investigation of these types of failure.

Plastic Design and Plastic Analysis

Most methods of structural engineering may be used both for analysis and design. The rigid plastic method is no exception in this respect, and both these aspects of the rigid plastic theory are equally treated in the literature. On the other hand, the non-rigid plastic theory deals only with design and not analysis. In answering the criticism on this point, Professor Baker intimates that this peculiarity of the theory cannot be viewed as a defect because the primary concern of the engineer is the design and not the analysis. The writer disagrees with this contention. To him a method that cannot be used for analysis resembles a collection of empirical rules, which the plastic method largely is, as has been presented earlier. The inability of the plastic method to make possible the determination of the intensity of the failure load, after the sections of the members have been established, may lead under certain conditions to underdesign of the structure.

Underdesign of Structure due to Overdesign of Members

In view of a limited choice of structural shapes, sections exactly equal to the ones required by calculation are usually unavailable and the members are, as a rule, overdedesigned of necessity. In the elastic design, if the members are made stronger than needed the whole structurse becomes stronger, but this is not necessarily so in the plastic design. To demonstrate this proposition, borrow an example from Professor Baker's paper:

Fig. 1 represents a part of the frame of the Cambridge University Extension. The four beams BD, BC, EA and AF are designed first, for which purpose they are loaded with full factored loads. This makes them form partial mechanisms with plastic hinges at both their ends and at the centre.

The loading condition assumed for the design of the colmun AB is such as to bend it into a single curvature with the greatest possible end moments. Accordingly, full factored loads W_f and W_f^1 are placed on the spans BC and AE, while factored dead loads W_d and W_d^1 act on the spans DB and FA. The joint moments at B and A are computed as the differences of the beam moments, plastic on one side and elastic on the other. Thus,

$$M_B = \frac{W_f l_1}{16} - \frac{W_d l_2}{12} \qquad (2)$$

After estimating in advance the stiffnesses of the column members, the unbalanced moment M_B is distributed between the three members BD, BA and BH, using ordinary elastic distribution factors. The beam BC, transformed into a mechanism naturally does not participate in this distribution. Following a similar procedure at the joint A, the column section AB is designed by the rules of plastic method on the basis of its axial load and end moments. This is the normal procedure recommended by Professor Baker for the design of columns.

Suppose now, that the actual section chosen for the beam BC happens to be substantially greater than what is required by calculation, while the other members, including the column AB, are chosen without much excess. Then the beam BC, loaded by the load W_f, will not be in the state of a mechanism, but its end moment may very well be plastic. With the beam BC overdesigned, its plastic moment is greater than $W_f L_1/16$. This makes the unbalanced moment M_B greater than its value in Eq. (2). The actual column end moment must then exceed its expected share, and the column must fail prematurely by lateral buckling, unless, of course, it is fully restrained against this action.

Thus the following situation arises, peculiar to the plastic theory: an overdesigned beam may make the structure fail prematurely unless the adjacent members are overdesigned comparably. Had a method of plastic analysis been available, the uncertainty created by the condition of partial overdesign could have been cleared, but unfortunately this way out of the difficulty is not open.

Loading Conditions

When designing a structure either elastically or plastically the live loads must be placed in the most unfavourable positions which, as a rule, are different for different members. In the elastic design a previous loading condition does not affect a new load placement, but in the plastic design it carries with it the residual moments, left from a previous loading. Under certain conditions, the residual moments may handicap some members severely giving rise to one of the most serious weaknesses of the plastic theory. This point may be illustrated on the example of Fig. 1 representing, as explained in the previous chapter, the critical loading condition recommended by Professor Baker for the design of the column AB.

A much more dangerous loading condition for the same column arises, however, if the beams BD and AF, carrying the dead loads alone, had been plasticized by a previous application of full factored loads, followed by a removal of the live load parts. The elastic recovery corresponding to this method of loading happens to bring with it a much more unfavourable condition than the one visualized by Professor Baker.

By Professor Baker's assumption (Eq. 2) the unbalanced moment of B is:

$$M_B = \frac{W_f l_1}{16} - \frac{W_d l_2}{12} = \frac{76.2(33)}{16}(12) - \frac{33.9(33)}{12}(12)$$

$$= 1885 - 1119 = 766 \text{ ton-inches.}$$

By the author's suggestion, the full loads in both spans result in zero unbalanced moment at B. The removal of the factored live load

$$W_L = 76.2 - 33.9 = 42.3 \text{ tons}$$

from the span BD is fully elastic and it results in the following unbalanced moment at B:

$$M_B^1 = \frac{42.3(33)}{12} 12 = 1395 \text{ ton-inches.}$$

The unbalanced joint moment and with it the design moment in the column, following the author's suggestion, thus exceeds the value found by Professor Baker by 82%, which means that Professor Baker's column, in the writer's view, has been grossly underdesigned.

It may be noticed that the unbalanced joint moment at B, determined according to the author's suggestion, corresponds to the elastic one-sided application of the factored live load, which is exactly the same loading condition as the one used in the elastic design, although in the latter the loads are employed, of course, at the working rather than the failure level. This, however, does not mean that the plastic design, in accordance with the author's suggestion, would be on a par with the elastic design. The unbalanced joint moment in the plastic design is distributed only between the three members at the joint which still remain elastic, while in the elastic design all four members participate in the distribution. Therefore, the column end moments in the suggested plastic design would be relatively much greater than in the elastic design, thus penalizing these members substantially. The penalty would be the greater the bigger the sections of beams in comparison with columns.

When this point was first brought to Professor Baker's attention, he met it with an argument, the gist of which was something like this: if the working load is multiplied by a load factor a degree of overload is tacitly assumed, whose probability of a single application is small, but not unreasonably so, and therefore the design should properly provide for it. However, the probability of a multiple, or even a double application of the same factored load, would equal the power of the probability of a single application. For this reason it would diminish to vanishing point and be quite unnecessary to provide for in the design.

The author strongly disagrees with this opinion. In the manner of loading which he suggests, no second application of the load at failure level is postulated, but rather the removal of the live load applied the first time. The high level live load cannot be expected to remain forever and is bound to be removed some time. The probability of this removal is 100%, which makes the probability of the condition assumed by the author virtually the same as the one assumed by Professor Baker.

To clarify this important point, analyze more closely both the load application and the load removal. It is certainly legitimate to assume several beams, located on the same floor in one straight line, to be loaded simultaneously with full factored loads. The live load parts of these loads must in time be removed. The question arises: is it legitimate to assume these loads to be removed only from some beams while still remaining on others, or should all loads be removed simultaneously? The last alternative is clearly arbitrary and unreasonable. It is also unrealistic. When an audience leaves an over-crowded public hall, some beams still remain heavily loaded while others are already relieved following a heavy loading. But this is exactly the situation visualized by the writer in his proposal for the most unfavourable design condition with regard to the columns.

By way of contrast, compare these loading conditions with the ones used in the elastic design. Here the most severe load arrangement is used for every member without regard for the probabilities of such loading and without any qualifications concerning previous loadings and unloadings.

It may be argued that a single application of the factored loads in the most unfavourable position, with no contemplation of a previous or subsequent removal, is the basic rule of the plastic theory. The answer to this is that such a rule would be specially made in favour of the plastic theory. When the plastic theory results in the economy of beams, due to their plastification, this is publicized as the advantage of the theory; but when the same plastification is found unfavourable to the columns, a special rule of no previous load removal is devised in order to avoid the penalty of the uneconomical design of columns.

The purpose of the factor of safety or the load factor is not altogether determined by the possibility of overloading alone, but also by the necessity of allowing for the deficiencies of the theory and of the members themselves, both with regard to size and quality of material. After what has been said, it is safe to conclude that the first factor certainly does not work in favour of the plastic design. As to the possible influence of the physical deficiencies of the members, there is nothing to choose between the two methods.

Connections

The plastic theory requires the use of special methods for the design of connections. These methods are fully described in the Commentary.[8] The author, however, is baffled by the first assumption on which the connection design is based: namely, that the web carries all the shear and the flanges carry all the normal stresses in the beam at the point of its attachment, even when the design moment equals the full plastic value M_p. The part of the assumption dealing with the disposition of the shear raises no objections, and the contention that the presence of shear makes only a negligible effect on the maximum value of the plastic moment carried by the beam is also accepted,[9] but the relegation of normal force and moment to the flanges alone appears totally unjustified.

In the knee connection shown in Fig. 2, with no normal load in the beam, the flange stresses T in the section AA, are found in accordance with the above rule as follows:

$$T = \frac{M_p}{d}$$

This expression for T implies the existence of the unit stress in the flange some 15-20% greater than the yield stress, necessary to make up for the plastic stress in the web. Such stress is impossible without a deep extension into the strain hardening range. It is felt that without an additional reinforcement of flanges in the vicinity of AA, the connection is not likely to work in the assumed manner: the web will carry some tributory normal stresses and the diagonal stiffeners, as well as their welds, will be overstressed.

Advantages vs. Disadvantages of the Plastic Theory

It is asserted by the advocates of the plastic theory that it is superior to the elastic theory in the following respects:

a) Simplicity of design;
b) More realistic factor of safety;
c) Better economy.

With some qualifications these assertions may be conceded in application to simple structures when instability is not involved. If, however, buckling is impending, and this normally seems to be the case, the claims are not justified. Not only the application of the theory is then very complex, but the factor of safety becomes uncertain in view of the impossibility of applying the theory to the analysis of a structure already designed. Furthermore, loading conditions, arbitrarily prescribed and seemingly devised to underline the alleged economy of the theory, make the factor of safety, as used in the design, fictitious. Economy under these circumstances is problematical.

Most weaknesses of the non-rigid plastic theory stem from its very nature. It is the fact that the plastic theory deals with failure loads rather than working loads that leads straight into the complicated inelastic buckling problems. To solve these, complex and questionable derivations have been devised. It was a dilemma, either to find solutions, no matter how vulnerable they might be, or to discard the already developed rigid plastic theory — a fine product of many years of successful research, but unfortunately not complete in itself. It is no reflection on the efforts of those concerned that the theory got out of hand as the problems proved to be unmanageably complex. Despite an excellent original promise, the theory has not lived up to its expectations.

The opinions expressed here differ sharply from the majority of authors of papers on the plastic theory. Some 10 years ago, when the writer first organized a graduate course in plastic design, he, too, thought differently, being impressed by the logie and rigour of the rigid plastic theory. Later, however, doubts crept in, which he was not able to dispel, and so the growing realization of the weaknesses of the theory has built up gradually his present negative attitude.

Much of what has been said is fully realized by the advocates of the theory. Professor Baker, in the paper referred to earlier, admits what he describes as "many sweeping generalizations to which exception can be taken." The writer of the present paper has endeavoured to formulate some of these exceptions so that they could be discussed, and either accepted or rejected, item by item.

1. **The Plastic Method of Designing Steel Structures,** J. F. Baker, Journal of the Structural Division of the American Society of Civil Engineers, April, 1959, Discussions: September, 1959 and June, 1960.
2. **The Steel Skeleton,** by J. F. Baker, M. R. Horne & J. Heyman, Cambridge, University Press.
3. Journal of the Engineering Mechanics Division of the American Society of Civil Engineers, July & October, 1959. January & April, 1960.
4. See Ref. 2, p. 236.
5. The Commentary, Journal of the Engineering Mechanics Division of ASCE, January, 1960, p. 132.
6. The Commentary, Journal of the Engineering Mechanics Division of ASCE, October, 1959.
7. See Ref. 1, September 1959.
8. See Ref. 3, April 1960.
9. See Ref. 3, October 1959, p. 143.

MARINE WASTE DISPOSAL

Erman A. Pearson,
Professor of Sanitary Engineering,
University of California, Berkeley

Studies of physical, chemical and biological characteristics as well as the waste asssimilating capacity of the receiving water are necessary to locate properly terminal facilities, to estimate performance and to design the dispersion system.

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AN OUTFALL dispersal system is an integral part of any waste treatment facility discharging into the marine environment. Design of the treatment facility as well as the submarine outfall installation is dependent upon the beneficial uses of the receiving water, the corresponding water quality criteria deemed necessary to protect the water use, and the waste assimilating characteristics of the receiving waters.

The economic and technical factors related to the design and performance of waste treatment installations are familiar to most sanitary engineers. However, the quantitative resolution of the waste assimilating or dispersal characteristics of receiving waters is not well understood generally, and the problem is even more complex when dealing with coastal or estuarine waters. The principal reason for the complexity in the marine environment is that the waste assimilating or dispersal characteristics depend upon numerous physical oceanographic factors such as wind, wave, swell, wind and littoral currents, tides, variable water mass circulation systems, density gradients and upwelling, in addition to the conventional physical, chemical and biological characteristics common to the aquatic environment.

The obvious function of a marine waste disposal installation is to convey a waste, treated to a suitable degree, to a point of final disposal where the effect of the waste on the receiving water is minimal even at the point of initial mixing as well as in the general area. While it may be desirable on a theoretical basis to treat a waste to a degree that even in the outfall pipe or in the area of initial mixing at the diffuser the waste has no significant effect on the receiving water, this may be unattainable from a technical viewpoint and is generally economically prohibitive. The point of final discharge must be selected on the basis of overall suitability for rapid and thorough initial mixing of the waste with the receiving water and to prevent the occurrence of excessive concentrations of waste in the critical area as a result of the subsequent transport and dispersion of the waste-sea water mixture.

TABLE I

Factors to be Evaluated in Design of Marine Waste Dispersion Systems

I. Beneficial Uses

1. Water contact sports
2. Marine recreation, boating
3. Marine working environment
4. Fishery, propagation, migration etc.
5. Economic fishery, propagation, harvesting
6. Industrial commercial use, coding, etc.
7. Waste disposal
8. Other

II. Water Quality Criteria to Protect Beneficial Uses

1. Public Health
   (a) coliform
   (b) other
2. Fishery
   (a) toxic substances
   (b) antagonistic substances
   (c) oxygen depressents
   (d) stimulants, fertilizers
   (e) transparency, turbidity
   (f) suspended and settleable debris
3. Nuisance
   (a) grease and oil films
   (b) floating debris
   (c) settleable debris
   (d) odors
4. Aesthetic
   (a) sleek areas
   (b) colors
   (c) turbidity—transparency
   (d) floating debris
   (e) plankton bloom
   (f) other
5. Economic and other

III. Oceanographic Characteristics of Outfall Sites

1. General water circulation system
2. Current
   (a) surface and subsurface
   (b) strength and direction as a function of time
   (c) effect of wind, wave, tide, littoral drift
3. Eddy diffusivity or dispersion characteristics
4. Density structure, salinity-temp-depth relationship
5. Wave and swell effects
6. Submarine topography
7. Submarine geology

IV. Waste Dispersion Considerations

1. Initial mixing—diffuser
   (a) Jet mixing
   (b) Buoyancy—gravitational mixing
   (c) Density gradients—thermoclines
   (d) Diffuser orientation
   (e) Waste dilution—flow continuity
   (f) Port selection, area—spacing
2. Waste transport—dispersion
   (a) Current regiment
   (b) Eddy diffusion
   (c) Mixing depth, effective
   (d) Rational dispersion equations
      (1) Concentration dilution only—conservative waste
      (2) Concentration including decay—nonconservative waste, i.e. bacteria radioisotopes, BOD etc.

V. Economic Analyses

1. Various types of treatment and effluent characteristics.
2. Length, depth and cost of outfall systems for each type effluent to meet water quality criteria requirements.
3. Selection of optimum and least cost combination of treatment and outfall system to protect beneficial uses.

Design Considerations

The rational design of a marine waste disposal system entails consideration of a multiplicity of factors. Table I presents an outline-summary of the principal factors that should be evaluated.

Beneficial Uses—Water Quality Criteria: One of the fundamental requirements in the development of a marine waste disposal system is determination of the beneficial uses of the waters which are to be protected. Once this is done, suitable water quality criteria may be established to protect these uses and also provide a basis for evaluating adherence or compliance to the criteria. In some areas, there may be limited information on precise water quality standards for a respective use ; however, for the most part reasonable criteria or standards can be established.

Oceanographic Analyses

Oceanographic investigations of potential disposal sites are necessary if an analytical selection of the most favorable outfall and diffuser location is to be made. However, it is recognized that there will be occasions of relatively minor discharges where neither time nor available funds would permit any significant field investigation. It is in these instances where experience and judgment are vital factors in selecting the most suitable outfall system.

Currents: It is obvious that information is needed on the general water circulation system including current characteristics with respect to both depth and time. The objective of any field study should be the development of statistically significant current descriptions ; consequently sufficient studies must be conducted to provide an adequate sample of the variable currents existing at a particular location. Short, "one-shot" studies may be more misleading than helpful. It is generally desirable to develop sufficient data so that at least a qualitative appraisal of the effect of wind, wave, swell, and tides may be made.

Current studies have been conducted using drogues or free floats, current meters, and drift cards consisting of small weighted plastic envelopes.[1,2,3,4] Today the most economic and practical method of resolving near-surface currents for outfall design appears to be use of drift cards. It is hoped that in the not-too-distant future the development of economic continuous recording current meters will permit a more definite resolution of current characteristics.

In relatively shallow coastal waters ($\leq$30 meters) it appears that a fair degree of correlation exists between wind and current strength and direction. In such instances this relationship can be used to develop a "synthetic" current rose based upon extended wind observations. The practical value of this possibility is obvious, in view of the general availability of wind data and the expense of obtaining adequate current records.

Stevenson[5] summarized the work of many investigators and concluded that in shallow waters, the ratio of current to wind velocity ranged from about 2.5 to 0.5%, decreasing with depth. Tibby[6] reported the average current velocity of the surface layers (top 1–2 ft.) of Santa Monica Bay was about 2.5% of the wind velocity following several hours of steady wind. However studies by da Motta and Selleck[7] in shallow waters off the coast of Rio de Janeiro, Brazil, have indicated an average current-wind ratio of about 3.5%. Recently, da Silva[8] has developed, and confirmed on a preliminary basis, a rational method for computing current strength and direction in shallow waters as a function of the wind and boundary characteristics (i.e. depth). However, in general the foregoing studies have indicated that the current direction in shallow waters follows the wind rather closely and normally is within 15° of the wind direction at steady state.

From an engineering standpoint, it would appear that the assumption of a current-wind ratio of about 2.5–3.0% with the current in the same general direction as the wind could be employed with conservatism and confidence. This, of course, should be checked if the magnitude of the project can justify such investigation.

Eddy Diffusivity: Estimates of the magnitude of the coefficient of eddy diffusivity for the receiving water are necessary if quantitative consideration is to be given the effect of eddy diffusion or dispersion in reducing the concentration of the waste in the waste-sea water plume. Field measurement of eddy diffusivity coefficients can be accomplished most easily by the use of dyes, chemical or radiochemical tracers such as sodium fluroscein, rhodamine B, Orzan (spent sulfite liquor) and tritium.[9,10,11,12]

Various investigators have observed that the magnitude of the eddy diffusion coefficient is dependent upon the scale of the diffusion phenomenon.[13,14] Richardson[15] and others[16] have theorized that the eddy diffusivity coefficient is proportional to the four-thirds power of the scale of the diffusion phenomenon. This has been confirmed by measurement of the phenomena in the ocean. Fig. 1 presents field data reported by many investigators indicating the general relationship between eddy diffusivity, k, and the scale of the phenomenon observed.[13,14] In the absence of field data crude estimates of the magnitude of k may be obtained from Fig. 1.

Density Structure: The density or temperature-depth character of an outfall site may be an important characteristic of its suitability for waste dispersion. If a marked density or temperature gradient (thermocline) exists at some depth below the surface, this gradient may prevent the waste-sea water mixture from rising to the surface of the sea, i.e., the specific gravity of the waste-sea water mixture is greater than the specific gravity of the upper layers of the sea. In fact, the density gradient acts similar to an inversion layer in the atmosphere and tends to "throttle" the waste-sea mixture below it. Generally, it is desirable to keep the waste-sea water mixture from reaching the surface of the sea because it is in the surface layers where the most rapid transport occurs. Material that might accumulate in a surface film is transported by the wind at very high velocities compared to the water mass immediately beneath the surface.

In determining the density-depth characteristics of a given site, the bathythermograph (BT) is used most frequently. BT traces are made at each station and the temperature-depth relationships as measured by a rapid temperature-depth response circuit are traced on a suitable slide. The presence of a marked density gradient is easily detected and recorded at the depth encountered. BT traces are adequate for indicating density gradients in water where no salinity gradient exists. However, if the outfall site is subject to considerable upwelling of deep ocean waters so that both temperature and salinity gradients are present, it is necessary to measure the salinity as well as temperature to determine properly the density gradient. It is obvious that if the density barrier is to be effective in preventing the waste field from surfacing, the density gradient will have to persist after introduction of the waste discharge to the nearshore circulation system.

Fig. 2 presents a sketch of a typical temperature-depth trace made with a bathythermograph as well as the effect such a density gradient may have on the gravitational diffusion of waste rising from a submerged jet.

Submarine Topography and Geology: Submarine topography varies widely and may be a controlling factor in the selection of a suitable site. Ideally, a uniform sloping bottom to considerable depth within reasonable distance from shore is desired. While there is no minimum length or depth of outfall, it would appear that for effective initial mixing and diffusion a minimum ratio of depth to outfall diameter of about 20 should obtain. Also it is desirable that the bottom topography be relatively flat in the vicinity of the diffuser to minimize hydraulic flow distribution problems with a multiport diffuser.

Bottom geology is an important consideration in selection of an outfall site. In the surf zone and to a water depth of about 30 ft. the pipe is buried and encased with either concrete or heavy rock cribbing. On most bottoms and for typical nearshore current velocities, it is generally adequate to lay the offshore section (depth greater than ~50 ft.) on the bottom with trap rock added up to the spring line or equivalent for stability.

Waste Dispersion Analysis

The two fundamental aspects of dispersion problem include the initial mixing of the waste in the immediate proximity of the discharge point and the subsequent transport and dispersion of the waste in the waste-sea water dispersion plume.

Initial Mixing: In mixing a given waste flow with the diluting water passing the discharge point, it is obvious from a continuity basis that the maximum dilution obtainable, assuming perfect mixing of the waste with the sea water, is the ratio of the two flows, Q_{diln}/Q_{waste}. For a single port discharge, there is some question as to the extent of the intercepted or diluting water. For a multi-port outlet or diffuser, the dilution of the waste can be expressed as follows:

$S_{oa} = Vbd/Q_w$ where

S_{oa} = average dilution ratio of waste
V = average velocity of new water past diffuser, ft./sec.
b = length of diffuser, ft.
d = effective (mixing) depth of water over diffuser, ft.
Q_w = waste flow, ft.³/sec.

The above is simply a statement of continuity and represents the maximum average dilution attainable at the source with perfect mixing—the obvious objective of a multi-port diffuser.

Jet Mixing—Gravitational Diffusion: The fluid mechanics of a single jet discharge into a body of water of different density is complex. The phenomenon is a combination of mixing resulting from jet action, i.e., the kinetic energy of the jet, and mixing resulting from the gravitational or buoyancy forces due to differences in density between the waste jet and receiving water.

Recently, Rawn, Bowerman and Brooks[21] in a paper covering the design of diffusers have re-examined the original Rawn-Palmer data[22] based on dimensional and Froude law relations. They reported a figure showing minimum dilutions, S_{om}, on the centerline of the rising column as a function of the ratio of depth above outlet to diameter of jet at outlet, y_o/D, and the effective Froude number,

$$\frac{V}{\sqrt{(\Delta S.G.gd/S.G.}}$$

More recently Abraham[23] conducted a laboratory study of jet diffusion in a liquid of greater density (approximating fresh and sea water). Abraham presented a modified form of the equation developed theoretically by Morton[24] for dilution in jets with buoyancy only, and verified the theory experimentally. Abraham concluded that the following equation represented accurately the concentration distribution in a jet with buoyancy for value of $F \geq 3$ and for distances from the port, y/D, >6 or 7.

$$\frac{C_m}{C_o} = 9.7F^{2/3}\left(\frac{y}{D} + 2\right)^{-5/3}$$

where
C_m = concentration at axis of jet at y
C_o = concentration at $y = 0$
F = effective Froude number

$$\frac{V_o}{\sqrt{[(\rho_s - \rho_o)/\rho_o]gD}}$$

D = diameter of port
y = length along axis of jet

Abraham presented graphical solutions of the above equation for various values of F with the experimentally determined values indicated.

Albertson[25] and Cooley and Harris[26] have developed experimentally similar equations for dilution in a jet. Cooley and Harris concluded that the average dilution in jets normally encountered in engineering practice could be expressed as follows:

$$S_{oa} = (y_o/3D)$$

where
S_{oa} = average dilution in jet (i.e. $Q_{\text{jet total}}/Q_{\text{jet}}$)
y_o = length of axis of jet trajectory, feet
D = diameter of outlet, feet

The preceding equations permit estimation of the dilution of waste in the jet mixing-gravitational diffusion plume. Analysis of the expressions indicates the obvious desirability of dividing a given flow into a number of smaller flows or jets such as in a multi-port diffuser.

Waste Transport—Diffusion: Once the discharge waste is mixed effectively with sea water in the immediate proximity of the outlet, what happens then to the waste-sea water mixture? Because the initial mixing and dilution achieved by the diffuser section generally does not dilute the waste to a harmless level, it is necessary that subsequent dilution and decay processes be considered.

Historically, most coastal outfall design has been based on judgment influenced by experience with the objective of keeping the fresh waste away from shore a minimum period of time. It is hoped that during this time, sufficient dilution and waste (bacterial) decay will occur so that the waste-sea water mixture reaching the shoreline will not exceed permissible waste concentrations or bacterial standards for the beneficial uses of the area.

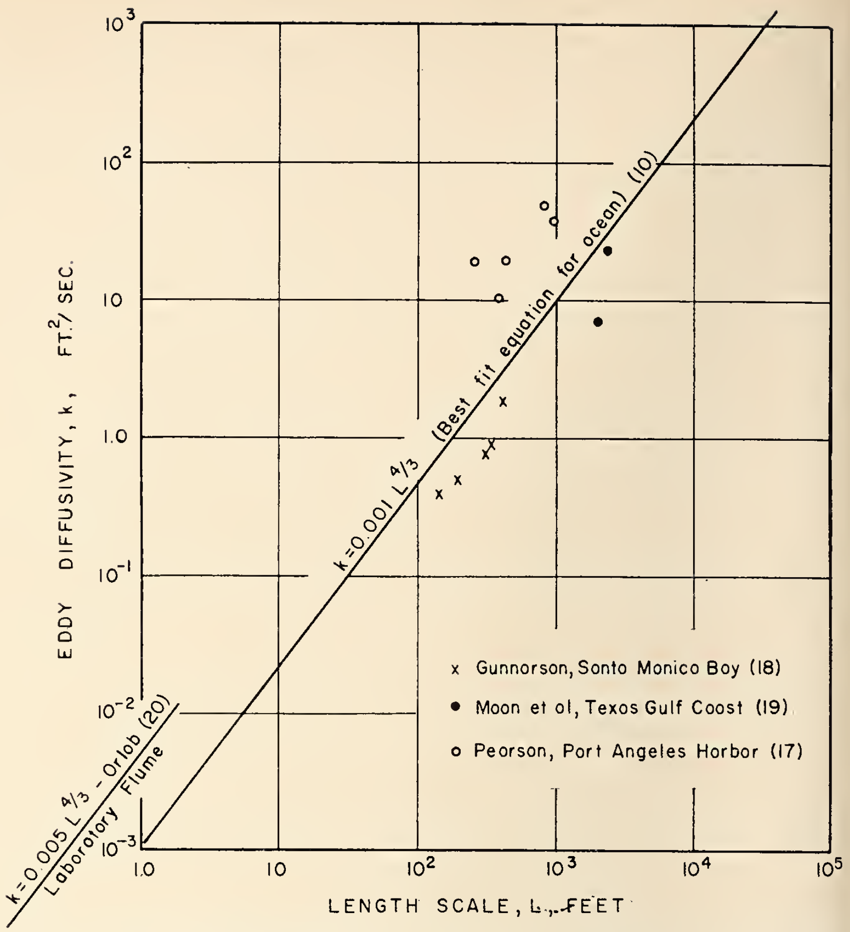


Fig. 1. Magnitude of Eddy Diffusion Coefficients (17). Plotted points—recent data.

Lateral dispersion or horizontal eddy diffusion of the waste-sea water mixture occurs whether the currents are such that the waste travels unidirectionally or whether it is transported in an irregular manner. Lateral dispersion is considered to be normal to the direction of principal transport (advection axis) of the waste-sea water mixture.

Classically the currents systems in nearshore waters have been assumed to be essentially rotational in character due to tidal currents[1] and probably periodic winds such as land and sea breeze. Fig. 3 depicts an idealized trajectory of a waste-sea water mass showing the effect of a rotational, critical shoreward current and horizontal eddy diffusion. Obviously the sketch ignores the influence of the shoreline boundary conditions. The trajectory of the waste-sea water mass may be likened to a plume of smoke emitted from a stack or point source. The plume follows the general direction of the current and the lateral width of the plume, as it develops, is a function of time and the turbulent characteristics of the receiving waters (i.e., coefficient of eddy diffusivity).

Diffusion Equations: The diffusion of wastes in the ocean can be described by the mathematical model for Fickian diffusion as follows:

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial y}\left(k\frac{\partial c}{\partial y}\right) = k\frac{\partial^2 c}{\partial y^2} \quad (1)$$

where
c is the waste concentration
y is space coordinate
k is eddy diffusivity coefficient.

Considering a unit area in the dispersion plume and writing a materials balance for the area including advection, the following differential equation is obtained considering two dimensional diffusion:

$$\frac{\partial c}{\partial t} + V_x\frac{\partial c}{\partial x} + V_y\frac{\partial c}{\partial y} = k\left(\frac{\partial^2 c}{\partial x^2} + \frac{\partial^2 c}{\partial y^2}\right) - ac \quad (2)$$

where V_x and V_y are the velocities in the x and y directions. a is a decay constant.

For steady-state conditions and unidirectional transport velocity in the x direction, the following simplifying assumptions are possible; that is

$$\frac{\partial c}{\partial t} = 0 \quad \frac{\partial^2 c}{\partial x^2} = 0 \quad \text{and} \quad V_y = 0$$

Therefore equation (2) can be rewritten in the following form:

$$V_x\frac{\partial c}{\partial x} + ac = k\frac{\partial^2 c}{\partial y^2} \quad (3)$$

Fig. 4 presents idealized definition sketches for solutions to the diffusion equation. Numerous investigators such as Ketchum and Ford,[27] Munk, Ewing and Revelle,[28] Pearson,[29,30] Brooks,[31] and others have reported solutions to the diffusion equation (3) for appropriate initial and boundary conditions. Assuming both point and line sources, steady unidirectional current, uniform mixing of the waste over a depth, d, and continuous uniform flow from the source, solutions to the diffusion equation in terms of the minimum dilution, S_{om}, along the CL axis of the waste sea water plume are as follows:

Point Source

$$S_{om} = \frac{2.35d\sqrt{kV_x x}}{Q} \qquad (4)$$

where

S_{om} = minimum dilution along axis of waste plume at distance x from source

k = assumed diffusivity, ft.^{2}/sec.

x = distance from source, feet

V_x = average velocity of water mass, ft./sec.

Q = waste discharge, MGD

d = mixing depth, ft.

Including the decay function for bacterial dieaway or disappearance, and expressing the waste concentration in terms of coliform concentration, the above expression becomes:

$$MPN = \frac{0.425QC_o}{d\sqrt{kV_x x}\, e^{(ax/V_x)}} \qquad (5)$$

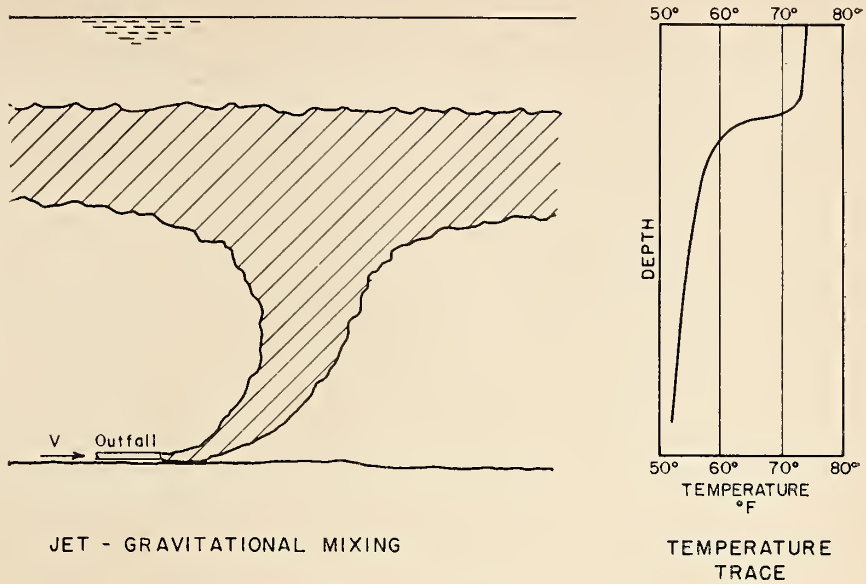


Fig. 2. Initial mixing—density considerations.

where

MPN = most probable number of organisms per ml. on plume CL at x

C_o = concentration of organisms in waste, MPN/ml.

a = bacterial dieaway (decay) constant, 1/sec.

Line Source

$$S_{om} = \frac{0.662V_x bd}{Q \operatorname{erf}\left[\frac{b}{4}\sqrt{V_x/kx}\right]} \qquad (6)$$

where b = width of diffuser or line source, feet; and

$$MPN = \frac{1.55QC_o \operatorname{erf}[(b/4)\sqrt{V_x/kx}]}{bdV_x e^{(ax/V_x)}} \qquad (7)$$

The above equations assume a constant eddy diffusivity[9] correspondingly, the value of k employed must be representative of the overall or average scale of the diffusion phenomenon.

Recently, Brooks[32] has reported a solution to the diffusion equation with a variable coefficient of diffusivity. It is assumed that the diffusivity coefficient, k, varies as the four-thirds power of the scale of the diffusion phenomenon, $k \cong \alpha l^{4/3}$ where α is a constant. Brooks' equation for a line source is as follows:

$$C_m = C_o e^{-at} \operatorname{erf}\sqrt{\frac{3/2}{[1 + \frac{2}{3}\beta(x/b)]^3 - 1}}$$

where

C_o = initial coliform concentration

C_m = maximum coliform concentration at time, t

t = time of travel = x/V_x

β = $12k_o/V_x b$

a = decay constant

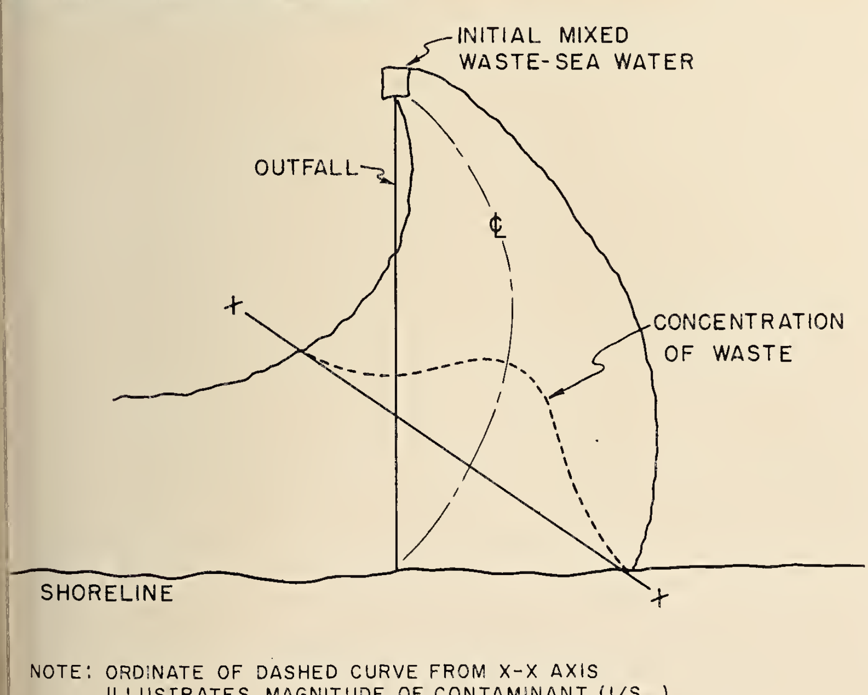
k_o = eddy diffusivity at source ($x = 0$)

b = initial width of sewage field

Empirical Analysis: For comparison, reference is made to the empirical relationship for determining the required length of an outfall developed by Pomeroy.[33] Pomeroy studied the performance of the Orange County Sanitation Districts outfalls with reference to observed coliform concentrations on the beach and concluded that the following relationship interpreted best the observed data:

$$N = \frac{KQ^2}{YX^2}$$

Fig. 3. Idealized trajectory of waste-sea water mass showing effect of current and horizontal diffusion for critical current.



where

N = coliform concentration (MPN/ml) equal to or less than 80% of the time at the station with highest bacterial concentration

Q = average sewage flow, gallons/day

Y = depth at discharge, feet

X = length of outfall to shore, or point of highest pollution, feet

K = constant depends upon effluent and location Orange County primary location

Orange County primary effluent, $K = 5 \times 10^6$

City of Los Angeles, high rate activated sludge effluent, $K = 10 \times 10^6$

Such a relationship expresses observed conditions at a particular site and for a particular effluent. As pointed out by Pomeroy,[33] a single constant K is not universally applicable, and it is recognized that oceanographic, waste and receiving water characteristics vary widely. However, the expression does have application with sewage outfalls of limited size such that oceanographic studies are not feasible, or as a check for analyses made in accordance with diffusion equations.

Diffuser Considerations: Since the eddy diffusivity coefficient increases with the scale of the phenomenon as shown in Fig. 1, the advantage of dispersing the waste over as wide an area as feasible, normal to the major set of the current is obvious. Of course, even greater benefit is obtained by the increased dilution resulting from mixing the waste flow with a large flow of "new" diluting water. Since the most critical areas of water quality generally lie directly shoreward from the outlet, the most effective orientation of the diffuser would be essentially normal to the axis of the "critical" onshore current. Maximum advantage is obtained from both initial diffusion as well as maximum values of eddy diffusion coefficients. In many cases, these considerations should result in the design of a diffuser oriented parallel or nearly parallel to shore.

Summary and Conclusions

A marine waste dispersion system is a functional component of the total treatment facility and should receive appropriate attention in conception and design. Studies of the physical, chemical and biological characteristics as well as the waste assimilating capacity of the receiving water are necessary to locate properly the terminal facility, estimate performance and to design the dispersion system. One of the most important steps in the rational development of a waste disposal system is resolution of the beneficial uses of the receiving water and water quality criteria necessary to protect the uses. Evaluation of the significant oceanographic factors affecting the design of coastal dispersion systems are discussed, and particular attention is given quantitation of nearshore circulation systems, current structure, density-temperature structure, and eddy diffusivity coefficients.

A rational method is presented for computing the concentration of waste in waste-sea water dispersion plumes including the initial mixing as well as the subsequent eddy diffusion. Solutions to the classical diffusion equation considering both point and line sources and constant and variable diffusion coefficients are presented. Application of these equations permits a quantitative appraisal of the cost and benefit of various degrees of waste treatment and corresponding outfall and diffuser systems for attainment of water quality objectives.

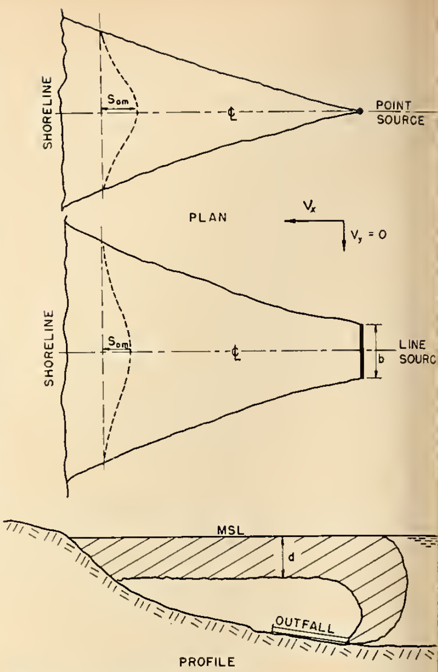


Fig. 4. Idealized definition sketch for dispersion equations.

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A SIMULATION OF THE ECONOMY OF BRITISH COLUMBIA

— A Guide to Industrial Development

R. E. Boston, JR.E.I.C.,

Assistant Professor, Department of Mechanical Engineering, The University of British Columbia, Vancouver

The economy of British Columbia depends largely on relatively few extractive industries. Industrial development authorities have suggested that more encouragement be given to secondary industries. Outlined is one method of testing this hypothesis.

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THIS paper is intended to describe the concept of the Leontief Input-Output Analysis method as a predictive device for estimating the magnitude of changes in an economy.

More specifically, the feasibility of using Input-Output Analysis is examined here as a means of evaluating a proposed industrial development program for the province of British Columbia.

Thus this presentation is to be viewed only as a first step toward the final goal of actually specifying an industrial development program over a definite time interval. Several industrial development questions are presented along with preliminary results to indicate the usefulness of the simulation. The details are to be the subject of another paper.

Introduction

Like a great many underdeveloped areas the economy of British Columbia is highly dependent on a relatively few extractive industries. The bulk of the products produced are shipped out of the province to be manufactured into consumer goods elsewhere. Thus the province is primarily a source of raw materials for others.

Since the economy is strongly dependent upon so few industries, seasonal operations often produce severe variations in business activity. Also, since a product is often not further processed nor consumed locally there is considerable dependence on foreign markets. Thus there is a great need to diversify and expand the B.C. economy. In this way the dependence on a few large industries and on foreign markets could be reduced. The result would be more stable employment; an increased value of goods manufactured in B.C.; increased employment, capital invested, and provincial income.

The solution most frequently suggested by those involved with industrial development is the encouragement of secondary industry. The validity of this view for British Columbia may well be challenged as the report of the Gordon Commission has suggested.

Problem

The rightness or wrongness of encouraging secondary industry should be checked. A method of testing this hypothesis needs to be found as well as a measure of the value of a given course of action. One approach is to make use of Leontief Input-Output analysis.

Application

Leontief-type analysis is a special type of linear programming whereby individual industry purchases and sales are isolated and arranged in a square matrix (Fig. 1). The rows of the matrix represent the disposition of that industry's products to other industries, or segments of the economy. Each column represents the source of each industry's acquisition of goods. *Row totals* represent *total outputs* by industries whereas *column totals* represent *total inputs* into each *sector of the economy.* By suitable manipulation of the matrix so formed each entry can be used as coefficients in a set of linear equations. New conditions in the economy can be simulated or forecast by substituting a new column for final demand. Solution of the equation system will then provide the level of economic activity within various industrial and economic sectors of the economy for the new set of conditions.

The value of this analysis is that by using such a static system over a series of time intervals a useful means of forecasting is provided. It is possible not only to forecast new labor or electrical power requirements for new levels of economic activity, but also the extra value added to the economy by expanding certain areas of production. Thus, for example, it would be possible to use Leontief Input-Output analysis to evaluate the effect of increasing secondary

Fig.1.

THEORETICAL INTERINDUSTRY TRANSACTIONS TABLE

Purchasing Sectors

Producing Sectors	*1*	*2*	—	*i*	*j*	—	*n*	*Final Demand*	*Gross Output*
1	x_{11}	x_{12}	—	x_{1i}	x_{1j}	—	x_{1n}	x_{1d}	X_1
2	x_{21}	x_{22}	—	x_{2i}	x_{2j}	—	x_{2n}	x_{2d}	X_2
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
i	x_{i1}	x_{i2}	—	x_{ii}	x_{ij}	—	x_{in}	x_{id}	X_i
j	x_{j1}	x_{j2}	—	x_{ji}	x_{jj}	—	x_{jn}	x_{jd}	X_j
—	—	—	—	—	—	—	—	—	—
n	x_{n1}	x_{n2}	—	x_{ni}	x_{nj}	—	x_{nn}	x_{nd}	X_n
Charges against Final Demand	x_{d1}	x_{d2}	—	x_{di}	x_{dj}	—	x_{dn}	x_{dd}	X_d
Gross Input	X_1	X_2	—	X_i	X_j	—	X_n	X_d	

manufacturing in the province of British Columbia.

Leontief Input-Output Analysis

If we examine an economy as a whole it is quite conceivable to consider it as made up of many elements. Each element or sector could be classed as a specific industry. Then each industry's output represents a contribution of a specific good to the gross production of the economy.

But not all of an industry's production will be consumed without further processing. Some of the product will be sold to other industries where it becomes a raw material to be converted into similar or even greatly different products.

Thus if we code each industry by numbers 1, 2, 3, . . . , *i*, *j*, . . . , *n* and let X_i be the gross output for industry *i*, we can examine the supply and the demand of the product by other industries. The amount of the product from industry *i* required to satisfy final demand for the product (i.e., demand for which the product requires no further processing) can be represented as x_{id}. Sales to other industries, such as industry *j*, are represented as x_{ij}. Purchases within the industry are x_{ii}. Then an equation for the supply and demand of product *i* can be written whereby:

$$X_i = x_{i1} + x_{i2} + \dots + x_{ii} + x_{ij} + \dots + x_{in} + x_{id} \qquad (1)$$

In some studies final demand x_{id} is the composite of:[15,11]

1. New private construction (excluding maintenance and repair).
2. Producer's durables.
3. Inventory change (net additions to stocks of finished products).
4. Household purchases.
5. Government purchases (including public construction).
6. Foreign trade (balance of exports and competitive imports).

From equation (1) a square array of similar equations can be produced (Fig. 1) for all *n* industries. In the resulting matrix each row entry is automatically a column entry. For industry *j* the *j*th column represents all its purchases from other industries so that x_{ij} is the purchase of goods or services from industry *i* and hence is an input for sector *j* of the economy. In addition each column shows the charges against the autonomous sector (final demand) of the economy. These charges comprise:[14,15]

1. Labor costs
2. Taxes.
3. Depreciation.
4. Profits.
5. Pension plan costs.
6. Taxes (including import duties).
7. Non-competitive imports (i.e., tin, tea, coffee).

and are indicated as x_{dj}. Then the balance of a sector's inputs with its gross output is shown by the equation (2).

$$X_j = x_{1j} + x_{2j} + \dots + x_{ij} + x_{jj} + \dots + x_{nj} + x_{dj} \qquad (2)$$

which appears as the *j*th column of the matrix formed from (1).

Assumptions for the Leontief Model

Since the foregoing description of the Leontief model is not overly detailed it is important to outline the basic assumptions necessitated by the construction of this model. Also since severe criticism of the use of Leontief interindustry coefficients in predictions of future industry outputs have been made,[15] it is necessary to estimate the validity of such criticisms with regard to this work.

The first basic assumption is that the amount of the production going from one non-autonomous sector to be further processed in another non-autonomous sector is a function of the level of production of the latter sector. It is further assumed that the function is directly proportional, or linear. Ritz[11] states that there are strong a priori reasons for supposing near proportionality for most of these functions over a reasonable, if limited period of time. For these reasons and for the computational problems which arise with other assumptions, the idea of proportionality is considered valid as well as convenient.

A more serious criticism is made by Shephard and others. This relates to the first assumption, that the output from one industry *i* into another industry *j* represents the output measured by X_i. This assumption necessitates that inventories are either held constant or ignored. An adjustment for this factor can be made in final demand. Then S.A. Jaffe on the basis of the 1947 U.S. interindustry study states that error in the treatment of the industries is negligible.

Another assumption is that the variety of products produced by any one firm, let alone an industry, do not fall within the classification of another industry. The finer the break-down of economic sectors into industries the greater will be the error due to secondary products of a given industry not being allocated properly. But it is argued,[7] this still need not be considered a serious problem. Industries are classified by government statistical agencies. Output figures provided are an aggregate of thousands of primary and secondary products, some of which may seem quite inappropriate for the industry classification. The assumption is then justified that what is more important is the input to make the products. Since many companies in industries (e.g., steel) make widely diverse products from a few similar inputs, the assumption is not considered invalidated. Where great diversity of inputs does exist the argument is still defended on the basis that the individual coefficient x_{ij} is an average of several input-output ratios considered as an aggregate for a given industry. This then leads to the next assumption.

It is assumed that the coefficients represent a given "product mix" within an industrial classification. Then if the Leontief model is used as a predictive device it is imperative that these coefficients be regarded as staying relatively constant over the time period. With many industries this may well be true. But certainly some industries (e.g. construction) are definitely characterized by product-mix instability. Furthermore technological changes occur within an industry to upset previous input-output ratios (e.g., the switch from coal to oil, or hydro-electric to natural gas for power generation). Economic_ upheavals such as rapid transitions to peace or war could also change the technical coefficients. However, Morgenstern[7] after an analysis by P. A. Samuelson concludes that such effects are not likely to be as severe in the short run as at first might be expected.

The same conclusion is used to defend the model against the effects of price changes for products. The importance of this is obvious when it is realized that the only common denominator for various inputs and outputs of different sectors can only be in terms of dollars. Tons of steel, cubic feet of gas, kilowatts, lineal yards of cloth, etc., cannot be compared otherwise. Thus each x_{ij} is an entry in dollars in *producer's* values. Over the period of a year it is unlikely that the overall price variations in any industry will contribute errors of any great magnitude. But price changes will necessitate that comparisons of inter-industry tables between time periods are made after modification by a suitable price index for the various component industries.

Numerical Evaluation of the Leontief Matrix

Once it has been acknowledged that the assumptions for the Leontief static input-output model are reasonable it is necessary to be able to solve the linear system of equations represented by the matrix of Fig. 1. But this cannot be accomplished until a rearrangement of the matrix has been made. This is achieved by dividing each x_{ij} of producing sectors by the appropriate X_j. This results in a matrix composed of unit-less ratios (or technical coefficients), instead of entries in dollars. These technical coefficients are designated by $a_{ij} = (x_{ij}/X_j)$.

But since this division was only done for the producing sectors, the equality of equation (1) has been destroyed. To restore the equality we multiply each a_{ij} by the appropriate X_j and equation (1) becomes

$$X_i = X_1 a_{i1} + X_2 a_{i2} + \ldots + X_i a_{ii} + X_j a_{ij} + \ldots X_n a_{in} + x_{id} \qquad (3)$$

To simplify the notation when we consider the system of simultaneous linear equations let

A = the square $n \, x \, n$ matrix of the technical coefficients a_{ij}

X = the column vector $\begin{vmatrix} X_1 \\ \cdot \\ \cdot \\ \cdot \\ X_n \end{vmatrix}$ for gross output

D = the column vector $\begin{vmatrix} x_{1d} \\ \cdot \\ \cdot \\ \cdot \\ x_{nd} \end{vmatrix}$ of final demand

Then the system of equations from (1) is

$$X = AX + D \qquad (4)$$

After division by X and rearranging

$$(I_n - A)X = D$$

whence

$$X = (I_n - A)^{-1}D \qquad (5)$$

where

I = the $n \, x \, n$ identity matrix $\begin{vmatrix} 1\,0\,0 & \ldots & 0 \\ 0\,1\,0 & \ldots & 0 \\ \cdot & \cdot\,\cdot\,\cdot & \cdot \\ \cdot & \cdot\,\cdot\,\cdot & \cdot \\ \cdot & \cdot\,\cdot\,\cdot & \cdot \\ 0\,0\,0 & \ldots & 1 \end{vmatrix}$

The usefulness of equation (5) is that knowing, or assuming, future demands for products by industries the new levels of gross output can be determined. But for this to be true, matrix theory[17] demands that $(I - A)$ be non-singular. That is, it must have an inverse $(I - A)^{-1}$. Also the inverse matrix must have all non-negative elements. Then there remains the problem of evaluating the inverse matrix. One of the ways of determining an inverse is by power series.[18] For the power series

$$(I + A + A^2 + \ldots + A^n)$$

$$(I - A)(I + A + A^2 + \ldots + A^n) = I - A^{n+1} \qquad (6)$$

where A^n is matrix A multiplied by itself n times using matrix multiplication. Since every element in A is a decimal and for each element $-1 < a_{ij} < 1$, then as $n \to \infty$, A^{n+1} tends to zero.

Then equation (6) becomes

$$(I - A)(I + A + A^2 + \ldots A^n + \ldots) = I$$

whence

$$(I + A + A^2 + \ldots) = (I - A)^{-1} \qquad (7)$$

If this process is continued through to A^{10} then the error in any element of the inverse matrix is $\leq \$0.005$.[18]

However, for the B.C. table actually devised, the inverse matrix was actually obtained by a Gaussian elimination technique. The calculations were made on the I.B.M. 704 computer at the University of Michigan computing centre. The details of the MAD (Michigan Algorithm Decoder) program for matrix inversion are available upon request.

Summary

From the foregoing it can be seen that the Leontief Input-Output Analysis is admirably suited to the simulation of an economy. The model could be used to determine the effect of introducing a new industry; expanding certain existing industries, whether primary or secondary; or increasing exports. It could also be used to estimate the value added to the economy of any such action; or to determine the type and magnitude of additional inputs for the economy. Thus it is a measure of effectiveness of any proposed industrial development program.

Design of the British Columbia Input-Output Table

On the basis of international experience during the past 30 years the use of a Leontief input-output analysis seems to be an ideal method for evaluating an industrial development program. In fact it has been used for this purpose in Italy, Norway, Great Britain, Puerto Rico, and Israel. Nearly every reported instance has used the static model. Leontief's dynamic model has proven to be far too complex for general use, particularly if no previous input-output table has been prepared. It was therefore decided to use a static Leontief model to examine the interactions of the B.C. economy with various industrial development plans.

The Dominion Bureau of Statistics publications provide 17 classes of manufactures for B.C. To these it was felt necessary to add

Agriculture
Fisheries
Transportation
Construction

to realistically portray the producing sectors of the economy.

Unfortunately only limited data is available for these classifications. It was originally hoped that the publication "Consumption of Materials and Supplies by the Principle Manufacturing Industries of B.C." would provide all the necessary data to fill the body of the table. This proved to be a vain hope. The data is merely a detailed breakdown of the products used in the province. It is therefore only an expansion of the column totals, of the Leontief model, since it does not list in detail the products used in various industries.

Due to the unavailability of sufficient detailed statistics, it was impossible to obtain the inputs into each industry classified by supplying industry. To complete the input-output analysis it was therefore decided to aggregate the 1949 Canadian interindustry table[26] to match the size of the B.C. matrix it was originally hoped to prepare. This was done on the assumption that the technical coefficients (each a_{ij} of Matrix A) would be little changed from 1949 to 1956 and would vary little between provinces or for Canada as a whole. This is an approach used successfully by Professor A. Raynauld of the Uni-

TABLE 1

BRITISH COLUMBIA DEMAND VECTOR — 1956

Industry Number	*Households*	*Gov't*	*Inventory*	*Foreign Exports*	*Domestic Exports*	*Gross Capital Formation*	*Total Gross Demand*	*Foreign Imports*	*Domestic Imports*	*Net Final Demand*
1	101.5	—	11	17.2	26.6	—	143.3	10.8	45.4	89.1
2	3.8	—	—	27.0	34.2	—	65.0	—	8.2	56.8
3	407.1	—	11.3	36.7	—	—	455.1	78.1	128.0	249.0
4	2.8	—	4.3	—	—	—	7.1	3.4	11.4	−7.7
5	13.9	—	—	1.9	—	—	15.8	1.4	10.7	3.7
6 & 7	10.3	—	0.2	0.9	4.6	—	16.0	18.0	—	−2.0
8	144.2	—	0.2	—	0.2	—	144.6	4.3	129.7	9.6
9	95.8	15.2	—	131.3	95.4	41.3	379.0	12.2	8.4	358.4
10	—	—	−0.1	112.0	83.0	—	194.9	4.1	—	190.8
11	31.5	—	0.3	0.2	—	—	32.0	4.4	—	27.6
12	227.5	—	8.0	13.7	—	109.0	358.2	165.3	131.6	61.3
13	235.9	—	1.6	0.6	—	—	238.1	68.3	131.2	38.6
14	19.6	—	−0.1	97.3	79.6	—	196.4	31.3	—	165.1
15	45.3	—	0.5	—	—	—	43.8	19.9	38.4	−14.5
16	2.6	—	0.4	6.3	9.4	—	18.7	18.4	22.3	−22.0
17	150.0	—	—	0.1	—	—	150.1	22.4	9.7	118.0
18	40.9	—	−1.4	41.6	—	—	81.1	19.8	21.8	39.5
19	39.7	—	0.1	4.8	—	—	44.6	36.7	4.7	3.2
20	42.5	—	—	—	—	—	42.5	—	—	42.5
21	188.7	39.3	—	—	—	421.8	649.8	—	—	649.8

versity of Montreal in his study of the economy of the province of Quebec.

For final demand the following sectors were used :

Final Demand
- Households (retail purchases)
- Government Expenditures
- Inventory Change (additions)
- Foreign Exports
- Domestic Exports
- Total Gross Output

Charges Against Final Demand
- Household (earnings)
- Government Taxes (B.C. only)
- Inventory Change (deletions)
- Foreign Imports
- Domestic Imports
- Total Gross Input

Another classification called Unallocated and Residual Error was necessary. Therefore the full table is 27 × 27 all told.

It was assumed that the magnitude of error caused by the use of 1949 Canadian technical coefficients was not likely to be any worse than some of the assumptions and errors involved in the final demand sectors. Besides, this assumption provided the only reasonable means of completing the table and of manipulating the model to show areas for more detailed analysis. This then is the justification for the use of the 1949 Canadian Data.

It was then necessary to aggregate the 1949 Canadian interindustry table. This reduced the basic 42 × 42 matrix into the desired 20 × 20 form for the B.C. interindustry table. Consequently the full 54 × 52 Canadian table was summarized in a 24 × 24 table.

The inverse of the aggregated Canadian table is shown in Appendix III. From many statistical sources and market research, the 1956 B.C. demand vector was prepared (Table 1). This vector was then multiplied by $(I_{20}-A)^{-1}$ to obtain a calculated gross output vector. The calculated output vector and the output vector compiled from statistical sources were compared (Table 2). The results showed that the calculated output vector was on the average 22% in error. However, total gross output (ΣX_i) was only 5% too low.

The Model as a Guide for Industrial Development

Having established the validity of the model of the B.C. economy, the problem now is to show how it may be used as a guide for industrial development. The reader is referred to the example in Appendix I. There the input-output data is shown in Fig. A for a simple five sector economy. The transactions matrix A of Fig. B was obtained by dividing each column entry by the column total to obtain the technical coefficients a_{ij}. Knowing given levels of final demand and gross production indicates that a solution to the original system of equations (Eqn. 3) has been obtained. But this is superfluous at this point. What a person interested in industrial development wants to know is the answer to a specific question. It can often be posed as follows: "If the demand for the output of the four industries is X_{1d}', X_{2d}', X_{3d}' and X_{4d}', what will be the new levels of output for each industry, and what will be the gross output ΣX_i?" The answer to this question is the solution of the equation

TABLE 2

COMPARISON OF 1956 BRITISH COLUMBIA OUTPUT VECTOR

All figures in millions of dollars

Number	*Industry*	*Calculated X*	*X From Statistics*	*Absolute Error*	*Relative Error (%)*
1	Agriculture	$202.9	$115.0	$87.9	76.5%
2	Fisheries	57.3	65.0	−7.7	11.9
3	Food and Beverages	252.0	374.0	−122.0	32.6
4	Rubber Products	0.3	0.5	−0.2	40.0
5	Leather Products	4.6	4.3	0.3	7.0
6 & 7	Textiles and Knitting	15.8	11.8	4.6	41.1
8	Clothing	10.3	11.0	−0.7	6.0
9	Wood Products	483.1	605.0	−122.1	20.1
10	Pulp and Paper	226.5	222.1	4.4	2.0
11	Printing and Publishing	34.5	46.4	−11.9	25.6
12	Iron and Steel Products	164.3	138.3	26.0	18.8
13	Transportation equipment	69.3	55.6	13.7	24.6
14	Non-ferrous metals	191.2	168.0	23.2	13.8
15	Electrical Apparatus	19.0	18.0	1.0	5.6
16	Non-metallic Minerals	19.6	25.7	−6.1	23.7
17	Electricity, Petroleum & Coal	201.2	152.1	49.1	32.3
18	Chemicals	78.2	63.9	12.3	19.2
19	Miscellaneous Manufactures	7.7	7.2	0.5	6.9
20	Transportation	315.3	282.0	33.3	11.8
21	Construction	689.3	839.6	−150.3	17.9

TOTAL............ 3042.4 − 3205.1 = −162.7 .... 5.1%

AVERAGE ERROR = 22% STANDARD DEVIATION = $19.6 million

TABLE 3

GROSS OUTPUT OF B.C. INDUSTRIES TO REDUCE IRON & STEEL PRODUCTS IMPORTS BY $100 MILLION

(All figures in millions of dollars)

	New Output	*1956 Output*	*Percent Increase*
Agriculture	203.0	202.9	.1%
Fishing	57.3	57.3	—
Food and Beverages	252.0	252.0	—
Rubber Products	1.0	0.3	233.3
Leather Products	4.7	4.6	2.2
Textiles and Knitting	16.0	15.8	1.3
Clothing	10.3	10.3	—
Wood Products	484.0	483.1	0.2
Paper Products	227.1	226.5	0.3
Printing	34.8	34.5	0.9
Iron and Steel Products	264.8	164.3	61.1
Transportation Equipment	70.6	69.3	1.9
Non-Ferrous Metals	193.3	191.2	1.1
Electrical Apparatus	20.0	19.0	5.3
Non-metallic minerals	20.3	19.6	3.6
Petroleum & Coal Products, & Electricity	206.9	201.2	2.8
Chemicals	78.9	78.2	0.9
Miscellaneous	7.8	7.7	1.3
Transportation	324.0	315.3	2.8
Construction	690.1	689.3	0.1
Total Gross Output	$3,166.9	$3,042.4	

$$X = (I - A)^{-1} . D \qquad (5)$$

which is shown in Fig. F.

For a more specific example, let us turn to the model of the B.C. economy. The demand vector shown (Table 1) relates specifically to the year 1956. The sole reason is that it was the most recent year for which sufficient data was readily available to the author to complete the demand vector. However, no great problems will be encountered if this is used as a starting point and merely considered as an initial feasible solution. This eliminates the need of preparing or forecasting a more recent demand vector. If this is agreed as acceptable, it is now possible to alter the demand vector to compare the effects of various industrial development possibilities.

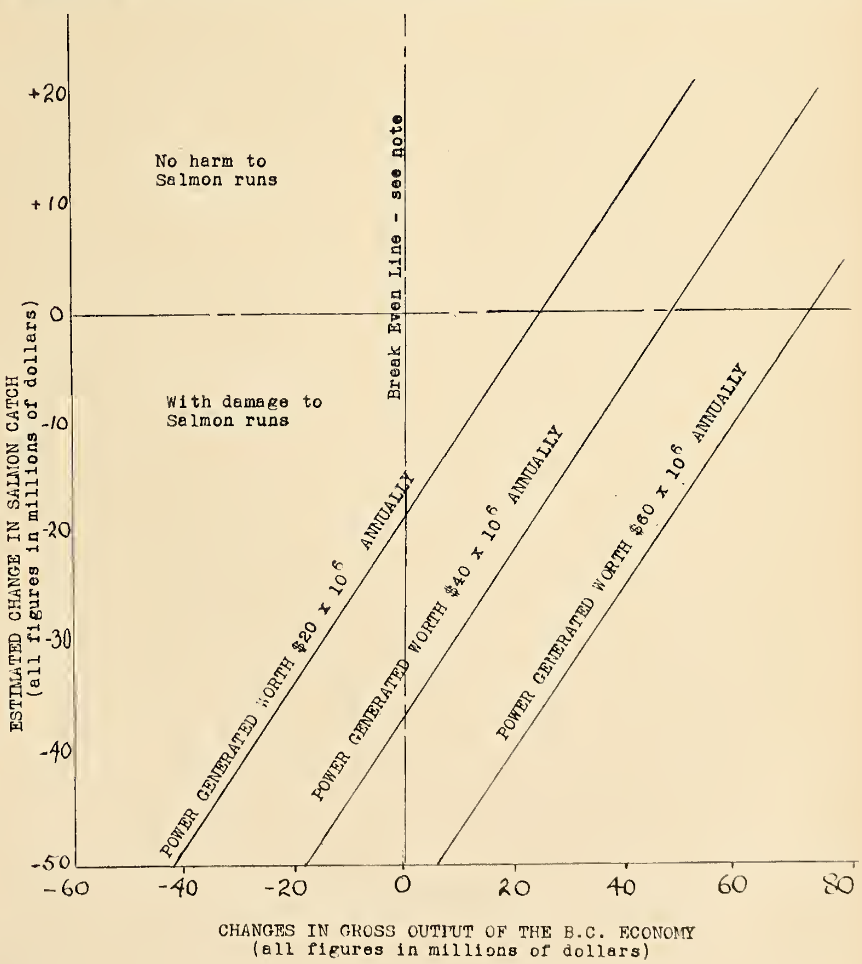
Perhaps it is desired to simulate the impact on the economy of expanding a given industry. For instance it might well be advantageous to consider the extent to which the availability of pig iron and ultimately steel from the new Consolidated Mining and Smelting operation would stimulate secondary manufacturing in B.C. One way of doing this is to assume that the total output proposed for 1963 will be sold. Final demand for this output is most likely to take the form of exports of pig iron, sheet and structural steel destined for the U.S. and other western Canadian provinces. In addition, such production would replace domestic and foreign imports of steel products into B.C. Thus the final demand of the iron and steel products industry would be increased accordingly, by some $15 million. Again our matrix multiplication of Equation (5), shows the result—gross provincial manufacturing output is increased by $19 million.

Yet another industrial development problem could be evaluated. That is, for a long term goal of reducing secondary imports of iron and steel products by $100 million, at what levels would the various industries have to operate? The answer is shown in Table 3.

One of the most controversial development problems in B.C. involves the alternative of building power generating plants on the Fraser River or reserving it solely for the salmon fishing industry. In a macro-economic fashion various proposals can be evaluated with the model. Consider the possibility of locating a power dam 130 miles upstream from Vancouver. From a pessimistic viewpoint it may be assumed that all the North Fraser salmon runs would be destroyed. A guess of the loss might be that since Fraser River salmon amounted to 65% of the total 1956 pack and of this figure 77% came from the North Fraser a figure of $22 million is reasonable. The construction cost of the power project would be of the order of $160 million. It would take about four years to complete and would generate some $20 million worth of power annually, assuming costs of 3 mills/kwh.

Commencing four years after the start of construction, the salmon run

Fig. 2. Power Generation on the Fraser River—Its Effect on Gross B.C. Industrial Production, with break even points for developing power and/or salmon on the Fraser River.



would begin to be affected if the runs were to be damaged. If the North Fraser run was destroyed, the loss would be $22 million. However, biologists suggest downstream changes might affect the Thompson River salmon runs. This might increase losses by a further $8 million annually. Should the North Fraser runs be capable of further rehabilitation and utilization as in recent years the loss due to forsaking this increase might be a further cost of $15 million. On the other hand, power development might not affect the salmon runs at all. Then the effect of their compatible development can be evaluated. Also the effect of generating larger blocks of power may be considered. All these possibilities may then be considered as shown in Fig. 2.

It is also possible to optimize the model. One criterion possible is the maximization of the value added during production. Such an analysis would then show the industries to be expanded and the extent of their development required to achieve the above goal. This could be done for any desired level of gross production. In terms of matrix algebra the problem may be stated as follows:

$$\text{Maximize } CX$$

$$\text{Subject to } \begin{aligned} (I - A)X + W &= D \\ X + U &= L \\ X &\geq 0 \end{aligned}$$

where

C = a row vector where each C_i is the net value added per dollar of output for industry i.

X = the production vector consisting of the outputs of the individual industries.

$(I - A)$ = the Leontief matrix of input-output technical coefficients.

W = a column vector of slack variables showing the amount by which any industry would be unable to satisfy demand for its production.

D = predicted final demand.

L = the capacity of the individual industries.

U = the amount of any industry's unused capacity.

Such a problem can be solved using the simplex method of linear programming. The magnitude of the problem for the B.C. model is such that it is not feasible to solve it manually. However, a digital computer such as the ALWAC III-E of the University of British Columbia can readily be programmed for this purpose. The input data can be punched in several hours. The machine's elapsed running time would be about one hour at a charge of some $40. Consequently, various optimal industrial development goals can be evaluated for several hundred dollars.

Should the inputs to individual industries be considered more important, such as would occur if certain resources were scarce, the dual of the above problem may be optimized. In this way the amounts of individual resources, labor content, profit, government revenue, etc., may be imputed. For the lack of adequate statistical data it has so far been impossible to prepare the necessary vector for charges against final demand which would permit computations of this sort. It is hoped that this work can be undertaken shortly.

Conclusion

From the foregoing discussion the value of Leontief Input-Output Analysis for industrial development purposes can hardly be questioned. However, there is considerable room for debate with regard to the validity of the model presented here.

For this reason it is of paramount importance to emphasize that the simulation is for purposes of macroscopic analysis. Detailed analysis must follow the preliminary findings revealed by manipulating the model. If it is used in this fashion inter-industry analysis is a valuable first approach to many of the problems of industry.

Some persons will undoubtedly desire a more accurate model, even for macroscopic analysis. The work entailed in this can be monumental. A simple aggregate model (20 × 20) can be prepared and tested in about one or two man years. The 450 interindustry study done by the United States at enormous cost was scrapped some years ago by the then new administration anxious to reduce government spending. Since then, with the value of the model clearly demonstrated, regional analysis or industry analysis has developed. The reason is that regions or industries can be more readily isolated and models for them prepared for more reasonable sums.

APPENDIX I

Fig. A

Dollar Value of Transactions Between the Five Sectors of an Assumed Economy

Producing Sectors	*Purchasing Sectors* 1	*2*	*3*	*4*	*Final Demand*	*Gross Production*
1	8	4	30	24	34	100
2	20	10	30	12	128	200
3	15	60	15	50	160	300
4	11	24	42	14	109	200
Charge against Final Demand	46	102	183	100	69	500
Total Input	100	200	300	200	500	—

Fig. B

Direct Purchases Per Dollar of Gross Output

(MATRIX A)

Producing Sectors	*Purchasing Sectors* 1	*2*	*3*	*4*
1	0.08	0.02	0.10	0.12
2	0.20	0.05	0.10	0.06
3	0.15	0.30	0.05	0.25
4	0.11	0.12	0.14	0.07

Fig. C

MATRIX (I-A)

0.92	−0.02	−0.10	−0.12
−0.20	0.95	−0.10	−0.06
−0.15	−0.30	0.95	−0.25
−0.11	−0.12	−0.14	0.93

Fig. D

INVERSE MATRIX $(I\text{-}A)^{-1}$

1.159	0.101	0.162	0.200
0.294	1.133	0.173	0.158
0.335	0.433	1.191	0.391
0.225	0.223	0.221	1.178

Fig. E

Schedule of Final Demand & Gross Production

Producing Sectors	*Final Demand*	*Gross Production*
	From Figure A	
1	34	100
2	128	200
3	160	300
4	109	200
	Forecast	
1	40	X_1'
2	120	X_2'
3	180	X_3'
4	130	X_4'

Fig. F

Forecast Gross Production (From Equation (5))

Sector	*Gross Production*
1	$X_1' = 111.64$
2	$X_2' = 197.82$
3	$X_3' = 326.66$
4	$X_4' = 216.90$
	$\Sigma X' = 853.02$

APPENDIX II

Industries from 1949 Canadian Interindustry Table Aggregated into Industries for B.C. Table

No. in D.B.S. Table	*No. in B. C. Table*	*Industry Name*
1	1	Agriculture
2	9	Forestry
3	2	Fishing & Hunting & Trapping
4	14	Metal mining, smelting and refining
5	17	Coal mining, crude petroleum & natural gas
6	16	Non-metal mining, quarrying and prospecting
7	3	Meat products
8	3	Dairy Products
9	2	Fish Processing
10	3	Fruit and vegetable preparations
11	1	Grain mill products
12	3	Bakery products
13	3	Carbohydrated beverages
14	3	Alcoholic beverages
15	3	Confectionery and sugar refining
16	3	Miscellaneous food preparations
17	19	Tobacco and tobacco products
18	4	Rubber products
19	5	Leather products
20	7	Textile products
21	8	Clothing
22	9	Furniture
23	9	Wood Products
24	10	Paper Products
25	11	Printing and Publishing
26	12	Primary iron and steel
27	12	Agricultural implements
28	12	Iron and steel products
29	13	Transportation equipment
30	19	Jewellery and silverware
31	14	Non-ferrous metal products
32	15	Electrical apparatus
33	16	Non-metallic mineral products
34	17	Products of petroleum and coal
35	18	Chemicals and allied products
36	19	Miscellaneous manufacturing industries
37	21	Construction (new and repair)
38	20	Transportation, storage and trade
39	22	Communication
40	17	Electric power, gas & water utilities
41	22	Finance, insurance, and real estate
42	22	Service industries
43	22	Unallocated
44	26 & 27	Imports of goods & services
45		Indirect taxes on imports
46	24	Indirect taxes less subsidies on domestic goods
47		Sub-total rows 1—46
48	23	Wages and Salaries
49		Investment income
50	23	Net income of unincorporated business
51		Capital consumption allowances
52	28	Gross domestic product a factor cost (rows 48—51)
53		Gross input
54		Gross input less intra-industry consumption

List of Industries in B.C. Interindustry Table

Number in B.C. Table	*Industry Name*	
1	Agriculture	
2	Fisheries	
3	Food and Beverages	
4	Rubber Products	
5	Leather Products	
6	Textiles	Textiles and Knitting
7	Knitting Mills	
8	Clothing	
9	Wood Products	
10	Pulp and Paper	
11	Printing and Publishing	
12	Iron & Steel Products	
13	Transportation Equipment	
14	Non-ferrous Metals	
15	Electrical Apparatus	
16	Non-metallic Minerals	
17	Electricity, Petroleum and Coal	
18	Chemicals	
19	Miscellaneous Manufactures	
20	Transportation	
21	Construction	
22	Unallocated	
23	Households	Final Demand
24	Government	
25	Inventory change	
26	Foreign exports	
27	Domestic Exports	
28	Gross Output	

APPENDIX III

The Inverse Matrix $(I-A)^{-1}$
(with intra industry transactions deleted)

from aggregated 1949 Canadian data

SOURCE: — D. B. S., Supplement to reference paper No. 72.

1.0038	0.0031	0.3803	0.0040	0.0499	0.0058	0.0068	0.0198	0.0230	0.0056	0.0009	0.0019	0.0018	0.0017	0.0033	0.0012	0.0517	0.1480	0.0022	0.0057
0.0014	1.0000	0.0015	0.0001	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0002	0.0000	0.0000
0.0060	0.0001	1.0025	0.0014	0.0431	0.0017	0.0006	0.0005	0.0010	0.0005	0.0002	0.0003	0.0004	0.0003	0.0012	0.0002	0.0196	0.0016	0.0001	0.0007
0.0081	0.0035	0.0052	1.0010	0.0083	0.0023	0.0018	0.0019	0.0018	0.0013	0.0067	0.0214	0.0025	0.0045	0.0031	0.0030	0.0021	0.0032	0.0039	0.0039
0.0005	0.0001	0.0003	0.0037	1.0001	0.0017	0.0006	0.0009	0.0012	0.0003	0.0005	0.0010	0.0001	0.0001	0.0001	0.0001	0.0001	0.0025	0.0003	0.0002
0.0084	0.0206	0.0049	0.1257	0.0133	1.0008	0.3037	0.0180	0.0137	0.0030	0.0021	0.0105	0.0018	0.0078	0.0044	0.0009	0.0034	0.0063	0.0026	0.0038
0.0001	0.0002	0.0002	0.0023	0.0132	0.0001	1.0001	0.0001	0.0002	0.0001	0.0001	0.0039	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0007	0.0002
0.0069	0.0123	0.0123	0.0056	0.0222	0.0076	0.0052	1.0042	0.2299	0.0466	0.0130	0.0132	0.0145	0.0202	0.0149	0.0111	0.0175	0.0171	0.0142	0.1044
0.0098	0.0057	0.0296	0.0126	0.0171	0.0127	0.0109	0.0043	1.0038	0.1980	0.0059	0.0056	0.0032	0.0099	0.0208	0.0050	0.0272	0.0314	0.0124	0.0254
0.0021	0.0029	0.0048	0.0040	0.0040	0.0021	0.0040	0.0021	0.0037	1.0013	0.0024	0.0019	0.0024	0.0030	0.0029	0.0029	0.0052	0.0044	0.0087	0.0037
0.0220	0.0428	0.0306	0.0155	0.0251	0.0084	0.0050	0.0316	0.0211	0.0070	1.0053	0.1193	0.0228	0.0491	0.0235	0.0126	0.0228	0.0122	0.0131	0.1000
0.0122	0.0227	0.0124	0.0099	0.0077	0.0075	0.0049	0.0138	0.0190	0.0071	0.0130	1.0044	0.0189	0.0098	0.0303	0.0098	0.0130	0.0084	0.0263	0.0160
0.0020	0.0024	0.0025	0.0025	0.0015	0.0017	0.0011	0.0052	0.0072	0.0021	0.0203	0.0189	1.0023	0.0795	0.0039	0.0045	0.0097	0.0316	0.0035	0.0302
0.0027	0.0039	0.0042	0.0066	0.0038	0.0051	0.0031	0.0048	0.0122	0.0042	0.0105	0.0315	0.0098	1.0023	0.0127	0.0104	0.0079	0.0040	0.0048	0.0352
0.0031	0.0062	0.0093	0.0024	0.0027	0.0018	0.0010	0.0016	0.0090	0.0025	0.0074	0.0084	0.0068	0.0061	1.0018	0.0029	0.0169	0.0021	0.0046	0.0512
0.0555	0.0482	0.0434	0.0295	0.0191	0.0174	0.0115	0.0335	0.0578	0.0269	0.0568	0.0267	0.0629	0.0236	0.0709	1.0051	0.0600	0.0305	0.0298	0.0365
0.0220	0.0040	0.0178	0.0540	0.0066	0.0202	0.0087	0.0089	0.0169	0.0200	0.0064	0.0114	0.0190	0.0144	0.0112	0.0118	1.0036	0.0168	0.0041	0.0311
0.0008	0.0131	0.0012	0.0011	0.0012	0.0008	0.0064	0.0009	0.0011	0.0011	0.0009	0.0055	0.0007	0.0022	0.0013	0.0011	0.0013	1.0006	0.0050	0.0032
0.1208	0.1147	0.1572	0.0732	0.1057	0.0533	0.0500	0.1008	0.1030	0.0708	0.0871	0.0734	0.0824	0.0741	0.0905	0.0745	0.1060	0.0927	1.0164	0.1935
0.0293	0.0111	0.0219	0.0095	0.0115	0.0107	0.0079	0.0186	0.0195	0.0109	0.0170	0.0114	0.0179	0.0106	0.0173	0.0356	0.0162	0.0136	0.0480	1.0139

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The Use of an Electronic Analog Computer for Determining Optimum Settings of Speed Governors for Hydro Generating Units

L. M. Hovey, M.E.I.C.
Consulting Engineer,
The Manitoba Hydro-Electric Board, Winnipeg

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THE Manitoba Hydro-Electric Board recently purchased a small nine-element electronic analog computer to demonstrate the usefulness of such a tool in solving the more difficult differential equations which are encountered in power system analysis, such as the performance of speed governors, generator voltage regulators and transient phenomena. This particular computer is much too limited for handling more complicated problems, but has proved very helpful in demonstrating the application of such a computer and familiarizing engineers in the technique of setting up a larger computer of this type for the solution of dynamic problems.

This computer, however, has been put to useful purposes in solving the performance of speed governors controlling hydraulic turbines where speed, head, and gate transients for various changes in governor parameters can be easily portrayed on a cathode ray oscilloscope or X-Y graphic recorder.

For purposes of this paper the computer will be described and demonstrated in solving the three simultaneous differential equations which represent the performance of a hydro turbine and governor when subjected to a load change.

The electronic analog computer which will be described consists of nine operational d.c. voltage amplifiers which can be connected to perform the following functions:

(1) Adding or subtracting
(2) Sign changing
(3) Multiplying by a constant >1
(4) Multiplying by a constant <1
(5) Integrating.

In solving a differential equation on the computer, the disturbing function is injected into the device in the form of a voltage and the solution as a function of time appears at the various outputs, also as a voltage proportional to the instantaneous values of the variables. Also included in the computer are several voltage sources to impose initial conditions for the complete solution of a particular equation. The basic element as used and the symbol used to designate each element is shown in Fig. 1.

To describe how the computer would be used to solve a simple first order differential equation, let us examine the familiar equation of current rise in an inductance resistance circuit when a d.c. voltage is applied. See Fig. 2 for the application of the computer for determining the current as a function of time. In Fig. 3 the computer is set up for the solution of a familiar second order differential equation where two initial conditions have to be taken into consideration.

To obtain a record of the solutions as obtained from the computer a Leeds and Northrup X-Y recorder is used. This instrument is actuated by voltage for both the X and Y motions and the chart displacement is taken as the Y axis and the pen taken as the X axis for recording the trace of the variable function.

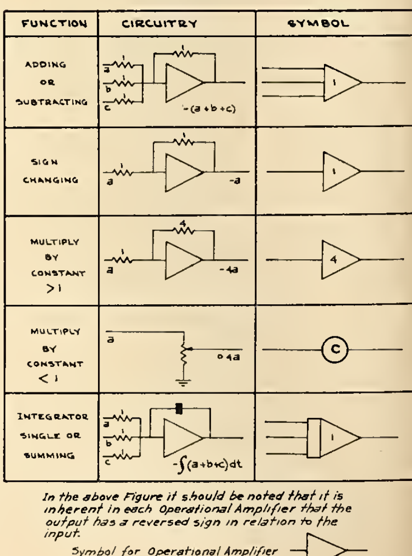
When the recorder is plotting the transient, the uniform time travel of the chart is supplied by the output voltage of one of the computer amplifiers connected as an integrator. See Fig. 4 showing how this amplifier is used for the above purpose. Fig. 5 shows a photograph of the computer and X-Y recorder combination.

As indicated previously, the computer has been used to determine the response characteristics of a hydro governor and assist in assessing the optimum response for purposes of setting the correct parameters into the governor.

In a paper describing governor adjustment on The Manitoba Hydro-Electric Board plants given at the Engineering Institute meeting last spring, the author developed the main differential equations for governing an hydraulic turbine and described how the parameters were obtained for chosen optimum conditions and how these were measured and applied to the actual machine.

In this paper the author will elaborate a little further on the mathematics of governing indicating the effect of load damping and how this effect tends to further stabilize the machine. A

Fig. 1. Symbols for Analog Computer



In the above Figure it should be noted that it is inherent in each Operational Amplifier that the output has a reversed sign in relation to the input.

Symbol for Operational Amplifier

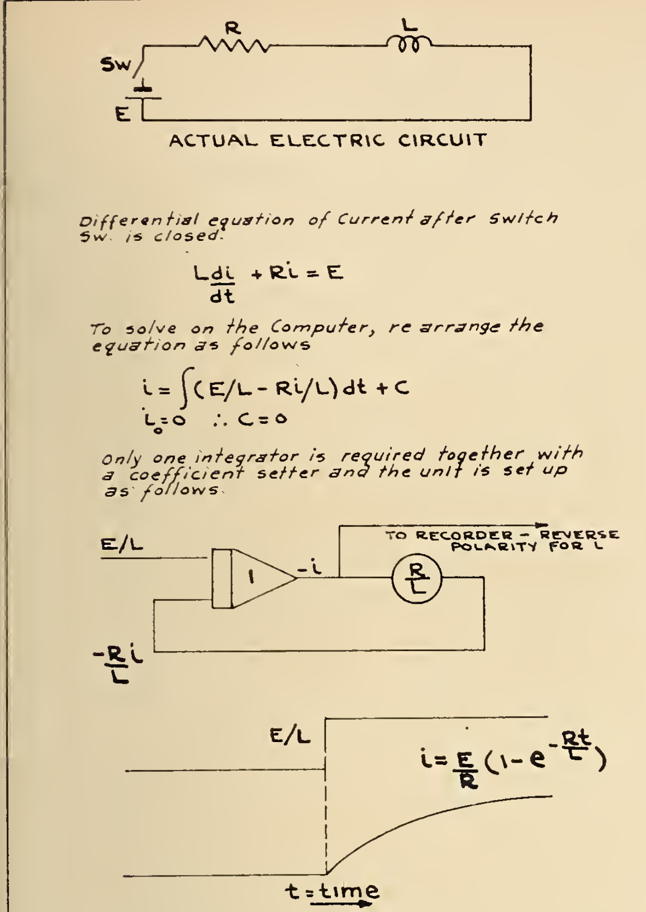


Fig. 2. Solution of simple differential equation on computer

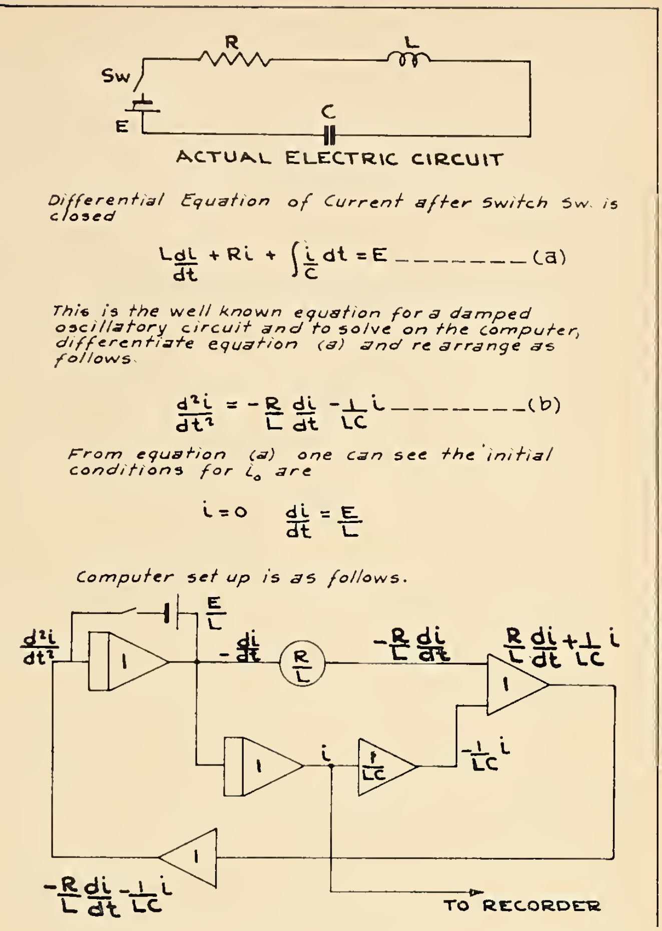


Fig. 3. Solution of second order differential equation

demonstration will be carried out on the computer showing the comparison of response with and without the effect of damping.

In the preceding paper, the following governor equations were developed.

Machine Acceleration

$$Tm \frac{dn}{dt} = g + 1.5h - \Delta m \qquad (1)$$

Water Acceleration

$$-\frac{Tw}{2}\frac{dh}{dt} = Tw\frac{dg}{dt} + h \qquad (2)$$

Governor Response

$$-\delta Tr \frac{dg}{dt} = Tr\frac{dn}{dt} + n \qquad (3)$$

When a machine is connected to a system having a composite load of motors, resistance, etc., the turbine net shaft torque for acceleration purposes is also a function of the speed change. This characteristic is affected by the type of motor load such as pumping, blowers, or pulp grinders. Fig. 6 shows the approximate shape of these characteristics and the effect on net damping where the linearized co-efficient of net damping is taken as α for small load and speed changes.

Fig. 4. Showing how integrator is used to provide for a uniform time scale for 'y' axis of 'xy' recorder

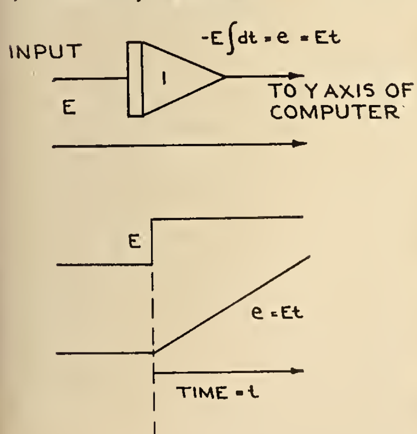
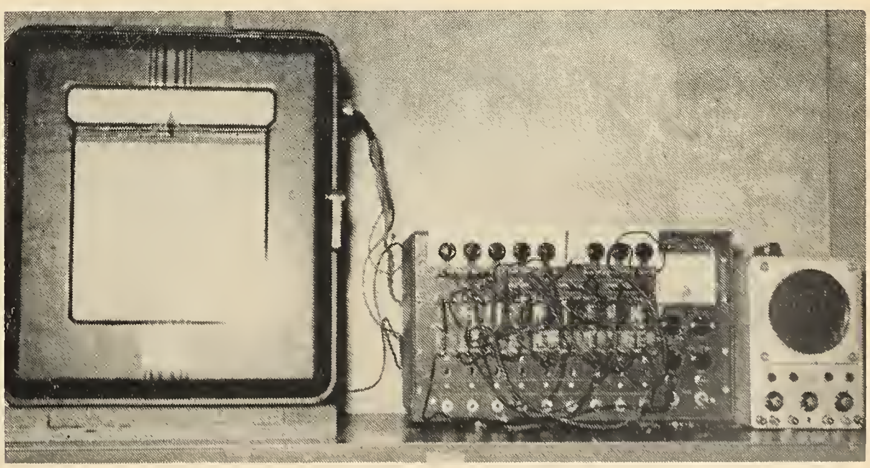


Fig. 5. Showing photograph of computor and X-Y recorder



Equation (1) can now be rewritten to include the effect of α.

$$Tm\frac{dn}{dt} = g + 1.5h - \alpha n - \Delta m \qquad (1a)$$

By eliminating g and h the following differential equation of n with and without damping become respectively

$$0.5\delta TrTmTw\frac{d^3n}{dt^3} + (\delta TrTm - TwTr)\frac{d^2n}{dt^2} + (Tr - Tw)\frac{dn}{dt} + n = 0$$

$$0.5\delta TrTmTw\frac{d^3n}{dt^3} + (\delta TrTm - TwTr + 0.5\delta TrTw\alpha) \times \frac{d^2n}{dt^2} + (Tr - Tw + \delta Tr\alpha) \times \frac{dn}{dt} + n = 0$$

In examining the latter equation it is seen that the effect of damping makes the two middle terms more positive and therefore assists in maintaining stability. Consequently, it is possible to reduce Tr after a machine is connected to a system with damping and still have stability together with better speed regulation and better response to signals from tie line load controllers.

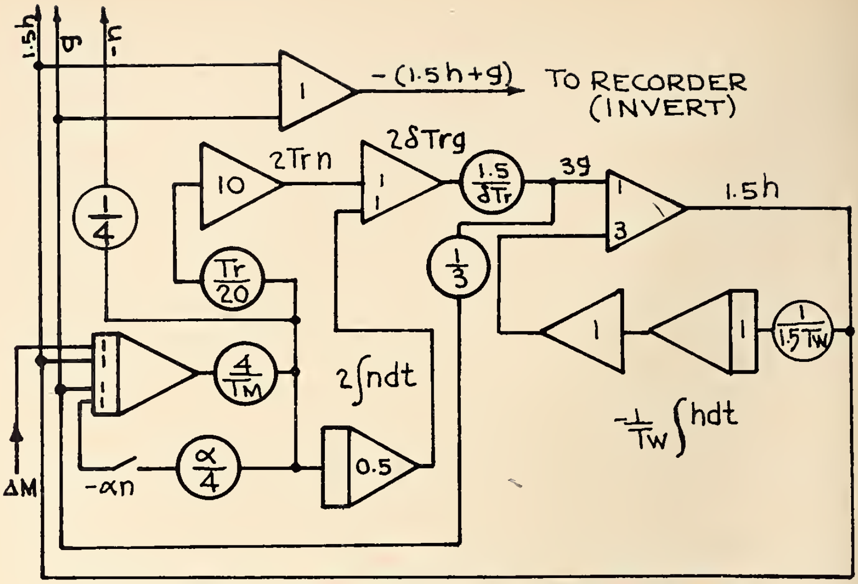


Fig. 7. Showing computer circuit for solving governor equations.

Machine Acceleration without Load Damping $TM\frac{dn}{dt} = g + 1.5h - \Delta M$ (1)

Machine Acceleration including Load Damping $TM\frac{dn}{dt} = g + 1.5h - \alpha n - \Delta M$ (1a)

Water Acceleration $-0.5Tw\frac{dh}{dt} = Tw\frac{dg}{dt} + h$ (2)

Governor Response $-\delta Tr\frac{dg}{dt} = Tr\frac{dn}{dt} + n$ (3)

From (1) $n = \frac{1}{TM}\int(g + 1.5h - \Delta M)dt$

From (1a) $n = \frac{1}{TM}\int(g + 1.5h - \alpha n - \Delta M)dt$

From (2) $-h = 2g + \frac{2}{Tw}\int h dt$

From (3) $-g = \frac{1}{\delta}n + \frac{1}{\delta Tr}\int n dt$

In solving equations (1, 1a), (2) and (3) on the analog computer the elements are connected as shown in Fig. 7. Therefore, it can be seen that the three equations are solved simultaneously for n, g, h and these variables can all be delineated on the X-Y recorder chart. Since the speed transient of the average hydro unit lasts anywhere from 10 to 20 seconds it is possible to record these on a real time basis. In obtaining traces for all three variables the X-Y recorder chart is set in motion and as the pen crosses the time 0 reference line the step load change is initiated after which the n transient is recorded until it dies away. The chart now is wound back and the g output is connected to the recorder and the initial load function is inserted at the previous time 0 point. This same procedure is repeated for the h variable. To demonstrate the computer, traces will be shown of the analysis of three typical hydro plants of the Board using the selected optimum values of

$$\delta = \frac{2Tw}{Tm}, \quad Tr = 4Tw, \quad \alpha = 0. \qquad \text{(Fig. 8)}$$

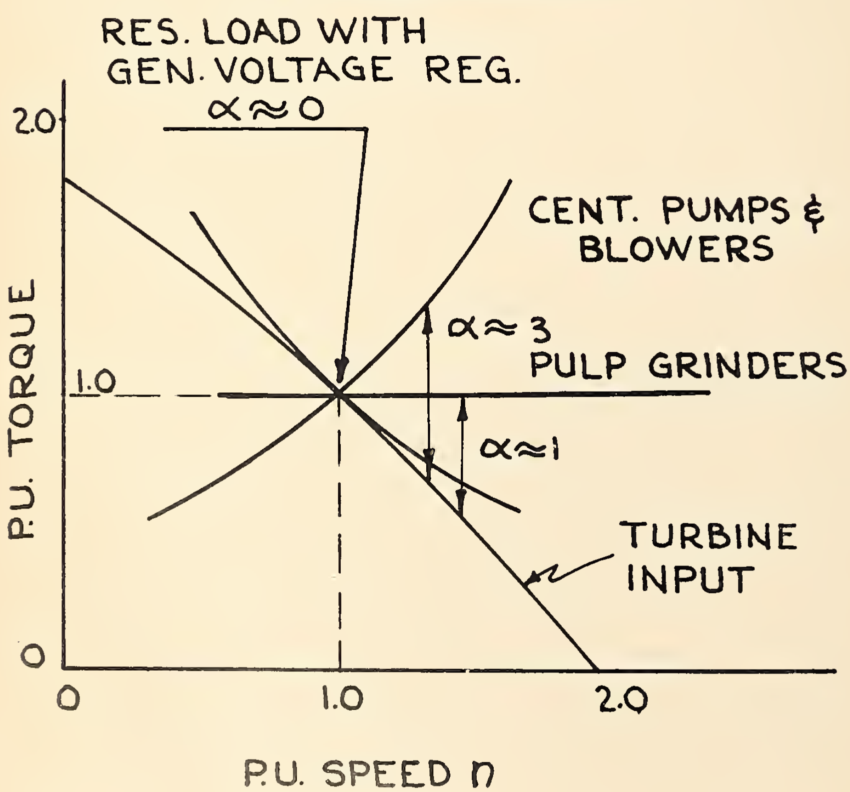
Curves will also be shown of the Kelsey plant assuming $\alpha = 1.0$ for $Tr = 4Tw$, $3Tw$, $2Tw$. (Fig. 9)

To demonstrate instability, a curve will be shown on Kelsey with $\alpha = 0$ and $Tr = 1.8Tw$. (Fig. 10)

For the above tests a Δm of -0.10 will be used. Table I indicates the computer settings for the above tests.

In examining the speed traces in Figs.

Fig. 6. Load damping characteristics



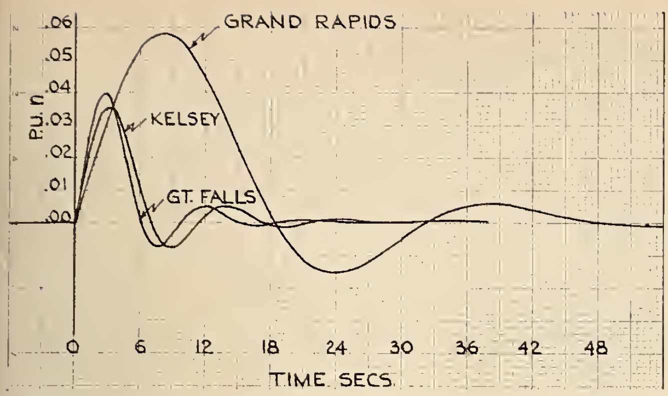


Fig. 8. Speed traces of three typical board stations ΔM=-0.10

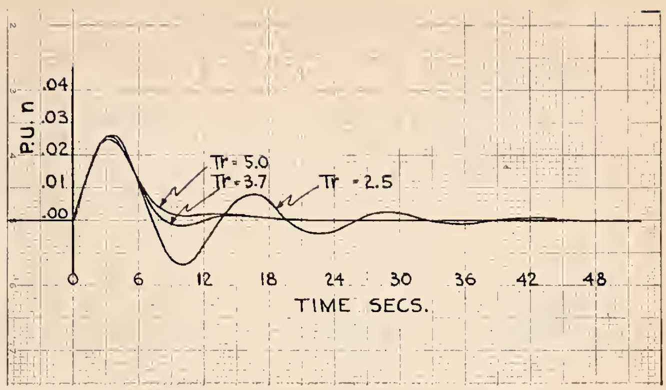


Fig. 9. Kelsey speed transients for α=1 and various values of Tr

TABLE I

Showing Parameters for Various Speed Transients

Type Test	*Station*	*Tm*	*Tw*	δ	*Tr*	α	*n*	1.5*h*	*g*	1.5*h* + *g*	*Fig. No.*
Optimum	Gt. Falls	5.10	0.85	0.333	3.4	0	√				8
Optimum	Kelsey	9.05	1.24	0.28	5.0	0	√				8
Optimum	Gr. Rapids	10.4	2.6	0.50	10.4	0	√				8
Damping	Kelsey	9.05	1.24	0.28	5.0	1.0	√				9
Damping	Kelsey	9.05	1.24	0.28	3.7	1.0	√				9
Damping	Kelsey	9.05	1.24	0.28	2.5	1.0	√				9
Instability	Kelsey	9.05	1.24	0.28	2.25	0	√				10
All four variables	Gr. Rapids	10.4	2.6	0.50	10.4	0	√	√	√	√	11

8, 9, 11, it can be seen that the higher the temporary droop δ is, the higher the speed excursions will be for a given load change, and the higher the water starting time *Tw* the longer will it take for the speed transient to die out. This points up the desirability of having as low *Tw* as possible and means that we should strive for as low *Tw* and high *Tm* as economically possible.

Examining Fig. 11, the phenomenon of increased turbine torque due to increased head (1.5*h*) resulting from gate closure is plainly seen. To more clearly bring out the net effect of increased input torque due to gate closure, the two variables 1.5*h* and *g* are summed and the trace on Fig. 11 of this variable shows a net increase in turbine torque initially which falls to zero in a few seconds and then goes negative.

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Fig. 10. Instability Kelsey

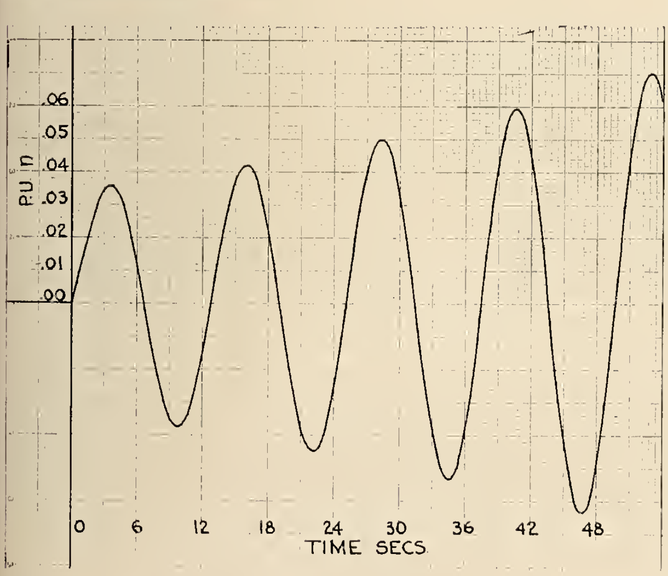
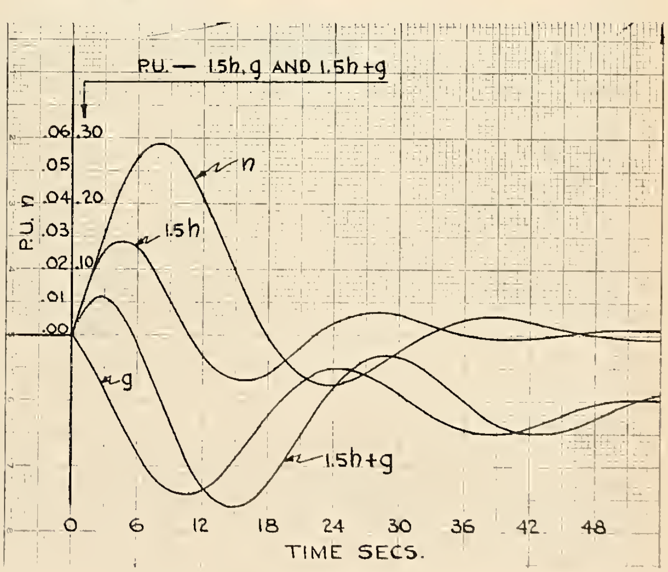


Fig. 11. Grand Rapids traces of n, 1.5 h, g and 1.5 h+g for ΔM=-0.10 P.U.



Discussion

ECONOMIC DEVELOPMENT OF HYDRO-QUEBEC POWER RESOURCES

Systems Studies Utilizing an IBM 704 Computer

J. Bourbeau, M.E.I.C.,
Quebec Hydro Electric Commission,
F. H. Jonker and J. G. S. Thomson,
H. G. Acres & Company Limited

The Engineering Journal, October 1961 page 72

Discussion by P. J. Croft, M.E.I.C.

The authors are to be congratulated on an interesting and timely presentation illustrating the use of the computer for solving a complex problem of the economical development and sequencing of hydro power resources. The problem of determining the economic sequence and the capacity factors for a multi-plant development on a river system is one with which most hydro utilities have at one time or another been concerned and the paper illustrates clearly that this particular problem is one to which modern electronic digital computers may gainfully be applied. Once the program has been written, alternatives and the effect and importance of numerous variables in such alternatives may readily be ascertained and a more comprehensive treatment of any can then be undertaken with smaller requirements in engineering manpower.

Treatment is of a somewhat general nature as must probably be the case in handling such a subject for general consumption and within the length requirements of a conference type paper. Nevertheless, the authors have set out quite clearly the principal parameters of the problem and by means of the computer flow-sheet provided as an appendix, have indicated quite clearly the sequence of operations leading to the desired results.

The method of "stacking" the various possible developments under a load duration curve in descending order of capacity factors, with the baseload plants at the foot of the diagram, is one which has been well-known to utility engineers for many years. Use of a large electronic computer permits the detailed examination of a great complexity of alternatives.

The paper is a welcome addition to the existing literature on the application of digital computers to public utility problems. At the present time it is of particular interest to readers close to the power picture in British Columbia as the problem dealt with in the paper, is parallel in many ways to a situation existing in this Western Province, though with numerous important differences. In British Columbia, the largest and most important load centre has its own nearby generating sources and those proposed for future addition are remote by several hundred miles of transmission from the main load centre. However, unlike the Quebec situation, the nearby generating sources do not consist of run-of-river hydro plants and thermal generation may figure somewhat more importantly in future local plants.

It is generally well known that there exists between the remote Manicouagan, Outarde, and Bersimis plants and the Montreal load centre a very considerable generating and transmission system belonging to others, with which the Quebec-Hydro has interconnections and it is also common knowledge that interconnections exist between the Quebec-Hydro system and the Ontario network to the West. No mention is made of these interconnections in the paper, nor does the computer flow sheet indicate that they were taken into consideration. Is it to be assumed that the self-sufficiency of the Quebec Hydro's present and future plants alone was being investigated, irrespective of such interconnections?

While the paper does not attempt to go into details of computer operation, the inclusion of a selection of the feed-in data cards and the print-out sheets would have been interesting as additional exhibits. Further, it would be interesting if during discussion the authors could say a few words regarding the engineering man-hours involved in the programming effort for this very fine computer application.

Discussion by H. Teekman

Hydro-Quebec's study of development of hydraulic sites on the Manicouagan and Outardes rivers is of interest to Ontario Hydro because of the comparison which can be made between it and the study of our undeveloped sites on the Moose River System in Northeastern Ontario.

Hydro-Quebec appears to be fortunate in having a substantial storage potential at Manicouagan 5, and large storages also at Manicouagan 3 and 2. Nonetheless, the output data given indicates that flood spillage and demand spillage may occur under some periods of the alternative development schemes studied. Could the authors describe the circumstances that give rise to these spillages? Are they confined to the construction period during which the plants are being developed, or are they expected to continue after the full development is completed?

Unless the available economic storage is sufficient to control flow completely, there would appear to be a possible inter-relation between the economics of development of storage capacity and of developing generating capacity at the storage dam and at downstream plants. Could the authors describe how the complex problem of optimizing the storage capacities was handled? What criteria were used to set the economic limits of development of storages and generating capacities — estimated revenues, estimated costs of future hydraulic sites, or future thermal plants? Will initial provision be made for the later installation of additional units?

The paper states that the study was based on monthly flows in an average water year, a low water year, and a high water year for the St. Lawrence and Ottawa rivers; but it does not state that flows corresponding to these were employed for the Bersimis, Outardes and Manicouagan rivers. Were similar flows used for these rivers, or was the analysis arranged to account for the complete range of inflow conditions on them? In this same connection, it would be of interest to learn the manner in which the low water year was selected.

The simplified computer flow sheet given in the Appendix to the paper indicates an unique sequence in use of storage, i.e. Bersimis 1, Outardes Mile 58, Lake St. Anne, Manicouagan 5. Are there no circumstances under which this procedure would lead to unbalance of the reservoirs, i.e. Bersimis or Outardes partially emptied, while water spill from Lake St. Anne or Manicouagan 5?

Although the paper does not deal specifically with the transmission required to incorporate into the system the output from the proposed sites, it would be of general interest to learn in what way the choice of transmission voltage from the Outardes and Manicouagan sites might be affected by the voltage of the existing transmission from Bersimis, and by the possible development of other sites in Quebec and Labrador.

Ontario Hydro's analysis of its Moose River System sites presents the major differences from Hydro-Quebec study:

(1) The sites will contribute only a small part of the total energy production on the system.
(2) There are very limited opportunities for economic storage development at the generating sites, and at upstream reservoirs. As a consequence, the regulated flow will vary through wide ranges. This adds to the value of increasing the installed capacity, and eliminates the complex problem of coincidentally optimizing both storage capacity and generating capacity.
(3) A large component of future generation will be thermal.
(4) Within a relatively few years, the entire hydraulic energy output will replace fossil or nuclear fuels, regardless of flow conditions.

As a consequence, the analysis can be more readily made, it being considered adequate to check energy balance under adverse water conditions in order to study alternative programs of development, and to base the economic analysis upon peak capacity and average energy output using estimated costs of future conventional and nuclear thermal capacity to form the basic cost criteria. The study being relatively simple, it was unnecessary to do it with a computer.

Discussion by L. A. Bateman

The authors of this paper have dealt with a subject of importance to all utility people in that the emphasis being placed on forward planning and scale model operation of complex hydro and hydro-thermal systems is an increasingly important subject to utility planning and operating people. The paper is easily read and follows a descriptive tone of light reading but underlying is a description of techniques being introduced to the planner which requires very careful consideration and thoughtful review.

I shall attempt to outline some of the areas I believe the authors have fallen short of their task and also point out some of the lighter areas which could have been enhanced by a more realistic approach, as for example, the description of the system. The present interconnected system should take cognizance of the availability of additional capacity and perhaps energy from neighboring utilities. Most utility people and certainly H. G. Acres & Company have been interested in interconnections between adjacent utilities and have pointed out the advantages of such interconnections.

All through the paper no mention has been made of the advantages that could be derived from interconnection with adjacent utilities, both for energy and capacity. This, I feel, is one of the areas the authors might still comment on.

There are other areas in which description is lacking, for instance, Manicouagan River storage "third largest in the world" is not sufficient. The author should tell us approximately how many acre feet are involved. This follows for several other references throughout the paper.

The authors state that the incremental cost of transmission is decreasing the economic advantage. While this statement is certainly true, I fail to see where this and other statements are dealt with quantitatively in the paper.

I feel that some exception should be taken with items listed as principal variables and the items listed as secondary variables in this paper. For example, I would think as we have found in some of our studies in the Manitoba Hydro, that the difference in interest rate on projects could have a major bearing upon the sequence of development. I would list as the principal variables:

the difference in storage capacity,
the difference in load growth and the inter-action with other systems, and
the differences in interest rate.

I also wonder in view of the large storage capacities dealt with, that it was possible to use only three typical flow years instead of some historical series of many years in order to find optimum storage ranges and rule curves.

In the Quebec System there is virtually no thermal generation. Hence, the flow regulation studies are only concerned with producing the power, that is, dependable flow is important (this can only be ascertained by reservoir operation by rule curve throughout the entire period of record and not by typical flow years as indicated was used).

The authors do not outline the method of system operation to the extent that one can follow the procedure, but based on a general understanding of the system and the problem being developed in this paper, I would think that the energy to be produced in any one year is fixed by the shape of the load curve. Hence, the spillage is fixed and the criterion of economic operation is lowest annual cost. Storage is only needed to provide prime power. I assume that the spillage incurred is that which is required to meet capacity requirements rather than energy requirements. Hence, the concept of using the average water year etcetera, is a debatable concept.

The problem in the operation of a system with multi-reservoirs and downstream plants is one of scheduling the discharge from reservoirs so that the capacity installed at the various plants will meet the shape of the load curve on a daily, a weekly, and perhaps even a monthly basis. This, I believe, is the fundamental that is being attempted in the computer program, and system model, under discussion in this paper.

This basic concept then requires a knowledge of the critical periods of records of flow, the time factors involved in stream flow conditions, and the expected variations in load year and the growth of load that the system must be expected to cope with. Under conditions of close scheduling of water from these reservoirs the impact of interconnections with adjacent utilities cannot be underemphasized.

The computer program has attempted to show that the system represented as a model is being operated by rule curves. However, I do not agree that this is the case. It would appear to me that this model has made use of the typical water year instead of the record of flow which would be more significant in determining whether the model would meet the load requirements in the worst water year of record.

Some concluding remarks on costs. It would appear to me that the processing of cost data in the program is of doubtful merit. I think the engineer with his slide rule can interpret without excess time consumption, the computer program output, not involving costs, in a manner which would give him an opportunity to assess more than one of the factors that go into the recommended sequence of development. Normally one employs a computer to do a large number of repetitive computations to save time and reduce the tedious nature of the computations. In this program, I believe, the cost computations do not fall within this definition.

Discussion by V. R. Ruskin

I would like to congratulate the authors for their most illuminating paper in connection with applying computers to evaluating alternative utility system expansion plans in Quebec. I thought it might be interesting to compare their programs with others we have developed for this purpose in Western Canada.

The river systems we have to deal with in Western Canada are rather complex. They have a number of multi-cyclical storage reservoirs, special flow and flood control requirements independent of the particular monthly load requirements, as well as power shipped over interconnections from outside the river basin, and imports (or exports). Tailwater effects are very important, the power output of certain plants is less under high flow than under low flow conditions. There is no such thing as a "critical year" or "average year", rather there are several "critical periods" extending over several years. It is not possible to predict when the critical period will occur, nor can rule curves be determined for the various reservoirs without carrying out studies over a 20-year period of monthly flows or longer.

Before we could use a plant scheduling program of the type employed by the authors, we first had to develop a program to carry out these 20-year power studies, taking all the foregoing factors into account. This is an optimizing program which automatically re-regulates all reservoirs so that all power and flow requirements are met and so that spill is held to a minimum. The normal order of reservoir drawdown is automatically changed if water can be saved thereby. Figure 1 shows the sample print out which comes in three parts. Type 1 summarizes each month for the whole system. Types 2 and 3 provide the detailed information for each plant within the system. The key to the listing is as follows:

Type 1 Sheet

(a) IDNTFCTN—Number of study, year and month of flow record.
(b) REQD Q—Flow in cu. secs at specified point.
(c) REQD KW—Load forecast for system, including imports and exports.
(d) GENR KW—Energy produced by the hydro plants only.
(e) MAX KW—Maximum capacity available on river system, excluding outside power and imports. This total allows for the increased hydraulic losses at full gate, and for penstock and generator capacity limitations.
(f) LD FACTR—Monthly system load factor (d) ÷ (e)
(g) MWHR—System energy for month.
(h) HLT CODE—Halt codes print when some unusual operating condition is encountered at some or all reservoirs in the system. For example code 4.0 means that all reservoirs at upper limit and there is a generation surplus.

Type 2 Sheet (handles up to 18 different plants)

(a) IDNTFCTN—As in (a) above, with a two-digit plant count added to the beginning of the word.
(b) PLANT—Plant Name
(c) CODE—These are halt codes at individual plants similar to the system halt codes described above.
(d) Q UP—Release entering reservoir or forebay from upstream plants, in cfs-months.
(c) Q INCRM—Incremental flow entering the reservoir or forebay, in cfs-months.
(f) Q STOR—Amount added to or removed from storage during the month, in cfs-months. Negative sign indicate a draft, plus a refil.
(g) FINL VOL—End-of-month reservoir volume, millions of acre-feet.
(h) FINAL EL—End-of-month reservoir elevation, in feet.
(i) AVG ELEV—Average reservoir elevation during month, in feet.

Type 3 Sheet

(a) IDNTFCTN—Identification — same as for (a) in Type 2 Sheet.
(b) ELEV TW—Elevation of tailwater with current average total flow passing down tailrace, in feet.
(c) AVG N HD—Average net head on plant, allowing for penstock losses, assumed independent of flow for mean month regulation.
(d) Q PLANT—Average flow passing through plant, in cfs-months. Note that reservoir evaporation and seepage losses through the dam are taken into account in the program so that Q UP, Q INCR and Q STOR will not usually add up to Q PLANT etc. Seepage losses are returned to the river and will be added to Q UP of the next plant downstream.
(e) Q SPILL—Mean spill, cfs-months. Spill will not be permitted until plant cannot pass the available flow when running at maximum capacity all month, and the reservoir feeding the plant has reached its maximum permitted value.
(f) Q BYPASS—Average demand spill, cfs-months. Bypass valves are normally not permitted to open until the reservoir reaches its maximum rule-curve value.
(g) GENR MW—Average plant generation during the month, megawatts.
(h) MWH LF—Plant monthly energy.

The aforesaid program has allowed us to determine the critical period and optimum rule curves. Using these rule curves, we can then use a plant scheduling program which "stacks up" the plants for planning and also as an actual plant dispatch guide.

The program also tries to run units at best efficiency as far as possible. It uses full gate only if it is necessary to meet the peak load, or if the amount of water available requires full gate operation to avoid spill. The program schedules the hydro plants so that either the load curve is met, or in a combined hydro-thermal system, so that there is a uniform deficit throughout the month, which means flat base load dispatch of the steam plants. Figure 2 shows a sample print out. The load and generation duration curve is divided into 10 slices shown at the top of the print-out. The print-out shows the mode of dispatch and generation for each plant. For example, plant 8 should be run at 148.0 mw (full gate two units) for 13.92% of the time and at 59.23 MW (best efficiency 1 unit) for 86.08% of the time.

The order of stacking is not fixed but depends on (a) the expected flow at each plant during the month and (b) the actual reservoir level is as compared with the theoretical rule curve. For example, if the actual reservoir level is below the rule curve, the program will cut the plant generation and stack the plant higher up the load curve.

The print-out also shows reservoir elevations. Given a theoretical rule curve for a reservoir, it automatically recalculates an improved rule curve based on the actual water level at the time — hence it can be used to up-date plant scheduling on an operational basis every week or month.

Knowing the characteristics of the plants, and the method of dispatch to meet the load curve with the least amount of spill and with base load on the thermal plants (if any), it is frequently necessary to evaluate numerous alternative plans for system expansion. A sample print-out from a program developed for this purpose is shown in Figure 3. The input consists of the plant capital and operating costs, as well as the costs of the associated transmision, the fuel costs of thermal plants, the amount of export and import over interconnections, the rates of load growth to be considered reserve requirements, interest rate and initial base year. The output shows the energy costs in mills per kilowatt-hour for every year and the average, the additional plant investment in millions of dollars, the annual operating costs for fuel, and operation (includes interest, depreciation, operation and maintenance), and the credit or debit payments for power exports or imports. The present worth of the operating costs can be referred to any base year and the total costs for period are also given.

We have no criticisms whatsoever of the authors' programs, on the contrary, we believe that the authors and Quebec Hydro should be commended for their farsightedness in applying computers to solve complex system plans, which must be reviewed constantly and involve investments of millions of dollars. The only reason we gave some details of our own programs is to illustrate that different factors become important with each individual utility, and that one utility cannot simply copy the programs used by another.

Authors' Reply

The authors wish to thank P. J. Croft for the discussion which he has submitted and for his appreciation of the form in which the computer program has been set up.

With regard to the question concerning the existing interconnections with other systems, these are at present handled by including the power and energy exchanges in the forecast. In the future, more complex problems of interconnection and appreciation of their economic aspects can be achieved by modification of the present computer program. Separate and parallel studies of transmission networks are also being made to ensure the proper integration of the new plants with the existing system. In these studies, system reliability is also taken into account.

Concerning the method in which input data is handled, a typical sequence input sheet is presented herewith. The ways in which the principal variables are handled may be noted. The whole of the characteristics of a sequence being tested, and the conditions to which the sequence is to be subjected, are contained in the input sheet. Cost data for transmission and switching is also included.

Typical output sheets are also presented herewith for study and further discussion, if so desired. It may be noted that the output sheets contain in permanent summary form, the whole of the characteristics of the particular sequence tested.

It is difficult to separate, in this instance, the number of engineer man-hours involved in setting up the program for the computer and in testing the various sequences, since so many other related studies have been made at the same time. It is probable, however, that the writing of a similar program would absorb about three man-months of engineering, and the assembly of basis data for use in the program would require from six to twelve man-months.

The authors also wish to thank Mr. Teekman of the Hydro-Electric Power Commission of Ontario for the discussion which he has submitted.

Concerning his question about spillage, it is true that some spillage may occur at any site, particularly during the initial years of the period of development when energy demand on the new plants is not fully developed. Such spillage would be flood spillage. Demand spillage is of a different nature. It is the release of water from an upstream site to a station downstream, for the purpose of meeting some particular monthly demands. Generally, however, for each sequence the various amounts of spillage are noted and the nature of the sequence is adjusted to minimize this. Additionally, the portions of spillage which may be considered as secondary energy may be evaluated and credited to the costs associated with each sequence. Towards the end of the period of development, the large reservoirs and the improved balance of the system, make possible the operation of the whole integrated system without any significant amount of spillage. In other words, ultimately, almost complete control and regulation are obtainable.

This, in many ways, makes easier the solution of the problem of defining the optimum height to which the upstream dams will be constructed. This problem is being handled in successive stages. Firstly, as discussed in the paper, approximate dam height were selected. Additionally, for the principal dam, further studies were made. Several trial sequences were run, using for each sequence several different water levels. From these results, the range of incremental energy costs associated with raising the dam were obtained. It became clear that the range of marginal economy was relatively wide and this permitted freedom of choice of dam height. Subsequent studies have also indicated the advisability of proceeding with the construction of the principal dam at Manicouagan 5. Hence, an assessment has already been made of the optimum height of this dam on the basis of the incremental values obtained.

Further work will be done to assess the optimum height of the other major dams at Outardes Mile 58. Once again, this will be done on a incremental cost basis, but after the initial sequence of development has been selected.

The terminal energy costs used were based on the assessed value of energy deemed applicable to construction costs at the end of the period of development being considered.

At present, the ultimate generating capacities to be installed are related principally towards obtaining a balanced system by the end of the 15-year period of development. Nevertheless, attention has been given to the character of future developments which could be made within the province and to the advantages of interconnection. The economics of thermal base plants are not yet attractive in comparison with the development of hydraulic resources within the province.

No particular provision has been made to include additional units at the various power developments at a later date. It is fortunate, however, that the best sequences to date are such that the last plant to be developed will be relatively large, and the estimated cost of incremental power at this plant is relatively low. This means that ultimate installation at this plant can economically take into account appreciable variation in system load factor.

With regard to river flows used in

the computer program, a period of 33 years of record for the Outardes River is contained in the input data. Of this period of record, any sequence of years can be used for simulation during and after the period development. Through the use of appropriate factors, the Outardes River flows are transposed also to represent flows on the adjacent Bersimis and Manicouagan Rivers. Hence, complete flexibility of flow handling is available within the program and the effects of any combination of flows in the various rivers can be considered.

The question concerning selection of the low water year relates only to the St. Lawrence and Ottawa Rivers. On the St. Lawrence River, the low flow was taken to be that equivalent to the minimum output of existing Beauharnois and Cedar plants. For the Ottawa River, because of changes in storage conditions there, conservative assumptions were made. In both cases, however, the probable percentage error of the assumptions should not be significant in relation to the size of the system.

It is true that the use of storage represented in the simplified flow sheet shows only one preferential order of storage drawdown. In the actual computer program, different orders of storage release are possible, and these depend on the conditions imposed by the preset operating criteria. Bersimis No. 1 reservoir is, however, generally operated preferentially. This is because it is an existing development. The real incremental value of the other reservoirs such as Outardes Mile 58 and Manicouagan 5 thus become determinable. The operation of Lake St. Anne reservoir, which is also an existing development, is of minor significance with regard to economics. In general, release of water is held over if possible, until the end of winter.

Transmission studies are, as yet, incomplete. It may be noted, however, that the computer program has been made sufficiently flexible to incorporate costs for a great variety of possible transmission networks, so that their economics can be assesed in conjunction with the development of the system as a whole.

Mr. Bateman's contributions to the discussion are also appreciated by the authors.

As discussed in the preceding replies concerning interconnection, it should be noted that the effects of existing interconnections are taken into account in the make-up of the load forecast. The program, which is the principal subject of discussion in this paper, can be modified to handle the effects of future interconnections, but the actual benefits of such interconnections are in preliminary stages of discussion only and therefore have not been included in the subject matter of this paper.

With regard to storage on the Manicouagan River, the authors have described that the reservoir at Manicouagan 5 is treated as the eontrolling reservoir on the system. The main point of significance here is that this reservoir is extremely large in comparison with the long-term average flows, and hence it has very high storage and regulating ability. The other reservoirs, although large, are operated on the basis of rule curves designed to minimize spillage while optimizing the operating head. For long-term regulation, the intakes will be submerged to permit at least 50 feet of drawdown. This is equivalent to 1,000 bcf of live storage. It is believed that this figure will give some further idea of the size of the reservoir at Mancouagan 5.

With regard to the criticism that the paper fails to deal quantitatively with the system studies, the authors acknowledge that this is true. They have, however, taken as their scope the description of the program devised for the system studies rather than dealing with the results of the studies. In fact, it should be noted that the studies are still being made and many decisions have yet to be made by the Commission.

Mr. Bateman's discussion of principal variables, particularly that concerning interest rate, is of interest. The relative importance of system variables will, of course, vary from system to system. In an almost exclusively hydro-electric development series, the effect of interest rate is less likely to be of significance between one sequenc and another than would be the case in a mixed hydro-thermal system. Within the present program, however, while the interest rate has been described as a secondary variable, the effects of change of this item can be easily studied. Similarly, the effects of variation in storage capacities and in load growth can be studied very simply in the present program. It should be understood that the program, as written, is in fact a model of the system, and the method of analysis is one of comparison of the results of particular runs. This type of program is different from one which includes optimization.

In the paper, the length of the period of record of flows on the Bersimis, Outardes, and Manicouagan Rivers is not specifically mentioned. Some 33 years of records have been compiled, however, for these rivers and the program includes the whole of these records. For the 15-year period of development being eonsidered, any 15-year period of flows can be used. Alternatively, the flows may be changed in any form. The establishment of initial storage ranges and rule curves have taken the whole range of past recorded flows into account. It is only in the St. Lawrence and Ottawa Rivers that flow records have been reasonably simplified. This is permissible, since the probable errors involved in assessment of minimum and maximum monthly flows would little affect the selection of one or other sequence of development.

It is true that the energy to be produced in any one year is fixed by the shape of the load curve. It does not follow from this, however, that spillage is fixed during the period of development. It does not follow either that the amount of spillage which can be considered as secondary energy is fixed. Part of the program is devoted, in fact, to investigation of these two things.

It is true also that a criterion of economic operation is the lowest annual cost. This is not the only criterion, however. For instance, a sequence of development which is designed to meet a partieular load curve with best economy, but which does not have the flexibility to cope with changes in conditions in the future without significant change in cost, is not a good investment. For this reason, each sequence of development is tested not only under typical average years of flow but under many different conditions and combinations of flows in the various rivers. A range of load forecasts is also used to test each sequence of development.

The inclusion of a cost program has proved to be convenient. It is not essential, however, but it is believed also to be economic. For any run, the cost program can be omitted or included as desired. It is particularly convenient, however, to have the costs associated with each run printed out in the concise form used in the print-out of output data. This is especially true in the case where several agencies or departments are interested in the cost results from day to day and week to week. Reference is therefore made particularly simple and records are easily kept. With the inclusion of cost data, the authors believe that the program is complete.

The authors wish to thank also Verne Ruskin for his interesting presentation of the computer programs with which he has been associated.

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WATERSHED RESOURCES VALUE— The Associated Development of Fish and Power

Val Gwyther, M.E.I.C.
Val Gwyther & Co. Ltd., Consulting Engineers. Vancouver

The Engineering Journal, November 1961 page

Discussion by T. A. J. Leach, M.E.I.C.

It is interesting and instructive to hear a paper on environmental control of the salmon during its fresh water life and it is apparent that the author has given much thought to the biological and hydrological problems that come up when the fishery industry is considered in multiple water use.

The main questions that arise are its adequacy in maintaining or increasing the present salmon runs, its engineering feasibility and the cost of construction and operation. My remarks will be confined to a few of the engineering problems involved while the speakers that follow will deal with the other main aspects.

Mr. Gwyther has gone into some detail to show that considerable food is available in the form of planktonic organisms to the salmon but that it is located in the lower portions of the lakes and reservoirs, which, because of the low oxygen content of the water (and high carbon dioxide) is not available to the fish. The questions that arise here, are:—

(1) Do not most of our interior lakes have a spring and fall turnover which in effect would bring these planktonic organisms from the bottom and make them available to the young salmon?

(2) If this is not sufficient or would be altered by storage reservoirs how does he propose to supply this bottom food to the upper fish zone?

The author has shown that generally following a year's feeding in fresh water lakes the salmon migrate to the sea. Under present conditions the rate of this movement is largely governed by the river velocity which is considerably greater than the swimming velocity of the salmon.

With the creation of reservoirs the river regime will be changed considerably and average current velocities in these regions will be reduced drastically. This, in turn, will delay the salmon seaward's migration. In fact, fishery authorities in taking the proposed 170 mile long Moran reservoir into account estimate the present time of passage of between 18 and 45 hours will be increased by some sixty times. The question then is how serious is the lack of a strong directing current which will apparently keep the salmon in fresh water for several months longer than they are accustomed to?

The passage of the seaward migrants over dams has never been adequately solved primarily because of the strong attraction resulting from power usage which carries the fingerlings through the turbines causing heavy mortality. The author's solution to this problem of combining the channelway for the fish with that for the power draft and separating out the former by screening ahead of the penstocks is a bold solution. He has also provided for a fish water zone through a floating intake which may select water from below the surface. It is also noted that while passage of the young salmon over the spillway cannot be prevented during high water mortalities have been kept to a minimum by the use of a sky jump spillway terminating in a vertical fall to a deep pool below.

Many points arise here but probably the most important is the efficiency of the screen intake to remove the fingerlings without injury and it appears that the screen area will be governed by the allowable velocity of approach within the fish zone. For mechanical screens fishery authorities recommend that this velocity should not exceed 0.4 feet per second for fingerlings rising to 1 foot per second for year old salmon. For the Clearwater system (which has been suggested as a fishery development area) the power draft is approximately 7500 cfs. At an allowable velocity of say 0.75 feet per second would indicate a screen area of 10,000 square feet which for say a 20 foot depth would require not less than 500 lineal feet of screen. This would have to be duplicated at least at all power dams on the Clearwater not to mention the much greater requirement for the four main Fraser River sites downstream of Lytton.

While the channelway width would be governed by the length of screen its depth would have to be equal to the drawdown at the dam which in many instances is approximately one third the height. In the case of the 510 foot high Hemp Creek dam within the Clearwater system, this would mean a channelway some 500 feet wide by not less than 180 deep.

The question is one primarily of cost but the engineering problems in operating such a Large screen appear formidable.

Finally, the salmon in their return journey some 3 years later are sorted out from the predators below the first dam they reach. If this should be in the main stem below Lytton the problem will be one of storing several million fish and providing for their transportation upstream on a very tight time schedule. The author does not indicate the size of these holding ponds but from information available they would appear to be in active operation for the sockeye from the middle of June to early October with the famous Thompson River and tributary runs peaking about September 21 .This is by far the largest run at present and could be the governing factor as to holding pond size.

There are a number of other major hydraulic factors but the points already raised will provide a measure of the magnitude of this problem. Certainly the elimination of at least a portion of the salmon predators, the enrichment of their feeding beds and possibly fish farming may provide some of the answers to the maintenance or enrichment of our fishery resources.

Discussion by
A. W. Lash

Mr. Gwyther in this paper strikes an optimistic and constructive note which is very welcome to some of us who have long been involved in the fish/power controversy. With the practical viewpoint of an engineer he proposes that both sides come together to determine the best development of watershed resources both for fish and power.

Before joint development of watersheds on these lines, however, can be achieved, the great complexity of the problems involved must be recognized. Mr. Gwyther has dealt in detail with some of the biological and engineering aspects. To these must be added the equally difficult economic and political problems. In the present situation in which control of power generation is a Provincial Government function but commercial fish protection a Federal Government function it is not easy to bring about the necessary meeting of minds to produce the optimum over-all result. Each group has a duty in regard to its own responsibilities and thereby may miss a sound co-operative solution.

It is well for the engineering group to have before it Mr. Gwyther's discussion of water quality and its effect on fish-life. The importance of more research in this subject cannot be overemphasized. An important point which came to my attention a year or so ago in this connection was to assess the effect of a slight increase in

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water turbidity on the fish rearing potentiality of lake. Very little seems to be known as to the possible quantitative effect of such a change.

Mr. Gwyther refers in some detail to the difficulty in effectively handling downstream migratory fish. He suggests a screening system for deflecting fry from a power plant intake. Many power engineers, however, have reservations regarding elaborate screening devices such as this, nor, do I think, have the fishery engineers and biologists any great love for them. To prevent damage to fry at the screens the water flow velocity, it is generally recognized, should be under 1 ft./second which makes the works very large and expensive. There are, however, other and perhaps more promising methods for dealing with fry. Up to 200 ft. head it is feasible to design turbines so that the fish can pass through them with very little loss or damage as discussed in the Annual General Meeting paper by Professor Muir and Dr. Ruus. With greater heads, a system of fixed louver screens in the forebay can be effective. The Department of Fisheries has carried out considerable experimentation with this type of screen at B.C. Hydro's Puntledge River plant and on Robertson Creek, Stamp River, both on Vancouver Island, with very favourable results.

Coming to the economic aspect, the difficulty that the hydroelectric engineer often finds it hard to justify to his employer or client is the making of very large expenditures on fish protection works — particularly when these expenditures appear to be disproportionately large to the value of the fish resource being protected. In some cases it would pay handsomely to buy out the whole fishery interest at a good price if only that could be done. But this would not be the best solution if the fishery resource can be increased on the lines suggested by Mr. Gwyther. Unfortunately, past experience has been that many otherwise sound hydroelectric schemes in B.C. have had to be abandoned or postponed indefinitely because of the difficulty of protecting the fish runs.

Three pleas arise from Mr. Gwyther's paper:

Firstly, that continued co-ordination to be given to the improvement of the procedures for dealing with fish-power problems. The difficulties arising from having two different administrations, one dealing with power and one with commercial fish may have to be overcome.

Secondly, it is hoped that the Department of Fisheries will continue the very constructive work it is doing at the present time in improving fish production in some rivers in this province. I refer particularly to the provision of spawning areas and other experimental work on Stamp River and Great Central Lake (incidentally made possible by a dam constructed for a purpose in no way related to fish) and also to the most important development at Little Qualicum River and Horne Lake.

It would be, I am sure, of great interest and be most helpful if the Department of Fisheries' engineers can later present to the Institute a paper dealing with this work.

Thirdly, it is hoped that the Department of Fisheries or a fisheries-engineering Board will extend further this experimental work so as to carry out, perhaps in a limited way at first, a complete program on the lines suggested by Mr. Gwyther. Much, I am sure, could be learnt from such work which could later be profitably applied to power and fish production in major rivers. As pointed out by Professor Muir the whole optimum multi-purpose development of the Fraser River system depends on the solution to the fish problem.

Before concluding these remarks, I would like to question Mr. Gwyther on two points which have me somewhat puzzled:

First — a question regarding delays in the passage of upstream migrants. Professor Muir mentions an instance of 2,000,000 sockeye moving up the Fraser in 2½ days. It is very hard to visualize how such a run would be handled, sorted and transported past dams as proposed by Mr. Gwyther, without considerable delay and dissipation of fish energy. How would this be done?

Secondly — How can feed material in a lake be obtained from lower lake levels for use in rearing areas?

Discussion by
C. H. Clay

There is an old Chinese proverb which runs like this:

If you wish to be happy for an hour, get intoxicated.

If you wish to be happy for three days, get married.

If you wish to be happy for eight days, kill your pig and eat it.

If you wish to be happy forever, learn to fish.

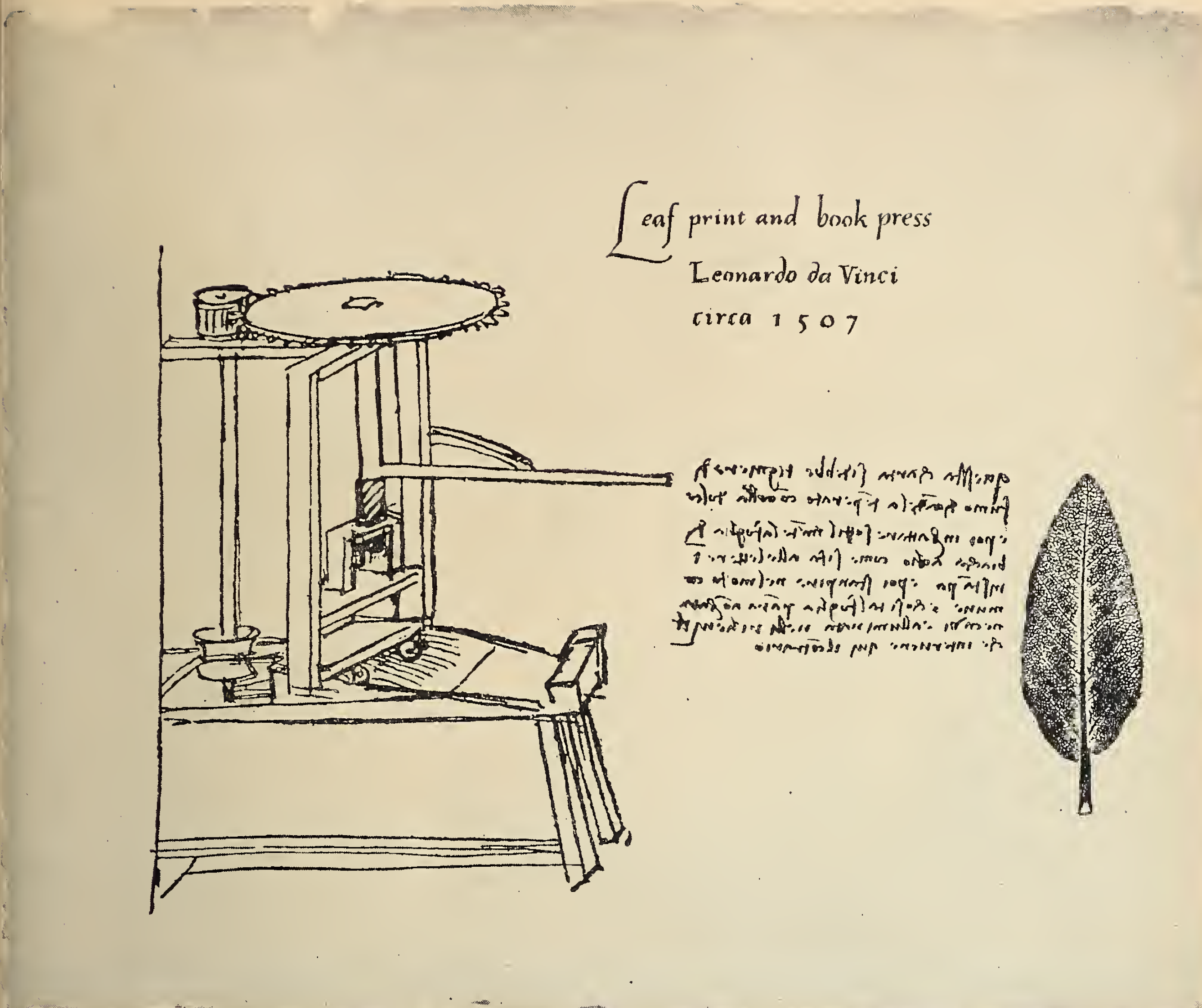
Today at least a quarter of the people of British Columbia are sport fishermen, and among their most prized targets are coho salmon, steelhead, and rainbow trout. All of these fish are predators on sockeye salmon. Their elimination, which has been suggested by Mr. Gwyther in his paper, would not only destroy the happiness (forever) of a third of a million sport fishermen, but would destroy the happiness of public servants such as myself, because of the clamour that would be raised by this vociferous segment of our population. British Columbia residents can readily imagine the results if, some years ago, the damming of Buttle Lake had been followed with a proposal to poison the lake, eliminating the trout population, and restock it with sockeye salmon.

Thus it is apparent that Mr. Gwyther's Utopian proposal is not as simple as it would seem on the surface. It has other weaknesses, any one of which could make the scheme impractical. Lake poisoning is not as simple as might be inferred from the paper. It has been found to be almost impossible to eliminate all undesirable fish in even the small lakes which have been treated to date. These fish often re-enter a treated lake from very small tributaries, and are even more likely to flourish in the lake than the introduced species. Since almost all of the predators and competitors of sockeye salmon are resident in the lakes and would not be susceptible to trapping at migratory fish barriers as suggested by Mr. Gwyther, the problem of maintaining a predator-free lake of any size for rearing sockeye is the most formidable one in the scheme. An additional problem would be the necessity to kill off at least one generation of sockeye salmon each year that poisoning was required to be repeated. Experience with small lakes indicates this repeat treatment would be necessary at frequent intervals.

There are many other incorrect statements and inferences made in Mr. Gwyther's paper most of which fall in the field of fisheries biology. These are so numerous, time does not permit me to list them all here. Among the most important are the following:

1. There is no demonstrated relationship between the productive capacity of a lake for rearing sockeye salmon and the total dissolved solids, or "hardness", the term used by Mr. Gwyther. There are a great many other limnological factors to be considered in trying to assess productive capacity.
2. In speaking of the results of a predator reduction experiment at Cultus Lake, Mr. Gwyther assumes that an increase in spawning population indicates an increase in the total population of sockeye. This is not the case. The total population consists of the

(Continued on page 90)


Leaf print and book press
Leonardo da Vinci
circa 1507

fish caught in the fishery plus the spawning population. Neither of these two elements in itself is a reliable indicator of the size of the total population.

3. It is implied that the Fraser River Board has discarded the Clearwater River watershed as a producer of fish. This is not the case, as can be verified by reference to the reports of the Board.
4. It is implied that fish facilities already in existence are capable of mainatining salmon runs over a series of dams on the Fraser, including a high dam at Moran. Study by our most able scientists does not verify this contention.

In conclusion may I say that Mr. Gwyther's paper provides much interesting ground for speculation, but for many reasons the schemes he has advanced are quite impractical from a biological standpoint.

Author's Reply

T. A. J. Leach has studied the paper in some detail from the depth of his experience in the problems of fish and power. In this study he has suggested that a more detailed explanation of some matters may be beneficial to broadening the scope of the paper. He has asked some very important questions which I wish to answer.

All relatively shallow lakes in B.C. will have at least two turnovers per year as seasonal changes in atmospheric temperatures occur. In deeper lakes only the upper strata, where a thermocline or temperature gradient exists, will the turnover take place. This is due to the lower densities of water above and below 4°C. or 39.2°F. As the lower depths of lake water are maintained at a constant temperature of 39.2°F. due to density alone, they will not be disturbed unless some added influence is supplied such as density currents, release and acceptance of gases during photosynthesis and chemical changes and, in the surface waters, by wave and current action.

The supply of bottom lake food into the upper zone which fish occupy, requires extensive discussion as other benefits are apparent when aeration is used to alter the density of the lower waters.

In sewage and water treatment we rely extensively on aeration for purification. More recently this process has been used for ice removal on lakes and ponded areas. It is used to retard encroachment of the salt water wedge which underlies the upper fresh water in large river estuaries.

By aeration supplied at depth, the density of the lower water is decreased. It rises and carries with it the food for fish. As it contacts the atmosphere, it releases carbon dioxide and accepts oxygen. In this process, the stratification of the lake can be eliminated.

The matter of oxygen is important. The minimum requirement of oxygen for these species of fish is about 5 p.p.m. They appear to be able to exist on lesser intensities for short periods of time. As these fish commence to swim, or feed, they may require 6 to 8 p.p.m. and when they are moving more rapidly they may require better than this saturation, as they are dissipating more energy.

As ice covers a lake, the oxygen supply of the lake cannot be replenished from the air and with extended periods of ice cover, the available oxygen will gradually diminish. The fish will then lie in a more or less dormant state in these months. If added numbers of fish are planted, mortality may occur, or the fish decrease in size, or quality. It is then important to be sure the fish are amply supplied with oxygen as well as food.

In the supply of air for aeration we appear to require only small amounts of power. Field tests show that with a 5 H.P. unit, one square mile of water 60 feet deep can be raised to the surface in 120 days. As wind power is available on the surface of all our lakes, even though intermittent, we may require no other source of energy for this purpose. This, then, means that a few windmills floating on the lake surface and passing air to single aeration units or a system of small plastic pipes floating at some depth may be able to raise the hardness from the lower levels and also supply oxygen deficiences.

With regard to Mr. Leach's thought relative to delay in migration in long reservoirs such as the 180 mile reservoir that is proposed on the main stem of the Fraser River at Moran, we now have races of these fish migrating through reservoirs of almost equal length. These are the Shuswap and Seymour races migrating through Shuswap Lake to Kamloops, the Stewart race migrating through the Stewart Lakes and the Babine race through Babine Lake. In all these cases, the river discharge at outlet at times of migration is much less than the Fraser at Moran and they do migrate. The figures that Mr. Leach has used were taken from a publication which had used an average cross sectional area of the lake to calculate the average velocity. All movement of water in reservoirs flow more in a density current pattern and not in average cross sectional flows. This adjustment will greatly increase the velocity for fish migration. Furthermore, with proper reservoir management by increasing outfall discharge at time of downstream migration these density current velocities can be greatly increased. Perhaps some storage must be retained in these reservoirs specially to assist this migration.

Mr. Leach has suggested some difficulties that may arise in screening off the fish from the entire flow of water to the turbines. The velocities that the fisheries authorities feel are satisfactory for fish preservation are for screens where there is no escapement for the fish other than swimming upstream. In cases of this type, the velocities quoted are relevant to eliminate mortality. The screen which I have used is sloping, with horizontal velocities of water in the screen bay greater than that through the screen area. The fish, in passing the screen bay, swim with their heads upstream. If their tails touch any obstacle, they will swim into upper water, thereby being deflected well above the screen. Deflectors have been provided for this purpose and automatic adjustment of open screen area is provided to maintain horizontal velocity as water demand changes with demand load. The entire screen portion is a hydraulic study and has nothing to do with biology as these fish pass over the screen end in flowing water.

I have assumed an average velocity of 2 feet per second passing through the screen. However, the velocities at the upstream end of the screen may well be greater than the downstream end as fish have the tendency of migrating near the surface. This tendency will be ensured if the density current is maintained in the surface zone. To pass 7,500 c.f.s. a screen area of 3,750 square feet or two screens 25 feet wide and about 75 feet long are required. One extra screen should be allowed for peak loading and to provide increased reservoir currents to assist in fish migration.

A. W. Lash has covered some very important problems which, as he says, must be recognized. The economic problems that exist today in hydroelectric power comprise those development costs that are necessary to maintain present fish production in those areas where power is being developed. This is an added burden on the users of electricity for benefit of another resource. The political problems arise from the statutes of two governments, (Federal and Provincial) each of which is obligated to maintain, through their respective

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agencies, the fish resource and the power resource.

Perhaps some of our problems could well be answered with understanding that the resource is not fish or power but it is water. With this basic understanding, the other benefits that are derived from water can well be appreciated.

I must reserve judgment on Mr. Lash's remarks relative to the fisheries installations at Robinson Creek and the Little Qualicum River, but only from the standpoint of lack of the fisheries' appreciation of the value of these areas in rearing and predation elimination which has not been included in these projects. Mr. Lash has contributed, from a very wide field of experience, the major thought that a central agency must be set up to control the resource of water in its many benefits. In this thought he is absolutely correct and no time should be lost in its formation.

Mr. Lash has suggested that further discussion would be beneficial in two questions.

The matter of delay and energy dissipation require explanation relative to present policy in natural spawning and in artificial propagation. Delay of fish in the present policy is important only because the fish in the interior spawning grounds must arrive before the flowage of water and therefore depth over spawning grounds is reduced so that spawning can be carried out. If hatcheries are used with their accompanying ripening ponds, the problem of delay is not so important.

In this case, I wish to quote an example; The Washington School of Fisheries, located on the banks of Lake Washington, has carried out extensive research on fish propagation for about 30 years with planted fish races. The entry to the fish ladder is directly from Washington Lake. Dr. L. R. Donaldson advises in the conclusions of his paper "Return of Silver Salmon to the Point of Release".

"Silver salmon, (our Coho) transferred as fingerlings, after a year of rearing, did not return to the native stream but to the point of release.

"Silver salmon returned successfully to an artificial environment even though they had to ascend a fish ladder in which the water flow is small (1.2 c.f.s.) to gain entrance to a concrete retaining pool. Fish did not move into the collecting traps in numbers until temperatures dropped to below 50°F. A delay of attaining suitable water temperatures of a month or six weeks past the normal spawning season seems not to interfere with the run."

So with reservations relative to water velocities a delay of a few days may not be important when hatcheries are used for propagation.

The matter of fish energy dissipation is however very important. In this it is beneficial to remove the fish as quickly as possible from relatively high velocities that occur in river channels to ponded areas where lesser velocities exist. In these ponded areas, the fish may rest, be sorted and passed to secondary transportation for their further migration. With large migrations of 750,000 fish per day, or 9 fish per second, and over some days, the total tank volume of the surge tank should be sufficient to accommodate the fish less secondary transportation rate, whatever it may be.

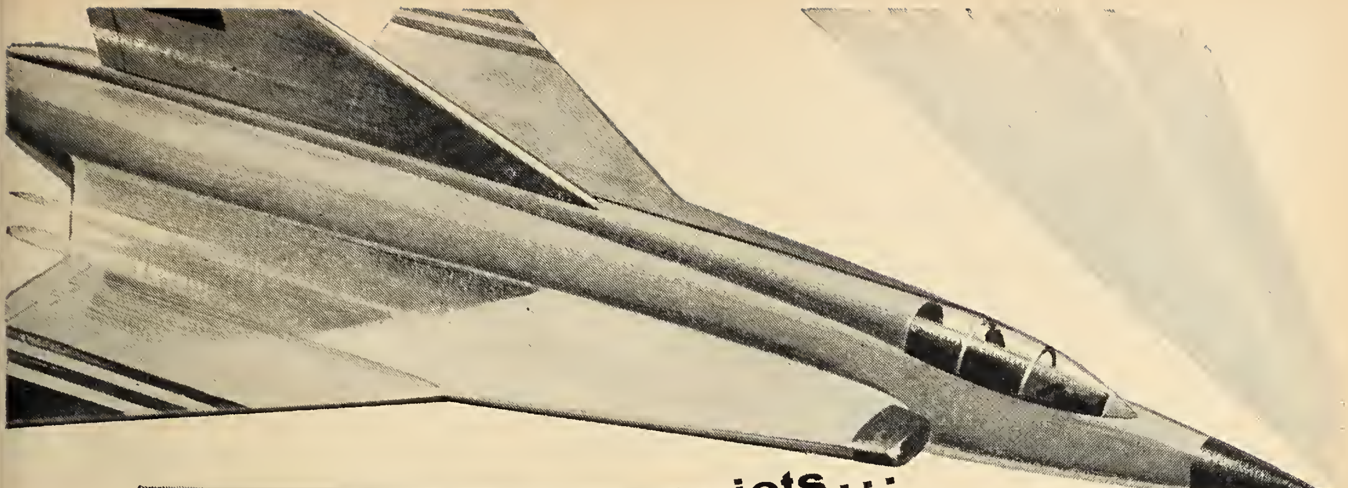
In this operation, tank volume to transport fish by truck is one U.S. gallon of water per pound of fish, or, for our sockeye species it requires about one cubic foot of water per fish. In fish ladders we appear to require two to four cubic feet per fish. The surge tanks must be designed in capacities to accommodate at least this migration less that which is accommodated in secondary migration.

In the secondary migration in high dams, it appears we may require large carriers on rail tracks either vertical or inclined. The carrier is loaded from the surge tank hoppers (Fig. 2) assuming the carrier is ten feet deep, ten feet wide and a hundred feet long, having a capacity of 10,000 cubic feet of water or 10,000 fish. This tank on rails is drawn up the inclined rails by a counterweight contained within a vertical shaft in the mountain. The counterweight is also a water container where the amount of water can be adjusted, namely, filled when we wish to raise the fish and emptied as the container is returning to its loading position. An adit tunnel with some pumping is also necessary to return the water to the surge tank. The flume which is shown on Fig. 2 is double decked. The top deck is for transportation of fish to headpond and the lower deck to return the water to the forebay and also to supply water to the counterweight.

In this operation the hoisting of 10,000 fish per load and a round trip every half hour would transport 480,000 fish to the upper flume every 24 hours. We then require 2 carriers of this type to accommodate the daily run of 750,000 per day.

Mr. Clay has raised some objections to development of fish in quantity regardless of what method is used. He cites a relationship of sports fishing and the commercial harvest. This is also a confliction due to governmental statutes where the former is under Provincial and the latter Federal authorities. It is well to remember that the Provincial Agency has removed the predators from 108 lakes in B.C. for betterment of sports fishing while the Federal Agency has done nothing in this respect in any rearing area. Mr. Clay is again incorrect when he advises that the predators cannot be controlled and also in the relationship of hardness as the food for fishes. He should digest some of the literature and inspect progress in practice where this is now being done, to produce fish in quantity. Mr. Clay knows very well that the general practice of the fishery is to attempt to allow escapement of 20% of the adults which arrive at the estuaries of our rivers and streams. This is amply indicated in the annual reports of the International Pacific Salmon Fisheries Commission. It is quite clear, from his remarks, that scientists know little about water control, in fact it is entirely out of their field of knowledge, especially when the most recent developments in the fishery resource, namely Robinson Creek and Little Qualicum River, are totally dependent on control of water and control of river bed gravels to allow sufficient oxygen for egg incubation.

I wish to thank T. A. G. Leach and A. W. Lash for the study they have given to broaden the scope of the paper. From Mr. Clay's paper the true meaning of our difficulties is apparent. With the wealth of information that has been presented to the people in the last few decades by scientists and others, the problem that faces us now is to apply this information for public benefit. EIC



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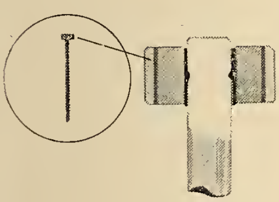

Adhesive bonding small pinion gears to rotor shafts provided savings of $56.37 per thousand by reducing rejects, and eliminating secondary operations and the necessity for 100% inspection.

A pump manufacturer reduced rejection rates from a high of 25% to nearly zero by adhesive bonding three separate die castings to form a single part.

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Canadian Developments

Seven Outdoor Test Sites Provide Study Area For Corrosion Effects

The corrosive effect on building materials caused by atmospheric conditions is being studied by the Canadian Government in seven outdoor test sites across the continent. Two sites are located at Halifax and one each at Montreal, Ottawa, Saskatoon, Norman Wells N.W.T. and Rocky Point on Vancouver Island. Site locations were chosen by the Division of Building Research of the National Research Council to provide a marine atmosphere, a marine-industrial, industrial, a rural location with high humidity, one with low humidity and a far northern site.

A variety of building materials have been exposed at the test sites since the beginning of the study in 1954. They include three steel alloys—a plain, low carbon, a copper bearing and copper-nickel bearing steel; three stainless steel alloys, two magnesium alloys, a rolled zinc, three auminum alloys and riveted galvanic couples of aluminum 3S alloy to milk steel, to zinc and to copper. These metals have now been exposed for seven of the 10 years of exposure planned for them. Recently specimens of sheet copper, Mantz metal, two types of sheet lead and monel metal have been set out.

Comparison of the performance of different metal coatings on steel has also been started. The coatings that have been set out at the sites to date have included hot-dipped galvanizing, electroplated zinc, sprayed zinc, sprayed aluminum, aluminized steel, and electroplated cadmium. Twelve specimens are prepared for each site of each type of metal coating or sheet metal selected for exposure. Three specimens of the sheet metal materials are removed at intervals of one, two, five and ten years of exposure. Specimens of metal-coated materials, however, are removed from the sites only as failure appears. Because of differences in the rate of corrosion at the various sites and differences in the resistance of the coating to corrosion the results are not yet sufficiently complete to be significant.

Two series of different paint systems applied to steel have been exposed at the sites. Series I consisted of five priming paints, a wash primer and one enamel for topcoating. Different systems were applied by dipping to cold-rolled SAE 1010 steel. In Series II, four CGSB steel priming paints plus a zinc dust primer and a zinc rich paint have been applied to structural steel for exposure. An alkyd enamel was used for topcoating. These paint systems were applied to the structural steel plate in the following conditions: mill scale intact; weathered and wire brushed; grit blasted and flash rusted. The last panels completing this series were set out in 1960.

Many building materials do not lend themselves to the type of test specimen normally used for exposing metals and protective coatings. Because of the size of the wallettes or test piers usually required for weathering different brick and mortar combinations it has been necessary to restrict exposure of these materials to the Ottawa and Halifax sites. Correspondingly, because the weathering of bituminous coatings requires removal of the panels after short exposure periods for laboratory examination these materials have only been exposed at Saskatoon and Halifax where regional stations of DBR are located and at Ottawa. In addition the Ottawa site is used to assist in deciding on the suitability of various coatings developed for specific needs, and for comparing the performance of different building materials exposed to natural weathering with the accelerated conditioner of weatherometers.

Some sites affect the performance of the materials far more than others. The results of exposure of the metal materials have shown the Halifax industrial-marine site to be the most corrosive. The loss of metal from specimens exposed at the Montreal industrial site was much less. The Halifax marine site, Ottawa, Saskatoon, Rocky Point and Norman Wells follow in that order. This order of severity in general applies to weathering of other materials and any differences in degradation that have occurred at some of the less severe sites have been attributed to a local condition.

A wide range of climatic conditions have been provided through the selection of suitable locations for the sites across Canada. Because climate is one of the main factors affecting the weathering of materials, weather records play an important part in interpreting the results obtained from exposure. All of the sites are near weather stations of the Meteorological Division of the Department of Transport and records are thus available of the precipitation, hours of sunshine, temperature, wind velocity and direction. Pollution of the atmosphere in urban areas has been a serious factor in the deterioration of materials. The corrosiveness of the Halifax marine-industrial site has been largely attributed to the high level of atmospheric sulphur dioxide in the immediate area. The relative level of sulphur dioxide is measured at each site and the chloride content determined at the east coast marine sites. Studies are in progress at some of the Canadian sites to measure atmospheric factors which affect corrosion. Installations have been made to obtain a correlation of the metal loss with time-of-wetness, temperature and pollution.

Trade and Commerce Department Lists Business Education Courses

With the view to strengthening the competitive position of small business enterprises the Small Business Branch of the Department of Trade and Commerce has published a booklet titled "Management Education".

The booklet lists Canadian universities which offer businessmen a choice of more than 400 part-time, non-degree courses in business subjects. It is the result of a nation-wide survey undertaken in cooperation with the Association of Canadian Schools of Commerce and Business Administration.

In a forward to the booklet, Dr. John C. Wawatsky, President of the Association of Canadian Schools of Commerce and Business Administration states that, "The necessity of business education for the large enterprize was recognized earlier but now its basic importance for small business management is realized too. We hope that many executives will avail themselves of the educational opportunities listed and will thereby extend their knowledge of principles and techniques of management."

Courses offered at the different Canadian universities in order of popularity are as follows: Principles of Administration and Management Theory, Accounting, Marketing, Labour Relations, Finance, Personnel Management, Supervisory Techniques, Investments, Public Administration, Real Estate and Home Building, Marketing—Sales, Executive Development, Retail Marketing, Taxation, Purchasing, Product Development, and Marketing—Advertising. EIC

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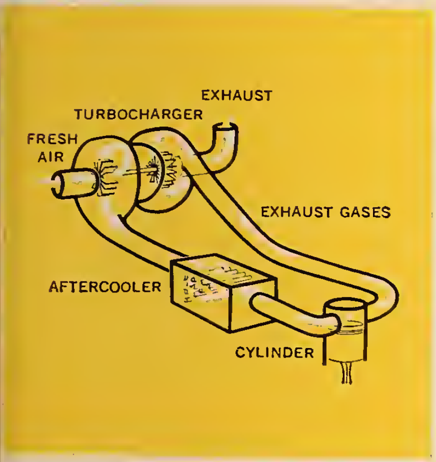

Turbocharging and aftercooling increase engine life

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The aftercooler increases power by 20% without adding to peak pressures, and actually reduces peak temperatures. Truckers know well that cooler valves give longer service life. Turbocharging and aftercooling mean more power with less engine wear—and therefore longer engine life.

Full-rated horsepower means shorter haul time

The Cat 1673 supplies more turning power to the wheels under lugging conditions when the driver suddenly calls for more power and speed to climb a steep grade or pull out of a mudhole.

Altitude? Unlike naturally aspirated engines, the turbocharged and aftercooled 1673 does not have to be derated 3% every 1000 feet. No derating need be considered until 7500 feet.

With the full-rated horsepower of the 1673 under the hood, drivers don't have to down-shift constantly, slowing truck speed and lengthening trip time. No matter where a truck goes, it goes there faster with the 1673.

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International News

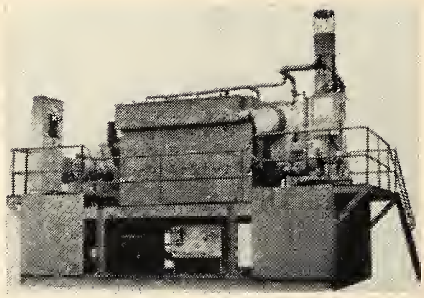
Water Distillation Plant For Arabia

A plant capable of producing 25,000 gallons of water a day has been shipped by a British firm to an arid land on the Gulf of Arabia. Ordered by the Government of Abu Dhabi, the plant consists essentially of a distillation unit, a steam generator to provide the operating steam, and a diesel driven alternator to provide the electric power for driving the pumps and other auxiliaries.

Sea water feed is drawn from the sea by the feed pump via a coarse strainer at the end of the suction pipe and a fine duplex strainer adjacent to the plant. The feed is circulated through the vapour condenser and feed heater tubes of the 11-stage distillation unit, its final temperature being 186 degrees F. It then flows in series through a number of flash chambers maintained at progressively higher vacua, the final stage operating at a vacuum of 28 inches Hg. The water boils vigorously, or flashes, in each chamber, and vapour is produced. The vapour passes through separators in the form of a blanket of knitted monel wire mesh, which effectively removes entrained moisture particles. The vapour then condenses on the outside of the condenser tubes, its latent heat passing into the incoming feed water, the temperature of which is progressively raised. The sea water remaining behind in the final flash chamber is discharged from the plant by the brine pump. The condensate is collected in each vapour condenser and cascaded down to the final stage, where the distillate pump delivers it either to the storage tank built into the plant, or direct to the consumer via one of four special hose connections.

A sterilizer unit, incorporated into the plant to ensure sterility of the distillate produced, effects sterilization by imparting a stream of silver ions into the distilled water passing through the unit.

As the feed water boils upon entering the first flash chamber, the dissolved gases liberated pass into the condenser with the vapour, where they tend to remain behind after condensation. To prevent blanketing of the tube nest, the gases are removed by steam jet ejector and discharged to atmosphere. Another ejector at the final flash chamber re-



Sea Water Distillation Plant For Arabia Designed To Produce 25,000 Gallons Daily

moves the small quantity of gases released after the first stage, and also compensates for any air leakage into the unit from the atmosphere. The latent heat of the steam from both ejectors is conserved by passing the ejector discharge into the feed heater, so that this heat passes into the sea water feed.

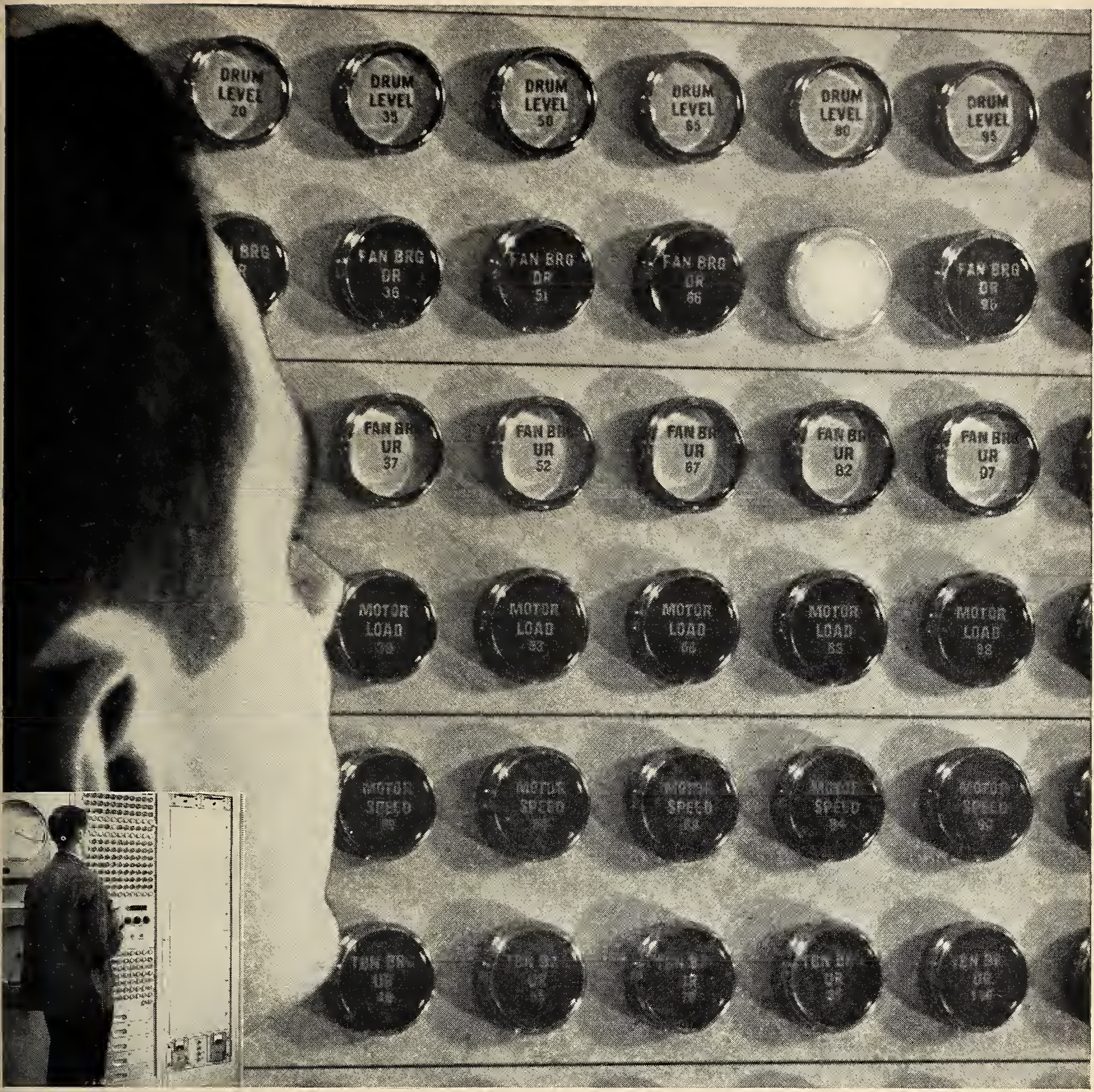
A steam generator and a storage tank for boiler feed water is built into the feed heater of the distillation unit. Water from the storage tank is pumped by the boiler feed pump to an accumulator, the pump being started and stopped by a liquid level control in response to high and low levels in the accumulator. The circulation pump draws water from the accumulator and delivers it to the single pass spirally wound heating coil in counterflow to the combustion gases that are passing over the outside of the coil. Upon leaving the generating section, the fluid passes through the thermostat tube and is delivered via the helically wound water wall tube to the separator in the accumulator, where dry steam is separated and delivered through the steam outlet to the distillation unit. The unevaporated liquid falls to the lower section of the accumulator for recirculation. The steam generator is fitted with an automatic blow down device which maintains the dissolved solids in the circulating water at an acceptable figure, the quantity of blow down being adjustable, and being automatically proportioned to the feed water rate.

Since the condensed operating steam returns to the feed storage tank, only a very small make-up is required, and this is maintained automatically by the distillate pump through a float operated level control valve. Since the make-up is distilled water containing small qualities of dissolved solids and virtually no dissolved gases, little feed water treatment is required. The chemical injection pump is built into the boiler to inject a small quantity of chemical treatment solution to maintain the pH value of the boiler feed water at about 10. The distillate used for make-up contains approximately 50 p.p.m. of NaCl, and has a pH value of 6.6. to 6.8.

The steam space of the feed heater operates at atmospheric pressure, any dissolved gases from the boiler feed water or from the ejector discharge being blown direct to atmosphere. This feature enables a novel method of cooling to be employed on the diesel engine. Water from the boiler feed storage tank is pumped to the diesel engine jacket at 212 degrees F. Cooling is effected in the jackets by partial vaporisation of the water, i.e. vapour phase cooling, and the resulting mixture of water and vapour is returned to the feed heater, where the heat generally wasted in a jacket cooler is conserved by being transferred into the sea water feed. On full output of the distillation unit, the diesel generator produces approximately 50 lb/hr. of steam, which represents about two per cent of the total consumption of the distillation unit, thus effecting a noticeable saving in fuel oil, which is the only external supply needed by this self-contained plant. The total consumption of oil is less than one gallon per 50 gallons of water produced.

The diesel alternator sets comprises a standard three cylinder engine driving a standard 25 KW alternator. The output from the alternator is fed directly to the automatic control panel for distribution to the various pumps and control devices.

The control panel carries all the instrumentation for the distillation unit and diesel generator, and incorporates the necessary pressure and vacuum gauges for sea water and vapour, together with a distillate flowmeter and a distillate salinity indicator. It also incorporates certain safety devices which shut down the whole plant in the event of alarm conditions arising, such a flooding of the unit, or failure of the feed pump or its motor, or of the brine pump or its motor.



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Month to Month

Charlottetown Meeting of Council

The Council of the Institute met Sept. 23 at the Charlottetown Hotel, Charlottetown, P.E.I. President Ballard presided.

Those attending included: Vice-Presidents T. C. Higginson, Saint John, N.B. and G. N. Martin, Montreal; Councillors H. B. Carter, Corner Brook, Nfld.; W. L. Coles, Charlottetown; P. W. Gooch, Montreal; W. A. MacDonald, Sydney, N.S.; W. J. Phillips, Halifax; C. L. Trenholm, Moncton, N.B.; J. W. Wilson, Amherst, N.B.; and, by invitation, W. R. Brennan and E. S. Chandler, both of Charlottetown.

Following are highlights of the meeting.

Membership

President Ballard said the Finance Committee would give serious consideration to the possibility of a reduced membership fee for members whose personal circumstances made it difficult for them to pay the regular fee, following a discussion during which Councillors suggested such a fee. Members to be so considered would be recommended by their Branches after an appropriate investigation.

Transactions

During discussion of the 1961 budget, the Institute's publication "Transactions" was considered. It was urged by Mr. Gooch and Mr. Phillips that Transactions be continued in some appropriate form, as the publication of such material is considered an essential function of a learned society. They said that although every paper is not of direct interest to every engineer, over the years there is sufficient of interest in Transactions to make the entire project worthwhile.

New Branches

Authorization was given by Council to the formation of the Institute's 59th and 60th Branches These are at Brampton, Ont., and Richmond Hill, Ont. Councillors expressed their pleasure at the initiative of the Toronto Branch executive and of the members in the Brampton and Richmond Hill areas.

E.C.P.D. Canons of Ethics

It was reported that the Engineers' Council for Professional Development had invited the Institute's approval of a proposed project to review the Canons of Ethics of E.C.P.D., and to reaffirm the present Canons of Ethics.

Councillors gave approval to the project, noting that Council will consider the implementation of the procedure to carry out the project at later meetings.

Canadian Conference on Education

In response to an invitation from the Canadian Conference on Education to have the Institute name five delegates to the Second Canadian Conference on Education, the following members were approached and agreed to serve: Dean R. R. McLaughlin, University of Toronto; Dean D. M. Mordell, McGill; Dr. Arthur Porter, University of Toronto and Chairman of the Engineering Education Technical Division of the Committee on Technical Operations; Dean Henri Gaudefroy, Ecole Polytechnique; and Dr. L. P. Bonneau, Vice-Rector, Universite Laval.

The Conference will be held in Montreal next March.

A.S.M.E.-E.I.C. International Council

Council ratified, with pleasure, the appointment of R. S. Sproule to serve a four-year term as A.S.M.E. representative on the A.S.M.E.-E.I.C. International Council. Concurrently, Mr. Sproule will replace C. G. Southmayd as A.S.M.E. representative on the E.I.C. Council. Council recorded its sincere appreciation for the outstanding contribution to the work of the Institute made by Mr. Southmayd whose term as representative expires this year.

Confederation

President Ballard reviewed recent developments regarding Confederation. The report of the Engineers Confederation Commission had been received by the E.I.C. Council late in April. The Institute had wished to publish the full text in the June, 1961, issue of the Engineering Journal. However, publication was deferred until September on the request of the Canadian Council of Professional Engineers so that some minor changes could be made to the report.

Dr. Ballard said the Institute requested only one such change. This was to ensure that it was made quite clear in the report that the proposed annual membership fee of $12.50 was over and above the fee now paid to the provincial associations.

Councillors, Branch officers and individual members had been asked by the President to study the report thoroughly and to make themselves aware of all possible implications.

Two sub-committees of the Executive Committee have been appointed by the President to make extensive studies of the report. The first will examine the financial implications, and the second will study the report as a whole and will review all comments received from members, Branches and Councillors. The second sub-committee is to prepare a statement of opinion of the Executive Committee for ultimate transmission to Council.

Dr. Ballard stressed that the Council is interested in obtaining all possible member reaction to the report, and is making intensive studies of the various aspects of the report. All of this will consume time and when Council has formed an opinion regarding the report, it undoubtedly will convey this opinion to the members at large for their information.

He noted that the report makes no recommendation for or against Confederation, but merely presents, for study and consideration, one possible means of achieving Confederation. He said there may very well be some changes to the report if, after careful study, the Institute and the C.C.P.E. agree on such changes.

A general discussion followed during which there was a frank exchange of questions and answers, and individual opinions regarding many of the items covered in the report.

By-Law Ballot Results

During the summer, ballots for proposed by-law changes were mailed to all corporate members of the Institute. The ballots were counted Sept. 7, 1961, and the following is a summary of the results.

Classes of Members

Twelve sections dealt with a change in the classes of members. In all cases the proposed changes were accepted.

The most significant changes were the addition of "Fellow" as a class and the elimination of "Junior" as a class. As of Sept. 1, 1961, all "Junior" members ipso facto became "Associate Members", a new designation.

Henceforth, no more than two new Honorary Members may be nominated each year. Honorary Members shall be elected from corporate members of the Institute who have achieved outstanding distinctions in fields other than engineering, or from non-members of the Institute who have achieved outstanding achievement in the engineering field.

Fellows (Fellow E.I.C.) must be at least 40 years of age and are to be elected from those corporate members who have achieved outstanding distinction in the engineering profession. The number of Fellows to be elected each year may not exceed one per 5,000, or fraction thereof, of the corporate members.

Fellows and Honorary Members are considered to be the equivalent to each other in recognition of achievements in the respective fields of non-engineering and engineering.

Generally, the class of Associate Member (A.M.E.I.C.) replaces the Junior Member class, with the same conditions of membership applying, except that Associate Members will be transferred automatically to Member without payment of transfer fee at the end of the fifth year after graduation.

Student Members formerly were transferred automatically, without payment of transfer fee, to Junior status in the second January after graduation. They now will be transferred to Associate Member in the first January after graduation.

Minor changes were made in other sections of the By-Laws to accommodate different classes of members.

Fee Increases

A proposed across-the-board increase in the fee schedule was defeated with 2,209 votes in favor, 2,612 opposed and 21 ballots spoiled. Also defeated, although by a smaller margin, was a related proposal which would have increased the single payment for compounding the fees of a Montreal Branch member.

Finance Committee Chairman Martin commented on the financial implications of the proposed increase in membership fees. He said the defeat of the proposal was a matter of great regret to him since, as long as the present fee structure continues, the financial solvency of the Institute depends on any surplus revenue from its publications. This is not a healthy situation as the normal operating expenses of the Institute should be financed completely by membership revenue.

Other

An amendment was approved which makes the Treasurer the ex-officio Vice-Chairman of the Finance Committee. Another amendment assigns to the Committee on Technical Operations the responsibility for co-ordinating regional technical conferences. Approved also were new terms of reference for the Publications Committee, based on an up-to-date concept of the committee's duties.

Engineers' Council for Professional Development

The 29th Annual Meeting of the ECPD was held at Louisville, Kentucky, October 2 and 3. Representing the Institute were: President Ballard; Col. W. S. Wilson, University of Toronto; G. R. Henderson, Sarnia; Guy Savard, Montreal; T N. Davidson, Montreal Councillor; J. W. Brooks, Kingston; and the General Secretary.

Preceding this was a meeting of the ECPD's Education and Accreditation Committee with Dean H. G. Conn of Queen's University present as the Institute's observer.

Accepted during the annual meeting were reports of the following committees: Guidance; Education and Accreditation; Student Development; Development of Young Engineers; Ethics; and Information.

The Guidance Committee reported that engineering as a career was discussed with more than 100,000 high school students in the United States during approximately 1,500 meetings arranged by the state committees, and by several thousands in Canada through meetings arranged by the Institute. Guidance literature was distributed in two major mailings. Surveys on the local level were designed to help future programs.

The period since 1955, when the bases for accreditation in the United States were sharpened substantially, has been one of significant development for the Education and Accreditation Committee. Changes in committee personnel were noted. Discussed were accreditation procedures, co-operation with military services on ROTC, and graduate study. The sub-committee on Technical Institutes also reported.

The Student Development Committee reported progress on the preparation of a brochure for first or second year engineering students. The Committee also plans to work with increasing vigor on a ritual for engineering graduates entering the profession in the U.S.A.

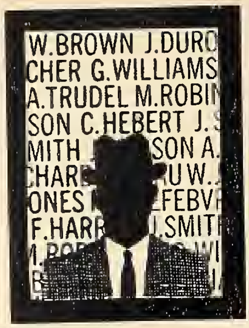
The Committee on the Development of Young Engineers is concerned primarily with the continuing development of the young engineer after graduation. To this end it makes use of various journals, promotional literature, special society committees and contact with local groups. Also heard were reports of several sub-committees.

During the 1960 annual meeting in Montreal, the Ethics Committee appointed a sub-committee charged with reviewing the Canons of Ethics. Constituent societies of the ECPD were asked to approve the scope of the project. Also discussed were the preparation of a problem book in professional ethics for engineers, and a students' code of ethics.

The information committee reported that publication sales made 1961 an active year in the dissemination of information on engineering. Existing material sold well and a new publication,

(Continued on page 113)

Personals



Dr. Frank DeMarco, M.E.I.C., (Tor. '42/-43/51) has been appointed a chief executive officer of the Corporation of Essex College. In this new capacity Dr. DeMarco will be responsible for administration of the academic, financial and administrative affairs of the college, subject only to policies laid down by the board of directors. Mr. DeMarco was appointed first principal of Essex College in 1959. As head of the chemistry department at Assumption University since 1946, he was appointed staff chairman of Essex College in 1956 and principal in 1959. He is also Dean of the Faculty of Applied Science of the University.

Rolland Verreault, JR.E.I.C., (Ecole Poly. '58) has been appointed chief engineer and Industrial Commissioner of the City of St. Jerome, Que.

J. M. Macé, M.E.I.C.

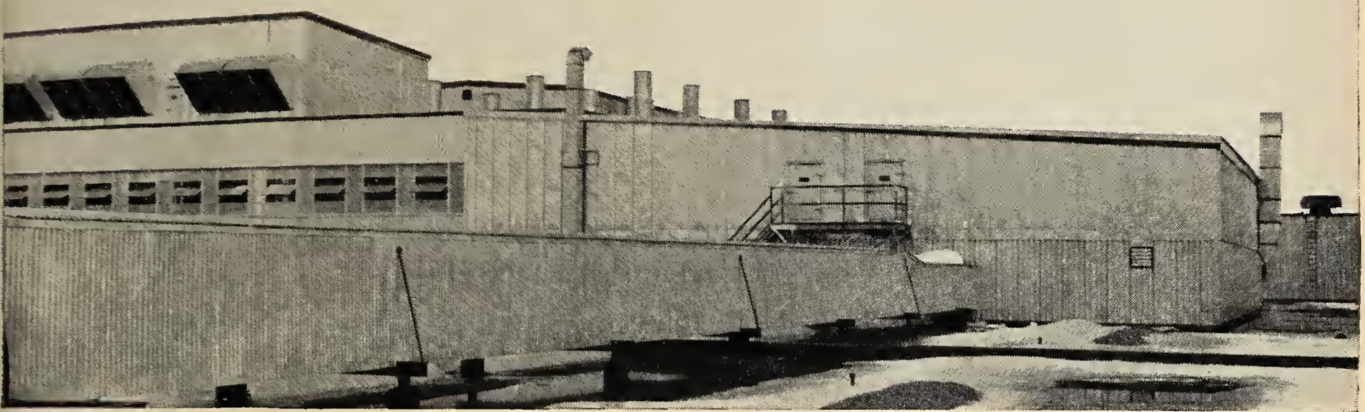
J. M. Macé, M.E.I.C., (McGill '35) has been appointed eastern zone power utilities sales manager for Northern Electric Company Limited. Mr. Macé has held many other positions in the Company before he was appointed Quebec regional manager, the position he held prior to his new appointment. An active member of the E.I.C., he was a vice chairman of the Quebec branch.

Dr. Keith L. Murphy, M.E.I.C., (Tor. '54) has been appointed sessional assistant professor of Civil Engineering at McMaster University where he will be in charge of the Sanitary Engineering program. Before going to McMaster Dr. Murphy was a research associate and instructor of Civil Engineering at the University of Wisconsin. Prior to this, he was assistant project engineer with the Greater Winnipeg Water and Sanitary Districts, and before this, junior design engineer with the City of Hamilton.

Stuart R. Muirhead, M.E.I.C., (Toronto '24) has been appointed superintendent of the Okanagan Telephone Company. Prior to joining the company in 1959, as assistant to the superintendent Mr.

(Continued on page 116)

How ROSS ENGINEERING is Helping To Produce One of Canada's Leading Cars

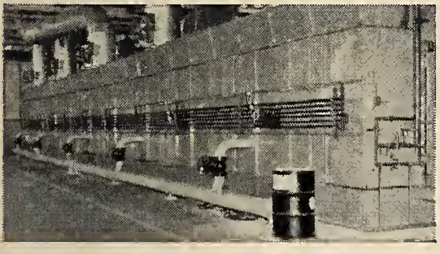


Outdoor type paint bake and lacquer ovens; 162 x 52 feet; 495 feet of conveyor in heat zone

Wet sanding dry-off oven and cooling tunnel (at left)

Interior 120 foot spray booth

Exterior of spray booth showing exhaust ducts, water recirculating header and paint lines



Specialists for many years in the broad field of 'Engineered Atmospheres', Ross Engineers applied their skills to the design and construction of the major units in this automobile finishing line. Of major importance, where controlled process air is concerned, are the spray booths, cooling tunnels, dry-off and paint bake ovens, for it is in these units and for these operations that the 'Engineered Atmosphere' must be precisely created and controlled.

Complementing their work on these key units, Ross Engineers designed and constructed auxiliary units such as sludge collection systems, tack rag tunnels, flash-off tunnels, and replacement air systems.

If you have *any* problem that calls for the use of 'air' as a major processing element, why not investigate this specialized Ross Service? For close to forty years, 'processing air' has been our business.

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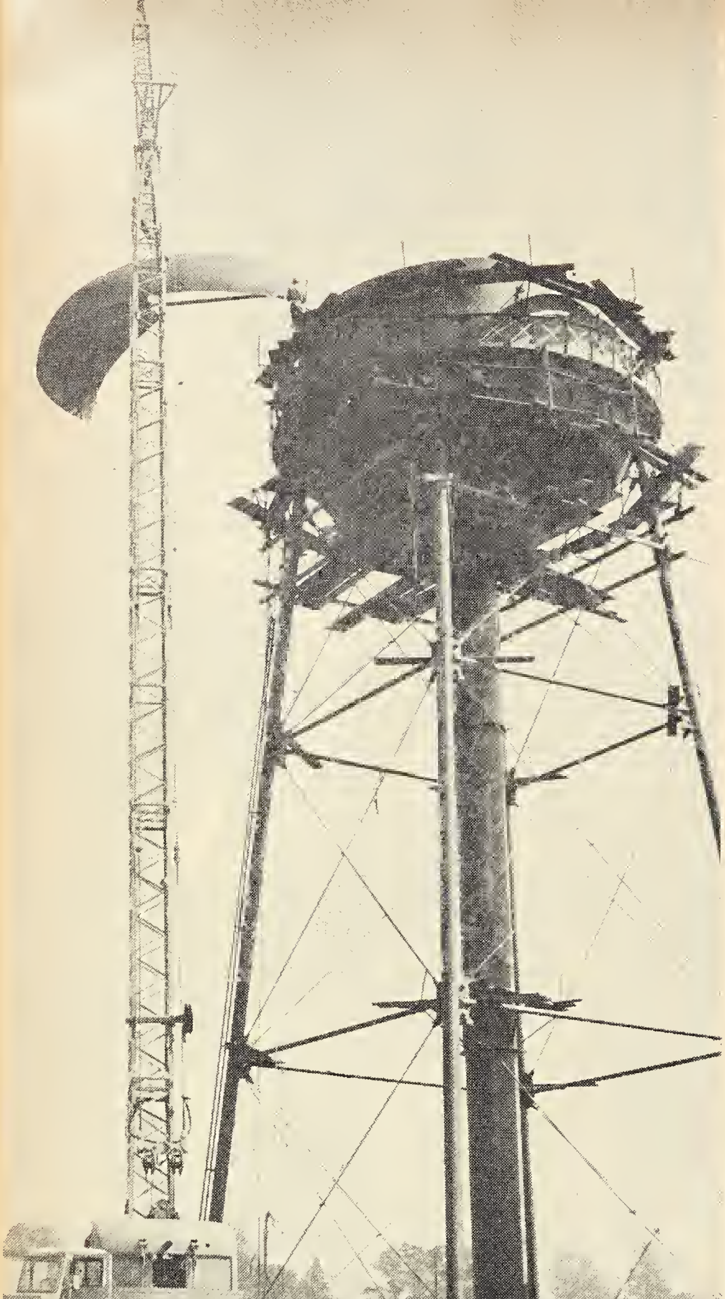
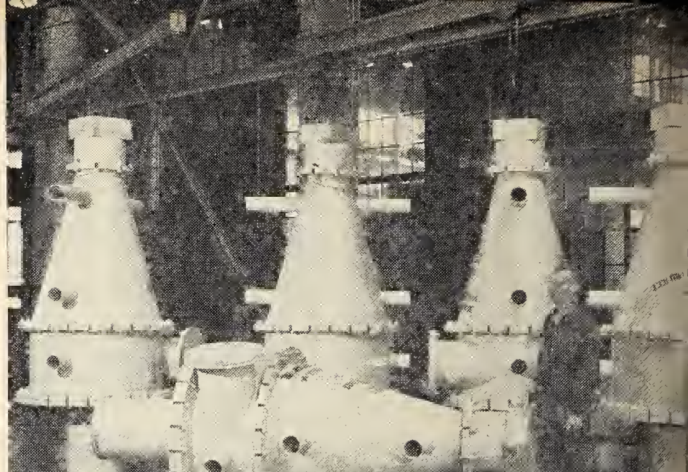
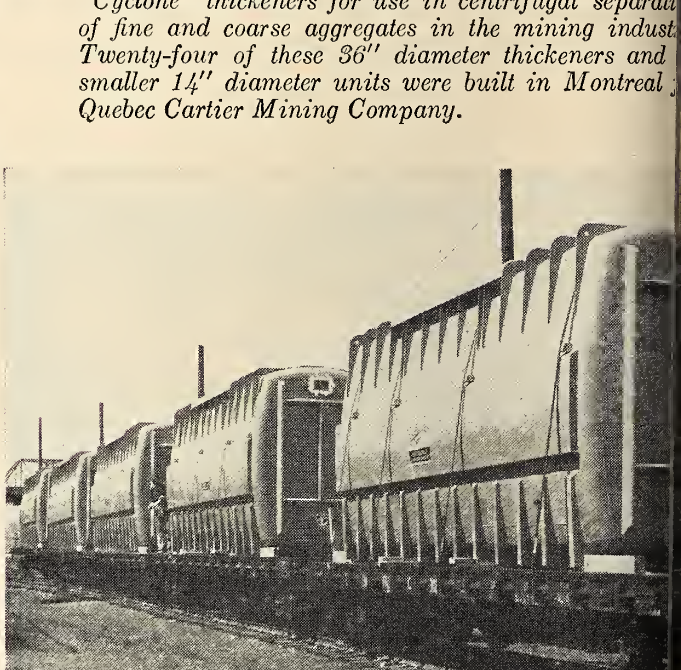


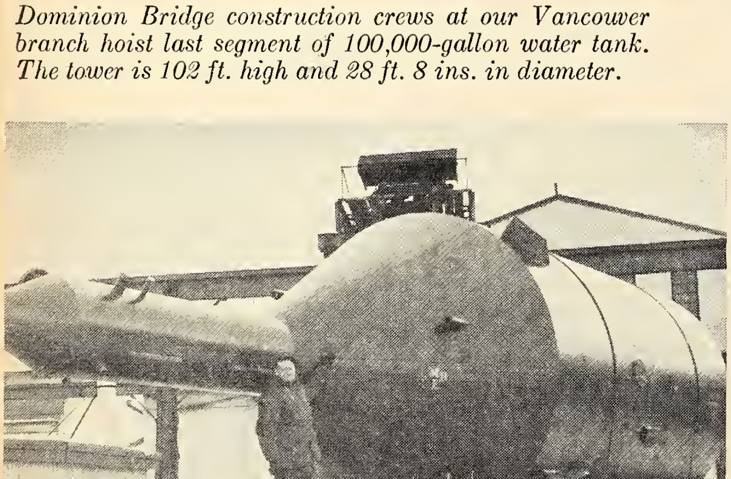
Dominion Bridge construction crews at our Vancouver branch hoist last segment of 100,000-gallon water tank. The tower is 102 ft. high and 28 ft. 8 ins. in diameter.



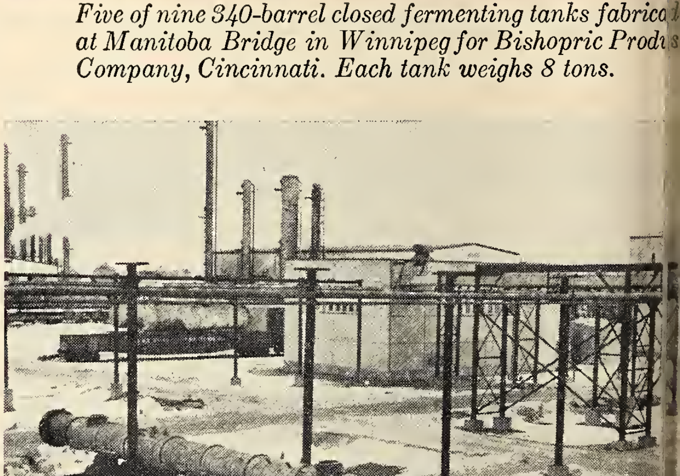
"Cyclone" thickeners for use in centrifugal separati of fine and coarse aggregates in the mining indust Twenty-four of these 36" diameter thickeners and smaller 14" diameter units were built in Montreal Quebec Cartier Mining Company.



Five of nine 340-barrel closed fermenting tanks fabrica at Manitoba Bridge in Winnipeg for Bishopric Prod Company, Cincinnati. Each tank weighs 8 tons.



One of 4 evaporators used in the salt industry leaving the Manitoba Bridge plant in Winnipeg. Each unit is 47 ft. in length and weighs 33 tons.



This 80-ft. long 36-inch diameter, stainless steel t was fabricated in Edmonton for an Alberta p chemical plant. Weight of the vessel is 22,000 pound

Other Societies

The Institute of Physics and the Physical Society

The Institute and Society announce a one day symposium on "Some aspects of vacuum science and technology" at the Imperial College of Science and Technology, London on January 5, 1962.

The symposium will cover both; continuously exhausted bakeable vacuum apparatus for pressures below 10^{-9}mm. of mercury, and the controlled deposition of evaporated film.

Further details and application forms may be had after the end of October, 1961, from the Administration Assistant, The Institute of Physics and The Physical Society, 47 Belgrave Square, London, S.W.1.

Engineers Joint Council

The Council, a federation of 24 national and regional engineering societies has moved to the new United Engineering Center located between 47th and 48th Streets. Eighteen other major engineering groups are located there.

The new quarters of the E.J.C. are on the third floor of the new building at 345 East 47th Street, New York 17, N.Y. This is now the address for the organizations for which the E.J.C. is secretariat including: the Engineering Manpower Commission; International Association for the Exchange of Students for Technical Experience; The United States Committee on Large Dams and the World Power Conference.

The Chemical and Petroleum Engineering Exhibition

The Second Chemical and Petroleum Engineering Exhibition is scheduled to take place at Olympia, London, June 20-30, 1962. Between 400 and 500 exhibitors will participate in what is expected to be the largest exhibition of its type ever held in Europe. The exhibition will cover petroleum and chemical processing and exploitation with plant, equipment, instruments, materials of construction and ancillary mechanisms for the extraction, production or handling of heavy chemicals, fertilizers, explosives; fine chemicals and pharmaceuticals; man-made fibres, plastics, resins, synthetic rubber; paints, varnish, cement; coal derivatives, coal-tar and petroleum products; chemical and petroleum fuels. Among the exhibitors will be manufacturers of nuclear and conventional power plant or suppliers of equipment for rocket fuel production.

Visiteurs Distingués

Le Dr. André Aycoberry, Vice-Président de la Société des Ingenieurs Civils de France, a visité au mois d'octobre dernier, le Bureau Principal de l'Engineering Institute. Lors d'une entrevue avec le Président, Dr. Ballard, le Vice-Président, M. G. N. Martin, et le Secrétaire Général, une fructueuse et cordiale discussion a eu lieu touchant les rapports entre les deux sociétés. Dr. André Aycoberry était accompagné de M. Treuil, attaché culturel du Gouvernement Français au Canada.

The American Society of Mechanical Engineers

Col. Lyndall F. Urwick, London, England, was awarded the Henry Laurence Gantt Medal at the Ninth Annual Joint Engineering Management Conference, held in New York City on Sept. 15. Col. Urwick, a distinguished English specialist in management, said that disease and undernourishment and disorder all over the world must be eradicated, not for compassion or idealism, but as the barest common sense of human survival.

"That means inevitably government action, on a national and international scale," he said, "and this in turn means putting management into government, and taking politics out of official action at the executive level."

Lord Brabazon Premiums

Four Canadians were honored October 19, when they were presented with Lord Brabazon of Tara premiums by the British Institution of Radio Engineers.

The premiums were presented to H. Ross Smyth, Dr. D. M. Makow, R. R. Real, and S. K. Keays, all with the Radio and Electrical Engineering Division of the National Research Council. Topic of their winning paper was a crash position indicator—a device designed to aid search aircraft locate a crash.

The presentations were made during a meeting of the Montreal Section of the IRE by Graham D. Clifford, General Secretary of the IRE.

Coming Events

- American Society of Mechanical Engineers. Winter annual meeting. New York City. Nov. 27-Dec. 1.
- Institute of Radio Engineers. Vehicular Communications. Annual Meeting. Minneapolis, Minn. Nov. 30-Dec. 1. American Institute of Chemical Engineers. 54th Annual Meeting. New York City. Dec. 3-6.
- American Institute of Mining, Metallurgical and Petroleum Engineers Inc. Nineteenth Electric Furnace and Steel Conference. Pittsburgh, Pa. Dec. 6-8.
- American Society of Agricultural Engineers. Winter Meeting. Chicago. Dec. 12-15.

The Associations and Corporation

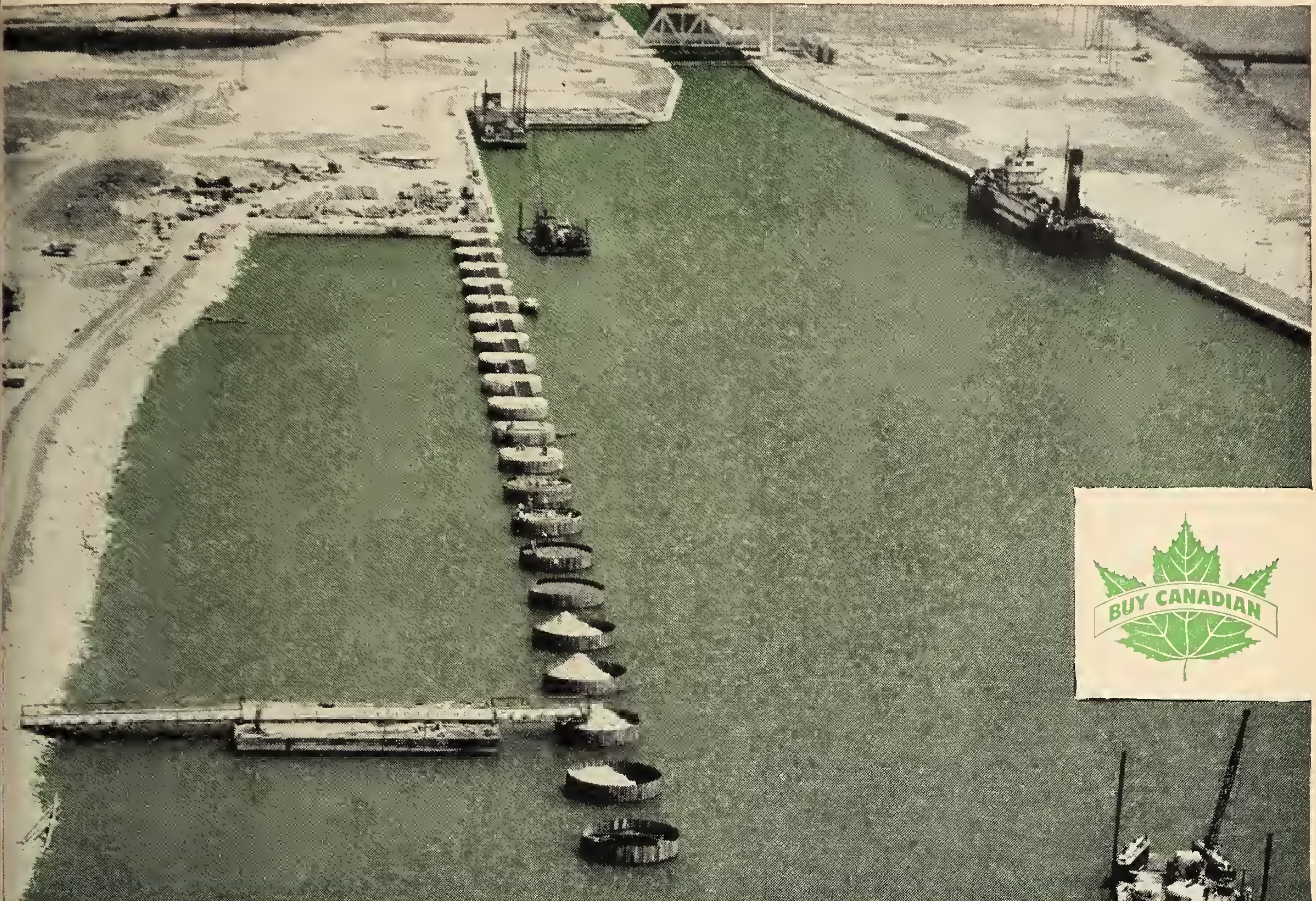
Canadian Council of Professional Engineers

A report dealing with engineers' salaries has been published by the Canadian Council of Professional Engineers. Entitled, "Report on Salaries of Professional Engineers by Levels of Responsibility as of July 1, 1961", it was issued on behalf of the Associations and Corporation of Professional Engineers of the 10 provinces and of the Yukon Territory. The results published are representative of salaries actually paid in British Columbia, Ontario and Quebec.

Six levels of responsibility have been defined in the report, and to indicate that there are levels beyond the scope of the survey, a seventh level has also been described. Each level embraces many fields of engineering activity which are described by individual job descriptions.

The spread of salaries for each level is that lying between the upper and lower deciles, that is, the middle 80% of the rates reported. The salary spreads reflect actual conditions within the participating organizations, including performance, proficiency and experience of individual engineers, the particular positions included in the level, and the general economic conditions which apply.

The section, "The Guide to Entrance Qualifications" lists academic requirements and a period of experience deemed to approximate, within its band, that normally required of an individual entering a given responsibility level.

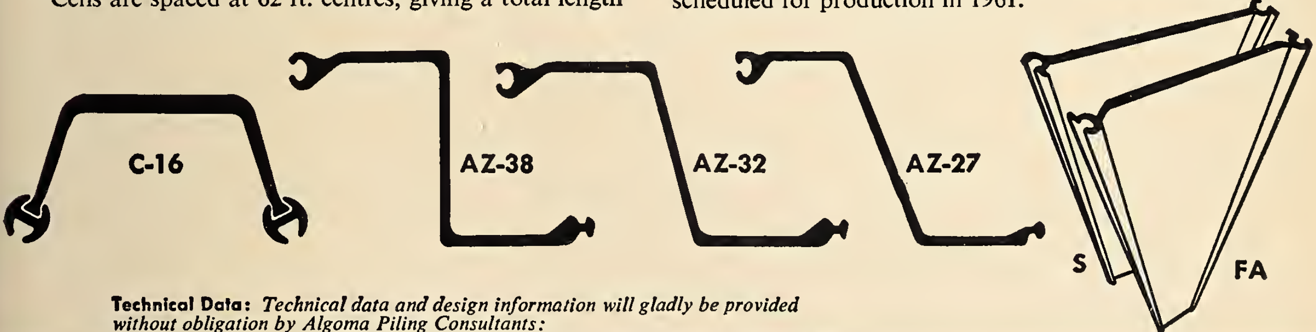


ALGOMA STEEL SHEET PILING

Shown above, during construction, is an aerial view of a modern type mooring dock located above the St. Lawrence Seaway Authority Upper lock at Beauharnois, P.Q. Ships tie up here when delayed or while awaiting passage through the locks. Algoma S-6 sheet piling was used in building this structure, comprising a line of 25 cells each 28 ft. diameter, rock-filled and capped with concrete slabs to carry mooring bollards.

Cells are spaced at 62 ft. centres, giving a total length of 1,540 ft., with linking structural steel roadways for movement of vehicles along the dock. Depth of water alongside is 30 ft.

Docks of this modern design can easily be extended at any time by building on additional cells. Besides types S and FA piling for this kind of structure, Algoma Steel also rolls deep arch type C-16 for other applications, as well as AZ-38 and AZ-32 sections. Type AZ-27 is scheduled for production in 1961.



Technical Data: *Technical data and design information will gladly be provided without obligation by Algoma Piling Consultants:*
H. E. McKEEN & COMPANY LIMITED, 160 ST. JOSEPH STREET, LACHINE, QUE.

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News of the Branches

Baie Comeau

G. W. Scott, M.E.I.C.
Correspondent

Forty-six members and branch affiliates visited, on Sept. 9, Site No. 5 of the Manicouagan Power Project of Hydro Quebec, located approximately 150 miles north of Baie Comeau.

The object of the visit was to inspect progress on the cofferdams and preliminary excavation work associated with the construction of the main No. 5 reservoir dam due to be started next year.

The No. 5 dam will be the longest buttressed multi-arch structure of its kind in the world—some 650 ft. high and 4000 ft. long. It is expected to require about 2,500,000 cu. yds. of concrete, and to meet this requirement a batching plant, with a capacity of 400 cu. yds. per hour, now is being constructed.

To establish the foundation of No. 5 dam the Manicouagan River is being diverted from the main dam site via two cofferdams and two parallel tunnels 47 ft. in diameter. The length of the outer tunnel is 2700 ft. and the inner tunnel 2400 ft. and the distance between cofferdams 1500 ft.

Progress on the upstream cofferdam and the two diversion tunnels was the focal point of interest to the visiting party. Both tunnels are now through and work on the upstream cofferdam well under way. The nature of the river bed at Manicouagan 5 presents unusual excavation difficulties in establishing the cofferdam foundations, and the manner in which these problems were being tackled was of great interest to the visitors.

The bedrock for the cofferdam consists of porous alluvial deposits of up to 250 ft. in depth, and since the main dam must be forged on a dry foundation conditioning operations are necessary to keep the water from seeping through. The answer, at Manicouagan 5, has been found by forming an impenetrable diaphragm of concrete piles through the alluvial deposit at the cofferdams. Holes 24 in. in diameter are drilled vertically through the alluvial deposit at 4 ft. centres, and filled with concrete, these holes form the frame of the diaphragm. Subsequently, a special drill is used between each adjacent pair of holes of the original frame, and when filled with concrete these secondary holes form a watertight diaphragm.

In addition to inspecting progress on the dam the visiting party toured the main construction camp which, at present, houses 1700 workers. Three separate airlines service the area.

The Baie Comeau Branch is indebted to the Quebec Hydro and especially to Project Manager, J. H. Huggard, and his staff for this interesting and informative field visit.

Belleville

A. F. G. Tooth, M.E.I.C.
Correspondent

J. Grant, chief engineer of Northern Electric Co. Ltd., Belleville, was guest speaker at the opening meeting of the Branch held on Oct. 2. His topic was 'Impressions of Jamaica, 1961.'

Mr. Grant who visited Jamaica this summer, spoke on the economy and general living conditions there. His talk was illustrated with color slides.

The guest speaker was introduced by S. Sillitoe and thanked by F/L A. C. Pickering.

Events scheduled for the coming months include: Nov. 13 a dinner meeting at the Queensway Hotel, Trenton, at which a professor from Queen's University will speak on 'Current Affairs'; Dec. 11, a tour of Mead-Johnson Plant, Belleville; Jan. 12, 1962, President's visit; Feb. 12, 1962, a speaker from R & D Army Headquarters will discuss 'guided missiles.'

Border Cities

V. Corin, JR.E.I.C.
Correspondent

A tour, on Sept. 20, of the recently expanded facilities of the Western Ontario Institute of Technology was made by 28 members of the Border Cities Branch.

A brief outline of admission requirements, scope of courses, and job possibilities upon graduation, was given by the staff of the school. The tour included a visit to the new buildings, housing, well-equipped chemistry, electrical, electronic and mechanical laboratories.

The efforts of Mrs. S. A. Stannard, K. H. Williams and their teaching associates were appreciated by the Branch members.

Cape Breton

Lloyd Boutilier, M.E.I.C.
Correspondent

President Ballard was guest of honor at the Cape Breton Branch meeting of Sept. 29. Dr. Ballard said that although Canadian engineers are as capable as those in other countries, they possibly lack the foresight necessary for development. For example, he said Canadian industry failed to capitalize on some items bulit or perfected by the National Research Council, whereas other interests took over their manufacture and benefited.

Dr. Ballard was introduced by C. M. Anson, Vice-President of Dominion Steel & Coal Corp. Ltd., a past President of the Institute. He was thanked by Chairman R. Bradley. Special guests included the Mayor of Sydney, Russell Urquhart, and his wife; Dr. William Reid of St. Francis Xavier Junior College and Mrs. Reid. A dinner and dance followed the meeting with some 50 couples present.

Central B.C.

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

A joint dinner meeting of the Central B.C. Branches of the Institute and of the A.P.E.B.C. was held Sept. 15 at the Kamloops Golf and Country Club. Branch Chairman J. W. Nelson presided.

W. J. M. Owen, who has served as Secretary-Treasurer of the Branch for a number of years, submitted his resignation because of poor health. Mr. Owen was commended on his diligence as a Branch officer. The balance of his current term is to be filled by R. J. Talbot.

M. L. W. Wade accepted the nomination for the office of Vice-President for Zone A, the Western Provinces.

A note from the wife of immediate past President George McK. Dick, thanking the members for their hospitality during the Presidential visit in May, was read.

Charles W. Nash, director of load development at the B.C. Power Commission, was guest speaker. His very topical speech, entitled "A New Look at Resource Development", dealt mainly with British Columbia.

Edmonton

W. Rutherford
Correspondent

The Edmonton Branch opened its 1961-62 season with a meeting Sept. 26 at the Seven Seas Restaurant. Vice-Chairman Brian Ellis presided. In his opening remarks Mr. Ellis said arrangements were being made for technical sessions relating to structural, civil, and electrical engineering. These technical meetings, scheduled to begin early in

(Continued on page 118)

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.

BOOK REVIEW

SOILS IN CANADA.

The subtitle Geological Pedological And Engineering Studies, is very descriptive of this book which shows the interdependence of these three aspects of soil science, and also shows some possible directions of future research.

The book originated in a symposium of the Royal Society of Canada, which was held at Queen's University, Kingston, in June 1960.

The book starts with Geology of the soils of Canada by V. K. Prest, followed by six papers on regional surficial geology entitled as follows: Soils of the coastal area of Southwest British Columbia by J. E. Armtsrong; Glacial deposits of Alberta by C. P. Gravenor and L. A. Bayrock; Soils of the Lake Agassiz region by J. A. Elson; Tills of Southern Ontario by A. Dreimanis; The Champlain Sea and its sediments by P. F. Karrow; and Glacial geology and the soils of Nova Scotia by H. L. Cameron.

Next comes a paper on muskeg entitled Organic terrain by N. W. Radford, followed by a paper on clay mineralogy entitled Clay mineralogy of Canadian soils by S. A. Forman and J. E. Brydon.

These are followed by four papers on pedological topics: The soils of Canada from a pedological viewpoint by A. Leahey; Characteristics and genesis of Poszol soils by P. C. Stobbe; Genesis and characteristics of solonetzic soils, with particular reference to those of Alberta, Canada by W. E. Bowser; and The soils of Southern Ontario by N. R. Richards.

The book is completed by four papers on soil mechanics topics: Correlation of engineering and pedological soil classification in Ontario by A. Rutka; Influence of geology on the design and construction of airports by N. W. McLeod; Engineering studies of leda clay by C. B. Crawford; and Engineering significance of soils in Canada by R. F. Legget and R. M. Hardy.

This book is not a textbook in soils, it is an excellent addition to the limited list of books that show the inter-relationship of different aspects of soil science.

The book is well written and shows the gentle touch of its editor. The illustrations are in general good and well selected, however some of the photographs, particularly in the paper on muskeg seem to have been reproduced from other publications and as a result are not as clear as they should be.

In closing, the reviewer believes that this is an excellent book particularly for those whose main soil interests are in the soils of the temperate zone. (Ed. by R. F. Leggett. Toronto, University Press, 1961. 229 p., $6.50.) Reviewed by Lionel Issen, M.E.I.C.

BOOK NOTES

*ECONOMICS OF WATERSHED PLANNING.

This volume contains the twenty-one papers and accompanying discussions which constitute the Proceedings of the Symposium on the Economics of Watershed Planning held at Knoxville, Tennessee in June 1959, and sponsored by the Southeast Land Tenure Research Committee, the Farm Foundation, and TVA. The aim of the Symposium was to examine the complex problems of small watershed development. The aim of the book is to contribute to a variety of working-level planning decisions that concern engineers, administrators and legislators in current water resources development but it also is concerned with how small watershed development can best fit into river basin and regional planning. (G. S. Tolley and F. E. Riggs. Ames, Iowa State University Press, 1961. 339p., $3.95.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

*NUMERICAL METHODS FOR SCIENCE AND ENGINEERING.

Developed from sophomore lectures at the University of Toronto, this book treats numerical methods for science and engineering from the standpoint of hand and desk-calculator techniques. A background in algebra, trigonometry, plane and solid geometry, and calculus is required. Now Chairman of the Department of Mathematics of the University of Waterloo (Ontario), Dr. Stanton discusses finite, divided, and central differences, computation with series and integrals, linear systems and matrices, and various methods of solution of ordinary, differential, difference and linear equations. The final chapter points out the transition from hand and desk to electronic techniques, in discussing the principles of automatic computation. (R. G. Stanton. Englewood Cliffs, Prentice-Hall, 1961. 266p., $9.00.)

*ADVANCED DESIGN IN STRUCTURAL STEEL.

The author terms this "a treatise on the design of statically-indeterminate structures". Design rather than analysis is emphasized, frequent reference however being made to other sources for methods of advanced analysis, and for derivation of equations. Work methods of analysis are favoured over the Cross methods and the method of slope deflection. The appendices include much useful information such as lists of frequently used formulas and equations. The book is intended as both an advanced text and a reference for practicing professionals. (J. F. Lothers. Englewood Cliffs, Prentice-Hall, 1960. 583p., $15.00.)

*FLUORESCENT LIGHTING MANUAL, 3rd. ed.

This new edition of the Manual attempts to indicate all the significant advances in fluorescent lamps, auxiliaries, applications, and performance in service since the second edition was published in 1947. The principal original purpose of the manual has been retained: to provide a ready and practical reference source giving the various types of information needed to design, sell, install and service fluorescent lighting systems. (C. L. Amick. Toronto, McGraw-Hill, 1960. 400p., $14.50.)

(Continued on page 124)

MISCELLANEOUS

ENGINEERS FOR MANAGEMENT. Project, design, sales, research, development, and control. Graduates of most types and ages are required by clients of the Technical Service Council, a non-profit industry-sponsored Placement Service. Write 2 Homewood Ave., Toronto 5, Ontario, or No. 1500 Stanley St., Montreal 25, Quebec, for an application. There is no charge for work done on your behalf. File No.: 6648-V.

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Month to Month *(Continued from page 101)*

"Citizenship and Participation in Public Affairs", was added. Other new material is expected to be added on branches of engineering.

The Recognition Committee report was accepted in principle by the ECPD but was referred to its constituent societies for comment. It was felt study should be made of a proposal to adopt the abbreviated title, "ing.", derived from the French word "Ingenieur" as the common identification for all engineers regardless of their specialties.

Engineering Education

"Where does professional specialization belong in the engineering curricula?", was the topic of an engineering education session on Oct. 3. Chairman was Ralph A. Morgen, President, Rose Polytechnic Institute.

Speaking from the standpoint of the undergraduate and graduate curricula, respectively, were: LeVan Griffis, Dean of the College of Engineering, Rice University; and Linton E. Grinter, Dean of Graduate School and director of research, University of Florida.

William K. Selden, executive secretary, National Commission on Accrediting, discussed the topic in relation to the effect on accreditation principles and procedures. Another approach was made by Lloyd E. Elkins, production research director, Pan American Petroleum Corporation, who discussed the topic in relation to industry needs.

Business and Industrial Briefs

Appointments and Transfers

J. H. Bolton, managing director of The Foxboro Company, Ltd. has announced the appointment of Edward R. Huckman as general sales manager. Experienced in the field of process measurement and automatic control, Mr. Huckman started his instrument career in 1927 at the company's main plant in Foxboro.

General Motors Diesel Ltd., has announced the appointment of **E. W. Airey** as supervisor, distributor parts sales and **S. W. Matheson** as sales engineer, locomotive parts and rebuild. Mr. Airey joined the company in 1950 and Mr. Matheson in 1951.

Earl Clements has been appointed executive sales engineer for New Brunswick by Continue-Flo Heating Products, Ltd.

Upon resignation from the board of directors of Dorr-Oliver Inc., **Dr. John V. N. Dorr** was elected director emeritus by the board. Dr. Dorr founded the Dorr Company. He received a BS degree from Rutgers College in 1894 and, during the years has received five honorary degrees.

Humphreys & Glasgow (Canada) Ltd., has announced the appointment of **J. Ian Jenks** resident manager for Western Canada for its new office in Calgary. Before coming to Canada in 1952 Mr. Jenks was engaged in the Middle East oil industry.

J. H. Ross, manager of Noranda Copper and Brass Ltd. has announced the appointment of **P. A. Scully** as general superintendent of technical services. Mr. Scully has served as plant metallurgist since the company's inception in 1947.

Continue-Flo Heating Products, Ltd. has announced the appointment of **A. K. Palmerson** as a special factory sales representative. Mr. Palmerson has had more than 32 years of experience in the warm air heating field. He was formerly associated with Fairbanks Morse.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

AN IMPROVED method of pneumatically loading ammonium nitrate/fuel oil blasting agents in underground mines has been announced by Canadian Industries Ltd. The new model ejector, called an "Anoloder", is used for short to medium length small diameter holes with loading rates from five to 12 lb./minute, the company stated. The device, which is relatively small and inexpensive, jets prill mixtures into boreholes at a velocity which causes crushing of the prills and results in increased sensitivity and loading densities (.85 to .95).

A $2.5 MILLION order has been given Canada Iron Foundries, Limited, Mechanical Division, to furnish finishing equipment required for the Algoma Steel Corporation's new $30 million hot strip mill which will be erected at Sault Ste. Marie, Ont.

A UNIQUE WEDGE and toggle system, devised by engineers of Dominion Bridge Company, was used in the final 'closure' of the steel superstructure of Montreal's new Champlain bridge over the St. Lawrence Seaway. Adjusting the steelwork to bring it into alignment for final pinning and bolting at the centre is one of the most intricate operations in cantilever bridge erection. With an overall length of 2,485 ft., the crossing spans the St. Lawrence Seaway canal near Laprairie, on the south shore of the St. Lawrence River opposite the Island of Montreal.

A $5 MILLION order has been received by Canadian General Electric's apparatus department to supply electrical driv eand control equipment for a new mill of Algoma Steel at Sault Ste. Marie, Ont. CGE announced that it is the largest single industrial equipment order ever placed at its Peterborough plant, and will provide the equivalent of a year's work for some 300 men. The CGE equipment will power and control a new 106-inch wide strip mill at Algoma, being built at a total cost of some $30 million dollars.

A NEW AIRLESS spray equipment catalogue is now available from De-Vilbiss (Canada) Ltd. The catalogue lists specifications and information on the new "compaet" medium production pump for a single gun operation, including available accessories; the heavy duty pump for multiple gun operation, including portable and tank mounted models; spray guns, including pole automatic guns; the range of spray caps available, and types of hose connections.

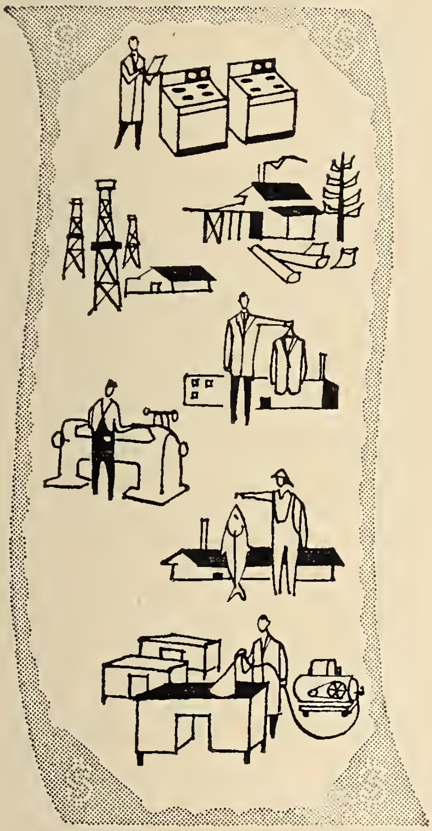
A FOLDER announcing a new system of designation for Inco Huntington Alloys now is available. This reference piece lists both the new and former designations, and the chemical compositions for each alloy.

A CONTRACT to supply 18 gas turbine powered electrical generating sets for installation in five new radar stations in Western Canada has been awarded Orenda Engines Ltd. The contract which covers the supply and installation of Gas Turbine, Electrical Generators, Steam Boilers and associated equipment is valued at approximately $3.5 million.

A NEW GAS density cell has been introduced by the Foxboro Company. This instrument which provides continuous precise measurement of gas density in pounds per cubic foot is identified as Type 35. Of value to the gas and chemical industries, the instrument produces a differential pressure directly proportional to density. This measurement, combined with a pressure differential across a primary device, makes it possible to determine mass flow of gas.

AN ELEMENTARY outline of the characteristics, operation and selection of reciprocating, rotary and centrifugal pumps is given in a 16-page booklet issued by Montreal Locomotive Works, Ltd., MLW-Goulds Division. Emphasis is placed on centrifugal pumps because of a wide usage of this type. Definitions, basic formulae, examples and miscellaneous data frequently used in pump application are included in the brochure.

(Continued on page 120)



(Continued from page 102)
Muirhead was general manager of the Saskatchewan Government Telephones and has been prominent in Canadian telephone activities for more than 25 years.

Cecil E. Carson, M.E.I.C., (McGill '22) has been elected General Chairman of the Canadian Highway Safety Council. He was previously the Council's treasurer. Mr. Carson is Director of Imperial Oil Ltd., and Vice President of Interprovincial Pipe Line Co.

Harvey D. Landells, M.E.I.C., (Toronto '50) has been named city engineer at Welland, Ont. He was formerly water works superintendent for the City of Welland.

Ralph A. Bowie, M.E.I.C., (McGill '42) has been appointd construction supervisor of Canadian Industries Ltd. Mr. Bowie joined C-I-L in 1951 and for two years he was resident engineer at the polythene plant in Edmonton, Alta. In 1954 he was transferred to the engineering department in Montreal as construction engineer.

Obituaries

Guy Raoul Rinfret, M.E.I.C., (McGill '26) President and a Director of the Shawinigan Engineering Company, Limited, Montreal, died Oct. 10 after a brief illness. He was 60.

Mr. Rinfret, born in Dawson City, joined the Shawinigan Water and Power Company in 1918, and the following year joined Shawinigan Engineering when it was organized and remained with the Company during his years at McGill University where he obtained a B.Sc. (Civil) in 1926.

He was resident engineer on construction of Rapide Blanc power development, 1930 to 1934, and held the same position for the La Tuque power development, 1938 to 1940.

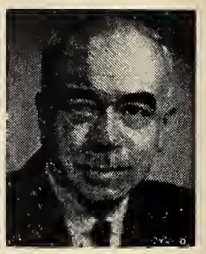
Between 1941 and 1946 he was general superintendent of construction, after which he was loaned to the Chinese Nationalist Government for which he travelled some 6,000 miles in China investigating hydro-electric sites.

Following his work in China, Mr. Rinfret served Shawinigan Engineering successively as supervising engineer, chief engineer, Vice-President engineering, and was appointed President in February of this year.

Mr. Rinfret joined the Institute as a Student Member in 1924, and became a full member in 1940. He participated actively in the affairs of the Institute and at the time of his death was a member of the Finance Committee.

Survivors include his widow, one daughter and two sons.

C. V. Christie, M.E.I.C.



G. R. Rinfret, M.E.I.C.

Clarence Victor Christie, M.E.I.C., (McGill '06) died in Montreal, Oct. 7, at the age of 79. During 45 years as a teacher and a research worker at McGill, Professor Christie earned the professional respect and personal regard of thousands of students and fellow engineers.

Widely acclaimed in the field of electrical engineering, Prof. Christie was made an emeritus professor when he retired from the university after five years of post-retirement teaching. He was an authority on electrical generation and distribution.

The son of a missionary, Prof. Christie was born in Trinidad in 1882. Four years later his family moved to Halifax. Prof. Christie earned a B.A. at Dalhousie in 1902, and the following year an M.A. in mathematical physics. He earned his B.Sc. in electrical engineering from McGill in 1906.

After working briefly in the United States, Prof. Christie joined the McGill faculty as a lecturer, ultimately becoming Macdonald professor and chairman of the Department of Electrical Engineering, a position he held from 1926 until 1947.

In 1913 the first edition of his important book, "Electrical Engineering" was published.

Prof. Christie is survived by his widow and one son. EIC

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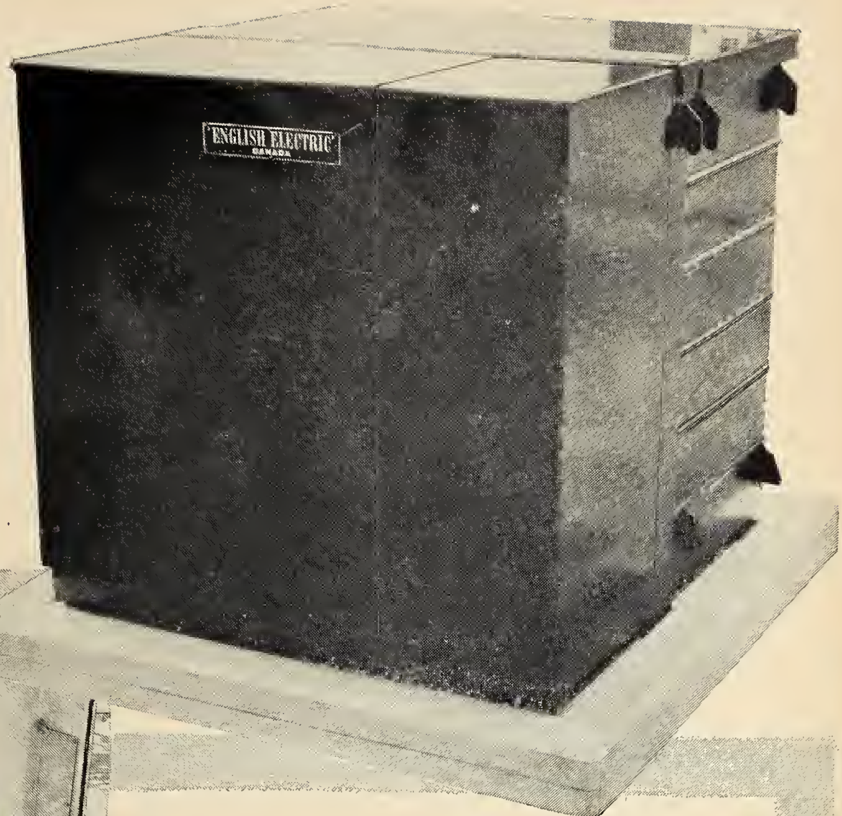

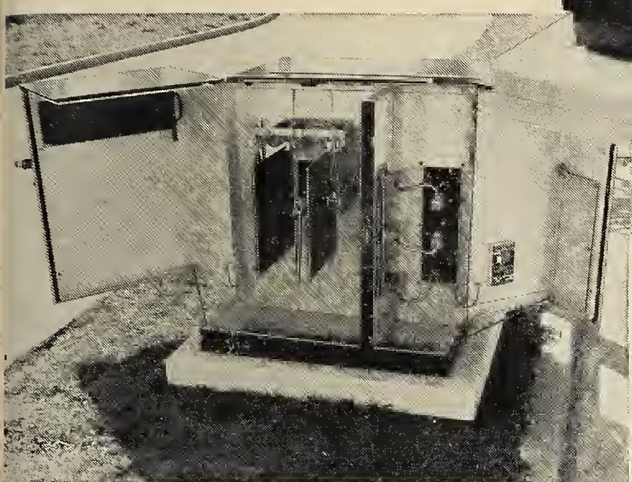

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(Continued from page 108)

1962, are being held in accordance with the wishes of the members as expressed in a recent referendum.

A distinguished member of the Branch, Charles E. Garnett, was presented with a Life Membership in the Institute by Lt. Col. Debney, a senior member.

The guest speaker was Len Gads, Assistant Dean of Engineering, University of Alberta, who was introduced by Hal. Morrison. In his talk entitled "Engineer in Paris", he spoke of the 13 months, from July, 1960, until August, 1961, which he spent in Europe. He was there primarily to attend the French National Geographic Institute, which is responsible for mapping French territory and areas of French influence. He reported on the type of work being conducted, illustrated with slides on aerial photography, applied optics, photogrammetry, geodesy, surveying and applied subjects.

Mr. Gads' talk included a description of his visit to the Caucasus Mountains in Russia, Moscow, Leningrad, Sweden, Denmark and France.

The descriptions and the excellent slides were received enthusiastically by the members.

Kitchener

A. R. LeFeuvre, M.E.I.C.
Correspondent

The Branch began its fall program Sept. 21 with a stag at Bingeman Park. Thirty-six engineers participated in games of horseshoes, golf and nail driving. The highlight of the evening's activities was a meal of pigtails and spareribs. The weather was ideal for such outdoor activities, and a good time was reported by all attending.

Newfoundland

Anthony O. Nemec, JR.E.I.C.
Correspondent

On arrival at St. John's, Sept. 30, President Ballard and Mrs. Ballard, accompanied by the General Secretary, were conducted on a tour of a nearby satellite tracing station. This tour was arranged and conducted by Chairman A. M. Butt and the executive members of the Branch.

A dinner meeting was held at the Old Colony Club in the evening of Sept. 30 with Dr. Ballard as guest speaker. His speech was entitled, "Engineering and the Economy of the Country." Dr. Ballard contrasted the long history of engineers and engineering with the newness of the profession in its modern applications. He said the tremendous growth of technology in the last few decades has surpassed that of the previous period, and that engineers have had a tremendous impact on the economy of the entire world, and particularly on the economy of Canada. However, he said, in Canada this impact has been almost entirely in the primary industries, and with the changing emphasis on manufacturing industries engineers must adapt themselves to the new conditions. He stated that we have failed to meet the challenge in many respects and cited Sweden, "a smaller country, where there is a greater diversity of secondary industry."

Dr. Ballard said the excuses that the markets in Canada are not large enough and the labor costs are too high do not explain the lack of venture in Canada. These same factors have been overcome in other countries, he said. The President continued that industry must develop a greater interest in new ideas and techniques that can lead to expansion of existing industry and the invitation of new ones. These ideas and techniques are continually being developed and, in Canada, we have an excellent source of such ideas in the National Research Council which covers many fields of basic and applied science, he said. Concluding his talk the President said that to insure a bright future for Canada we must use our imagination and engineering skills, not only to develop new ideas but to apply these ideas in the development of new markets and industries.

The meeting was well attended and enjoyed by the members, their wives and friends. After dinner a local orchestra played for those who wished to dance.

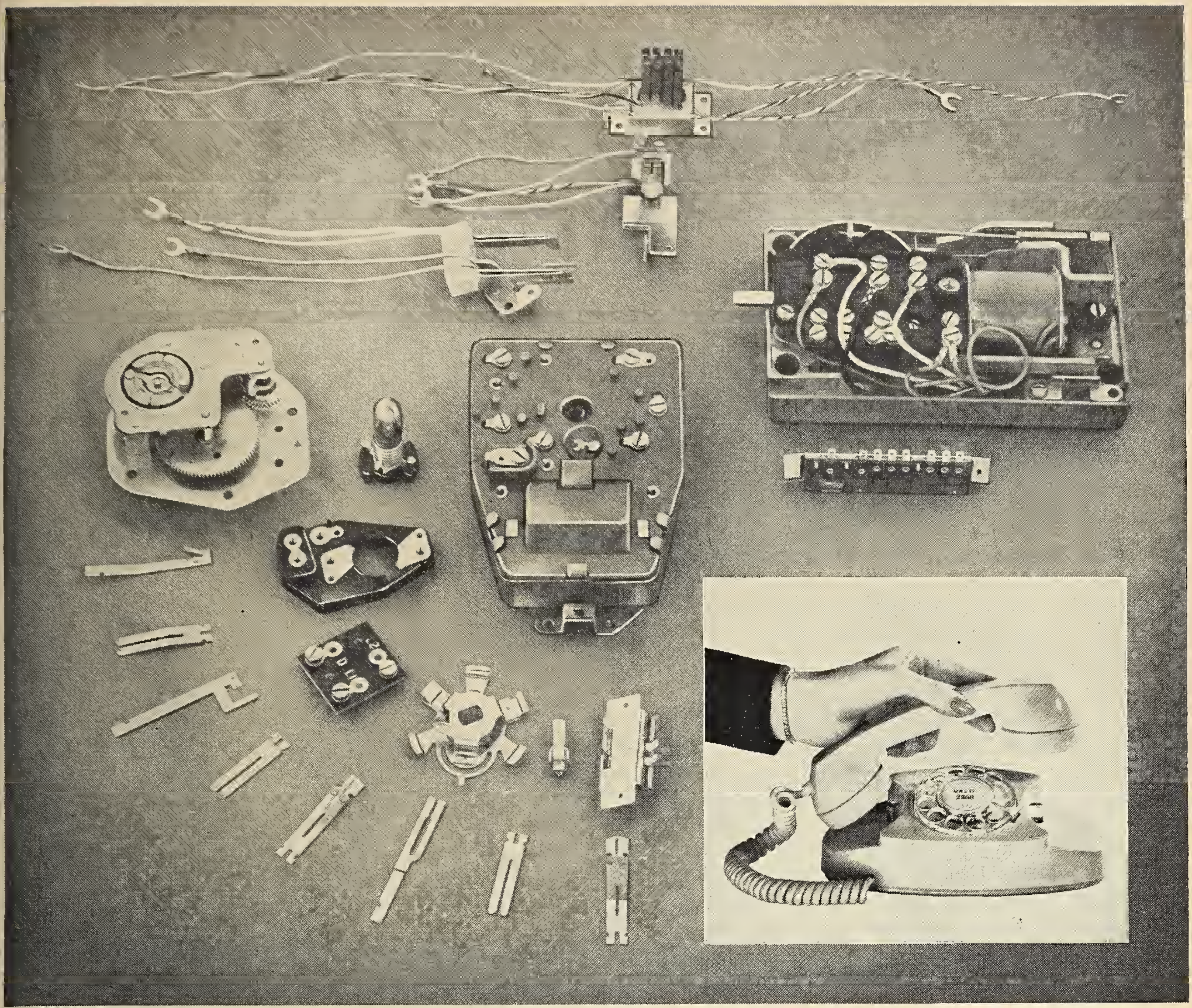
A meeting with the Branch executive was held on the following day before the departure of the President's party.

Nipissing and Upper Ottawa

J. S. Cooper, M.E.I.C.
Correspondent

A Sept. 20 field trip to Sault Ste. Marie, Ont., was the opening activity of the Branch's 1961-62 season. Ten mem-

(Continued on page 120)



(Continued from page 118)

bers of this Branch, including Chairman R. A. Booy, and 50 members of Sudbury Branch inspected the Algoma Steel Corporation Limited plant.

Following lunch at the Caswell Hotel, the group was conducted to the plant where an introductory film on the company's operations was shown.

A conducted tour followed and included the ore docks, coke plant, open hearth and oxygen process steel plants and rolling mills, which amply demonstrated the expansion which has taken place in Algoma's activities.

The meeting concluded with a dinner, sponsored by Algoma Steel, at the Windsor Hotel.

Sarnia

Joseph P. Zanyk, M.E.I.C.
Correspondent

The Institute's Ontario Vice-President, Edgar A. Cross, was guest speaker at the Sept. 19 meeting. Speaking on "Development of Engineering Societies", Mr. Cross outlined the history of professional societies and the reasons they were formed. He covered the development of engineering societies from their beginnings until the present, and elaborated on the need for these societies and organizations as a vehicle for the discussion and practical development of discoveries.

The second part of the meeting was taken up with the showing of two films on underwater construction. Rod Martin of International Underwater Construction Ltd. introduced the films and answered questions concerning his company's operations. The first film dealt with the training of divers for underwater work and the tools necessary. The second film showed the actual demolition and removal of a sunken ship in the St. Lawrence River.

After the meeting a lunch was served.

Saskatoon

S. J. Warder
Correspondent

The fall program of the Branch began with a meeting on Oct. 5 with 58 members and students present. Guest speaker was J. M. Crook, chief engineer, Conservation and Development Branch, Sask. Department of Agriculture, Regina. In his speech he dealt generally with irrigation in Saskatchewan, describing existing projects, problems and improvements which have been made. He mentioned future developments in connection with the South Saskatchewan River Dam. His talk was illustrated with slides. EIC

(Continued from page 114)

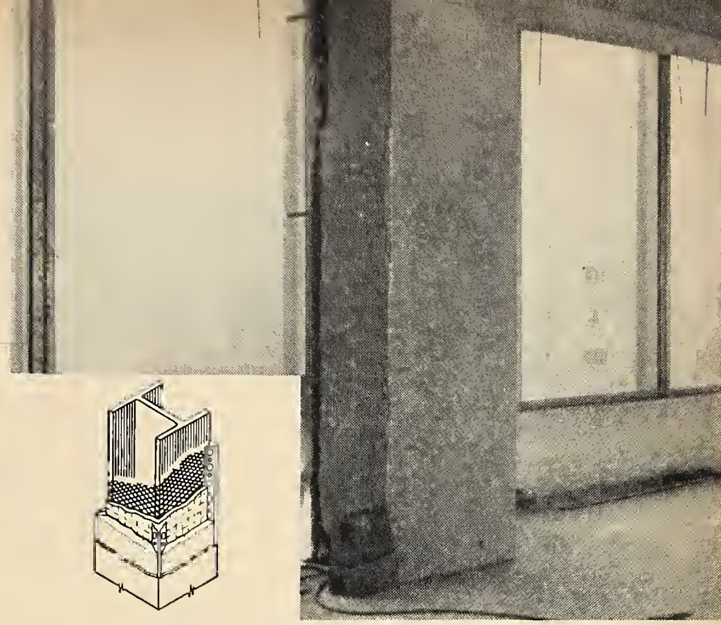
RECENT TESTS carried out by British Oxygen Canada Ltd., in the use of nitrogen shrinking in assembling components for heavy machine tools, have shown impressive savings in time and money. Nitrogen shrinking involves immersing a metal component in an insulated tank of liquid nitrogen (boiling point – 195.8 degrees C.) for a period varying according to the metal concerned and the amount of contraction required.

A NEWLY-PUBLISHED manual issued by Canadian Zurn Industries, Ltd., describes a wall closet supporting system that makes possible up to 19 off-the-floor siphon-jet closets in a horizontal battery on a single vertical stack, without impairing the physical qualities of structural slabs. The manual describes in detail how the recently developed Zurn "Monolithic" System supports long-run batteries of siphon-jet wall closets without resorting to costly modifications, slab re-designs, or expensive floor fills.

PLANS FOR the construction of a chemicals plant in New Brunswick and a TNT plant in Beloeil, Que., have been announced by Canadian Industries Ltd. The chemicals plant to manufacture chlorine and caustic soda is slated for completion in 1963. The exact location of the plant will be announced later. The TNT (trinitrotoluene) and dinitrotoluene plant is expected to be completed by mid 1962. TNT is not now manufactured in Canada.

CAM - OPERATED PROGRAM controller-recorders which control process programs cut into plastic cams and record them on circular charts, are described in a four-page specification sheet recently issued by Honeywell Controls Ltd. Various types of pneumatic, electric contact or electric proportional control are available.

(Continued on page 125)

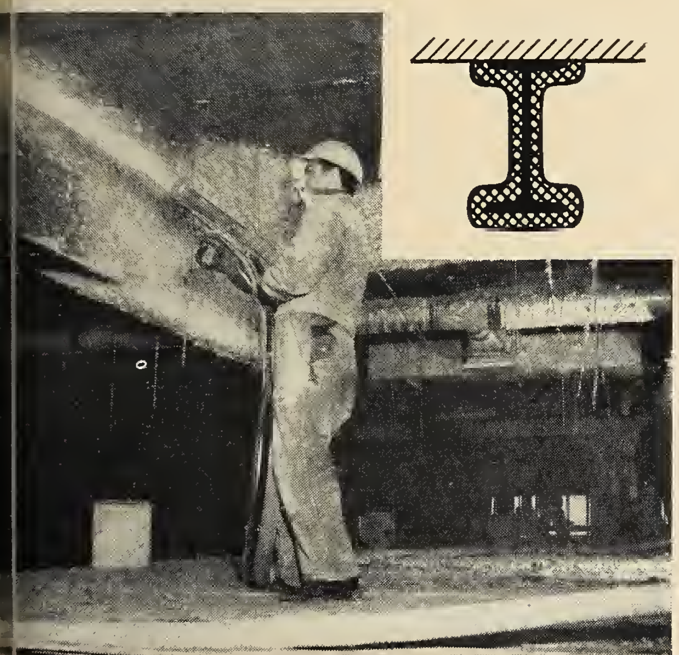


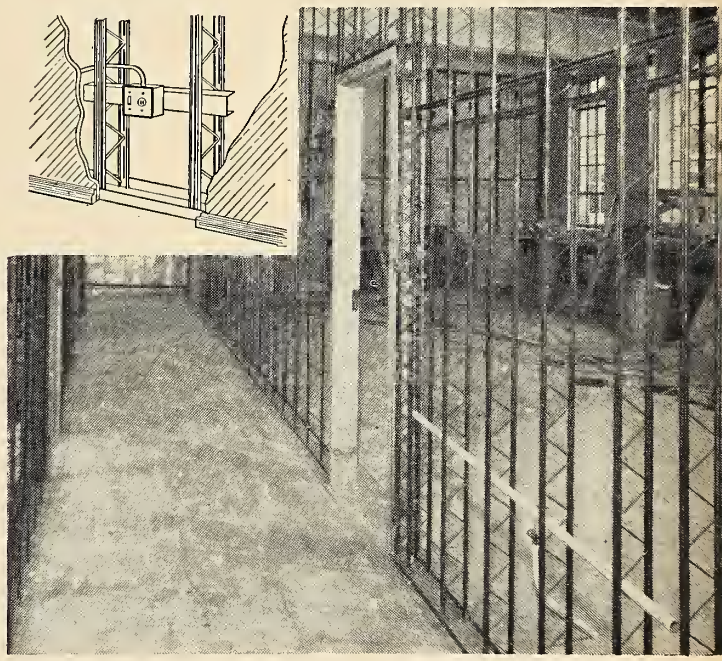
ht gauge steel cellular floor is covered with thin layer of crete. Material is available in several shapes and sizes suit span and service requirements. Cellular floors can vide built-in air conditioning duct, and raceways for trical services, etc.

Vertical columns are fireproofed and finished with gypsum plaster over self furring metal lath. Recesses between column webs provide excellent ducts for service pipes.

neral fibre, in this case asbestos, is sprayed on steel to vide light weight fireproofing. Material also provides uable acoustical characteristics.

DB Litebilt open web steel stud sections provide one of the most efficient methods of building light weight low cost partitions. The material is available in four stock sizes of various lengths.





structures — here's why

If you are planning construction, consider carefully the merits of steel. Dominion Bridge have engineers, fabrication and erection facilities in most of the major cities. Their experience and the quality of their performance have no equal in Canada.

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Structural Division **DOMINION BRIDGE**

FIFTEEN PLANTS COAST-TO-COAST

(Continued from page 120)

NEW RE-RATE induction motors, frames 504UU, 505U, and 506U, 600 rpm to 300-hp, 3600 rpm, have been announced by Canadian Westinghouse. The new, compact design will provide continuity in appearance, size and performance with the firm's 364U and 445U re-rate motors. Increased capacity in smaller, more compact motors and greater insulation protection will be other advantages.

THREE NEW BULLETINS have been published by Canadian General Electric: one describes the company's new clear silicone potting compound (LTV-602); another describes the properties and handling characteristics of silicone rubber as they pertain to wire and cable insulation for use in aircraft and missile support equipment; and the third describes the company's new box furnaces with cooling chamber.

DESIGNED for use with natural gas and propane, two-piece gouging nozzles have been introduced by Union Carbide Canada Ltd., Linde Gases Division. These new nozzles are said to produce greater preheat than before possible using natural gas or propane. They are ideal for gouging heavily-scaled or rusted plate, or castings with sand incrustations. Designated the "Oxweld" 1542 Series, the new design incorporates a slotted internal nozzle with an external sleeve.

A NEW TRUCK MIXER drum control which provides complete control of discharge, by one man, at the end of the mixer chute, has been announced by the construction machinery section of Chain Belt Company. The new Rex push-button drum control is air operated and can be operated via a flexible remote air line stretching up to 30 feet or more. EIC

(Continued from page 110)

*MAGNETIC MATERIALS IN THE ELECTRICAL INDUSTRY, **2nd. ed.**

Intended to bridge the gap between an academic study of the properties of magnetic materials and the limited treatment of the subject possible in most textbooks for engineers, and to link the properties of materials with their applications, this book will be helpful to senior students in physics and electrical engineering, and to physicists and engineers in industry. Following explanations of magnetic terminology and units, and a discussion of the influence of magnetic theory on the development of materials, the author discusses the historical development, application and testing of permanent magnets and of soft magnetic materials, and describes special devices such as sound-recorders, non-destructive testers, transductors, and transducers. Selection of new material for this edition has been made to indicate salient trend rather than attempt to catalog the tremendous recent advances both theory and practice. (P. R. Bardell in London, Macdonald, 1960. 320p., 32/6.)

*LA DYNAMIQUE DES PROCESSUS INDUSTRIELS.

Translated from the English, this volume is 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. Paris, Dunod, 1961. 302p., 56 NF.)

ACTIVE NETWORKS AND FEEDBACK SYSTEMS.

The Proceedings of the tenth, 1960, Microwave Research Institute Symposia Series, sponsored by the Polytechnic Institute of Brooklyn, in co-operation with the I.R.E. and the U.S. joint services.

The thirty-two papers presented at the symposium are divided into six groups covering: the state of the art and future trends; feedback networks and systems; synthesis of active networks; active network concepts; time-variable and nonlinear networks; time varying systems. References are included with most papers.

The 1961 Symposium was to be on Electromagnetic and fluid dynamic properties of plasma. (Brooklyn, Polytechnic Press, 1961. 658p., $8.00.)

*MODERN PRODUCTION MANAGEMENT.

Methods of analysis, the design, and the operation of production systems are dealt with at length. The production system is defined rather broadly to include such activities as hospitals, supermarkets, retail stores, and offices, although the factory model is predominant. In his approach the author attempts to integrate much about the new analytical methods and material from operations research, management science, and industrial engineering with the methods that have been used traditionally. (E. S. Buffa. New York, Wiley, 1961. 636p. $10.25.)

*THEORY OF ELASTIC STABILITY, 2nd. ed.

This second edition of a book on the stability of structures emphasizes fundamental theory. The authors have brought their material up to date and added new material on the buckling of bars under the action of non-conservative forces, periodically varying forces, and impact; on the determination of critical loads of columns by successive approximations; on the tangent modulus in the elastic buckling of beams; and on the buckling of plates. (S. P. Timoshenko. Toronto, McGraw-Hill, 1961. 541p., $15.00.)

*FOUNDATIONS AND SOIL PROPERTIES.

The subtitle describes this book as a "practical guide to the methods of improving the physical properties of ground to increase its strength". A British civil and railway engineer, the author first describes the nature of soil formation and the testing of soil properties both on site and in the laboratory. He then discusses various actual soil formations, methods of overcoming undesirable tendeneies, the strengthening of needed qualities, and selection of the best processes for this purpose. In giving illustrations of the discussion, the author describes "in reasonable detail" many construction projects of particular interest throughout the world. (Rolt Hammond. London, Macdonald, 1961. 181p., 30/-.)

TABLES OF THE HYPERGEOMETRIC PROBABILITY DISTRIBUTION.

The hypergeometric probability distribution has usually been approximated by means of binomial, Poisson and normal distribution. These tables were computed in connection with another of the authors' projeets, and the sample and lot values on which they are based were chosen to provide exact (six-decimal-place) point and cumulative probability values in the ranges where most sampling is done, and where the usual approximations are poor. The tables are given for N=Z, n=1 through N=100, n=50 and N=1000, n=500, and K=n–1, n; n=N/2; N=100, n=50 through N=2000, n=1000.

Research workers in engineering and other fields should find these tables useful. (G. J. Lieberman and D. B. Owen. Stanford, University Press, 1961. 726p., $15.00.)

GRAPHIC STATICS.

Intended for both engineers and architects, this text shows how graphic statics are used for working out internal forces in a determinate frame. The 78 examples included cover: roof trusses; girders; three-pinned arch bridge; cantilever bridge; trestles, etc. (C. S. Benson. Toronto, British Book, 1961. 96p., $5.75.)

*SYMPOSIUM ON RADIATION EFFECTS AND RADIATION DOSIMETRY.

This symposium presents some of the latest research on the effects of radiation on materials properties, as well as discussions of parameters to be considered in predicting and evaluating such effects. Also presented are newer techniques for radiation measurement. (Philadelphia, American Society for Testing Materials, 1960. 156p. $4.75.) (s.t.p. no. 286.)

*FOUNDATION FAILURES.

The author discusses the diversity of factors that result in the failure of foundations; and provides guidance on the means by which they can be prevented or remedied. The investigation of the site, unsuitable types of structures and foundations, defects and failures due to defective execution, and failures due to external influences are covered. Numerous examples are cited and described. (C. Szechy. London, Concrete Publications, 1961. 141p., $5.00.)

(Continued on page 126)

(Continued from page 125)

AXIAL FLOW FANS.

This volume presents an authoritative treatment of the aerodynamics of ducted axial flow fans. The results of aerodynamic research are analyzed, and a working theory evolved. Finally, a design method is developed, with enough basic data to enable it to be applied to problems of design, ducting or analysis likely to arise in connection with these fans. Some of the topics covered are: aerofoil data for blade design; vortex flows; ducts; rotors; stators; tail fairing design; noise; testing. A useful list of references is included.

The author, who is with the Australian Aeronautical Research Laboratories, has had wide experience in fan design and aerodynamics. (R. A. Wallace. Toronto, British Book, 1961. 366p., $10.50.)

*ELEMENTS OF NUCLEAR ENGINEERING.

A general survey is given of radiation, fission, fusion, and other nuclear transformations, with indications of how these transformations may be exploited in industrial and engineering applications. Beginning with a discussion of the concepts, principles, and ideas necessary for an engineering understanding of nuclear transformations and of radiation, the text continues with a simplified presentation of modified one-group theory of homogenous, bare, thermal reactor cores. It concludes with a review of radiation, its measurement, and the hazards associated with it. (G. Murphy. New York, Wiley, 1961. 213p., $7.50.)

1961 SAE HANDBOOK.

This latest edition of the Handbook Davis Brown Co. Ltd., consulting engi-contains some 400 standards, recommended practices, and information reports prepared by SAE Committees, providing dimensional specifications, test requirements and procedures, and material compositions. The main sections cover: ferrous and non-ferrous metals; nonmetallic materials, threads, fasteners, and common parts; electrical equipment and lighting; power plant components and accessories; passenger cars, trucks, and buses; tractor and earthmoving equipment and marine equipment. Among the 23 new reports are ones for methods of testing steel; central system fluids; air spring terminology; sealed beam headlamps and automotive flashers; ratings for hot water heaters; automotive transmission diagrams; tire selections for agricultural machines. (New York, Society of Automotive Engineers, 1961. 914p., $20.00.)

SPRING DESIGN.

A practical treatment of spring design for engineers, draughtsmen and spring users, covering all types of springs, their special aspects and manufacturing processes. The topics dealt with include: helical, coiled and tension springs; end connections of helical springs; axially loaded springs; volute springs; torsion bars; cantilever and laminated springs; springs for fluctuating and cyclic loads. The author has converted many of the design formulae into nomograms, and has included detailed instructions for their construction. (W. R. Berry. Manchester, Emmott, 1961. 324p., 40/-.)

OPTICAL SPECTROMETRIC MEASUREMENTS OF HIGH TEMPERATURES.

The proceedings of a symposium held in 1960 (a) to promote fuller understanding of the meaning of temperature and the plasma state of matter; (b) to discuss the theories involved, and review experimental techniques for optical spectrometric methods for the measurement of high temperatures; (c) to consider areas to be studied further.

This volume contains the 13 papers presented at the four sessions, and the discussions on them. The sessions were devoted to the fields of astrophysics, thermonuclear research, arc research and shock-tube work. (Ed. by P. J. Dickerman. Toronto, University Press, 1961. 268p., $12.50.)

COMBUSTION ENGINEERS' HANDBOOK.

Adapted from the German Walther-Taschenbuch, this handy reference book provides condensed information for combustion engineers, plant designers and fuel technologists. It covers temperature and heat; fuels and combustion; thermal technology in boiler construction; materials and standards (German and British); operation and maintenance. Much of the information is presented in tabular or graphical form. (Ed. by L. J. Fischer. London, Newnes, 1961. 288p., 30/-.)

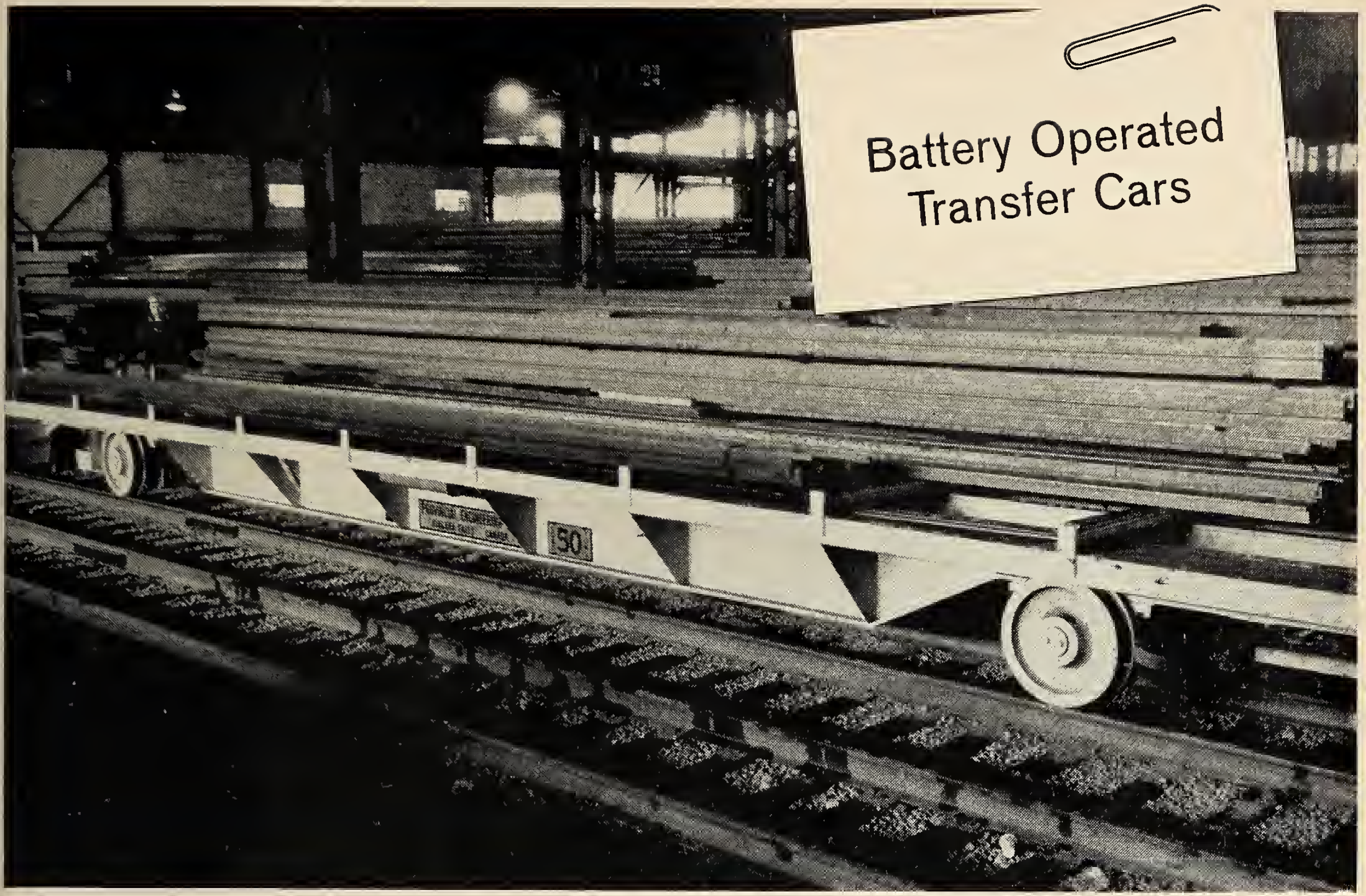
(Continued on page 136)

EIC CERTIFICATE OF ADVERTISING MERIT

Winner of the Monthly Award for the best advertisement in the August, 1961 issue of The Engineering Journal was Bethlehem Steel Export Corporation, Bethlehem, Pa., U.S.A. The winning advertisement, which appeared on pages 86 and 87, was a black and white bleed, double page spread headed "The old: The New:" Each page was dominated by a picture of a bridge—one built in 1896, the other (apparently) within the past year or two. Large type captions stressed the reliability of structural steel for the older bridge, the clean designs and speed of construction offered by steel today.

Each month a different panel of fifty Journal readers from across Canada is asked to nominate an award-winning ad of their choice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION. Winners and their advertising agencies receive a framed certificate of Advertising Merit.

The Manager of Publications for Bethlehem Steel Export Corporation is Wm. H. Jess. The advertising agency is Gotham-Vladimir Advertising, Inc., New York, Mr. Rufus Choate, Account Executive.



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An example is the Transfer Car shown above, two of which were supplied to The Algoma Steel Corporation Limited, Sault Ste. Marie, Ontario for their new Universal Beam Mill. They convey 50 ton loads of wide flange beams, up to 80 feet long, from the mill to the stockyard.

At the mill end the cars are loaded by lifting magnets from a specially designed PROVINCIAL Double Trolley Overhead Travelling Stacker Crane, 91 foot span.

In the stockyard, the cars are also unloaded by lifting magnets from two PROVINCIAL 20 Ton Double Trolley Overhead Travelling Cranes, 110 foot span. The transfer cars are of substantial construction to withstand severe impact. The 28″ diameter rim toughened railwheels are driven by a D.C. motor through a totally enclosed self-contained high efficiency worm reduction unit.

Cars have adequate battery capacity, and a rectifier battery was provided for charging from an A.C. Source.

For convenience in operation, there are two control stations, one at each end of each car.

Effective braking is obtained by a hydraulic brake, operated by pedals at both control stations.

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Library Notes *(Continued from page 126)*

***DOCK AND HARBOUR ENGINEERING, vol. 3. BUILDING AND EQUIPMENT.**

This, the third of four volumes, is concerned with operating and cargo-handling practice. It covers the layout of the dock area with its roads, railways, transit sheds and warehouses, and equipment for general and bulk cargo handling. As in the previous volumes, the descriptive matter is presented in detail, and is accompanied by numerous diagrams and photographs. A comprehensive work, based on Brysson Cunningham's Dock Engineering and Harbour Engineering. The first two volumes covered the design of docks and harbours, and the fouth volume is to deal with construction of docks and harbours. (H .F. Cornick. London, Charles Griffin, 1960. 320p., £6.6.0.)

FILTERS AND ATTENUATORS.

A discussion of the major factors and new techniques in filters and attenuators, covering the characteristics of low-pass filters, choke-input and capacitor-input filter systems, tuned low-pass and other filters. The problems of audio filters and radio and television filters are discussed as are wave filters, attenuators and equalizers. (Ed. by Alexander Schure. New York, Rider, 1961. 87p., $2.25.)

STEREOPHONIC SOUND, 2nd. ed.

An account of stereophonic sound for the general reader, covering the elements of binaural listening, the theory of sound waves, and of stereophonic sound waves, the various types of stereo systems available for the home, and for movie theatres and auditoriums, and recording procedures. New material in this edition includes a chapter on evaluating component parts, and the possibilities of conversion, as well as information on the 45/45 disc, stereo tape, and playback units. A useful bibliography is included. (N. H. Crowhurst. New York, Rider, 1961. 136p., $2.90.)

TRANSFORMERS.

An analytical examination of transformer theory, and of the varied types of transformer operations and applications. The topics covered include transformer magnetics, fundamentals of iron-core transformers, power transformers, audio and high-frequency transformers, and special transformers and applications, such as variable and instrument transformers, saturable reactors, voltage-regulating transformers, and balancing transformers. (Ed. by Alexander Schure. New York, Rider, 1961. 82p., $2.00.)

***TRANSISTOR LOGIC CIRCUITS.**

Both logical mathematics and transistor logic circuits are presented in an integrated treatment. Beginning with elementary binary arithmetic and Boolean algebra, the author continues with minimization techniques and implementation concepts. This is followed by a basic treatment of diodes and transistors. A variety of application examples are employed to clarify the integration of the mathematics and devices into useful combinational circuits. The book concludes with sequential systems and the circuits appropriate to these systems. (R. B. Hurley. New York, Wiley, 1961. 363p., $10.00.)

INDUSTRIAL BUILDINGS.

This volume contains the 38 papers presented at the first Industrial Building Congress, held in New York in December 1960. The topics covered include: deciding the type of building a company requires; finances; modernization as opposed to a new plant; plant location and site selection; employee services; new uses of concrete; use of prefabricated components, structural steel, aluminum and plastics; company experiences in plant construction; modernization; cost control; construction abroad. (New York, Clapp and Poliak, 1961. 232p., $10.00.)

*ERROR-CORRECTING CODES.

Error-detecting and error-correcting codes for information transmission and storage systems are discussed. The implementation of codes in practical systems is considered in detail with emphasis on types of codes that have mathematical, especially algebraic structure. The mathematics necessary for an understanding of coding theory is included in the book. Five appendices provide useful supplementary information, including a table for the entropy function and a table of irreducible polynomials over GF(2). (W. W. Peterson. New York, Wiley, 1961. 285p., $7.75.)

*SCIENTIFIC THINKING AND SCIENTIFIC WRITING.

Addressed mainly to students in the biological and physical sciences, this book is based on the premise that good expository prose cannot be written without knowledge and application of the general logic of science. To instill these requisites, Dr. Peterson here presents the essence of traditional inductive logic, the logic of several special methods, the role of hypothesis, and the general pattern of complete scientific investigation in relation to the development of a professional background for scientific writing. The final chapter describes various types of scientific writing and thinking. (M. S. Peterson. N.Y., Reinhold, 1961. 215p., $6.95.)

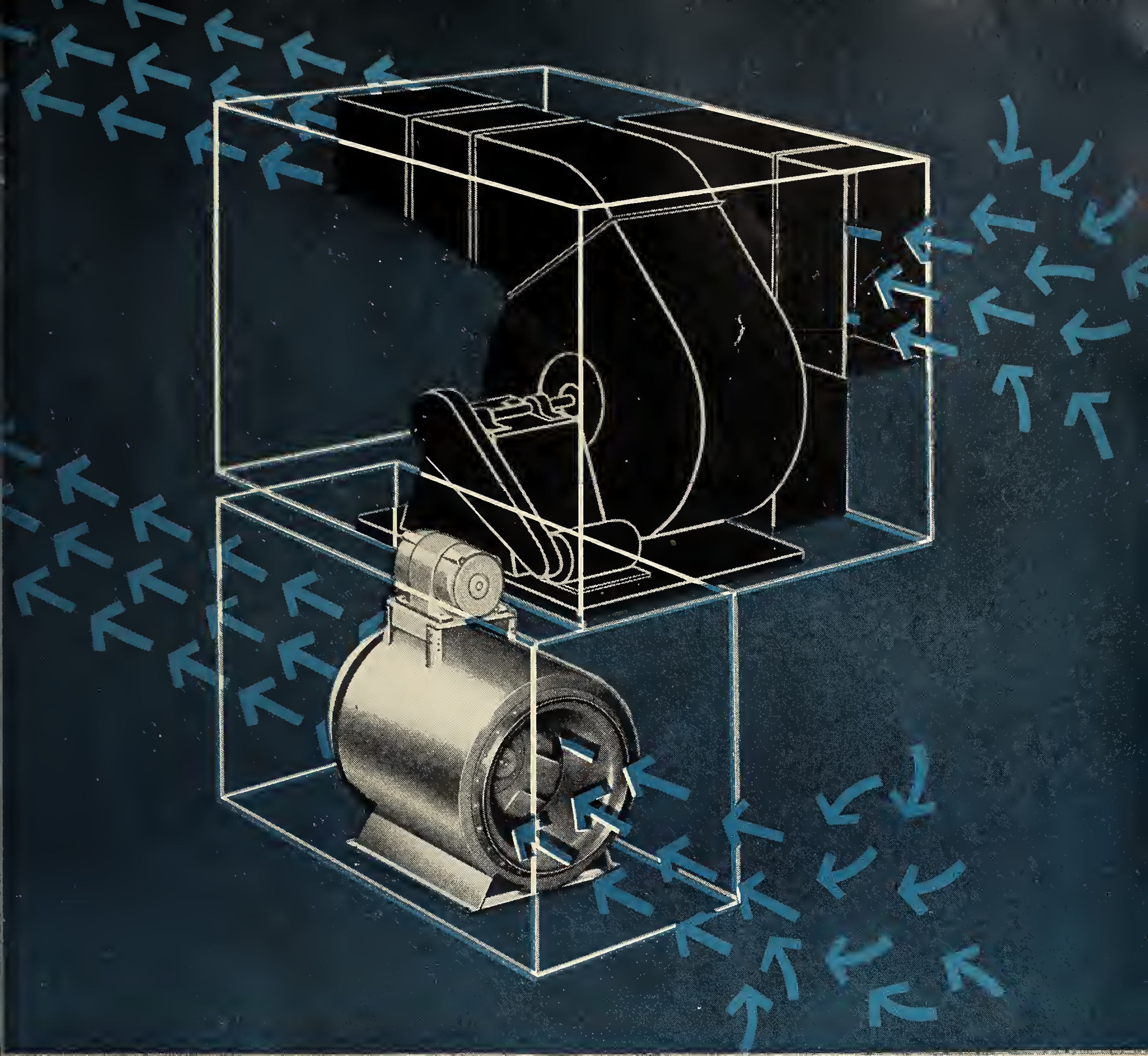
CONFERENCE ON ELECTRONIC COMPUTATION, 1958.

The Proceedings of the first conference organized by the American Society of Civil Engineers on the application of electronic computers to civil engineering. The papers are divided in three sections, the three papers in the first being concerned with programming, coding and organization. The second group consists of nine papers dealing with mathematical methods. The final nine papers are concerned with the use of computers in structural design, covering such uses as: rigid frame analysis, analysis of continuous I-beam bridges, stress analysis of trusses, suspension bridge truss analysis. (New York, A.S.C.E., 1959. 436p., $10.00.)

*INTRODUCTORY SOIL MECHANICS AND FOUNDATIONS, 2nd. ed.

A scientific approach to soil and foundation problems is stressed, and the theories applicable in situations that engineers are likely to encounter in practice explained. Over two-thirds of the text has been rewritten in this edition, which emphasizes the importance of mineralogy, physico-chemical forces and structure, and their relation to shear strength, consolidation, compaction, and soil stabilization. The newer concepts of bearing capacity of shallow foundations and of piles are also treated. (G. B. Sowers and G. F. Sowers. Galt, Brett-Macmillan, 1961. 386p., $8.00.)

(Continued on page 140)



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*HIGH VOLTAGE DIRECT CURRENT POWER TRANSMISSION.

Much has been written on the subject since the early days of electrical power. This book has sifted, and sums up this literature, fortifying it with new material. Topics covered include converter circuits and valve connections; bridge rectifier and invertor parameters; grid control; compounding and regulation; commutation, harmonics, insulators, and corona; mercury arc valves; and d.c. cables. A list of 225 references is included. (C. Adamson and N. G. Hingorani. London, Garraway, 1960. 284p., $14.00.)

*ENGINEERING DRAWING AND GEOMETRY, 2nd. ed.

A fundamental text that deals with basic drawing, descriptive geometry necessary for solution of problems in design and drafting, various types of graphical computation, and various specialized applications of engineering drawing. In this edition five new chapters have been added on material specifications, nomography, graphical vector analysis, curve fitting, and graphical mathematics. The chapters on dimensioning have been rewritten so as to conform to the latest American standards. (R. P. Hoelscher. New York, Wiley, 1961. Various pagings, $8.95.)

*A GUIDE TO THE B.S. CODE OF PRACTICE FOR PRESTRESSED CONCRETE.

The British Standard Code of Practice, no. 115, "The Structural Use of Prestressed Concrete in Buildings", was first published in November, 1959, by the British Standards Institution, and deals with the design and construction of prestressed concrete. The present volume is a commentary on this code, with particular emphasis on the recommendations concerned with those aspects of prestressed concrete construction which are not common to other forms of concrete construction. (F Walley and S. C. C. Bate. London, Concrete Publications, 1961. 96p., $3.00.)

*LAND FOR THE FUTURE.

A study made under the auspices of Resources for the Future, Inc., a nonprofit corporation for research and education in the development, conservation and use of natural resources, of changing uses of land in the U.S., in the past, the present, and in the light of expectations extending to the year 2000. Most of the book is of general, albeit absorbing, interest, discussing the methodology of the study, and describing the present and the historical situation and future projects. There are, however, chapters dealing with specific uses of land, of which those dealing with urban uses and planning, and uses for transportation, water regulation, mineral production and possibly forestry will be pertinent to the engineering profession. (Marion Clawson. Baltimore, Johns Hopkins, 1960. 570p., $8.50.)

(Continued on page 144)


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(Continued from page 140)

*PROCEEDINGS, FIRST INTERNATIONAL CONFERENCE ON WASTE DISPOSAL IN THE MARINE ENVIRONMENT.

The 27 papers presented at the Conference, held at the University of California, Berkeley in July 1959, are arranged in topical sections dealing with public health (public bathing facilities); effects of wastes on marine biota and the use of marine invertebrates as indicators of water quality; design considerations (discharge of wastes into the sea, river and ocean confluence, ocean currents, etc.); nearshore oceanography and waste disposal; receiving water analysis; and estuarine hydrography in relation to waste disposal. Useful bibliographies are included. Mr. Pearson has written many papers on this subject, including one presented at the 1961 Annual Meeting of the Institute. (Ed. by E. A. Pearson. New York, Pergamon, 1960. 56p., $12.50.)

*PULP AND PAPER, VOLUME III: PAPER TESTING AND CONVERTING, 2nd. ed.

The present edition reflects the changes that have occurred in the pulp and paper industry over the past ten years. This volume, which completes a series of three, is concerned with paper testing and converting. It specifically covers the properties of paper, the use of statistics in the paper industry, pigment coating, printing, laminating and corrugating, saturation of paper and paper plastics, coating with resinous materials, and resins. (J. P. Casey. New York, Interscience, 1961. Various pagings, $29.50.)

*REINFORCED PLASTICS FOR ROCKETS AND AIRCRAFT.

The papers included in this volume are the proceedings of two symposia held in San Francisco in October, 1959 on the related subjects of "Reinforced Plastics" and "Thermal Ablation" They encompass the difficult problems of design, fabrication, quality control, and testing of these plastics. (Philadelphia, American Society For Testing Materials, 1961. 134p., $5.50. s.t.p. no. 279.)

*AN INTRODUCTION TO THE THEORY OF VIBRATING SYSTEMS.

Affiliated with the Mathematics Department of the University of London, the authors derived this book from a course of lectures for engineering students. They assume a considerable background in mathematics of the reader. The book describes the principles which underlie the behavior of systems exhibiting vibratory wave motion and explains the mathematical concepts and techniques that are useful for the study of these systems. Energy methods, including Lagrange's equations of motion, are used extensively, and there is detailed discussion of the applications of Rayleigh's principles. Analogies between mechanical and electrical oscillating systems are stressed. (W. G. Bickley and A. Talbot. Toronto, Oxford, 1961. 238p., $4.50.)

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(Continued from page 144)

DIGEST OF LITERATURE ON DIELECTRICS, vol. 23, 1959.

A digest of international technical publications on the theory and applications of dielectric and related subjects, including magnetic phenomena and materials, and electrical measurements in general. The twelve chapters, each containing a long bibliography, cover: instrumentation and measurements; tables of dielectric constants; molecular and ionic interactions in dielectrics; conduction phenomena in solid dielectrics; breakdown of dielectrics; ferroelectric and piezoelectric materials; magnetic materials; rubber and plastic insulation; insulating films and liquids; solid organic insulation; applications. (Ed. by L. J. Frisco and T. D. Callinan.)

MODERN ARC WELDING PRACTICE.

A concise reference source for both students and professional welders, covering both British and foreign welding methods, and various techniques such as stud and dot welding, submerged arc welding, hard facing, carbon arc cutting, argon arc welding and automatic welding. Also covered are plant and equipment; work preparation; weld defects and tests; the welding of different metals, steel, iron, aluminum alloys, copper and nickel and their alloys, and stainless steel. (J. A. Oates. London, Newnes, 1961, 293p., 30/-.)

*ANNUAL REVIEW IN AUTOMATIC PROGRAMMING, volume 1.

This first volume of a proposed series of annual reviews contains the eighteen papers presented at the Conference on Automatic Programming of Digital Computers held at Brighton Technical College (England) in April, 1959. Most of the papers have been modified to deal with points made in discussion. Constituting a review of work being done in this field, particularly in Britain, the papers discuss such topics as future trends, autocades, interpretative and translating programs, special automatic programming systems, and the philosophy of programming. Also included are the two pioneer papers on computable numbers by Dr. A. M. Turing, enunciating the fundamental theory on which automatic programming is based. (Ed. by R. Goodman. New York, Pergamon, 1960. 300p., $10.00.)

*KEMPE'S ENGINEERS YEAR-BOOK FOR 1961, 66th ed.

This compendium of the modern practice of civil, mechanical, electrical, marine, gas, aeronautical, mining and metallurgical engineering contains revised information in almost every one of its 84 sections. It is a useful compilation, with an extensive index in Volume 2, though its wide coverage lessens its specificity making it more useful in general reference than for the specialist. Though of British origin, its careful attention to other national standards and units makes it of universal application. (C. E. Prockter. London, Morgan Brothers, 1961. 2 vols. 87/6.)

*CONTROLE ET ESSAIS DES CIMENTS, MORTIERS, BETONS.

This is a synthesis of the results of recent research in France concerning the quality control and testing of various types of "liants hydrauliques"-water-mix bonding elements. The manufacture, classification, physical and chemical properties, and methods of control and of test (both destructive and non-destructive) of various types of cement, concrete and mortar are described, as well as the properties and actions of water, both as a mix and as an environmental enemy. One chapter is devoted to aggregates, and the final chapter to the use of statistical methods. New standards of AFNOR (Association francaise de normalisation) are given where applicable. (Michel Venuat and Michel Papadakis. Paris, Eyrolles, 1961. 465p., NF 70.05.)

***BIBLIOGRAPHIC SURVEY OF CORROSION, 1956.**

This is the seventh in a series which covers corrosion literature for the period 1945-56 inclusive. This volume includes abstracts of almost all of the articles published during 1956 that have come to the attention of the association, and also 58 abstracts of articles published in prior years which have come to the attention of NACE since publication of the 1954-55 Bibliographic Survey. (Houston, National Association of Corrosion Engineers, 1960. 240p., $27.50.)

***HYDROMETRY.**

The author of the 1960 Polish original of this translation is professor of hydraulics at the Technical University, Wroclaw, Poland. He examines the theory and practice of hydraulic measurements as they are applied in "hydrotechnics and water-supply engineering". Section one discusses the principles and methods of measurements of time, angle, linear quantities, surface, volume, pressure, velocity, intensity of flow and total flow. Section 2 describes the instruments and apparatus used to measure these same hydromechanical quantities. Measurements of the physical quantities which determine the properties of a liquid are not discussed. The final section is a brief account of hydrometric laboratories — their classification, equipment, design principles, and supply installations such as overhead reservoirs, conduits, water meters and accessories. (A. T. Troskolanski. New York, Pergamon, 1960. 684p., $18.00.)

***MECHANIZATION OF MOTION.**

The fundamentals of kinematics, the techniques of ideation, and recent techniques for synthesis and analysis are combined into a step-by-step discussion of logical procedures for synthesizing the solution to any motion requirement. The text is divided into three parts dealing with the creative approach to design mechanization of uniform rotary motion; and mechanization of nonuniform motion. Extensive bibliographies are included for each area discussed. (Lee Harrisberger. New York, Wiley, 1961. 363p., $8.50.)

***THE CONSULTING ENGINEER.**

The professional and management problems involved in the practice of consulting engineering are discussed. The first part is concerned with the consulting engineer's professional relationships to his client, to other consultants, and to the public. The second part deals with internal problems of a consulting practice. It considers the many areas of organization, personnel, plant facilities, procedures, and management situations with which the consulting engineer must cope. Emphasis is placed upon the problems relating to the operation of a consulting practice and not upon the technical problems involved in engineering and design. Sample contracts are appended. (C. M. Stanley. New York, Wiley, 1961, 258p., $5.95.)

***FRAME ANALYSIS.**

The mathematical analysis of structural frames is presented. Introductory material outlines the basic concepts of equilibrium, compatibility, and the stress-strain relationship, and describes how they may be used in finding structure problem solutions. This is followed by a discussion of flexibility analysis and stiffness analysis, each of which are shown to be reciprocal approaches to the problem. Several well-known methods are dealt with briefly to illustrate the way in which all other techniques are variants of these two main methods of analysis. Matrix algebra is used extensively. (A. S. Hall and R. W. Woodhead. New York, Wiley, 1961. 247p., $8.50.)

(Continued on page 152)

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(Continued from page 147)

*SYMPOSIUM ON ADHESION AND ADHESIVES.

The papers included deal with the problems relating to metal-to-metal adhesives used in the aircraft industry. Also included is a statistical analysis of the effects of increases in the rate of loading on the strength properties of adhesives. (Philadelphia, American Society for Testing Materials, 1961. 65p., $2.25. s.t.p. 271.)

NEW METHODS IN LAMINAR BOUNDARY-LAYER THEORY.

A detailed account of the modern analytical methods used in other branches of mathematical physics, now used for the solution of laminar boundary layer equations. The general method of solution of boundary layer equations in two dimensions is also covered. Application to various problems is shown, including: flow past a semi-infinite plane; wedge, elliptic cylinder and three-dimensional flow; forced heat convection; convection from a surface of variable temperature; viscous flow, etc. The solutions of the problems are reduced to integration of linear differential equations containing a large parameter, the main difficulty of the solution being the transformation of the integrals. Useful lists of references are included. (D. Meksyn. Oxford, Pergamon, 1961. 294p., $12.00.)

COASTAL ENGINEERING, PROCEEDINGS OF THE SEVENTH CONFERENCE, 1960.

Sponsored jointly by the Council on Wave Research, and the Rijkswaterstaat of the Netherlands, this 1960 conference was held in the Hague. The 59 papers comprising the Proceedings are divided into five sections, the first of which covers wave theory and measurement. The other sections have as their titles: Beach and shoreline processes; Tides, tidal flow, and storm surges; Dynamic action of waves; Coastal engineering problems. Eight of the papers are in French, the others are in English, and all were contributed by experts from 14 countries. Many illustrations, graphs and useful bibliographies are included. (Ed. by J. W. Johnson. Richmond, Calif., Council on Wave Research, 1961. 2 vols., $12.50.)

*THE DESIGN OF SMALL DIRECT-CURRENT MOTORS.

A compendium of methods for solving the problems involved in the calculation and design of direct-current machines. Methods are given both for those cases in which mechanical parts are available and for those in which no mechanical parts are available. In every instance, presentation of a method includes precise instructions, alternate procedures, numerical examples, and exact results. Emphasis throughout the book is on the electromagnetic aspects of design problems. (A. F. Puchstein. New York, Wiley, 1961. 407p., $12.00.)

*SIMPLIFIED ENGINEERING FOR ARCHITECTS AND BUILDERS, 3rd. ed.

A guide to the determination of the proper size of every-day structural members. This edition has been rewritten to conform with the current allowable unit stresses and specification requirements, and includes many new technical problems, tables and figures. The abbreviations for scientific and engineering terms have been brought into agreement with the recommendations of the American Society of Mechanical Engineers. The major portion of the book is devoted to the solution of practical problems dealing with mechanics, timber construction, steel construction, reinforced concrete construction, and roof trusses. (Harry Parker. New York, Wiley, 1961. 325p., $7.00.)

*REPORT ON AVAILABLE STANDARD SAMPLES AND RELATED MATERIALS FOR SPECTROCHEMICAL ANALYSIS, 1960.

A ready reference to the availability and sources of standard samples, reference samples, and high-purity materials. The present edition contains a total number of 3400 entries. (Philadelphia, American Society for Testing Materials, 1961. 122p., $3.75. s.t.p. 58-D.)

*HANDBOOK OF MECHANICAL WEAR.

This collection of papers examines many of the different processes which result in wear, and such related factors as material composition, environment, and history of the manufacturing operation. The papers are presented in six major groupings: fundamental aspects of wear; pitting, scoring, and spalling; corrosion; abrasion; wear resistance materials; and manufacturing processes. (Ed. by Charles Lipson, and L. V. Colwell. Ann Arbor, University of Michigan Press, 1961. 469p., $20.00.)

*ELEKTROTERMIE, 2nd ed.

Papers of ten authors dealing with the electrical production and engineering applications of high temperatures, mostly over 1000°C. The manufacture of steel, aluminum, copper, molybdenum, tungsten as well as that of the semiconductors—germanium, silicon, graphite, etc. is discussed. Other topics covered are refining of hydrocarbons; the mass production of spare parts from pressed and sintered powders; the design and construction of electric furnaces. The last chapter discusses new laboratory methods for the research engineer. (Ed. by M. Pirani. Berlin, Springer-Verlag, 1960. 451p., DM 61.50.)

*DER FREILEITUNGSBAU.

A comprehensive, practical book on the engineering of high-voltage, overhead transmission lines. The entire field is covered: surveying and planning; materials for cables; insulators and other accessories; grounding; tower design; foundations; and the complete erection process. Though based largely on German standards, some reference is made to standards and practices of other countries. (Hermann Rieger. Berlin, Springer-Verlag, 1960. 312p., DM 45.00.) EIC

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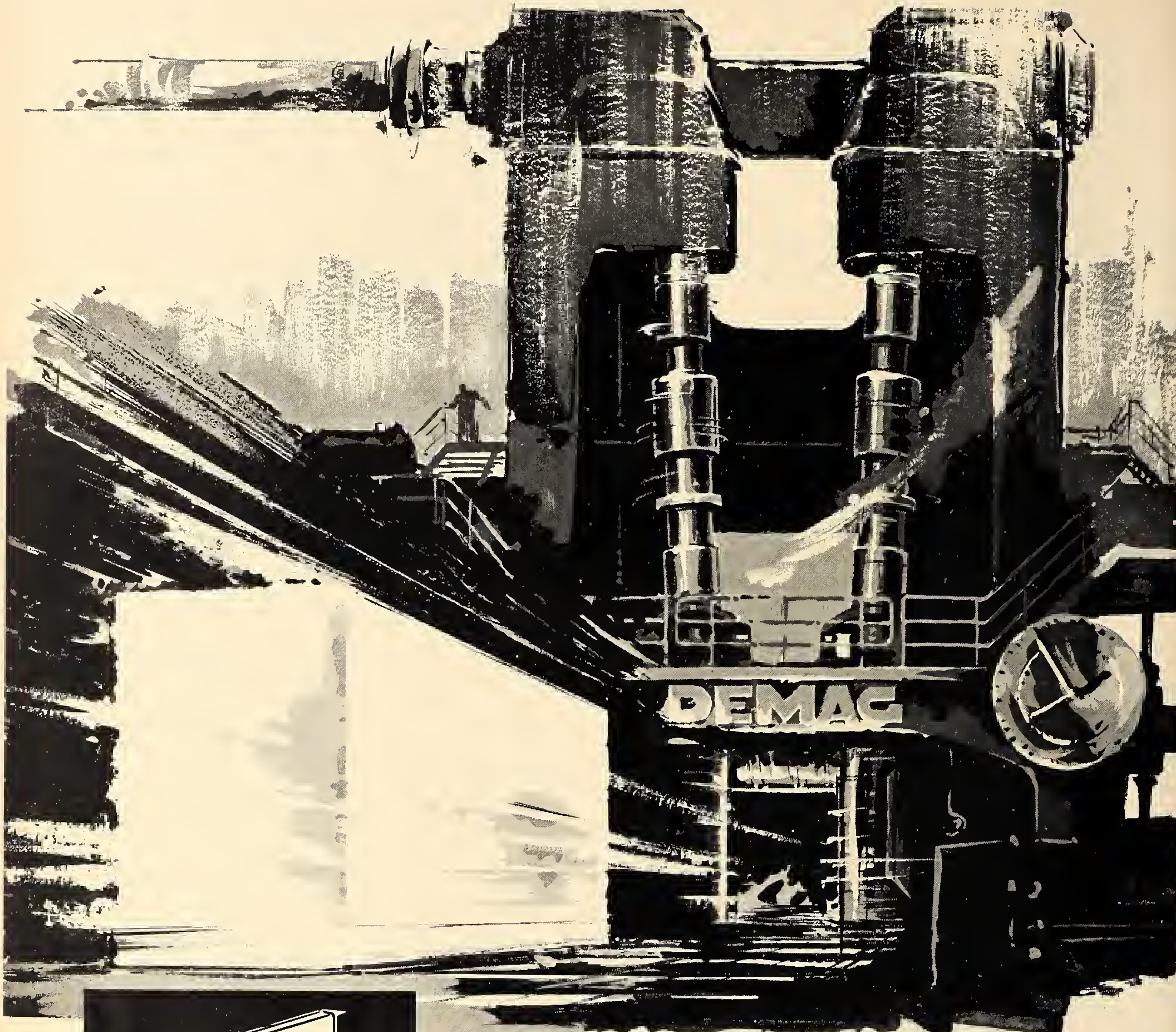

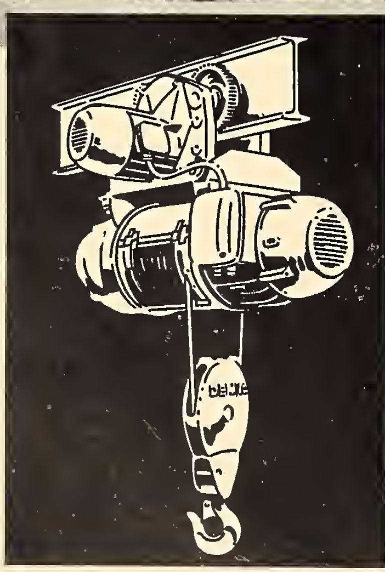

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IN THIS ISSUE

A general description of the Champlain Bridge is given, and some of the methods of construction used in the building of the prestressed concrete sections are examined in *The Champlain Bridge—Steel and Prestressed Concrete Crossing of the St. Lawrence River.* The total length of the bridge, including the approaches, will be in excess of four miles and the cost is estimated at $35 million. It is scheduled for completion in the fall of 1962. The author, **Boris A. Hesketh,** M.E.I.C., is Associate Professor of Structural Engineering, Ecole Polytechnique, University of Montreal. He was born in Warsaw, Poland, and educated in France and Germany. He received his Master's degree in Paris in 1931. He has specialized in structural steel, reinforced and prestressed concrete design and construction, and has been engaged in consulting in Canada since 1947. Mr. Hesketh has been associated with the Ecole Polytechnique since 1957.

The Champlain Bridge will cross the northern branch of the St. Lawrence River between the Island of Montreal and Nun's Island, then lead across Nun's Island, extend across the southern branch of the St. Lawrence and span the Seaway canal to reach the south shore. A six-lane highway is provided for along the entire length of the bridge with a possibility of a seventh lane between the Island of Montreal and Nun's Island. The bridge, being built for the National Harbours Board, comprises a high level steel structure about one-half mile long spanning the Seaway canal and three prestressed concrete sections with a total length of more than two miles. These sections include the crossing between the Island of Montreal and Nun's Island, the part of the bridge between Nun's Island and the Seaway crossing canal and the section between the Seaway and the south shore approaches.

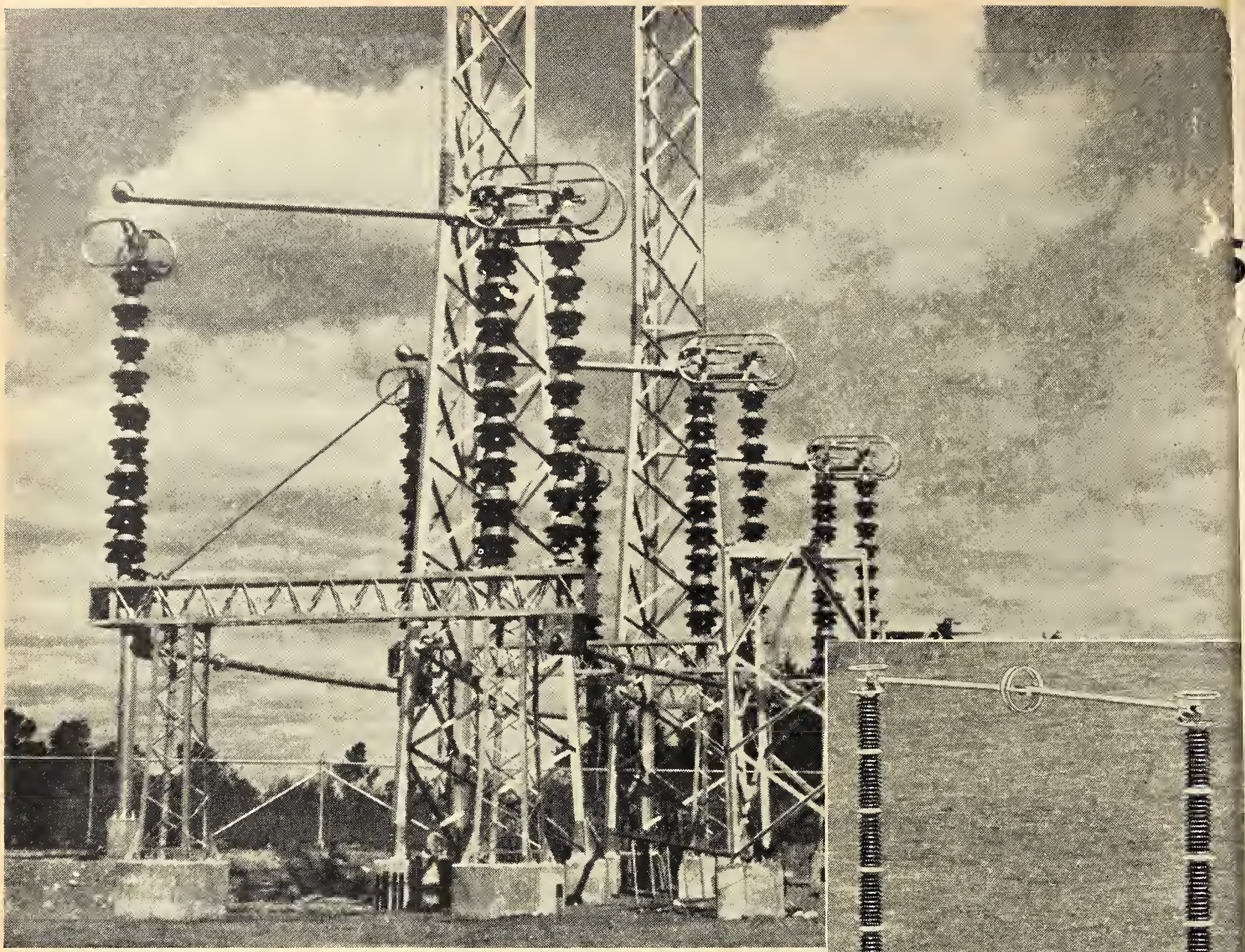
L. O. Long, M.E.I.C., author of *Outlook on the Relationship between Load-Frequency Control & Turbine Governors on Interconnected Power Systems,* was born and educated in Vancouver. He graduated from the University of British Columbia in 1946 with a B.A.Sc. in Electrical Engineering. From graduation until 1948 Mr. Long was an instructor at UBC in the Faculty of Applied Science in the Electrical-Mechanical Engineering Department. From 1948 until the present he has been with the Shawinigan Engineering Co. Ltd., Montreal, as a Design Engineer in the Electrical Division. In view of the trend towards interconnection of power systems for the many benefits derived therefrom, the paper reviews briefly the basic requirements of the mechanical-hydraulic turbine governors and automatic load-frequency control. Certain operating problems caused by inter-action between governors and load-frequency control and between control systems of interconnected utilities are described. Suggestions are advanced to improve power regulation on interconnected systems.

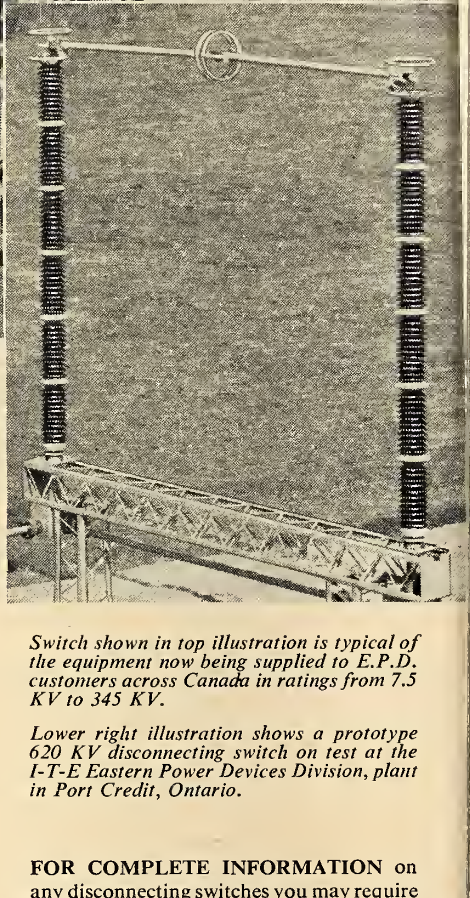
I. S. Evans, M.E.I.C., author of *The Saskatoon Productivity Program,* graduated in mechanical engineering from the University of Wales in 1939 and from the Military College of Science in 1943. He is, at present, Head of the Division of Information Services, Saskatchewan Research Council, Saskatoon. The author's observations in Saskatchewan industry revealed that the largest single problem facing it is to find some means of using its resources, or increasing its productivity. Believing this to come within the sphere of competence and authority of the provincial research council and the Technical Information Service of the National Research Council an attempt, officially a pilot experiment, was made to examine the productivity techniques now used, and to teach them to foremen and management. The second phase of the experiment will be to see if these conventional techniques need to and can be modified to suit Saskatchewan conditions better.

The Production, Handling and Uses of Tonnage Oxygen by COMINCO is a semi-technical narrative of how The Consolidated Mining and Smelting Company of Canada Ltd., developed worthwhile uses for a by-product material that might otherwise have been wasted. Details of production, collection and distribution of oxygen are given in this paper, and materials of construction, special operating problems and hazards are discussed. The author, **C. H. Simpkinson,** is with COMINCO as Assistant Superintendent of Development Research, Chemicals and Fertilizers Division. He was born at Hyde, Sask., and received his primary and secondary education at Grenfell, Sask., before going to Queen's University where he studied metallurgical engineering. In 1929 he obtained his B.Sc. degree and that same year joined COMINCO as an assayer. After the startup of the new Chemical and Fertilizer Plants in 1931 he was transferred to the operating staff of that Division. In 1944 Mr. Simpkinson transferred to the Development Research Group of the Chemicals and Fertilizers Division. During the Second World War, he was on loan to the National Research Council, Ottawa, for special design work on chemical extraction plants to recover plutonium and uranium 233. Returning to COMINCO in 1946 Mr. Simpkinson resumed work in development engineering.

COVER ILLUSTRATION

Shown is an aluminum bus bar at the Beauharnois Light, Heat and Power sub-station, Beauharnois, Que. (Photo courtesy Aluminum Company of Canada, Ltd.)





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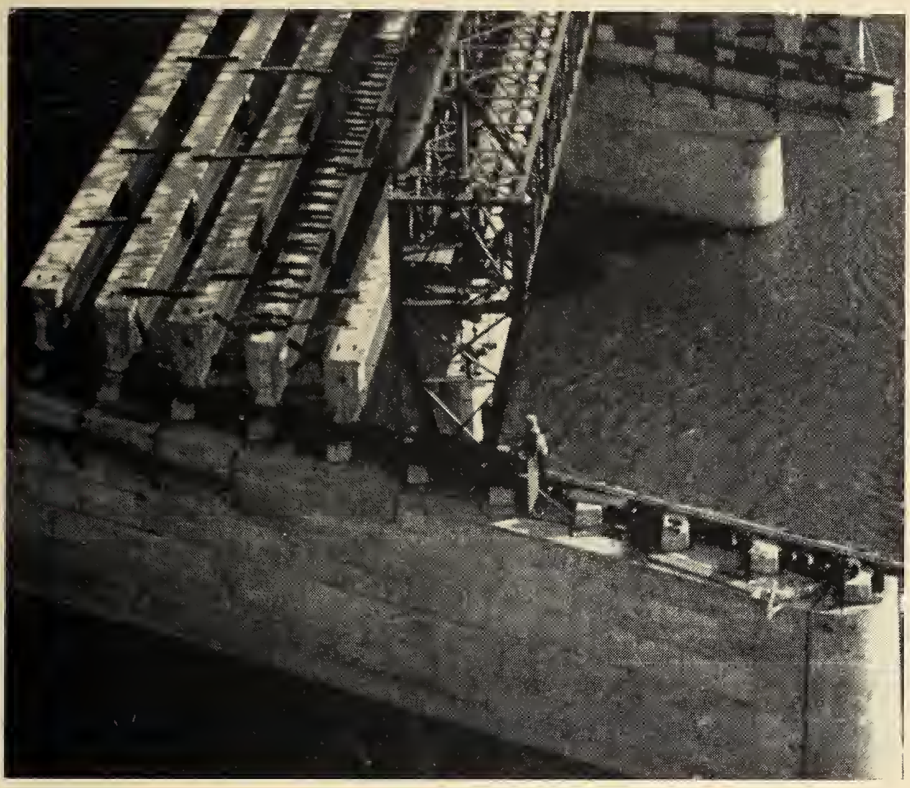

B. A. Hesketh, M.E.I.C.,
Associate Professor of Structural Engineering,
Ecole Polytechnique, University of Montreal

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

HE OBJECT of this paper is to give a general description of the lge and to examine some of the hods of construction used in the lding of the prestressed concrete tions.

The Champlain Bridge, when comted, will connect the Island of ntreal with the south shore comnities of the Saint Lawrence River. will constitute a greatly needed lition to the roadway traffic capa/ of the three existing bridges — Jacques Cartier, Victoria and Honoré Mercier.

The new bridge will cross the northern branch of the Saint Lawrence River between the Island of Montreal and Nuns' Island, then lead across Nuns' Island, extend across the southern branch of the Saint Lawrence River and span the Seaway canal to reach the south shore.

A six-lane highway is provided for, along the entire length of the bridge, with a possibility of a seventh-lane addition between the Island of Montreal and Nuns' Island.

The total length of the bridge, including the approaches, will be in excess of four miles and the cost is estimated at $35 million. The bridge, built for the National Harbours Board, is scheduled for completion in the fall of 1962.

Description

The bridge comprises a high level steel structure about ½ mile long,

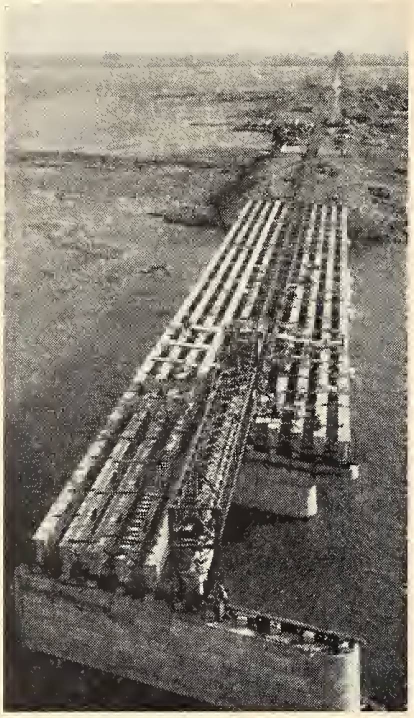

Fig. 1. Part of section three between the Island of Montreal and Nuns' Island.

spanning the Seaway canal and three prestressed concrete sections with a total length of more than two miles. These sections include the crossing between the Island of Montreal and Nuns' Island, the part of the bridge between Nuns' Island and the Seaway canal crossing and the section between the Seaway and the south shore approaches. Additional overpasses in prestressed concrete are part of the approaches on the Island of Montreal and of the Nuns' Island crossing.

Roadways: Two roadways, 38 ft. wide, each with three lanes of traffic, run along the whole length of the bridge, with the exception of Nuns' Island, where a toll plaza with nine-lane roadways in each direction will be built.

Design Loads: The bridge is designed for a load 25% greater than the 20 ton truck-16 ton trailer combination, with two trucks and trailers per lane.

Construction Sections: For construction purposes, the bridge was divided into eight sections.

Section 1—Approaches on the Island of Montreal, between the northern entrance and Wellington Street in Verdun, are part of this section. The roadways will be partly built on fill and partly carried by prestressed concrete structures. These structures will bridge the crossing of a large twin sewer 17½ ft. and 14½ ft. diam. and also carry the roadways across poor foundation soil where the use of fill is not practicable. These structures are now in the design stage.

Section 2—This section, limited by Wellington Street and the northern shore of the Saint Lawrence River, includes various approaches to the bridge with part of the roadways built on fill. Three overpasses are part of this section with one of these to be built of prestressed concrete. Structures for this section have now reached the design stage.

Section 3—It spans the northern branch of the Saint Lawrence River, between the Montreal and Nuns' Island. This section of the bridge is composed of twelve 128 ft. long prestressed concrete spans resting on reinforced concrete piers and abutments. The bridge is designed to carry two three-lane roadways with a possible future addition of a seventh-lane. The total length of this prestressed concrete section is 1536 ft.

Section 4—This section constitutes the crossing of Nuns' Island and is composed of roadways on fill with a two span, 74 ft. prestressed concrete overpass. A toll plaza with two nine-lane roadways will be built on the Island. The total length of this section is about 3000 ft.

Section 5—It extends from Nuns' Island to the Seaway Canal Crossing. The whole of the superstructure is composed of forty prestressed concrete spans, each 176 ft. 4 in. long, resting on piers with heights varying from Nuns' Island elevation to the required elevation of the high span Seaway canal crossing. This part of the bridge carries two roadways with three lanes each and the total length of this section is approximately 7,053 ft.

Section 6—This is the steel section of the bridge crossing the Seaway canal with a clearance of 120 ft. above the canal water level. The total length of the steel bridge is 2501 ft. It includes a main span 707 ft. long, with two anchor spans 385 ft. long each. This part of the bridge is composed of three trusses. Four simple spans composed of four trusses 256 ft. long each, are also part of the steel bridge. Two of the spans are located at the end of the north anchor arm and two others at the end of the south anchor arm. All the spans are supported on reinforced concrete piers, the main four piers having been built during the construction of the Seaway Canal.

This section of the bridge carries two 38 ft. wide three-lane roadways and is in conformity with the original design in steel. It includes over 11000 tons of steel, with about 1500 tons of low alloy steel.

Section 7—It extends south of the steel bridge and has a total length of 1730 ft. The superstructure is prestressed concrete resting on reinforced concrete piers. This section was subdivided into 7-A with 1042 ft. and 7-B with approximately 688 ft. Part 7-A includes four prestressed concrete spans 176 ft. 4 in. long and two spans 168 ft. 8 in. long. Part 7-B includes four spans 172 ft. long.

Section 8—South shore approaches on fill.

Three Prestressed Concrete Sections

These include construction sections 3, 5 and 7. Original bids for section 5 and part 7-A of section 7, also for section 3 were based on designs in steel and reinforced concrete, but bids on alternate designs proposed by the bidders were also allowed. Several bids based on alternate prestressed concrete designs were submitted and the following were accepted after extensive study of the proposals.

Section 3

Structural: The prestressed concrete superstructure comprises 12 spans 128 ft. long, including 132 prestressed concrete girders with 11 girders per span. These girders are supported on 11 piers and two abutments in reinforced concrete and are resting each, on two STUP-type, double Neoprene-stainless steel, bearing plates. The I-shaped girders are 7 ft. 2 in. deep with a top flange 4 ft. 4 in. wide, a bottom flange (heel) 2 ft. 2 in. wide and a web 6½ in. thick. These girders are manufactured in a precasting yard located on Nuns' Island and are each prestressed by means of twelve Freyssinet cables with 12 wires of 0.276 in. diam. in each cable. The girders are then shipped from the Island to the erection site and installed on 8 ft. 9½ in. centres. This bridge has a skew of 25°

Five transversal diaphragms, 8 and 12 in. thick and 5 ft. deep are built between the girders in each span and then prestressed with two cables per diaphragm.

The girders and diaphragms are topped with a 5½ in. thick reinforced concrete deck slab, with a 6½ in. thickness between girders. Shear connectors made of three loops of No. 4 reinforcing steel bars placed on 10 in. centres project from the top of the girders 4 in. into the deck slab and insure a positive composite, prestressed-reinforced concrete, construction action. An asphalt topping 1½ in. thick placed on the deck slab protects the concrete structure and acts as wearing surface for the roadways.

Prestressing steel with a minimum ultimate tensile strength of 235,000 p.s.i. is supplied in 8 ft. diam. coils. Portland cement concrete has a minimum compressive strength of 5000 p.s.i. for girders and diaphragms and 4000 p.s.i. for the deck slab and contains 4% of entrained air.

Manufacturing and erection: The precasting plant is equipped with 18 casting beds and four sets of removable steel lined plywood forms.

Prestressing cables and ducts are fixed at predetermined locations to tack-welded reinforcing steel cages which are then picked up with a gantry crane travelling on rails, and installed on the casting beds on plastic chairs. The removable sides are then assembled and concrete is placed and vibrated.

The manufacturing is organized on the basis of two girders per day, in a nine hours per day—five days per week operation. Prestressing is applied when the concrete has reached a strength of 4200 p.s.i. and cable ducts are grouted after prestressing.

Each 80 ton girder is lifted by means of the travelling gantry crane and placed on two dollies of which one is self-propelled. These dollies, also travelling on rails, deliver the girders to the erection site.

A truss launching bridge, travelling on rails in a direction transversal to the bridge can then place each girder in the prescribed location. Transversal diaphragms are then formed and the concrete placed. After completion of the transversal prestressing the deck is formed with the use of ¾ in. plastic coated plywood forms, and reinforcement and concrete for the deck are placed. All the lifting machinery is equipped with specially designed hydraulic jacks.

Sections 5 and 7-A

Structural: The prestressed concrete superstructure is supported on piers built by the same contractors.

Section 5 comprises 40 spans of 176 ft. 4 in. each including seven prestressed concrete girders. 7-A has four spans 176 ft. 4 in. long and two spans 168 ft. 8 in. long. These six spans also include seven prestressed concrete girders each. The contract covers the manufacturing and erection of a total of 322 girders for the 46 spans, or 308 girders 176 ft. 4 in. long and 14 girders 168 ft. 8 in. long. It also includes the building of four prestressed eoncrete diaphragms per span and of an 8½ in. prestressed concrete deck slab. This slab is eomposed of the upper flanges of the girders with slab strips built between the flanges.

Each girder is resting on two STUP type, triple Neoprene-stainless steel bearing plates.

The I-shaped girders are approximately 10 ft. deep with a top flange 5 ft. 9 in. wide, a bottom flange or heel 3 ft. 3 in. wide and a 7 in. thick web. All these girders are manufactured in a precasting yard on Nuns' Island and are prestressed with cables. Each cable is made of 12 — 0.276 in. diam. wires and supplies a prestressing force of about 40 tons after deduction of all losses. Girders 176 ft. 4 in. long have 24 prestressing cables, while the 168 ft. 8 in. girders have only 22 cables.

As a first step in the girder prestressing operation, 14 cables are tensioned after concrete has reached a strength of 3,500 p.s.i. The girders are then moved to a storage yard on Nuns' Island.

The second prestressing step takes place when concrete has reached a compressive strength of 4000 p.s.i.

Six more cables in the case of 176 ft. 4 in. girders are tensioned and the ducts of all tensioned cables are grouted. The girders are now ready to be moved to the erection site. Only four cables are tensioned in this second step of prestressing with 168 ft. 8 in. girders.

The third step of the prestressing takes place after the girders have been placed in their final location and the building of the diaphragms and deck-slab strips completed. The remaining four cables are then tensioned and the cable ducts grouted.

During the manufacturing process, parts of the future transversal diaphragms are cast with the girders.

Once the girders are installed in their final location on 12 ft. 2½ in. centres, the remaining 6 ft. deep parts of the diaphragms are formed and held ready for concreting. Two diaphragms are located at the supports, each including one prestressing cable transversal to the bridge. Two other diaphragms, with five transversal prestressing cables, are located near the third points of the girders.

Six deck-slab strips 8½ in. thick are formed between the top flanges of the seven girders of a span. Concrete for the deck-slab strips and the diaphragms is then placed. The combined deck-slab will be prestressed transversally to the bridge with 54 cables for the 176 ft. 4 in. spans and 52 cables for the 168 ft. 8 in. spans.

Approximately 1/3 of the transversal cables in the deck and 2/3 in the diaphragms are tensioned on the day following the placing of concrete in order to allow for girders of the next spans to be shipped across the deck. The remaining transversal cables are tensioned later.

An asphalt topping 1½ in. thick will be placed on the deck at a later stage in order to protect the concrete and also to aet as a wearing surface for the roadways. Prestressing steel has a minimum ultimate tensile strength of 235,000 p.s.i.

Portland cement concrete has a minimum eompressive strength of 5000 p.s.i. for prestressed concrete and contains a minimum of 4% entrained air.

Manufacturing and Erection: The manufacturing of the girders takes place in a precasting yard on Nuns' Island which is equipped with eight steel casting beds and four sets of steel side forms. The production is organized on the basis of 14 girders per week with a basic 10 hour shift per day, five days a week.

Fig. 2. Part of section three south of Nuns' Island.

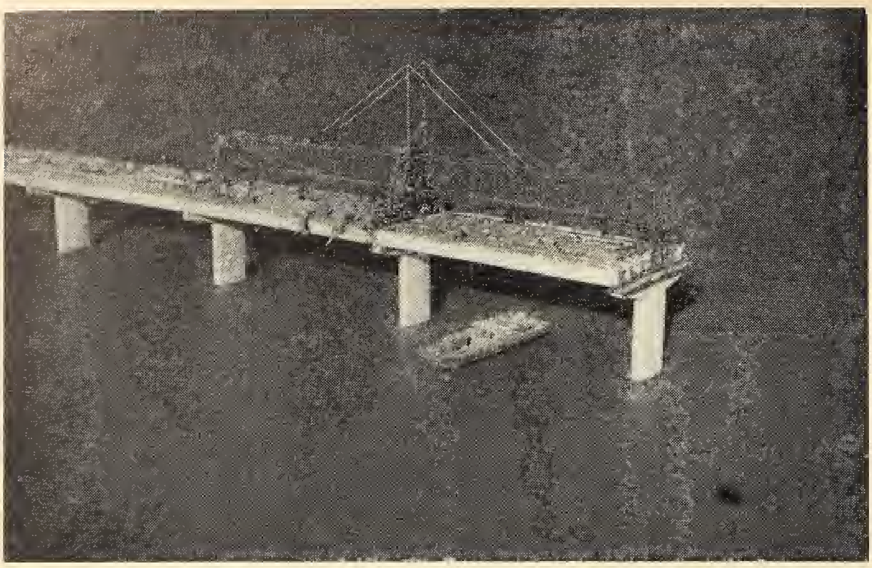

Fig. 3. Launching truss in section three.

The steel casting beds have removable vibrators which slide under the beds and can be fixed at any point along the length of the girder. Three vibrators are used while placing concrete. Additional form vibrators are fixed to the side forms.

Cable ducts are manufactured on the site from a strip of sheet steel welded by means of a continuous welding machine. Cables are made on the job with a machine which pushes the 12 wires of the cable through the ducts.

The yard is equipped with four A-frames dollies rolling on rails and supporting a 180 ft. beam from which hang the assembled reinforcing cages. All the cables of a girder are placed in a cage by hanging them on hooks welded to the vertical bars of the cage.

The individual cables are thus well positioned and quickly installed. Gantry cranes on rails can then move the completed cage to the casting bed where it will be standing on small precast concrete blocks.

Thirteen of the cables are threaded through holes in precast concrete end-blocks with embedded Freyssinet cones. The forms are then assembled and the concreting is placed. Emulsion is used to facilitate stripping of forms.

Placing of concrete is done in continuous operation for one girder with 1 cu. yd. buckets handled by a tower crane. Eighty-eight cu. yd. of concrete required for one girder can be placed in about three hours. The exposed part of concrete at the top of the girder is protected with a curing compound after concreting operations are completed.

Side forms are usually removed after 24 hours or less, depending on the temperature and the sides of the girders are sprayed with curing compound. The first step in prestressing is then performed (14 cables) and straddle trucks on rails move the girders to a storage area.

After the second step in prestressing is completed (six cables for 176 ft. 4 in. girders and four cables for 168 ft. 8 in. girders) the girders are loaded on two low-bed trucks running on rails and moved over the formerly completed portion of the bridge deck towards the launching bridge.

The steel launching bridge is a triangular truss 350 ft. long reaching across two spans of the bridge. The truss is supported on three A-frames equipped with dollies on rails, the A-frame located near the middle of the truss being double. Two monorail trolleys equipped with lifting devices are suspended from a longitudinal beam. Each of the trolleys has a 100 ton lifting capacity.

The launching truss travels longitudinally along the last completed span of the bridge until the front end of the truss reaches the next pier across the span where girders will be placed. During this stage, the trolleys are moved to the rear end of the truss and act as a counter-weight for the structure. When the launching of the truss has been completed, the front A-frame is supported on transversal rails placed on top of the pier and part of the double A-frame near the middle of the truss can move on transversal rails installed on top of the girders at the end of the last completed span. The rear A-frame rests on the deck of this last completed span.

The girder to be launched is lifted, at its two ends, by means of the 100 ton capacity trolleys and moved towards the front of the launching bridge. When the girder is in the correct longitudinal position, the dolleys under the rear frame are removed and the launching truss can move transversally to get the launched girder into its correct lateral position. The girder is then lowered about 12 ft. by means of the 100 ton capacity trolleys and placed into final position on its two bearing plates.

Parts of the diaphragms and the deck-slab strips are formed with the use of panels suspended from the girders. Transversal cables and reinforcing bars are then set in position and concrete is placed and vibrated. Curing compound is sprayed on the top surface of the deck.

All transversal cables are threaded through preformed holes, located in the top flange and web of the girders. Tensioning of the remaining prestressing cables, grouting of cable-ducts and miscellaneous finishing operations complete the building of the spans. All equipment of the precasting yard and on the launching bridge is electrically operated.

Section 7-B

Structural: The prestressed concrete super-structure comprises four spans 172 ft. long including seven prestressed concrete girders each, or a total of 28 girders. The I-shaped girders located on 12 ft. 2½ in. centres are approximately 10 ft. deep with a top flange 5 ft. 9 in. wide, a bottom flange 2 ft. 3 in. wide and a 7 in. thick web. The contract also covers the building of seven transversal prestressed concrete diaphragms per span and of an 8½ in. prestressed concrete deck slab. This deck slab, as in sections 5 and 7-A, is composed of the upper flanges of the girders and of slab strips built between these flanges. The girders are resting on two STUP-type bearing plates, similar to those used in sections 5 and 7-A.

In this section, G.T.M. prestressing cables each supply a prestressing force of approximately 52 tons after deduction of all losses. Nineteen cables are used for the prestressing of each girder, cast in situ with the use of steel forms.

Seven transversal diaphragms 5 ft. deep are prestressed with three to five cables transversally to the bridge. Fifty-four cables are used to prestress the deck-slab transversally. (Deck slab composed of seven upper flanges of the girders and six deck-slab strips cast between these flanges). An asphalt topping 1½ in. thick will later be placed on the deck slab.

Prestressing steel strands are grouped in cables with a minimum ultimate strength of 250,000 p.s.i.

Portland cement concrete has a minimum compressive strength of 5000 p.s.i. for prestressed concrete with a minimum of 4% entrained air.

Manufacturing and Building: Steel forms are used for the girders. These forms are resting on a formwork at or near the final location of the girders. The lower part and one side of the steel form are erected first. The reinforcing cage and prestressing cables for the girder are then carefully installed. The other side of the steel form is assembled and everything is made ready for placing concrete.

The forms are built along the same lines as the forms used in sections 5 and 7-A, the vibration methods being also similar.

After concrete has been placed and has reached a compressive strength of 4000 p.s.i., the longitudinal cables are tensioned and cable ducts are grouted. Forms for transversal diaphragms and deck-strips are erected and the required reinforcement and transversal prestressing cables installed. Concrete is placed and the transversal prestressing cables are tensioned at a later date with cable ducts subsequently grouted.

All transversal cables are threaded through holes provided for, in the girders. Handling of forms, panels, formwork parts, reinforcing cages and concrete is done with a tower crane.

This tower crane is located on the ground on one side of the bridge and can be moved on rails, in a direction parallel to the bridge.

Special Materials for Three Prestressed Concrete Sections

Under this heading are grouped special materials used for prestressed concrete, such as high tensile steel, prestressing anchors, cable-ducts and high strength concrete.

QUANTITIES

Bridge deck: The total length of the bridge deck is approximately 10,420 ft. for the three sections.

High tensile steel: This includes high tensile steel wire and wire strands with a total of close to 2200 tons.

Prestressing anchors: They include anchors for cables with 12—0.276 in. diam. wires and anchors for wire cables of seven strands. The total number of anchors is close to 27,000.

Cable ducts: These are made of manufactured steel tubing having a total length of over 1.8 million feet.

High strength concrete: Concrete used in the prestressed concrete bridge deck has generally a compressive strength of 5000 p.s.i. at 28 days with certain parts of the deck being built of concrete with a compressive strength of 4000 p.s.i. at 28 days. This concrete is placed with a slump of approximately 2 in. Admixtures include air-entraining agents and cement dispersing agents. A minimum of 4% of entrained air is present in the concrete. 49,000 cu. yd of concrete will have been placed when this portion of the bridge deck is completed.

Fig. 4. Section 7b on the south shore of the St. Lawrence River.

TESTS

Standard tests: Tests of slump, air content and compressive strength are carried out by a commercial laboratory under the supervision of the consulting engineers. Other tests are also carried out by the contractors. These cover testing of concrete as well as of steel wires used in the construction.

Special tests: Some of the tests were carried out at the Laboratories of Ecole Polytechnique in Montreal. These included the following:

Testing of steel wires for ultimate tensile strength, also determination of other characteristics such as the stress corresponding to 0.2% strain and resistance to repeated bending. A seven days relaxation test on a 0.276 in. diam. wire was also carried out.

Testing of concrete included laboratory preparation of standard test cylinders with 4% entrained air and a 2 in. slump. Part of these cylinders were tested to determine the compressive strength of concrete and three cylinders were subjected to constant loading for 50 days with corresponding creep measurements.

Conclusion

The general description of the structure of Champlain Bridge was given in this paper with a particular attention to the main prestressed concrete sections of this bridge. The prestressed concrete spans being among the longest built on this continent presented many design and construction problems and these were solved with the co-operation of Canadian and French Engineers and Technicians under the direction of the National Harbours Board and their Consulting Engineers.

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OUTLOOK ON THE RELATIONSHIP BETWEEN LOAD-FREQUENCY CONTROL AND TURBINE GOVERNORS ON INTERCONNECTED POWER SYSTEMS

Luke O. Long, M.E.I.C.
Special Assignment Engineer
The Shawinigan Engineering Company Limited, Montreal

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THE REGULATION of power generation has always been concerned with two major inter-related variables. These are the system load and frequency. Initially, in the simplest case of a single unit connected to an isolated load, power regulation was automatically controlled by the governor with minimum requirements and assistance.

The evolution of power regulation soon imposed additional requirements on the governing system. Because of inherent limitations of the governor, it became necessary to assist the governor to maintain an equilibrium between the generation and the load in addition to the maintenance of constant frequency. This process is known as "Load-Frequency Control" and can be performed manually or automatically.

The advent of Automatic Load-Frequency Control equipment was inevitable. The requirements for this equipment developed with the transition from the control of individual generating stations to the control of many stations under a centralized system.

Interconnection between adjoining power systems is an inevitable development in the utility industry because it offers the mutual benefits of inherent economy, reliability of operation and improved frequency stability. It offers the advantage of diversity which often results in deferment of the capital cost for new generating stations. The prospect of transferring large blocks of power over long transmission distances between neighbouring systems in different time zones to assist each in turn through its respective peak load period is very attractive and a great incentive to large-scale interconnection. In its realization, many new problems and difficulties are confronting the power utilities. The many benefits offered by interconnection of power systems are worthy stimuli for interconnection of more and more power systems and it is believed that continent-wide interconnection of power systems will be realized in the not-too-distant future.

With the ever-increasing demands for electric power and the desire to improve still further the quality of service, utilities must constantly meet the challenge of seeking improved methods of regulating power generation. Such improvements logically suggest closer scrutiny of the turbine governor and automatic load-frequency control requirements.

The purpose and scope of this paper is summarized as follows:

1. To review the basic requirements of the mechanical-hydraulic turbine governor;
2. To review the basic requirements of automatic-load frequency control.
3. To outline the features and advantages of the electro-hydraulic turbine governor;
4. To outline the operating problems encountered, advocate the adoption of certain requirements and advance certain suggestions for the governor, automatic load-frequency control equipment, and inter-utility co-ordination, to improve the regulation of power generation for interconnected power systems.

Basic Requirements of the Mechanical-Hydraulic Turbine Governor[1-5]

Basic Concept of the Turbine Governor:

(a) General

The basic concept of the governor has always been to sense speed, detect any error in speed levels between the actual and desired speeds, and through the measured error both effect a corrective change in the amount of generation of the unit so that it is in equilibrium with the power requirements of the connected load and restore the speed to that desired. Such a governor which seeks to provide constant speed regardless of load within the capacity of the unit is known as an isochronous governor and has a flat-frequency steady-state characteristic.

(b) Ball Head Assembly

Fig. 1 shows the schematic diagram of the mechanical-hydraulic turbine governor. The sensing and detection of speed error is achieved in the ball head assembly through a fly-ball system which is belt, gear or motor driven. The motor can be driven from the generator potential transformers or from a permanent magnet generator coupled to the generator shaft. Speed error is detected by comparing the centrifugal force of the flyweights against a force exerted by the speeder spring. The centrifugal force varies as the square of the speed and the speeder spring has a matching non-linear load-deflection characteristic. The speeder spring force is adjusted by movement of the speed adjusting collar which supports the speeder spring. The position of this collar determines the unit speed.

(c) Actuating Mechanism

Speed error results in a movement of the flyweights from a given position either in towards or out from the axis of rotation. This movement is transmitted to the turbine wicket gates by the actuating mechanism which is a mechanical - hydraulic amplification system consisting of mechanical linkages, pistons, valves and an oil pressure system.

(d) Oil Pressure System

The oil pressure system is the power medium required to open and close the turbine gates. The capacity of this system must provide the maximum power required by the wicket gate mechanism to function within a required gate operating time, plus a liberal safety margin. The gate operating time for opening or closing the gates full travel is determined by physical limitations. These limitations are the structural strength of the pipe line, which includes the penstock, scroll case and draft tube; hydraulic considerations of water hammer; mechanical considerations of the turbine and generator, such as overspeed and runaway. The oil pressure supply requires a pumping system capable of providing approximately 2½ to 3 1/3 servo volumes per minute and an accumulator pressure tank capacity of approximately 20 servo volumes.

Stabilizing Requirements for Unstable Influences:

(a) General

The isochronous governor is inherently unstable. To cope with unstable influences, certain means of stabilization are required, some of which are inherently a function of the turbine, generator and connected load characteristics and thus automatically provided, and others which must be built into the governor. The more important unstable influences and means for stabilization are discussed below.

(b) Self-Regulation

Self-regulation is the effect which, with a change in speed and no change in turbine gate position, results in a difference between the required and output torques in such a direction as to oppose further speed change. Fortunately, with all turbines the output torque decreases with increasing speed to some varying extent. However, the trend of water turbine design is towards a progressive increase in the specific speed resulting in a smaller self-regulation coefficient. On the other hand, the required torque depends on the load-speed characteristics of the network which must be accepted as they exist. A load characteristic which would result in the required torque increasing proportionally with the speed acts in a direction to oppose further speed change. Combined with the self-regulation of the turbines, such an arrangement would result in stability. If the load characteristic were such as to result in a constant required torque with increasing speed, the total self-regulating effect would only be that contributed by the turbine. If the load were purely resistive and the voltage were held constant by high-speed voltage control, the required torque would decrease with increase in speed, since power is proportional to the product of torque and speed. Such a condition combined with a high specific speed turbine may result in a total self-regulation effect e_s of zero or even a negative value. Fig. 2 shows typical speed-characteristics of the required and output torques.[1]

The self-regulation effect, based on variation in speed, increases as the speed deviation becomes larger, and becomes more effective as control by the governor is effected more slowly. Thus, it assists the governor and is a very important stabilizing characteristic. It is especially effective in hydraulic turbines where its effects are able to compensate for the unfavourable effect of water inertia since the influence of both these factors increases with load. The equation in Fig. 2 shows the relationship mathematically.[2]

Although the stabilization effected by self-regulation generally assists governing, the degree of stabilization afforded by the turbine design and the load characteristic is inadequate in itself. Additional means of stabilization are required.

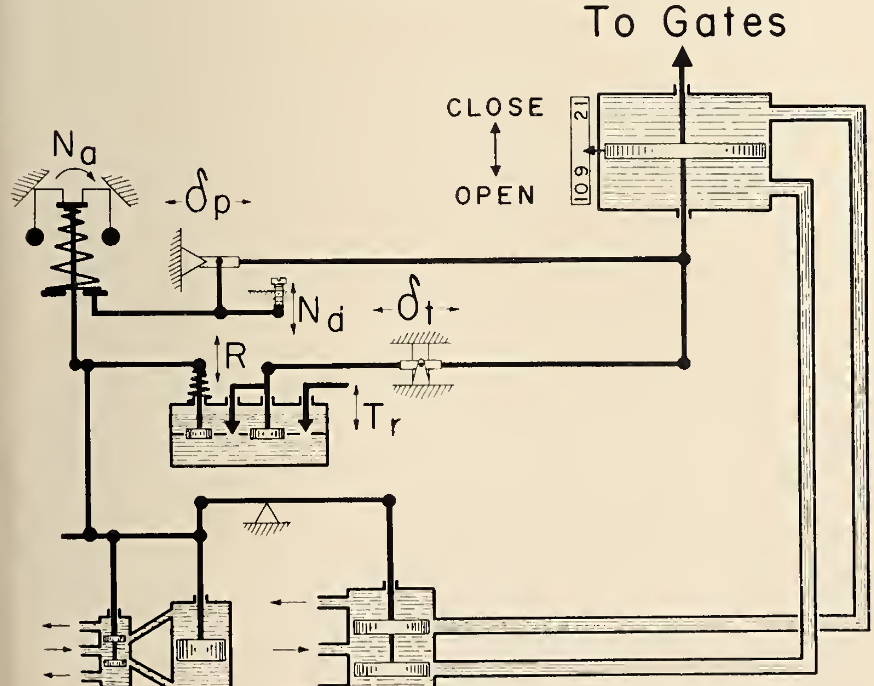
(c) Permanent Speed Droop

Regulation can be introduced by utilizing permanent speed droop. Permanent speed droop is the automatic proportional reduction of the governor speed setting in a certain fixed ratio as the turbine gate opening increases (Fig. 1). It is effected through the governor restoring mechanism and is required for steady-state stabilization and load sharing of units in parallel.

Fig. 3[3] shows the characteristic curves of the isochronous and permanent speed droop governors. As the speed droop is increased, the load change decreases for a given frequency change and hence increases stability. Conversely, as the speed droop is decreased the load change increases for a given frequency change and hence decreases stability. As the speed droop approaches zero, the load change tends to be infinite for any frequency change, and demonstrates the need for a temporary speed droop factor, which gradually diminishes to zero as the frequency change likewise approaches zero. Operating two or more units isochronously with mechanical-hydraulic governors should be avoided because no matter how slight the system frequency may vary above or below the normal speed setting, the units would have a tendency to oscillate with one another, i.e. to hunt.

Fig. 1. Simplified schematic diagram of mechanical hydraulic governor.

Legend:
N_a = actual speed
N_d = desired speed
δp = permanent speed droop
δ_t = transient speed droop
T_r = relaxation time constant



For a small system, where the capacity of one unit is all or a large portion of the total generating capacity, it is often desirable to operate one unit isochronously to regulate for the varying system load and to maintain the system frequency at a normal value. It is necessary to introduce temporary speed droop to operate such a unit satisfactorily as mentioned earlier. The other units in parallel can be operated on a permanent speed droop to maintain a certain base load. As the system grows and more generating units are added, it becomes impractical to have any one unit operating isochronously. Instead it is necessary to operate all units with a certain degree of permanent speed droop.

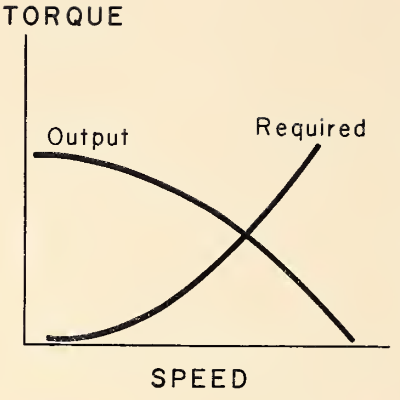
For steady-state stabilization, where the load and frequency changes are slow or gradual, the regulation afforded by self-regulation and permanent speed droop is usually adequate. However, where the load and frequency changes are of a transient or sudden nature, means for transient stabilization are necessary.

(d) Moment of Inertia

The moment of inertia (WR^2) or the fly-wheel effect of rotating machines is of great importance in providing transient stabilization due to its inherent property of absorbing or delivering kinetic energy in such a direction as to oppose any speed change. The WR^2 includes that of the generator unit and the connected load. System load increase is accompanied by a proportional increase in WR^2 and the transient stabilization is increased accordingly. Closer frequency control should therefore be possible as systems grow.

(e) Water Inertia

Unfortunately, the mass and inertia of the water column has the opposite effect on the hydraulic turbine to that of the WR^2. For a sudden load increase, some time is required to accelerate — and for a sudden load rejection, some time is required to decelerate — the water column to a new flow rate. During these periods of deficiency or excess in torque developed, the runner will tend to underspeed or overspeed respectively. Not only are the operating times for opening and closing the gates restricted by the physical limitations mentioned earlier, but there would not be any benefit gained by operating the gates at a faster rate than the equivalent change in the rate of flow of the water column. Moreover, the water inertia effect introduces further difficulties during the transient periods because, due to the relatively slow change in flow rate,



$$T_a \frac{d\phi}{dt} = \mu + 1.5\, Z\, \phi_h - Z_o\, e_s\, \phi$$

Where

T_a = Charact. Time To Accelerate Rotating Masses. (WR^2)

ϕ = Instant. Speed Deviation.

ϕ_h = Instant. Pressure Deviation. (Pressure Impact)

μ = Instant. Servo-Motor Deviation.

e_s = Self-Regulation Coefficient.

Z_o = Load Factor Related To Output.

Z = Load Factor Related To Water Consumed.

Fig. 2. Illustration of self-regulation.

the pressure of the water impinging on the runner momentarily decreases with gate opening resulting in a torque decrease which is quickly arrested and a steady-state torque greater than the initial value is established. Conversely, gate closure results in transient torque increase which quickly dies away to a steady-state torque less than the initial value. Summarizing, it can be stated that water inertia acts against the attainment of transient stability.

(f) Compensation

As demonstrated above, a certain time lag exists between movement of the gates to a new position and the development of torque at the corresponding new level required. In other words, the speed correction demanded by the movement of the speed sensing element will lag behind the positioning of the gates. Since the speed sensing element will not return to the neutral position until the system speed is normal, an anticipatory action must be introduced to stop the gate motion at the proper position. This anticipatory action must be a function of the acceleration of the unit and must be introduced along with the speed error measurement to influence the pilot valve movement in such a manner as to avoid over-or-under-shooting of the proper gate position. For the mechanical-hydraulic governor, the anticipatory action is referred to as compensation and is effected by the feedback signal of the gate movement through the dashpot of the restoring mechanism.

Compensation can be considered as consisting of two phases, namely, primary and secondary compensation. Primary compensation is a function of the feedback ratio from the turbine gate operating mechanism to the dashpot, i.e., it is the degree of damping and is expressed as percent temporary droop. Secondary compensation is the recentering action of the dashpot after a disturbance and is a function of the slipping action of the restoring mechanism effected by the controlled leakage in the dashpot (Fig. 1). As shown in Fig. 4, the movement with respeet to time follows an exponential curve. It is expressed as the dashpot recovery time or the damping time constant. The setting of both adjustments for stable operation are made in the field to suit the dynamic requirements.[4] With the unit off-line, these characteristics are a function of the water starting time of the water column and the mechanical starting time of the machine. It has been shown through analog computer studies[5] that the optimum compensation settings for units off-line and for units on a small system will be of the order of magnitudes given in the equations of Fig. 4. With the unit on-load, the optimum settings are greatly influenced by the inertia of the connected load and its power-frequency rigidity which increases proportionally with the growth of the power system. For small systems, where the capacity of one unit is all or a large portion of the total generating capaeity, the on-load compensation cannot be appreciably less than that required for off-line (speed-no-load) operation. For large systems, however, where the capacity of the unit is a small portion of the total generating capacity, the compensation is greatly reduced after the unit is synchronized on to the system, because, for a sudden fast applied change of the speed setting the transient feedback of a temporary droop dashpot governor interferes with the change of speed signal and results in sluggish response. Compensation reduction to a value at which the unit, if by itself, would be unstable, can be tolerated to a certain extent on a large system because stabilization is provided by the other machines on the system. This is accomplished by opening a bypass in the dashpot mechanically or electrically, which has the effect of automatically opening the needle valve and decreasing the damping time constant to 1/16 or less of its off-line value. Medium sized systems are in a category between the small and large systems and the on-load compensation must be set at some intermediate value. Often, a normally large system effectively becomes a medium sized system under light load conditions, (such as during the night or on weekends), or in the event of system separation into area components. The dynamic qualities of the connected load are, by no means constant but vary with load changes and with switching operations. Consequently, compensation adjustments for the mechanical-hydraulic governors, not being easily accessible for adjusting under changing system conditions, must of necessity be compromise settings.

Basic Requirements of Automatic Load-Frequency Control[6, 7]

Individual Power System:

(a) General

With the employment of permanent speed droop on all units of a system where it is impractical to operate a unit isochronously, each change in load alters the operating frequency of the system in a manner determined by the characteristics of the average speed droop and dynamic properties of the system. However, constant frequency is a quality which consumers require of the power supply for accurate time keeping, accurate machine operation, and uniform quality of manufactured products. The only way, then, to keep the system frequency at its original value is to adjust continuously the generation level manually or automatically so as to be in equilibrium with each load demand. Manual load-frequency control is tedious, bothersome, and inaccurate, and prevents the operator from attending properly to his other duties. Automatic load-frequency control relieves the operator of this chore and regulates generation automatically to maintain the load and frequency levels desired.

(b) Power System Control

The extent of controlling a power system are manifold. Only the more important objectives of power regulation are outlined as follows:

Power production must be adapted to the daily requirements of consumers by laying down a basic load schedule and correcting any differences between the anticipated load and actual consumption by supplementary regulation. Sustained fluctuations of a nature such as that of the daily load curve can be controlled by a stepwise approximation based on experience and laid down in the form of a schedule, thus providing the reference inputs for several machines or stations to which are allocated the base and peak loads. Only the difference between the stepped schedule and the actual consumption is controlled by supplementary regulation.

Fluctuations of an appreciable nature are caused by substantial load changes such as load switching by large consumers. The main function of the system controller is to convert fluctuations of load and frequency into a manipulated variable which is fed to the turbine governors of individual or groups of power stations to smooth out these disturbances.

Brief power fluctuations are produced by numerous small and medium consumers and by rotor oscillation of various units. These "fringe" fluctuations are superimposed on the sustained load fluctuations and are reflected in the variation of the loading of the power lines, and to a much lesser degree, the system frequency. According to statistics, the magnitude of these fringe fluctuations increases with the size of the system. Where these power fluctuations are very minute and very brief, lasting a few seconds or less, it is hopeless to attempt correcting them for technical reasons alone, since the turbine output could not follow the corresponding rapid fluctuations of the control signal. However, where the fringe fluctuations are sizeable, lasting several seconds or more, and are within the response capabilities of the regulating units, it is desirable to make an effort to curb these fluctuations through the system controller.

Fluctuations of a sudden nature, such as are caused by major disturbances in the generation or distribution facilities, can be considerable and may last a long time. Often these fluctuations are of a magnitude which cannot be dealt with by automatic control alone, and require additional manual adjustment of the desired value to effect a balance.

(c) Load-Frequency Control

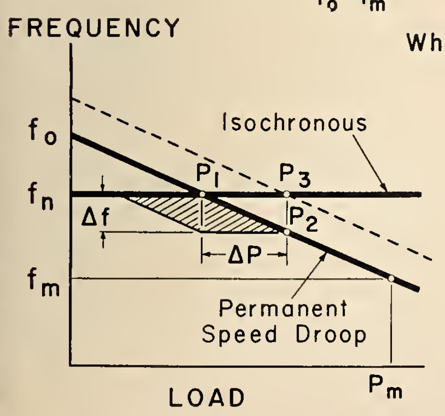
Flat Frequency Control

The solutions of problems associated with power regulation of a system are made more obscure than for many other control problems by the unknown behaviour of elements within the system. Initially, on a simple power system, the system frequency was a satisfactory reflection and indicator of the system requirements as to deficiency or excess of generation with respect to the connected load. Straight frequency control equipment was devised and installed in a generating station of a capacity large in proportion to the total generating capacity of the system. By comparing the actual system frequency against a desired frequency setting, the equipment would send either raise or lower frequency correcting signals to the turbine governors to correct the frequency error. The station, in performing this frequency regulating function, behaved collectively as a large isochronous unit with respect to the power system and was referred to as being on Flat Frequency Control. This characteristic is shown in Fig. 5.

The initial response of all system units to a frequency change (including the units of the Flat Frequency Control station) would be automatic regulation to correct for this change in accordance with the various permanent and temporary speed droop

Fig. 3. Isochronous & permanent speed droop characteristics.

$$\Delta P = -\frac{P_m}{f_o - f_m}\cdot \Delta f = -\frac{P_m}{\delta_p \cdot f_n}\cdot \Delta f = -k\cdot \Delta f$$



Where

ΔP = Load Change

Δf = Frequency Change

P_m = Full Load

f_o = Frequency At No Load

f_n = Rated Frequency

f_m = Frequency At Full Load

$\delta_p = \frac{f_o - f_m}{f_n}$

= Permanent Speed Droop

settings. As the system is brought back to normal by the automatic shifting of the speed settings of the units in the Flat Frequency Control station, the initial load distribution between the various units and stations will be gradually restored. Thus the Flat Frequency Control process, in shifting the permanent speed droop curves of the units in the controlling station, also cancels the inherent regulation performed by all the turbine governors.

Because the individual units in the Flat Frequency Control station are subjected to more work than other base load units on the system, it is undesirable to assign one generating station consistently on Flat Frequency Control. In addition to the problem of excessive wear of parts, there are other problems to contend with such as regulation of the river flow. Therefore, it is desirable to install automatic control equipment in other generating stations of sufficient regulating capacity. These stations could then take turns in maintaining constant frequency. It should be noted that placing two or more generating stations on Flat Frequency Control through their own station controllers should be avoided, otherwise, serious hunting would develop as in operating two or more units in parallel isochronously.

Flat Station Load Control

While one station on the system is on Flat Frequency Control, it may be convenient to operate one or more stations at a fixed output with the facility provided of changing the station output stepwise from time to time (such as required in the daily loading schedule) by simply altering the station load set point. Such a generating station behaves collectively as a large unit on a fixed turbine gate position ignoring any frequency changes with respect to the power system, and is referred to as being on Flat Station Load. It is obvious that placing all stations in the system on Flat Station Load Control should be avoided as then there would be no automatic frequency regulation to keep the system frequency constant.

Station Load Bias Control

As the capacity of the system grows to such an extent that one generating station on Flat Frequency Control alone can not cope adequately with the frequency regulating duty, it is necessary for this duty to be shared with other stations. The Flat Station Load Control can be biased by the frequency error signal so a compromise between Flat Frequency Control and Flat Station Load Control characteristics results. A generating station under such control is referred to as being on Station Load Bias control. The station behaves collectively as a large permanent speed droop unit with respect to the power system. By increasing the frequency bias setting, the station increases its contribution toward frequency regulation. By shifting the station load set point, the Station Load Bias curve shifts accordingly.

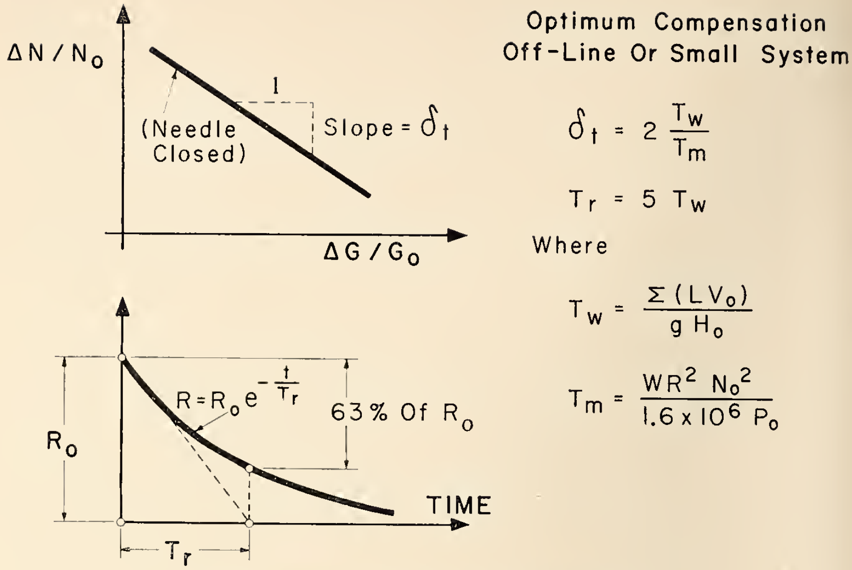


Fig. 4. Primary & secondary compensation.

Fig. 5 shows the characteristic curves and a block diagram of the circuit arrangement for Automatic Load-Frequency Control of a generating station supplying an isolated load. The illustrations are considered self-explanatory.

(d) Centralized Automatic Load-Frequency Control

On a large system, it may become necessary to spread the frequency regulation duties in predetermined proportions among several generating stations throughout the system. The simplest method which possibly presents the least technical difficulty while providing the most flexible operational facilities is the logical arrangement of controlling these stations in a coordinated manner from a centralized Automatic Load-Frequency Controller located at the system dispatching office. With frequency regulation under the control of the central control equipment, the individual participating stations must be relegated to slave stations following diligently the command signals from the central controller. It should react to no other intelligence except to that from the system controller, otherwise, it would upset the coordination of the system control. Telemetering control channels would be required for transmitting the command signals. The performance and success of the frequency regulation control process would be the entire responsibility of the central controller. The block diagram of the circuit arrangement for centralized Automatic Load-Frequency Control is shown in Fig. 6 for two interconnected power systems.

Interconnected Power System:

(a) General

The advantages and benefits derived from the interconnection of power systems have already been outlined in the introduction. However, the problems and difficulties associated with these interconnections are rather complex. While power regulation for the individual power system is achieved by the continuous correction of only one variable, viz., the frequency, the problem of power regulation for interconnected power systems involves the control of two variables, viz., the frequency and the tie line power. Moreover, where there are fundamentally at least two partners concerned in interconnected systems operation, two or more quite separate control circuits determine the process of control. Each of these systems may have several generating stations participating under the influence of either their own respective station controllers or a centralized system controller. Each generating station may consist of units which are quite different in characteristics to those of another station. The regulating control signals emitted from the controllers may be either a manipulated variable signal correcting for the differences between the actual and desired values of frequency and tie line power (such as a raise or lower impulse), or a manipulated variable signal correcting for this difference value and the programmed load schedule (such as a percentage generation signal).

It is emphasized that interconnected utilities are usually committed to stringent quotas of power interchange on the tie lines by contracts which may stipulate penalties in the event of prolonged failure to meet the quotas within certain limitations. On the other hand, constant frequency is inherently maintained as there is a greater combined moment of inertia and a greater diversification of load changes in an interconnection. As the capacity and number of systems in the interconnection increase, the frequency becomes extremely stable, and the control of the power transfers over the tie lines becomes increasingly more important.

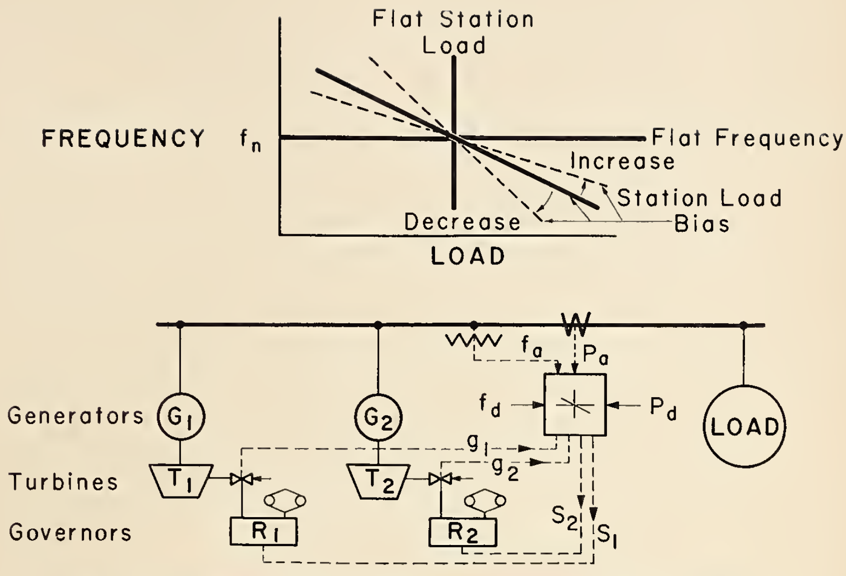


Fig. 5. Automatic load frequency control individual power system.

(b) Load-Frequency Control

The basic requirements and principles of operation of Automatic Load-Frequency Control for interconnected power systems are basically the same as for the individual power system. They can even be compared with individual units operating in parallel on a power system.

The initial method selected for interconnection control was for one system, usually the largest, to maintain a constant frequency while the smaller systems controlled their tie line power interchange in accordance with the stipulated transfer quotas. The largest system would be on Flat Frequency Control and would behave as a very large isochronous unit, while the smaller systems would be on Flat Tie Line Control and would behave as smaller units with fixed gate positions. The operating characteristics are shown in Fig. 6. The advantage of this arrangement is the deferment of installing Automatic Load-Frequency Control equipment. While it may be possible to operate manually in such a manner, the problems are considerable, the operation most tedious and the results proportionally as accurate as the vigilance of control. Instead it is more practical to install automatic control equipment on the largest system for Flat Frequency Control. It should be noted that as in the case of individual units or individual generating stations operating in parallel, the operation of two or more power systems on Flat Frequency (Isochronous) Control, or the operation of all systems on Flat Tie Line Control must be avoided.

As the smaller systems grow in capacity and begin installing Automatic Load-Frequency Control equipment, continued Flat Tie Line Control of the tie line power transfers no longer represents the optimum operating condition. A compromise form of control is more desirable wherein each system contributes toward the maintenance of constant frequency in a proportion consistent with its capacity while striving to maintain the scheduled power transfer quota on its tie lines. This form of control is referred to as Tie Line Bias Control and offers the best solution to interconnected power systems operation. Tie Line Bias Control is essentially Flat Tie Line control biased by the frequency error. Employment of Tie Line Bias Control by each interconnected power system fulfils three basic requirements. First, each system corrects its generation to meet all local load changes that occur within its boundaries. Secondly, each system which is temporarily out of balance between its load and generation is assisted by the remainder of the interconnection until it has restored its balance. Finally, each system corrects its generation to contribute towards the maintenance of constant frequency of the interconnection in proportion to the degree of frequency bias selected.

(c) Basic Configuration of Power Systems Interconnection for Power Pool Operation

Fig. 7 shows the basic configuration of power system interconnections for power pool operation. The tie line power must be the summation of all tie line readings as each system must control the sum of all exports.

Series or cascade operation is perhaps the simplest arrangement. In general each system has two transfer points and must control the sum of the tie line powers to the adjacent systems.

In delta or polygon operation, each partner must control the sum of its exports to the adjacent two systems. Note that for polygon operation, if the diagonals are used as transverse connections, the power transfers must be measured and integrated with the net interchange reading, otherwise there would be more power values than controlled values and thus the flow of power would be undefined.

In "T" or star operation, each partner can only be interconnected through one transfer point. With 'n' partners, there must be at least n-1 metering points. The one system which has no metering in its tie line to the transfer point has the responsibility of controlling the summation of the total powers of the other systems in the interchange, so that its transfer quota is also fixed.

From the basic configurations of power system interconnections, viz., series, polygon or star, it is possible to develop almost any combination imaginable. However, care must be taken that no uncontrolled tie line power flows exist.

Features and Advantages of the Electro-Hydraulic Governor

General: The turbine governor is seen to be the cornerstone of power regulation in its application to systems from the simplest possible (consisting of a single unit) up to large complex systems consisting of many units interconnected with a power pool grid-network. It is necessary to regulate the power on the system either through the intelligence of its governors or through the intelligence of the Automatic Load-Frequency Controller.

As there is a greater and greater trend towards interconnection of power systems, the associated problems are becoming more and more complex. It is expected that the requirements of the turbine governor will also grow in complexity. The tendency will be to require the governor to be very flexible with respect to ease of adjustment to facilitate changing the settings and obtaining at all times the optimum characteristics. It will become more and more difficult to devise methods and auxiliary equipment for adapting the conventional mechanical-hydraulic governor until it may become impossible to cope with the increasingly complex requirements. Because of the limitations of the mechanical governor, the electro-hydraulic governor shows promise of fulfilling the complex requirements anticipated in the future.

The Electro-Hydraulic turbine governor is essentially the same as the mechanical-hydraulic counterpart with the exception that the ball head assembly, the compensating dashpot and the restoring mechanism are replaced by electrical equivalents. In addition, the associated adjustments required such as the speed setter and speed droop setter, which consists of mechanical connections and linkages in the mechanical governor, are of necessity replaced by electrical equivalents in the electric governor. All the basic essentials of the conventional mechanical governor are retained by the electrical governor and some designs of electric governors still retain some features of the mechanical governor for standby purposes, such as the restoring mechanism, auxiliary transfer valve, start-stop and partial shutdown solenoids.

There are at least five commercial makes of electrical governors available on the market today. Fig. 8 shows a block diagram of the arrangement of the major components of a typical electro-hydraulic turbine governor.[1]

Features:

(a) Speed Sensing Components

The voltage and frequency outputs of the permanent magnet generator are proportional to the actual speed of the unit and are fed into the speed sensing circuit where conversion to an appropriate signal either through a tuned resonant L-C circuit or a rectifier-bridge circuit is effected and the new output fed into the pre-amplifier circuit as one of several inputs.

(b) Amplifier Circuits

The pre-amplifier circuit receives, in addition to the signal from the speed sensing circuit, signals from the speed setting, permanent speed droop and transient stability circuits and from any other circuits that may be required. From all these inputs, the pre-amplifier circuit, which usually consists of magnetic amplifiers, computes the result and amplifies it. The pre-amplifier output is further amplified through a power stage before being applied to the electro-hydraulic transducer. The power amplifier stage can be a circuit consisting of either thermionic vacuum tubes [9] or magnetic amplifiers. [1,8]

(c) Actuating Mechanism

The electro-hydraulic transducer converts the resultant electrical signal to a mechanical movement. This movement is transmitted to the turbine wicket gates by the actuating mechanism in much the same manner as the conventional mechanical-hydraulic turbine governor.

(d) Feedback Circuits

Although the mechanical feedback or restoring mechanism is generally retained to perform certain essential functions and for standby purposes, the feedback required for the electric governor for regulation, stabilization and other purposes is provided by variometers. The variometer is essentially a brushless A.C. variable control transformer, which provides an output proportional to the gate position, and which is not susceptible to the same troubles associated with slide-wires and the wipers of potentiometers. The variometer output is usually fed into the permanent speed droop, temporary speed droop, and joint control circuits.

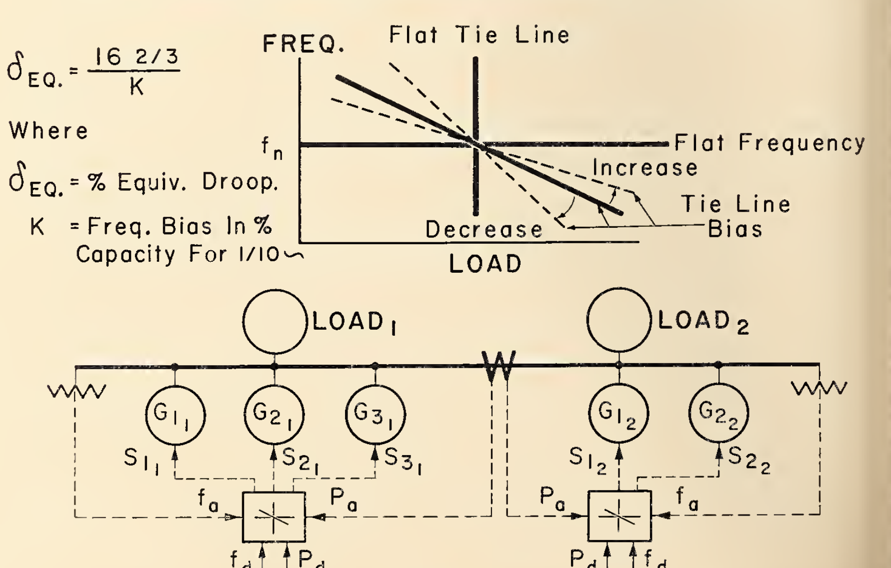
(e) Stabilization Circuits

The permanent speed droop circuit is simply the modifying factor applied to the proportional gate position output signal from the variometer feedback circuit and is usually effected by a potentiometer circuit. The modified signal is introduced as a load bias to the speed setting signal in the pre-amplifier circuit.

Two types of transient stabilization are available for the various makes of electric governors. These are temporary speed droop stabilization [9] and speed derivative (acceleration) stabilization. [1,8]

The temporary speed droop stabilization circuit corresponds to the compensating dashpot of the mechanical governors. It usually consists of an R-C circuit fed from the rectified variometer output dependent on the position of the turbine gate. The capacitor is either charged or discharged according to the direction of movement of the gate and the capacitor current gives a voltage drop across the resistors which is fed as a control voltage to the pre-amplifier. When the gates stop this control voltage decays exponentially. Its polarity is arranged to oppose the gate movement and thus provides transient stabilization. To avoid sluggish response when the unit is connected to a large power system, it is necessary to reduce the compensation considerably, (as for the temporary droop dashpot), by a switching arrangement from no-load

Fig. 6. Automatic load-frequency control interconnected power systems.



damping to service damping. As mentioned earlier, machines which have their degree of stabilizing reduced upon synchronizing are stabilized by other machines on the system; should the dynamic characteristics of the network change during service operation there is no ready means whereby the damping of the mechanical governor can be set to match. However, for the electric temporary droop governors, a range of service damping settings is provided for easy adjustment to obtain optimum stabilization for changing system conditions.

The cause and effect of governor action are the sensing of speed error and the movement of the turbine gates. Temporary droop stabilization is the derivative of the gate movement (gate acceleration) and is therefore a function of the effect. On the other hand, speed derivative stabilization is the derivative of the speed error of the unit and is therefore a function of the cause. While it is necessary to reduce the compensation on a temporary droop governor to avoid sluggishness when the unit is connected to a large system, full derivative action can be retained with the derivative governor so that the governor inherently possesses the fastest possible response to speed change signals without jeopardising the system stability.[10] Consequently, the switching arrangement from no-load to service damping is not required for the derivative governor. The net result is that, for sudden changes in load or frequency, the derivative governor responds just as quickly as a temporary droop governor (with reduced compensation) but stabilizes much quicker with smaller transient deviations. The speed derivative circuit usually consists of an R-C differential circuit [8] or a differential transformer circuit.[1]

(f) Load Sensing Circuit

The electrical governor can be arranged to sense load, detect any error in load levels between the actual and desired loads, and initiate corrective gate movements to restore equilibrium. Such an arrangement is desirable when the unit is a slave unit operating under Automatic Load-Frequency Control and avoids the conflict between its own intelligence and the intelligence it receives from the controller. However, a governor which is strictly load sensing only is undesirable, as it furnishes inadequate control when, for example, the loaded unit is tripped from the system by a protective feature, or when the unit is starting up to be synchronized with the system. Control of the unit by sensing speed is definitely preferable under these conditions. The load sensing circuit is usually a simple bridge circuit with a desired load setter on one side of the bridge and a gate position follower on the other.

(g) Joint Control

Joint control is the control of a number of units connected in parallel under a master set of adjustments which control all of these units collectively as if they were one integrated unit. The joint control usually has a master frequency setter, a master load setter and a master permanent speed droop setter. The master load setter can be calibrated in MW capacity in which case the feedback signals of the units must be summated to balance against the desired setting or it can be calibrated in percentage generation in which case the feedback signals of the units are each compared with the reference signal of the desired setting.

Advantages

(a) Accuracy

The high accuracy of the electrical governor is one of its key advantages. This accuracy is the result of replacement of the conventional mechanical parts of the governor by the more accurate and permanent electrical equivalents at the front end of the governor control system. Speed detection, compensation and speed droop functions being performed by electrical means results in faster response, better stabilization and higher sensitivity. Moreover, with the replacement of mechanical parts, such difficulties as dead band, dead time, and back lash caused by static friction, inertia and wear of mechanical linkages are minimized or eliminated.

(b) Flexibility

The flexibility of locating governor components is perhaps the greatest advantage of the electrical governor from the point of view of design layout. Because the controls and adjustments are electrical, they can be separated from the actuator valve cabinet, mounted on a control cabinet or panel and located in the control room or wherever convenient. The actuator valve cabinet can then be located on the turbine floor nearer the turbine gate servomotors thus permitting the use of shorter piping runs.

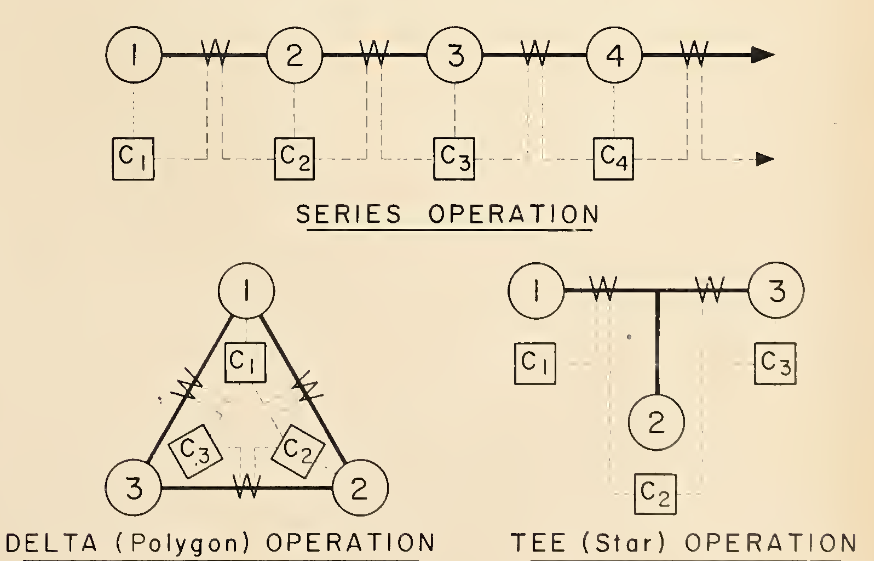
(c) Facility of Adjustment

The ease of adjustment of critical governor settings is the chief advantage of the electrical governor from the point of view of control operation. The temporary speed droop and the damping time constant adjustments for the mechanical governor are not readily adjustable. These adjustments are relatively simple and easy for the electrical governor. Thus, as the dynamic characteristics of the connected system change, it is relatively easy to make changes in the compensating adjustments to approach the optimum setting for the best stability. These adjustments, as mentioned earlier, are not required for the speed derivative governor.

(d) Versatility

Perhaps the greatest advantage of all for the electrical governor is its inherent versatility. The joint control feature, for instance, not only distributes the load evenly amongst all the participating units, but it permits isochronous operation of as many units

Fig. 7. Basic arrangements for power pool operation.



in parallel as desired, a feat which is difficult, if not impossible, to achieve by the mechanical governor. Therefore, this feature may be of particular advantage for individual power systems as it provides automatic frequency regulation without recourse to Automatic Load-Frequency Control equipment. When interconnection with neighbouring power systems becomes desirable, the command signals from the centralized Automatic Load-Frequency Controller can be fed into the joint controller directly. The Station Automatic Load-Frequency Control equipment is thus eliminated.

The electrical governor lends itself most readily to automatic sequential control. Thus, through control voltage manipulations directly through the pre-amplifier stage or even the power amplifier stage, it is possible to perform such functions as speed-no-load and gate limit control, or even complete operation under the directions of a computer data program. Because of the wide scope, great potential and versatility of the electrical governor, a particular governor characteristic readily obtainable is advanced later as a requirement for the improvement of power regulation of interconnected systems.

Operating Problems, Requirements Advocated for Improvement and Suggestions Advanced

General: The earlier operating philosophy of Automatic Load-Frequency Control was based on a steady-state stability rather than a transient stability approach. As a result, the earlier vintages of equipment operated relatively slowly. The error signal of load and frequency, or area requirement, was integrated over a relatively long period of time. The control proeess was further delayed by routing the control signals to one station at a time and in turn routing the control signals to one unit at a time. Combined with poorly maintained mechanical governors and appreciable time lags in the telemetering control channels, the results left much to be desired. At present, there are still some advocates of this philosophy.

On the other hand, there are strong advocates in favour of adding computer attachments to the Automatic Load-Frequency Control equipment for such refinements as most economical loading based on considerations of incremental heat rate for thermal plants and transmission line losses. These functions are accomplished within the limits of the individual power system and independent of the other interconnected systems.[11] While such refinements are interesting, they are not within the scope of this paper. Rather, there are still basic mutual problems existing which are common to all members of an interconnection and which should merit considerable attention and concern.

Operating Problems:

(a) Interaction between Automatic Load-Frequency Control and the Turbine Governor.

It is particularly important to draw attention to the interaction between the Automatic Load-Frequency Control and the turbine governors which causes undesirable effects on the equipment and the stability of the system. This interaction can be illustrated quite clearly by referring to the arrangement of an individual power system where one station is on Flat Frequency Control while another station is on Flat Station Load Control. The shaded operating area of Fig. 3 illustrates this interaction. If the system frequency were to drop suddenly from fn to (fn-Δf), the governors in the Flat Station Load Control station would react in accordance with their permanent speed droop curve by opening their gates and tend to reach equilibrium at a new power output P_2. The automatic controller at this station would recognize an increase in station output and send "lower" signals to the governors to restore the flat station load output to P_1 on a parallel droop characteristic. Meanwhile, the Flat Frequency Control station on the system has been picking up load to bring the system frequency back to normal and the governors in the Flat Station Load Control station again react in accordance with their newly-modified speed droop curve to close their gates to reach equilibrium. The station automatic controller would now recognize a decrease in station output and send "raise" signals to the governors in an attempt to re-establish flat station load, and so on, thus tending to cause this station to hunt within the shaded area.

This interaction can be reduced and even eliminated by two possible methods. The first method is to increase the speed droop. In the limit, if the speed droop were increased to infinity the interaction would be completely eliminated and the governor would become a flat load regulator rather than a frequency regulator. Such a governor raises other problems which were discussed earlier. Alternatively, the second method is to introduce the frequency error as a bias to the Flat Station Load Control. The station controller then recognized that, for any upsets in system frequency, the station output would

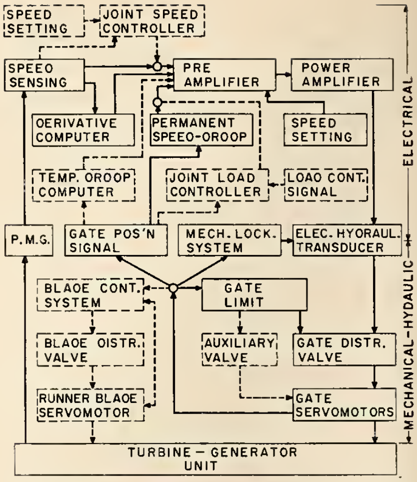


Fig. 8. Electro-hydraulic governor block diagram.

change in accordance with the average speed droop characteristics of the units to assist in frequency correction. As the frequency bias is increased, the parallelogram enclosing the shaded area in Fig. 3 would recede to the right until it coincides with the permanent speed droop curve when the frequency bias exactly matches the speed droop characteristic of the governors. On the other hand, if the frequency bias were increased further, the parallelogram would gradually develop on the right-hand (or P_3) side of the droop curve and interaction would again result.

If it be assumed that all slave stations under a centralized Automatic Load-Frequency Controller have their station controllers tuned to match the average speed droop of their respective governors, it is necessary to telemeter the slave station output back to the station allocator in the central system controller for rebalancing since each station may have different average speed droop settings and hence different frequency bias settings. Moreover, each station may have different dynamic response characteristics.

(b) Interaction between Slave Stations of Different Dynamic Response

In contrast to the philosophy of advocates for the relatively slow response of the system Automatic Load-Frequency Control, the outlook for system control should be one of faster response consistent with good stability of the system whether on an individual or interconnected basis. This outlook should be a natural aspiration of power utilities in their continuing quest for higher quality service and economy of operation.

The control equipment designed by the earlier school is of an "integral control action" type. This action is also known as "sustained" or "reset" control. The sloping line in Fig. 9 illustrates the response of reset control to a step load change. Note that the slope of this curve can be increased for a faster response and vice versa. If the control signals were emitted from a centralized system controller to a fairly fast responding station only, the slope of the reset curve should be tuned to match the response capabilities of the fast station. Similarly, adjustment of the reset curve slope can also be tuned to match a fairly slow responding station.

Discordant responses result in interaction (Fig. 10). Take case (a) where the reset control action (dotted curve) is too fast for the response action of a slow station (lower curve), interaction or hunting between the controller and the station is illustrated following a .05 per unit load change. If it were necessary to operate both stations simultaneously through a common control signal to both the fast and slow stations, the slope of the reset curve must not be steeper than for the slow station. Any increase of the slope above the low setting would give a proportionate interaction between the fast and slow stations.

In case (b) the common reset control action for a .10 per unit load change is assumed to match the response of the fast station and is assumed to be emitted simultaneously to both the fast and slow station of equal capacity. The interaction between the two stations is identical to that between the controller and the slow station in case (a). The total system response is shown as the heavy upper curve. It will be noted that in both cases (a) and (b), if the load changes were continuous, the interaction would be perpetuated indefinitely. Thus, to avoid interaction under such an arrangement, the speed of response of the automatic system control would be determined by the speed of response of the slowest station participating in regulation.

(c) Interaction between Interconnected Power Systems

The principles just discussed outlining the causes of interaction which exists between the station Automatic Load-Frequency Control and the turbine governor, and which exists between slave stations of different dynamic response, applies also for interaction between interconnected power systems. If the frequency bias setting of the centralized Automatic Load-Frequency Controller is not tuned to correspond to the equivalent speed droop of the system as a whole, interaction will result between the system controller and the power system. If the dynamic response of interconnected systems are different, interaction between systems will always result.

Requirements Advocated and Suggestions Advanced for Improving Power Regulation of Interconnected Systems:

(a) General Considerations

A power system interconnected with others should correct for its own load changes as rapidly as possible. If these changes occur faster than the system can handle safely, the neighbouring systems should assist on a short time basis. However, this available assistance should not be abused by a complacent attitude as it imposes difficulties on utilities whose outlook is to improve their power regulation performance. An indifferent attitude adopted by any one utility towards improving its power regulation performance is detrimental to the common welfare of an interconnection by thwarting the efforts of conscientious members. To improve the power regulation performance of an interconnection, a better understanding and cooperative effort by each member to overcome the difficulties encountered is required.

Although the system frequency becomes more and more stable as the interconnection grows in capacity and membership, the tie line load fluctuations become increasingly difficult to control. The difficulty is largely due to the increasing magnitude of the "fringe" fluctuations on the tie lines. Although these fluctuations may be initiated by the continuous load changes within each system, they are aggravated by interaction between component areas and the inherent "torsion spring" effect of the electrical coupling between the various rotors within a system and between systems. Electrical induction type damping is a major factor in damping these oscillations and contributing to stabilization. This is a function of the internal and external reactances, the terminal voltage and the instantaneous slip of the machines; just one example is the damping provided by amortisseur windings in the generator pole faces.

At first thought, the concept of electrically stiffening the tie lines by employing series capacitors or by adding parallel circuits might appear reasonable. However, analytical studies have indicated that, while such tactics may reduce the period of oscillation and the phase angle deviation between rotors due to disturbances, the magnitude of the power swings are not necessarily reduced and may even be increased. Some authorities propose to improve stability by slowing down the governor response to allow larger deviations in speed and thus make greater use of the self-regulation effect. It has also been proposed to slow down the response of voltage regulation despite the continued development of high-speed voltage regulation to increase the steady-state stability limit of long E.H.V. transmission lines. Some people propose slow response for automatic load-frequency control. All these proposals appear to be the outcome of negative thinking. Without sacrificing fast response of the governor, the voltage regulator, or the automatic load-frequency controller, the road open for improving stability of interconnected systems appears to lie in the direction of overcoming the causes of interaction. EIC

Fig. 9. Transient response of the control system to a step load change.

$$C_1(\Delta P + K\Delta f) + C_2\int_0^t (\Delta P + K\Delta f)\,dt = Y_N$$

Proportional — Integral — Manipulated Variable

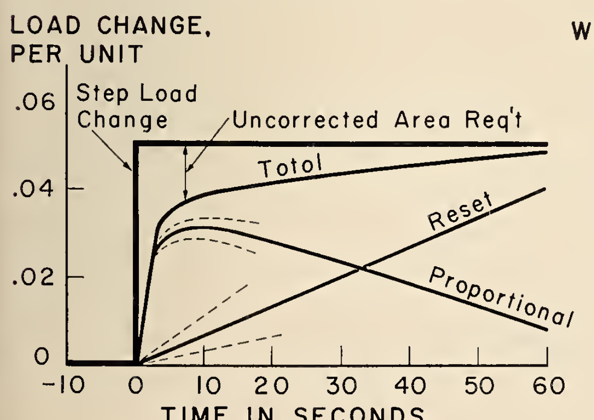
Where

ΔP = Deviation Of Load

Δf = Deviation Of Frequency

K = Frequency Bias

C_1, C_2 = Constants



(b) Ascertain Optimum Frequency Bias Settings

The frequency bias settings of interconnected systems operating on tie line bias control should all be adjusted to the same slope in order that each system will be responsible for carrying its fair share of tie line load and frequency regulation. On some interconnections, the agreed bias setting is 1% of each system's capacity for 0.1 cycle/sec. deviation. Now, for 60 cycle/sec. systems, the relationship[6] between the percentage capacity bias setting and the equivalent percentage permanent droop setting is that one is equal to the reciprocal of the other times a constant of 16-2/3 (Fig. 6). For example, 1% capacity bias is equivalent to 16-2/3% permanent droop, 2% capacity bias is equivalent to 8-1/3% permanent droop and 3% bias equivalent to 5.5% droop, and so on. A frequency bias which exactly matches the natural speed droop of a system will not interfere with the natural governing characteristic of the system. Therefore, it is advocated that the mean natural permanent droop of all the individual power systems of an interconnection be ascertained[13] and that the frequency bias derived therefrom be adopted as a common setting for each system in order to reduce interaction to a minimum between the system controllers and the systems.

It is further advocated that each individual power system should minimize the interaction between the station controller and the individual governors. The slope of the station bias curve should coincide with the speed droop of the governors and the station output be telemetered to the station allocator in the central system controller for rebalancing. The alternative is to utilize a governor with a straight follow-up load sensing characteristic which is insensitive to frequency changes within a predetermined band width—this characteristic is developed later.

(c) Strive for Optimum Dynamic Response

The same basic interaction between slow and fast stations under reset control also determines the relative performance between slow and fast responding systems of an interconnection. To reduce interaction, the fast responding station or system must be slowed down to match the response of the slower station or system as the case may be.

The introduction of proportional action in the control system reduces interaction. The rounded saw-tooth curve in Fig. 9 illustrates response action typical of proportional control in conjunction with reset control for a step load change. Note that as the reset control approaches the new load level, the proportional control approaches zero. The resultant control action is the summation of the two characteristics and is shown (see 'Total' curve) in Fig. 8. The mathematical expression relating the proportional and reset (integral) control to the resultant (manipulated variable) is also shown in the figure.[7] It should be noted that this equation for load-frequency control is derived from general control theory assuming the turbine governor to be a simple proportional follow-up device and ignores the effect of its speed droop on the frequency.

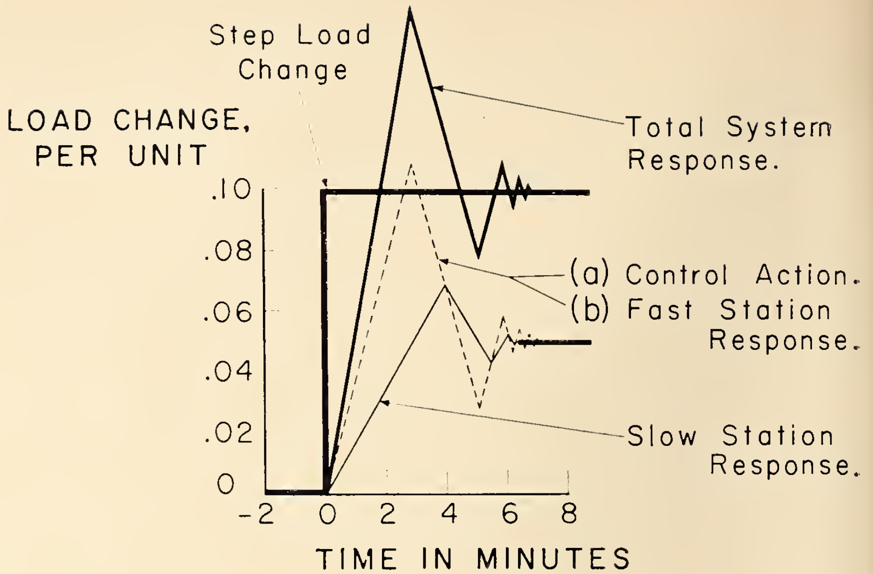


Fig. 10. Interaction from discordant dynamic response.

In the control of generation of an interconnected power system, the proportional control action can be allocated to the faster responding stations while the reset control action is allocated to the slower responding stations. Interaction between stations is minimized and the overall system response improved. On the other hand, it may be inconvenient or undesirable to separate the proportional and reset control functions into two corresponding categories of slave stations, in which case the two types of control action can be combined and a common signal dispatched from the system controller to the slave stations. Such an arrangement in practice functions satisfactorily without perceptible interaction. It is advocated that each member of an interconnection should strive to achieve the best possible response consistent with good system stability in order not to hamper the overall performance of the interconnection. To achieve this, reset control should be augmented by proportional control.

With reference again to the equation in Fig. 9, the term in brackets is the area generation requirement. The constants C_1 and C_2 are highly significant. Increasing C_1 increases the amplitude of the saw-tooth curve, while increasing C_2 increases the slope of the reset curve (see dotted curves in the diagram). Just as it is necessary to seek the optimum settings for the temporary droop governor to obtain the best response consistent with good stability, it is found from experience that it is necessary to optimize C_1 and C_2 to obtain the best performance. It is advocated that these values C_1 and C_2 be adjustable rather than fixed settings, i.e., parameters rather than constants, and that consideration be given to ascertaining the optimum settings for these values under each system configuration by a more scientific approach than trial-and-error procedure.

It is interesting to note that both the temporary droop and speed derivative governors have a proportional-integral action and are considered as such in mathematical analysis.[8] The proportional action of the measuring system produces an integral action of the servomotor in governor action. To keep the disturbance caused by a load change to a minimum, the governors are equipped with a means of limiting the proportional action by temporary droop or derivative action. Therefore, it would seem logical to suggest that, in place of the arbitrary settings of proportional and reset control values, a measure of the rate of change of area requirement, i.e., the derivative of area requirement, be used as an automatic means of regulating for the optimum dynamic response of the control system for all system operating conditions.

(d) Reduce Time Lags in the Control Loop

The reduction of time lags in the control loop is an important contribution in the quest for improved power regulation performance of power systems. Increasing the system response is one phase of reducing time lag. Other phases are reducing time lags in the system controller, telemetering system and turbine governor.

Major advances in the development of solid state techniques are revolutionizing the electrical industry. Not only do solid state techniques reduce the time lags in the control loop and reduce equipment space, but experience shows that they provide a high degree of accuracy, reliability and longevity of service with reduced maintenance. Solid state telemetering equipment has been on the market for several years and has performed exceptionally well. Similarly, solid state computer equipment has been proven to give excellent service. It is appropriate that solid state Automatic Load-Frequency Control systems are now available on the market and that solid state devices have also been introduced into the control system for electro-hydraulic turbine governors. Hence, it is advocated that solid state techniques be adopted by the power utilities for application to equipment of such primary importance as power regulation especially where such equipment shows a decided superiority of performance over its predecessor.

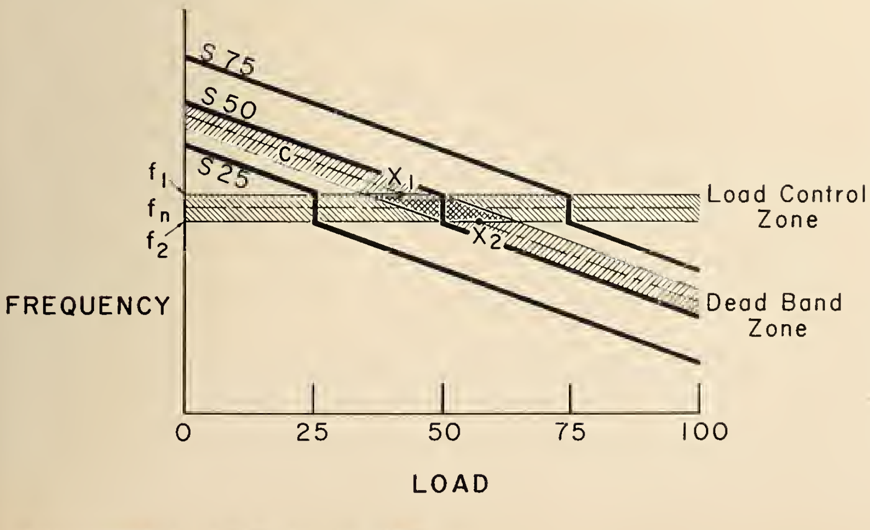
While the advancement of solid state technique has eliminated the slidewires, motors, gear trains and vacuum tubes which are used in the conventional electro-mechanical controllers and telemetering systems, the prospects of what solid state techniques may provide in the future captures the imagination. For instance, the utilization of digital principles, i.e., a process of counting instead of comparison with a standard, shows particular promise in providing extremely precise control and telemetering functions for such applications as decentralized load-frequency control operation as is the case in some European countries. Reducing time lag and increasing accuracy in the controller and the telemetering equipment is a major improvement in the control loop, but possibly the greatest scope in the quest for improved power regulation performance lies in the electro-hydraulic governor.

(e) Pursue the Ultimate Use of Electro-Hydraulic Governors on Participating Units Under Load-Frequency Control.

In the course of pursuing time lag reduction in the control loop, the development of means for increasing to an optimum the response of the governor consistent with good stability should be one of the major spheres of endeavour for improving interconnected systems power regulation performance. Increase in response for the mechanical temporary droop governors to corrective signals from the controller is accompanied by a reduction in stability and attachments have been devised to minimize this difficulty. One attachment operates on a solenoid-actuated auxiliary dashpot bypass as the speeder motor is impulsed in the raise or lower direction. Another scheme is to actuate the pilot valve directly with corrective signals by a speed-setting transducer and the necessary mechanical linkages, and bypass the speeder motor. These are all serious efforts to adapt the mechanical governor for more difficult and complex requirements as the interconnected power grid grows.

Many features and advantages of the electro-hydraulic governor have been outlined earlier. With the electrical temporary droop governor, the ease with which the adjustments are made to reach optimum response consistent with good stability is a great asset for improving system performance. With the electrical speed derivative governor, there is the added advantage of retaining full derivative action while permitting the fastest possible response to corrective signals. Both types of electrical governors permit the introduction of corrective signals directly into the preamplifier stage. Also, there is the tremendous advantage of the joint control system discussed earlier. It is advocated that each member of an interconnection pursue the ultimate use of electro-hydraulic governors on participating units under automatic load-frequency control.

Fig. 11. Stepped permanent speed droop characteristic.



(f) Consider the Stepped Permanent Speed Droop Characteristic as a Governor Requirement

The relegation of participating units or stations to slave units or stations under automatic load-frequency control should ensure their complete control by the controller. The slave units or stations should not have any intelligence of their own to conflict with the superior intelligence they are called upon to follow from the controller, as the area generation requirements should be determined at all times by the automatic computing network.

Because of its versatility, the electric governor can be arranged to have a combined speed sensing and load sensing characteristic. A special govnernor characteristic is advanced as a logical requirement for governors responsive to automatic load-frequency control and can be described as a discontinuous stepped permanent speed droop characteristic. (Fig. 11) The discontinuous portion of the curve is a vertical line intersecting the normal frequency line at right angles and thus has an infinite speed droop or flat load characteristic within a prescribed frequency band. This characteristic, referred to as "Stepped Permanent Droop" in this paper, is being provided for a large hydro-electric generating station presently under construction.

For comparison purposes, the

dashed line "c" in Fig. 11 indicates the permanent droop characteristic of a conventional governor. Curve S50 illustrates the stepped permanent droop with the unit at 50% load, while curves S75 and S25 illustrate the stepped permanent droop characteristies with the unit at 75% and 25% load respectively. The shaded horizontal area represents the limited band of frequency within which the unit is insensitive and which is adjustable and preset. From the outset, a distinction must be made between this load control zone and the dead band of the conventional governor. They should not be confused with one another. The dead band zone of the conventional governor is represented by the shaded sloping area. Under conventional operation, if the insensitivity of the governor were between f_1 and f_2, the load and speed of the unit would drift anywhere within the cross-shaded area of the parallelogram without governor action. With increased sensitivity of the governor, the parallelogram contracts. While the dead band zone indicates inability to correct for speed errors due to the deterioration of the governor, the load control zone represents a prescribed zone of accurate and sensitive follow-up action of the governor to load correcting signals as commanded by the external controller. Although it is conceivable that such a governor characteristic may be desirable on a unit basis, it is simpler and more practical to consider employing such a scheme on the basis of joint control.

The load control zone is centered about the normal frequency setting, is adjustable in band width and can be switched in or out of service. The speed setting of the joint speed controller determines the speed level of the load control zone and the load control setting of the joint load controller determines the load position of the units. The required height of the step in the permanent droop (i.e. the band width of the load control zone) is obtained by appropriate back biasing with adjustable limits of frequency error, whereby the biasing completely neutralizes the frequency error within the prescribed limits of the load control bandwidth. With a large interconnection of many systems, the frequency deviations are very slight and normally may not exceed ±1/40 cycle sec.; with this variation the bandwidth of the local control zone for instance could be set at ±1/10 cycle/sec. Should the system frequency deviate beyond the prescribed limits, the governors will assist frequency restoration under the joint controller in accordance with the slope of the stepped permanent droop curve.

The switching in or out of the stepped permanent droop characteristic must be scheduled for semi-automatic operation. Switching-in of the characteristic would be required when the station is being transferred from normal base load to automatic load-frequency control operation under steady-state conditions and should be straightforward. On the other hand, switching-out of the characteristic should be of greater concern. Other than when the station is being transferred from automatic load-frequency control to base load operation under steady-state conditions, the switching out of this characteristic would be effected either manually or automatically upon the occurrence of severe system disturbances as detected by predetermined frequency or area requirement limits. These limits might be of the order of ±5/10 cycle/sec. and ±100 mw. Inadvertent swtching-out of the characteristic could be serious. Referring to curve S50, Figure 11, should such an operation take place, for instance, when the frequency deviation is at a limiting value of the load control zone, the governor characteristic would immediately revert to the conventional speed droop curve 'c' to either close the gates to point x_1 for frequence f_1 or open the gates to point x_2 for frequency f_2, thus creating a power disturbance which may be embarrassing as it occurs at a time when there is already a system disturbance.

Conclusion

It is advocated that each member of a power interconnection should adopt a progressive attitude towards the problem of power regulation. With improved equipment on the market and with advances in technology in all phases of the industry, it is advocated that utilities should keep abreast of these advances, and seriously consider their adoption.

The cornerstone of power regulation is the turbine governor. The adoption and acceptance of the electro-hydraulic turbine governor is strongly recommended, especially where the generating stations will be under automatic load-frequency control. Optimum adjustment of frequency bias and dynamic response, and the reduction of time lags in the control loop are all requirements highly advocated for adoption.

As power system interconnection becomes more extensive, transmission distances become greater and inter-system power transfer loadings increase, the art and practice of automatic load-frequency control must be constantly reviewed and improved upon for the mutual benefit of participating power systems. It is envisaged that possibly a central authority may be neeessary, when the interconnections expand to national or even continental proportions, to enforce certain standards to be met by each member utility for the welfare of all. Possibly the art of computer practices will widen out from economic dispatching into the realm of optimum performance dispatching in order to realize a stable, responsive, and accurate control of power regulation on a continent wide basis while obtaining the maximum economic benefits of interconnection.

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THE SASKATOON PRODUCTIVITY PROGRAM

I. S. Evans, M.E.I.C.,
Head, Division of Information Services,
Saskatchewan Research Council, Saskatoon

Several factors add to the difficulties of mapping a program of productivity for Saskatchewan. Included are uneven labor force; small domestic market; and considerable distance between cities

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THE READER should be warned at the outset that this paper contains little engineering and is, in most respects, an engineer's attempt at philosophy. It will deal only with the productivity program in Saskatoon, with which I was intimately concerned and which was officially a pilot experiment. Our efforts were directed towards solving a local problem and since some of you might wish to extrapolate our results for application to other areas, a description of the local scene would be appropriate.

Saskatchewan has an area of one quarter of a million square miles. The northern half is sparsely inhabited. Its population of approximately 900,000 lives in the agricultural southern half and of this population 90,000 are farmers. The province has two major cities, Regina with a population of 100,000, and Saskatoon with a population of 90,000. Although the cities are growing rapidly, partly at the expense of the rural areas, we do not yet resemble Manitoba with half its population in Winnipeg or Alberta with half its population in the Edmonton and Calgary complex.

Our problems include:

i. Considerable distances between the larger centres;

ii. A small domestic market;

iii. An increasing labor foree since farm mechanization and crop prices are constantly increasing the minimum economic size of the farm;

iv. A larger availability of seasonal labor, e.g. farm labor in winter when no major operation is possible on the wheat farm.

Further, one is influenced by the organizations now working in the province. Amongst the more important of these is the Centre for Community Studies. The Centre's Director, Prof. W. B. Baker, recently stated that Saskatchewan has known constant change in its half century of existence and that the social atmoshere of today is charged with a sense of urgency. This is seen in the constant efforts made to foster a spirit of self-help and local co-operation on the level of the farm and small community. A strong sense of rugged individualism combined with an equally strong sense of collective responsibility has always been a built-in feature of Saskatchewan's population.

The social change in the country is taking place concurrently with the industrialization of the province and an evolution in industry. There is a growing realization that there is an essential identity of interests between managers, workers, and consumers. Industry now seeks to deploy men, materials and machines in a way which will make it easier and more rewarding for workers to use their efforts and ingenuity.

Imposed upon this scene are the Research Councils. In our case we have to consider the National Research Council, more particularly, its Technical Information Service and the Saskatchewan Research Council. The National Research Council and the five provincial research councils maintain a free and confidential service to help industry to solve its technical problems. What is actually done varies from province to province. This is quite understandable since we are in many respects dealing with an under-populated continent rather than a compact national entity.

In Saskatchewan we believe we have at least four functions to perform. These are:

1. First and foremost, to help industry to solve its technical problems;
2. To acquaint industry with any advances in science or technology which it might profitably exploit;
3. To maintain for industry a watching brief for new plant, tools and materials which it might use;
4. To keep the Saskatchewan Research Council aware of industry's particular needs in research.

During the period of operation of the Technical Information Service, our national economic picture has changed completely. No longer is it sufficient to provide only the technical solution for the problem, for example, producing an article or processing some particular material. Goods must now be produced at a competitive cost and of internationally acceptable quality. This requires more than straight technology.

Saskatchewan stands in particular need of such help. The domestic market is, often, not large enough to support the minimum economic plant. If our industry is to expand it must export beyond the provincial boundaries. Our choice is clear, either to accept a lower standard of living, or to be industrially more efficient than our competition in British Columbia, Alberta, Manitoba, and Ontario. Again, since the average industrial undertaking in Saskatchewan is small and the people, in Prof. Baker's words, "rugged individualists", we have, in Saskatchewan, the highest proportion of owner-operated and family-owned businesses in the country. Personal observation shows these people to be supporters of the "promotion from within" school of thought. This is often an euphemism for promotion from within the family. Since nature is quite indiscriminate in its distribution of genius, this feature of our industrial pattern is not a source of strength. Finally, the freight rate umbrella which sheltered the local producer in the provincial market is a distinct disadvantage in our extra-provincial activities.

This is the scene in which we tried to foster the idea of increased productivity. Our first consideration was the method of sponsorship. Basically, I believe at least three ways were possible. The first would be the application of the productivity program by government. This has been done, apparently successfully, in Israel, Egypt and India, but quite obviously this would not suit the "rugged individualists" in Saskatchewan. The French scheme of holding seminars for a particular industry seemed very attractive but where we have enough industry to support such an activity, the distances between plants are prohibitive, e.g. the sodium sulphate producers. Accordingly, we based our plan on the British model in which government, industry and trade unions combine to promote productivity. The principal differences are:

1) That no financial grant was made by anybody. We were founded on faith and have been self-supporting since;

2) The trade unions have not participated in the initial program;

3) Employers and manufacturers federations are only now beginning to support us;

4) Neither the provincial nor federal governments has been involved other than that the provincial government has provided two lecturers.

Perhaps with more courage than common sense we began with the 1959-60 program, which consisted of two series of 15 lectures each, one for management and one for foremen and a two-day materials handling seminar. Quite obviously, with no financial support we had to find our lecturing talent in the locality and we received the wholehearted support in the University, Research Councils, Industry and Government. In fact, each provided, more or less, a quarter of the lecturers. No locality can supply all the talent needed and we failed to locate a materials handling expert. Since the handling of materials adds much to the cost of production and nothing to the value of the goods, the subject deserved a thorough treatment. Accordingly, we hired the services of an expert and quickly realized that the money was a true investment. His advice to one company alone, on their own testimonial, was worth more than 50 times the entire cost of the seminar.

Encouraged by the results of the program, and the fact that we now had money in the bank, we embarked on a second program in 1960-61. Two series of lectures were again attempted, a combined introductory course for junior management and foremen and a "second-year" course for management, which will be supplemented by full-time seminars.

Description of the Course

Details of the 1960-61 courses and lecturers are given in Appendix I.

An industry is a complex of land, buildings, machines and tools, raw material and people. It is manipulated and controlled by management to produce goods or services, and in so doing, profits. Management may use any technique, provided it does not break federal and provincial law to achieve these results. Perhaps the first function of a productivity course, therefore, is to teach management techniques. Productivity is in many respects a measure of industrial efficiency. Quite obviously maximum efficiency will only be achieved when all the components of the industrial machine are individually working at maximum efficiency. This thought indicates the scope of a productivity program, which must, to be effective, consider all the components which collectively become a factory. Prof. L. W. Mathew in his pamphlet, *Productivity Measurements as an Aid to Management* defines the index of productivity as the product of technical efficiency and worker effectiveness. Technical efficiency is the ratio of the target time for a particular job to the time currently allowed. Management controls all of the factors which influence target time. For example, management decides on the design of the product, the choice of the raw material, the method by which it will be made, the type of machine or tools to be used, the determination of the economic lot size, measures for reducing the work content of the product and the work content of the process. The same authority defines worker effectiveness as the ratio of time currently allowed to the time actually taken. Productivity, or at least the aspect of productivity with which we were concerned is then, the ratio of target time to the time actually taken, which is, of course, a pure number.

Our productivity program, therefore, endeavoured to demonstrate how each element in a factory or any other business enterprise might be used more efficiently. To be worthy of its name it had to:

i. Acquaint management at all levels, of applying and using analytical techniques;

ii. Show management how to apply these techniques to industrial management problems, e.g. design, process and inventory control;

iii. Give management an opportunity to exercise and increase its talents, e.g. management games;

iv. Teach people to direct and work with other people;

v. Have the active support of, at least, the business community and the educational institutions.

We started our course with the study of the individual person influenced undoubtedly by the philosopher who said that the proper study of mankind is man. His mental attributes were described and discussed by a psychologist and his physical characteristics were similarly treated by an industrial health specialist. Following this introduction, the problems of providing the optimum physical environment were solved for the group by engineers. The appraisal of labour and means of increasing the individual's abilities were discussed by personnel specialists. The ultimate goal of this section of the course was to make labor more effective and some considerable time was spent on the satisfactions, other than wages, which we all expect from work. However, take-home-pay is still the greatest incentive in the majority of cases, and our program should have dealt with piece rates and incentive schemes. Until there is demonstrated competence in the field of work measurement, this subject will not be discussed. At our present rate of progress we are still a year or two away from even this minor goal.

The second major area of discussion was work study, which was divided quite conventionally into method study and work measurement. Method study should reveal inefficiency in design, methods of manufacture, and plant layout, while work measurement should reveal the ineffective use of time. In order to give the class some practice in these techniques, some simple operations were filmed in a highly successful local plant. It was very interesting to hear students express their confidence in their ability to increase productivity four fold in these filmed operations. At the same time we emphasized that productivity was equally important and equally measurable in the office, store and warehouse, and have dealt specifically with office productivity.

The third portion of the program was a number of lectures to improve personal skills. The first of these was the increase of reading speed and the improvement of comprehension. Such an ability allows the executive to produce more daily. Management requires to know something of law, especially contracts and trade union law. Aspirants to management positions must be trained and training schemes were discussed. The role of communications and advertising in business were taught by social scientists and advertising executives. Finally, the increasing role of mathematics in modern business was demonstrated by lectures on inventory control, work sampling and operations research.

Although the program was reasonably broad, there were very obvious gaps. This year's program is being supplemented by full-time seminars on labour relations, management games and materials handling.

What has been achieved is a matter of conjecture. Most certainly no plant in Saskatchewan has ever measured its productivity, as defined here, before or after the course and so there is no nice set of results to present. However, there are reports that methods are improving and it is assumed that there is a corresponding increase in productivity. Some of the improvements in methods have been observed.

In retrospect, I think the interesting portion of the experiment, and it is officially a pilot experiment, has been the attempt to apply a fairly large portion of the whole human knowledge to the task of increasing industrial efficiency to demonstrate that increased productivity starts with the president and then considering its effect upon the company, the individual and the community. Much remains to be done especially the work which might be termed research. Particularly, we must discover what the application of the newer sciences, e.g. control theory, cybernetics, ergonomics, and improved industrial design techniques can do for Saskatchewan industry. More emphasis must be given to management training and organization. Ultimately, we may hope to contribute to the optimum design of a plant to operate under Saskatchewan conditions. There are reasonable grounds for assuming that it will not be an exact replica of competitive plants in other areas.

Undoubtedly we tried to do too much too quickly. This was justified by economic conditions and the willingness of local people to take part in the program. Management, itself, was not so ready and has co-operated only by sending junior management to the courses.

Having said something of the past, it would be appropriate although perhaps hazardous to speculate on the future. I believe it is being demonstrated that the maintenance and improvement of our economic status depends upon our rate of scientific discovery and the subsequent successful commercial explcitation of these discoveries. We have substantial, though very probably not adequate investment in pure and applied research. It is now time to consider the establishment of some institution to conduct research into the means of, and problems of, production. This need is illustrated by our use of the intrinsically variable unit, the man hour, to measure human effort and our lack of knowledge of human fatigue, whether it is imaginary or real and how it may be conveniently measured. The technical committee of NATO has suggested that the first area of investigation should be machine tools. If farm machines are machine tools, we have a large and immediate area of investigation in our own province.

For these, and similar reasons, I welcome the formation of the National Productivity Council. Alone it cannot solve our problems, and there must be an honest desire by both management and labor to examine problems critically and adopt the logical solutions which critical analysis will reveal. At the same time, Government must maintain a favorable economic and industrial climate.

Our future efforts will undoubtedly be greatly influenced by the activities of the National Productivity Council with whom we shall co-operate whole-heartedly. I am sure I speak for many when I ask that the Council should make a full declaration of policy as soon as it possibly can.

APPENDIX I

Advanced Management Lectures	
Work Study I	I. S. Evans, Sask. Research Council
Psychology and Human Relations	Dr. F. E. Coburn, psychologist at the University Hospital in Saskatoon.
Work Study II	I. S. Evans
Communications	Prof. P. K. Walmsley, College of Commerce, University of Saskatchewan.
Leadership and Management Techniques	J. Cunningham, Hudson's Bay Co.
Operations Research	J. C. Clapham, British Columbia Research Council
Contracts	Prof. D. H. Bonham, Special Lecturer in Accounting, University of Saskatchewan.
Work Study III	I. S. Evans
Union Law	G. J. D. Taylor, barrister
Faster Reading (3 lectures)	Prof. A. F. Deverell, College of Education, University of Saskatchewan
Advertising and Public Relations	L. Edwards and C. Bourassa, C.F.Q.C.-T.V. News Editor and Sales Manager
Work Study IV	I. S. Evans
Work Study Lab.	I. S. Evans
Work Study Lab.	I. S. Evans
Combined Introductory Lectures	
Method Study	I. S. Evans
Health and Productivity	Dr. N. Williams, Director, Occupational Health Branch, Provincial Dept. of Public Health
Financial Controls	Prof. J. S. M. Allely, College of Commerce, University of Saskatchewan
Plant Conditions	A. D. Scharf, Saskatchewan Research Council
Accounting	Prof. S. Laimon, College of Commerce, University of Saskatchewan
Communications	Dr. H. Cooperstock, Federated Co-operatives Ltd. Director of Research
Motivation and Personnel Management	Dr. F. E. Coburn
Personnel Selection	D. Thomas, Federated Co-operatives Ltd.
Work Measurement	I. S. Evans
Faster Reading (3 lectures)	Prof. A. F. Deverell
Office Productivity	K. S. Orr, Provincial Department of Public Works
Work Sampling	T. Tribe, Imperial Oil Ltd.—Regina
Work Study Lab.	I. S. Evans
Work Study Lab.	I. S. Evans.

The Production, Handling and Uses of
TONNAGE OXYGEN BY COMINCO

C. H. Simpkinson,
Assistant Superintendent of Development Research, Chemicals and Fertilizers Division, The Consolidated Mining and Smelting Company of Canada Limited

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

IN THE period since the Second World War the production of oxygen for use in metallurgical and chemical processes has become an important operation the world over.

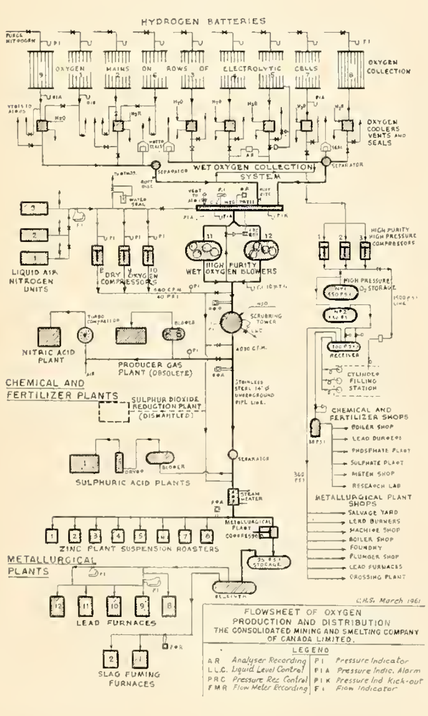
The development of Linde Fränkl air liquefaction units was the improvement which made the industrial use of oxygen economically attractive. These plants were built on-site and produced large volumes of low grade oxygen (averaging 95% O_2) at a low cost. It became known as "tonnage oxygen".

The increased benefits of very pure oxygen are now recognized and the trend in the newer plants is towards more costly equipment to make gas of 99.5% purity. The name "tonnage oxygen" is still in general use but it is no longer indicative of grade or cost—hence it is in disfavour.

The total production of oxygen in the United States is estimated at 80 billion cu. ft. per year, half of which is now high purity oxygen.[1]

The Consolidated Mining and Smelting Company of Canada Limited (Cominco) at Trail, B.C. entered the chemical fertilizer field in 1931 at which time production of ammonia was a prime objective. An electrolytic plant was built for the generation of hydrogen from water and a Claude air liquefaction plant was installed to obtain nitrogen from the air. In both these plants oxygen was an important by-product.

Fig. 1.



The production of oxygen at Cominco today is about 2½ billion cu. ft. per year, most of which is high purity gas. The utilization of oxygen has been a step-by-step development which has taken place over the years without great publicity, since the advances have been looked upon more as a matter of preventing waste than productive utilization.

This paper represents a semi-technical narrative of how Cominco has developed very worthwhile uses for a by-product material that might otherwise have been wasted.

Uses of Oxygen

A survey of the market for oxygen in 1931, when it became available at Trail, showed that the new supply was 3½ times the annual Canadian consumption, but because of transportation difficulties the possibility of selling oxygen was ruled out. The natural solution to this disposal problem was the development of in-plant uses.

The only consumers of oxygen, at Trail in 1931, were the maintenance shops where oxyhydrogen torches were used for cutting steel plate, and the smelter where oxygen lances were employed for opening stubborn tapholes in the lead furnaces and the drossing kettles. These demands were easily filled, but the main volume of oxygen from the new plants was wasted until 1936. In that year a process to recover elemental sulphur from metallurgical gases was put into full scale operation. A key step in this process was the use of 400 c.f.m. of dry oxygen available from the nitrogen units. This gas was mixed with sulphur dioxide and fed to a modified coke gas producer in which the SO_2 was reduced to sulphur. The oxygen reacted with a portion of the coke and produced heat to maintain the temperature of the furnace. Operation of this plant was discontinued in 1943, when all the SO_2 was in demand for acid production.

In 1937 the oversupply of oxygen was further increased by the expansion of the electrolytic hydrogen plant. In view of this, and considering the experience with oxygen in the sulphur reduction furnaces, it was decided to enrich the air supply to the zinc sulphide suspension roasters with 2000 c.f.m. of the oxygen. Again the results were good. The oxygen improved the performance of the roaster and gave a more completely oxidized calcine which resulted in a higher recovery of zinc in the metallurgical process. A more rapid sulphur removal rate from the calcine was realized and thus the plant capacity was increased.[2] The enriched air had a lower nitrogen content which increased the strength of SO_2 discharged from the roasters. This in turn improved the performance of the sulphuric acid plants.

The next development in the use of oxygen as an industrial chemical came in 1942 when water gas producers were installed to provide synthesis gas for an ammonia expansion programme. The producers were operated with coke as a fuel and were blown with a steady air-oxygen-steam blast instead of the customary air blow followed by a steam blow repeating every few minutes. With oxygen, combustion was vigorous and temperatures were sustained in spite of the damping effect of the steam. As a result continuous operation was possible and a steady flow of ammonia synthesis gas was produced. At times when the nitrogen supply was sufficient from other plants, the producers were operated on coke, with a blast of pure oxygen and steam. Under these conditions a flow of pure hydrogen was provided.[3] The water gas producer plant has since become outmoded and shut down.

In 1944 a new use for oxygen was devloped in sulphuric acid manufacture. Previously a system of absorbing low concentrations of sulphur dioxide from smelter gases had been worked out at Trail, yielding a considerable volume of pure sulphur dioxide. It was found that a stoichiometric mixture of pure sulphur dioxide and oxygen could be fed to a standard acid plant with very satisfactory results. The oxidation of SO_2 to SO_3 was very rapid as it cycled over the catalyst. A converter designed normally for 35 tons per day of sulphuric acid was made to produce 200 tons per day.[4]

In the nitric acid plant, oxygen has been found useful in enriching the air that is used for the reaction with ammonia to produce nitric oxide. The reaction takes place over a platinum gauze catalyst at 900°C. The nitric oxide first formed, is oxidized to nitrogen peroxide and then dissolved in water. With oxygen enrichment, the dilution effect of the atmospheric nitrogen is reduced and the efficiency of the process is increased from a normal 91.6% to 92.4%.

The most recent developments in the use of oxygen have been in the lead smelter. Experiments conducted since 1947 have shown that, in the operation of both the blast furnaces and the slag retreatment furnaces the addition of oxygen to the tuyere air is beneficial. In the former case the advantages claimed are increased furnace capacity, fuel saving and trouble-free operation. In the latter case, oxygen assists the melting of cold slag and increases the rate of elimination of zinc.[2] These metallurgical uses for oxygen have become the most important at Trail.

As the demand for oxygen began to overtake the supply, a system of priorities was drawn up based on the value of oxygen to the various plants. On top of the list was the cyclic sulphuric acid plant and the coke producer gas plant, for without oxygen these could not operate. The remaining plants were graded according to economics. The order of priority in 1960 was: lead blast furnaces, slag retreatment furnaces, zinc roaster and nitric acid plant.

In spite of a fivefold increase in oxygen at Trail since 1931 its use has gained steadily and consumption to-

Fig. 2. Electrolytic Gas Cell Room. Shows typical arrangement of cells with oxygen and hydrogen row mains leading gases to coolers at the far end of the batteries. Hose connections in foreground are nitrogen supply lines for purging purposes.

day (with oxygen withheld from the nitric acid plant), equals production.

Producing Plants

The large tonnage of high purity oxygen made by electrolysis of water is a distinguishing feature of the Trail plant. The gas from the air liquefaction (nitrogen) units makes up only one-seventh of the total volume. In Cominco operations the two types are known as "wet" and "dry" oxygen rather than high purity and low purity, which latter terms are better understood in the industry.

The three Claude liquid air units which produce the dry oxygen were purchased. The principle on which these operate is well known. Air is compressed to 300 p.s.i.g., cleaned, purified and dried. Next it is precooled and filtered through packed cotton waste to remove oil and any solids. The air flow is split into two streams—in one, 30% is cooled and condensed to the liquid state by heat exchange with the cold out-coming gases; in the other, 70% is further cooled by means of an expansion engine. The streams are rejoined in the first rectification column, operating at 60 p.s.i., and there the temperature is controlled to give a crude separation of the nitrogen from the oxygen. Proceeding next to a second rectification column operating at 6 p.s.i. most of the nitrogen is obtained fairly pure but the oxygen is left with a high nitrogen impurity. After evaporation and warming up, the oxygen is piped in a 10 in. steel line to a central compressor house and makes up part of the supply to the metallurgical plants. Its purity ranges from 85% to 93% O_2 and it is completely dry.

The electrolytic hydrogen plant supplies the wet oxygen which results when water is electrolysed and broken up into its two elements, hydrogen and oxygen. The process is a large consumer of power requiring 78,500 kw. for its operation. The 3229 cells installed are arranged in series in nine batteries each operating with an electric current which varies from battery to battery, and ranges between 10,000 amp. at 670 v. and 16,000 amp. at 830 v. The cells are small mild steel tanks holding electrolyte composed of 28% potassium hydroxide solution, in which electrodes with their diaphragms are suspended from a top. The top is a concrete structure which supports the whole internal assembly, acts as a cell cover and contains separate collecting chambers for the hydrogen and oxygen.[5] With the passage of current the water of solution is decomposed and the hydrogen and oxygen rise from the cathodes and anodes respectively. The diaphragms which hang between the electrodes prevent mixing and conduct the gases to their separate collecting chambers.

Present Oxygen Production

		Tons/Day	*C.F.M.*
Oxygen from electrolytic plant		275	4280
Oxygen from air liquefaction		41	640
	Total	316	4920

Present Oxygen Consumption

	C.F.M.
Oxygen to sulphuric acid plant	500
Oxygen to zinc plant roasters	2300
Oxygen to slag retreatment	30
Oxygen to lead blast furnaces	1816
Oxygen to shops and cylinders	24
Oxygen wasted (unknown loss)	250
Total	4920

The main reason for operating the plant is to produce hydrogen, and every effort is made to ensure a pure product—99.9% or better. One result of this is that the oxygen purity is sacrificed purposely by keeping its pressure lower than that of the hydrogen so that if there are any imperfections in the cell which allow leakage of one gas into the other, it will always be from the hydrogen side to the oxygen side rather than in the reverse direction. The purity of the oxygen produced normally averages 99.5% O_2 and 0.5 H_2. An abnormal condition in a cell will usually cause its oxygen purity to drop, in which event the rest of the oxygen downstream in the battery main, and perhaps as far as the plant main will be affected. Because of this a regular schedule for oxygen analyses is maintained and comprises an imporant check on the performance of the battery and the plant.

The Problem of Gas Collection

At the point of origin of the hydrogen and oxygen in the electrolyte cell the two gases are separated by a porous asbestos cloth. This diaphragm when wetted with electrolyte is an effective barrier, providing differential pressures are kept low—not higher than an inch of water. This limit on pressure difference imposes an exacting restriction under which the two gas collecting systems must work. Controls must be such that the gas produced, and the gas withdrawn are exactly in balance at all times, The normal chemical engineering practice in situations such as this, is to provide a surge vessel of some sort but the low operating pressure of tank type hydrogen cells, 2½ in. of water, is not enough to inflate a gas holder.

Electrolytic High Purity or Wet Oxygen Collection System

The complete oxygen collection and distribution systems are shown in Fig. 1 and it will be seen that the electrolytic plant section is by far the more complex. Oxygen from the cells is collected in a parallel system to that for hydrogen (see Fig. 2). It passes down the row mains, which are formed of interconnected lengths of Transite pipe (for electrical insulation between cells), into the collecting mains (see Fig. 3). It is then led in mild steel pipes through water coolers to the battery headers and finally out by the plant header to the compressor house.

A rule followed in the collection of both the hydrogen and oxygen is that at no time must the system be placed under suction. This means that the 2½ in. of water pressure of the cells must deliver the oxygen to the inlet of the distributing blower. The sizing of the pipes is therefore important. The Transite sections along the cells start at a 4 in. size, change to 5 in. then connect to 12 or 14 in. mild steel battery mains, which lead the oxygen through the coolers. The main plant header, which receives the gas from the batteries, has two branches each 24 in. in diameter and these connect to a section of 36 in. pipe 14 ft. long, which is the blower suction header in the compressor house (to be described later). The pressure at this point is maintained at 0.20 in. of water by an automatic controller.

Operating Variables

Since the production of oxygen is a side-line to the generation of hydrogen, it is affected by all changes that occur or are made to alter the flow of hydrogen. These quite often come suddenly, so the oxygen system must be designed to adapt itself to the changes on very short notice, otherwise pressures at the cells would get seriously out of balance. The main control of abnormal flow or pressure situations lies in the distributing compressor room, but positive action can be taken in the plant by venting batteries to air or by blowing of relief valves.

The quality of oxygen is kept under close surveillance for two reasons: one as check on cell operation (mentioned before), and the other to ensure that safe gas is passed to the consuming plants. Since hydrogen is the main impurity, gas analysis is done with a combustion apparatus. The tests are made manually, except at two key points on the mains where Leeds Northrup continuous analysers are installed.

Characteristics of Electrolytic Oxygen

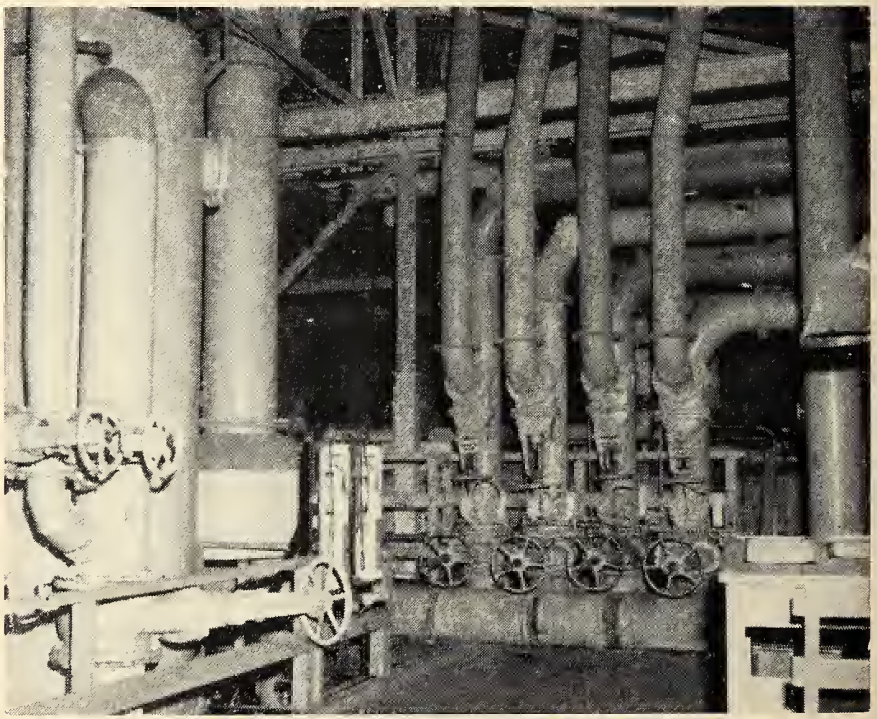
The major impurity in oxygen from electrolytic cells is hydrogen, although nitrogen can enter if the purge valves on the row mains leak. Oxygen as produced is saturated with water vapour, but this is not a harmful impurity in the final product, as its concentration is greatly reduced by condensation in the coolers, mains, separators and compressors. With the plant at full load approximately 12 g.p.m. of condensate is collected from the system and returned to the cells as feed water.

As the oxygen bubbles break from the surface of the electrolyte inside the cells a potassium hydroxide mist is formed. This fine suspension, once entrained in the oxygen is difficult to separate completely. The condensate naturally carries a lot of it out, but a thorough scrubbing after compression is necessary to eliminate the major portion. A slight trace of alkalinity remains with the oxygen until it is used, but fortunately this is beneficial, being an inhibitor of corrosion for steel.

Compressor Arrangement

The compression of all the oxygen prior to distribution to the consumers is carried out in a central compressor

Fig. 3. Oxygen Collection Piping. The picture shows the collecting mains leading gases towards the tube and shell water cooler on left. Manual battery isolation valves and vents centre. Gas analysis station centre with bell-shaped water-sealed pressure relief apparatus behind.



house. The mains from the hydrogen plant and the nitrogen units come together here, but the gases are not mixed, under normal circumstances, each being handled separately.

The compressor installation comprises machines of three different makes and sizes (see Figs. 4 and 5). The reason for this is that some consumers require oxygen at different pressures and others want only the high purity gas. Details of the compressor banks are shown in Table 1.

Low Pressure High Purity (Wet Oxygen) Distribution System

The main flow of high purity oxygen from the hydrogen plant is handled by two Roots Connersville blowers Nos. 11 and 12. These machines aspirate the gas from the 36 in. header but are closely controlled, both manually and by instrument, to keep the header pressure at 0.20 in. of water. To do this, speeds of the blowers are adjusted by the operator according to the approximate load to be handled, while a Foxboro recording flow controller (No. R83) automatically operates a valve to bypass oxygen around the machines to hold the suction pressure at a pre-set point.

Should some major upset suddenly occur in the system, which the controllers cannot cope with, then there are a number of safeguards which go into operation to protect the cells. Slightly too much suction will sound an alarm, and if this condition grows worse the blowers will automatically shut down—one at a time. An alarm sounds when pressures increase and should this rise to 1¾ in. of water, relief seals on the mains blow. If a situation arises where the compressor room operator sees that fast emergency action is necessary, he may open a valve manually and vent the whole collection system to air.

The Roots Connersville blowers raise the pressure on the oxygen to 10 p.s.i.g., which is sufficient to pass it through the caustic mist scrubber and distribute it to consumers' plants. The scrubber is a 6 ft. diam. copper tower 37 ft. high fitted with 20 plates of bubble caps. The gas flows upward against a downward stream of 1 g.p.m. of distilled water, which picks up about 1000 lb. of potassium hydroxide per month.

The clean oxygen from the top of the tower is conducted away to the chemical plants in a 10 in. steel underground line about 1000 ft. long, and to the metallurgical plants by a 14 in. stainless steel (Type 347) underground line 5000 ft. long. Mild steel undeground oxygen lines have been found to have a life of only 10 years, thus stainless steel is used where permanence is required. Corrosion by acid soil from the outside is the main cause of failure. The lines are buried, where practical, to avoid frost conditions in the winter. In exposed lines the very high moisture content of electrolytic oxygen results in a rapid buildup of ice on the inside of the pipe. When a thaw comes this drops off and is carried along to a bend or other point of restriction where it piles up and plugs the line. Where outside wet oxygen lines have to be run above the ground they are provided with steam jacket heaters at points approximately 400 ft. apart.

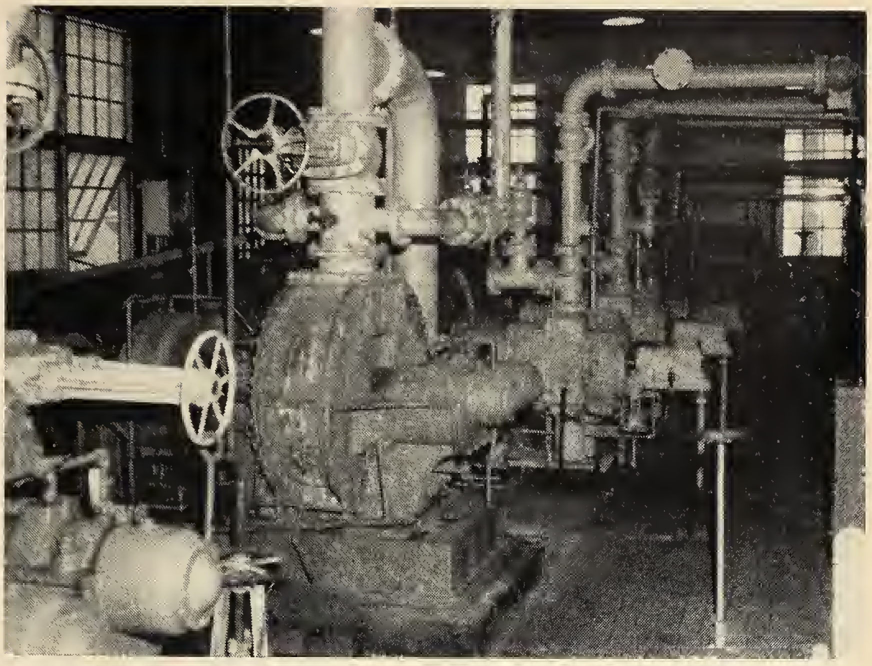


Fig. 4. Oxygen Compressor Room. Low pressure blowers in foreground. Dry oxygen compressors centre rear. Control panel on right.

Except for the zinc plant roasters and the nitric acid plant, consumers of oxygen require the gas at a higher pressure than is supplied by the low pressure system. Because of this, common practice is to have each consumer draw off the main with a compressor of his own. Details of the consumers' compressors are shown in Table 2.

Low Purity Oxygen Distribution System

The dry oxygen from the nitrogen units is handled by three reciprocating C.I.R. compressors, Nos. 8, 9 and 10. The gas discharges from the compressors under 40 p.s.i.g. and is made to bypass the scrubbing tower and run in a separate 4 in. overground steel line to the zinc roaster area and there to join the low pressure system. This arrangement keeps the high and low purity oxygen separate until after the point of offtake to the sulphuric acid plant, which requires the pure oxygen. The flow through the dry system averages 640 c.f.m. approximately.

High Pressure High Purity Oxygen Distribution

For oxyhydrogen welding and burning, a supply of high pressure hydrogen and oxygen are made available about the plants in pipes or in gas cylinders. The remarks in this section specifically cover only the oxygen side of this service, but the hydrogen is handled in a similar parallel system with minor modifications.

The high pressure oxygen is compressed by three Norwalk three-stage compressors which draw gas from the high purity main at a point well upstream from the junction with the dry oxygen, to make sure there is no mixing.

The compressors discharge at 550 p.s.i.g. into two 2500 cu. ft. (free gas) storage tanks which form a reservoir of high pressure high purity oxygen. The average flow handled daily by each of the three machines is 10 c.f.m.

There is a sporadic demand for oxygen at 1500 p.s.i.g. for filling special cylinders. For this service one of the compressors is isolated from the others and connected so that the gas passes through a small condensate trap and then goes directly to the cylinders.

The high pressure oxygen supplied to the consumers undergoes a series of pressure reductions. From the main storage it discharges to a small receiver, held at 300 p.s.i.g., which is the common take-off point of three distributing lines. These are:

a) A 1¼ in. line to the metallurgical shops operating at 300 p.s.i.g.
b) A ½ in. line to the cylinder

filling station operating at 300 p.s.i.g.

c) A 1 in. line to the chemicals and fertilizer shops operating at 80 p.s.i.g.

All consumers reduce pressures further at their outlets, to suit their particular apparatus.

Compressor Characteristics

The compression of oxygen is a specialized business in that the lubrication of the compressors cannot be done with oil. For low pressure work Roots Connersville machines have been adopted since they are designed with clearance enough to operate without oil. The shafts turning the lobes of the blowers have outboard bearings spaced away from the oxygen-containing compartment which is sealed off with packed glands. It was originally supposed that the pressurized oil lubricating system servicing the bearings and the gear box would not be a hazard. This supposition proved fallacious, however, when one day an explosion occurred in the base of the blowers where a large oil reservoir is located. An investigation brought out the reason. Usual safety precautions had stipulated that the few inches of exposed shaft between the stuffing boxes and the bearings be covered with a guard plate of solid metal bolted to the bearing housing. This had diverted a stream of oxygen leaking from a loose gland in such a manner that it impinged on the bearing housing. The jet had enough force to jump the gap, enter the housing, get into the oil system and displace the air above the oil bath. The mixture of oil mist and oxygen exploded spontaneously, or was ignited by a static spark. The cure for this trouble was to constantly displace the atmosphere above the oil bath with a flow of pure nitrogen from the purging supply maintained for the hydrogen plant.

The three compressors handling the dry oxygen are converted C.I.R. air compressors. The cylinders of these machines are each equipped with a tail rod on the piston which extends through the cylinder head and allows the weight of the piston assembly to be carried on an oil-lubricated outside bearing. After years of experimentation with material for piston rings in these machines a satisfactory one has been found in K30, a Teflon glass graphite self-lubricating composition. Previous to this, carbon rings running dry and bronze bearings lubricated with soap solution were used. La France carbon packing rings are used in the piston rod glands. The metal in the cylinders and pistons is cast iron.

The pressure on the discharge of the dry oxygen compressors is controlled and held at a constant level by means of an automatic cutout. This is a homemade accessory which consists of a 3 ft. x 12 in. diameter oxygen reservoir connected directly to a small cylinder and piston and indirectly to diaphragm chambers above the compressor inlet valves. When the oxygen pressure in the discharge header and the reservoir reaches a predetermined level the small piston moves upward to open a sleeve valve which allows oxygen to enter the diaphragm chambers. The movement of the diaphragms cause blocks to push against the inlet valves and hold them open. By means of weights placed on the piston it is possible to adjust its action to take place at various pressures.

The Norwalk high pressure compressors have been adapted for oxygen service by the substitution of water lubrication for oil and the installation of plastic piston rings. Distilled water is charged into a small tank above the machine and after pressurizing the water it is dribbled to the inlets of all cylinders.

The three stages of these machines have cast iron cylinders and pistons and these are fitted with rings as follows:

1st stage—wearing rings of Nylatron G S (a nylon plastic with molybdenum filling)
—piston rings of Nylatron G S with stainless steel expanders underneath

2nd stage—wearing rings of Nylatron G S
—piston rings of Nylatron G S with stainless steel expanders

3rd stage—all rings Nylon 101 plastic

Note: The expansion of plastics with heat is much greater than that of steel and it is very important that sufficient clearance be left for ring widening, thickening and lengthening. Forces sufficient to crack a piston can be generated if this is not done.

In flanged and threaded joints and glands around the oxygen system, both Teflon and asbestos are in common use for packing. The plastic ribbon dope Permacel also stands up well in the service. Litharge and glycrine are used where a permanent seal is required.

Corrosion

As stated previously the alkalinity of the oxygen produced from cells is beneficial in preventing corrosion of steel. In spite of the high moisture content, under normal conditions, a life of 30 years or more for mild steel can be expected.

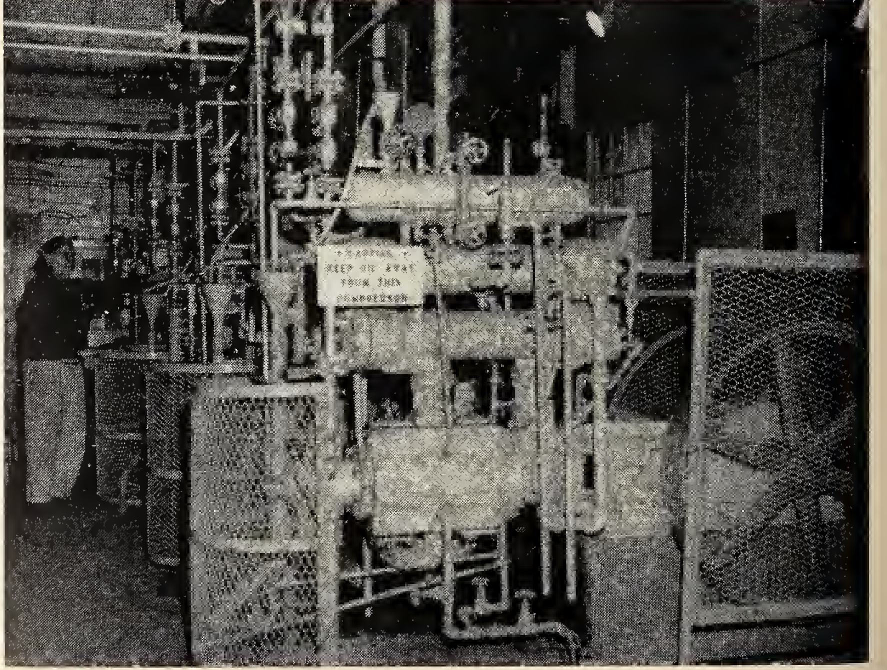
Copper was used in the scrubbing tower because corrosion of steel by distilled water was anticipated. This metal has given good service for 18 years to date.

Transite in the row mains is renewed only infrequently when it becomes impregnated with KOH and loses its electrical insulating properties.

Gas Cylinder Filling Station

The cylinder filling service is carried on in conjunction with the operation of the oxygen compressor station, but in a different room separated from the machines by a brick

Fig. 5. High Pressure Oxygen Compressor Room. Shows a view of one of the 3-stage machines equipped with pressurized water tank (top) for dispensing water to glands and cylinders.



wall, since there is some hazard involved. The construction of the room is such that there is good ventilation to atmosphere at floor and roof level. Wooden flooring is used, the material being easier on the bottoms of the steel cylinders, and it also provides a rough nonskid surface to prevent slipping which might cause a cylinder to strike something and be damaged.

While filling, the cylinders are placed in a special stall, the front of which enclosure is the brick wall of the compressor house, the sides are heavy steel barriers and the back is open. On the outside of one of the barriers are the guages and valves which the operator uses while controlling the filling. The stall holds three cylinders which can be filled at the same time, thus enabling one man to handle and fill 20 cylinders an hour. In the plant, provision is also made for filling hydrogen cylinders. To ensure against mix-ups, standard procedures are followed, for instance, the threads on the cylinders and the flexible filling hoses are right hand for oxygen and left hand for hydrogen. The oxygen cylinders are painted a light green in contrast to bright yellow used for hydrogen. The same distinguishing color scheme is used for all equipment and piping in the plants.

In Cominco's operations there are 140-300-p.s.i., 100 cu. ft. capacity cylinders in circulation. When these are returned for refilling it is required that enough pressure is left in each to allow a sample to be taken for gas analyses before refilling. With the normal cylinder the gas analysis is not taken after filling for it is assumed that the gas is pure (99.5% O_2) since it has been checked each 15 minutes as it discharges to storage from the high pressure compressors. These analyses are made alternately by absorption to detect nitrogen impurity and by combustion to detect hydrogen.

Table 1.
Oxygen Blowers and Compressors Primary Distribution

	*Wet Oxygen Distribution High Purity Gas**	*Dry Oxygen Distribution Low Purity Gas†*	*High Pressure Oxygen Distribution High Purity Gas‡*
Number of Machines	2	3	3
Plant Number	11 and 12	8, 9 and 10	1, 2 and 3
Type of Machines	Blowers	Single stage double acting compressors.	Three-stage horizontal compressors. 1st stage double acting.
Make	Roots Connersville Blower Corp., Ind.	Canadian Ingersoll Rand	Norwalk Company Incorp., S. Norwalk, Conn.
Size	20 in. x 12 in.	14 in. stroke 11 in. diam.	1st—6 in. 2nd—3 7/16 in. 3rd—1¾ in.
Design Pressure	12½ p.s.i.g.	90 p.s.i.g.	1st—50 p.s.i.g. 2nd—200 p.s.i.g. 3rd—1800 p.s.i.g.
Rated Capacity	3500 c.f.m. each	250 c.f.m. each at 175 r.p.m.	12 c.f.m. each at 127 r.p.m.
Working Pressure	10 p.s.i.g.	40 p.s.i.g.	1st—65 to 75 p.s.i.g. 2nd—215 to 275 p.s.i.g. 3rd—500 to 1500 p.s.i.g.
Lubricating	Rorots—none. Bearings—oil.	Cylinders—none. Crankcase—oil.	Cylinders—distilled water. Crankcase—oil.
Horsepower Motor	250 each	50 each	5 each

Miscellaneous information:

*Gland packing, asbestos. Nitrogen atmosphere over oil bath. Bypass valve to control pressure. Cast iron construction throughout.

†Equipped with small pressure reservoir operating mechanical cutout on inlet valve for pressure control. Outboard bearing for piston tail rod. Cylinders—cast iron. Pistons—cast iron. Rings—K30 (Teflon glass graphite composition).

‡Pressurized reservoir for lubricating water. Cylinders—cast iron. Piston rods—steel. Pistons—cast iron. Rings—Nylatron GS and Nylon 101.

Oxygen, a Hazard

Being a gas so necessary for the sustenance of life it is unnatural to look upon oxygen as a dangerous gas. Yet experience gained in handling the material leaves no doubt that there is a serious hazard involved. Aside from the formation of explosive mixtures with other gases, oxygen in the atmosphere in concentrations greater than 21% increases the violence of combustion of many common materials to a surprising degree. Fire in the clothing of men working unsuspectingly in an oxygen-enriched atmosphere has proved to be the most insidious of the accidents that have happened.[6]

In an attempt to prevent mishaps wherever oxygen is handled, Cominco's Pressure Vessels Committee and Safety Departments have drawn up a set of rules which apply throughout all operations.

Conclusion

Oxygen, produced originally as a waste gas incidental to the manufacture of ammonia, is now put to profitable use in other Cominco plants. The development has come slowly over a period of years as new applications were discovered.

Acknowledgements

In preparing this paper the author acknowledges the assistance of various members of the technical staff of Cominco, particularly Messrs. E. C. Phillips, S. C. Ross, D. Dolgoy and W. McCulloch.

Table 2.
Oxygen Blower and Compressor Consuming Plants

	*No. 1 Acid Plant**	*Smelter Distribution†*
Number of Machines	one	one
Plant Number	No. 1	No. 1
Type of Machine	Blower	One side of twin cylinder double acting air compressor.
Make	Roots Connversville Blower Corp.	Canadian Ingersoll Rand.
Size	10 in. x 24 in.	26 in. diam. 24 in. stroke 130 r.p.m.
Design Pressure	5 p.s.i.g.	30 p.s.i.g.
Working Pressure	5 p.s.i.g.	25 p.s.i.g.
Rated Capacity	1000 c.f.m.	1600 c.f.m.
Lubrication	None	Cylinder and glands—water detergent sol. (tergitol).
Horsepower of Motor	35	300/2 each twin cylinder.

Miscellaneous Information:

*No changes.

†Cylinder moved away from crosshead housing. Piston rod lengthened 22 in. Oil wiper gland installed on rod. Cast iron piston exchanged for aluminum with bronze rings.

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Canadian Developments

"Crossroads", an Industrial Estate

A major industrial development has been designed to allow 20 plants to operate at peak efficiency in a pleasantly landscaped setting. Functional efficiency and visual design harmony will be combined in one of the first attempts in North America to provide plant sites which will preserve both prestige and value.

The site is a 126-acre tract only 20 minutes from downtown Toronto and six minutes from Malton Airport. Residential and recreational facilities for management and employees of the industries are adjacent, in suburban Etobicoke.

All buildings in the Estate will be reviewed architecturally to ensure compatibility of external colour and design without sacrificing the individuality of each plant. Parking bays will be screened from view, overhead wiring clear of main boulevards.

Natural gas, hydro, water, sewers and paved roads are already in. The first building, a public curling rink, is nearing completion. C.P.R. Piggyback spur lines are in, a truck bonded warehouse is only a block away and Toronto Harbor is only 15 minutes from "Crossroads".

Complete shopping facilities for future employees (expected to total about 1200 in the 20 plants) are available in the Cloverdale Mall at the intersection of Highways 27 and 5. Residential areas are within 10 min. by car. Clubs, hotels, golf courses and other amenities are close at hand.

"Crossroads" site showing plant locations and relationship to highways.

Canada and USA to study increased Power Potential at Niagara River

The Canadian and United States governments have been asked by Ontario Hydro and the Power Authority of the State of New York to study the possibility of, and to make experiments in, increasing the diversion of water from the Niagara River for power production. The request has been referred to the International Joint Commission by the two governments.

The proposal was made after extensive tests using Hydro's large hydraulic model of Niagara Falls and aerial photographs indicated that additional water could be diverted without detracting from the beauty of the Falls. This same model was used for studies which resulted in measures to increase the flow over the flanks of the Falls in the early 1950's, enhancing the beauty of the cataract.

The amount of the additional diversion to be requested will not be decided until current studies are completed to determine how much water is necessary to preserve the appearance of the Falls. Any modification in the diversion of water would require an agreement between the Canadian and American governments. The 1950 Niagara Treaty between Canada and the United States established a minimum flow of 100,000 c.f.s. between 8 a.m. and 10 p.m. EST from April 1 to Sept. 15. From Sept. 15 to Oct. 31 the flow must be maintained at 100,000 c.f.s. between 8 a.m. and 8 p.m. EST. The minimum at other times is 50,000.

Regulations governing the flow over Niagara Falls which were incorporated into the 1950 treaty were based largely upon a report made in 1929 on the preservation of the Falls. This report was made by a special international Niagara Board consisting of prominent engineers representing both countries. Since that time, scientific tests on the specially-constructed hydraulic model and experience gained in the operation of hydro-electric plants on the river, have added a great deal of new information about Niagara flows.

In addition, remedial works, including excavation at the flanks of the Falls and construction of a control dam above the Falls, have greatly improved the distribution of flow along the crestline of the American Falls and Horseshoe Falls and reduced erosion in their centre. A five-gate extension to the dam, costing $7 million, is currently under construction.

If approved, the proposal would enable Ontario Hydro and the Power Authority of the State of New York to generate low-cost power from water now being wasted. Since this water is the last major source of undeveloped hydro-electric power in Southern Ontario or Northern New York, the alternative is the development of more expensive sources of power, which would eventually raise the cost of electricity to the ultimate customer.

An Ontario Hydro spokesman said the proposed plan would result in savings to the consumers of electric power in Ontario of approximately $3 million a year, which would assist in keeping rates to customers low. He emphasized that neither Hydro nor the Power Authority of the State of New York have any intention of taking any action which would detract from the appearance of Niagara Falls. From the beginning of Ontario Hydro developments at Niagara in 1917, the Commission has worked closely with local authorities to enhance the beauty of the Niagara area as an attraction for visitors.

Bridge for Peace River Power Damsite Slated for completion early in 1962

Construction has started on a $300,000 temporary bridge to span the Peace River canyon a mile or so upstream from the projected Peace River Power damsite. The contract was given Western Bridge by B.C. Electric Co. Ltd. The damsite is approximately 16 miles west of Hudson Hope.

The Western Bridge contraet covers the design, fabrication, erection of steel superstructure as well as construction of piers, abutments and approaches.

The bridge, designed as a temporary structure for heavy construction traffic, will be a two-pin arch deck span, 510 feet long and 18 feet wide, to accommodate single lane traffic and a walkway 120 feet above water. A notable feature of the structure is that, after completion of the dam construction, it is to be disassembled and the components re-used as permanent short-span bridges in the area. Despite severe weather conditions anticipated, it is planned to have the structure ready for traffic in February, 1962. EIC imum compressive strength of 5000 p.s.i. for girders and diaphragms and 4000 p.s.i. for the deck slab and contains 4% of entrained air.

Manufacturing and erection: The precasting plant is equipped with 18 casting beds and four sets of removable steel lined plywood forms.

Prestressing cables and ducts are fixed at predetermined locations to tack-welded reinforcing steel cages which are then picked up with a gantry crane travelling on rails, and installed on the casting beds on plastic chairs. The removable sides are then assembled and concrete is placed and vibrated.

The manufacturing is organized on the basis of two girders per day, in a nine hours per day—five days per week operation. Prestressing is applied when the concrete has reached a strength of 4200 p.s.i. and cable ducts are grouted after prestressing.

Each 80 ton girder is lifted by means of the travelling gantry crane and placed on two dollies of which one is self-propelled. These dollies, also travelling on rails, deliver the girders to the erection site.

A truss launching bridge, travelling on rails in a direction transversal to the bridge can then place each girder in the prescribed location. Transversal diaphragms are then formed and the concrete placed. After completion of the transversal prestressing the deck is formed with the use of ¾ in. plastic coated plywood forms, and reinforcement and concrete for the deck are placed. All the lifting machinery is equipped with specially designed hydraulic jacks.

Sections 5 and 7-A

Structural: The prestressed concrete superstructure is supported on piers built by the same contractors.

Section 5 comprises 40 spans of 176 ft. 4 in. each including seven prestressed concrete girders. 7-A has four spans 176 ft. 4 in. long and two spans 168 ft. 8 in. long. These six spans also include seven prestressed concrete girders each. The contract covers the manufacturing and erection of a total of 322 girders for the 46 spans, or 308 girders 176 ft. 4 in. long and 14 girders 168 ft. 8 in. long. It also includes the building of four prestressed concrete diaphragms per span and of an 8½ in. prestressed concrete deck slab. This slab is composed of the upper flanges of the girders with slab strips built between the flanges.

Each girder is resting on two STUP type, triple Neoprene-stainless steel bearing plates.

The I-shaped girders are approximately 10 ft. deep with a top flange 5 ft. 9 in. wide, a bottom flange or heel 3 ft. 3 in. wide and a 7 in. thick web. All these girders are manufactured in a precasting yard on Nuns' Island and are prestressed with cables. Each cable is made of 12 — 0.276 in. diam. wires and supplies a prestressing force of about 40 tons after deduction of all losses. Girders 176 ft. 4 in. long have 24 prestressing cables, while the 168 ft. 8 in. girders have only 22 cables.

As a first step in the girder prestressing operation, 14 cables are tensioned after concrete has reached a strength of 3,500 p.s.i. The girders are then moved to a storage yard on Nuns' Island.

The second prestressing step takes place when concrete has reached a compressive strength of 4000 p.s.i.

Six more cables in the case of 176 ft. 4 in. girders are tensioned and the ducts of all tensioned cables are grouted. The girders are now ready to be moved to the erection site. Only four cables are tensioned in this second step of prestressing with 168 ft. 8 in. girders.

The third step of the prestressing takes place after the girders have been placed in their final location and the building of the diaphragms and deck-slab strips completed. The remaining four cables are then tensioned and the cable ducts grouted.

During the manufacturing process, parts of the future transversal diaphragms are cast with the girders.

Once the girders are installed in their final location on 12 ft. 2½ in. centres, the remaining 6 ft. deep parts of the diaphragms are formed and held ready for concreting. Two diaphragms are located at the supports, each including one prestressing cable transversal to the bridge. Two other diaphragms, with five transversal prestressing cables, are located near the third points of the girders.

Six deck-slab strips 8½ in. thick are formed between the top flanges of the seven girders of a span. Concrete for the deck-slab strips and the diaphragms is then placed. The combined deck-slab will be prestressed transversally to the bridge with 54 cables for the 176 ft. 4 in. spans and 52 cables for the 168 ft. 8 in. spans.

Approximately 1/3 of the transversal cables in the deck and 2/3 in the diaphragms are tensioned on the day following the placing of concrete in order to allow for girders of the next spans to be shipped across the deck. The remaining transversal cables are tensioned later.

An asphalt topping 1½ in. thick will be placed on the deck at a later stage in order to protect the concrete and also to act as a wearing surface for the roadways. Prestressing steel has a minimum ultimate tensile strength of 235,000 p.s.i.

Portland cement concrete has a minimum compressive strength of 5000 p.s.i. for prestressed concrete and contains a minimum of 4% entrained air.

Manufacturing and Erection: The manufacturing of the girders takes place in a precasting yard on Nuns' Island which is equipped with eight steel casting beds and four sets of steel side forms. The production is organized on the basis of 14 girders per week with a basic 10 hour shift per day, five days a week.

Fig. 2. Part of section three south of Nuns' Island.

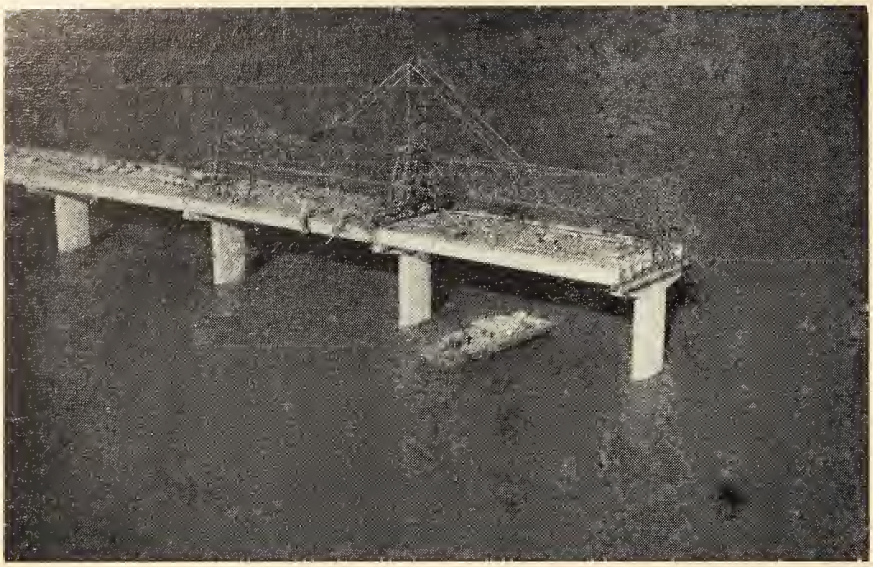

Fig. 3. Launching truss in section three.

The steel casting beds have removable vibrators which slide under the beds and can be fixed at any point along the length of the girder. Three vibrators are used while placing concrete. Additional form vibrators are fixed to the side forms.

Cable ducts are manufactured on the site from a strip of sheet steel welded by means of a continuous welding machine. Cables are made on the job with a machine which pushes the 12 wires of the cable through the ducts.

The yard is equipped with four A-frames dollies rolling on rails and supporting a 180 ft. beam from which hang the assembled reinforcing cages. All the cables of a girder are placed in a cage by hanging them on hooks welded to the vertical bars of the cage.

The individual cables are thus well positioned and quickly installed. Gantry cranes on rails can then move the completed cage to the casting bed where it will be standing on small precast concrete blocks.

Thirteen of the cables are threaded through holes in precast concrete end-blocks with embedded Freyssinet cones. The forms are then assembled and the concreting is placed. Emulsion is used to facilitate stripping of forms.

Placing of concrete is done in continuous operation for one girder with 1 cu. yd. buckets handled by a tower crane. Eighty-eight cu. yd. of concrete required for one girder can be placed in about three hours. The exposed part of concrete at the top of the girder is protected with a curing compound after concreting operations are completed.

Side forms are usually removed after 24 hours or less, depending on the temperature and the sides of the girders are sprayed with curing compound. The first step in prestressing is then performed (14 cables) and straddle trucks on rails move the girders to a storage area.

After the second step in prestressing is completed (six cables for 176 ft. 4 in. girders and four cables for 168 ft. 8 in. girders) the girders are loaded on two low-bed trucks running on rails and moved over the formerly completed portion of the bridge deck towards the launching bridge.

The steel launching bridge is a triangular truss 350 ft. long reaching across two spans of the bridge. The truss is supported on three A-frames equipped with dollies on rails, the A-frame located near the middle of the truss being double. Two monorail trolleys equipped with lifting devices are suspended from a longitudinal beam. Each of the trolleys has a 100 ton lifting capacity.

The launching truss travels longitudinally along the last completed span of the bridge until the front end of the truss reaches the next pier across the span where girders will be placed. During this stage, the trolleys are moved to the rear end of the truss and act as a counter-weight for the structure. When the launching of the truss has been completed, the front A-frame is supported on transversal rails placed on top of the pier and part of the double A-frame near the middle of the truss can move on transversal rails installed on top of the girders at the end of the last completed span. The rear A-frame rests on the deck of this last completed span.

The girder to be launched is lifted, at its two ends, by means of the 100 ton capacity trolleys and moved towards the front of the launching bridge. When the girder is in the correct longitudinal position, the dolleys under the rear frame are removed and the launching truss can move transversally to get the launched girder into its correct lateral position. The girder is then lowered about 12 ft. by means of the 100 ton capacity trolleys and placed into final position on its two bearing plates.

Parts of the diaphragms and the deck-slab strips are formed with the use of panels suspended from the girders. Transversal cables and reinforcing bars are then set in position and concrete is placed and vibrated. Curing compound is sprayed on the top surface of the deck.

All transversal cables are threaded through preformed holes, located in the top flange and web of the girders. Tensioning of the remaining prestressing cables, grouting of cable-ducts and miscellaneous finishing operations complete the building of the spans. All equipment of the precasting yard and on the launching bridge is electrically operated.

Section 7-B

Structural: The prestressed concrete super-structure comprises four spans 172 ft. long including seven prestressed concrete girders each, or a total of 28 girders. The I-shaped girders located on 12 ft. 2½ in. centres are approximately 10 ft. deep with a top flange 5 ft. 9 in. wide, a bottom flange 2 ft. 3 in. wide and a 7 in. thick web. The contract also covers the building of seven transversal prestressed concrete diaphragms per span and of an 8½ in. prestressed concrete deck slab. This deck slab, as in sections 5 and 7-A, is composed of the upper flanges of the girders and of slab strips built between these flanges. The girders are resting on two STUP-type bearing plates, similar to those used in sections 5 and 7-A.

In this section, G.T.M. prestressing cables each supply a prestressing force of approximately 52 tons after deduction of all losses. Nineteen cables are used for the prestressing of each girder, cast in situ with the use of steel forms.

Seven transversal diaphragms 5 ft. deep are prestressed with three to five cables transversally to the bridge. Fifty-four cables are used to prestress the deck-slab transversally. (Deck slab composed of seven upper flanges of the girders and six deck-slab strips cast between these flanges). An asphalt topping 1½ in. thick will later be placed on the deck slab.

Prestressing steel strands are grouped in cables with a minimum ultimate strength of 250,000 p.s.i.

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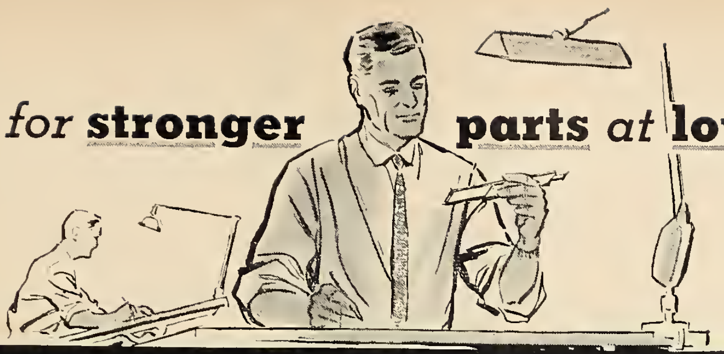

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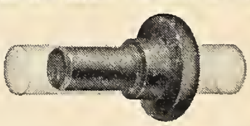

Wire of any forgeable metal up to 1″ in diameter can usually be upset for at least 4½ diameters of the length of stock measured in units of its own diameter to produce contoured parts. Secondary operations such as hot heading, bending, flattening, threading, drilling, punching, pointing, milling, coining, shaving, facing, knurling, slotting, form turning, counter boring, countersinking, cut-off, and polishing make design variations almost unending.

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International News

Fast Reactor Programs Discussed at Seminar held by IAEA in Vienna

Scientists from 22 countries and two international organizations discussed the physics of fast and intermediate reactors at a seminar held by the International Atomic Energy Agency (IAEA) in Vienna last August.

Fast reactors are those in which the neutrons emitted in the fission process are not "moderated" or slowed, while in intermediate reactors they are moderated to a limited extent. When the neutrons are not slowed, they are particularly effective in converting the abundant uranium istotope, U-238, which accounts for more than 99% of natural uranium but which itself is not fissionable, into plutonium-239, which is readily fissionable, like uranium-235. It is, therefore, possible to "breed" fresh nuclear fuel in a fast reactor even in larger quantities than the fuel consumed.

This advantage of fast reactors, which may become the ultimate means of economic power generation from nuclear fission, has led to large programs of research and development in many countries. Some of these national programs were reviewed during the closing stages of the IAEA seminar. The highlights of this review are as follows:

France

Dr. G. Vendryes said his country's program was initiated four years ago in the hope that within the decade 1970-80 fast breeder reactors would become competitive as a source of cheap nuclear power, the more so as conditions in France lend themselves particularly to this development. The construction of graphite reactors by Electricité de France would provide France with ample supplies of plutonium.

The first step taken by the French Atomic Energy Commissariat was to begin construction of the experimental reactor "Rapsodie" at Cadarache. Plutonium, probably in the form of a plutonium-uranium-molybdenum alloy, will be used in the first loading of "Rapsodie". When the reactor becomes operational by the end of 1964, one of its main purposes will be the carrying out of experiments on irradiation of fuel elements.

As a second step in the French program it is planned to design and build a 250 Mw thermal reactor towards the end of the present decade. This would help in designing a true electrical plant prototype.

Russia

Dr. Ivan Bondarenko said the problem of basing the production of electrical power on nuclear energy was not acute in his country, in view of its large reserves of fossil fuels. Nevertheless, power needs constantly grow, making it necessary to open new sources of energy. Interest in fast reactors, Dr. Bondarenko pointed out, was linked to the hope of obtaining cheap electrical power in the relatively near future.

The USSR program in the fast reactor field, which started in 1948, might be divided into a theoretical and a practical stage. During the first stage, research on various physical aspects was conducted. This confirmed the original assumptions and strengthened confidence in fast reactors. The transition to the practical stage began with the construction and operation of a five Mw plutonium oxide reactor called BR-5. At the same time work started on the BN-50 project, a fast power reactor with an electrical output of 50 Mw. and a thermal power of 250 Mw. Work on this project helped in solving many problems but was later dropped, since it was considered that a reactor with a thermal output of 250 Mw. was still not the facility from which the real advantages of the fast reactor could be obtained.

Soviet scientists and engineers now are thinking of designing a larger reactor of 800 Mw. or possibly more. At the same time, work on fast reactor fuels and on various technological and engineering problems continues, with the BR-5 reactor providing the necessary experience.

United Kingdom

Interest in fast reactors in the United Kingdom is based on the belief that they have the possibility of being both low capital and low fuel cost power producers, it was pointed out at the seminar. It is also heightened by the prospect of abundant supplies of plutonium from the natural uranium power stations now being built there.

Dr. Derek Smith, who described the UK's fast reactor program, said designs of fast reactor power stations for use in the 1970's are at present under study, since it is likely that at that time electricity generating boards will be looking for power stations with outputs of the order of 1,000 to 2,000 Mw. (eleetrical) with two or more reactors per station. Reactors of the 1,000 Mw. size have been studied and development programs initiated to study engineering problems, including the design of fuel elements.

A fairly big irradiation program of fuel element materials is under way in the material testing reactors DIDO and PLUTO at Harwell and DMTR at Dounreay. A radiation program will shortly be started in the fast reactor at Dounreay, which has been modified for testing fuel elements as distinct from fuel materials.

Reactor physies studies are being carried out at Aldermaston and Harwell. The ZEBRA reactor, under construction at Winfrith and due to be operational in about a year's time, will produce plutonium and permit investigation of fuel assemblies.

United States

Dr. Bernard Spinrad said that there were many institutions in the U.S.A. working on competing concepts, and he reviewed the activities of some of them.

(a) The fast reactor program at the Argonne National Laboratory is based in the EBR-2 reactor at present under construction there and on the EBR-1 reactor. This program provides for investigations into the use of metal fuel, reprocessing and fabrication of fuels with emphasis on remote fuel fabrication teehniques. It also provides for the ultimate conversion of the EBR-2 reactor from uranium-235 fuel to plutonium. Safety and engineering problems of fast reactors are also being studied.

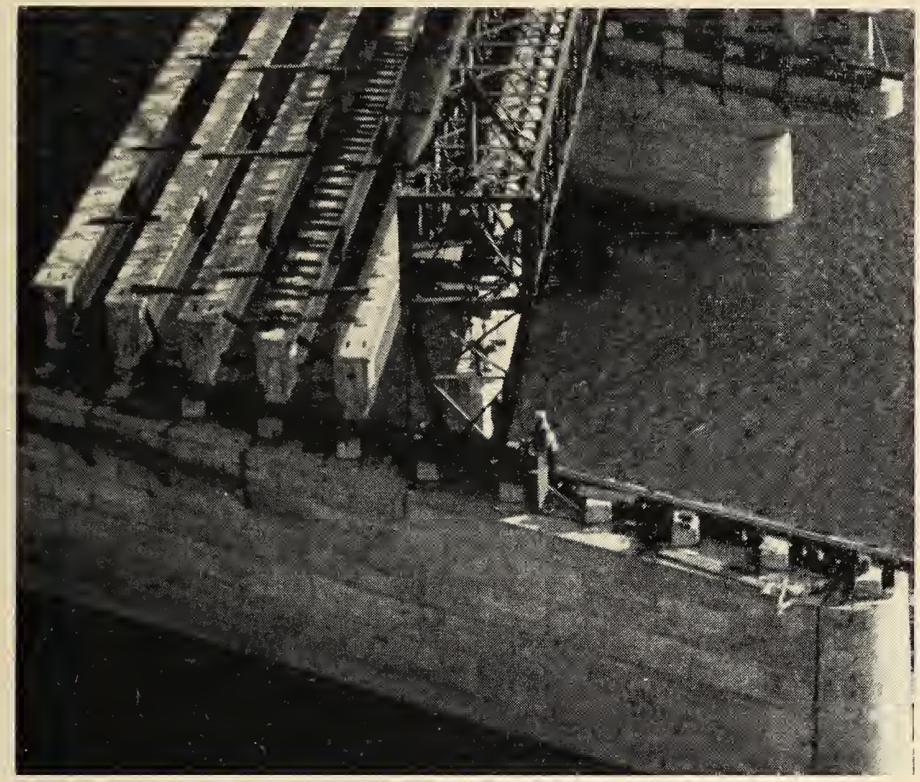
(2) The Los Alamos Scientific Laboratory is one of the first scientific institutions to start work on fast and intermediate reactors, and various measurements of basic properties and experiments in this field have been carried out there. This laboratory now is active in a plutonium alloy chemistry program, fast reactor safety and in engineering and physical research. A core-test facility is being built at Los Alamos to be used in developing and testing advanced concepts of molten fuel fast reactors.

(c) The Atomic Power Development Association, which was the designer of the Enrico Fermi Reactor, carries out fast reaetor economics analysis and works on fuel concepts.

(d) The Brookhaven National Laboratory is active in the intermediate reactor field.

THE CHAMPLAIN BRIDGE

Steel and Prestressed Concrete Crossing of the Saint Lawrence River



B. A. Hesketh, M.E.I.C.,
Associate Professor of Structural Engineering, Ecole Polytechnique, University of Montreal

Presented at the 75th E.I.C. Annual General Meeting, Vancouver, May 1961.

THE OBJECT of this paper is to give a general description of the bridge and to examine some of the methods of construction used in the building of the prestressed concrete sections.

The Champlain Bridge, when completed, will connect the Island of Montreal with the south shore communities of the Saint Lawrence River. It will constitute a greatly needed addition to the roadway traffic capacity of the three existing bridges — Jacques Cartier, Victoria and Honoré Mercier.

The new bridge will cross the northern branch of the Saint Lawrence River between the Island of Montreal and Nuns' Island, then lead across Nuns' Island, extend across the southern branch of the Saint Lawrence River and span the Seaway canal to reach the south shore.

A six-lane highway is provided for, along the entire length of the bridge, with a possibility of a seventh-lane addition between the Island of Montreal and Nuns' Island.

The total length of the bridge, including the approaches, will be in excess of four miles and the cost is estimated at $35 million. The bridge, built for the National Harbours Board, is scheduled for completion in the fall of 1962.

Description

The bridge comprises a high level steel structure about ½ mile long.

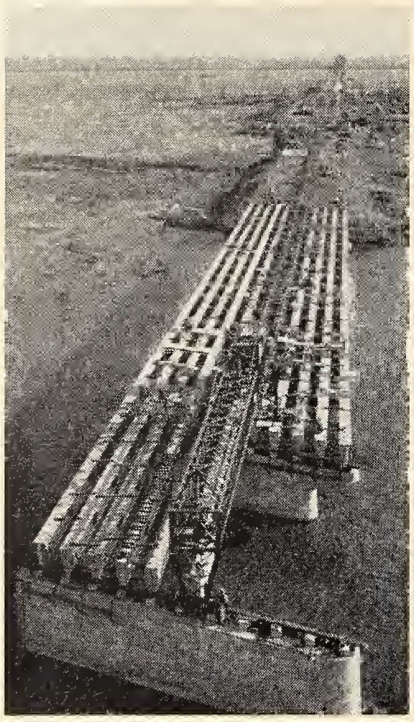


Fig. 1. Part of section three between the Island of Montreal and Nuns' Island.

spanning the Seaway canal and three prestressed concrete seetions with a total length of more than two miles. These sections include the crossing between the Island of Montreal and Nuns' Island, the part of the bridge between Nuns' Island and the Seaway canal crossing and the section between the Seaway and the south shore approaches. Additional overpasses in prestressed concrete are part of the approaehes on the Island of Montreal and of the Nuns' Island crossing.

Roadways: Two roadways, 38 ft. wide, each with three lanes of traffic, run along the whole length of the bridge, with the exception of Nuns' Island, where a toll plaza with nine-lane roadways in each direction will be built.

Design Loads: The bridge is designed for a load 25% greater than the 20 ton truck-16 ton trailer combination, with two trucks and trailers per lane.

Construction Sections: For construction purposes, the bridge was divided into eight sections.

Section 1—Approaches on the Island of Montreal, between the northern entrance and Wellington Street in Verdun, are part of this section. The roadways will be partly built on fill and partly carried by prestressed concrete structures. These structures will bridge the crossing of a large twin sewer 17½ ft. and 14½ ft. diam. and also carry the roadways across poor foundation soil where the use of fill is not practicable. These structures are now in the design stage.

Section 2—This section, limited by Wellington Street and the northern shore of the Saint Lawrenee River, includes various approaches to the bridge with part of the roadways built on fill. Three overpasses are part of this section with one of these to be built of prestressed eoncrete. Structures for this section have now reached the design stage.

Section 3—It spans the northern branch of the Saint Lawrence River, between the Montreal and Nuns' Island. This section of the bridge is composed of twelve 128 ft. long prestressed concrete spans resting on reinforced conerete piers and abutments. The bridge is designed to carry two three-lane roadways with a possible future addition of a seventh-lane. The total length of this prestressed concrete section is 1536 ft.

Section 4—This section constitutes the crossing of Nuns' Island and is composed of roadways on fill with a two span, 74 ft. prestressed concrete overpass. A toll plaza with two nine-lane roadways will be built on the Island. The total length of this section is about 3000 ft.

Section 5—It extends from Nuns' Island to the Seaway Canal Crossing. The whole of the superstructure is composed of forty prestressed concrete spans, each 176 ft. 4 in. long, resting on piers with heights varying from Nuns' Island elevation to the required elevation of the high span Seaway canal crossing. This part of the bridge carries two roadways with three lanes each and the total length of this section is approximately 7,053 ft.

Section 6—This is the steel section of the bridge crossing the Seaway canal with a clearance of 120 ft. above the canal water level. The total length of the steel bridge is 2501 ft. It includes a main span 707 ft. long, with two anchor spans 385 ft. long each. This part of the bridge is composed of three trusses. Four simple spans composed of four trusses 256 ft. long each, are also part of the steel bridge. Two of the spans are located at the end of the north anchor arm and two others at the end of the south anehor arm. All the spans are supported on reinforced conerete piers, the main four piers having been built during the construction of the Seaway Canal.

This seetion of the bridge carries two 38 ft. wide three-lane roadways and is in conformity with the original design in steel. It ineludes over 11000 tons of steel, with about 1500 tons of low alloy steel.

Section 7—It extends south of the steel bridge and has a total length of 1730 ft. The superstructure is prestressed concrete resting on reinforced concrete piers. This section was subdivided into 7-A with 1042 ft. and 7-B with approximately 688 ft. Part 7-A includes four prestressed concrete spans 176 ft. 4 in. long and two spans 168 ft. 8 in. long. Part 7-B includes four spans 172 ft. long.

Section 8—South shore approaches on fill.

Three Prestressed Concrete Sections

These include construction sections 3, 5 and 7. Original bids for section 5 and part 7-A of section 7, also for section 3 were based on designs in steel and reinforeed concrete, but bids on alternate designs proposed by the bidders were also allowed. Several bids based on alternate prestressed concrete designs were submitted and the following were accepted after extensive study of the proposals.

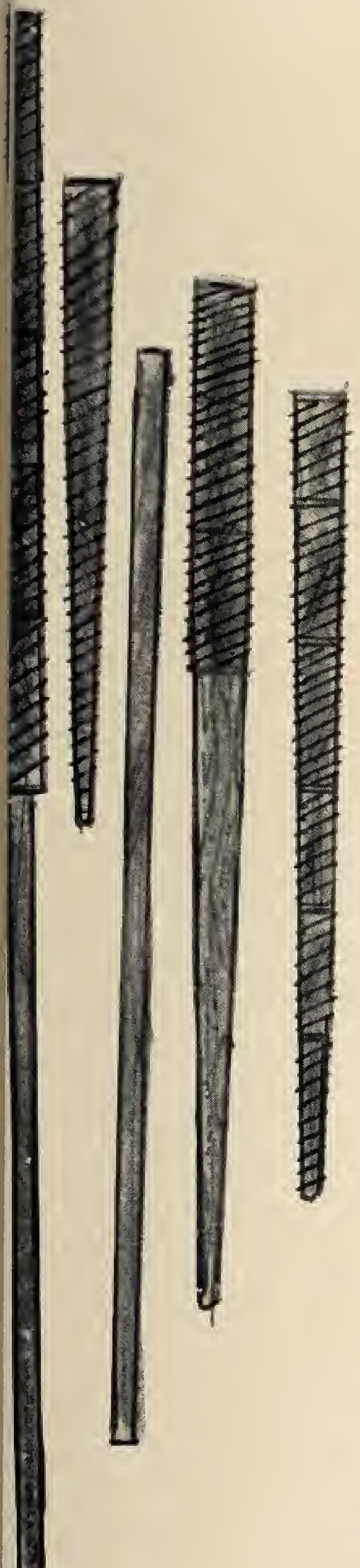
Section 3

Structural: The prestressed concrete superstructure comprises 12 spans 128 ft. long, including 132 prestressed concrete girders with 11 girders per span. These girders are supported on 11 piers and two abutments in reinforced concrete and are resting each, on two STUP-type, double Neoprene-stainless steel, bearing plates. The I-shaped girders are 7 ft. 2 in. deep with a top flange 4 ft. 4 in. wide, a bottom flange (heel) 2 ft. 2 in. wide and a web 6½ in. thick. These girders are manufactured in a precasting yard located on Nuns' Island and are each prestressed by means of twelve Freyssinet cables with 12 wires of 0.276 in. diam. in each cable. The girders are then shipped from the Island to the erection site and installed on 8 ft. 9½ in. centres. This bridge has a skew of 25°

Five transversal diaphragms, 8 and 12 in. thiek and 5 ft. deep are built between the girders in each span and then prestressed with two cables per diaphragm.

The girders and diaphragms are topped with a 5½ in. thick reinforced concrete deck slab, with a 6½ in. thiekness between girders. Shear connectors made of three loops of No. 4 reinforcing steel bars placed on 10 in. centres project from the top of the girders 4 in. into the deek slab and insure a positive composite, prestressed-reinforeed concrete, construction action. An asphalt topping 1½ in. thick placed on the deck slab protects the concrete structure and acts as wearing surface for the roadways.

Prestressing steel with a minimum ultimate tensile strength of 235,000 p.s.i. is supplied in 8 ft. diam. coils. Portland cement concrete has a min-



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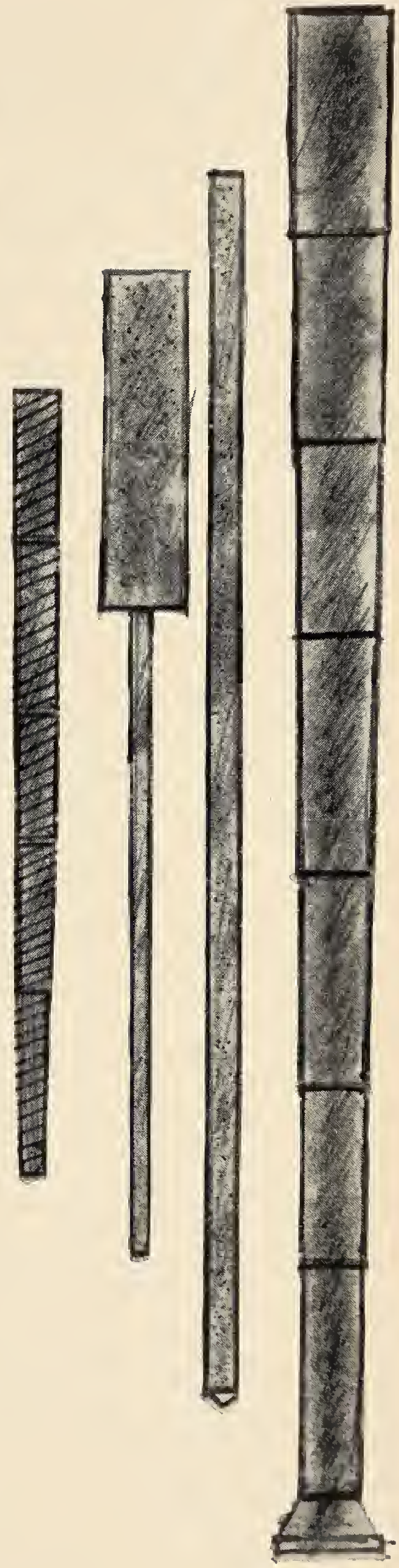

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Month to Month

Meeting of Council

The Council of the Institute met in Montreal on October 28. President Ballard was Chairman. Following are highlights of the meeting.

Finance

Council stressed again the need for adequate follow-up at the Branch level with regard to resignations, special cases and other items connected with the maintenance of membership. Special attention was given to the problems faced by those members who, because of reduced income, ill health or similar reasons were unable to continue to pay the regular membership fee and who were not yet eligible for life membership. The Council approved, in principle, the introduction of special reduced fees for such members. It stipulated that a recommendation from the member's Branch would be required in each case, and that when a member concerned is not elderly, provision should be made for review of the case every three to five years. Council requested the Finance Committee to make a detailed study of this and to recommend regarding its implementation.

Council noted that even though a sufficient majority of members had not ratified the proposed increase in membership fees, the Institute still requires increased revenue from the membership to finance its continuing program of membership services and activities. It was noted that revenues from the Engineering Journal continue to pay the full cost of the Institute's complete publications program and that the financial problem is not in this area. While there may be some increase in total membership revenue in 1962 due to earlier transfer from Student to Associate and from Associate to M.E.I.C., a deficit is anticipated in 1962. Based on this, Council authorized the President to request a voluntary contribution from each member when the invoices for 1962 membership fees are distributed. Council also noted that it may possibly initiate action to increase the membership fees, and provide even more data to the membership on the reasons for this action.

Open House

Referring to action taken by Council in the spring of this year, Council again discussed the fact that it is highly desirable for Branehes to make every effort to establish liaison between the senior cngineers and the engineering students in their area. The necessity to establish continuity in the Institute's relationship with students was stressed.

Membership

Council noted with pleasure that for the first time in the Institute's history, membership was well above 22,000. The meeting had an interesting discussion on the value of the Institute to members of the profession and of ways in which members of the profession could, in turn, contribute to the work of the Institute.

Publications

The Council noted with pleasure that the Publications Committee is making excellent progress in its efforts to improve the appearance of the Engineering Journal and to make it more readable. At the present time the content of the Journal, other than technical papers, is being carefully reviewed to examine the usefulness of each department to the readers in the light of the Journal's overall objectives. Preliminary studies are now being made of the possibility of changing the Institute's policy regarding Transactions in an effort to make each issue of more specific interest to specified areas within the membership and to reduce the total cost.

Confederation

Council went into committee of the whole and discussed the report of the Engineers Confederation Commission, published in the September, 1961, issue of the Engineering Journal. During this discussion the Council heard interim statements from the Executive Committee concerning a number of items in the report which require further consideration and clarification. Council empowered the Executive Committee to consult with the Executive Committee of the Canadian Council of Professional Engineers with a view to discussing those matters relating to Confederation which require further consideration and clarification.

The Executive Committee has not yet completed its studies of the report, and every effort is being made to submit its final report and recommendations to Council at the earliest opportunity.

Library Service

Council received from the Library and House Committee a report which proposed a method of implementing Council's views as expressed at its meeting of June 1, 1961, that the EIC Library service be discontinued from Headquarters and that it be replaced by a similar service to be provided by the National Researeh Council Library supplemented by a library in Montreal which would be available to Montreal members. The Committee proposed that the present EIC book and periodical collection be turned over in part to NRC and in part to a library in Montreal.

Council debated the wisdom of this proposal at length. Finally it was agreed to postpone further discussion until the January meeting of Council, prior to which the library and House Committee would be enabled to conduct studies of possible methods of reducing the costs of the present EIC library service if it were to be continued.

Resources for Tomorrow Conference

Major-General Guy Turner, EIC representative to the Resources for Tomorrow Conference, held in Montreal October 23 to 28, reported to Council on the work and achievements of the Conference. The Institute was also represented at this important meeting by Past-President Dr. R. E. Heartz.

Executive Committee

Council examined the work of the Executive Committee since its inception on a trial basis two years ago and authorized its continuing until December, 1962. At the same time it requested the Committee on By-Laws to draft a proposed amendment to the by-laws which would incorporate the Executive Committee into the formal administration of the Institute.

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Chairman, D. H. Hobbs, 212 Gay Lussac, Arvida, Que.
Secretary-Treasurer, Guy Robin, 258 St. Leon Street, Jonquiere, Que.

SAINT JOHN
Chairman, P. W. Hastings, 56 Parks St. Extension, Saint John, N.B.
Secretary-Treasurer, Eldon D. Thompson, 62 Wright Street, Saint John, N.B. Bus. Tel. Oxford 2-8294.

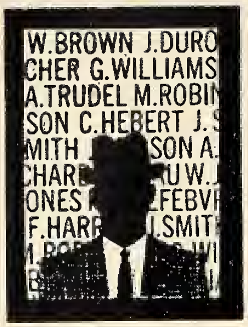
SAINT MAURICE VALLEY
Chairman, J. S. Whyte, Consolidated Paper Corp. Ltd., Riverside, Grand'Mere, Que.
Secretary-Treasurer, MacGregor Fraser, Laurentide Inn, Grand'Mere, Que.

SARNIA
Chairman, H. V. Page, 541 Charlesworth Drive, Sarnia, Ont. Bus. Tel. ED 7-8282. Res. Tel. DI 4-4392.
Secretary, R. W. Hodgson, 885 Kemsley Drive, Sarnia, Ont., Tel. ED. 7-8221, Loc. 656.

SASKATCHEWAN
Chairman, M. F. Pardoe, 645 - 19th St. W., Prince Albert, Sask.
Secretary-Treasurer, R. Bing-Wo, 2043 Cameron Street, Regina, Sask.

(Continued on page 86)

Personals



Edward J. Bobyn, M.E.I.C., (Sask. '44, Johns Hopkins '48) has been appointed Chief Systems Research Group at the SHAPE Air Defence Technical Centre at the Hague, Holland. Mr. Bobyn is a Canadian Defence Research Board scientist on loan to SHAPE.

David D. Reeve, M.E.I.C. (U.B.C. '33) has also been appointed to the sales and engineering staff of the new company. The changes have been made because of the merger of Canadian Wood Pipe and Tanks Ltd. and Pacific Coast Pipe Co. Ltd.

N. E. Lang, A.M.E.I.C., (McGill '51) has been appointed general superintendent of production at Noranda Copper and Brass Ltd. During the last ten years Mr. Lang has served in various production and engineering capacities with the company, and is now responsible for all production and processes in the casting, rod, wire, tube and sheet operations.

Gilmour S. Boa, M.E.I.C. (Tor. '46) has been appointed Manager of the Standard Steel Construction Company Division of United Steel Corporation at Port Robinson, Ont.

Cecil M. Brant, M.E.I.C. (London Poly. '34) has been appointed Deputy Director, Air Services, Department of Transport. His appointment is for two years and his duties will include representing the Assistant Deputy Minister, Air, on high-level committees and at international organizations. Mr. Brant's last position was Chief of Technical and Policy Co-ordination in the Department of Transport's Telecommunications Branch.

Antoni Martynowicz, M.E.I.C. and **Colin B. McMillan,** M.E.I.C. announce the formation of a partnership for the practice of Consulting Engineering in Montreal under the name of McMillan and Martynowicz. Mr. McMillan established his own office three years ago. Mr. Martynowicz, who now joins him to provide expanded services, has many years of experience in the consulting field, both in England and Canada.

Pierre C. Lefrancois, A.M.E.I.C. (Poly '56) has recently been appointed Vice-President of Edsall Research Limited, Marketing Consultants. Mr. Lefrancois is an active member of the Marketing Association of Canada.

J. J. Leydon, M.E.I.C. (N.S.T.C. '50) has been appointed Manager of the Sarnia Plant of Sifto Salt Ltd. He joined the company in 1951 at its Amherst Plant. Prior to this appointment, he was Plant Superintendent at Sarnia.

G. L. Gooding, M.E.I.C. (Tor. '50) has been appointed Manager of Operations of Sparling Tank & Mfg. Co. Mr. Gooding was formerly Chief Engineer. In his new post he will be responsible for the plant and field operations of the company.

K. L. Macdonald, A.M.E.I.C. (Man. '56) has been appointed Plant Superintendent of the new Kentville Plant of The Formex Company of Canada, a Division of Kenwood Mills Ltd. Mr. Macdonald joined Formex Company in 1959 and after spending a year at the Company's Greenville, Tenn. plant, came to Kentville in September 1960. He was Resident Engineer during construction of the Kentville Plant.

Dr. C. J. Mackenzie, Hon. M.E.I.C. (Harvard '15) retired recently from his post as President of Canada's Atomic Energy Control Board. Dr. Mackenzie, who was President of E.I.C. in 1941, leaves public life after a distinguished 22-year career in the federal government service during which he served as president of the National Research Council and Atomic Energy of Canada. He played a key role in 1943 in the establishment of Canada's nuclear research project at a remote site 130 miles northwest of Ottawa. Dr. Mackenzie has received honorary degrees from 18 universities, including the University of Algiers. His honors include those as a Companion of the Order of St. Michael and St. George, holder of the United States Medal of Merit, and as a Chevalier of the French Legion of Honor. He has also won the Kelvin Medal awarded by the Institution of Civil Engineers in London, and the Plummer Medal and the Sir John Kennedy Medal of E.I.C. Dr. Mackenzie is a former chancellor of Ottawa's Carleton University.

Obituaries

Charles Edward Napier, M.E.I.C., president of the Charles E. Napier Company, died in Toronto Aug. 31, 1961. He was 58. A native of Montreal, he graduated from McGill University in 1925 with a B.Sc. in mechanical engineering. In 1930 Mr. Napier formed his own company which distributes water treatment and sewage disposal equipment. He became a member of E.I.C. in 1945.

Bernard E. Norrish, M.E.I.C., died Aug. 29, 1961. He was 76. Mr. Norrish was retired president and managing director of Associated Screen News. Born at Walkerton, Ont., he was a graduate of Queen's University, where he obtained an M.Sc. degree. Mr. Norrish was considered one of the outstanding authorities on photography and photographic development in Canada. He was a founder and manager of Associated Screen News in Canada in 1920. In 1926 he was appointed managing director, and in 1940 was named president of the company. He retired in 1953.

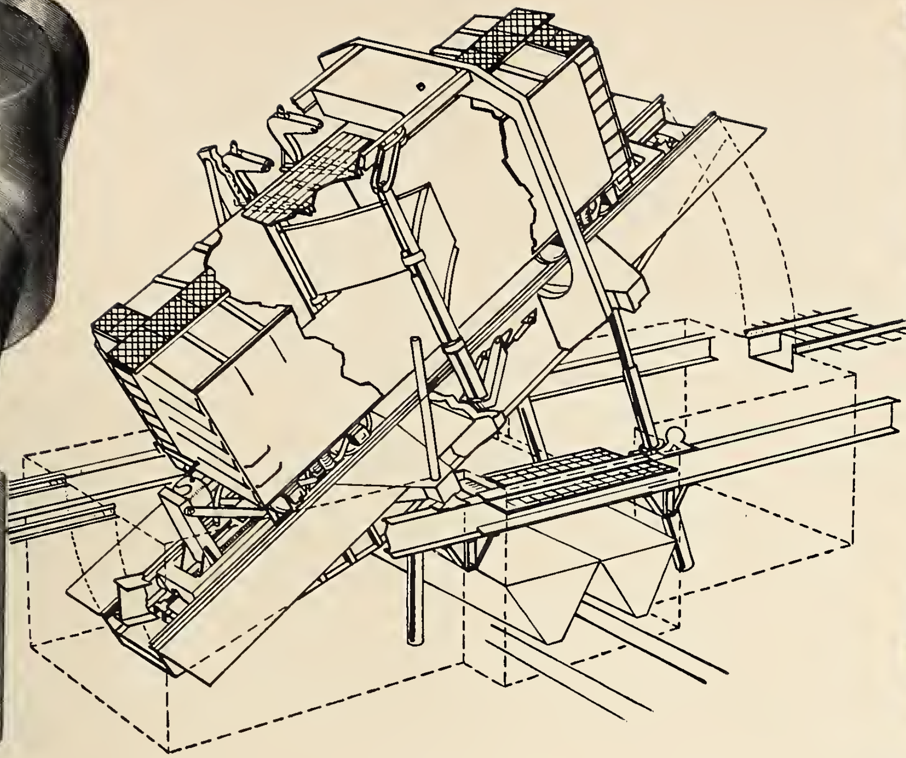
Mr. Norrish became an associate member of E.I.C. in 1912, a member in 1940 and was made a life member in 1948.

Hugh James Leitch, M.E.I.C., died Sept. 24, 1961. He was 61. Born in Westmount, Mr. Leitch attended St. Leo's School and Loyola College and graduated in engineering from McGill University in 1926. For a period of about four years, he was employed by Steel Gates Company as resident engineer during the construction of the Welland Canal. Subsequently, he became design engineer for the Phoenix Bridge Company in Montreal, and when that firm was merged with the Dominion Bridge Company in the early 30's he joined it. He later joined Algoma Steel Corporation as sales manager, and during World War II was assistant director general of naval ship building, Department of Munitions and Supplies. Following the close of hostilities he returned to the Dominion Bridge Company and became sales manager of the structural division.

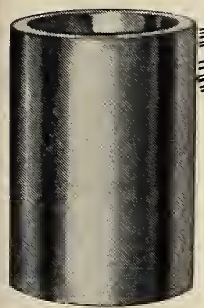
Mr. Leitch joined E.I.C. as a student member in 1920. He became a junior member in 1927 and an associate member in 1934. In 1940 he attained full membership. He was a member of the Professional Engineers of Canada and the Engineers' Club. He was a former alderman for the Town of Hampstead and chairman of the Sub-Contractors Section of the Canadian Construction Association in 1960.

John McLeish, M.E.I.C., a life member of the Institute, died Sept. 22, 1961. Mr. McLeish graduated from the University of Toronto in 1896. He became a member of the Institute in 1923 and was made a life member in 1953.

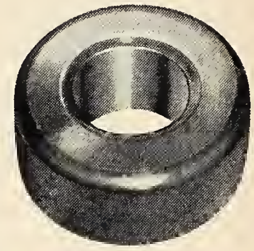
Power screw nut



Power screw bearing



Baffle post bushing



Door opener linkage bearing

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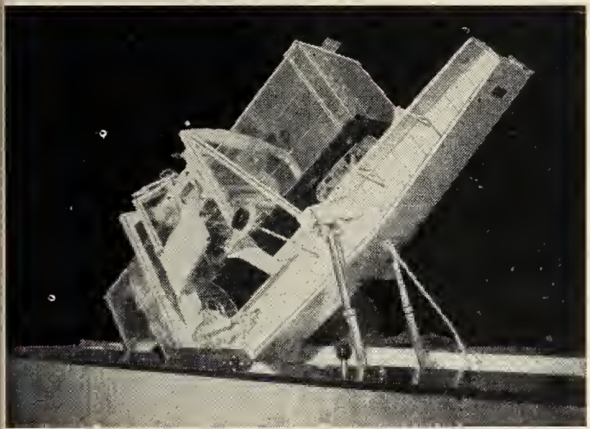

Working model of new Seabar automatic railroad grain car dumper. Ni-Vee Bronze bushings and bearings were cast by Canada Metal Company Ltd., Toronto, Ont., and A. H. Tallman Bronze Co. Ltd., Hamilton, Ont.

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News of the Branches

Brockville

A. N. Campbell, M.E.I.C.
Correspondent

Some 30 members and guests were present at the Branch meeting of Oct. 12. J. R. Allen, Protective Coatings Engineer, E. I. duPont de Nemours, was guest speaker. "Protective Finishes" was the subject of Mr. Allen's address. He outlined the work done by his company's Protective Coatings Committee since its inception in 1950. He discussed the work that has gone on in the fields of application, surface preparation and finishes specifications, particularly in plants where corrosion was a severe problem. He said that success has been notable in the reduction of painting costs which have been achieved, and the reduction in costs by corrosion prevention. Mr. Allen illustrated his talk with slides.

The speaker was introduced by F. F. Walsh and thanked by G. M. Woods.

Central B.C. Branch

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

W. J. Owen, retiring Secretary-Treasurer of the Branch, was honored at a Branch dinner meeting held on the SS Sicamous at Penticton on Oct. 6. The members expressed their appreciation of Mr. Owen's work in connection with the Branch by presenting him with a book on B.C. Resources. Mr. Owen has had to give up his position with the Branch because of poor health.

W. Hall, President of the Association of Professional Engineers of British Columbia, was present on his annual visit to the Branch (The Association and E.I.C. Branch meet jointly). He spoke of his impressions of the advance of industry and development which had taken place in British Columbia in recent years and the place engineers had taken in this development.

Edmonton

W. Rutherford, M.E.I.C.
Correspondent

R. Bruce Angus, Federal Assistant District Engineer, Engineering Development of The Department of Northern Affairs, was guest speaker at the Branch meeting of Oct. 25. He spoke of the conditions and problems experienced when working as an engineer in Canada's North, and in particular on the construction of highways for which he is responsible out of Yellowknife in the Northwest Territories. In his talk he drew attention to the restrictions on development because of high costs resulting from isolation, weather conditions, muskeg and permafrost. He said that as the search for natural resources moves northward the role of an engineer in carrying out adequate planning of development assumes much greater importance. Transportation facilities would be improved by the development and improvement of existing types of transport, he said. The importance of ground transportation facilities such as roads and bridges was pointed out by the speaker, with particular reference to the use in winter of snow roads and ice bridges over lakes and rivers. Mr. Angus pointed out the importance of educating and training native manpower. He illustrated his talk with color slides showing a review of the country, engineering difficulties, types of construction.

The speaker was introduced by Stan Rogan and thanked by W. Rutherford.

The meeting was held at the Seven Seas Restaurant. Adam Sandilands presided. The Chairman drew the attention of the members to the subject of confederation. A new member, Harry Bolt of the National Research Council, was introduced to the other members.

Estevan Section

O. P. Lesiuk, M.E.I.C.
Correspondent

At the Branch meeting of Sept. 11, Douglas Baldwin, production engineer for Imperial Oil Co., Frobisher, Sask. was the guest speaker. His speech was entitled, "Design Considerations West Carnduff Waterflood Injection System." Mr. Baldwin dealt with the pattern of waterflooding, the equipment used in the water source well, and the reasons for using the single piston ajax gas driven engines in the two waterflood stations.

During the meeting members were informed of the new regulations regarding certification of engineering technicians and technologists into the section, and were asked to encourage new membership.

A farewell dinner was held for E. Y. Carlson, former chairman of the section, who has taken up a position in Streetsville, Ont.

Moose Jaw

R. J. Tomlinson, M.E.I.C.
Correspondent

J. Wells of the Saskatchewan Power Corporation, Regina, was guest speaker at the Branch's meeting of Oct. 5. In his speech entitled, "Squaw Rapids Hydro Electric Power Development," Mr. Wells discussed the construction of the dam, spillway, canal and turbine house of the power project. The various problems encountered in the construction were related in detail and accompanied with color slides. The speaker discussed the hydraulics of the North and South Saskatchewan Rivers and the effect on Squaw Rapids. The future potential hydro electric power sites on the Saskatchewan Rivers, and the factors determining their development were also discussed by Mr. Wells.

At a business meeting preceding Mr. Wells' speech, H. Johnson was elected Secretary-Treasurer replacing A. Brown who has been transferred by British American Oil Co.

Nipissing and Upper Ottawa

J. S. Cooper, M.E.I.C.
Correspondent

At a Branch dinner meeting, on Oct. 18, held at the Imperial House Restaurant, P. J. Vincent, Traffic Superintendent, Huntsville Section, Bell Telephone Co. of Canada, was guest speaker. In his speech entitled, "Direct Distance Dialling," Mr. Vincent stated the reason for Direct Distance Dialling was to provide faster, more efficient telephone service and provide greater capacity for future expansion. He said the new system permits direct customer dialling between North Bay and 50 million other telephones in Canada and the U.S. through 117 numbering plan areas. Mr. Vincent said the capacity of the new system in each area is 6,000,000 different numbers using two letters and five digits. This number can be increased 50 per cent using seven digits, he said. The speaker demonstrated, with actual telephone equipment, how such calls are placed.

(Continued on page 82)

(Branch News continued from page 80)

Mr. Vincent was introduced by R. Cruikshank, M.E.I.C., of North Bay and thanked by P. M. Rebin, M.E.I.C., of Sturgeon Falls. Nineteen members attended the meeting.

Events planned by the Branch include: a meeting, on Nov. 15, at Temiskaming, Que. at which "Water Filtration" will be discussed; a meeting, on Dec. 6, at which Chief Engineer Physical Laboratory, Timken Roller Bearing Co., Canton, Ohio, will speak of "Stress Analysis"; and a meeting, on Jan. 17, at Sturgeon Falls, Ont., when the members will be taken on a plant tour of the Abitibi Power and Paper Co. Ltd.

North Shore Lower St. Lawrence

George S. Jardine, M.E.I.C.
Secretary

The Annual General Meeting of the Branch was held October 31 in conjunction with President Ballard's visit. The agenda included: A visit to the port facilities of the Quebec Cartier Mining Company; a tour of the Company's new administration building preceded by an introduction to the Company delivered by J. P. Drolet; a conducted tour of the new townsite; the installation of the executive for 1961-62 at the Branch meeting where they were introduced to Dr. B. G. Ballard, and Mr. C. Miller, Vice President, Baie Comeau Branch.

One hundred and eleven members, guests and wives heard Dr. Ballard's address on Confederation.

Gifts displaying the ore metal of this region were presented to President and Mrs. Ballard, Mr. Miller, and Mr. R. W. Pryer, Past Chairman of the Branch.

The executive for 1961-62 are: B. A. Kelly, Chairman, G. Y. Roy, Vice Chairman, G. S. Jardine, Secretary, L. Dignard, Treasurer. The Committee members are: J. P. Drolet, A. E. Rodin, N. S. Hammond, M. Storrier, P. N. R. Payne, D. O'Connor, R. Y. Pryer, Councillor (second year).

Oakville

J. W. Kirk, M.E.I.C.
Correspondent

D. R. Abbey, Tech Services Engineer, Industrial Accident Prevention Association of Ontario, was guest speaker at the meeting of Oct. 12. In his speech entitled, "Fire Protection in Industry," Mr. Abbey described how different fire protection plans had to be made for different industries. He said all had different problems with no one common solution. He explained the necessity of trained fire organizations with definite duties, and provision for alternates in cases of the absence of any key members. Mr. Abbey discussed the pros and cons of various fire extinguishing methods including: pyrene, CO_2 pumps, foam, sprinklers, solid extinguishers such as sodium bicarbonate. A discussion period followed the speech.

Peterborough

R. C. Johnston, M.E.I.C.
Correspondent

Hon. Robert Winters, President of Rio Tinto Mining Co. and former minister of public works, was guest speaker at the Branch dinner meeting on Oct. 10. held at the Empress Hotel. His topic was 'Power from the Atom.' In his speech Mr. Winters said that there must be constant effort to educate the public on the real advantages to be gained by the peaceful exploitation of the atom and the extent to which the inherent health and safety hazards can be controlled. He said that the main visible impact of peaceful nuclear power on our daily lives is, or will be, in the form of electricity derived from heat produced inside nuclear reactors. He mentioned Britain, Western Europe and Japan as areas with major nuclear power programs. He expressed a firm belief in the continued growth in the application of peaceful power from the atom, and that this applies to Canada as well although our needs to develop an alternative source of power are not so pressing as in some other countries.

The speaker was thanked by Walter G. Ward, vice president Canadian General Electric Co.

Guests at the meeting included I. F. MacRae and J. H. Smith, Chairman of the Board; and President respectively of Canadian General Electric Co.; Five members of the United Kingdom, Central Electricity Generating Board also attended the meeting. The leader of this group, Howard Gott, gave a brief address on some of the factors affecting power generation in the U.K.

Sudbury

A. B. Platt, M.E.I.C.
Correspondent

A tour, on Sept. 30, of the Algoma Steel Corporation's Sault Ste. Marie holdings was a feature of a field trip by 65 members of the Branch, following a film of Algoma's Steel Works. Included in the tour of inspection were the dock facilities, blast furnaces, coke ovens and a tour of the new wide flange beam mill.

Later, Algoma Steel entertained the group at a reception and dinner.

The efforts of those responsible for the day's events were appreciated by the members.

Vancouver

R. W. Lockie, M.E.I.C.
Correspondent

Leslie Edgeworth, Senior Engineer of the Department of Fisheries of Canada at Vancouver, spoke of the work of the Fish Culture Development Branch of his Department at a Branch meeting, on Oct. 11, at Holyrood House.

Mr. Edgeworth spoke of his Branch's work in conservation and maintenance of the fish resource with artificial spawning beds, an emergency work like clearing rockslides and obstructions such as the Babine Slide in 1951. Protection against pollution, insecticides and other natural and man-made hazards were also illustrated. He enlarged on the development work of the Fish Culture Branch in passing fish to the spawning beds—14 fishways have been built in B.C. in the last few years. Mr. Edgeworth told of work on the Big Qualicum River to improve spawning conditions by controlling river flows, and at the same time maintaining optimum temperature by mixing water from three levels of Horne Lake. He said the Department hopes to make the Big Qualicum River a major production stream and that this project may point to a solution to the fish problem on other British Columbia streams too.

The speaker discussed the third phase of the Fish Culture Development Branch's work in applied research, illustrating the Robertson Creek research area near Alberni, where artificial spawning channels, transplanting eggs, and flow of rate requirements for spawning are being studied.

Films taken by the staff of the Fish Culture Development Branch, and a film on west coast salmon fishing by the National Film Board were shown.

Mr. Edgeworth was introduced by T. A. J. Leach, Chief of the Hydraulic Investigations Division of the B.C. Water Rights Branch. He was thanked by W. A. Bowman of the B.C. Department of Highways. Both are past chairmen of the Branch.

Winnipeg

P. M. Abel, A.M.E.I.C.
Correspondent

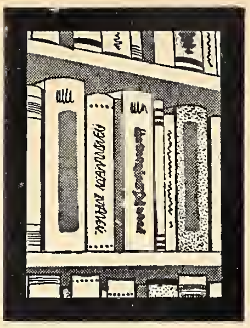
"Petroleum Fuels — Properties and Applications," was the topic of the speech given at the Oct. 12 meeting by T. C. Elliot, Process Superintendent, Winnipeg Refinery, Imperial Oil Ltd. The speaker dealt generally with the geologic formation and current reserves of petroleum, and the place petroleum fills in today's energy requirements. He talked about molecular structure using models and charts, and refining processes. In his speech, Mr. Elliot covered all the refinery products from motor gasoline and kerosene, through aviation gasoline, turbine and jet fuels, diesel fuels, heating and furnace oil and down to bunker C. He dealt at some length with octane rating, heptane and trimethyl pentane, and anti-knock additives including tetraethyl lead. He stressed the research and development by which his company is endeavouring to improve their products.

The speaker was introduced by the Secretary-treasurer, W. N. Isberg, and thanked by Lt. Col. C. G. Kirby, R.C.A. (retired).

A question and answer period followed. Later, a lunch was served.

The **LONDON BRANCH** held a meeting Oct. 17 at which Blake Goodings, Associate of Professional Engineers of Ontario, spoke of "The Work of the Association." On Nov. 1 the **CALGARY BRANCH** held a meeting. C. K. Hurst, arbours & Rivers Engineering Branch, Department of Public Works, Ottawa, was guest speaker. He chose as his topic, "International River Development." The General Secretary of E.I.C. addressed the members of the **LOYOLA COLLEGE STUDENT SECTION** on Oct. 13. Mr. Page spoke of "The Engineering Institute of Canada.

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.

*FLEXURAL VIBRATIONS OF ROTATING SHAFTS.

The reliability of turbo-machines is closely connected with the vibrational characteristies of the rotor and with the maintenance of the permissible level of vibrational stress. This volume is concerned with the problem of flexural vibrations in rotating rotors, and calculations are presented relating to critical speeds, methods of balancing, stability in inter-critical speed ranges, and strength during prolonged operation and when subjected to repeated starts. The results of experiments on actual rotors and on a laboratory model are given, and are in accordance with the theoretical conclusions reached. A translation from the Russian. (F. M. Dimentberg. Toronto, Butterworth, 1961. 243p., $11.25.)

GEOMETRIC DESIGN OF MODERN HIGHWAYS.

The object of this volume is to make available to practising highway engineers, town planners, etc., in England the experience gained in the geometric design of highways in both the United States and Europe. The author, a member of the A.S.C.E., was a professor of highway engineering at both Northwestern and the University of California, and served as a consultant for the U.S. Interstate Highway System. The chapters cover: design controls and criteria; design elements; cross-section elements; signs and guardrails, etc.; junction design; grade separations; analysis of existing (U.S.) highways.

The user of this text should bear in mind that the information it contains has been adapted for use for traffic travelling on the left of the road. (J. H. Jones, London, Spon, 1961. 244p., 63/-.)

INTRODUCTION AU CONTROLE BUDGETAIRE.

Intended for all those concerned with the operation of a company, this volume discusses the value of a budget in company organization, showing how it can help define the aims of a company, and outline the responsibilities of each department. The topics covered include: market studies; cost prices; balance sheets; budgetary control. The bibliography includes many American texts. (R. Ghez. Paris, Dunod, 1961. 173p., 16 NF.)

LES APPAREILS DE LEVAGE. T. 3 APPAREILS SPECIAUX.

Translated from the German, this text contains information of the development of special types of cranes and lifting apparatus, notably in the United States. The types covered are: travelling cranes in workshops; lifting apparatus in foundries; shipyard cranes; floating cranes; cranes and derricks on wharves; hoisting apparatus on vehicles; tipping, freight-cars; aerial buckets; construction equipment; gantry cranes.

The first volume dealt with the general principles and construction of lifting machinery, and the second with the usual types of cranes, hoists, etc. (Hellmut Ernst. Paris, Gauthier-Villars, Eyrolles, 1961. 340p., 78 NF.)

FAST REACTORS.

Another in the series of Nuclear Engineering Monographs intended for students and research assistants, this volume gives an overall account of fast reactor technology, pointing out the special problems encountered. This type of reactor is of great significance in the long-term development of nuclear power. The topics covered include choice of material; liquid-metal technology, statics and dynamics of fast reactors, the prediction of heat transfer coefficients. A bibliography is included. (R. G. Palmer and A. Platt. London, Temple, 1961. 93p., 12/6.)

THE ENGINEERING INSTITUTE LIBRARY

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

Library hours are: Monday to Friday: 9 a.m. to 5 p.m.; Saturdays: 9 a.m. to 12 noon. All requests and enquiries should be addressed to the Librarian at 2050 Mansfield Street, Montreal.

DICTIONNAIRE FRANCAIS-ANGLAIS: ELECTRONIQUE PHYSIQUE NUCLEAIRE.

A French-English dictionary of over 27,500 terms in electronics, nuclear physics and related fields, collected by the author during the course of his work as a translator. The terms are arranged in strict alphabetical order, and where U.S. and British expressions differ, both are given.

The English-French volume of the dictionary appeared in 1959. (G. G. King. Paris, Dunod, 1961. 395p., 38 NF.)

LES TECHNIQUES BINAIRES ET LE TRAITEMENT DE L'INFORMATION.

Introductory chapters discuss the elements of logical algebra, and circuits using relays, electron tubes, transistors and ferrites. Following chapters cover binary and decimal enumeration, binary arithmetic calculations, programming techniques, information input, and memory devices.

The remaining chapters are concerned with the automatic transmission of information, the use of computer techniques in telecommunications, and applications in power plants, chemical plants, refineries, and industry in general. (H. Soubies-Camy. Paris, Dunod, 1961. 424p., 75 NF.)

TRANSMISSION DE LA CHALEUR.

Translated from the 1954 U.S. edition, this volume presents the developments in heat transfer which came with the advent of nuclear reactors, and jet engines. The text is divided into three sections: conduction, radiation and convection. The investigations reported cover the ranges of available correlations for heating and cooling of gases, and have been extended to include many cases of supersonic compressible flow inside tubes and outside objects of various shapes. The introduction of molten metals as practical heat-transfer media in high-performance applications is discussed.

Among the new techniques described are the use of fluidized beds for the contacting of fluids and solids, and the development of highly compact plate-and-fin and finned-tube exchangers. Incremental methods for the computation of transient heat conduction have been further developed and explained. (W. H. McAdams. Paris, Dunod, 1961. 585p., 115 NF.)

(Continued on page 102)

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(Continued from page 77)

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Please notify the Journal's Circulation Department

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ONE GRADUATE ELECTRICAL ENGINEER with three to five years' experience, preferably in pulp and paper but not essential. Prospect for rapid advancement to position of assistant electrical superintendent.

And

One graduate mechanical engineer with two to four years' experience, preferably in pulp and paper industry, for engineering office of large newsprint mill.

Include complete resume of education, experience, marital status and salary expected with application. All applications will be treated confidentially and should be addressed to:

MANAGER, INDUSTRIAL RELATIONS
THE GREAT LAKES PAPER
COMPANY, LIMITED
FORT WILLIAM, ONTARIO.

TRANSMISSION ENGINEER — Functions: Coordinates, prepares and recommends transmission plans for additions, rearrangements and replacements of Toll facilities; supplies transmission information such as transposition plans, cable loading arrangements; revises projects, estimates and orders to check consistency with practices, standards and specifications; verifies and accepts installations from transmission point of view. Qualifications: B.Sc.A. (Electronic or Electricity). From 3 to 5 years experience on similar work. Bilingual. Conditions — Very good working conditions. Good salary. Send applications form to: Department of Personnel Quebec Telephone, 5 St. Jean St., Rimouski, P.Q. File No. 7380-V.

PLANT EXTENSION ENGINEER — Functions: Coordinates preparation of construction budgets for current year and subsequent years; prepares and revises construction schedule. Supervises and controls the execution of the construction program; keeps a progress record of operations; analyses and revises estimates and coordinates work to conform with policies limits of authorization, priority of projects, and availability of materials. Prepare in cooperation with the accounting department cost, depreciation and mortality studies. Qualifications: B.Sc.A. Electronic or Electricity, from 3 to 5 years experience on similar work. Bilingual. Conditions: Very good working conditions. Good salary. Send application form to: Department of Personnel, Quebec Telephone, 5 St. Jean St., Rimouski, P.Q. File No. 7381-V.

MECHANICAL

PROFESSIONAL ENGINEER required by a manufacturer of processing equipment located in the area of Quebec City, to be manager of design office which involves strength of materials, Thermodynamics, heat transmission and distillation. Occasional contact with customers on technical problems. Applicant should be a graduate in Chemical or Mechanical engineering, must be bilingual. Age 40 to 50 years. Experience should be in Mechanical engineering works, boiler works, or metallic containers factory. Please submit application in own handwriting outlining experience background and salary required. File No. 7378-V.

GRADUATE MECHANICAL ENGINEER, 30 to 35 years of age with experience in pulp and paper preferably a fibre board mill. Position involves equipment design, development and layout. Would be located in Montreal. Some travel. File No. 7384-V.

MISCELLANEOUS

ENGINEERS FOR MANAGEMENT. Project, design, sales research, development and control. Graduates of most types and ages required by clients of the Technical Service Council, a non-profit industry-sponsored Placement Service. Write 2 Homewood Ave., Toronto 5, Ontario, or No. 1500 Stanley St., Montreal 25, Quebec, for an application. There is no charge for work done on your behalf. File No. 6648-V.

METALLURGIST — Required for research program involving investigation of the uses of uranium metal. M.Sc. or PH.D. in Metallurgy preferably with experience in vacuum induction melting of high purity metals and alloys and phase diagram studies. Please write details of qualifications and experience to the Personnel Officer. Ontario Research Foundation, 43 Queen's Pk Cr., Toronto, Ont. File No. 7370-V.

ENGINEERS—MECHANICAL AND CIVIL — A Montreal firm of Consulting Engineers serving the process and petroleum industries has challenging openings for permanent positions available in their Montreal office. Mechanical Engineer capable of assuming project engineer responsibilities. Applicant should have a minimum of 10 years design experience in related industries. Mechanical Engineer with a minimum of 5 years design experience in related industries. Civil Engineer with a minimum of 5 years experience in reinforced concrete and structural steel design for industrial structures. Attractive salary. Group Insurance. Apply in writing, stating experience to: Integrated Consultants Limited, 6484 Sherbrooke West, Montreal 28, Quebec. File No. 7374-V.

GRADUATE ENGINEER, bilingual, to visit architects and consulting engineers, etc., manufacturers of heating and air conditioning equipment. Salary commensurate with qualifications. Retirement plan, health benefits, life insurance. This position to be filled soon. Apply File No. 7376-V.

METALLURGISTS

Openings at senior and intermediate level in a reactor design and development organization in Toronto engaged in the design of a 200 MW nuclear power station under construction in Ontario. Duties will consist of advising on the use of materials, preparing specifications, product control liaison with suppliers, supervision of laboratory work and assisting in development projects.

Applicants should be metallurgical graduates or equivalent and should have experience in heavy engineering, corrosion work or reactor metallurgy. Superannuation, group insurance, hospital, medical-surgical and vacation plans.

Please state all particulars in first letter to

File T 11 B

ATOMIC ENERGY OF CANADA LIMITED
NUCLEAR POWER PLANT DIVISION
P.O. Box 905
Toronto 18, Ontario

STANDARDS ENGINEER — Graduate with three to five years' time-study experience in heavy industry, to supervise small time-study section in the establishment and maintenance of incentives and work measurement standards. Send resumé and salary requirements to — Supervisor of Salaried Employment Atlas Steels Limited, Welland, Ontario. File No. 7369-V.

WELDING ENGINEER

A graduate engineer is required to work under the direction of a senior engineer to develop welding practices for aluminum alloys when used in such structures as pipe-lines, motor transports and trucks, ships, railway vehicles, etc. Complete familiarity with all welding processes will eventually be required and a certain amount of actual welding skill will have to be developed. As soon as capable, will be expected to plan and carry out investigations dealing with original development and customer service. Co-operation with group companies on sales problems and some travel will be expected. Location: Aluminum Laboratories Limited, Kingston, Ont. *Please write confidentially to:*

ALCAN

ALUMINUM COMPANY OF CANADA, LIMITED
Staff Personnel Department,
Box 6090,
Montreal 3, P.Que.

Business and Industrial Briefs

Appointments and Transfers

Canadian General Electric Company has announced the appointment of **D. John Dalton** as manager of marketing-apparatus and supplies in the wholesale department of the company. Mr. Dalton has been with the company since 1934.

R. E. Haskins has been appointed as vice-president-production for B. C. Cement Co. Ltd. and Evans, Coleman & Evans Ltd. Mr. Haskins has managed the Bamberton plant of B. C. Cement for the past 11 years.

The Franklin Institute Laboratories has announced the appointment of **Dr. Frederick T. Hedgcock** as manager of the magnetics and semiconductor laboratory. Dr. Hedgcock was former associate professor of physics at the University of Ottawa.

Harry R. Yates, executive vice-president of J. A. Wilson Lighting Ltd., has announced the appointment of **Donald C. McCormack** as director of research and product development and **Hedley R. Davidson,** P.Eng., as manager of engineering for the company. Mr. McCormack joined the company in 1950 and prior to his new appointment was manager of product development and engineering. Mr. Davidson joins the company with extensive experience in the field of illumination.

Two new executive appointments at Montreal Locomotive Works, Ltd. include **A. Hugh Paton** as manager engineering and development, and **Ira I. Sylvester** as manager transportation products.

Claude Senneville, P.Eng. has been appointed president of Terratech Ltd. He obtained his B.A.Sc. (engineering) from the Ecole Polytechnique de Montreal in 1947, and his Master of Science degree in soil mechanics from Harvard University.

New appointments to the faculty of engineering at McMaster University include: **Dr. Keith H. Swainger**, sessional professor of civil engineering; **Dr. Robert G. Ward**, associate professor, Steel Company of Canada Chair of metallurgy and metallurgical engineering; **Dr. Albin I. Johnson**, associate professor of chemical engineering; **Dr. Michael B. Ives**, sessional assistant professor of metallurgy and metallurgieal engineering; and **Dr. Neville F. Rieger,** sessional assistant professor of mechanical engineering.

Frick of Canada Ltd. has announced the appointment of **Robert B. Kay** as executive engineer. Prior to his present appointment Mr. Kay was with an English manufacturer of industrial and marine refrigeration and air conditioning equipment, and in 1955 he joined their Canadian operation.

Peter D. Stevens has been appointed vice-president of Crane Ltd. Mr. Stevens, who organized the Engineered Products Group of the company and has directed its sales operations since its formation early this year, will retain management of this group.

Honeywell Controls Ltd., has announced the appointment of **Peter M. Wood** as engineering field representative. Prior to joining Honeywell he held senior engineering positions with firms in the commercial combustion equipment manufacturing field.

Union Carbide Canada Ltd. has announced the appointment of **Arthur A. Allan** as assistant to the vice-president, operations. Mr. Allan was formerly sales manager, plastics, for the company's chemicals and plastics division.

Developments

Information contained in this section has been obtained from press releases. Mention of products and services does not imply endorsement by the Institute.

DOMINION M. I. LTD., is a new Canadian firm with plants in Montreal and Toronto. This company was formed to take over the activities of Bepco Canada Ltd., which ceased operations at the end of October. Dominion M.I.'s manufacturing facilities will produce a wide variety of standard and custom-built equipment making use of electronic, transistor and magnetic amplifier techniques, ranging from simple devices to complex integrated automatic control systems.

NEW, HIGH-QUALITY Sandvik Coromant HF-treated tapered rods have been introduced to the Canadian mining market by Atlas Copco Ltd. Tests have indicated that the new tapered rod will reduce rod costs by more than 25 per cent. This has been achieved through high-frequency treatment which produces a surface-hardened outer layer on the rod, while providing a softer and tougher core for increased strength.

THE DIRECTORS of Advocate Mines Ltd. have decided to equip the Newfoundland Advocate Mill with a capacity of 5,000 tons of ore per day, rather than the 3,000 tons per day originally planned, it was announced recently by Karl V. Lindell, Chairman of the Board of Canadian Johns-Manville Co. Ltd.

IN CONSTRUCTING the walls of the reactor building at Douglas Point Nuclear Power Station last summer, Ontario Hydro used ice-cooled concrete. Atomic Energy of Canada Ltd. is building the 200,000-kilowatt plant on the shore of Lake Huron and Ontario Hydro is acting as construction agent and will operate the station when it goes into service in 1965. The thick wall of the circular reactor structure, which is 135 feet high and 130 feet in diameter, had to conform to rigid specifications calling for a leakproof building. This posed a problem, as when concrete is placed at high temperatures there is a greater possibility of cracks developing as it cools. Hydro solved the problem by mixing crushed ice with the concrete to keep the temperature down. The method may be employed again at Douglas Point next year for concrete in the reactor vault, and may also prove useful on future projects.

GARDNER-DENVER CO. of Quincy, Illinois, has introduced a new line of heavy duty compressors for continuous operation in all types of industrial service. Five types are now included in this series including standard, oil-free, tandem, gas, and vacuum type compressors. These new compressors will be in the 20 to 150 horsepower range with maximum speeds up to 675 RPM and capacities ranging from 108 to 1,592 CFM displacement. The addition of a new five-inch stroke machine permits comparable air deliveries with smaller units than those previously available.

"ADVENTURE IN STEEL," a film portraying the operations of the steel mills of Algoma Steel Corporation Ltd. at Sault Ste. Marie, Ont., is now available in French. The film is a 16 mm., color, sound film of 32 minutes running time, of interest to technical and non-technical groups.

CANADA IRON FOUNDRIES, LTD., is merging its wholly-owned subsidiaries into the corporate structure of Canada Iron. H. J. Lang, president, announced that by Nov. 30 the main operating subsidiaries will function as seven operating divisions. These Divisions will include: Foundry, Mechanical, Municipal Products, Pressure Pipe, Tamper, Dominion Structural Steel and Western Bridge. The new divisions, except Western Bridge, will retain their company names. Western Bridge will encompass the steel fabricating activities formerly handled by C. W. Carry Ltd.; Calgary Structural Steel Ltd.; and Western Bridge and Steel Fabricators Ltd. Railway & Power Engineering Corporation, Ltd. and C. M. Lovsted (Canada) Ltd., wholly-owned sales agency companies will retain their present corporate identities.

AN ILLUSTRATED POSTER put out by The Master Builders Co. Ltd., describes the importance of and the methods used in curing concrete. It covers the effects of temperature on curing and describes many curing techniques, including water spray, damp burlap, waterproof paper and membrane curing compounds.

DOMINION BRIDGE COMPANY has purchased from Runnymede Steel Construction Ltd. of Toronto, substantially all of its fixed assets consisting of land, buildings, machinery and equipment and its inventories of materials. The properties acquired consist of an office and plant on three acres of land on Dundas Street in Toronto, and a fabricating plant on 15 acres of land at Dixie, Ontario.

TWO NEW TYPES of fire for effective heat control in prepared atmosphere have been produced by Canadian Johns-Manville Co. Ltd. The new bricks, JM 23 and JM 20, are designed for direct exposure and back up insulating purposes. They have been designed for service to 2300 degrees and 2000 degrees F respectively. Planned primarily for resistance to the effects of CO, H2, and CH4, they are made from clays which are blended with a burn-out material and plaster of Paris.

CONSTRUCTION of a 20,000-ton polybutadiene plant for Polymer Corporation, Sarnia, is scheduled for completion in the fall of 1962. This is the fourth major Polymer project started in Sarnia this year. The others are: facilities for the production of black masterbatch, a new butadiene extraction unit, and a new marketing building.

(Continued on page 98)

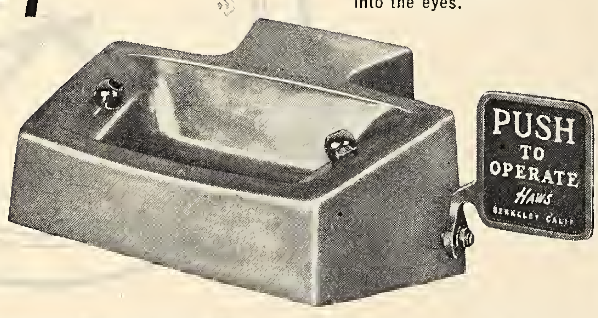
EIC CERTIFICATE OF ADVERTISING MERIT

After sharing the Monthly Award for the best advertisement in the Engineering Journal for July, The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ont., has won again for September.

The Algoma advertisement announces the Canadian produetion of wide flange beams in the Company's new Universal Beam Mill, "fully competitive with imports". The illustration is a striking 4-colour photograph of the rolling mill in action.

The advertising manager of The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ont. is L. F. Mason-Tulby, and the advertisement was prepared and placed by Cockfield, Brown & Company, Toronto. Aeeount Executive, F. D. Adams.

Each month a different panel of fifty Journal readers from aeross Canada is asked to nominate an award-winning ad of their ehoice from the viewpoints of ACCURACY — INFORMATION — ATTRACTION.



More Briefs (continued from page 97)

CANADIAN WESTINGHOUSE has introduced a 10-ampere silicon transitor with a current gain of 1,000 at two amperes and a 0.35-ohm saturation resistance. The device, designated WX118, has voltage ratings up to 150 volts and a power dissipation rating of 150 watts. It is ideally suited for application in high-power, high-efficiency regulators, amplifiers, and switching circuits.

A BOOKLET, describing a liquid oxygen cylinder with a capacity of 3,000 cubic feet of oxygen, is now available from Union Carbide Canada Ltd., Linde Gases Division. The large capacity "Linde" LC-3 liquid oxygen cylinder supplies the equivalent of 12 "K" type high-pressure cylinders. The cylinder's weight is only 463 pounds and it requires only one third the space in storage or operation as its equivalent in high-pressure cylinders.

PLANS for the enlargement and modernization of the head office building of Canadian Kodak Co. Ltd. have been announced by Donald C. Kerr, president. Changes will include the addition of two floors and the complete renovation of the present three-storey structure.

A SERIES OF NEW EXTERNAL PRIMERS exceptionally powerful and designed in all sizes to initiate blasting agents with a high degree of efficiency, even under particularly adverse conditions, is now available from the explosives division of Canadian Industries Ltd. These "Pento-Mite" primers are made from cast pentolite, are cylindrical in shape, with a suitable hole to accommodate the Primacord downline and a rectangular opening to allow a special retaining hook to be employed.

ACCESSORIES to facilitate transportation of the portable, 66-lb. "Pionjar" combined rock drill and concrete breaker are described in a folder issued by Flygt of Canada Ltd. The caddy cart, with rubber-tired wheels, provides easy transit between working sites, while the carrying harness is useful in areas of rugged terrain where manual conveyance over exceptionally long distances is necessary.

CANADIAN GENERAL ELECTRIC's high temperature box furnaces with molybdenum resistor for operation at 2300 F or 3200 F are described in a new four-page bulletin, GED-4305. The publication discusses economical operation of furnace designed for bright brazing, annealing, sintering and forging stainless steel, magnetic materials and molybdenum. EIC

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

Address all information to The Engineering Journal, Editorial, 2050 Mansfield Street, Montreal 2, P.Q.

Libary Notes (continued from page 84)

*THERMODYNAMIC FUNCTIONS OF GASES, VOLUME 3.

Methane, nitrogen, and ethane are covered in this volume, which is the third in a series designed to provide reliable thermoydnamic data for all gases of industrial importance. Existing data on their thermal properties are surveyed in a critical fashion, tables of the most reliable values are given, and constructions of the thermodynamic diagrams are included. The information included was gathered together under the direction of the Thermodynamics Committee of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research, Great Britain. (Ed. by F. Din. Toronto, Butterworths, 1961. 218p., $12.50.)

*DIFFUSION AND HEAT FLOW IN LIQUIDS.

The first section of this work is an exposition of the principles of non-equilibrium thermodynamics, and their application to diffusion flow and heat flow in liquids. This section is fairly complete in itself, and is followed by sections devoted successively to diffusion in isothermal and non-isothermal liquid systems and to thermal conduction in liquids. In each section, the relevant experimental techniques are described, and the results discussed in terms of currently used theories. (H. J. V. Tyrrell. Toronto, Butterworth, 1961. 329p., $12.25.)

*ELEMENTARY FLUID MECHANICS, 4TH ED.

An introductory work which is concerned with the application of fluid mechanics to the solution of the numerous and diversified problems encountered in many fields of engineering. It covers fluid statics, kinematics of fluid motion, flow of an incompressible and of a compressible ideal fluid, the impulse-momentum principle, flow of a real fluid, fluid flow in pipes and open channels, fluid measurements, and fluid flow about immersed objects. The significant changes in the present edition include more stress on flowfield concepts requiring use of the partial derivative, a deeper treatment of compressible flow, and a new chapter on some elementary concepts of mathematical hydrodynamics. (J. K. Vennard. New York, Wiley, 1961. 570p., $7.95.)

UNITES DE MESURE DES GRANDEURS PHYSIQUES.

Rather than promoting any one system of measurements, this volume attempts to make easier the relations between them, and solve the problems connected with changing systems.

It defines the various physical measurements, gives equations for changing from one system to another, and discusses the various systems in existence in geometry, mechanics, electricity, magnetism, heat and photometry. An appendix gives more detailed information on the rationalized MKSA system. (P. Debraine. Paris, Dunod, 1961. 186p., 24 NF.)

*SERVOMECANISMES ET REGULATION, T. 2.

Translated from the 1955 U.S. edition, this is an advanced treatment intended for practical designers and graduate students. It covers measurement techniques; specifications; methods of selecting power and stabilizing elements; amplifier design; all-a.c. servomechanism design; and non-linearities in control system design. Illustrative problems adapted from actual design projeets are included. (H. Chestnut and R. W. Mayer. Paris, Dunod, 1961. 406p., 68 NF.)

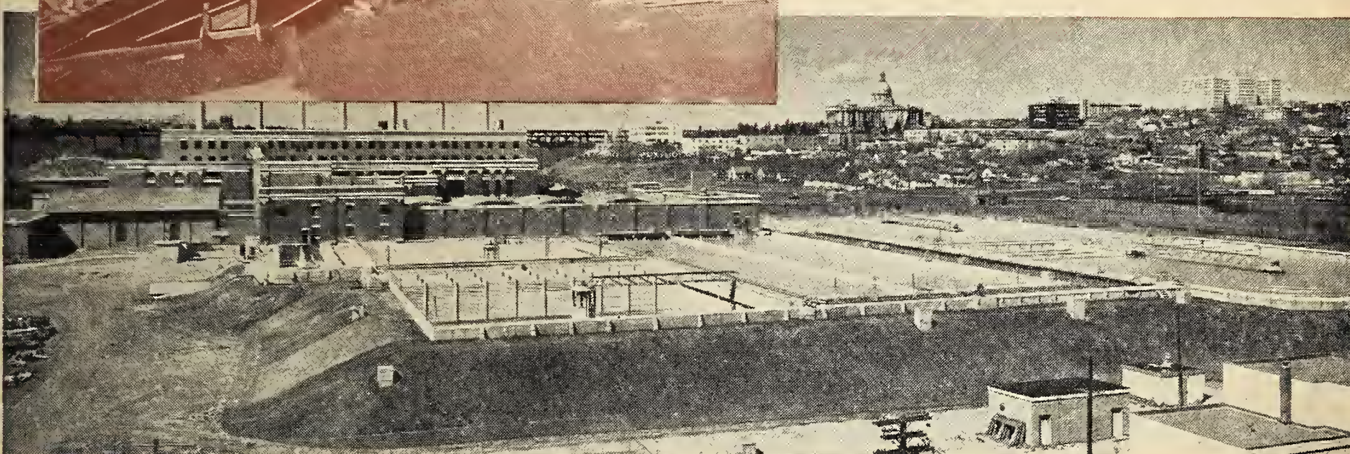
*THE BRITTLE FRACTURE OF STEEL.

Dr. Biggs (Cambridge University) writes to reconcile the differing approaches to the problem of brittle fracture by the engineer, the metallurgist, and the physicist, and to emphasize those metallurgical features which determine whether the material will behave in a ductile or a brittle manner. This is neither a source-book nor a textbook on the plastic deformation and fracture of engineering materials. It is an attempt to promote a clearer understanding of the material, design, and fabrieation problems involved in the brittle behavior of metals. The author discusses service failures, mechanical aspects of flow and fracture, the effect of external conditions and of such fabrication processes as welding, the nucleation and propagation of fracture, mechanical tests and correlation of test results, and residual stresses. (W. D. Biggs. Toronto, Burns and MacEachern, 1961. 420p., $15.00.)

(Continued on page 104)

TRADE MARK REG'D

CCC Pressure Treated Foundation Piling



Modern water filtration plant at Edmonton, Alta., supported on "CCC" timber piling — shown at top during installation.

an example of

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Strength, permanence and economy are three big reasons why "Triple C" Brand Piling and other Pressure Treated Wood Products are specified for so many important construction projects across Canada. Roof and deck planking; wharf and mine timbers; wood block floors; poles and lumber for versatile, low-cost pole type buildings . . . these are a few of the long-lasting, economical "CCC" Brand Pressure Treated Wood Products available *when you need them* from Canada Creosoting's coast-to-coast network of plants and sales offices to serve you.

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Trenton, Ont.	Prince Albert, Sask.	North Vancouver, B.C.

CANADA CREOSOTING COMPANY LIMITED

1400 METCALFE ST., MONTREAL, QUE.

DIVISION OF DOMINION TAR & CHEMICAL COMPANY, LIMITED

Library Notes (continued from page 102)

*ELEMENTARY STATICS OF SHELLS, 2nd. ed.

A simple and comprehensive presentation of the theory of shells of revolution, cylindrieal shells, and shells of general shape. Translated from the German, this work is primarily a graphic study of the spatial interplay of forces in shells. The author's approach permits visual interpretation of equations, and once the basic equations are set down, their result can be interpreted practically in tables and graphs. (Alf Pfluger. New York, Dodge, 1961. 122p., $8.75.)

NEWTONIAN SCIENCE.

The history of seience of one particular period, the seventeenth and eighteenth centuries, which laid the foundations of modern science, and determined the course of modern civilization. The author considers the nature of science, and the historical development whieh brought scientific problems to the attention of educated men. He discusses the work and influence of such men as Johann Kepler, Simon Stevin, Descartes, Isaac Newton, Christian Huygens, John Locke, and Voltaire. (A. E. Bell. Toronto, Macmillan, 1961. 176p., $4.10.)

CONSTRUCTIONAL STEELWORK SIMPLY EXPLAINED, 4th ed.

Revised by John Faber, this fourth edition has been brought up-to-date to comply with the 1959 issues of British Standards 15 and 449, in which the allowable stresses have been revised, as is shown in the practical examples given. Also in this edition, additional information is given on high-strength friction grip bolts, welded and bolted connections, shear forces in beams, broad-flange and universal beams. Other topics covered are properties of steel, elasticity, safety factors, bending moments, and stanchions and stanchion bloom-bases. The volume is intended for students and those interested in the design of steelwork in a practical way. (Oscar Faber. Toronto, Oxford, 1960. 123p., $2.50.)

More Library Notes on page 109

Library Notes (continued from page 104)

*WAVE PROPAGATION IN A TURBULENT MEDIUM.

This translation and Chernov's "Wave propagation in a random medium" (McGraw-Hill, 1960) furnish a comprehensive and authoritative survey of the present state of research in the field of wave propagation in turbulent media, with special emphasis on important Russian contributions. Tatarski's material has been supplemented by remarks by the translator, lists he has compiled of readily available English translations of Russian papers, and an appendix qualifying the material in Chapter 5 (scattering of sound waves in a locally isotropic turbulent flow). The four sections of the book deal with the theory of random fields and turbulence theory, scattering of electromagnetic and acoustic waves in the turbulent atmosphere, parameter fluctuation of electromagnetic and acoustic waves propagating in a turbulent atmosphere, and experimental data on parameter fluctuations of light and sound waves propagating in the atmosphere. (V. I. Tatarski. Toronto, McGraw-Hill, 1961. 285p., $9.75.)

*LARGE ELASTIC DEFORMATIONS AND NON-LINEAR CONTINUUM MECHANICS.

In a previous book (Theoretical Elasticity, 1954), Mr. Green collaborated in presenting the general theory of elasticity for finite deformation, with applications for isotropic incompressible materials. The present book concentrates on subsequent developments, including the strain energy function for the basic crystal classes; stress-strain relations for orthotropic and transversely isotropic materials; curvilinear aeolotropy and exact solutions of the finite theory, mainly for aelotropic bodies; development of the theory of plane strain; plane stress and the membrane theory of thin shells; a method of successive approximation; and the reinforcement of elastic materials by systems of thin flexible inextensible cords. The final chapters deal with the theories of thermoelasticity and elastic stability for finite deformation, and recent developments in non-linear continuum mechanics. (A. E. Green and J. E. Adkins. Toronto, Oxford, 1960. 348p., $8.25.)

*THE COMPLETE SCIENTIST.

"An enquiry into the problem of achieving breadth in the education at school and university of scientists, engineers and other technologists" as the subtitle indicates, this is a report of the Leverhulme Study Group to the British Association for the Advancement of Science. It reviews for the first time and considers as a whole the successive stages in the education of the would-be graduate scientist or engineer from elementary school to the post-graduate course. "It will make a significant contribution to the problem of giving adequate weight to non-scientific subjects in the education of these students . . .", states Sir George Thomson, President of the B.A.A.S. in the Preface. (Toronto, Oxford, 1961. 162p., $2.75.)

*PLASMAS AND CONTROLLED FUSION.

The major portion of this work is concerned with plasma physics, hydromagnetics, and elementary gaseous electronics in association with transport and electromagnetic theories. The last four chapters deal in a more specific way with the controlled fusion problem, including experimental and theoretical approaches, and methods of eventual energy recovery. Problems and references are attached to each chapter. (D. J. Rose and M. Clark. New York, Wiley, 1961. 493p., $10.75.)

*MANAGEMENT PROBLEMS IN THE ACQUISITION OF SPECIAL AUTOMATIC EQUIPMENT.

The key steps in the acquisition of nonstandard, nonconventional automatic equipment are described. There are analyses of commonly encountered trouble spots such as debugging, working with equipment vendors, co-ordinating product design and the automatic equipment, and the important organizational relationships between the equipment group and other units. Emphasis is placed on administrative rather than technical or engineering matters. (Powell Niland. Boston, Harvard University, Graduate School of Business Administration, 1961. 336p., $5.00.)

*STABWERKKNICKUNG.

A ready-reference book on buckling which summarizes the various theories to date and deals with the different methods of analysis of buckling members of various types. Emphasis has been put on helping practising engineers find quick data on stability, on the determination of the critical P_k load, etc. For the nearly 1000 methods and formulas extensive charts and numerical tables have been developed. (Heinz Vetter. Berlin, VEB Verlag Technik, 1960. 612p., DM 50.00.)

*OPTIMUM DESIGN OF MECHANICAL ELEMENTS.

After a fundamental consideration of the general problem of mechanical design, the author discusses some approximations for explicit design, the effects of manufacturing errors on product performance, optimum choice for method of analysis, and the mechanical properties of materials. He then presents a method of optimum design for mechanical elements which is formulated on the basis of an overall study of solutions to many specific design problems. This method is illustrated by its application to the design of axially loaded members, torsion shafts, beams, a shaft with combined loading, and gears. (R. C. Johnson. New York, Wiley, 1961. 535p., $11.50.)

*INFLUENCE LINES FOR PLANE AND THREE-DIMENSIONAL CONTINUOUS STRUCTURES.

A practical guide for obtaining influence lines for statically indeterminate plane and three-dimensional structures. The method used allows a three-dimensional structure to be solved in the time normally required for the solution of a two dimensional one. A clear visualization of the physical phenomenon and automatic self-correction of computation errors are other features of this work. (S. Chemecki. New York, Ungar, 1961. 85p., $4.50.)

*THE IMPACT OF THE PROFESSIONAL ENGINEERING UNION.

The subtitle describes the book as a study of collective bargaining among engineers and scientists and its significance for management. It reports on research into the experiences of eleven companies where professionals have organized certified bargaining units. The three main sections discuss the impact on compensation, on personnel administration, and on the engineering organization. Appendix A is a compilation of existing unions representing engineering and technical employees. (R. E. Walton, Boston, Harvard University, Graduate School of Business Administration, 1961. 419., $5.00.) EIC