APPLIED SCIENCE

INCORPORATED WITH

TRANSACTIONS *of the* UNIVERSITY *of* TORONTO ENGINEERING SOCIETY

Vol. IX - New Series

May, 1914, to April, 1915

PUBLISHED BY

THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

ENGINEERING BUILDING

UNIVERSITY OF TORONTO, CANADA

Index, Vol. IX.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, MAY, 1914 New Series Vol. IX. No. 1

THE MANUFACTURE OF STEEL TUBING

Illustrated from Mine to Finishing Operations

F. N. Speller, B.A.Sc., '93.

Metallurgical Engineer, National Tube Company, Pittsburgh, Pa.

This industry, as a whole, is illustrated for the first time by motion pictures and lantern slides this evening. That portion which deals with the mining operations, blast furnaces, mixer, steel works, blooming and slabbing mills and skelp mills is common to the manufacture of practically all steel products. The manufacture of welded tubes is shown in detail, and the seamless processes are taken up in outline by means of diagrammatic slides.

In consideration of the presence of the members of the Central Railway and Engineering Society, what follows will have special reference to the application of steel tubing to mechanical construction, particularly to locomotives.

The proportion of iron and steel tubing used in locomotive construction is so large that experience with the various materials of which this tubing is made in locomotive practice, forms by itself a good criterion of the value of such materials for general machine construction. Hence we might first consider locomotive tubes and the relation which has been found between the properties of the material and the mileage record of the engine.

Service and Laboratory Tests

We have, as you are aware, three classes of tubing for boiler work: lap weld charcoal iron, lap weld steel and seamless steel. The first of these has been able to hold its own until recently, in spite of the comparatively inferior physical properties, probably due to the impression that charcoal iron was better able to resist corrosive conditions and was easier to weld than most grades of steel. The numerous laboratory tests which have been made in researches on this subject, particularly during the last ten years, have not shown the difference expected under natural conditions of corrosion; however, these tests were not considered entirely satisfactory by practical men. Service tests were started by a number of the leading railroads, about the same time as these laboratory investigations and there is now available plenty of data from both sources. Most of these practical service tests were made by applying charcoal-iron and steel tubes, side by side, in the same boiler. When conditions developed which made it necessary to remove the tubes, they were cleaned and inspected, the corrosion being judged usually by the number of tubes of each set which had to be discarded, and the relative depth of pitting. Table 1 contains several recent examples of such investigations, typical of tests which have been run on many roads.

Tubes for Corrosive Conditions

When it comes to a choice of tubes to withstand corrosive conditions, we usually recommend "National" lap-weld steel tubes, which have the advantage of a patented process of roll-knobbling, that the steel receives in being worked down from the bloom to the plate. By this kneading operation the metal receives considerably more mechanical work laterally, is made uniformly dense, and other conditions being equal, is more resistant to corrosion.

Advance in Modern Steel Tubes

The increased use of steel tubes in later years, is probably due to a recognition of the physical superiority of the material, together with a better understanding of the causes of corrosion. A special grade of open hearth steel has been developed which is now used in the manufacture of both lap-weld and seamless tubes. Particular attention is given to the welding quality of this steel, and its power to withstand manipulation in setting and reworking. There is now practically no loss in installing modern steel tubes, either lap weld or seamless, and as they will withstand, without cracking, so much more expansion than the old charcoal iron, it is not a matter of much consequences; if the flue-sheet hole happens to be worn a little large. The sectional expander may be used in setting, without fear of splitting the tube, and a good shoulder obtained behind the sheet and a strong bead in front, thus holding the tube firmly in the flue sheet. The sectional expander, or if preferred, the roller expander, may be used on this class of steel tubes until the tube is too thin for further service without injury to the metal. The steel being stiffer than the iron, requires less attention on account of leaking while in service, which means, of course, considerably less cost for maintenance. The steel beads are stronger than charcoal iron and much better able to resist the various stresses incident to modern service. In order to be sure that each lap-weld tube is up to the required standard, a machine was designed to turn a flange on the crop ends cut from each tube. This testing operation, as carried out every day in the mills, is illustrated in motion pictures at this meeting.

Wearing Quality in Flue Sheet

With respect to durability in the flue sheet, there is abundant evidence on record to show that the mileage with modern "National" steel tubes is considerably greater under the same conditions than with charcoal iron. In table II, we give a few comparative figures from various railroads indicated by letter. One of the most remarkable examples of unbroken service is that illustrated by the Lehigh Valley Railroad passenger engine No. 2479, which in June, 1913, completed 245,675 miles in 28 months, pulling an average 450-ton train, on one set of lap-welded steel tubes.

(Details regarding this engine can, no doubt, be obtained by addressing the superintendent of motive power.) This brief summary will suffice to explain why the leading American tube interest has discontinued the manufacture of charcoal iron tubes.

Safe Ending

With a little attention and some experience, the welding on of safe ends, steel to steel, should cause no particular difficulty. Much less is heard of difficulty in this connection to-day and there is certainly less possibility for trouble when the practice is to use steel exclusively, as is now the case in a number of shops, rather than to switch from iron to steel alternately; for the same reason the manufacture of one grade of steel for all tubes has also helped to bring about a more favorable condition.

In safe ending in the usual way it is best to heat the body tube to a bright orange color (about 1750° F) for expanding, and allow it to cool to at least a blue heat before reheating for welding. Precaution should be taken not to overheat the metal near the weld, which is more liable to occur if there is much difference in gauge between the body tube and safe end.

Electric Butt Welding

The recent application of electric butt welding to safe ending is worthy of careful consideration. It has an important advantage in that the metal away from the weld cannot readily become overheated. It appears to be easy to control, is economical and should give a continuous, fine grained structure through the weld. Some tests recently made in our laboratory show an electric butt weld to have ninety per cent. of the strength of the metal.

About ninety per cent of the locomotives in America are now equipped with steel safe ends. Some still adhere to the use of charcoal iron body tubes carrying steel safe ends. The reason for this apparent inconsistency is not plain.

Seamless Tubes in Machine Design

An increasing amount of seamless tubing is being used for mechanical purposes. The variety of shapes and physical properties which can be obtained in tubular sections gives this product special advantages for many purposes. A large proportion of the tonnage of mechanical seamless tubing made in America goes into automobile parts, bushings, roller and ball bearing, hollow axles, gas containers, working barrels, drill pipe, etc., etc. We have compiled a list showing 300 separate uses.

A few typical examples of the application of seamless tubing to machine design are illustrated at the end of this paper, these showing bending, expanding, swaging, tapering, deforming, closing of ends, upsetting and various combinations of these operations.

Table III gives in brief form the physical properties of the standard steels used in the manufacture of Shelby Seamless Steel Tubing, with standard heat treatment. The low carbon grade is particularly adapted to case hardening, and is frequently used in tubular forms for this purpose.

American vs. German Practice

The manufacture of tubes and pipe in the United States differs from the German practice, principally in that the welding process has been further developed and predominates in United States; whereas in Germany the manufacture of seamless tubes has been so simplified and cheapened as to generally fill the uses to which welded pipe is more generally applied in this country. In Germany this is accomplished by the use of small cast round ingots which are fabricated directly into tubes without the intermediate blooming mill and bar mill rolling operations. Of course the finished product is comparatively inferior in quality and cannot be compared with the tubes made from the rolled round or cupped plate, but may be sufficiently sound for many purposes. In Germany, as here, solid rolled rounds made of selected steel are used for the better class of tubing, and in special cases the solid round is drilled through cold and then rolled down over mandrils in the usual manner. There is naturally a wide difference in price in German seamless tubes, depending on the purchasers' specifications, which determines the process by which the tubes are to be made and how rigid an inspection shall be given.

Investigation has shown that so far as the quality of steel itself is concerned, our methods of manufacture give as good a quality of metal for seamless tubes as the best quality made in Germany. The fabrication of the steel puts a great strain on the metal and more or less loss is expected, principally on account of cracks and light surface defects. Most of these are quite insignificant in depth and do not affect the strength of the tube perceptibly, but, as they tend to spoil the appearance of the highly finished surface, a rigid inspection is employed to cull out tubes showing such defects. The surface defects caused in the first operations of manufacture are removed, as far as practicable, with pneumatic chisels, before the blank is worked any further. At present in the United States, practically all seamless steel tubing is made from solid rounds rolled from the blooms, the principle exception being seamless containers which are made by the plate and cup process.

Significance of Inspection

If any difference in quality or finish is noticed between American and German seamless tubes it is probably due to the system of inspection which depends on the specifications and the use for which the tubes are made. For instance, it would be waste to put more than fifty cents per ton on inspection of a lot of tubes for one purpose, whereas the same lot might require several dollars per ton to fit it for other conditions. Hence it is most important in ordering seamless tubes to specify clearly for what they are to be used, and as far as possible, adhere to standard specifications.

In looking at the relative advance in the iron and steel industry in America and Germany, it would be well to consider what industrial research has had to do with efficiency.

The details of the industry in each of these countries have been worked out so far in a way best suited to their respective conditions. The problems in America have been handled, for the most part by men who have depended more on practical than high technical training with the object of achieving immediate results to satisfy the pressing demands of the times.

Our general public have a confused or imperfect idea of the significance of industrial research to the ultimate development of our industries.

In Germany, on the contrary, industrial research has become a highly specialized branch of their industries and receives the popular recognition and support so necessary to the largest success.

It seems safe to predict that with the dispelling of public indifference to this kind of research and the training of men along sound scientific lines who will combine in their work energy and audacity with a strong sense of initiative, even Germany must soon yield to America in the worth and volume of achievements in this field.

Value of Standard Specifications

In closing it might be of interest to say a word briefly on the question of specification for steel tubes. Several years ago there were in use in America twenty or thirty specifications for locomotive boiler tubes, all differing slightly but sufficiently to require special attention to each individual order going through the mill. This, of course, increased the cost to the manufacturer and consumer, with no corresponding benefit in the quality of the product.

The author endeavored to arouse interest in this matter in a paper before the American Society for Testing Materials, June 27, 1911, after which a committee was appointed, consisting in the majority of railroad engineers through whose work the first standard American tube specification was adopted in 1912. In the following year this committee, in conjunction with another of the American Master Mechanics' Association, who had been laboring along the same lines, adopted a combined specification for tubes in June, 1913, which is reprinted on another page for reference. (See below).

Whatever your personal views may be on the question of specications, this one should receive your careful study and consideration before deciding to write any other. It was only adopted after years of discussion and investigation on every item by engineers representing large manufacturers and users of tubes, and their recommendations were accepted without change by two of the largest engineering societies of the country. The National Tube Company also have a number of specifications for special products, such as steel shipping containers for compressed gases and liquids, trolley poles, signal pipe, etc. Whenever standard specifications are agreed upon, it has been our practice to accept these as the standard of manufacture.

Standard Specifications for Lap-welded and Seamless Steel Boiler Tubes, Safe Ends and Arch Tubes (including superheater tubes) as revised jointly, 1913, by the American Railway Master Mechanics' Association and the American Society for Testing Materials

1. Manufacture

1. Process. The steel shall be made by the open-hearth process.

II. Chemical Properties and Tests

2. Chemical composition. The steel shall conform to the following requirements as to chemical composition:

Carbon	0.08—0.18 per cent.
Manganese	0.30—0.50 per cent.
Phosphorus	not over 0.04 per cent.
Sulphur	not over 0.045 per cent.

3. Chemical Analyses. · (a) Analyses of two tubes in each lot of 250 or less may be made by the purchaser, which shall conform to the requirements specified in Section 2. Drillings for analyses shall be taken from several points around each tube.

(b) If the analyses of only one tube does not conform to the requirements specified, analyses of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

III. Physical Properties and Tests

4. Flange Tests. (a) A test specimen not less than 4 inches in length shall have a flange turned over at right angles to the body of the tubes without showing cracks or flaws. The flange as measured from the outside of the tube, shall be three-eighth inch wide for tubes 2½ inches or less outside diameter, and ½ inch wide for tubes larger than 2½ inches outside diameter.

(b) In making the flange test, the flaring tool and die block as shown should be used.

5. Flattening Tests. A test specimen 4 inches in length shall stand hammering flat until the inside walls are in contact, without cracking at the edges or elsewhere. For lap-welded tubes, care should be taken that the weld is not located at the point of maximum bending.

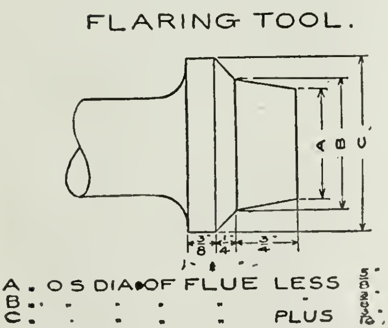
6. Crush Tests. A test specimen 2½ inches in length shall stand crushing longitudinally until the outside folds of metal are in contact, without showing cracks or flaws.

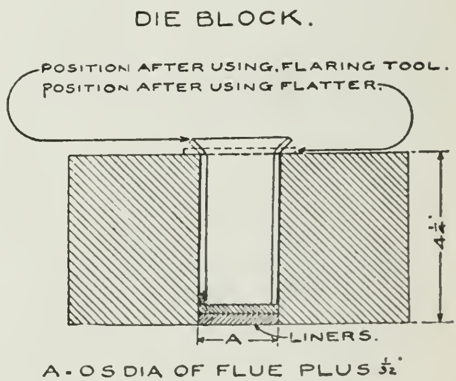
7. Hydraulic Tests. Tubes under 5 inches in diameter shall stand an internal hydraulic pressure of 1,000 pounds per square inch, and tubes 5 inches in diameter or over an internal hydraulic pressure of 800 pounds per square inch.

8. Test Specimens. (a) Test specimens shall consist of sections cut from tubes selected by the inspector representing the purchaser from the lot offered for shipment. They shall be smooth on the ends and free from burrs.

(b) All specimens shall be tested cold.

9. Number of Tests. One flange, one flattening and one crush test shall be made from each of two tubes in each lot of 250 or less. Each tube shall be subjected to the hydraulic test.





10. Retests. If the results of the physical tests of only one tube from any lot do not conform to the requirements specified in Sections 4, 5, or 6, retests of two additional tubes from the same lot shall be made, each of which shall conform to the requirements specified.

IV. Standard Weights

11. Standard Weights. The standard weights for tubes of various outside diameters and thicknesses are as follows:

Weight in Pounds Per Foot in Length

Thickness		Outside Diameter in Inches												
In.	Nearest B. W. G.	1¾	2	2¼	2½	3	* 3½	* 4	* 4½	* 5	* 5¼	* 5⅜	* 5½	* 6
0.095	13	1.68	1.93	2.19	2.44	....	....	....	....					
0.110	12	1.93	2.22	2.51	2.81	3.40	....							
0.125	11	2.17	2.50	2.84	3.17	3.84	4.51	....						...
0.135	10	2.33	2.69	3.05	3.41	4.13	4.85	5.57	....	....	....	....	....	....
0.150	9	2.56	2.96	3.36	3.76	4.57	5.37	6.17	6.97	7.77	8.17	8.37	8.57	9.37
0.165	8	....	....	....	4.11	5.00	5.88	6.76	7.64	8.52	8.96	9.18	9.40	10.28
0.180	7	....	....	....	4.46	5.42	6.38	7.34	8.30	9.27	9.75	9 99	10.23	11.19

*Note. It is regular practice of National Tube Co. to furnish for locomotive purposes sizes larger than 3″ O.D. in Seamless only.

12. Permissible Variations. The weight of the tubes shall not vary more than 5 per cent. from that specified in Section 11.

V. Workmanship and Finish

13. Workmanship. The finished tubes shall be circular within 0.02 inch, and the mean outside diameter shall not vary more than 0.015 inch from the size ordered. The thickness at any point shall not vary more than 10 per cent. from that specified. The length shall not be less, but may be 0.125 inch more than that ordered.

14. Finish. The finished tubes shall be free from injurious defects and shall have a workmanlike finish. They shall be free from kinks, bends and buckles.

VI. Marking

15. Marking. The name of the manufacturer and "Tested at 1,000 pounds" for tubes under 5 inches in diameter, or "Tested at 800 pounds," for tubes 5 inches in diameter or over, shall be legibly stenciled in white on each tube.

VII. Inspection and Rejection

16. Inspection. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tubes ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tubes are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and are to be so conducted as not to interfere unnecessarily with the operation of the works.

17. Rejection. (a) Tubes when inserted in the boiler shall

stand expanding and beading without showing cracks or flaws, or opening at the weld. Tubes which fail in this manner will be rejected and the manufacturer shall be notified.

(b) Unless otherwise specified, any rejection based on tests made in accordance with Section 3, shall be reported within five working days from the receipt of samples.

18. Rehearing. Samples tested in accordance with Section 3, which represents rejected tubes, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for rehearing within that time.

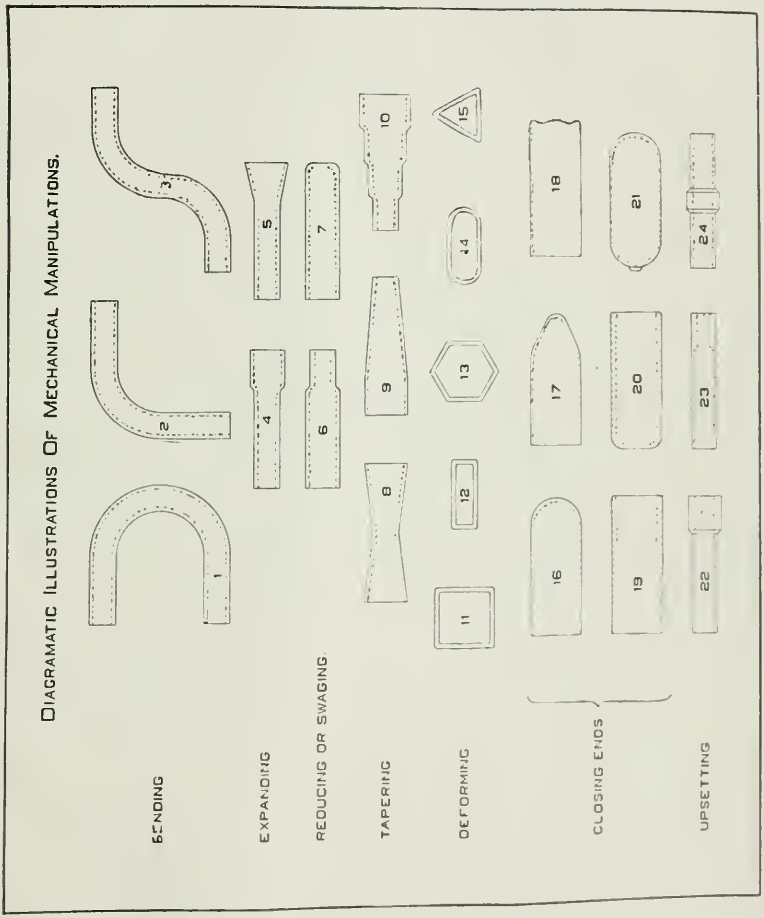


TABLE NO. 1

SERVICE CORROSION COMPARISONS

Rail-road	Material Installed	Water Conditions	Length of Service	No. Discarded: Steel	No. Discarded: Iron	Cause of Rejection	Remarks
A	Charcoal-iron and lap-weld steel tubes in opposite sides of same engine.	Not stated	14 months	14 out of 176	49 out of 176	Pitting	
B	Tests made on three engines using half-sets of lap-weld steel and charcoal-iron tubes on each engine.	Bad	Three years (3 re-settings) Test continued	None	None		Steel tubes are in as good condition as iron. Tubes still in service.
C	Charcoal-iron and lap-weld steel.	Very bad	60,000 miles	25	75	Pitting	Engines in which iron and steel tubes were used, were in same service under same conditions.
D	Tests made on one engine, using lap-weld steel tubes on right side and charcoal-iron on left side.	Bad	11 months (Test continued)	3	6	Pitting	Tubes removed and examined after 11 months. All put back in boiler except 9 which were discarded.
H	Ingot iron and lap-weld steel tubes.	Bad	Iron—15,000 miles Steel—30,000 miles	3%	All Scrapped	Pitting	
I	Swedish iron and lap-weld steel in opposite sides of same engine.	Very bad	14 months (When examined)	None	All scrapp'd (one at end of 8 months)	Pitting	They report that 18 to 24 months' service is obtained from steel; best service from charcoal-iron was 12 to 14 months.
E	See "Remarks"	Extremely Bad	—See Remarks—				Now using lap-weld steel tubes on this division and obtain 25% more mileage and have less pitting than with charcoal-iron.

TABLE NO. II.

MILEAGE—FLUE SHEET PRACTICE

Railroad	Mileage		Water conditions	REMARKS
	Steel	Iron		
A	101,000 (One engine)	50,000—60,000 Was considered good	Not stated	Test made on one engine equipped with lap-weld steel tubes under same conditions as the charcoal-iron previously used.
C	95,000 (Average)	46,000 (Average)	Bad	Engines equipped with lap-weld steel tubes tested in comparison with engines equipped with charcoal-iron tubes under same conditions.
B	80,500 (Average)	40,000 (Average)	Probably most severe in country	Tests made on engines equipped with lap-weld steel tubes under same conditions as the charcoal-iron previously used.
F	70,000 to 75,000 100,000 to 125,000*	Freight 20,000 to 25,000 Passenger 40,000 to 50,000	Not stated	About three years ago the use of charcoal-iron tubes on this railroad was abandoned in favor of steel tubes after comparative tests on these two materials.
G	78,000 (One engine)	40,000—50,000 (Average)	Not stated	Tests made on engine equipped with lap-weld steel tubes under same conditions as the charcoal-iron previously used. Tubes still good and in service.
H	Test on engine equipped with Swedish iron on one side and Shelby seamless tubes on the other side of same engine		Not stated	After 13 months engine was shopped. Nearly all beads on Swedish iron tubes were in bad condition; those on Shelby seamless tubes were apparently as good as ever.

*One engine on this road in fast passenger service equipped with lap-weld steel tubes made 245,675 miles before the tubes were removed. This exceptional case is probably the largest tube-mileage ever made in America. Full data as to this run is given on page 2.

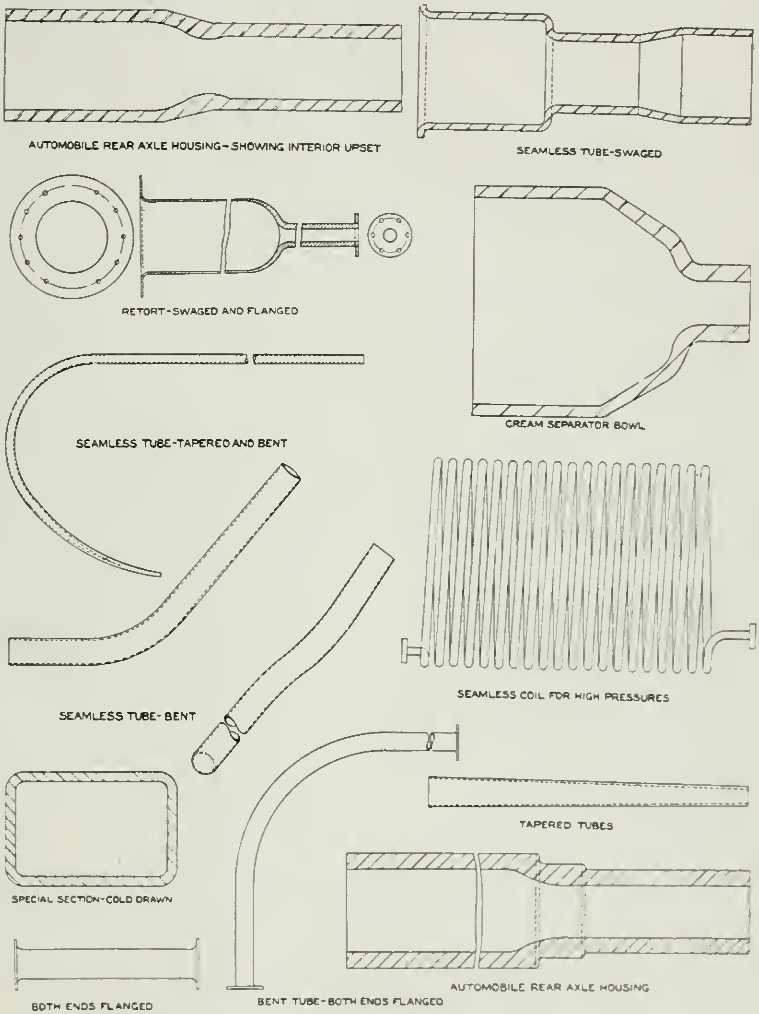
TABLE No. III.

PROCESS OF MANUFACTURE:

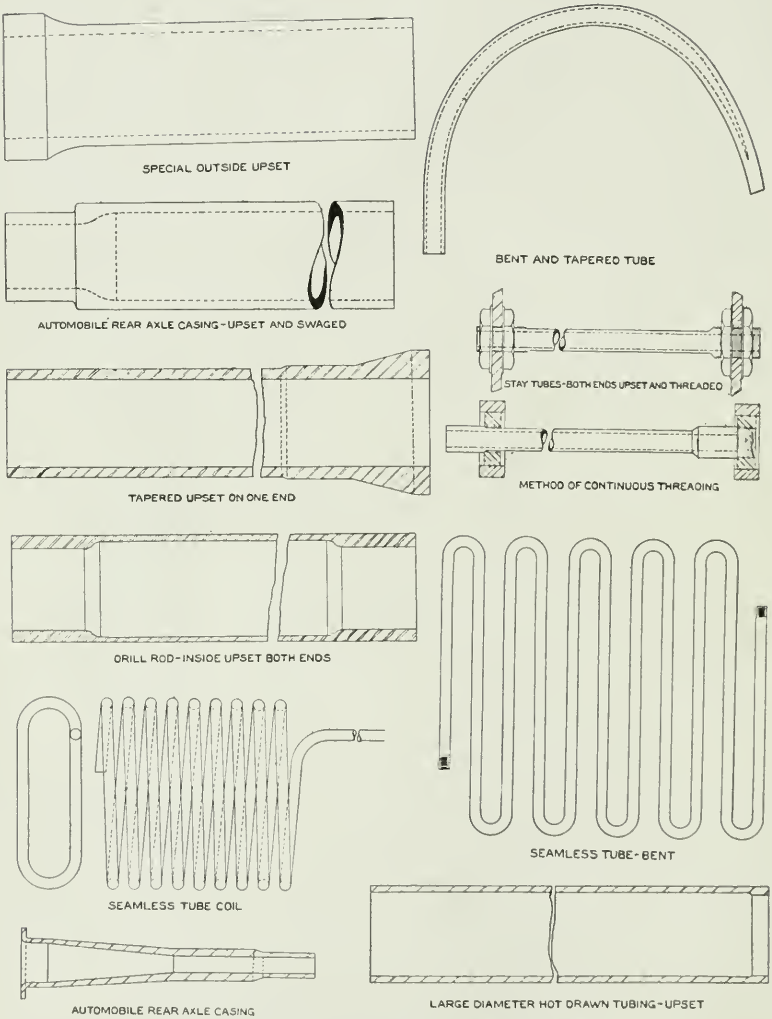
- WELDED { BUTT, LAP } — MATERIAL USED: WROT IRON, BESSEMER AND OPEN HEARTH STEELS OF EASILY WELDABLE QUALITY
- SEAMLESS { ROTARY PIERCING. PUNCHING. HOLLOW CAST BILLETS. PLATE CUPPING PROCESS. } — MATERIAL USED: ALL GRADES OF OPEN HEARTH STEEL OF LOW MEDIUM AND HIGH CARBON. ALSO VARIOUS GRADES OF DIFFERENT ALLOY STEELS. IRON CANNOT BE USED, AND BESSEMER STEEL WITH ONLY INDIFFERENT SUCCESS.

GRADES		CHEMICAL ANALYSIS S	P	MN	C	NI	ELASTIC LIMIT IN LBS PER SQ. IN.	ULTIMATE STRENGTH IN LBS PER SQ. IN.	% ELONGATION IN 2 IN.	% ELONGATION IN 8 IN.	% CONTRACTION	HEAT TREATMENT
BESS.	AVERAGE	.045	.100	.30	.07		37000	57000		22	50	FINISHED HOT
O. H.	AVERAGE	.035	.030	.38	.10		32000	52000		25	55	FINISHED HOT
PUDDLED IRON	AVERAGE	.030	.200	TR	TR		27000	45000		13	30	FINISHED HOT
.17 CARBON	AVERAGE	.035	.030	.50	.17		40000	57000		30	50	FINISHED HOT
.17 CARBON COLD DRAWN	MAX.	.040	.030	.60	.19		70000	80000	18	7	30	NOT ANNEALED
	MIN.	.015	.010	.40	.14		55000	65000	12	3	20	
							65000	75000	25	16	45	FINISH ANNEALED
							50000	60000	18	10	35	
							48000	65000	60	28	60	MEDIUM ANNEALED
							35000	52000	50	22	50	
							35000	55000	65	33	62	SOFT ANNEALED
							27000	47000	55	28	52	
.35 CARBON COLD DRAWN	MAX.	.040	.030	.60	.40		90000	100000	15		18	NOT ANNEALED
	MIN.	.015	.010	.40	.30		75000	85000	10		12	
							85000	95000	30	18	32	FINISH ANNEALED
							70000	80000	20	12	25	
							65000	80000	45	30	42	MEDIUM ANNEALED
							50000	65000	35	20	35	
3½% NICKEL COLD DRAWN	MAX.	.040	.030	.60	.30	4.00	100000	110000	18		32	NOT ANNEALED
	MIN.	.015	.010	.40	.20	3.00	85000	95000	10		22	
							90000	105000	25		35	FINISH ANNEALED
							75000	85000	15		25	
							60000	85000	50	28	50	MEDIUM ANNEALED
							45000	70000	40	20	45	
Cr 1.00%	*MAX*	*.040*	*.030*	*.60*	*.40*		*120000*	*165,000*	*30*		*55*	*900°C-Water.*
20% V.	*MIN*	*.015*	*.010*	*.40*	*.30*		*100,000*	*125,000*	*15*		*40*	*600°C-Air.*

Torpedo Tubes
Submarine Air Flasks



Various manipulations of Shelby Seamless Steel Tubing



Various manipulations of Shelby Seamless Steel Tubing

CLAY AND SHALE DEPOSITS OF NEW BRUNSWICK

J. Keele, B.A.Sc., '93

The Geological Survey Branch of the Department of Mines, Ottawa, has just published a report by Mr. J. Keele, B.A.Sc., '93, on the clay and shale deposits of New Brunswick, covering the work done in that province by the Geological Survey during 1911 and 1912. Practically all the field examinations and the greater part of the laboratory work was done by Mr. Keele, he doing the laboratory work in the laboratories of the Mining building, University of Toronto.

The object of the work was to investigate the clay or shale deposits of sufficient extent to be of economic value, and which would be useful to the manufacturer of burned clay wares, for structural or other purposes. Oil-bearing shales are not included in the report, as it is impossible to mould such material into shape, and afterwards burn it so that it will retain its shape intact.

The work on clays and shales involves (1) The description of their mode of occurrence and of the areas underlain by them. (2) The sampling of the deposits in the field. (3) The laboratory work to determine their industrial value.

The laboratory work includes those physical tests which give the clay worker the most information regarding the quality of the clay, viz., tensile, working, shrinkage, burning and porosity tests. Chemical analyses were not made for this report as they are generally regarded by ceramists as being useless for foretelling the working and burning properties of a clay.

We make the following extracts from a chapter which is devoted to the present extent of the clay industry in New Brunswick.

Up to the present time the clay deposits of New Brunswick have only been developed to a very limited extent.

Wooden construction prevails, to the exclusion of almost all other kinds, except in the business portions of the cities and towns, because lumber has hitherto been plentiful and cheap in this Province.

The danger from extensive fires is always present when wooden construction is so freely used in closely built communities. This was evident in the total destruction of the town of Campbellton by fire during the summer of 1910. Since then, the demand for structural clay wares is increasing, but they are not yet used as largely as they might be, because everything except common brick has to be imported.

New Brunswick possesses in its Carboniferous rocks, certain shale beds, adapted for making those higher grades of clay wares which cannot be produced in the Provinces of Quebec or Ontario, where these raw materials are absent. Clayworkers will probably find it to their advantage to locate works for the production of materials, not only for home consumption, but also for export.

Proximity to markets, although desirable, is not so essential to manufacturers of the higher grades of clay wares, such as face bricks, paving bricks, sewerpipe, electrical conduits, fireproofing, etc., as these materials are frequently transported for long distances. A plant equipped for a large output of common brick can only be maintained close to cities, where the demand for them is constant during the greater part of the year. These plants frequently represent a considerable expenditure of capital, being furnished with artificial driers, continuous kilns, and machinery driven by steam or electric power. The surface clays can be worked in a primitive manner, with a small outlay of capital, to suit the demands of small towns or rural communities. Such plants are able to maintain their position, because the price of common brick would not pay the cost of carriage from large centres where their manufacture is carried on more scientifically.

When the need for underdraining the cultivated areas in the Province becomes more generally known, these clays will have a much wider application. Drain tile can be made from any of the surface clays mentioned in this report. Tile are made from stiff mud, usually by an auger machine having a circular die, although different styles of plunger machines and also hand presses are used in their manufacture. They are made in sizes varying in diameter from 2 inches to 3 feet. Any means of drying and burning may be used with the smaller sizes, but the larger sizes require considerable care to prevent cracking. Contrary to the popular notion, it is not necessary for drain tile to be porous, so that they should be hard burned. Besides sufficient hardness, the important requirements for drain tile are straightness, uniformity of diameter, and smoothness of ends.

The only pottery in operation in the Province is located at St. John, on Loch Lomond Road. It is owned by J. W. Foley and Company, who manufacture butter crocks, teapots, jars, and flower pots. Most of the raw material is imported from the State of New Jersey.

The following details concerning the clay-working industry of the present time in New Brunswick are briefly given.

Fredericton.—M. Ryan and Son are the only brick manufacturers at this city. The material used is a surface clay, of the estuarine type, somewhat similar in character to that worked in the Annapolis, and Shubenacadie valleys of Nova Scotia. The clay is moulded in a soft mud machine, without any preliminary pugging, but nevertheless makes a good grade of brick. The freshly moulded bricks are hacked out on the ground to dry in the air, but since the writer's visit, Mr. Ryan has installed a steam drier. Burning is done in a patent double chambered downdraft kiln, each half having a capacity of 90,000 bricks. The brick settles 12 inches in 31 courses during the burning.

St. John.—Two brickyards are in operation in the vicinity of this city. The clays used are all similar, being evidently remnants of marine or estuarine deposits laid down at a slight elevation above present sea-level. The clays are smooth and plastic, and free from pebbles. Any pebbles found in the finished bricks have probably come from gravels overlying the clays.

The brickyard of Mr. John Lee is located on Courtney bay at the Little river. The material used here is a tough, reddish brown clay and worked to a depth of 6 or 7 feet below the surface. The brick clay rests on a very hummocky boulder drift, which crops out in a few places in the bottom of the pit. The clay, after being broken down from the bank, is dumped into soak pits, along with some sand, and kept there for a day or so before going to the machine. Sand moulded or soft mud bricks, some re-pressed bricks for facing buildings, and field drain tile are manufactured. The freshly moulded bricks are placed on covered pallet racks and air dried. There are two downdraft kilns, two updraft case kilns, and one scove kiln. The output is 25,000 bricks per day during the season, which are mostly sold in St. John.

St. Stephen.—There are two brick yards in operation near this town, making soft mud brick and drain tile. The material used is taken from a terrace of marine clay which occurs along the valley of the St. Croix river.

Mr. John Laming has made bricks here during the last 31 years. He uses a small stiff mud machine for making wire cut brick for facing, and for drain tile. He also makes soft mud bricks, which form the greater part of his output. The demand for drain tile is intermittent, these are only made to order, and not stocked. The principal object of interest is the tiles with which the building is roofed. These tiles were made by Mr. Laming, 22 years ago, from the clay in his own pit. These tiles are S shaped, and although not hard burned, are still quite intact for the most part.

Sussex.—The brickyard operated by Mr. John Heffer is situated a few miles northwest of Sussex. The material used is a stiff, reddish clay, from 3 to 10 feet in thickness, overlying boulder clay. A stiff mud machine driven by horse-power is used. The bricks are hacked out on the open ground to dry, and afterwards burned in a scove kiln.

The burned bricks contain some scattered, small pebbles and clay lumps, showing the need of passing the clay through rolls, or through a long pug mill, to prepare the clay for the machine. As the clay is becoming too thin for working at this locality, the plant will shortly be moved to a fresh clay deposit in the neighborhood.

Moncton.—The brickworks are located at Lewisville, 2 miles from Moncton. The material made is a glacial clay situated almost at tide level, and underlain by boulder clay. The maximum depth of the clay is 7 feet. This plant is equipped with a stiff mud machine, and steam driers. The burning is done in scove kilns. The brick clay also occurs at various points around the city of Moncton, but is worked only at this locality at present.

Chatham.—There are two brick plants in the neighborhood of Chatham, owned by the W. S. Loggie Company. The plant at Nappan river uses a stratified, reddish clay, about 12 feet deep, lying on bed-rock, to which is added about 10 per cent. of sand. Sand moulded bricks only are made; they are dried on pallet rocks, and burned in scove kilns. The bricks are set 36 courses high in the kiln, and the fuel used is dry spruce and tamarack. The output is hauled in wagons to the railway, and shipped principally to Campbellton. The working season lasts from the middle of May to December. An excellent deep red, hard, building brick is produced at these works.

The plant at Nelson is worked in a similar manner, and produces common brick of a quality very much like those at Nappan. This plant is better situated for transportation, as the bricks have only to be hauled over the bridge across the Miramichi river, to the railway station on the north bank.

A NEW FIELD FOR GRADUATES IN MECHANICAL ENGINEERING

H. T. Routly, '06

During the last few years a new and very important field has been developing for the graduates in mechanical engineering—a field at present very much neglected by them. It is modern highway construction, which must not be confused with highway engineering, of which it is the fufillment or complement. The latter has always demanded and will continue to demand the best services of the civil engineer.

In the good old days when the famous Roman roads were being constructed there was small demand for the mechanical engineer. How the layman likes to tells us that we cannot build such roads now, little understanding why, or what the result would be if we did. It was not engines they used then but slaves, and no technical knowledge was required in the roads department save that pertaining to location and design of the roads and to the choice and arrangement of the materials of their construction, all such matters being then, as now, within the range of practise of the civil engineer whether he be attached to a military or to a municipal organization. And so well was his work done then that all down through the ages since, where intelligence has directed highway affairs, a civil engineer has been placed in command. He has had a practical monopoly of the technical side of all highway work and ably and devotedly has he applied himself to his duty. During the last decade especially the advent of the automobile has added tremendously to the problems and difficulties of the roadway engineer and the demand for the services of the experienced and capable has increased much faster than it could be supplied. For location, design, and general superintendence he will ever be in demand and without him we could have no good roads.

But while tremendous changes in design and materials of construction have taken place in recent years, there have been even greater changes in the manner of actually carrying out the plans and designs of the engineer, all these changes being coincident and interdependent on each other.

Self-propelled road rollers have revolutionized our construction methods. As road building received a great impetus and a remarkable development associated with military movements and by means of unlimited cheap slave labor in the time of the Roman Empire, so now it is receiving a hundred-fold greater expansion and development associated with the demand for rapid tranpsortation and by means of costly though cheap labor saving machinery. The slave-driver with his horde of humans has given place to the mechanical engineer with his battery of engines and machines of wonderful variety and usefulness.

And now, once a system of roads has been located, designed and laid out by the civil engineer his work is practically over—except for passing the estimates of work done. The business of actual road construction is a question of machinery in three phases: (1) selection and purchase, (2) operation and care (3) maintenance and repair. And here is an ever widening and remunerative field for our students and graduates in mechanical engineering, with suitable positions as stepping stones all along the line and at its best during the students' vacation season. Few of them are taking advantage of the opportunity. The positions are filled mostly by men who have graduated from a threshing engine in one season; many have to be trained on the work without previous experience. As a matter of fact these latter men are usually the most satisfactory for they come admitting their inexperience and ready to learn, are usually very careful, and while ambitious for advaancement, are more willing to earn it by strict attention to duty. But their lack of technical education is so serious a handicap that they can rarely reach the higher ground and are unable to render themselves as useful to their employers as they otherwise might.

It is seldom that a road outfit is found under the charge of a first-class practical mechanic or engineer and yet nowhere are his services more urgently needed. The man in charge of all such outfits, whether owned by municipalities or by contractors, should be first of all a manager of men, and after that, a first-class machinist, and lastly a practical road builder. Others may arrange these essential requirements differently; all will agree about the first requirement being the ability to handle his men. I maintain that it is easier for the machinist to acquire a thorough knowledge of practical road building than for the road builder to acquire a thorough knowledge of the machinery he is required to use. Without that knowledge he is only half efficient and is always at the mercy of and dependent upon his various machine men, his lack of such knowledge detracting from his prestige not only with the machine men themselves but with the other men as well. Only a large development of the first quality has saved many a superintendent and engineer in many a difficulty where the necessary knowledge of his machinery would never have allowed it to develop.

Ordinarily a road outfit will be working at some distance from any machine shop where repairs can be readily obtained. The building season is short at the best, and delays for machinery repairs very expensive. The superintendent who can detect and remedy faults before they become dangerous and who can repair on the ground the ordinary breaks, is able to keep his plant working a much larger percentage of the possible working time and save a larger proportion of maintenance and depreciation charges than the superintendent who lacks the thorough knowledge of his machinery. He is able to decide intelligently and at once the numberless questions which are always arising in connection with the proper and economical operation of the different machines.

To the college student in mechanical engineering the highway work should offer a strong appeal. It is at its best when he is free on his summer vacation. It takes him out into the clean pure fresh country air; the hours are regular; the board wholesome; the remuneration fairly high and the work varied but not arduous. To the man who has spent a couple of vacations on the work, has had some shop practice and has the ability to handle men, there are abundant openings at really good salaries. There is no standard scale of wages in this country, but a fair average would probably be from $1.50 to $2.00 per day and board running a stationary engine and rock crusher and from $2.00 to $3.00 operating a road roller or tractor. The man who has filled these positions, knows his road building, and can take charge of a complete outfit, is worth from $125.00 and expenses per month up, to any contractor or municipality and with work practically all year, the winter months being spent mostly in thoroughly overhauling all the plant which should commence each season in first-class condition.

C. A. Chilver, '04, is Sec-Treas. of C. A. Chilver Co., Limited, Builders' Supplies, Walkerville, Ont.

J. J. Hanna, B.A.Sc., '14, is on the staff of the city engineer, Calgary, Alta.

W. G. Millar, B.A.Sc., '14, is with P. H. Secord & Sons, Limited, General Contractors, on the erection of the new post-office at Newmarket, Ont.

(Capt.) N. C. Sherman, '10, is with Militia and Defence, Canada, at the ordnance office, Esquimalt, B.C.

R. C. Purser, B.A.Sc., '06, has been engaged on D. L. S. work in the West for the past three years.

J. L. Rannie, B.A.Sc., '07, has since January, 1913, been with the International Joint Commission in charge of topographic surveys, made under the Lake of the Woods reference. Mr. Rannie is now in the West in connection with this work.

W. A. Cowan, '04, of 137 Pleasant St., Halifax, is resident engineer for the Halifax Ocean Terminals Railway.

C. W. B. Richardson, B.A.Sc., '07, is at the Ottawa office of the Dominion Bridge Company, Limited.

EXAMINATION RESULTS, 1914

The following are the results of the examinations held in 1914. Candidates whose names are followed by brackets must pass supplemental examinations in the subjects indicated.

SCHOLARSHIPS

The Boiler Inspection and Insurance Company's scholarship for general proficiency in the third year mechanical engineering has been awarded to Mr. C. G. Davey.

M.A.Sc. DEGREE

W. C. Murdie received the degree M.A.Sc. His subject was "Stereophotogrammetry Applied to Surveying." Mr. Murdie is the first candidate to receive this new degree.

FIRST YEAR

Civil Engineering.

Honors—A. E. Berry, W. A. Bishop, R. S. C. Bothwell, G. A. H. Burn, F. C. Christie, H. F. Coon, R. A. Crysler, W. P. Dale, F. L. Eardley-Wilmot, J. A. Fraser, R. R. Hawkey, U. C. Holland, C. A. Hughes, W. H. Hunter, R. W. Hurlburt, R. E. Jones, H. L. Longworthy, R. C. Manning, G. A. McEwen, J. R. McLean, F. L. Mitchell, E. L. Moorhouse, H. R. Nicholson, A. F. Norris, H. A. Parr, G. P. Pearson, C. L. Pool, W. O. Proctor, C. M. Purchas, L. R. Shoebottom, G. E. Stephenson, B. Thompson, C. E. Tilston, F. M. Waddle, G. E. Wait, R. S. Warwick. G. A. Whately, G. Wood.

Pass—W. H. Aggett (trig., elem. chem.), O. V. Ball (elem. Chem.), C. A. Bishop (surveying), K. H. Chamberlain, E. H. Corman (trig., elem. chem.), E. R. Defoe, F. C. Darch (trig.), H. L. Dowling, E. B. Dustan (trig.), J. R. Gilley, T. S. Glover, D. S. Graham, K. W. Jamieson (trig., elem. chem.), E. W. Johnston, W. R. Kay, W. J. LeClair (algebra, anal. geom.), H. J. Legate (elem. chem.), J. A. Macdonald, R. Manzer, G. A. McClintock, W. H. Nixon, T. L. Ryan, (elem. chem.), G. H. Sohn (alg., trig.), C. W. G. Stevenson (alg., trig.), R. D. Taylor, A. P. Thomson (trig.), G. A. Webb, L. E. Willmott (alg., trig.).

Mining Engineering.

Honors—E. R. Gilley, H. L. McClelland, J. E. Sharman.

Pass—E. A. Howes (algebra).

Mechanical Engineering.

Honors—E. Bell, G. E. Booth, M. A. Snider.

Pass—S. B. Bingham (French, algebra), H. O. Dobbin (anal. geom.), A. B. Harris, M. G. Henderson, V. E. Ives (alg., trig), S. G. McCandlish (anal. geom.), P. E. McIlhargey, G. R. Sinclair (alg., anal. geom.). C. E. Tindale, O. D. Vaughan (alg.).

Architecture

Honors—E. W. Haldenby, A. S. Mathers, H. R. Watson.

Pass—J. Banigan (alg., anal. geom.), F. R. Gibson (anal. geom., accounts), A. G. Hume (alg., elem. chem.), C. C. Thompson (trig.).

Analytical and Applied Chemistry.

Honors—J. V. Dickson.

Pass—O. G. Lawson, A. P. Maclean (accounts), E. J. Tyrrell (alg., anal. geom.).

Chemical Engineering.

Honors—J. R. Belton.

Pass—A. B. Honeywell (magnetism and electricity, electric circuits), A. G. Knight (mag. and elec.).

Electrical Engineering.

Honors—N. Burwash, C. R. Catherwood, C. E. Harrop, C. Hewson, R. D. Huestis, G. F. Hutchison, F. C. Mayberry, W. J. Nichol, W. A. R. Offerhaus, R. D. Ratz, W. F. Secord, O. W. Titus, A. A. Tufford, J. S. M. Wallace, I. W. Webb.

Pass—W. B. Andrew (elec. cir.), J. G. Ballinger (elec. and mag., elec. cir.), R. A. Barbour (anal. geom., elec. cir.), W. R. Bauer, F. M. Bryans, S. W. Bumstead (trig.), C. E. Burton (elem. chem.), E. S. Byers, J. C. Colleran (alg.), P. A. Durbrow, R. T. Eyre (alg.), D. W. Ferrier, J. I. Gram (alg., anal. geom.), A. F. Hanley (alg., anal. geom.), D. M. Morgan, H. A. Tuttle, J. W. Ward, F. A. McKinley (alg., anal. geom.).

SECOND YEAR

Civil Engineering.

Honors—T. E. Armstrong, H. A. Babcock, L. F. Barnes, C. A. Doherty, J. H. Eastwood, K. B. Jackson, W. B. Mitchell, E. A. O'Callaghan, J. E. Pringle, S. R. Ross, W. B. Scott, R. L. Seaborne, R. L. Sievewright, R. E. Williams.

Pass—E. B. Allan (hydrostatics), R. R. Brown (spher. trig., org. chem.), E. Crosby, R. S. Dale (calculus), G. R. Dashwood, R. W. Downie (org. chem.), C. W. Edmonds, L. F. Gaboury (calculus), C. E. Gage (calculus, first year trig.), D. B. Gardner, G. D. Hagarty (hydrostatics), G. C. Hagedorn (mineralogy), G. W. Harron, J. R. Kirby, R. W. Kirby, L. A. Lee, O. Margison, F. J. Matthews (org. chem.), F. T. McPherson (calculus, org. chem.), A. R. Mendizabel (org. chem.), H. B. Norwich, V. R. Pfrimner (cal., org. chem.), W. W. Ritchie, H. C. Rose (spher. trig., hydrostatics), C. E. Smith (calculus, hydrostatics), C. Smythe (org. chem.), G. B. Snow (trig., spher. trig), R. M. Speirs (surveying, money), W. H. Stark (optics, org. chem.), F. S. Storms (money), G. S. Stratford (cal., optics), J. A. Sureda, M. S. Taylor (surveying, org. chem.), J. E. Tremayne (money), R. C. Ward (hydro.), A. B. Whaley, C. H. Wheelock, F. C. Wilson (chem. lab., spher. trig.), R. M. Hare (spher, trig., first year trig.).

Mining Engineering.

Honors—B. A. McCrodan.

Pass—C. E. Macdonald (calculus), F. W. Norton (elem. chem., mineralogy lab.).

Mechanical Engineering.

Honors—M. W. Keefer, J. C. Newcombe, J. P. Russell, H. A. Washington, J. M. Watson, L. L. Youell.

Pass—H. E. Bruels, J. N. Cunningham, L. Delisle (calculus, electricity), R. A. Macdonald (org. chem., money), F. S. Merry (steam engines, electricity), J. A. N. Ormsby (calculus, org. chem.), R. W. Kirn (aeg.), S. W. Ross (cal, hydrostatics).

Architecture.

Honors—R. T. C. Hoidge, L. Husband, W. S. Kidd.

Pass—F. H. Marani (accounts, hydro-statics), T. W. McLellan (aeg.), G. W. Schwartz, P. L. Stevens (money), F. A. Swinnerton (hydro., money), R. Tyerwhitt (cal., money), D. M. Waters, W. S. Wilson (calculus), J. L. Skinner (calculus, money).

Analytical and Applied Chemistry.

Honors—W. G. Birrell, F. W. Ward.

Pass—N. B. Brown (optics, physical chem.).

Chemical Engineering.

Honors—C. C. Anderson, D. Boyd, C. E. Oliver.

Pass—S. J. Krug (phys., chem.), W. H. O'Reilly (phys. chem., elec. and mag.).

Electrical Engineering.

Honors—J. B. Chapman, S. K. Cheney, L. G. Dande, T. A. Daniel, G. E. Nott, J. S. Panter, R. M. Thomas, A. R. Wells, H. S. Wepp, J. S. Wilson.

Pass—F. C. W. Ball (calculus, optics), F. W. Booth, K. M. Cumming, L. L. Cunningham, M. P. Fallis (steam engines, org. chem.), R. L. Flegg (cal.), A. Fleming, R. A. Fraser, H. A. M. Grasett (calculus), E. G. Gurnett, S. J. Hubbert (elec., Eng. chem.), J. Kelleher (I. year trig., dynamics), G. F. King, H. B. Little (hydrostatics), T. R. Manning (elec.), W. B. Pater (calculus, elec.), W. A. Smelser (cal., money), A. E. Widdicombe.

Metallurgical Engineering.

Honors—O. H. Hugill.

THIRD YEAR

Civil Engineering.

Honors—P. Bennett, G. G. Blackstock, E. D. Brouse, L. R. Brown, F. M. Buchanan, J. D. Cook, A. B. Crealock, W. R. Da Costa, E. V. Deverall, W. L. Dickson, G. A. Downey, A. C. Evans, J. W. H. Ford, W. J. Fulton, W. R. Fraser, W. G. French, E. R. Grange, C. E. Hogarth, C. W. H. Jackson, G. W. F. Johnston, R. E. Laidlaw, G. J. Lamb, W. E. Longworthy, C. T. Lount, C. R. McCort, J. P. Macdonald, K. D. Macdonald, D. F. McGugan, W. H. Meitz, G. Mitchell, H. S. Nicklin, C. F. Porter, J. E. Porter, W. E. Raley, G. Rankin, A. A. Richardson, H. M. Rowe, E. H. Scott, R. G. Scott, C. N. Simpson, L. P. Vezina, F. E. Weir, C. W. West, J. N. Williams.

Pass—L. S. Adlard (geology), W. W. Code, A. C. Anderson (field work, surveying), G. A. Arksey, F. D. Austin (surveying, astronomy), F. N. D. Carmichael (th. of structs., hydraulics), R. M. Cockburn (photography), C. P. Cottn (th. of Structs.), N. H. Daniel, H. S. Falconer (des. geom., surveying), R. D. Galbraith, C. N. Geale (th. of structs., hydraulics), G. A. Gooderham (th. of structs., geology), E. D. Gray (th. of structs), G. S. Gray (th. of structs., hydraulics), R. W. Harris (surveying, th. of structs.), C. Hayward, E. H. Jupp, W. E. Lockhart (hydraulics), R. G. Lye, H. E. Macpherson, G. L. Magann (hydraulics), W. R. McCaffrey, E. V. McKague, F. L. Mills, J. T. Mogan (th. of structs., geology), B. M. Morris (surveying, ast. and geod.), M. A. Neilson, E. B. O'Connor (calculus), P. L. Pearce, H. M. Peck, S. M. Peterkin, C. C. Rance (ast. and geod., th. of structs.), W. B. Redmond (ast. and geod., hydraulics), J. T. Rose (surveying, th. of structs.), J. H. Shaw, J. S. Sheehy, R. A. Steven (ast. and geod., hydraulics), D. H. Storms, L. B. Tillson, J. A. Tom (th. of structs), J. C. Wilson, H. A. Wood.

Mining Engineering.

Honors—M. B. Glazier, W. T. Hall, J. E. Hanlon, L. T. Higgins, I. M. Macdonnell, J. B. Stitt, W. S. Wilcock.

Pass—W. N. Allan, R. M. Arthur (mineralogy lab., th. of structs.), E. R. Emmerson (surveying, th. of structs.), M. S. Haas, R. D. Jones (metallurgy, ltd. cos.), F. L. mills (mining, French), J. M. Muir, J. Ross, J. E. C. Stroud.

Mechanical Engineering.

Honors—C. G. Davey, boiler inspection and insurance companies' scholarship for general proficiency; R. H. Lloyd, W. R. McGie, A. N. Payne, F. G. Reid, W. G. Shier, C. A. Smith.

Pass—A. S. Robertson, J. Gray, A. H. Smyth, (alt. current), J. D. Stone, H. C. Taylor (elect. lab., elect.), G. D. Tillson (th. of structs., hydraulics).

Architecture.

Honors—H. J. Burden, K. C. Burness, M. Denison, A. Morris.

Pass—R. W. Catto (calculus), J. J. Davidson (limited cos.), G. R. Edwards (th. of structs., calculus), T. S. Graham (limited cos.), H. A. Heaton, G. W. Rutter (des. geom., th. of structs.).

Analytic and Applied Chemistry.
Honors—H. Kohl, W. Morris, W. Uffelmann.
Pass—L. T. Watson (crystallography, metallurgy.)

Chemical Engineering.
Honors—J. E. Breithaupt.
Pass—L. G. Glass.

Electrical Engineering.
Honors—J. Diblee, W. H. R. Gould, G. Ironside, G. W. Lawrence, W. A. Steel, A. L. Ward.
Pass—W. V. Ball (thermo., elect. design,). T. R. Banbury, V. A. Beacock, A. L. Birrell (hydraulics, thermo.), W. H. Bonus (hydraulics, ltd. cos.), H. C. Budd (alt. current, elect. design), F. H. Chandler (elect. lab., ltd. cos.), G. P. Davidson (hydraulics, electricity), W. A. Dean (mech. of mach.), R. V. Elliott, G. E. Griffiths, T. P. Ireland, K. A. Jefferson (elec. lab., elec. des.), C. M. Jones, H. C. Karn (aeg.), C. R. Keys, E. T. Martin (electrochem.), E. M. Monteith (hydraulics), W. F. P. Purdy, A. C. Ross (elec. design), W. E. Russell (hydraulics, thermo.), W. M. Ryan (electricity, elec. design), A. G. Scott (mech. of mach., alt. current), N. F. Seymour (alt. current, electrochem.), A. N. Suhler, A. N. Taylor (hydraulics, elec. design), E. W. Savage.

FOURTH YEAR (B.A.Sc. Degree).

Civil Engineering.
Honors—F. C. Adsett, J. L. Alton, H. J. Bedard, J. M. Blyth, J. H. W. Bower, D. H. Campbell, J. J. Campbell, R. M. Christie, W. Cuthbertson, R. Dashwood, R. D. Davidson, F. W. Douglas, H. E. Eyres, O. M. Falls, J. L. Foreman, J. J. Hanna, L. T. Hayman, B. B. Hogarth, S. A. Hustwitt, R. P. Johnson, R. E. Lindsay, H. N. Macpherson, J. A. P. Marshall, R. C. McDonald, C. A. Meadows, F. C. Mechin, W. G. Millar, J. S. Mitchell, E. P. Muntz, C. Noecker, J. B. Nicholson, R. G. Patterson, C. V. Perry, H. L. Sheppard, B. N. Simpson, J. B. Skaith, N. L. Somers, C. N. Temes, G. E. Treloar, F. T. Van Dyke, H. G. Waddell, H. W. Wagner, H. D. M. Wallace.

Pass—E. M. Abendana (th. of structs.), E. L. Bedard, J. T. Belcher, S. S. Bennett (th. of structs.), P. V. Binns, J. W. Crashley (st. of mats., lab., ast. and geod.), G. F. Dalton, J. A. Elliott, G. O. Fleming, C. H. R. Fuller, R. W. Gouinlock (thermo.), J. H. Hawes, J. Kay (th. of structs.), J. A. Knight, W. A. Maclachlan, S. B. McGill (thesis), A. S. Miller, J. R. Montague, C. J. Mullins (thermo., electricity), J. A. Owens, A. H. Parker (thesis, st. of mats., lab.), C. W. Pennington (electricity, th. of structs.), P. H. Raney, R. H. Rice (hydraulics general), F. S. Rutherford, N. E. D. Sheppard, S. Shupe, C. E. Sinclair (th. of structs.), H. M. Smith, I. R. Strome, J. A. Tilston, R. L. Whitley, H. P. Wilson.

Mining Engineering.
Honors—H. R. Banks, S. D. Ellis, J. R. Gill, S. A. Lang, W. A. Macdonald, R. W. Young, H. J. MacKenzie.
Pass—F. C. Andrews, R. T. Carlyle, J. M. Carter, E. V. Chambers, J. S. Fleming (petrography lab., ore dressing), W. Hutchings (mineralogy, electrochemistry), P. W. Meahan (mineralogy), G. M. Smyth (power), J. S. Taylor.

Mechanical Engineering.
Honors—H. H. Brown, H. M. Campbell, E. D. W. Courtice, H. F. Elliott, W. H. Hall, G. H. Hally, H. W. Maxwell, J. G. Scott, S. G. Tackaberry, E. H. Tennant, M. F. Verity.
Pass—K. M. Clipsham, R. D. Delamere (const. notes), H. S. Kerby, J. A. Kerr, B. MacKendrick (thesis, th. of structs.), A. H. MacQuarrie, P. H. McQueen (th. of structs.).

Architecture.
Honors—J. M. Robertson, W. C. Skinner, A. C. Wilson.
Pass—E. E. H. Hugli, N. G. Keefer (struct. design).

Analytical and Applied Chemistry.

Honors—J. G. G. Frost, O. G. Lye, W. E. Phillips, G. E. Smith.
Pass—A. R. Bonham.

Chemical Engineering.

Honors—C. N. Candee, W. E. Milligan, A. E. Wigle.
Pass—D. Morrison, A. W. Sime (org. chem.. hydraulics), E. A. Twidale.

Electrical Engineering.

Honors—W. D. Brown, A. W. Crawford, H. J. Franklin, E. I. Gill, A. S. Jannati, J. I. Kamman, C. W. Latimer, A. M. Mackenzie, R. C. Matthews, P. H. Hills, C. L. Nicholson, J. D. Peart, G. O. Philp, W. M. Philp, F. M. Servos, E. C. R. Stoneman, W. S. Tull, J. A. H. Wigle.

Pass—C. E. Armer, H. A. Campbell (electricity, first and second papers), C. E. B. Corbould, H. C. Edwards (electricity 2), D. G. Ferguson, C. I. Grierson, G. E. Kewin, N. H. Lorimer (electrical lab., electricity 1), J. A. Marshall, D. L. McLaren, A. S. Robertson, H. D. Rothwell, R. O. Standing.

Degree of Master of Applied Science (M.A.Sc.), W. C. Murdie.

Supplemental Examinations Passed.

First year subjects:—Accounts—R. R. Brown, F. S. Storms, F. W. Norton, K. M. Cumming. Field work—R. R. Brown. Trigonometry—L. Delisle, G. F. King, R. T. Park, H. Ramsay. Algebra—H. C. Rose, G. Hanmer, S. J. Hubbert, W. B. Paterson, R. W. Catto. Dynamics—H. S. Smith, R. M. Hare, F. C. Wilson, C. K. Macpherson. French—A. F. Pym. Elementary chemistry—F. S. Storms, F. C. Wilson, G. Hanmer, L. Delisle. Analytical geometry—K. A. Jefferson. Electricity and magnetism—R. L. Flegg, L. Levesque.

Second year subjects:—Spherical trigonometry—A. C. Anderson, R. W. Harris, W. E. Rockhart. Astronomy—R. G. Lye, W. H. Meitz. Calculus—F. D. Austin, E. V. Deverall, W. E. Lockhart, E. V. McKague, D. E. Murphy, L. B. Tillson, R. D. Jones, H. J. Burden, H. C. Taylor, H. C. Budd, G. P. Davidson, E. M. Monteith. Steam engines—E. T. Martin. Organic chemistry—W. H. Bonus, W. W. Code, J. A. Tom, R. G. Lye. Optics—W. H. Bonus, C. Hayward, G. Rankin, L. P. Vezina. Electricity—H. C. Taylor, L. W. Railton, M. E. Nasmith, E. A. Jamieson. Metallurgy—L. T. Watson, F. N. D. Carmichael. Hydrostatics—W. N. Allan, G. R. Edwards. Dynamics—F. D. Austin. Inorganic chemistry—F. N. D. Carmichael, R. M. Arthur, E. R. Emmerson, R. D. Jones. Strength of materials—G. A. Gooderham, E. D. Gray, G. J. Lamb. Mineralogy laboratory—G. Rankin, C. W. West, J. Ross, G. A. Gooderham, G. S. Gray. Money—G. S. Gray. Descriptive geometry—R. W. Harris. Surveying—P. L. Pearce. Practical chemistry—H. M. Rowe, J. S. McIntyre. Geology—W. Hutchings.

Third year subjects:—Mechanics of machinery—W. M. Philp. Thermodynamics—A. H. McQuarrie, J. S. McIntyre, C. E. B. Corbould. Hydraulics—A. H. MacQuarrie, J. A. Marshall, P. V. Binns, J. W. Crashley, J. B. Nicholson, N. E. D. Sheppard, J. A. Tilston, W. Hutchings. Alternating current—H. A. Campbell, C. E. B. Corbould, Electricity—W. H. Hall, B. MacKendrick. F. C. Andrews. Electro-chemistry—H. D. Rothwell. Surveying—E. M. Arendana. Theory of structures—J. B. Nicholson, R. H. Rice, H. E. D. Sheppard, H. M. Smith, N. G. Keefer, G. F. Dalton, A. S. Miller, C. E. Sinclair. Astronomy and geodesy—J. R. Montague. Metallurgy—J. S. Fleming. Geology—G. E. Sinclair, J. M. Blyth, J. B. Skaith, H. M. Smith. Petrography—J. M. Carter. Ore dressing—F. C. Andrews, J. M. Carter, H. J. MacKenzie. Mining—D. S. Halford, J. G. Shepley. Analytical chemistry—J. S. Fleming, H. J. MacKenzie, D. Morrison. Organic chemistry—D. Morrison. Engineering chemistry—S. A. Hustwitt. Biology—E. L. Bedard. Assay laboratory—D. S. Halford, J. G. Shepley. Modelling—J. M. Robertson. Photography—J. A. Tilston.

Fourth year subjects—Geology—G. M. Carrie. Thermodynamics—A. M. German. Hydraulic laboratory—A. M. German. Metallurgy laboratory—C. A. Bell, W. H. Garnham. Assay laboratory—W. B. Caldwell. Chemical laboratory—H. A. Clark. Mining—W. B. Caldwell. Electricity—G. R. Johnson. Theory of structures—H. D. Davison.

Supplemental Examinations to be Taken

First year subjects—Algebra—H. D. Wallace, F. L. Mills, H. S. Smith. Electrical laboratory—R. A. Cross. Trigonometry—R. A. Cross, M. Johnston, S. R. Seaman, D. P. Barr. Accounts—C. K. Hoag. Electricity and magnetism—M. Johnston, R. H. Wilson. Elementary chemistry—A. F. Pym, L. Levesque. Dynamics—H. Reid.

Second year subjects—Organic chemistry—J. M. Carswell. Calculus—W. W. Code. Optical laboratory—M. Gurofsky. Alternating current—W. E. Longworthy. French—F. L. Mills.

C. A. Meadows, '14, sailed for England on May 14, for a couple of months holiday on the continent.

Gower Markle, '09, is with the Sewers Department, City Hall, Toronto.

C. A. Webster, B.A.Sc., '13, is with Sheldon's Limited, Galt, manufacturers of heating and ventilating equipment.

W. M. Philp, B.A.Sc., '14, is employed as draftsman for Turnbull Elevator Mfg. Co., Toronto.

W. P. Murray, B.A.Sc., '08, is at present at Lytton, B. C., for the Dominion Bridge Co., on engineering work in connection with several bridges now being constructed by that company on the line of the Canadian Northern Pacific Railway.

R. J. Marshall, B.A.Sc., '08, has recently been appointed town engineer of Trenton, Ont.

H. P. Wilson, B.A.Sc., '14, is with Elias Rogers Co. as engineer in charge of the construction of their new coal yards and sheds.

In mentioning the Past-Presidents who attended the twelfth annual banquet of the University of Toronto Club of New York in the March issue, the name of Mr. H. F. Ballantyne was unfortunately omitted. Mr. Ballantyne is one of the very best workers for the club and has been elected Secretary-Treasurer, which position he filled a few years ago. At the Twelfth Annual Meeting of the club, the following officers were elected.

President: L. L. Brown, '95; Vice Presidents: W. A. Merkley M.D.; H. V. Serson, '05; John S. Thompson, Arts; Secretary-Treasurer: Henry F. Ballantyne, B.A.Sc., '93; Membership Committee (to serve three years): H. P. Rust, B.A.Sc., '01.

B. B. Tucker, B.A.Sc., '04, is with the Rapids Power Co., Limited, Morrisburg, Ont.

A. U. Sanderson, B.A.Sc., '09, is with the Water Supply Section, Department of Works, Toronto.

W. F. Wright is in the motor sales department, Canadian General Electric Co., Limited, Toronto.

Russell Young, '08, has for the past two years been electrical superintendent of construction for the B. C. Electric Ry. Co. in charge of all sub-station construction work.

H. Goodridge, '10, is resident engineer on sidewalks for the city of Edmonton.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL

CLASS '09 MEETING

On Monday, May 18th, the Toronto members of Class '09 held a meeting at the Strollers' Club on Yonge Street, where dinner was served at 6.15 p.m. Mr. J. A. M. Williams of A. E. Ames Co. gave a very interesting talk on "Finance" after which he answered many questions which arose out of the discussion which followed. Messrs. Williams, Turnbull, Irwin and Workman were appointed to secure a speaker for the next meeting and to draft a constitution to govern these meetings, which will be financed wholly by the members af the class who attend and not by the class organization, although all members of the class are considered members of the club now being formed. It is desired that any '09 men, who are not receiving notice of these meetings, will send their address to the class secretary, G. R. Workman, 1 Wood St., Toronto.

BOOK REVIEW

Canadian Patent Law and Practice.—By Harold Fisher, B.A., L.L.B., and Russel S. Smart, B.A., M.E., with an Appendix on Canadian Patent Office Practice by W. J. Lynch, I.S.O.; published by Canada Law Book Company, Limited, Toronto, 478-xxxii pp.; 6 in. x 9 in. half leather binding; price $7.50.

This book, while it was meant primarily for patent attorneys and solicitors, affords a great deal of information of interest and value to engineers who have occasion to investigate patent claims or regulations pertaining to them.

Considerable space has been devoted to cases of infringement of a patent, and practice in infringement cases. A chapter is devoted to general regulations governing the application for and granting of patents in foreign countries. In fact, the entire subject of patent law has been very thoroughly treated by the authors and has been so presented as to be readily appreciated by any person who is at all interested in the laws and customs relating to patents.

The work is divided into 20 chapters and is supplemented by an appendix by W. J. Lynch, Chief of the Canadian Patent Office, in which are discussed in detail the essentials for guidance in preparing and prosecuting applications and other proceedings relating to patents. The volume also contains copies of standard forms for petitions, specifications, assignments, disclaimers, etc.

Note.—Mr. Smart graduated from the "School" in Mechanical Engineering in 1904.

"SCHOOL" MEN IN BRITISH COLUMBIA

The annual report of the Minister of Lands for the Province of British Columbia for the year ending 31st December, 1913, contains reports by several "School" graduates on work which they had been doing for that department of the government during the year. A perusal of these reports impresses the reader with the magnitude of the undeveloped resources of that province and we cannot but realize that the "School" is doing a very great deal toward the development of those resources, so that they will add to the coffers of the country.

On page 114 is the Water-Power Investigation Progress Report by the Engineer in Charge, Mr. A. V. White, M.E., '92, of the Commission of Conservation, Ottawa. It is followed by the report of R. G. Swan, B.A.Sc., '09, chief engineer, of the British Columbia Hydrographic Survey. Other reports in the Water-Power Branch are submitted by the following District Engineers, E. A. Jamieson, '10, W. Chester Smith, B.A.Sc., '10, and A. W. Campbell, B.A.Sc., '06. Mr. Jamieson's report relates to work done on the Capilano

River and watershed and the power possibilities of the Coquihalla River near Hope; Mr. Smith's report relates to watersheds available for Greater Vancouver water supply and that of Mr. Campbell to work done in the Quesnel and Barkerville Water Districts.

The section of the book relating to the Survey Branch contains reports by J. E. Umbach, '03, chief draughtsman, Lands Dept., Department of Interior; T. A. McElhanney, B.A.Sc., '10, on surveys in vicinity of Nazko River; D. O. Wing, '08, on surveys in Groundhog District; S. M. Johnson, B.A.Sc., '94, on Anarchist Mountain surveys; J. A. Walker, B.A.Sc., '08, on surveys on the South Fork of Fraser River, Cariboo District, and J. E. Ross, '88, on surveys made on the upper portion of Deadman River and its tributaries.

GABY—MACBETH

On Wednesday, May 20, Mr. F. A. Gaby B.A.Sc., '03, Chief Engineer, Hydro-Electric Power Commission, Toronto, was united in marriage to Miss Catharine Florence MacBeth, 60 Brock Ave., Toronto. Mr. and Mrs. Gaby have gone on a fortnight's motor trip through the Berkshire Hills. Applied Science extends congratulations.

GOODEVE—DAVIDSON

The marriage of Vincent S. Goodeve of class '10, to Miss Grace Davidson of Dickinson's Landing, Ont., took place at Nelson, B.C., on Saturday, May 9th, the ceremony being performed by Rev. R. J. McIntyre.

Mr. and Mrs. Goodeve will reside in Phoenix, B.C., where Mr. Goodeve is employed by the South Kootenay Water Power Co. We extend to them our best wishes.

W. Snaith, '07, is at present on a business trip in the California oilfields for the Thor Iron Works Limited.

L. T. Rutledge, B.A.Sc., '09, is manager of Excelsior Electric Mfg. Co., 419½-421 Queen St. W., Toronto.

K. M. Van Allen, B.A.Sc., '10, is engaged in fruit-farming at Summerland, B.C.

W. P. Brereton, B.A.Sc., '01, has recently been appointed city engineer of Winnipeg, Man.

Walter J. Francis, C.E., '93, accepted the invitations of the Ottawa and Calgary branches of the Canadian Society of Civil Engineers to address them on April 2, and April 9th, respectively. The subject of address in both cases was, "The Engineer and the Public." These addresses were of the high calibre characteristic of Mr. Francis' several previous lectures relating to the Engineer, and were exceedingly well received.

Greenwood, W. K., '04, is engineer for Orillia, Ont., Water, Light and Power Commission.

Guernsey, F. W., '95, is engineer for the Consolidated Mining & Smelting Co., at Trail, B.C.

Gulley, C. L., '08, is with the Northern Electric & Mfg., Co., Limited, Toronto, as sales engineer.

Gunn, W. W., '09, is in the Toronto office of the Dominion Bridge Co.

Gurney, W. C., '96, is vice-president of the Gurney Foundry Co., Limited, Toronto.

Guest, W. S., '00, is Lecturer in Electrical Engineering, University of Toronto.

Guy, E., '99, is in Toronto at present. His address is 541 Euclid Ave.

H

Hackner, J. W., '08, whose home is in Sandford, Ont., is assistant engineer for the Department of Public Works, Ontario.

Hadcock, J. P., '13, was in the test department of the Canadian General Electric Co., Peterborough, when last heard from.

Hagarty, R. E. W., '07, is manager of the Vancouver office of Western Pavers, Ltd.

Haight, H. V., '96, is chief engineer of the Canadian Ingersoll Rand Co., Sherbrooke, Que.

Hall, H. G., '11, is assistant superintendent, Woodstock Water & Light system, Woodstock, Ont.

Hall, K., '07, is assistant engineer C.N.R. Peace River Branch. Address mail to A. T. Fraser, district engineer C.N. Railway, C.N.R. depot, Edmonton, Alta.

Hamer, A. T. E., '01, is on the engineering staff of the Canadian Northern Ontario Railway, and is resident at Cochrane, Ont.

Hamilton, J. F., '03, is a member of the firm of Hamilton & Young, Dominion Land Surveyors and Civil Engineers, Lethbridge, Alta.

Hamilton, C. B., '06, is owner and general manager of the Hamilton Gear & Machine Co., Toronto, Ont.

Hamilton, C. T., '07, is in Vancouver B.C., residing at 1414 Haro St., and is a member of the city engineer's staff.

Hamilton, G. M., '11, is on the engineering staff of the Welland Ship Canal. His addre s is Box 57, Humberstone, Ont.

Hanley, S. C., '93, used to be with the Midland (Ont.) Engine Works Co. We do not know his present location or employment.

Hanes, G. S., '03, is mayor of North Vancouver, B.C.

Hanning, G. F., '89, whose home is in Toronto, is divisional engineer for the Canadian Northern Railway at St. Eustache, Que.

Hara, L. D., '04, is in St. Catharines, Ont., as superintending engineer on the Welland Canal construction.

Hare, R. A., '07, is in charge of the test department of the Canadian Crocker Wheel Co. at St. Catharines, Ont.

Harcourt, F. Y., '03, is assistant engineer, Department of Public Works for Ontario, at Port Arthur, Ont.

Harcourt, H. E., '11, is resident engineer, sewer department, city of Toronto. He is also secretary-treasurer for J. H. Tromanhauser Co. Ltd, engineers, architects and contractors, Temple Building, Toronto.

Hare, W. A., '99, is president and managing director of the Hare Engineering Co., Limited, Toronto.

Harkness, A. H., '95, is senior member of the firm of Harkness & Oxley, consulting structural engineers, Toronto, Ont.

Harkness, A. L., '06, was in the engineering offices of the St. Lawrence Bridge Co., Montreal, Que., when last heard from.

Harper, C. J., '09, is in Collingwood, Ont., at present.

Harris, C. J., '04, resides in Brantford, Ont., in the employ of the Brantford Screw Co.

Harris, J. H., '10, is superintendent for W. Harris & Co., manufacturers of glue, fertilizers, etc., Toronto, Ont.

Harris, F. K., '09, is with W. Harris & Co., Toronto.

Harris, R. C., was resident engineer for C. P. Ry. at Medicine Hat, Alta. We are not certain of his present address.

Harrison, R. L., '06, is engineer in charge of the Toronto Eastern Railway, and resides in Oshawa, Ont.

Harrison, F. W., '05, is engineer for H. D. Best Co., builders, New York.

Harrison, E., '06, is senior member of the firm of Harrison & Ponton, engineers and surveyors, Calgary, Alta.

Harston, R. G. L., '09, is superintendent for W. S. Tomlinson & Co., contractors, Toronto, Ont.

Hartney, J. C., '06. We do not know his present address or occupation.

Harvey, C., '01, resides in Kelowna, B.C. He is consulting civil engineer and land surveyor.

Harvey, D. W., '09, is assistant engineer of railways, department of works, Toronto.

Harvie, N. J., '10, whose home is in Orillia, Ont., has no record of professional employment with us.

Hastings, M. B., '10, is sales engineer for A. H. Winter Joyner, Limited, electrical supplies, Toronto.

Haultain, H. E. T., '89, is Professor of Mining Engineering, University of Toronto. He also has an office as consulting engineer at 123 Bay St., Toronto.

Haviland, F. L., '08, is with the Hamilton Bridge Works Co., Hamilton, Ont., in the engineering department.

Hawley, H. A., '13.

Hay, C. O., '09, deceased, September 5, 1911.

Hayes, L. J., '03, is manager of the Niagara Falls (N.Y.) office of the Development and Funding Company.

Hayman, A. W., '13, is engaged in building construction at London, Ont.

Hearn, R. L., '13, is on the staff of the Hydro-Electric Power Commission, Toronto.

Heebner, M. B., '11, is at Pitt River, B.C., as engineer in charge of construction work for the Foundation Cement Co.

Helliwell, J. G., '10, is on the design of structural steel work with the Canadian Bridge Company at Walkerville, Ont.

Helson, F. J., '07, is division engineer for the Canadian Northern Ontario Railway, at Hobon, Ont.

Hemphill, W., '00, is superintendent of lines for the Cataract Power and Conduit Co., Buffalo, N.Y.

Hemphill, J., '09, is construction engineer for the mines department, Algoma Steel Corporation, with headquarters at Magpie Mine, Ont.

Henderson, E. E., '85, although we do not hear from him, we have no knowledge of any change from his old address, Henderson, Maine.

Hawley, H. A., '13, is with the Lewis Construction Co., Toronto.

Henderson, F. D., '03, resides in Ottawa, Ont. He is on the staff of the topographical surveys branch, Department of the Interior.

Henderson, J. F., '10, is resident engineer for Chipman & Power at Thorold, Ont.

Henderson, S. E. M., '00, is switchboard sales engineer for Canadian General Electric Co., Toronto, Ont.

Henderson, C. D., '08, is with the Canadian Bridge Company at Walkerville, Ont.

Hendry, M. C., '05, whose home is in Toronto, is with the Waterpower Branch, Department of the Interior, Ottawa.

Henry, J. A., '00, resides in Schenectady, N.Y. He is with the General Electric Company as designing engineer.

Henry, R. A., '13, formerly with the Dominion Bridge Co., Montreal, was at Barrie, Ont., when last heard from.

Henwood, C., '02, is secretary-treasurer of the Toronto office of Ross & Macdonald, engineers and architects, Montreal.

Herald, W. J., '94, who was with the Canada Foundry Company for some time has no address with us since then.

Hermon, E. B., '86, is in Vancouver, B.C., where he is in the employ of the Vancouver Power Co., as assistant chief engineer.

Heron, J. B., '04, is with the Canadian Northern Railway Co., at North Bay, Ont., as district engineer.

Hertzberg, C. S. L., '05, is a member of the firm of James, Louden & Hertzberg, structural engineers, Toronto, Ont.

Hertzberg, H. F. H., is chief engineer for the Trussed Concrete Steel Co. of Canada, Limited, Walkerville, Ont.

Hett, S., '06, is locating engineer for the Hudson Bay Ry. We do not know his address.

Hewson, W. G., '05, is with the Hydro-Electric Power Commission of Ontario, Toronto Office, as assistant engineer.

Hewson, E. G., '08, division engineer of Ontario lines of the Grand Trunk Railway, resides in Toronto, Ont.

Hickling, F. G., '10, is in the engineering office of the Westinghouse Electric and Manufacturing Co. at East Pittsburg, Pa.

Hicks, W. A. B., '07, resides in Philadelphia, Pa.

Hill, E. M. M., '04, is in Edmonton, Alta., in the engineering department of the Canadian Northern Railway.

Hill, S. N., '04, is with the Topographical Surveys Branch, Department of the Interior, Ottawa, Can.

Hill, H. O., '07, is designing engineer for the Blaw Steel Construction Co., Pittsburg, Pa.

Hill, H. R., '11, is cost engineer for the Toronto Hydro-Electric system.

Hill, T. A., '13. His home is at Ninga, Manitoba.

Hillis, C. R., '96, whose home is in Toronto, is consulting engineer for the Canadian Westinghouse Co., of Hamilton.

Hinch, E. F., '10, is resident engineer at Port Credit, Ont., for the Toronto Power Company.

Hodgins, Geo. S., '81, is mechanical engineer, National Transcontinental Ry., Ottawa, Ont.

Hogarth, G., '09, is assistant engineer, Ontario Department of Public Works, Toronto.

Hogg, T. H., '07, is assistant hydraulic engineer for the Ontario Hydro-Electric Power Commission, and resides in Toronto.

Holcroft, H. S., '00, is in Toronto with the Canada Life Assurance Co.

Holden, O., '13, is with the Hydro-Electric Power Commission, Toronto, Ontario.

Holmes, A. E., '09, is in Montreal, Que., with the Canadian Westinghouse Co. as sales engineer.

Holmes, C. R., '09, is in Detroit, Mich., with the Electric Storage Battery Company.

Hookway, C. W., '06, is with the Canadian Allis Chalmers Co., in the Winnipeg office.

Hopkins, P. E., '10, is stationed at Porcupine, Ont., for the Ontario Bureau of Mines.

Hopkins, R. H., '06, is on the engineering staff of the University of Toronto, as lecturer in electrical engineering. He is also town engineer of Lindsay, Ont.

Horton, J. A., '03, was in Northern Ontario when last heard from, several years ago.

Hoshal, G. C., '09, is with the Hydro-Electric Power Commission, with headquarters at Niagara Falls, Ont.

Houston, R. S., '06, is assistant engineer with the Vulcan Iron Works, Winnipeg, Man.

Howard, J. T., '13, is on the staff in engineering at University of Toronto as demonstrator in drawing.

Howlett, T. F., '13, is in the West at present.

Huber, W., '06, is assistant to the chief engineer, Department of Public Works, Toronto.

Huether, D. J., '08. We do not know his address.

Huether, A. D., '08, is a member of the engineering staff of the city of Toronto, main drainage works.

Huff, A. J., '11, is in Edmonton, Alta., with the Huff Gravel Co., Limited.

Huffman, K., '11, whose home is in Toronto, is with Mackenzie, Mann & Co., construction department.

Hughes, C., '09, is location engineer for the St. John & Quebec Railway, with the Fredericton, N.B., office.

Hull, H. S., '95, was with the Cambria Steel Co. in their works at Johnstown, Pa., as structural engineer when last heard from.

Hull, A. H., '06, is assistant electrical engineer in the Toronto office of the Ontario Hydro-Electric Power Commission.

Hunter, A. E., '09, has no address with us.

Hunter, A. N., '08, is with Geo. J. Beattie, electrical contractor, 72 Victoria St., Toronto.

Hutcheon, J., '90, is on the staff of the Department of Lands, Forests and Mines, Toronto.

Hutton, C. H., '07, formerly with the Dominion Power Co., of Hamilton, Ont., as electrical engineer, is now living in Toronto.

Hyatt, H., '11, is assistant engineer for P. Lyall & Sons Construction Co. Ltd., Toronto.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, JUNE, 1914 New Series Vol. IX. No. 2

MECHANICAL EQUIPMENT OF MODERN BUILDINGS*

Melvern F. Thomas

Secondary only in importance to the design of the enclosure and the planning of the interior arrangement of a building by the architect, stands the proper design and layout of the mechanical equipment by the engineer. It is the province of the architect to plan a structure best adapted to the site and the utilities to be housed, and it is the duty of the engineer to arrange the mechanical equipment to fulfil the requirements of the building and its services. It is the duty of them both to produce a building that will give a fair monetary return upon the investment if it is a commercial proposition, and to fulfil a need of whatever character it may be.

The province of the engineer is not so broad as that of the architect, but has sufficient scope to tax the ingenuity of most men, and the problem is becoming more complex each year.

While, of course, the character and the number of services to be provided will depend, to a large extent, upon the class of the building, every modern building will include several or all of the following services.

1st. Electric Generating Plant.
2nd. Plumbing, Water Supply and Drainage Systems.
3rd. Heating Equipment.
4th. Ventilating System.
5th. Electric Lighting, Power, and Sundry Electric Services.
6th. Elevator Service.
7th. Refrigerating Equipment.
8th. Sundry Minor Services.

Almost every building will have a system of plumbing, heating and electric services, and a great many of our buildings have some means of providing a positive circulation of fresh air and for the removal of vitiated air. If the building is a hotel or a club there will be a refrigerating system, and a great many of our large office buildings have some refrigeration, for cooling drinking water, or to serve a restaurant or lunch service.

Since it is impossible to give attention to the mechanical equipment of all different classes of buildings within the scope of one short

* Read before the University of Toronto Engineering Society

paper, only the essential services of a modern office building will be discussed.

Plumbing

This branch of the work includes the distribution of hot and cold water throughout the building, the draining of the water from rain and melted snow from the roof to the sewer, and the disposal of the sewerage to the sewer system. Cold water is usually obtained from the city mains, and in most cases a storage tank is provided in the attic or above the roof of the building to serve as an emergency supply for domestic purposes and for fire protection, should the main supply be temporarily discontinued. Check valves must always be placed in the supply pipes from the street so that the building system will not be drained in the above emergency. If the city pressure is always sufficient to raise the water to the tank it will be allowed to flow in through a ball or float cock, which will automatically maintain a fixed level in the tank. If, however, the building is a tall one, it will be necessary to install house pumps to raise the water to the tank. From the storage tank and from the water mains in the lower section of the building, pipes are extended to all fixtures throughout the structure. In the case of a tall building the pipes will all connect to the storage tank and should also be brought down and connected to the system in the basement or the lower portion of the building. Valves should be provided to divide the upper portion of the system from the lower, so that the lower part may be supplied from the city pressure, while the upper stories are supplied from the tank. This arrangement will economize in pumping, as it will not be necessary to raise all of the water to the top of the building. Care should be taken to provide check valves in all pipes leaving the storage tank so that water cannot back up through these lines and overflow the tank in case the city pressure becomes unusually high, if it is a building in which the water is ordinarily elevated by means of pumps.

The drainage system from the roof of the building usually consists in extending pipes called rain water leaders from the gutters and low points in the roof down through the structure of the building and connecting same with the sewer piping. Every connection to the sewer must be provided with a running trap, which is kept filled with water to prevent gases from backing up through the piping. Refuse and water from the fixtures in the lavatories is discharged into soil stacks which extend down through the building and connect through the main house trap to the street sewer. The arrangement of the fixtures and the flushing devices must be such that ample water will be allowed to pass down this system of soil piping to keep same washed clear. Every fixture throughout the building is provided with a trap to prevent gases from escaping into the building, and on the opposite side of the trap from the fixture there is provided a vent connection which extends up through the building and is left open to the atmosphere at a point several feet above the roof. Great care should be given in the selection of drainage fittings so that there will be no pockets which will not drain clear. These fittings are usually recessed and the pipes should be screwed in to the bottom of the counter bore.

To safeguard the public health, almost every city has more or less stringent by-laws governing the arrangement of the plumbing services and standardizing a great deal of the work. This, of course, leaves less opportunity for varying the equipment which must be provided in any given building.

If it is necessary to place plumbing fixtures where they cannot be drained by gravity into the sewer system, provision must be made for elevating the sewerage so as to discharge it from the building. There are several methods used, some of which consist of a centrifugal pump and a closed tank for the collection of waste matter. There is often more or less difficulty with this method of handling sewerage due to incrustation in the pump. In most of the important installations a pneumatic ejector is used. This equipment consists of an iron tank located so that the sewerage will flow to same by gravity. From the bottom of a tank a pipe is connected to the sewer. Both the supply and discharge pipes are provided with check valves. A supply of compressed air is furnished by a compressor. When the receptacle is nearly full a float or air lock automatically operates the valves and admits air to the top of the vessel and the contents is forced through a discharge pipe to the sewer, and when the tank is emptied the flow of air is automatically cut off and the equipment is ready for the beginning of another cycle. There is also a system of sewerage disposal which utilizes the energy of the sewerage from the upper floors to compress the air, which in turn is used to raise the sewerage from the lower section of the building. This method, however, has not been extensively used on this continent.

Hot water for domestic purposes is usually heated by passing it through a tank which contains a steam coil. This coil should generally be made of brass or copper. If, however, steam is not available throughout the year, a jacket heater, using coal as a fuel, or some form of gas heater will be installed. Gas may be consumed at a higher efficiency than coal, and it is more convenient to handle, but with coal at $8.00 per ton gas must cost only 20 to 25 cents per thousand cubic feet in order to be on a par with coal in fuel cost.

The hot water system should always be under thermostatic control and except in the case of hotels and laundries, a temperature of about 160 degrees F. is maintained. The dish washing service in hotels and the washers in laundries usually require water at a temperature higher than that given above. For these services the water is often heated almost to the boiling point, and in some cases the steam is blown directly into the washing tank. There are several forms of thermostatic regulators for controlling gas burning equipment in a satisfactory manner, but in selecting a design great care should be given to the pilot light equipment to insure against it becoming extinguished and the building filled with gas. No damper should be allowed in the smoke flue from an automatically controlled gas burning equipment. The steam supply to heater and the draught dampers of the jacket heaters may be controlled by a thermostat placed in the storage tank.

The cold water supply to the domestic heater is usually obtained from the gravity tank, if it is a tall building, and circulating pipes should be brought back to the heater from the ends of all hot water branches, and the system should be arranged so that the water will circulate by gravity throughout the building, unless it is an extremely large installation, or the water has to be transmitted through a group of buildings, in which case it will generally be necessary to install a circulating pump. In any case the water must not be allowed to remain still in the pipes, as it will become cool and cause waste and inconvenience, for it will be necessary to run a large amount from the faucet before the water becomes hot enough to use.

Heating

In all the colder climates it is necessary to heat buildings throughout the winter season. The temperature which is to be maintained will depend to some extent upon the occupation of the inhabitants, and also upon the race and customs. On this continent a temperature of 70 degrees F. is usually considered desirable for all buildings where people are not engaged in manual labor. In France and England a temperature of from 65 to 68 is considered satisfactory, and under most conditions this lower temperature is probably more desirable for health than is the higher.

Steam, hot water, and heated air, are the mediums commonly utilized to transmit heat from the generating plant throughout the building. Steam is used more than the others. It is adapted to smaller buildings and is practically the only one used for very tall structures, but is difficult to regulate to meet the varying heating requirements. Hot water is well adapted to small installations, in which it is usually allowed to circulate by gravity, and to large heating systems, where forced circulation is obtained by means of pumps, or the so called rapid circulation by allowing some steam to be generated and pass up the pipe, thereby reducing the static pressure in the flow pipe. Hot water has the advantage of easy regulation. In tall buildings the pressure due to the static head of the water will be excessive on the lower floors, and for this reason buildings taller than 6 or 8 storeys are seldom heated by hot water.

The hot blast system, using hot air which is circulated by means of a fan, has been extensively used for heating factories and may be used for heating large buildings. This method has not been used to any extent for heating office buildings, although almost every large office building has some ventilating equipment to furnish fresh air to the lower floors, and this same equipment is very often used to warm these floors. In 1910 the writer installed a fan blast system throughout a 12 storey building, but there are very few installations of this character where the heating requirements are severe.

In order to transmit and distribute air for heating throughout a building it is necessary to run large ducts, and in a modern office building it is very difficult to find space for these, although if the floor space given up to radiators and piping is all considered, the space lost due to fan blast heating would probably not be greater than with direct radiation.

The modern forced blast heating and ventilating unit consists of tempering coils, an air washer, a centrifugal fan, and reheaters, with a system of galvanized iron ducts to distribute the air.

The temperature of the air having been raised to 50° to 55°F. by the tempering heater, passes through the air washer to the fan, which forces it through the reheater into the hot air chamber or around the by-pass in the tempered air chamber. A thermostat located in the tempered air chamber regulates the amount of steam supplied to the tempering coils and maintains the tempered air at a constant temperature, and a thermostat in the hot air chamber regulates the steam supply to the reheating coils and maintains a constant temperature in the hot air chamber, or located in the cold air supply duct regulates the reheaters to meet the requirements. Each air duct is connected to both the tempered and the hot air chambers and has a damper in each connection. These dampers are connected by a bar and arranged so that opening one closes the other. A thermostat located in the room which is supplied by the duct controls the position of these dampers and in that manner allows the desired quantity of hot and tempered air to enter the room to maintain a constant temperature and at the same time give a constant air supply.

Incidentally, this apparatus, if properly operated, will give an approximate humidity control, for the air washer will very nearly saturate the air passing through, and will therefore give a nearly constant percentage of humidity in the rooms supplied so long as the automatic regulating equipment is in satisfactory operation, and the air outside does not contain more than the desired amount of moisture.

The supply registers are usually placed upon interior walls and about eight feet from the floor for average rooms, and the exhaust, or vent registers, are placed near the floor unless there are fumes or smoke to be removed in which case a part of the outlet openings may be placed near the ceiling.

No positive fresh air supply is usually provided in lavatories, but an exhaust system should always be provided and arranged to remove air from above each fixture.

There are too many details to the various kinds of heating system to be covered in one paper, and I will give attention only to vacuum heating, which is the usual method in large office buildings.

In this method steam is supplied at a very low pressure, often not appreciably above the atmosphere. Some form of vacuum trap which will allow the water and air to pass but will close as soon as steam enters it, is placed in the drip or return connection to each radiator.

Vacuum Pumps are connected to the return mains and from 5 to 15 inches of vacuum is maintained. This causes the water and air to quickly flow from the radiators and allows the steam to make efficient use of the heating surface.

With this system it is not necessary to have all the return piping drain to pumps, as lift fittings may be installed and the water raised.

It is very common practice to extend a steam main to the top of the building, provide a circuit around the attic and extend pipes down the columns to supply radiators upon the various floors and to collect the condensation by means of a system of return risers, also on the columns and extending down to the basement where they are connected to the return mains or joined in groups and extended back to the return header, which is connected to the vacuum pumps.

The steam supply to the radiators may be regulated by throttling so as to have a partial vacuum in the radiators, and to operate under a temperature lower than 212.

Vacuum heating has led to the development of a large number of thermostatic traps and water seal valves. The thermostatic trap usually has some form of motor which contains a vessel filled with a liquid which will generate a pressure by boiling at the desired temperature and by expansion close the passage.

In any heating system one of the most difficult questions to handle is the disposal of the air from the radiators and the piping. The air must either be discharged through automatic valves, placed on each radiator and wherever there is an opportunity for air to collect, or it must be drawn back by some mechanical means through the return system. In vacuum heating the pumps exhaust the air from the return mains at the same time that the return water is removed from the system, and the apparatus is nothing more than a wet vacuum pump arranged to handle hot water. These pumps are usually automatically controlled so as to maintain the desired vacuum on the return system, and the pumps are allowed to discharge into a receiving tank where the air is separated from the water and allowed to escape through a vent pipe. The water is usually drawn from the receiving tank by the boiler feed pumps and returned to the boiler.

Vacuum heating is somewhat more economical than so called gravity steam heating, because the steam may be distributed throughout the building in a more uniform manner, and not have excessive back pressure in the exhaust piping of the steam power equipment. Also, by lowering the pressure, a condition better adapted to moderate outdoor temperatures may be obtained.

Thus far it has not been found practical to arrange any method of adjusting the amount of heating surface of a given unit which is to operate, and the only means of regulation at the present time is to decrease the temperature of the entire radiator, either by decreasing the pressure or by cutting off the steam at intervals. Increasing the number of radiators in each room allows for partial regulation by turning on or off some of the units. However, any increase in the number of units will increase the cost of the system, though the heating surface is not made greater. The labor and material, other than the radiators necessary to install a steam heating system, will usually amount to from 70 to 80 per cent. of the total cost, and every additional unit added will increase the cost of the system. In factory buildings it is possible to economize in first cost by using very large units in the form of pipe coils, but in office buildings it is necessary to have at least one radiator in each room, and in a great many rooms where there is a probability that tenants will ask to have changes made by dividing the room into several smaller ones, it may be desirable and economical in the end to install two or more small radiators.

All the piping in the heating system of a modern office building may be concealed in the structure of the building unless there are architectural features which make it impossible to do so. The risers are usually enclosed by providing chases in the walls or furring out to cover them, and the branches to the radiators are placed in the concrete floor structure.

One of the most important things to be considered in the installation of a heating system is the proper provision for the expansion and contraction of the piping. Provision is usually made for the pipe to have a slight movement by taking off each branch in such a manner that there will be a swing connection formed, built up of elbows and nipples, and in buildings which are more than 8 storeys in height it is usually necessary to provide an expansion connection in the body of the risers. The pipes which are concealed in the cement floor structure are covered with asbestos and usually have a sheet metal covering or gutter laid over the asbestos covering before the cement is poured over them. The asbestos covering will allow for the necessary expansion in the short runs which are placed in the floors.

Electric Services

The electric circuits, throughout a modern building, which serve the various outlets for lighting and in some cases power, are always enclosed in wrought iron conduits concealed in the structure of the building. The layout is usually arranged so that each floor or a small section of the building will be provided with a panel box containing switches and fuses to control and protect the secondary circuits which are placed in the floor and ceiling and furnish current for the lighting outlets. These secondary circuits usually are arranged so that each will supply not more than 660 watts. Modern lighting systems usually operate on 110 to 115 volts either direct or alternating current. If direct current is used it is common practice to install the three wire system, arranged to transmit current at 230 volts between the main leads, and to have a neutral wire with a difference of potential of 110 to 115 volts from each main lead. The layout must be arranged and the system balanced so that the difference in load between the two sides of the circuit will be reduced to a minimum. The modern three wire electric generator provides for a difference in load between the two sides of about 25 per cent., and it is necessary to use a two wire 230 volt machine, a motor-generator balancing set will usually be required to provide for the difference in load to prevent burning out lights.

The electric conduits usually terminate in outlet boxes concealed in the structure of the building. The fixture wire or the connection to the receptacle is made in this outlet box, and the whole is concealed either by a plate or by a part of the fixture.

Power service is usually provided in the same general way, except that 230 volts or higher is very commonly used, and each motor, unless it is a very small unit, has in its outlet box a cut out consisting of fuses and possibly a knife switch.

In every modern building there are sundry minor electric services such as a telephone system, call bells, telegraph calls, watchmen's time clock systems and fire alarm circuits. It is very common practice to arrange a system of risers extending up through the building and connecting to distribution panels placed upon each floor to provide telephone service. In buildings where the furniture and fittings are fixed it is common practice to extend one-half inch and three-quarter inch conduits from these distribution boxes to telephone outlets in the various rooms and offices, but in a great many office buildings where it is impossible to determine where the tenants will desire their phones to be located it is common practice to provide a wiring moulding or gutter around the entire corridor, and to conceal the telephone wiring in this gutter and to make a connection therefrom to the distribution panels. The telegraph and call bell services are usually installed in very much the same manner as the telephone system. None of these minor electric services are ever allowed to be placed in the same conduits with lighting or power circuits. The watchman's recording system usually consists of one or more magnetic stations placed upon each floor and located in such a manner that it is necessary for the watchman to pass through almost the entire building in order to visit all the stations. A recording system is provided in some part of the building which automatically records the time at which the watchman visits and rings each station.

Elevator Service

Most modern buildings having more than three storeys are equipped with some form of elevator to quickly transport passengers from the street level to all floors. The importance of the elevator service increases with the height of the building, and in the "sky-scraper" it forms one of the most elaborate and expensive parts of the mechanical equipment.

The worm geared and the gear-less 1 to 1 traction type electric elevators and the plunger type hydraulic elevators are used in modern buildings, and the demands of the tall structures have led to the development of elevators to run as high as 700 feet per minute. The latest type of elevator is the 1 to 1 gear-less electric traction, which is operated by a 35 h.p. motor running at from 40 to 63 R.P.M., and operating a car having a floor surface of approximately 30 square feet at a speed of about 550 feet per minute with a load of 2,500 pounds.

A canvass in 1910 of 18 New York office buildings, having from 9 to 25 storeys, shows that there are 149 elevators in service, that the cars have from 25 to 30 square feet of floor surface each and that there is an average of 1 elevator per 16,600 square feet of rentable floor surface. In the Woolworth Building, New York, there are 29 electric passenger elevators. Two of these have a run of 679 feet from the street level to the 53rd floor, and have a capacity to lift 2,500 pounds, at a speed of 700 feet per minute. This elevator installation is a striking example of the advancement of the art in less than a half century.

Minor Services

There is often a demand for artificially cooled drinking water in an office building and in some cases a small amount of refrigeration is desired in connection with a restaurant or lunch service. A small ammonia compression machine can conveniently be installed to meet these requirements.

A vacuum cleaning plant is installed in most office buildings. Connections should be provided so that all parts of floors to be cleaned can be reached with 50 to 75 feet of hose, but in old buildings it is not always possible to accomplish this distribution, and very long lines of hose must be used. In one of Toronto's largest department stores, vacuum cleaner tools operate upon 200 feet of hose, but under this condition the service is not satisfactory.

In preparing specifications for the mechanical equipment of a building, the engineer should give close attention to the division of the work between the several trades and each contract should definitely state exactly the scope of work to be covered and where connections are to be made to the other trades. There often arises such questions as, who provides the foundations? Who does the electric wiring to the motors? Is contractor to paint apparatus after it is all installed? Is contractor to make connections to steam exhaust and drain piping? What operating conditions are guaranteed? One of the most difficult parts of the engineer's duties is to avoid interference between the different services. Alterations in the building often disturb the layout of the equipment and you will find the ventilating ducts, the plumbing and steam pipes all attempting to occupy the same space.

Four of this year's graduates in mining engineering, viz., W. E. Milligan, Toronto, S. D. Ellis, Victoria, B.C., R. W. Young, Bothwell, and S. A. Lang, Toronto, have accepted positions in the metallurgical works of the Braden Copper Company, Chili, South America.

R. W. Downie, '16, is with the Department of Mines, Forests and Lands at Fort Francis, Ont.

J. W. Peart, B.A. Sc., '13, is with the Waterworks Commissioner at London, Ont.

A. A. Scarlett, B.A. Sc., '13, is with the Ontario Hydro-Electric Power Commission at their experimental station on Strachan avenue, Toronto.

THE PURIFICATION OF PUBLIC WATER SUPPLIES

C. H. R. Fuller, B.A.Sc.

The interest attaching to the purification of public water supplies originated principally in the proof, which has been furnished by medical men, that some zymotic diseases are communicated through drinking water. The communicability of Asiatic cholera and typhoid fever forms one of the fundamental principles of modern sanitary science, which each year is becoming more generally accepted and is probably now universally recognized. The ancient Romans appreciated this fact when they spent much time and labor to bring their water supplies through magnificent aqueducts from unpolluted sources. In some cases the water was even passed through artificial reservoirs to purify it by sedimentation.

The most important use of a public water supply is the furnishing of suitable water for domestic purposes. The value of a pure supply to a city compared with one polluted by sewage can scarcely be overestimated. Pure water is of great value to small towns and villages as well as to large cities. In some cases the supply is designed solely for fire protection, when pure water is to be desired quite as much as for a city supply. An adequate or copious supply is not to be considered if it means that quantity is procured at the expense of quality. This fact may be noted on comparison of American and European supplies. The consumption of American municipalities per capita is very much higher than that of Europe, but in quality the European water supplies excel American standards.

A suitable supply for drinking purposes should be pleasant and palatable, and if possible, free from color and turbidity. The latter requirements are not binding, since many peaty and turbid waters may be safely used. Waters heavily charged with mineral matters should not be used as they are supposed to produce diseases of an intestinal and gastric nature. The most important requirement of a water supply is to have it unimpaired by organic refuse of human, animal, or vegetable origin, as this contains germs of a character which are dangerous to human existence. For this reason the use of surface waters in populated districts where sewage is discharged into the rivers and lakes is dangerous to public health and should be first subjected to a system of artificial purification.

Bacterial Content of Various Waters. The micro-organisms causing disease, which are present in water and are the polluting elements, are the pathogenic bacteria. The bacterial pollution of a stream is always greater during high-water stages as the more rapid flow increases the carrying power and much more dirt is carried along with the bacteria that accompany such a disturbance of soil particles. Theobald Smith found that the Potomac River water contained the following number of bacteria at different seasons:—

Dec.	Jan.	Feb.	March	April	May	June	July	Oct.
967	3774	2536	1210	1521	1064	348	255	75

The same general result was noted by the Massachusetts State

Board of Health on the Merrimac River water. It appears as follows:—

	Average No. of Bacteria per C.C.
January	3,800
February	3,700
March	3,500
April	1,600
May	2,600
June	15,100
July	4,400
August	5,000
September	13,800
October	4,200
November	7,800
December	11,200

According to Johnson, the bacterial content of uninhabited streams like the Saguenay in Canada is not materially different from that of the rivers flowing through farming regions, although where a stream flows through a city or town of any considerable size, especially if it receives the sewage of the same, the amount of pollution is naturally much increased. The following data were determined for the Isar River at Munich:—

	No. of Bacteria per c.c.
Above the city of Munich	531
150 feet above sewer outfall	1,339
Directly opposite sewer outfall	121,861
450 feet below sewer outfall	33,459
Ismaning (8 miles below sewer outfall)	9,111
Freising (20 miles below sewer outfall)	2,378

Not only is there a marked increase in the bacterial content of the river, but also it is evident from the above table that a large part of this pollution is lost in a comparatively short time, as it takes only eight hours for the current to reach Freising, twenty miles below.

A few American streams have been more or less perfectly studied in this regard. The most extensive study yet made was that on the Illinois River in connection with the Chicago Drainage Canal. The waters of this stream were studied bacteriologically, both before and after the opening of the Sanitary Canal, in order to determine whether the introduction of the sewage of the city of Chicago would exert any deleterious influence on the quality of the St. Louis water supply drawn from the Mississippi. The data showed that the bacterial reduction is continuous for a distance of 160 miles, until the river receives at Wesley City the large amount of refuse of Peoria.

The Relation of B. Coli to Polluted Waters.—In the case of most water borne diseases, it is generally admitted that the organism causing disease is more or less distinguishable from other bacteria, although in typhoid fever, the "bacillus typhosus" is closely related to an intestinal organism called "bacillus coli communis." When the latter are found in water, it is an indication of intestinal discharges and the water supply should not be regarded as safe. The Massachusetts State Board of Health found the numbers of bacillus coli communis in the Merrimac River water in various years as shown in Table 1.

YEAR	No. of Samples Tested for B. Coli	Average No. of B. Coli per c.c.	Per Cent Containing B. Coli
1898	163	49	98.2
1899	180	47	99.4
1900	199	87	99.5
1901	144	40	97.9
1902	196	73	99.0
1903	136	53	98.5
Total:	1018	58	98.7

TABLE 1.

It will be noticed that B. Coli has been present in all samples of the river water. In the water at the intake of the Lawrence City filter and in the water as it flows to the filters, higher numbers of B. Coli per cubic centimeter have been found during the summer months than during the winter months and in the same water after receiving sewage of the city of Lawrence, the numbers of B. Coli have been higher in the summer season.

Table 2 shows interesting results of tests for B. Coli in surface waters. These show that the surface waters of inhabited localities nearly always contain B. Coli. This is a positive indication of sewage pollution.

Number	Area of water Surface in Acres	Area of Water Shed in sq. miles	Population of water shed per sq. mile	Total population per sq. mile.	Number of Samples	Per cent. cont. B. Coli	Av. No. of Bacteria per c.c.
1*	243	5.00	1,400	7,000	30	13.3	612
2	85	0.94	356	380	29	3.5	319
3*	222	4.96	60	290	44	2.3	48
4*	621	5.40	50	270	43	4.6	66
5	38	0.32	47	15	45	0.0	133
6	379	5.18	42	148	43	0.0	107

* Shores used for pleasure resorts.

TABLE 2

Typhoid Outbreaks.—A most instructive case of this simultaneous development of disease due to sewage pollution is seen in the series of typhoid epidemics that occurred in the towns in the valley of the Mohawk and Hudson rivers in 1890-91.

In July, 1890, typhoid became epidemic in Schenectady and continued until April, 1891. Seventeen miles down the Mohawk at Cohoes, a city of about 22,000, typhoid broke out in October 1890, and before April 1891 there had been 1,000 cases. The disease was exceptionally mild; but notwithstanding this, the typhoid death rate for the period of the epidemic was equal to the annual death rate of 45 per 10,000 inhabitants, or about 12 to 15 times the normal.

West Troy, taking its supply also from the Mohawk above Cohoes, suffered from an epidemic from November 1890, till February 1891, except for a brief period when the supply of the village of Green Island was used. Six miles below West Troy is Albany. Here, again, the disease became epidemic in December, lasting until the spring. Waterford, Lansingburgh and Troy took their supply from other sources than the Mohawk or the Hudson below the junction with the former stream. So far as this outbreak was concerned, they escaped entirely.

The progressive development of the disease in all those towns that used water from the Mohawk, and its absence in other towns situated on the Hudson that were supplied from other sources, shows conclusively the influence which the sewage pollution of Schenectady and other towns had on the distribution of the disease.

Necessity of Purification.—Disasters have occurred from drinking sewage polluted water usually because of the failure to purify a surface supply exposed to pollution or of the inefficiency of the purification. The following comparison of typhoid rates in different towns before and after purification will show the marked necessity of taking precautions against outbreaks and the value of purification.

Cohoes.—In February, 1908, the Mohawk river pollution was investigated and the need of a pure supply to lower the high typhoid rate was pointed out. Water filtration was strongly urged, and in 1911 a filter plant was installed. Notice the reduction in rate in 1912.

Year	1900–5	1906	1907	1909	1910	1911	1912
Typhoid rate per 100,000	92.9	57.8	62.0	82.2	76.8	108.5	48.0

This is a good example of the necessity of having a system of purification.

A consideration of the case of Elmira will show the necessity of having an efficient system of purification. In 1896, as a result of a serious epidemic, a filtration plant was installed. In 1909, an investigation showed continued high rates of typhoid and it was recommended to increase the efficiency of the plant. After this the operation was improved through the use of hypochlorite, which was used during the two succeeding years. Notice the reduction in the rate of 1909.:

SEDIMENTATION PROCESSES

Year	1900-5	1906	1907	1908	1909	1911	1912
Typhoid rate per 100,000	45.5	44.7	28.0	30.7	33.5	26.9	13.3

Other examples of the same kind will be found in the records of New York, Niagara Falls, Ogdensburg, etc.

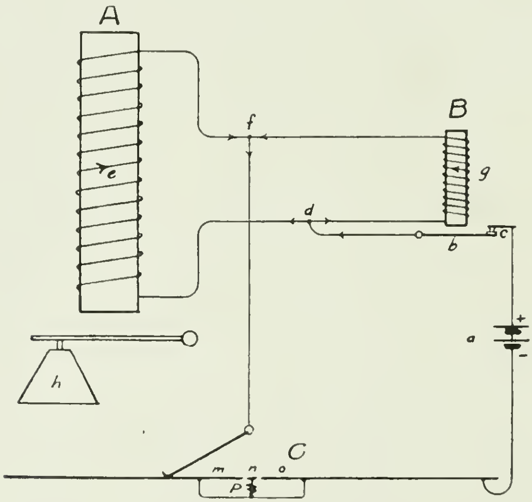
(To be continued in next issue)

LOW-VOLTAGE HIGH-SPEED RELEASING MAGNET

PROFESSOR H. W. PRICE, B.A.Sc.

Occasionally it happens that, when a mechanism appears impossible for specified service, the very property of it which caused difficulty can, if properly utilized, be made to correct all the troubles, and yield results that are better than one's most optimistic wish. A case in point is offered herewith:

Some time ago the writer had necessity to design an automatic mechanism including an electromagnet which was to start the mechanism into its cycle of operations every time the current in a control circuit through the magnet was momentarily destroyed or even reduced to half or less than half its normal value during a time not to exceed one-thirtieth of a second. This problem presented some real difficulties, because the magnet was required efficient so as to work with minimum drain on low-voltage batteries, and large enough



to securely resist a normal pull of 100 pounds on the armature. These two demands made impossible any design without a great many turns of conductor, and considerable inductance, which involved a magnet relatively slow in releasing its armature, liable to cause a small arc at the control contact, and with not the faintest chance of releasing because of a one-thirtieth of a second interruption of control current.

After some consideration a novel scheme was hit upon of making the large stubborn magnet work in combination with a small high-speed magnet, somewhat as an elephant and a bronco might work in combination, pulling a 6-foot whiffle-tree and a logging chain, the chain 5 feet from the bronco's end and one foot from the elephant's end of the whiffle. If, while the pair were ambling along at eight miles an hour, the chain caught solidly in a rock crevice, the bronco would suddenly be projected backwards along the trail at about thirty miles per hour before his mate could commence to stop.

In the diagrammatic figure herewith, *A* is the large, efficient, relatively slow-acting magnet designed entirely for its work with the 100-pound pull on the armature. *B* is a small quick-acting magnet designed entirely from the speed point of view. The two magnets are connected in parallel to operate from common battery *a*. At *b* is shown the light armature of *B*, which when attracted, stops mechanically against contact *c* through which the current to excite both magnets must pass. *C* represents that part of the control circuit in which a complete or partial opening may be made at any time. It is shown arranged as we had it for testing purposes, and was capable of opening the circuit for periods as short as one-five-hundredth of a second.

Normally, battery *a* sends current through contact *c* to junction *d*, thence in senses *e* and *g* around cores *A* and *B*, holding armatures up to support pull *h* and hold closed contact *c*. Any sudden break or reduction of current resulting from changes at *C* tends to reduce both currents *e* and *g*. Coils *A* and *B* both object to sudden reduction because of and in proportion to their inductance. Coil *A* having much the greater inductance persists momentarily in maintaining its current in the same sense *e*, and in so doing forces reversal of current *g* and the magnetism in small magnet *B*. This reversal of magnetism cannot occur without passing magnetism and magnetic pull on armature *b* through zero value, of which instant a spring takes advantage by *starting* armature *b* to move away from the poles. Since contact *c* serves also as the mechanical stop from which the armature started to move, the battery circuit is now absolutely open, and remains so whether closed again or not at *C*. Coil *A* may take its own time, but must release the pull on *h*.

The results obtained from this combination were surprising. An interruption at *C* for one-four-hundredth of a second would invariably trip the armature supporting *h*, leaving a safety factor of 13 over the speed required, one-thirtieth of second. Magnet *A* alone required one-half second to release after break of current through it. Further, as contact *c* always opens at the instant of zero current, there was no possibility of arcing at the contact regardless of design or size of the big magnet.

The automatic mechanism for re-setting the armatures for the next cycle of operations is not shown.

It may be of interest to know how one could accurately time a current reduction or break of one-five-hundredth of a second. Mechanism *C* was arranged for the purpose. Two copper straps *m* and *o*, were electrically connected, but mechanically separate from a short strap *n* by one-thirty-second of an inch air gaps. If it were desired to *open* the circuit for one-four-hundredth of a second, *n* was electrically disconnected from *m o*, and the contact arm moved uniformly from left to right at such speed as to spend one-four-hundredth of a second on *n* and the two gaps. Any slight arcing would shorten instead of lengthen the time of opening, so that time of opening was certainly not more than one-four-hundredth of a second, and might be somewhat less. If it were desired to *reduce* current for a similar test, any desired resistance was inserted between *n* and *mo*, which resistance was therefore inserted in series with the magnets while the contact arm was passing over *n*.

THE INDUSTRIAL MANUFACTURE OF HYDROGEN

J. E. Breithaupt, '15

Hydrogen is now sold at Griesheim & Bitterfeld, in Germany, at 10 pfennigs per cubic metre, one cubic metre weighing 89.6 grams. This is about 12 cents per pound. As hydrogen constitutes 17.6% by weight of ammonia, the quantity required to produce one pound of ammonia would cost 2.11 cents, and to produce one kilo 4.65 cents. Further, the hydrogen necessary to produce one kilo of combined nitrogen in the form of ammonia, i.e., 1.21 kilos of ammonia, would cost 5.62 cents. With ammonium sulphate selling at a rate which gives its nitrogen content a value of about 13 cents per pound, the value of nitrogen present, after deduction of the cost of the sulphuric acid, is well above 12 cents per pound. There is evidently here an unusually wide margin under existing price conditions to cover the expense of manufacture as nitrogen may be obtained in quantities at 0.32 per pound, or less. Where circumstances permit, the direct use of the hydrogen now liberated in the electrolytic manufacture of chlorine, and the alkalies, as at Griesheim and Bitterfeld, an admirable utilization of what is now often a waste produce, could be attained. Germany produces annually ten million cubic metres of hydrogen (896 metric tons) as a by-product of the electrolysis of the alkaline chlorides. The same can be said of the hydrogen liberated in the electrolytic production of oxygen for commercial purposes from solutions of alkaline hydronides.

The Machinenfabrik Oerlikon is now producing hydrogen on a large scale by electrolysis, using a solution of potassium carbonate as electrolyte. This hydrogen contains 1% of oxygen, while the oxygen produced at the same time contains 2% of hydrogen. The Heraeus Co., in Honan, uses as electrolyte a 20% solution of caustic potash maintianed at a temp. of 60°-70° C. Both firms require an expenditure of 6 kilowatt hours per cubic metre of hydrogen.

Where electric power costs 80 marks, or $19.04 per horse power year, as is frequently the case in Germany, this means an outlay 7½ pfennig per cubic metre of hydrogen for electric energy or 9 cents per pound. As each cu. metre of hydrogen involves a production of one half cu. in. of oxygen, valued ordinarily at 12 pf. per metre, it is possible to produce hydrogen electrolytically, with great economy, at all points where there is a continuous demand for oxygen in large quantities.

This electrolytic method is probably the oldest and the best established on an industrial scale. The great increase in the demand for hydrogen has, however, brought forth many new processes, a few of which I shall describe.

G. F. Jaubert has taken out several patents for processes and apparatus for the preparation of hydrogen by auto combustion. He uses metals such as aluminium or zinc, or their alloys, or metalloids, such as silica or carbon, or their compounds, mixed with alkali or alkaline earth hydroxides in the form of dry powders. These yield mixtures quite stable at ordinary temperatures. If, however, reaction be induced by local application of heat, hydrogen is evolved and sufficient heat is developed to cause the propagation of the reaction throughout the entire mass. A suitable apparatus consists of a tube closed at one end by a screw cap and having near this end an opening, also with a screw cap, through which a quick mass or piece of hot iron may be introduced to induce the commencement of the reaction. The other end of the tube is formed by a perforated plate, through which the hydrogen evolved passes into a chamber packed with filtering material, and thence into an annular space formed between the tube and a jacket extending nearly the whole length of the latter. The hydrogen accumulates in this annular space under pressure and is withdrawn as required through a suitable outlet.

Another of Jaubert's patents is for a process in which certain alloys of iron, especially ferrosilicon, containing 75% silicon, when heated to a very high temperature are capable of decomposing steam with sufficient evolution of heat to carry on the reaction $3\ Fe\ Si_6 + 40\ H_2 0 \longrightarrow Fe_3 0_4 + 18\ Si\ O_2 + 40\ H_2$.

The reaction may be regulated by the addition of lime, which has the further advantage of forming an easily workable slag. The apparatus comprises a refractory chamber surrounded by a steam coil, the delivery end of which terminates in a series of injectors which admit steam into the chamber. A feeding hopper is provided at the top of the chamber and a door for the withdrawal of the slag at the bottom.

The Internationale Wasserstoff Aktien-Gesellschaft, of Frankfurt, has established on an industrial scale, the manufacture of the gas by passing steam over glowing iron. Pyrites is found by the company to be the best material for use in the alternating operations of reduction and oxidation, as it retains its porous character. There is no tendency to fall to powder or to cake and thereby delay the process of reaction, more especially when undergoing reduction to the metallic state.

Water gas, which contains on an average 48% hydrogen, 43% carbon monoxide, 4% carbon dioxide, 4% nitrogen and small amounts of oxygen and methane, is an economical source of hydrogen. The oxides of carbon may be removed by suitable absorbents, such as alkaline hydroxides, cuprous chloride, etc. Frank passes the gas over calcium carbide at 300° C., securing an almost pure hydrogen. More economical is the separation by the use of compression and refrigeration, analogous to the method used in the separation of the constituents of the air. A company has been organized in Germany to produce hydrogen by this process, using for the purpose, when possible, the Dellwick water gas, which averages 51% of hydrogen and

42% of CO. Such a gas in the Linde apparatus easily yields a product containing 97% hydrogen, 1% nitrogen or less, and 2% carbon monoxide. The small amount of the latter can be easily removed by passing the resultant gas through a cuprous chloride solution. From this solution it can afterwards be expelled by boiling, supplying perfectly pure monoxide for use as a fuel gas. By a recently patented process the residual carbon monoxide can readily be removed by bringing the gas, while under high pressure, in direct contact with soda lime. The hydrogen is then over 99% pure, containing less than 1% nitrogen as the only impurity. The remainder of the carbon monoxide, originally present in water gas, is secured in this process, likewise in a form admirably adapted for fuel purposes, the liquefied gas containing 85%. It serves to supply the necessary power for the entire operation.

The 99% hydrogen gas can be furnished at a maximum rate of 12 pfennigs per cu. metre or 14.4 cents per pound. The purer gas, containing 99.2-99.4% hydrogen, would cost 15 pfennigs per cu. metre which is 18 cents per pound. This, the Linde-Frank-Caro method, so named after the inventors of the different features therein combined, has been installed in different parts of Germany and is doing good work. The cost of production on a large scale will ultimately sink materially below the rates given.

A patent entitled "Construction and method of operation of hydrogen gas producing apparatus" has been taken out by H. Lane. In his process hydrogen is prepared by passing steam over heated iron, or other easily oxidisable material, and the oxidised product is then reduced by means of a reducing medium such as water gas. In practice it has been found that the latter reaction takes considerably longer than the generation of hydrogen; the process is therefore carried out in three or more groups of retorts, the greater part of which are constantly subjected to the action of reducing gases for the regeneration of the iron, or other hydrogen producing substance. The retorts communicate with one another by means of suitable pipes, fitted with controlling valves, so that steam or the reducing gases may be admitted as required. The hydrogen which is evolved during the first few minutes of the operation, being impure, is diverted from the collector of pure hydrogen, and mixed with the water gas used for reduction. A considerable excess of water gas is used for this purpose and it undergoes a very thorough system of purification before being admitted to the retorts; the excess, which issues, is freed from the accompanying steam and used again. Means are provided for forcing hot air through the apparatus, which is done periodically between the two reactions so as to burn out objectionable impurities, especially sulphur.

Another process which is quite similar to this has been patented by A. Messerschmitt. The process depends upon the alternate oxidation of spongy iron by means of steam with the evolution of hydrogen, and the reduction of the resulting iron oxide by means of reducing gases such as water gas. An upright, cylindrical, unlined, iron reaction chamber is suspended inside a refractory, masonry furnace chamber, with which it is in open communication at the bottom, the lower end of the cylinder being provided with a grate to support the column of reacting mass. The width of the reaction cylinder is relatively small, so that the mass may readily be heated from all sides, and the furnace chamber is provided with a checker-work of refractory masonry constituting a super-heater. Both the reaction chamber and the furnace chamber are capable of being heremetically sealed, and are provided with a system of pipes and valves, whereby either steam or water-gas, may be introduced as required into the reaction chamber, the furnace chamber, and a chimney communicating with the atmosphere respectively. In addition, an air supply pipe communicates with the furnace chamber, and the pipe leading from the top of the reaction chamber can be put into communication with a gas-purifier and the steam-raising plant. The process is carried out in three phases. Water gas and air are first burnt in the furnace chamber until the mass inside the reaction cylinder has reached the required temperature. The air supply is then cut off and water gas, flowing in at the bottom of the furnace, becomes strongly heated, traverses the mass of iron oxide through the open, lower and in an upward direction, and finally escapes at the top through the pipe system, which connects with the steam-raising plant, where any unburnt reducing gases are utilized. When the reduction of the iron oxide is complete the supply of water gas is shut off and steam is introduced, first into the bottom of the furnace to sweep out any residual gases from the second operation (the furnace being in communication with the exit chimney while this is going on) and then into the top of the furnace chamber from which it passes downwards through the super-heating system, and finally upwards through the mass of spongy iron. Hydrogen issues from the top of the reaction chamber through a purifier into a gasometer. The iron reaction chamber may take the form of two concentric cylinders, the reaction mass being in that case charged into the annular space between the two. The cylinder or cylinders in question are periodically heated and reduced by means of the reducing gases, both inside and out.

In another process in which hydrogen is manufactured by the alternate decomposition of steam by metallic iron, and subsequent reduction of the iron oxide produced, by means of some reducing gas or substance, alloys of iron with manganese, chromium, tungsten, titanium, aluminium or other similar elements are employed as the primary materials. These have the advantage that they are not fusible, do not soften, and do not form fusible or soft compounds with iron or its oxides. In place of alloys, mixtures of iron or its oxides with the other elements specified, or their oxides, may be employed, for instance, in the form of briquettes. The same materials may be used for the manufacture of nitrogen, or of mixtures of nitrogen and hydrogen, by substituting air, or a suitable mixture of air and steam for steam alone in the oxidizing operation and eliminating the excess heat, if necessary, by external or internal cooling.

In the process of N. Caro portions of the water gas are burned in different parts of the reaction chamber, so that in addition to the reduction of the iron oxide, a super-heating of the reduced iron is affected. It is claimed that by working in this manner the gas-making period can be considerably prolonged.

The Badische Anilin and Soda Fabrik prepare hydrogen by the alternate action of steam on iron and of reducing gases on ferric oxide. The iron soon looses its activity owing to fritting, etc. As remedies are claimed, the use of fused iron oxides, especially in conjunction with refractory and difficultly reducible oxides such as magnesia, zirconia or the like. The iron oxides are prepared by the fusion of metallic iron in the presence of air or an oxidising agent. Fused iron oxides are also used in conjunction with a silicate or a similar naturally occurring mineral, such as magnetite.

By the Cedford process the greater part of the CO in the water gas is removed by liquifaction and fractionation and can be used for heating purposes. The residual gas, rich in hydrogen and poor in monoxide, is passed over nickel as a catalytic agent, with the result that the oxide is reduced to methane, thus: $CO + 3H_2 = CH_4 + H_2O$. The result is a good illuminating gas containing about 30% methane and 62% hydrogen. The methane can easily be decomposed into carbon and hydrogen as will be seen further on.

The Griesheim Elektron Co. has perfected a method by which the CO in water gas is almost entirely replaced by hydrogen. In a special form of apparatus the gas, with the requisite amount of steam, passes at the proper temperature through wire gauze composed of catalytic metals, such as iron, nickel or platinum. The result is that CO_2 is formed in abundance, and through rapid cooling and lack of contact with the catalytic agents, there is little or no reduction to the form of the monoxide. The requisite temperature can be maintained by allowing a limited amount of oxygen to enter into the gas current—or even air if there is no objection to having nitrogen present in the residual hydrogen—after the CO_2 has been absorbed. This gives an especially economical source of hyrdogen for use in the synthesis of ammonia.

W. Naher and K. Muller claim to secure the same result by passing water gas fresh from the generator, with the requisite amount of steam, over rhodium or salladium asbestos, as contact materials, at the temp. of 800° C. The resultant CO_2 is removed by the customary absorbents, and nearly pure hydrogen remains.

Another method perfected by the Griesheim Elektron Co. is likewise yielding very good results. Water gas, hot from the generator, is passed into a heated retort and charged with quick lime in company with a current of steam. The CO reacts with the lime and steam, forming $Ca\ CO_3$ and hydrogen according to the equation $Ca\ O + CO + H_2\ O = Ca\ CO_3 + H_2$

The elimination of the monoxide is very complete. According to the size of the plant the hydrogen produced (which contains the nitrogen originally present in the water gas) costs from 8 to 10 pfennigs per cu. metre or 10 to 12 cents per pound.

Dr. F. Sauer claims to get very satisfactory results by treating water gas with an excess of super-heated steam, securing in a continuous, uninterrupted current a mixture of steam, carbon dioxide and hydrogen. The latter is easily isolated in a relatively pure condition.

An entirely different process from these has been patented by F. A. Barton. Dilute sulphuric acid is allowed to act on zinc and the zinc sulphate solution produced is filtered and mixed with a solution of sodium carbonate or bicarbonate, thus giving, as by-products, a precipitate which is separated, washed and dried, and sodium sulphate which is also recovered. The insoluble zinc precipitate is proposed as "an excellent substitute of oxide of zinc used in the paint and rubber industries." The apparatus claimed consists of a generating vessel, communicating with an acid tank by a feed pipe and a return pipe, and also with a gasometer and a mixing tank, the latter receiving the zinc sulphate solution from the generator and sodium carbonate solution from another vessel and connected in turn with a centrifugal separating and washing apparatus. The generator may be fitted with electrodes for the production of electric energy.

In most of the processes outlined the hydrogen secured is accompanied by various amounts of nitrogen which naturally do not affect its value for the synthesis of ammonia.

W. Lachmaun goes a step further. He proposes to produce the desired mixture of hydrogen and nitrogen in the proper proportions from a mixture of air and steam, 1 to 2.4. The current of such a mixture is first conducted over copper at the proper temperature, which removes the atmospheric oxygen, and then over glowing iron to remove the combined oxygen present in the steam. The resultant gas is 75% hydrogen and 25% nitrogen. A current of reducing gas is passed in the reverse direction over the oxides of iron and copper to restore them to the metallic condition. The furnace for this resembles a Hoffman brick kiln. It consists of a circle of compartments separated from each other by radiating walls. The method is ingenious, but involves no material economy of production over the separate preparation of the two gases.

Many other recent methods for the production of hydrogen need not be mentioned. They are designed more particularly to meet the demands of aeronautics, especially when a balloon gas is required at a distance from industrial centres.

J. M. Thompson, B.A. Sc., '13, is with the Hamilton Bridge Works Co., Hamilton, Ont.

R. G. Matthews, '14, is with the Toronto Hydro-Electric System, 226 Yonge street, Toronto, in the distribution department.

W. A. Sibbett, B.A. Sc., '11, is Division surveyor at North Bay for the Canadian Pacific Railway.

J. A. Baird, B.A. Sc., '10, is town engineer, Leamington, Ont.

E. P. Bowman, B.A. Sc., '10, who is with the Topographical Survey Branch, Department of Interior, is now in the West in charge of D.L.S. work.

T. R. Moore, B.A. Sc., '13, is engaged at St. Catharines as draftsman on the New Welland Ship Canal.

RELATION OF THE TECHNICAL PRESS TO THE GOOD ROADS MOVEMENT*

By Hyndman Irwin, B.A.Sc.,
Managing Editor, The Canadian Engineer.

Engineering literature has as important a mission to fulfil in the field of highway work as it has in any other line of municipal or national development. It would not be difficult to substantiate a claim that it bears a much heavier responsibility here than in other phases of engineering work. For, in the road movement, as we of the present generation are obliged to regard it, we have many transitory practices to supplant, many precedents to uphold and many innovations to establish. The principles of dynamics, unchanged, of course, are served up in new and dissimilar ways, because of the variableness of traffic, climate and quality of materials. Generally speaking, each piece of work differs in several essentials from every other. The problem of making a dollar do the most work has innumerable counter-claims and conditions attached to it.

The successful engineer of today is necessarily a most diligent consumer of engineering literature. It is the most valuable instrument at his command. By it he acquires a knowledge of the experience and findings of others. To the highway engineer this knowledge is quite indispensable, particularly at this time when we are in the throes of revolutionary tendencies occasioned by the co-mingling on our thoroughfares of diversified methods of travel, heavier loads, increased speeds in every season, over arteries of commerce and pleasure fed by longer and more numerous tributaries than ever before. It is the lot of the road expert to strive constantly against the repellency of nature and the added negative influences of the transportation of man and his effects. The question of expenditure seldom allows him a conquest that is forceful and positive, but he is oblegid to be satisfied with a compromise which is temporary and in need of constant vigilance. He cannot expect his own personal judgment and experience to carry him over all the difficulties of his work. In fact, without a knowledge of the experience of others he is unable to judge from an economic standpoint the success or failure of his own. Modern highway improvement and maintenance do not entirely submit to old and well-defined principles that, once inculcated serve for all time. New methods, new machinery, new materials, up-to-date organization and management—these are vital points in the foundation upon which the good roads movement of today depends. Without a working knowledge of them the road man is not suitably equipped for his work. This knowledge, however, can be acquired in a sufficiently comprehensive degree in only one way—through the pages of the technical press.

In dealing with the relation of the technical press to the good roads movement one must include under the general title not only periodic literature, such as technical and trade journals, bulletins, proceedings of engineering and road organizations and reports of

*Read at the First Canadian and International Good Roads Congress, Montreal, May 20, '14 governmental departments, but also books, pamphlets and catalogues. They are all of value to the road expert. From catalogues, for instance, he obtains information respecting new machinery and appliances, their general construction, capacities, efficiencies and costs. This information is a very important asset as the problems of road construction, maintenance and repair, from the viewpoint of the road superintendent, are largely a matter of machinery and are rapidly providing steady employment for men who have had a training in mechanical work. Likewise the publications of producers of road materials contain information scientifically compiled and arranged in a manner that admits of ready assimilation without material effort or study. Government books of records and statistics of physical and climatic conditions, reports of official tests, etc., are of great value. In short, there are many elements of the technical press which should be included. It is the purpose here, however, to refer to the class of technical literature for which the road man is obliged to pay money; viz., books and periodicals and define their degrees of usefulness in the general establishment and upkeep of road systems.

There is something of historical interest to be said with respect to books on roads and road-making. About 4½ centuries ago a book was published in England entitled "The Duties of Constables and Surveyors of Highways." Some 25 years later another entitled "A Profitable Work Concerning the Mending of Highways" introduced the subject of road repair. These were slowly followed by others on road making. Later MacAdam, Telford and others preached new doctrines and advocated new theories. The advent of the stone crusher, the steam roller, excavating and grading machinery was followed by street cleaning apparatus and mechanical devices for surface treatment, materials for road making and paving. These innovations called for many more books and pamphlets. Then the automobile arrived with its peculiar propensities to cut holes in well established processes. It has caused deep concern in the matter of road maintenance. The resulting production of literature on the subject is fast attaining mammoth proportions.

A prominent authority on engineering literature, Mr. Harwood Frost, has stated in one of his works that he compiled a list some years ago of nearly 500 titles in the English language alone on the subject of road-making. This list covered a period of over 400 years. In the 17th century 15 books were issued, 50 in the 18th, 250 in the 19th and 150 in the first 10 years af the present century. The close of 1915 will probably see as large a number published within 5 years. The extent of road literature 20 years hence is difficult to imagine.

With the publishing houses pouring forth an avalanche of new books it is perhaps opportune to observe that there are many classes of books as well as many books on road engineering and administration. This applies, of course, to literature of all descriptions, but as at this juncture of the road movement so much dependence is to be placed on written thought, attention may well be called to its varying qualities.

Books may be based upon right or wrong theories, they may describe good or poor practice, they may be well or poorly written.

Their contents may consist of old material in new garb, or valuable and unpublished facts in unreadable form. Books may be evenly balanced, smoothly written, comprehensive treatises of principles or they may be misleading and unreliable accumulations of jumbled notions. How often we find in our libraries two books on the same subject, one a veritable interest binder and another as difficult to read as a blue book on banking statistics. Again a book may be abnormally padded with the apparent view of approaching the size of a higher priced volume, while its antithesis is found to possess in concise and logical manner, thoughts that are exceptionally clear and every thought in its proper sequence with its antecedent.

Comparatively few road men have large sums to invest on the literature pertaining to their work but when a man on the job wants information of a technical character he generally wants it badly and he is not generally so located that he can examine the reference books in the library or the samples on a publisher's shelves in order to ascertain whether or not the information he desires is contained in the books which would there be presented to him for examination. Not every man knows, moreover, just what the information which he desires to secure will entail in the matter of such examination. Book purchasing under these circumstances bears a marked resemblance to the old-time horse trade in so far as hidden qualities are concerned. The book purchaser, however, is not distrustful of the author or publisher and is more likely to infer that the book is a good one else it would not have been published. The circulars descriptive of the scope and qualities of the published work should naturally be expected to bring out the good points which it may possess, but other features, perhaps undesirable, may be quite overlooked. It is to be remembered that among the very reputable publishers of engineering works even the best are not immune from misjudging a manuscript which may, when published, prove to fall very short of expectations, and to be unauthentic on some of its important statements.

Evidently the selection of sources of technical information is an important one to the road expert. Briefly the reviews of newly published books, to be found in the recognized technical journals have gradually become, through a process of evolution, beginning with a general rehash of the author's preface, an unprejudiced and straight-forward summary of the scope and fundamental features which a book may possess. Such reviews can be depended upon. Journals that devote space to them are cultivating the practice of careful criticism. The result is noticed in the discrimination on the part of the publisher in the matter of sending books to these journals for review. The publisher who desires to increase the sale of an unlikely book would rather have it left unreviewed than severely criticized; hence, the reader may safely increase his dependence upon the books which are reviewed in such journals provided the review discloses an indication of the sort of information he is after.

The value of keeping up-to-date in technical reading cannot readily be overestimated. This is so widely recognized that little reference need be made to it here. There are books on roadwork that are out of date in many of their statements before they have been in print for five years, or even less. The growth of road literature as a result of new types and new methods is a fair example of the varying tendencies of general practice. In order to keep pace, therefore, with the new developments in the field of road building it is necessary to be in touch with the best technical literature of the day on the subject.

Reverting to technical periodicals on roads a century ago they were practically non-existent. Since then the inception of numerous local and national organizations, with their proceedings devoted to paper and discussions presented in their meetings, and the birth of scores or more of technical journals, also of thousands of trade publications issued by manufacturers, have more or less adequately responded to the need for the broadcasting of information. When we consider what is being accomplished in America in this respect, and add to this the production of similar literature in the civilized countries of the old world, the bulk of printed material on roads assumes gigantic proportions.

Evidently there is the necessity for careful selection on the part of those having to do with this movement and its literature. No man can read by any means all of the information which is presented. Yet the old saying that "experience is the best teacher" was never truer in any line of industry, it being universally accepted, of course, that no man can ever expect to achieve success if he depends solely on his own experience for enlightenment. It is upon the experiences of others, as already stated, that he very largely depends, and in the record of such experiences lies the reason for the existence of the technical press. The technical journal benefits its readers by conveying to them first-hand the sort of information that is not yet to be found in the pages of treatises on the subject. It outlines methods of doing work that are newer and better than others. It describes the maiden efforts of machinery, tools, and processes recently devised. It thoroughly investigates the achievements of progress and endeavors to present them in the most acceptable way for the general good of mankind. It is, therefore, an indomitable factor in the equipment of the man associated with the good roads movement.

The problem of culling from the growing mass of road literature that which he needs most is an important one for the road engineer. To illustrate its extent we may refer to the recently issued Good Roads Year Book for 1914 of the American Highways Association. It is found to contain a section devoted entirely to a summary of articles published in 1913 in the various journals devoted to the movement. It lists over 650 articles published in that year alone, besides innumerable bulletins, circulars, pamphlets and documents. It also contains a list of texts including over 400 books. Evidently there is plenty of material with which a man may equip himself, but a wise selection is a difficult matter.

Of course, the road man is not alone on the problem. The publishers of this information are fully aware of it, recognize its importance, and are endeavoring to present the desired information in such a way that he can readily make practical use of it. The rest devolves upon himself, and in this age of specialization the problem is not without serious difficulties. The road man is unwise if he limits the scope of his reading to that which satisfies his immediate needs and them alone. Those who achieve the fullest measure of success in any walk of life are those who have worked, read and thought more than was absolutely necessary for the carrying out of whatever work was in hand. It is this superfluous labor and desire for supplementary knowledge that equips one for the things in life that count, by storing the additional knowledge as a sort of emergency reserve. This is readily illustrated in the field of road work. A man interested therein is also interested in methods of surveying, drainage, construction of dams and bridges, mechanical operation of machinery, transportation of materials, use of cement and concrete, geology of rocks and clays, and the road laws of the country. Manifestly there is no defining line between his work and that of men in numerous other phases of development. Therefore, if a road engineer is judicious and discreet he will read that literature which pertains to his own special work—and much more.

Finally, there is the important question of the preservation and filing of technical literature. This applies chiefly to periodicals. Once in a while the road man may be unable to peruse his journals as he would like owing to press of duties. He may glance over an article that promises to be of value to him but is obliged to lay it aside for further consideration, and it may be misplaced or forgotten. The obvious solution lies in the method adopted by almost every up-to-date engineer in other lines of work—that of carefully examining the journal when it is received, and having all articles that have a bearing upon his work listed in a card index system. In a few years every phase of work with which he has to do will be well represented. If he has been wise he will have had his periodicals bound. He is then equipped with a library of information that is of the greatest value to him. He may, for instance, meet a problem which requires additional knowledge of sub-drainage. His card index immediately brings before him a summary of all the information on the subject that has been published by his journals since he began the system, and reference to the articles indicated places him in possession of the required data. They are not the opinions of one man, but of many. Moreover, they are not from an early edition of a volume that has since been succeeded by others which may not be in his possession. He has all the information of intervening years before him. He is not necessarily a voluminous and costly library, but one that is ready to serve him well in more ways than one. Besides acquainting him, on the publication of each issue, of the new methods and new machinery just sprung into use, and of road activities in other countries and in other sections of his own, his periodicals, if used in a scientific manner, soon create a reference library for him of excellent quality that can be added to at small cost as years go on, the whole system thereby becoming more valuable.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science

Engineering Bldg., University of Toronto,

Toronto, Ont.

EDITORIAL

ALUMNI DIRECTORY

We wish to express the indebtedness which we feel toward a number of our graduates who have forwarded information to us concerning themselves and other graduates. It is a difficult task to "round up" the information for the Alumni Directory, and we would appreciate very much if our readers would lighten our labors, by sending us any information which they can, that would make the Directory more complete and more reliable. We would direct your attention in particular to those whose addresses we have not on file, or concerning whose professional work we have no record. If you change your own address or occupation we would like you to write to us and draw our attention to the fact. A change of address on a letterhead might easily be overlooked unless our attention is directed to it, for otherwise it would be necessary to compare each piece of correspondence with our records to find out whether the address had been changed or not.

PROFESSOR C. H. C. WRIGHT MEETS "SCHOOL" MEN IN THE WEST

Professor Wright has just returned from a month's visit throughout Western Canada, and brings back glowing reports of what our graduates are doing in that part of the Canada Dominion. The "School" has undoubtedly placed her imprint on the West and it is after a few weeks' immediate contact with the activities of the Western provinces that one begins to fully realize the magnitude of the part which Dean Galbraith and the "School" are playing in developing that newer part of Canada. Throughout his entire journeying Professor Wright was in the company of "School" men practically all the time. A Toike-oike atmosphere seemed to surround him everywhere he went, and the enthusiastic loyalty, characteristic of "School" men, seemed to have been given increased impetus by the energetic influences of Western activities.

On the evening of Monday, June 1st, the graduates in Edmonton tendered a luncheon to Professor Wright at which Mr. J. Chalmers, '94, acted as chairman and toastmaster. The others present were: A. T. Fraser, '94, G. H. Richardson, '88, R. H. Knight, '02, A. J. Latornell, '03, H. H. Depew, '04, E. M. M. Hill, '04, Kells Hall, '07, D. D. MacLeod, '10, V. A. Newhall, '10, G. G. Macdonald, '15, C. I. Grierson, '14, L. P. Yorke, '11, R. M. Christie, '14, H. Goodridge, '10, R. H. Douglas, '09, A. W. Pae, '09, C. C. Sutherland, '09, W. W. Gray, '04, B. F. Mitchell, '06, J. H. Smith, '03, H. L. Seymour, '03, A. J. Huff, '11, and A. J. Sill.

The graduates in Edmonton decided at the luncheon, that they would organize a branch of the Alumni Association in the near future, and no doubt have acted upon their decision before this has gone to press.

The Winnipeg graduates, who quite recently organized a branch of the Alumni Association, tendered a luncheon to Professor Wright at the St. Charles Hotel on June 16th. In spite of the fact that everything was arranged with only a day's notice after Professor Wright's arrival in the city, a large number were present, although some were unable to attend owing either to absence from the city or insufficient time to receive notification. Those who were present were: Wm. Fingland '93 (chairman), L. T. Burwash, '96, Donald A. Ross, '98, W. P. Brereton, '01, R. A. Sara, '09, J. B. Ferguson, '09, F. F. Phillips, '09, A. W. Lamont, '09, O. E. Harman, '95, H. Helliwell, '94, R. A. Paul, '11, R. D. Torrance, '11, J. Young, '07, L. R. Brereton, '13, J. L. Whiteside, '10, H. P. Frid, '11, N. C. Sherman, '10, E. H. Nickel, '11, H. E. Brandon, '06, J. B. Minns, '07, W. C. Foulds, '10, G. A. Warrington, '10, M. V. Sauer, '01, J. F. S. Madden, '02, W. G. Chase, '01, F. H. Alexander, '97, and A. A. McQueen, '11.

A DRAFTSMAN'S DETAILS

By A. T. N.

Oh what a life
The draftsman leads,
In this old world today;
He draws his plans,
He draws his breath,
He draws also his pay.
His weary hours
Are long-drawn out,
While waiting for a "raise";
His wrinkled brow
Is drawn down more,
No increase meets his gaze.
He fills his pen,
Then draws a line,
And mutters "Things ain't square,
I think I'll chuck
This bloomin' job
For one with more fresh air,
I glue my nose
Down to my board
The bloomin' live-long day;
The bloomin' boss
Is standing near,
To see I earn my pay!
The boss, he thinks
I ought to know
All things from A to Z,
And still be glad
To work for him
At what he now pays me.
This drafting life
Is 'on the Fritz,'
It surely makes me 'sore!!'"
He "beats it" home
But in the morn'
He comes right back for more.

—Engineering News.

LEAVER—PALMER

Mr. Chas. B. Leaver, B.A.Sc., '10, was united in marriage to Miss Olive Vera Palmer, on Wednesday, June 10th at the home of the bride's parents, Mr. and Mrs. Wilberton C. Palmer, Woodrowe Beach, Sarnia, Ontario. Applied Science extends congratulations.

A correspondent sends us the following "pome," by J. B. Randall in the Malheur Mining News:

MINING EXPERTS

Come, listen, fellow miners, and a tale I will relate
'Bout the facts concerning mining, right here within this state;
This country's overburdened with so called mining men
Who will bond a mine, black-eye the camp; then leave the state again.

They put on their yellow leggins, and with little pick in hand,
Look wise and air their knowledge and ignore a common man;
They talk about geology, or some rock which ends with —ite.
Then build a good-sized stamp mill—not a pound of ore in sight.

Here's a case in plain philosophy—come, listen, if you will—
If you educate a burro, you will have a burro still,
And your college-bred expert is just as competent
As this animal I've mentioned for a superintendent.

See the stamp mills lying idle, about a score or more;
First-class mine equipment, with not a pound of ore!
Why? Because they "learned" their "mining" (not underground, I say),
But in some eastern college—that's why our mines don't pay.

A word to you investors who are seeking mining claims:
When you send out your agent, send out a man with aims,
Commission a real miner to investigate the mine,
Not a man who's never seen one—it isn't in his line.

For there's failure after failure, recorded every year.
And pocketbooks depleted by sending "experts" here;
Yet we have dividend-payers, soon they'll begin to loom;
Mark you well! the town of Malheur will once more commence to boom.

A. J. McLaren, B.A.Sc., '11, is with the Westinghouse Church Kerr Co., engineers and contractors, on their work of alterations and additions to the C. P. Ry. terminals at Winnipeg.

G. L. Wallace, B.A.Sc., '11, and J. H. Hawes, B.A.Sc., '14, have recently been appointed to the staff of the Topographical Surveys Branch, Dept. of Interior, Ottawa.

W. C. Cale, B.A. Sc., '10, formerly with the Stone & Webster Engineering Corporation, Keokuk, Ia., is now with the Mississippi River Power Co. of that place.

E. A. Twidale, B.A. Sc., '14, is with the National Electrolytic Co., Niagara Falls, N.Y.

WHAT OUR GRADUATES ARE DOING

S. Kidd, '16, is in the chief architect's office, Department of Public Works, Ottawa, Can.

C. T. Hamilton, B.A. Sc., '07, is a member of the firm, Broadfoot, Johnston & Hamilton, (W. J. Johnston, '09, and F. C. Broadfoot, '06), engineers, contractors and land surveyors, 73 Exchange Bldg., Vancouver, B.C. The information in the directory last month was incorrect.

D. H. Campbell, B.A., Sc., '14, is with the Topographical Surveys Branch, Department of Interior, Ottawa, Can.

F. C. White, B.A., Sc., '09, who is with the Canadian Bridge Co. of Walkerville, is at present at Prince George, B.C., where the company is erecting a bridge across the Fraser River for the Grand Trunk Pacific Railway. The bridge includes a 100 foot lift span to be electrically operated. The whole development of the electrical features is under Mr. White's supervision.

J. A. Walker, B.A. Sc., '08, is in charge of the British Columbia Government's survey work in the valley of the South Fork of the Fraser River, along the main line of the Grand Trunk Pacific Railway.

L. W. Rothery, B.A. Sc., '11, has severed his connections with the Allis-Chalmers Mfg. Co., and is now with the Westinghouse Machine Co., at Turtle Creek, Pa.

W. J. T. Wright, B.A. Sc., '11, and J. T. Howard, B.A. Sc., '13, are in partnership in architectural engineering. Their offices are at 121 Simcoe St., Toronto.

A. B. Garrow, B.A. Sc., '07, formerly assistant engineer, main drainage department, City Hall, Toronto, is now with the Toronto Harbor Commission, designing the new sewer outlets along the waterfront.

W. A. Richardson, B.A. Sc., '11, is with the Bates & Roger Construction Co. of Chicago and Spokane, U.S.A. He is at present engineer for that company on the erection of a half-mile bridge across the Fraser River, at Fort George, B.C.

J. M. Duncan, B.A., Sc., '10, is with the Wallsend Slipway & Engineering Co. at Newcastle-on-Tyne, England.

W. G. Ure, B.A. Sc., '13, has recently been appointed assistant to the city engineer at Stratford, Ont.

E. T. Austin, B.A., Sc., '09, has been appointed smelter superintendent of the Mond Nickel Co.'s smelter at Coniston, Ont.

E. R. Frost, B.A. Sc., '09, is night mechanical engineer for the Foundation Co. on the C.P.R. elevator at North Transcona, Man. Mr. A. W. Chestnut is assistant field engineer on the same work.

F. F. Phillips, '08, is chief draughtsman for the C.P.R. lands department at Winnipeg.

DIRECTORY OF THE ALUMNI

Hyland, H. M., '07, is a member of the Hyland Construction Co., railroad contractors, Toronto.

Hyman, E. W., '07, lives in London, Ont., where he is assistant superintendent of the London Electric Co.

I

Iler, S. B., '08, is assistant engineer with the Brantford Hydro-Electric System, Brantford, Ont.

Ingles, C. J., '04. We have not his present address.

Innes, W. L., '90, is general manager of the Dominion Canners Limited plants at Simcoe, Ont.

Ireland, L. G., '07, is manager of the Brantford Hydro-Electric system, Brantford, Ont.

Ireson, E. T., '13.

Irvine, J., '89, deceased.

Irwin, H., '09, is managing editor of *The Canadian Engineer*, Toronto.

Irwin, W. J., '10, is with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Isbister, J., '09, is electrical superintendent for the Mond Nickel Company at Coniston, Ont.

J

Jackes, F. P., '09, is commercial engineer for the Bell Telephone Co., Toronto.

Jackson, J. G., '03, was at Kingston, Ont., when last heard from.

Jackson, F. C., '01, is a member of the firm of Jackson & Connelly, railway contractors, La Tuque, P.Q.

Jackson, W., '07, is with the Ontario Power Co., Niagara Falls, Ont., as field engineer on construction.

Jackson, C. B., '07, is in Kenilworth, Ill., in the estimating department, C. Everett Clark Co., Limited.

Jackson, J. E., '09. His home is at Oxford Centre, Ont.

James, O. S., '91, has a practice as assayer and chemical analyst, in Toronto.

James, D. D., '89, resides in this city. He is senior member of James & James, Ontario land surveyors.

James, E. A., '04, is chief engineer, York County Highway Commission, and member of the firm of James, Loudon & Hertzberg, Toronto.

James, E. W., '09, resides in Winnipeg, Man., where he is engaged in the Public Works Department.

James, F. L., '10, whose home is in Tillsonburg, Ont., has no business address with this office.

Jarvis, R. H., '11. We have not his present address.

Jepson, W. C., '06, is assistant engineer, Welland Canal office, Niagara Falls, Ont.

Jeffrey, D., '82, has had no record of address with us for a number of years.

Jermyn, P. V., '04, is engineer for the Reg. N. Boxer Wall Paper Co., Limited, of New Toronto, Ont.

Job, H. E., '94, is manager of the Toronto and Hamilton Electric Co., Hamilton.

Johnson, C. C., '09, is with Chipman & Power, engineers, Toronto. He is at present at Wallaceburg, Ont.

Johnson, G., '96, has a practice as mining engineer at Castleford, Ont.

Johnston, D. M., '02, resides in Toronto. He is with the Hydro-Electric Power Commission as construction engineer and inspector.

Johnston, H., '03, is city engineer of Berlin, Ont.

Johnston, H. C., '10, is looking after the Toronto interests of Anglin's Limited, building contractors, Montreal.

Johnston, A. C., '94, is vice-president and chief engineer of the J. M. Dodge Co., Philadelphia.

Johnston, S. M., '94, is engaged in land surveying in British Columbia.

Johnston, H. A., '00, has Stettler, Alberta, for his present address. We do not know the nature of the work in which he is engaged.

Johnston, J. C., '00, has no address whatever with us at present.

Johnston, J. A., '00, resides at Ignace, Ont., where he is engaged in general contracting.

Johnston, C. K., '03, has a business as general merchant at Pefferlaw, Ont.

Johnston, R. H., '10, is engaged in survey work in Toronto.

Johnston, W. J., '09, is a member of the firm of McKenzie, Broadfoot & Johnston, engineers and contractors, Vancouver, B.C.

Johnston, C., '06, is district engineer for the Canadian Northern Railway at Hamer, Ont.

Johnston, C. E., '09. Deceased, Dec. 31st, 1913.

Johnston, J. T., '08, is hydraulic engineer in the Water Power Branch, Department of Interior, Ottawa.

Jones, J. E., '94, is with the streets commissioner, City Hall, Toronto.

Jones, L. E., '11, is a member of the firm Jones & Cornell, engineers and contractors, New Westminster, B.C.

Jones, G. S., '05, has for his home address Smiths Falls, Ont. He has no business address with us.

Jones, G. R., '06, is engaged in missionary work in China.

Jones, T., '06, is general manager of the Canadian Brake Shoe Company, Montreal.

Junkin, R. L., '13, is with the Federal Improvement Commission of Ottawa and Hull.

Jupp, A. E., '06, is assistant engineer with Routley & Summers, in their Toronto office.

K

Kay, E. W., '07, is assistant manager of the Reinforced Brickwork Co., Limited, with head office at Winnipeg.

Keefe, W. S. H., '04, is manager of the Light, Heat & Power Co., Fort Covington, N.Y.

Keele, J., '93, is engineer for the geological surveys branch, Department of the Interior, Ottawa.

Keffer, A. H. E., '09, is resident engineer, T. & N. O. Railway, near North Bay, Ont.

Keith, J. C., '10, is engaged in contracting and surveying, Calgary and Moose Jaw.

Keith, D. F., '07, is a member of Keith's Limited, mechanical and electrical contractors, Campbell Ave., Toronto.

Keith, H. P., '07, is a member of the city commissioner's staff, Moose Jaw.

Kelly, E. A., '11, is resident engineer at Winnipeg for the Canadian Pacific Railway.

Kemp, J. B. O., '09, is structural steel draughtsman for the Toronto Structural Steel Co., Toronto, Ont.

Kennedy, J. H., '82, is assistant chief engineer of construction for the Vancouver, Victoria & Eastern Railway & Navigation Co. at Vancouver, B.C.

Kennedy, H. G., '08, is at Cobalt, Ont., as engineer for the Cobalt Lake Mines.

Kennedy, M. D., '09, is manager of the Beaconsfield Consolidated at Elk Lake, Ont.

Keppy, J. D., '06, has an office at 50 Pearl St., Toronto, where he has a practice as mechanical engineer.

Kerr, A. E., '13. We understand he is with the Canadian Westinghouse Company, Hamilton.

Key, W. R., '09, is assistant engineer for the Turnbull Elevator Co., Toronto, Ont.

Kettle, T. H., '09, is assistant sales manager, Milwaukee Light & Power Co., Milwaukee, Wis.

Keys, W. R., '08, is at North Bay, Ont., as resident engineer for the T. & N. O. Railway.

King, C. F., '97, is Toronto representative of the *Financial Times*, Montreal.

King, J. T., '10, is demonstrator in the Department of Mining, Faculty of Applied Science, University of Toronto.

Kinghorn, A. A., '07, is president and general manager of the Asphaltic Concrete Co., 24 King St. E., Toronto.

Kingstone, G. A., '10, is Toronto representative for Jones & Glassco, Montreal.

Kirkland, W. C., '84, is principal assistant engineer, drainage, sewage and water board, of New Orleans, La.

Kirkwood, M., '11, is with the American Telephone & Telegraph Co., New York city, in the engineering department.

Kirwan, G. L., '10, is in the topographical surveys branch, Department of the Interior, Ottawa.

Kirwan, P. T., '10, is at Ottawa, Ont. His address is Westminster Apts., Ottawa.

Klingner, L. W., '07, is with the Dominion Construction Co. Limited, of Toronto, at their office in Belleville, Ont.

Klotz., H. N., '09, is chemist for the Gutta Percha Rubber Co., Toronto.

Knight, R. H., '02, is a member of the firm of Driscoll & Knight, engineers and surveyors, at Edmonton, Alta.

Knight, S., '10, is in the employ of Driscoll & Knight, Edmonton, Alta.

Kormann, J. S., '98, is general manager of Kormann Brewing Co., Limited, Toronto.

Kribs, G., '05, is with the Hydro Electric Power Commission, Toronto.

L

Laidlaw, J. T., '93, has a practice as consulting minnig engineer at Cranbrook , B.C.

Laidlaw, R. A., '01, is engineer and

sales agent for the Trussed Concrete Steel Co., Houston, Texas.

Laing, W. F., '96, (deceased).

Laing, A. T., '92, is secretary of the Faculty of Applied Science and Engineering, University of Toronto, and lecturer in Highway Engineering.

Laing, J. S., '13, is assistant to the town engineer at Galt, Ont.

Laing, P. A., '05, is divisional engineer for the Transcontinental Ry. at Cochrane. Address is Div. 3-4, c. T. C. Ry., Cochrane, Ont.

Laird, R., '86, is a member of the firm of Laird & Routley, engineers and surveyors, Haileybury, Ont.

Lamb, F. C., '07, is with Phillips, Stewart & Lee, engineers, at Saskatoon, Sask.

Lamb, G. J., '09. The only address we have on fyle is Walkerton, Ont.

Lamont, A. W., '09, is assistant engineer with the Canadian Westinghouse Co., 158 Portage Ave., Winnipeg, Can.

Lane, A., '91, (deceased).

Lang, A. G., '03, is underground superintendent for the Toronto Hydro-Electric system, Toronto, Ont.

Lang, J. L., '06, is a member of the firm of Lang & Keys, engineers and surveyors, Sault Ste. Marie, Ont.

Langley, C. E., '92, is a member of the firm of Langley & Howland, architects, Continental Life Building, Toronto, Ont.

Langmuir, C. B., '09, is manager of the electrical department for the Factory Products, Limited, Toronto, Ont.

Langmuir, F. L., '02, is chemist for the M. Langmuir Manufacturing Co., Toronto, Ont.

Lanning, J., '11, is with Routley & Summers, engineers and surveyors, Haileybury, Ont.

Larkworthy, W. J., '04, deceased.

Laschinger, E. J., '92, is mechanical engineer with H. Eckstein & Co., Johannesburg, Transvaal, S.A.

Lash, F. L., '93, is manager of the Electrical Supply Co., Board of Trade Building, Bandoeng, Java.

Lash, N. M., '94, is assistant electrical engineer with the Bell Telephone Co., Montreal, P.Q.

Latham, R., '99, is chief engineer, T. H. & B. Railway. His address is 146 Aberdeen Ave., Hamilton.

Latornell, A. J., '03, is city engineer for Edmonton, Alta.

Latornell, A., '05, is assistant engineer in the sewer department, City Hall, Toronto.

Lavrock, J. E., '98, was draftsman for Herman & Burwell, engineers, Vancouver, B.C., when last heard from.

Lawler, E. R., '10, is engaged as inspector with the Toronto Hydro Electric system, Toronto, Ont.

Lawless, N., '11. We do not know his address.

Lawson, W. L., '92, is manager of the Great Western Sugar Co., Sterling, Col.

Lawrie, R. R., '96, deceased.

Leadman, H. L., '11, is with the department of naval service, Hydrographic Survey, Ottawa, Ont.

Leaver, C. B., '10, has Sarnia as his address with us.

Lee, W. A., '92, deceased.

Lee, R. G., '10, is assistant sales manager with the Toronto Hydro Electric system.

Leighton, J. W., '05, is president of the Leighton-Jackes Mfg. Co., Toronto, Ont.

Leitch, J. N., '10, deceased.

Lennox, A. E., '09, is publicity engineer for the National Electric Lamp Association, Cleveland, Ohio.

LePan, A. D., '07, is assistant superintendent of Buildings and Grounds, University of Toronto.

Leslie, A., '13, is with the Bell Telephone Co., Toronto, Ont.

Leslie, J. N. M., '08, is with the Canadian Westinghouse Co., Toronto, as sales engineer.

Lethbridge, W. R., '11, is at Cumberland, B.C. We do not know the nature of his employment.

Lewis, F. C., '08. His address is 637 Somerset Block, Winnnpeg, Man. We do not know the nature of his work.

Leibermann, M., '11. His address is care of H. A. Friedmann, barrister' solicitor, etc., Rudyk Bldg., Edmonton, Alta.

Lillie, G. L., '11, is with the Toronto Hydro Electric System in the distribution department, Toronto.

Lindsay, J. H., '07, is district surveyor and engineer, Prince Albert Public Works District, Prince Albert, Sask.

Linton, A. P., '06, is with the Board of Highway Commissioners, Regina, Sask.

Livingston, H. D., '13, is a member of Angus & Angus, architects, engineers and surveyors, North Bay and Sudbury, Ont.

Lloyd, N. C. A., '09. We do not know his address.

Long, A. L., '11, is chemist for Park, Blackwell & Co., Toronto, Ont.

Longstaff, J. C., '10. We do not know where he is employed.

Lott, A. E., '87, has a practice as consulting railway engineer, 441 Bradbury Building, Los Angeles, Cal.

Loucks, R. W. E., '09, is a member of the firm of Brown & Loucks, engineers and contractors, Saskatoon, Sask.

Loudon, T. R., '05, is lecturer in metallurgy, University of Toronto. He is also a member of the firm of James Loudon & Hertzberg, engineers, Toronto.

Lowrie, A. W. P., '11. We do not know his address.

Ludgate, B. A., '85, is assistant engineer for the P. & L. E. Railway, Pittsburg, Pa.

Lumbers, W. C., '01, is assistant engineer with Frank Barber, Toronto.

Lynar, H. R., '08, is employed on the Welland Ship Canal at St. Catharines, Ont.

Lytle, L. B., '13, has Tralee, Ont., as his permanent address.

Mac

Macallum, A. F., '93, is city engineer at Hamilton, Ont.

MacAndrews, W. M., '11, was with the Allis-Chalmers-Bullock Co., Dominion Trust Building, Vancouver, B.C., as assistant sales manager when last heard from.

Macauley, R. V., '11, is commercial engineer, Montreal Division, Bell Telephone Co. of Canada. His address is Central Y.M.C.A., Montreal, Que.

MacCarthy, T. V., '13, is assistant engineer on pitometer surveys, waterworks department, City Hall, Toronto.

MacColl, E. B., '11, is assistant engineer, Hydrographic Survey, Department of Naval Service. Address mail to Hydrographic Survey, Ottawa.

MacBain, J. T., '11, 124 Fourth St., Niagara Falls, N.Y.

MacBeth, C., '96, deceased.

MacBeth, R. E. A., '11, is with the Roadways Department, City Hall, Toronto.

MacDonald, A. D., '10, is assistant superintendent, Penn-Canadian Mines, Cobalt, Ont.

MacDonald, J. B., '10, is district manager for the Canadian Inspection & Testing Laboratories at Winnipeg.

MacDonald, J. A., '10, is employed in surveying in the West.

MacDonald, G. A., '10, is at Fernie, B.C., where he is engaged in Dominion and Provincial Land Surveying.

MacDonald, F. M., '11, is a contractor with the Randolph MacDonald Co. Limited, Toronto. His address is 3 Rusholme Rd., Toronto.

MacDougall, A. C., '01, was assistant superintendent of the Aluminum Co. of America, Massena, N.Y., when last heard from.

MacFarlane, E. D., '09. We do not know his address.

MacGregor, A. E., '10, is with Chipman & Power at the city engineer's office, London, Ont.

MacKay, A. G., '07. We do not know his address.

MacKay, J. T., '02, is an undergraduate in the faculty of medicine at the University of Toronto.

MacKay, E. G., '10, is a member of the firm, MacKay, MacKay & Webster, civil engineers and surveyors, 607 Bank of Hamilton Bldg., Hamilton, Ont.

MacKenzie, H. R., '13, is inspecting engineer, Board of Highway Commissioners, Regina, Sask.

MacKenzie, H. A., '13, has Hyde Park, Ont., as his home address.

Mackenzie, K. A., '06, is a member of the firm of K. A. Mackenzie & Co., Ft. George, B.C.

MacKenzie, W. S., '11, is with the Canadian Linderman Co., Limited, Woodstock, Ont.

MacKinnon, J. G., '09, is resident engineer for the C. N. Railway at Albreda Summit, Rocky Mountains. His P. O. address is Henningville, B.C., via Edmonton, Alta.

Mackinnon, W. C., '06, is in the designing department of the Dominion Bridge Co., Lachine, Que.

MacIntosh, D., '98, is chief superintendent with F. M. Andrews & Co., Metropolitan Tower, New York, N.Y.

MacLachlan, K. S.,'13, is superintendent, Metals Chemical Co., smelters and refiners, Welland, Ont.

Maclachlan, W., '06, is chief engineer for the Electric Power Co., Limited, Confederation Life Building, Toronto, Ont.

Maclachlan, W. A., '09, has just completed his post graduate course in civil engineering, University of Toronto.

MacLaurin, J. G., '11, is in the water power department of the Algoma Steel Corporation, Sault Ste. Marie, Ont.

INDEX TO OUR ADVERTISERS

J. Galbraith

Born Sept. 5th, 1846
Died July 22nd, 1914

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, JULY, 1914 New Series Vol. IX. No. 3

OUR BELOVED DEAN GALBRAITH

On Wednesday, July 22nd, we received the sad news that Dean Galbraith had passed away early that morning at his summer cottage on Go-Home Bay, Muskoka. The message came as a shock to his very many friends, for although he had not been en-enjoying very robust health for some time, he displayed such resolute fortitude and presented so cheerful a front, that no one suspected that the end was near. We all cherished the hope that after a quiet summer at his home in Muskoka he would return with renewed vitality to assume his duties and to welcome back his engineering family over which he had presided and with whom he had patiently labored since the birth of the institution.

For several years Dr. Galbraith had been suffering from heart trouble, but he never made any complaints. His benevolent consideration for others led him to bear his troubles patiently and with admirable endurance, and in spite of his indisposition, he always attended with unbroken regularity to his many arduous duties.

He had not been as well as usual since the close of the academic year in April, and for a part of the time he was confined to his bed at intervals. It was thought a few months at his favorite abode would renew his strength and so he and Mrs. Galbraith and their younger son, Douglas, went to Go-Home early in July. The Dean, being a close companion and an ardent student of nature, felt a peaceful invigorating influence in his new environment and began to feel much stronger.

On the evening before his death, while he was having dinner on the verandah of the cottage with members of the family and friends, he remarked on the quiet beauty of the evening and thought that surely no one could wish for anything nicer than what had been their lot that day. He was in great spirits and sat on the verandah until late in the evening admiring and enjoying, with the true appreciation of a lover of nature, the quiet solitude of the surroundings as the sun in all its splendor, sank behind the horizon.

When he had retired a short while he was seized with a chill, no doubt due to a weakening of the heart, but he soon felt better and insisted that they should retire again, stating that he would be quite well in the morning. However, about four o'clock the family were summoned to his bedside and he peacefully passed away without awaking from a quiet sleep. In the quiet solitude of the early morning a noble life in all its splendor sank behind the horizon of mortality to cast off the earthly burden of clay, and awake arrayed with celestial radiance, in the Mansion which he had been building with his good and noble deeds on earth.

The remains were brought to Toronto on Thursday evening, and after the funeral service on Saturday afternoon at the Church of the Redeemer, were conveyed to Mount Pleasant Cemetery for interment. It is certain that a more impressive or more representative funeral was never held in Toronto. Every engineering class since the founding of the "School" was represented and engineering organizations throughout and beyond the Dominion paid tribute to the father of engineering in Canada. The Provincial and Dominion Governments expressed their appreciation of one of the greatest builders of the country which they represent. Prominent engineers from Canada and United States attended, to show their respect for the leader of the profession in Canada. The floral tributes from the numerous engineering organizations and the various year classes of graduates and undergraduates, as well as from personal friends and many other sources, expressed in no uncertain tone the continent wide admiration with which the Dean was regarded, and the deep regret which was felt at his unexpected death.

Dr. Galbraith was born of Scotch parentage in Montreal on September 5th, 1846. He received his early education at Port Hope and registered in arts at the University of Toronto in the fall of 1863. In 1868 he graduated, receiving the degree of B.A., with a double scholarship in mathematics and general proficiency. He was gold medallist in Honour Mathematics, and he won the Prince's prize for highest general proficiency, established by the late King Edward VII during his visit to Canada, when he was Prince of Wales. He received the degree of M.A. from the University of Toronto in 1875. In 1902 the honorary degree of LL.D. was conferred upon him by his alma mater, and in 1903 Queen's University honored him with the same degree.

In 1886 he married Miss Emily Stupart, youngest daughter of the late Capt. R. D. Stupart, R.N. His widow and one daughter, Beatrix, and two sons, John Stupart, of the engineering staff of the Toronto Harbor Commission, and Douglas, an undergraduate in civil engineering at the University, survive him.

Dr. Galbraith was one of that body of eminent men whose working life has been contemporaneous with that of the Dominion, and who with quiet and consistent patriotism have struggled for its upbuilding and have prospered with its growth. With the establishment of Confederation there came an outburst of engineering activity, especially in transportation work, throughout the settled portions of Canada. Upon graduation, Dr. Galbraith found employment in the railroad field, getting his professional training as apprentice to Professor L. B. Stewart's father, Mr. Geo. A. Stewart, at that time chief engineer of the Midland Railway, and also an engineer and surveyor of extensive private practice. He completed his apprenticeship, qualifying as provincial and also Dominion land surveyor. In 1871, after a year's service as contractor's engineer on the construction of the Intercolonial Railway, then being built by the Dominion Government, he returned to the Midland Railway as resident engineer, and afterwards division engineer, on the Midland Railway extension to Georgian Bay. From 1875 to 1877 he was employed on surveys for the Canadian Pacific main lines, then under direct government control, and for the projected Georgian Bay branch of that undertkaing.

Upon the founding of the School of Practical Science in 1878, Dr. Galbraith was appointed to the chair of engineering and in 1889 was made Principal of the "School." In June, 1906, the "School" became the Faculty of Applied Science and Engineering of the University of Toronto, and Dr. Galbraith was appointed Dean of the Faculty, which position he so ably and nobly filled until the time of his death.

His activities were by no means limited to his academic work, although it received his first attention, he having consistently refused to undertake professional work as a consulting engineer whenever it was likely to interfere with his work at the "School." He has occupied many honorary positions, including those of vice-president of the Ontario Land Surveyors' Association, vice-president of the Engineering Section of the British Association for the Advancement of Science, vice-president of the Engineering Section of the American Association for the Advancement of Science, and vice-president of the Canadian Institute, Toronto. He was an associate member of the Institute of Civil Engineers, England, and was one of the founders of the Canadian Society of Civil Engineers, of which society he was a councillor for many years, and of which he was elected president in 1909.

When, in 1907, the engineering world was startled by the fall of the Quebec Bridge, it was recognized in Canada that the disaster must be investigated by commissioners of unquestioned impartiality and integrity and of sound engineering knowledge, whose conclusions would be unhesitatingly received by the country at large, the undertaking having been practically a Government work. Dr. Galbraith was appointed a member of the commission to inquire into the cause of the disaster, his ability as an engineer having long before been realized by the engineering profession. The thoroughness and comprehensiveness of their report speaks volumes for the capable and painstaking work of the commission, and contributes a valuable addition to the engineering literature of to-day.

On November 4th, 1908, the graduates and undergraduates in engineering presented the University with a large portrait of their Dean, in recognition of the unselfish interest which he had always taken in them, and of the true worthiness of the subject of the portrait.

Although he had not quite lived the allotted span of three score years and ten, we must remember that there is breadth and depth to life as well as length. His life was broad in every sense of the word, his influence reaching out to every class of men, for he manifested an interest in every movement which appeared to be in the interests of humanity. Through his strength of mind he could control the strongest men, and revelled in the intricacies of the many weighty problems connected with his work and profession, while his kindness and largeness of heart made him the idol of children and rendered him appreciative to the fullest degree, of the beauty and healing influences of God's teacher, Nature. His benign influence penetrated the deepest depths of every heart which came within the sphere of his life, and his comprehensive understanding fathomed the deeper problems of life, and won for him a place among the men whose efforts have enthroned them on the pedestal of honor and respect.

In his demise the engineering profession has lost a leader. He had undoubtedly accomplished more in the interests of the profession in Canada than any other individual. At the time of the founding of the S.P.S., engineering education had not been introduced in Canada, and by many was not deemed practicable or worthy of serious consideration, but in spite of discouraging circumstances it was fostered by Dean Galbraith until he finally proved the justification of his contentions, which were prompted by a foresight reaching far into the future. He built up the "School" until to-day it stands among the foremost engineering colleges of the world. He has prepared thousands of young engineers to go out and develop the wealthy resources of the Dominion.

The loss to the University is indeed a serious one. His name inspired confidence in the manufacturer and in the commercial man, and as a result the University enjoyed the accumulated patronage which was the outcome of credit reflected upon it by the life and associations of Dean Galbraith. He had effected a bond among the graduates in engineering, which fostered a loyalty to their alma mater such as is not evidenced in any other faculty or in any other University.

He had always been the students' friend. He was one of the very few men of our universities, who properly appreciated the position and capacity of the undergraduate. In preparing a curriculum he always gave the students' needs his first consideration, and did not make the curriculum suit as conveniently as possible the courses of lectures which might be given. He won many a concession for the undergraduates quite unknown to those whose cause he had championed. He always had a willing and sympathetic ear for a student in trouble, and his kind and helpful attitude won their confidence, with the result that he was looked upon by them as a real friend in whom they could confide, and whom they could approach with difficulties which confronted them. He will be missed, and sadly missed, in the corridors of the old "School" where he had been the constant recipient of well merited respect since the founding of the institution which he fostered and fashioned until his death.

His many worthy characteristics were developed and manifested to the greatest degree in his home. To those who knew him,—and our readers all knew him well,—it would be superficial to try to convey an impression of the kindness and unselfish love and companionship, which he afforded the members of his family. He was a companion to his boys and spent many days with them alone, in the pleasant retreats of Northern Ontario. He was an inspiration for good to the whole household, and his greatest enjoyment was derived from his home life.

His eulogies were spoken while he lived. Homage and tribute were paid him throughout his life, the crowning mark of respect probably being the banquet tendered to him last December in the Engineering building, by the graduates and undergraduates in engineering, in celebration of the fiftieth anniversary of his entrance to the University, and of the thirty-fifth anniversary of his appointment as head of Engineering in the University. It was a happy family reunion when over six hundred of his boys assembled, and hundreds of others too far away wired messages of appreciation, to pay tribute to the grand old man to whom they owed so much.

As President Falconer has said, he was a thoroughly trustworthy man, thorough in training, honesty, and patience. His name will be handed down to posterity as an emblem of true worth, and his life will find a prominent and enviable place in the pages of history.

The following extracts from correspondence received during the last week reveals the measure of esteem with which the Dean was regarded by the graduates and other men who had felt the influence of his personality.

The loss of Dean Galbraith will be felt far and wide throughout the Dominion, wherever there are engineering students or engineers in the active practice of their profession. He was not only a very able engineer but a man of wide human sympathies and with a great power of inspiration.

Frank D. Adams,
Dean of Engineering, McGill University.

Montreal, July 28th, 1914.

Dr. Galbraith was one of the greatest men of his age, for he has been instrumental in producing the men who are now so strong a factor in the development of our Dominion.

I shall always cherish his memory with sincere affection.

H. G. Tyrrell, '86.
Consulting Engineer.

Evanston, Ill., July 24th, 1914.

Dean Galbraith was the greatest practical engineering educator of his time, and, through his graduates, he has influenced all parts of the engineering world. I count it a great privilege to have studied under him, and the friendship which has since continued makes me mourn his loss most keenly.

Louis L. Brown, '95,
Vice-president, The Foundation Co.

New York, July 25th, 1914.

For thirty-two years I had the great good fortune of the acquaintance, advice, instruction and friendship of Dean John Galbraith.

The late James Ross, a thorough judge of men, said in 1883, that Galbraith was an exceptionally capable engineer and teacher, and that any boy who was fortunate enough to graduate under his instruction would need no further collegiate training in Europe or America.

The advice given me by Dean Galbraith has been repeated to many young men, as I have felt sure that it would benefit them as it has benefitted me.

There is no man living whom I respect, admire and love as much as I did Dean Galbraith.

T. Kennard Thomson, '86,
Consulting Engineer.

New York, July 25th, 1914.

He has left his mark in Canada through his great influence. He was beloved and revered by every student who studied under him and few men will be more widely mourned.

T. R. Deacon, '91,
Mayor.

Winnipeg, Man., July 27th, 1914.

Dean Galbraith possessed, I believe, more of the Christian virtues than any other man I have known. He was of a most kindly disposition, and was considerate, almost to a fault, of the feelings of all with whom he came in contact.

For over twenty years he has been my most intimate friend, and in this long period I cannot recall his ever having spoken uncharitably of anybody, although he occasionally expressed righteous anger at manifest wrong doings. He practiced to the fullest extent the Golden Rule, "Do unto others as you would have others do to you."

He was extremely happy and content in his home life and had practically no outside interests, other than those connected with the University and the School of Science.

R. F. Stupart,
Meterological Service.

Toronto, July 25th, 1914.

For a long while I have known him—thirty-three years—and in all that time, first as a pupil and afterwards as one of the many who had the good fortune to possess his friendship, I grew to respect more and more and admire those rare qualities of heart and mind which so endeared him to all who knew him well.

His personality was extremely attractive. He appealed to all sorts and conditions of people, to young and old, to the plain workman as well as to the educated college man.

He had all the qualities of a truly great leader. He had wonderful tact and intuition and was very, very kindly. His modesty and genial good nature, keen sense of humor, and charity for human weaknesses, gained him friends everywhere, and yet when necessary, he could be very strong, but he ruled through love and not through force.

He possessed the faculty to a remarkable degree of imparting knowledge to others, and of stimulating a desire for thoroughness. I have met none who were his equal in this respect. There was something in him which unconsciously brought out the best in his pupils. I do not remember that he ever lectured his class on conduct or ethics; but his influence somehow stimulated the best that was in us. He was not only a great teacher of Applied Science—he was an upbuilder of character—he made Men as well as Engineers.

His loss to Canada and to the University is very great. To his wife and family and to his many devoted friends, it is irreparable; but he had lived to see the fruition of his life's work, and it gave him much joy in his later years to see the bountiful return which his early strenuous and loyal work had produced. The influence of his life will long survive him. The world is better for John Galbraith having lived.

Eugene W. Stern, '84,
Consulting Engineer.

New York City, July 24th, 1914.

Dean Galbraith's death is a great personal loss to me. When I came under his instruction in 1880, there were, I think, only ten undergraduates. I was his first assistant in 1884, and at that time had the advantage of much intercourse with him. It was but natural that those qualities that have endeared him to so many appealed to me and have increased my regard in these thirty-four years.

Dean Galbraith's achievement in making the School of Science and the Engineering Faculty of Toronto University what it is to-day is a goal that few have won. It has been the lot of few men to gain the affection and respect of all in the same generous measure as he did and nothing can add to these testimonies of his sterling character, his humanity and ability.

The manner in which the graduates and his fellow engineers seized opportunities to honor him could only have been possible to a man of his exceptional parts.

It was natural that we, of more intimate intercourse with him, should have felt his influence, but it has been a constant wonder and pride to us that all the graduates of all the intervening years should have kept his personality and name as the reason for the esprit-de-corps of the School.

We older graduates have realized that the growth and influence of the "School" was in large measure due to the example and the enthusiasm inspired by its principal.

The "School" will, of course, sorely miss his leadership, but his name will still remain a watchword and we must console ourselves with the knowledge of what he accomplished. His life's work could hardly have been more complete.

G. H. Duggan, '83.

Vice-president and Chief Engineer, Dominion Bridge Co.,
Chief Engineer, St. Lawrence Bridge Co.

Montreal, July 27th, 1914.

THE PURIFICATION OF PUBLIC WATER SUPPLIES

C. H. R. Fuller, B.A.Sc.

(Concluded from last issue)

Purification of Water for Drinking Purposes

Sedimentation Processes.—Impure water has a tendency to become purer if left standing. The process of sedimentation consists in taking water through basins in which the velocity of flow is reduced and the heavier suspended matters sink to the bottom by gravity. Sedimentation is now largely used as a process preliminary to the purification to which the water supply is subjected. There are two principal methods of sedimentation: (1) Plain Sedimentation. (2) Sedimentation with coagulants.

Plain Sedimentation.—This consists of allowing the water to enter reservoirs and to remain for a certain period of time until the water becomes clarified. Where water is to be filtered after sedimentation, a high degree of clarification is not needed although the reduction of suspended matter should be great enough to avoid clogging the filter beds and to reduce the frequency of cleaning.

A period of twenty-four hours' subsidence is about the minimum limit, although in some cases a shorter period is used. At Cincinnati a delay occurred in completing a second reservoir. The first reservoir was in constant service and a period of subsidence of 8 to 10 hours was all that could be allowed. It was found that during the months when the turbidity of the Ohio river water ran over 100 parts per million, an average of 48 per cent. of suspended particles was removed in passing through the reservoir. On the completion of the second reservoir it was found possible to allow three days' sedimentation before filtration. The average removal of suspended matter was as follows:

Time of Subsidence	Amount of Suspended Matter Removed
24 hours	62 per cent.
48 hours	68 per cent.
72 hours	72 per cent.
96 hours	76 per cent.

The average capacity of each reservoir is 160,000,000 gallons. The plan used is to draw water from one reservoir while the other is filling. This allows a period of subsidence averaging 40 hours for each reservoir. The reservoirs are formed by the construction of two earth dams across the lower end of two branches of Lick Run, a tributary of the Little Miami River and by excavations and embankments necessary to remove unsuitable material and to reduce the surface of the ground above the dams to uniform slopes and grades. The interior surfaces of the reservoirs so formed were covered with a blanket of rolled clay not less than 3 feet thick. A stone curb one foot thick and three feet deep was set, with its top around the upper end of the slope of each reservoir. For 36 feet below this, the slopes were covered with a 12 inch layer of crushed stone and gravel mixed with sand. Upon this layer of stone and gravel, a six inch layer of compressed Portland cement concrete was spread and covered with a smooth coat of cement mortar. This layer of concrete was covered with a mixture of asphalt which was applied hot in two coats one-eighth inch thick. The second coat was covered with a layer of vitrified brick while still hot and the joints filled with cement grout. The bottoms of the reservoirs dip from there 108.50 at the southerly ends to elev. 89.00 at the floating tube piers back of the dams at the northerly ends of the reservoirs.

The water enters each reservoir over the cascade and is taken out through two steel riveted floating tubes four feet in diameter, which by means of swinging elbows, connect with two five-foot diameter cast-iron effluent pipes which pass down through the masonry pier into a brick archway (See Fig. 1). This archway, which is 16 feet in diameter, passes under the dam at an elevation of 60.00 and terminates in a brick shaft outside of, and at the foot of the dam. The shaft is 18 feet in diameter and rises to elev. 98.00,

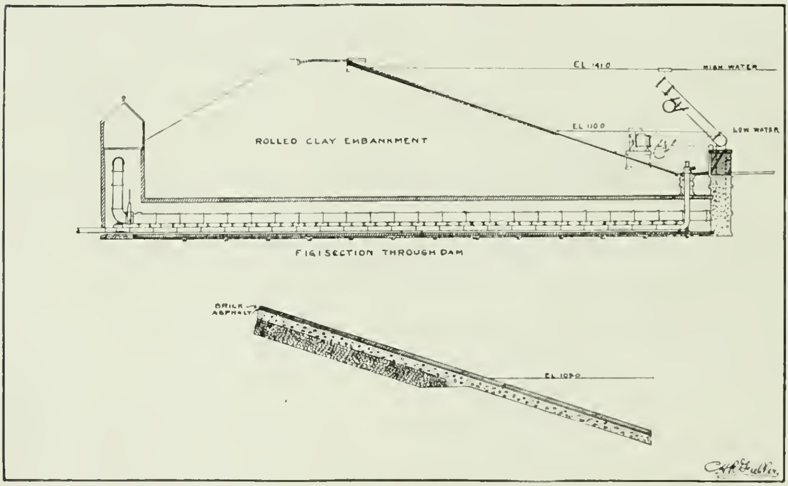


Fig. 1 and Fig. 2—Enlarged Section of Revetment

above which it terminates in a circular shaft house. The effluent pipes pass through the archway, up through and out of the shaft at elev. 93.00 where they connect with each other and with two like effluent pipes from the adjoining reservoir. Gate valves on these effluent pipes at the bottom of the shafts on the connections outside of the shafts permit the water to be drawn down through either one or both of the five foot cast iron mains which convey the settled water to the filtration works. Provision is made for washing the accumulated sediment out of either reservoir by means of large effective hose streams which cut up and carry the mud to four drainage outlets in the bottom of each reservoir. The drain pipes pass as a 30 in. cast iron main through the archway and out at the bottom of the shaft. Mud valves over the outlets, operated by hydraulic pressure and a gate valve at the bottom of the shaft, control the draining and washing of the reservoir.

An overflow connection 15 feet wide and 92 feet long between the two reservoirs prevents the water in either reservoir from rising above elev. 142.50. The slopes were trimmed and sodded to add to the general appearance of the grounds. The accompanying drawings Fig. 1 and 2 show a sectional view of the dam and a section of revetment.

Cincinnati is one of the few cities on the American continent using the Sedimentation Process on a large scale. In Toronto there is a danger of the lake water clogging the slow sand filter beds of the present plant. If this occurs, a plain settling reservoir of sufficient size would probably be a remedy.

Sedimentation with Coagulants.—It is known that various chemicals when added to water will combine with the fine suspended matters causing precipitation of relatively large masses which may be more readily removed by filtration. The use of coagulants with water is generally employed as a process preliminary to rapid sand filtration as it enables the filters to be operated at a high rate.

Sulphate of Alumina, commonly called Alum, is perhaps the most widely used coagulant. When this substance is introduced into water containing carbonates of lime and magnesia, the alumina unites with the water to form a bulky gelatinous hydrate, which is the coagulating agent. This is absorbed by the clay particles of suspended matter. It is important to use only the amount of alumina which will combine with the quantity of carbonates present, as an overdose may have injurious effects. Theoretically, one grain of sulphate of alumina will decompose 8 parts per million of carbonates. In practice the amount of chemical required depends on the amount and character of the sediment, on the degree of purification required and the time of settlement. For a preliminary treatment a high degree of efficiency is not necessary and it is customary to reduce the suspended matter only 45 parts per million, allowing about 6 to 8 hours sedimentation.

For waters with suspended matter running from 100 to 200 parts per million, 0.7 to 2.0 grains of alumina per gallon is necessary. In Saskatoon, where a new filtration plant of the rapid sand type was recently installed, the suspended matter varied from 130 to 400 parts per million. It was considered necessary to use 1.52 grains per gallon of alumina during periods of excessive turbidity and 0.28 grains per gallon for periods of normal turbidity. The cost of sulphate of alumina varies from $2.20 to $2.40 per hundred weight.

Coagulation is also produced by the use of ferrous sulphate and caustic lime in the form of milk of lime. Where the alkalinity of water is low, this coagulant may be used with good results. It is quite as efficient as sulphate of alumina, and its cost is considerably less. It, therefore, is considerably more economical for use in those waters where experiments show that it can be used successfully. Where the amount of suspended matter is over 50 parts per million, it is considered advisable to use coagulants instead of plain sedimentation.

In the operation of settling basins using coagulants, the continuous flow system is universally used. The water is given a brief period of sedimentation. Where the water is rather high in turbidity two basins are needed in order that one may be cleaned without interrupting the supply. This effect can be secured by an inexpensive partition in a single basin.

A necessary precaution in using alum as a coagulant is to pave the floor of the basins with asphalt; otherwise the alum will attack the concrete, decomposing it and causing sand to accumulate in the bottom of the tanks. All exposed metal surfaces in tanks should be coated with red lead.

FILTRATION PROCESSES

Slow Sand Filtration

It is well known that sand is a universal filter medium. The main improvement in filtered water is the removal of the suspended matter and the elimination of bacteria and other micro-organisms. When working under favorable conditions, a sand filter will remove 98 per cent. of bacteria present in the raw water. The effluent on the first day of operation will contain organic matter and bacteria. As the filter is kept working the organic matter decreases and fewer bacteria are found in the effluent. This is explained by the fact that a jelly-like deposit is forming at the surface and also there is an appreciable action of a similar nature going on in the depth of the filter. This substance contains many minute organisms which destroy the bacteria, and arrests the organic matter. After a time even the water passes too slowly and a layer is scraped off the top of the filter.

In the design of a filter plant the first question to be settled is the adoption of a rate of filtration. In Europe the practice is to use a rate of from two to three million gallons per acre per day; while in America the rate varies from three to six million gallons per day, depending on the turbidity of the water. Sudden changes in the rate of filtration should be avoided. especially any large increase over the normal.

To economize area and to avoid rapid changes in rate, a pure water reservoir should be provided. It should have a sufficient capacity to equalize the demand throughout the day. It is customary to assume the maximum daily rate of consumption to be 150 per cent. above the average and the filters are usually designed to deliver at this maximum rate. A reserve area for cleaning must also be provided, usually one bed to every five or ten beds.

The proper size of beds is a question of economical construction. The larger the beds, the less is the cost per acre. Covered beds, which are generally used, vary in size from 0.4 to 0.8 acres.

The following calculation is of assistance in determining the economical number and size of beds. The cost of a filter may be estimated as made up of two items (1) a portion proportional to the area, which would include cost of bottom, filling, small drains, cover, and the end walls, assuming basins rectangular and placed side by side, and (2 a portion nearly independent of the size, such as cost of piping, valves, valve chamber, division walls, etc.

Let c = Cost of first portion per acre.

and C = the cost of the latter portion per filter.

If q = area of one filter

n = number of filters

A = Total net area required.

Then, assuming one filter in reserve

$$n = \frac{A}{q} + 1 \qquad (1)$$

The total cost is

$$K = Cn + c\,n\,q \qquad (2)$$

$$= C\left(\frac{A}{q} + 1\right) + c\,q\left(\frac{A}{q} + 1\right)$$

$$= \frac{CA}{q} + C + cA + cq \qquad (3)$$

We then have $\frac{dK}{dq} = \frac{CA}{q^2} + c$

When for a minimum cost

$$q^2 = \frac{C}{c} A \qquad (4)$$

i. e. the economical area of one filter is proportional to $\sqrt{A}$ and to $\sqrt{\frac{C}{c}}$.

The larger the value of "c," the smaller is "q". The values of "$\frac{C}{c}$" will hardly be larger than 1/9 or less than 1/16, giving a value of "q" = 1/4 $\sqrt{A}$ to 1/3 $\sqrt{A}$. Thus, when A = 9 acres, the capacity q = 3/4 to 1 acre giving 9 to 12 beds. Where A = 1 acre, the capacity would be 1/4 to 1/3 acre giving 3 to 4 beds. Larger beds than 1 acre are undesirable on account of increased difficulty of operation.

Filter beds are usually rectangular and arranged side by side. It is usual to place them in two rows with a space between for sand washing, regulating houses, etc. The economical proportions of the beds is given by the following formula:

$$\frac{b}{a} = \frac{n + 1}{2n}$$

where b = width, a = length, and n = number of beds in a row.

Concrete, well reinforced is generally used in construction of the filters. The covers are constructed either of plain or reinforced concrete and are of the groined arch type.

At Toronto, there has recently been erected a very modern slow sand filtration plant, a description of which it is considered well to give, as this may be used as a standard in plants of this nature.

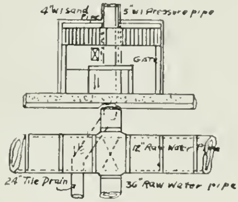
Toronto is situated on the north shore of Lake Ontario. Along the front of the city is a long low island composed entirely of lake sand and gravel. The intake of the city water supply lies in about 50 feet of water at a point one-half a mile south of the southernmost point of the island. From the intake a six foot steel pipe runs to the shore of the island, across the bay through a tunnel to the main pumping station of the waterworks system.

The population of Toronto is about 450,000. The per capita consumption is about 130 U.S. gallons per day. The rate of filtration assumed in the design of the plant was 6,000,000 gallons per acre per day. The size of the beds is about 0.8 acres. A low lift pumping station was designed to give the necessary lift to overcome the friction through the filters and the piping. The filters are laid out in two rows of six filters on either side of a central court. The effluent pipes from the filters run to two regulator houses in the central court and from these regulator houses another large concrete pipe carries the filtered water to the pure water reservoir which has a capacity of 7,500,000 gallons. A short line of 72 in. concrete pipe connects the pure water reservoir with the 6 ft. steel pipe crossing the island. The water is lifted at the pumping station to the level of the filters which is naturally above the lake level and flows through the filters, regulator houses, etc., into the pure water reservoir and thence into the 6 ft. pipe, at an elevation which gives practically the same condition for operation of the pumps at the main pumping station in the city as existed before the plant was in operation. The general arrangement of the plant and other features are shown in Fig. 3.

The filter floors were placed directly on the sand as excavated. Care was taken to avoid carrying the excavation at any point below the grade of the floors, as well as precautions to wet and compact the exposed sand surface before placing each floor block. So far there is no evidence of large or unequal settlement although the structures have stood full of water for more than a year. The floor blocks were placed in alterante sections, the intermediate sections being laid afterwards and screeded to the first ones laid. The groined arch vaulting was placed as is usual, in alternate sections.

The main drain of the filter was formed as a depressed section of the concrete floor with a cover slab of reinforced concrete placed across the top of the low side-walls of the drain. The reinforced concrete cover slab is made to fill in completely the space between the two pier foundations upon either side of the drain, in order that there may be no lack of continuity in the arch action at that point to resist the thrust. The entrance houses to the filters contain the sluice gates, controlling the flow of unfiltered water to the filters and also the gate valves controlling the discharge from above the surface of the filters to the waste drain. This is shown on the plan of the entrance house in Fig. 3.

The lower layers of the filtering material consist of gravel and crushed stone. It was placed in three layers. The first has a depth of 7 inches and consists of gravel or stone which is retained on a one inch screen and generally not larger than two inches. The second layer has a depth of two and a half inches and consists of material which passes a one inch screen and is retained on a 3/8 inch screen. The third layer has a depth of 2½ inches and consists of material which passes a 3/8 inch screen and which has an effective



Plan of Filter Entrance

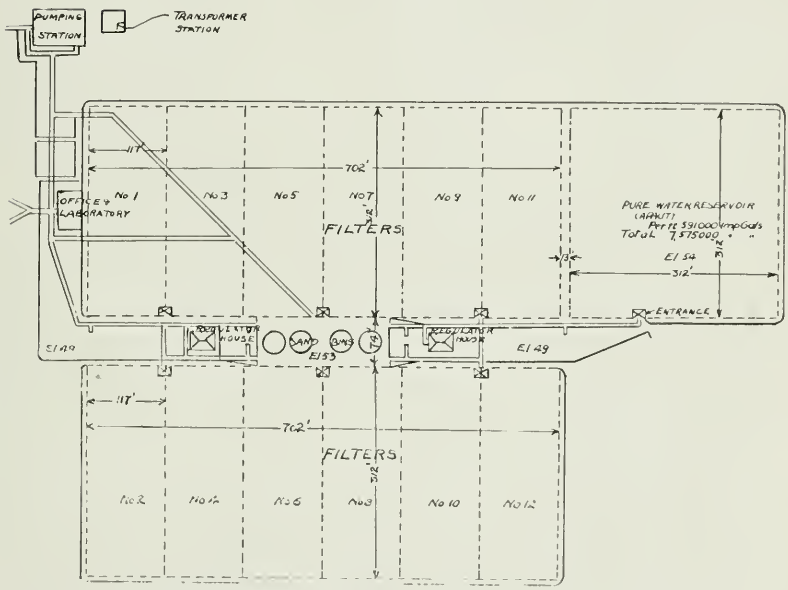


Fig. 3—General Plan of New Water Filtration Plant at Toronto

size of about three or four mm. The specifications called for an effective grain size of sand of 0.25 mm. to 0.35 mm. and a uniformity co-efficient not greater than 3.

A complete system of drainage is provided for the plant. This consists of a main drain of 36 in. concrete pipe with 24 in. branches of vitrified tile entirely surrounded with concrete from various filter entrances and numerous smaller connections with catch-basins, sand bins, sand washers, electric and duct manholes, etc.

The sand washers are in principle similar to the ones designed for Washington and Springfield, consisting briefly of reinforced concrete hoppers into which the slush of dirty sand and water from the filters is discharged. A jet of water subject to adjustment is admitted into each of these hoppers at the bottom, causing a vertical velocity of water in the hopper, which is designed to carry the dirty water away at the overflow while still permitting the scrubbed sand to fall freely into the bottom of the hopper, where it is picked up by an ejector and carried forward to the sand storage bins.

Mechanical or Rapid Sand Filtration

Rapid sand filtration first attracted attention as a method of purifying water supplies in 1885, when a small rapid filter plant was built to treat the supply of Somerville, N.S. Since that time this method has come into use in more than 350 cities in different parts of the world and supplies a total daily demand of considerably over 700,000,000 gallons. The largest plant of this type is installed at Cincinnati, Ohio. Others are located at Columbus, Ohio, Hackensack, N.J., Little Falls, N.J., and Saskatoon, Canada.

The essential differences between rapid and slow sand filters are as follows. In rapid sand filters, the rate of filtration is very much higher (100 to 125 million gallons per acre per day); the filter units are much smaller; the sand grains comprising the filter bed are much coarser; a coagulant is always used in preparing the raw water for final filtration, and the whole filter bed, when dirty, is cleaned in the tank itself by forcing water upward through the sand instead of scraping off the surface layers as in slow sand filters.

These peculiarities lead to a difference in construction from that of the slow sand type. The units are relatively small in area, the coagulating basin becomes an essential part to the plant and the sand washing which must be done every few hours requires special devices. Nearly all rapid filter plants are now built of concrete, although wooden and steel tanks are still used. The filter tanks are ordinarily built of monolithic concrete and embedded in the floor of the tanks is the underdraining system, composed of perforated pipes or strainer cups, designed to permit the filtered water to pass out without allowing sand to escape and to permit an even distribution of water throughout the sand layer when the filter is being washed. Over the strainer system a shallow layer of coarse sand or gravel is placed, and on this rests the sand layer which forms the filter proper. When the raw water has been sufficiently clarified by coagulation, and sedimentation, it is passed on to the surface of the filter, over which water ordinarily stands to a depth of several feet, and allowed to pass downward through the bed at a rate of 100,000,000 to 125,000,000 gallons an acre daily, such rates being automatically controlled by special devices.

The water supplied to the filter always contains a considerable amount of coagulated matter, such as mud, vegetable stain and bacteria, which is retained at or near the surface of the bed. As operation is continued the frictional resistance in the sand layer increases to a point where it is necessary to close the filter for washing. At such times the water standing over the bed is drained down to the level of the overflow gutters which are located a foot or more above the sand layer, and filtered water is then forced upward through the filter, being evenly distributed by means of the strainer system. Water is forced backward through the strainers and at the same time the sand is stirred up to its full depth by means of long iron fingers which reach into the sand, and which are attached to a transverse arm mounted on a vertical shaft, the whole being rotated by means of suitable gearing.

The rapid filters just described are known as "Gravity" filters and are contained in open tanks.

Pressure Filters.—In this filter the entire bed is enclosed in a cylindrical steel tank. One of the best types of this is that manufactured by the Bell Filtration Co. of Toronto. The accompanying cut, Fig. 4, shows a view of the internal arrangement of the filter.

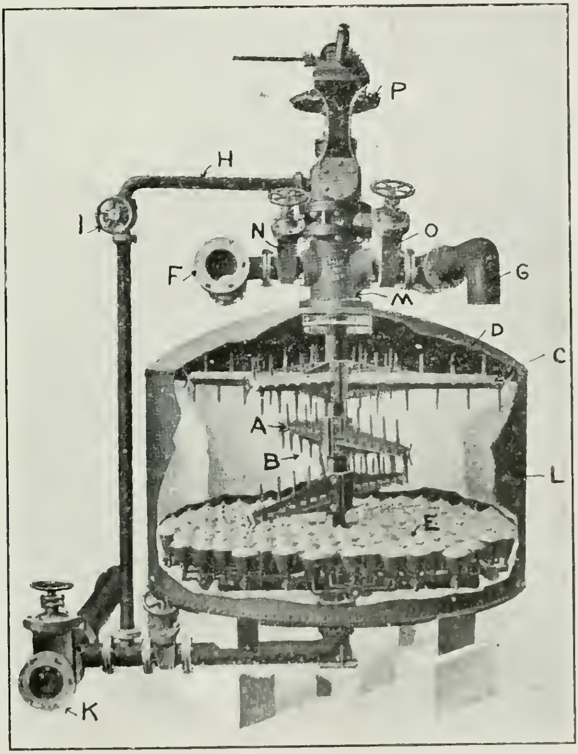


Fig. 4

A—Valves in Wash Arms.
B—Rakes on Wash Arms.
C—Hydraulic Hollow Wash Arms.
D—Hydraulic Hollow Shafts.
E—Perforated Strainers.
F—Inlet Pipe for dirty water.
G—Washout Pipe for Cleaning.
H—Top Pipe.
I—Vertical Wash Valve.
K—Outlet for Filtered Water.
L—Steel Filter Shell.
M—Top Block on Shell.
N—Inlet Valve for Dirty Water.
O—Wash Out Valve.
P—Bevel Wheels.

The shells "L" are made of mild steel and are so constructed that when in operation an ample margin of strength is provided for. After being mixed with a suitable amount of chemical, the water to be filtered is passed into pipe "F" and through inlet valve "N" into the top block on shell "M" and into the top of filter shell "L," then after passing through filtering material it is collected by strainers "E" and passes out through the bottom pipe into the main filtered water discharge pipe and out through valve "K."

The process of filtering is continued until the pressure gauge shown on illustration on inlet pipe indicates that the resistance from accumulated dirt makes it necessary to wash the filtering material.

The Bell plants are erected in batteries, each separate filter doing the same amount of filtering. The size of installation depends upon the quantity of water to be filtered.

Since pressure filters are erected in batteries with a common filtered water main, one or more filters are washed in one operation, the number depending on the size of the plant; the remainder continue to filter. Only filtered water is used in removing the collected impurities from the filtering material. The washout valves "O" (see figure) of the compartments to be washed are opened and the inlet valves are shut. Valve "K" is partially shut. A current of clean water is forced through bottom pipe and strainers "E" upwards through the filtering beds, putting the same in suspension, the water flowing through the top blocks "M" and valves "O" and out through pipe "G"; as soon as the beds are in suspension, vertical wash valves "I" are opened and a current of water is passed through top pipes "H" into hollow shafts "D" and into hollow arms "C" and out through back-pressure valves "A." When this is done the arms and shafts are revolved by means of the wheels "P" on top of hollow shafts "D" breaking, stirring and loosening the dirt, etc., from the filtering material; by means of rakes "B" the beds are thoroughly broken up and the whole of the dirt loosened is carried out by the amount of water issuing from the pipes "G." The whole operation is performed in from three to six minutes.

In the larger plants the revolving of the washarms is done by bevel wheels driven from a small motor. The speed of the arms is about 80 feet per minute.

The important features of pressure filters are as follows:

(1) They are simple in construction, easily managed and are perfect and economical in operation.

(2) They purify the water continuously.

(3) The filtering material never requires changing, being cleaned in three to six minutes with a very small quantity of water.

(4) They are capable of treating all kinds of waters.

(5) Great economy of space, 1,000,000 gallons per day can be purified on an area of 600 square feet.

(6) The filters are installed in such a way that the risk of unseen leakages is minimized.

(7) They are 99% efficient from a bacteriological point.

The cost of a rapid sand filter plant under ordinary conditions will range from $8,000 to $12,000 per million gallons capacity, for filters, coagulating basin, clear water well, and auxiliary pumping apparatus. The total cost of operation will range from $10 to $12 per million gallons.

Sterilization Processes

CHLORINATED LIME.—This process is generally used as a supplementary purification process, although in some instances it is the only process of purification. This strong disinfectant consists of a mixture of calcium hydroxide Ca $(OH)_2$, calcium chloride, $CaCl_2$, and calcium hypochlorite Ca $(Clo)_2$. On account of the active chlorine it contains it will destroy all bacteria in a few hours in extremely dilute solutions. Water thus treated is perfectly harmless, although in some instances its taste is impaired.

The sterilization of potable waters by the use of chlorinated lime was first put in operation for the Jersey City Water Supply Co. at Boonton, New Jersey, in connection with the supply of Jersey City. Since then it has been employed in connection with nearly every water supply throughout the country.

The utility of this process has been established beyond dispute as an adjunct to sedimentation and filtration, either slow or rapid sand. It cheapens the installation of filtration by practically eliminating for the future all necessity for slow sand filtration. The desired results of filtration being obtained more cheaply, more rapidly and on a much less area, by rapid sand filtration and sedimentation. The chlorine lime is usually added to give .25 to .60 parts per million of available chlorine. It costs about $25. per ton.

As stated above, the taste of the chlorine is sometimes objectionable. In a paper by Lederer and Bachmann of Chicago presented to the Illinois water supply association at their March 11th meeting, is set forth their findings on a series of tests to eliminate the taste. Chemicals which seemed of value for the purpose of eliminating the taste from chlorinated waters are sodium sulphite and sodium thiosulphate, both of which are strong reducing agents and form tasteless compounds when brought into contact with chlorine.

For .01569 gm. of chlorinated lime containing approximately 33 per cent of available chlorine, .01815 gm. of crystalline sodium sulphite was required or 1.2 pound of sulphite for each pound of lime. No harm can be done with a reasonable overdose. There are, however, serious drawbacks to the continued use of sodium sulphite, one of which is the fact that it deteriorates readily forming sulphates which are completely inert as far as taste removing properties are concerned.

The sodium thiosulphate, Na_2 S_2 O_3, 5aq. has striking advantages over the soldium sulphite. The theoretical quantity of thiosulphate necessary to complete the reaction and remove the taste as well as odor coincides always with the amount necessary to satisfy the total available chlorine in the chlorinated lime employed. The acids formed in the reaction immediately combine with the bases to form neutral salts.

For one pound of chlorinated lime containing approximately 33% of available chlorine, the theoretical quantity would be 0.28

lbs. of crystalline thiosulphate, or approximately 30% of the weight of chlorinated lime. Any harmful effects from an excess of thiosulphate is impossible. It is recommended that the application of thiosulphate be in quantities of one-half of the quantity of the chlorinated lime to be on the safe side at all times. The price of the commercial preparation of sodium thiosulphate is cheaper than that of chlorinated lime. The combined cost of the treatment is within easy reach of a community since it adds about 40% to the cost of the chlorinated lime. Even when less than the theoretical quantity of thiosulphate is added, it is bound to lessen the frequency of complaints.

It might be pointed out that the thiosulphate stops the germicidal action of chlorine the moment it comes in contact with the treated water. This is not serious, however, as the destruction of bacteria by chlorine is extremely rapid, in most cases completed in five minutes. It is recommended, however, that a margin of at least ten minutes be allowed before an addition of thiosulphate. Where the treated water is directly discharged into mains, without previous storage, provisions will have to be made to dose the treated water continuously at a point where disinfection has been practically completed.

Ultra-Violet Ray Sterilization.—Within the last few years a great deal of work has been done in Europe in the development of ultra-violet ray for water sterilization and it may be safely said that the ultra violet ray sterilizing system is now an industrial process.

The treatment of water on a large scale with ultra-violet rays requires preliminary clarification by means of filters since the suspended particles will prevent the action of the rays on the bacteria. Filtration at three to ten times the speed of normal biological sand filtration for the same water is sufficient to free the water of matter in suspension. An existing biological filter could multiply its output to a very great extent and produce a better effluent if combined with ultra-violet ray treatment. Once the water is free from suspended matter the speed and the depth of flow past the ultra-violet light have to be fixed according to the specific transparency of the particular water.

The Engineering Record of Dec. 10, 1910, describes an apparatus which is running at different places in Europe; one plant at Naromme les Ronen had been in continuous service for two years and a half and gave constantly sterile water. The water is sand filtered and then passed at a speed of 130,000 gal. per 24 hours through the rays of a one h.p. lamp.

For large city plants, however, a one h.p. unit is too small; hence a new type of lamp was constructed in July 1913, with the following objects in view:—To locate the lamp as close to the water as possible, to use as much of the light as possible, to produce ultra-violet rays with a minimum of electric energy, to run the lamps so that they would have economic life and finally to stir up the water during its exposure so as to turn over all microscopic particles which might allow bacteria to hide in their shadows.

Theoretically an extremely short exposure is needed, scarcely more than a tenth of a second at a distance of one inch from a lamp, to sterilize the water completely. It is safer, however, to lengthen the period of exposure as is the practice with the new type of lamp.

This new apparatus is called the pistol lamp. It runs on 500 volts and requires 3 amperes. Its peculiar luminous tube is "U" shaped, the two branches of the "U" being very close together. The entire luminous part of the lamp is enveloped by a two inch quartz tube, which forms the lamp chamber, separating the lamp from the water. In the new apparatus practically all the light enters the water while the older apparatus allowed only about 60 per cent. of the light to be used. The efficiency of the lamp is increased not only by its peculiar shape but also by a greater production of ultraviolet light than one would expect from the wattage. The water to be sterilized is passed through a canal in such a way as to keep the water under the influence of the light.

C. B. Jackson, '07, and F. C. Lewis, '08, are engaged in contracting in Toronto under the firm name of "Jackson-Lewis Co. Ltd." with offices in the Bell Telephone Building.

A. G. Lang, '03, and E. R. Lawler, '10, formerly with the Toronto Hydro Electric System, are now with the Hydro Electric Power Commission of Ontario.

A. W. J. Stewart, '08, is general manager of the Toronto Hydro-Electric System, 226 Yonge St., Toronto.

W. A. Cowan, '04, is resident engineer for the Intercolonial Railway at Truro, N.S.

S. B. Iler, '08, formerly with the Brantford Hydro-Electric System is now at Vegreville, Alta., with Maxwell & McKenzie, consulting engineers, of Edmonton.

F. E. Watson, B.A.Sc., '11, has gone to Edmonton, Alta., for the summer to traverse some lakes in the vicinity of the city.

J. A. P. Marshall, B.A.Sc., '14, formerly with the Department of Public works at Medicine Hat, Alta., has recently accepted a position with the Department of Public Works of Ontario as resident engineer in the Highways Department for the counties of Middlesex, Perth, Oxford and Waterloo, with headquarters at the county buildings, London, Ont.

T. A. Fargey, B.A.Sc., is with the construction department of the Canadian General Electric Co. at Winnipeg, Man.

R. E. Lindsay, B.A.Sc., '14, is in the erection department of the Hamilton Bridge Works Co., of Hamilton, on construction work throughout Ontario.

A. A. McQueen, B.A.Sc., '11, is with the Northern Electric Co. at Winnipeg, Man.

W. S. Winters, B.A.Sc., '13, is with Speight & Van Nostrand, surveyors, Toronto.

O. M. Falls, B.A.Sc., '14, is engineer in charge of the construction of new pavements at Oakville, Ont.

TWO TYPES OF GERMAN SEWAGE SCREEN

P. Gillespie, C.E.
Associate Professor of Applied Mechanics

The processes taking place in the present day sewage treatment plant may be classified as mechanical on the one hand and chemical and biological on the other. The former involve the removal of the grosser solids either by screening or sedimentation, or both, and the latter embrace whatever else is employed, be it land treatment, filtration or sterilization. The object sought in the mechanical treatment is sometimes merely the removal of inorganic and non-putrescible matters which will not yield to subsequent treatment and which, if left, would only burden the processes to follow; sometimes such a reduction in the amount of visible organic matter that the effluent may be discharged into a body of water or a stream without occasioning offensive conditions or undue pollution; sometimes the preparation of the sewage for subsequent treatment where impairment of function would result from the presence of an undue amount of suspended matter and sometimes the removal of only those coarser entities which, if permitted to remain, might choke pump passages or other channels.

Obviously, then, the means to be employed in the mechanical treatment of a sewage must be selected with an eye to the end to be achieved. Screening and sedimentation are in their results identical. Screens, if sufficiently fine, will produce as great a clarification as sedimentation tanks of common proportions. If sewage is to be prepared for tanks of the Emscher type, which are essentially devices for the treatment of sludge, coarse bar screens are all that is necessary since there is no object in arresting anything except that which, through its greater size, might choke the six-inch slots at the bottom of the sedimentation chamber or the sludge discharge pipes. The use of fine screens in such a case will result in the production of two sludges instead of one, for the disposal of one of which, little or no provision may have been made. The screens ordinarily employed by the Emscher Board consist of ¾-in. bars spaced about 2½ ins. centre to centre. Similarly for the protection of sewage pumps, coarse screens are adequate.

It is difficult to give an approximate estimate of either the quantity of suspended matter in sewage or of the amount which a given screen is likely to remove. These things are influenced by so many variables that a generalization is well nigh impossible. Even where screens of the finest mesh practicable are employed, the bulk of the suspended matter is too finely divided to be intercepted at all. At Providence, R.I., by a grating with bars 1 inch in the clear 41 pounds of screenings per million U.S. gallons of sewage was reported as the average for the year 1906. This would be equivalent to one cubic foot nearly. An experimental Riensch-Wurl screen at Dresden with slots 1 mm. (1-12 inch) wide under test prior to the installation of the present plant, removed some 23 cubic feet of screenings per million gallons. It must be remembered, however, that German sewages are much more concentrated than those of American cities. Mr. Weand's rotating screen at Reading, Pa., with wire cloth having meshes 1-40 inch square, according to official reports, yields 19 cubic feet per million gallons. This represents only 42% of the entire matter in suspension. Mr. Irving Nevitt, superintendent of the Morley Avenue Disposal Works, Toronto, informs the writer that the coarse bar screens at that station separate about 3¼ cubic feet per million Imperial gallons. This is equivalent to nearly 4 cubic feet per million U.S. gallons. Generally speaking, experience seems to indicate that coarse screens, as coarse screens are ordinarily understood, will remove up to 10 cubic feet per million U.S. gallons, and that quantities in excess of the latter must be obtained by the use of screens of fine mesh.

On the other hand, the preparation of sewage for dilution in rivers, lakes or the sea in certain cases, constitutes the chief field of usefulness for the fine-meshed screen. Dilution has come to be regarded as a legitimate and satisfactory method of disposal, provided always that the volume of filth does not exceed the assimilating capacity of the water into which it is discharged. Sewage which is delivered at the end of an outfall sewer is often in a highly putrescible condition, and its putrefaction on the one hand robs of its oxygen, the water into which it is discharged, and on the other reduces the organic materials to stable and innocuous forms. The effect on the water is practically harmless when not used for domestic purposes until the reduction of oxygen has continued through a considerable percentage of the saturation quantity. For instance, the first indication of pollution is the disappearance of major fish life for the preservation of which 70% of the saturation volume is necessary. When the oxygen content is reduced below 30% of saturation, the condition of the water is such as to constitute a nuisance during the summer season. In 1887 Mr. Rudolph Hering advised a dilution of 1 in 22 as a basis for the design of the Chicago Drainage Canal. This ratio was afterwards adopted. While the results have been in the main satisfactory, disagreeable odors at all points have not been prevented.

It will be apparent then, that a partial treatment such as is afforded by fine screening or sedimentation preparatory to discharge into lakes or rivers will result in the removal of much of the solids which create visible nuisance and in lessening by the amount of the solids thus removed, the burden on the assimilating water. Such has been the practice with most of the cities situated on the Great Lakes including Toronto, Rochester, Erie, Oswego, Buffalo and Milwaukee. In Germany, where many of the cities are located on relatively large streams, not sources of public water supply, the method is very general. The cities of the Emscher valley, Hamburg, Dresden, Frankfort a/M, Cologne, Düsseldorf, and Gottingen are a few of those that follow the mechanical treatment of their sewage by discharge into streams. With the exception of those in the Emscher valley, which since 1907 have adopted the two-story sedimentation tank, they have favored the fine screen in preference to the method of sedimentation.

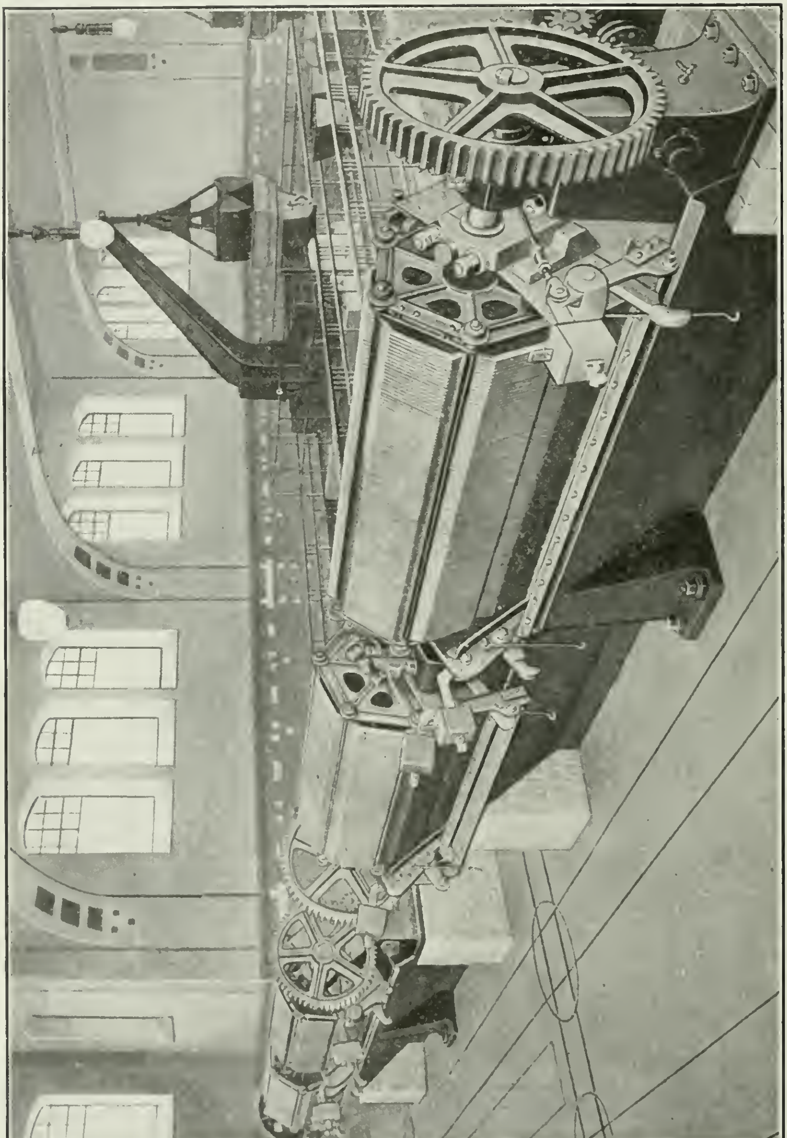


Fig. 1.—Four Brunotte Sewage Screens at Hamburg, Germany. The Energy Required to operate is 1 H. P. per Screen

The choice in such cases as those cited, it seems to the writer, will depend on two things, viz.:—the relative costs of the two methods and on whether or not a satisfactory method of disposing of screenings is available. If not, the employment of the two-story sedimentation tank is a solution worthy of careful consideration. The city of Hamburg removes the screenings by scow and they are disposed of on land. It should be remembered that the manurial content is generally greater in fresh than in rotted sludge. At Dresden, where the fat content is said to be 18% of the dried residue, it is now proposed to dry the screenings and extract the grease by the use of a solvent, experiments looking toward this end having been made there on a somewhat extensive scale.

For the purpose of this article, screens may be classified as fixed and moving. The former includes, e.g., the bar screens from which the debris is removed by moving rakes operated either by hand or mechanically. The latter is represented by those types in which the particles in suspension are arrested by the screen while submerged and are removed after the screen or part of it has been lifted above the flow-line. The writer's observation leads him to believe that the latter type is much better adapted to those cases where fine screening is essential. A long distance movement of screenings over the face of a screen is likely to result in macerating and squeezing through the screen much of the arrested matter. Rakes, for example, moving over bar screens from below the water line to a place of discharge well above it, are always observed to lose much of their burden on the way. The removal of the material in the quickest possible way and without affording an opportunity for it to be crushed through openings seems to be fundamental and essential to the successful working of a fine-meshed screen. Obviously this is best accomplished in the moving type.

Of those continental fine screens familiar to American engineers, the Brunotte and the Riensch-Wurl rotating screen are probably best known. These are both of the moving type.

The Brunotte screen has been installed at Hamburg, Schöneberg, Crefeld and some other places within the German Fatherland. A fair conception as to its operation may be had from an examination of half-tone illustration, Fig. 1, and the line drawings, Figs. 2 and 3. Figure 1 is from a photograph of the installation at Hamburg, the great shipping and industrial metropolis of Germany. This city is situated on the Elbe some 50 miles from its mouth and has a population of approximately one million. The sewage from the city, after screening as its only treatment, is discharged through three outlets into the river. Enquiry elicited the information that there has been no sludging up of the bed of the river and the belief seems to be general that accumulations, if they form at all, are eventually carried out to sea by the current. The dilution at times of minimum flow is 1 in 100.

Structurally, this screen consists of a well braced steel frame, rectangular in form, whose plane is placed transverse to the line of the flow in the screening chamber and inclined upward in the

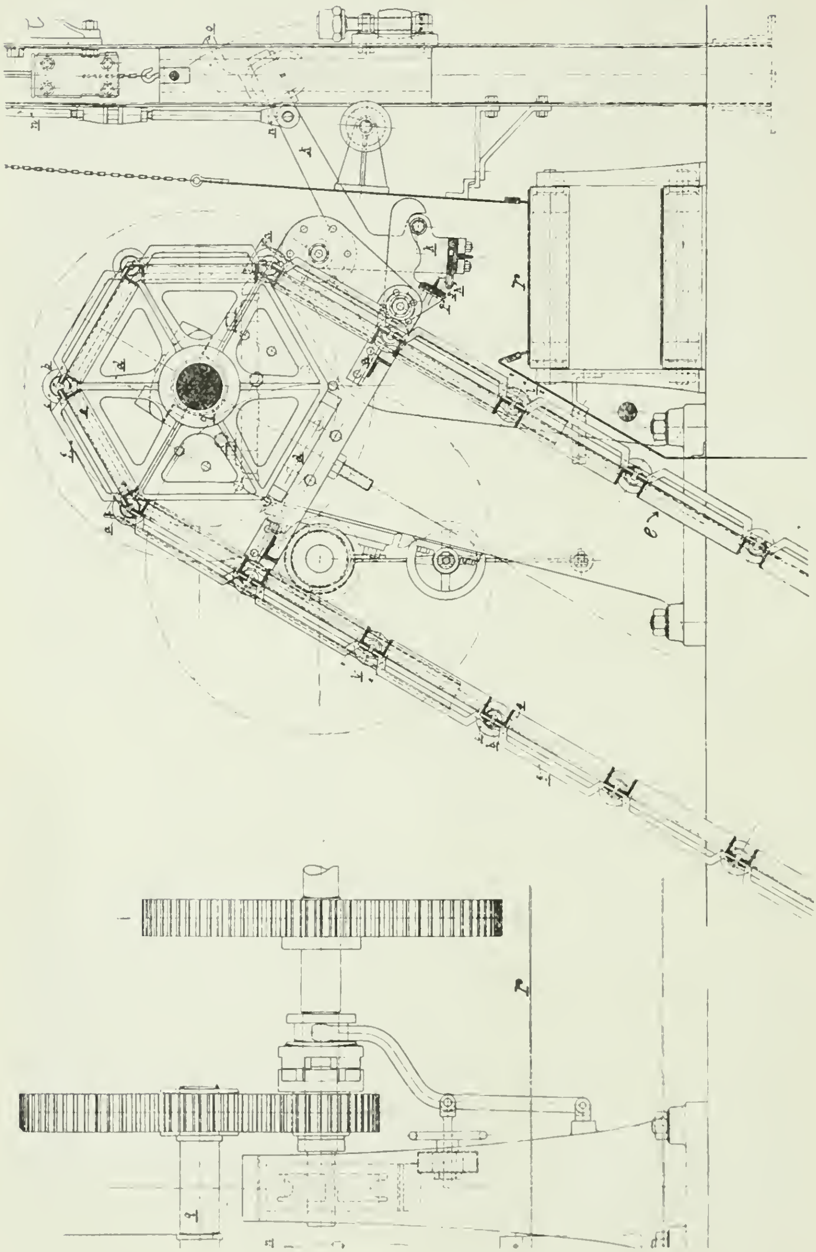


Fig. 2—Details of the Brunotte Screen

direction of flow at an angle of 60° with the horizontal. Along its upper and lower edges are attached shafts each bearing two sprocket wheels over which pass two endless chains which engirdle completely the steel frame. Of these shafts, the upper is the driver. Spanning from chain to chain and separated by suitable distances are a series of rectangular steel frames to which the metallic bars constituting the screen proper or "grid" are fastened. These bars are from 12 to 16 inches long, are made of a non-corrosive metal and are separated by distances varying from ⅛ to ⅝ inches, depending on the minimum size of particle which it is desired to arrest. In the Hamburg screen the spacing is 2/5 in (10 mm.) in the clear. In figure 2, *q* is the upper shaft, *d* a sprocket wheel and *e* the rectangular frame carrying the grid bars which are denoted by *f*. The sense of rotation is clockwise so that the rising portion of the screen is on the left. The screen bars are so shaped that they lie throughout their entire length quite clear of the grid frame, thus facilitating the cleaning of the screen by the comb to be referred to below. Upon their upper shoulders and in the recess shown at *l* is afforded a support for the larger solids which in the ordinary case fall into the belt conveyor *r* as the sections round the separate sprockets at the top of the frame. The velocity of the screen is from 1 to 2 inches per second.

To clean the grid of those smaller matters which adhere to it after the screen sections have rounded the highest point of the sprocket, a comb shown in Figure 2 and in more detail in Figure 3 is provided. This comb consists of an indented plate of rubber *g* supported by an iron plate *h* below and covered by a smooth brass plate *i* above, both of which are indented to correspond with the teeth in the rubber plate between. The width of the teeth in the metal plates is somewhat less than that of those in the rubber so that only the latter comes into rubbing contact with the bars of the screen. The comb is attached to a reciprocating lever *k* whose motion is electrically controlled and which serves to alternately advance and withdraw the comb from engagement with the grid. This withdrawal and replacement take place while the space *l* between grid sections is being traversed downward opposite the normal position of the comb. As the comb is withdrawn, the scraper *p* lying on its upper surface serves to remove the debris which has been separated from the grid just passing. This immediately falls by gravity to the belt conveyor below. The withdrawal and advance are quite rapid and the latter is complete by the time the next approaching grid has arrived in the position where combing is to begin again. The endless belt delivers the screenings to a worm conveyor, which in turn passes them to a storage hopper. The various parts of the screen are easily removable and the whole may be elevated from the water by winch if repairs become necessary. To the observer the operation of this screen seems almost ideal. It is manufactured by the Maschinenfabrik Buckau A. G., Magdeburg, Germany.

The advantages possessed by the Brunotte screen are the fact

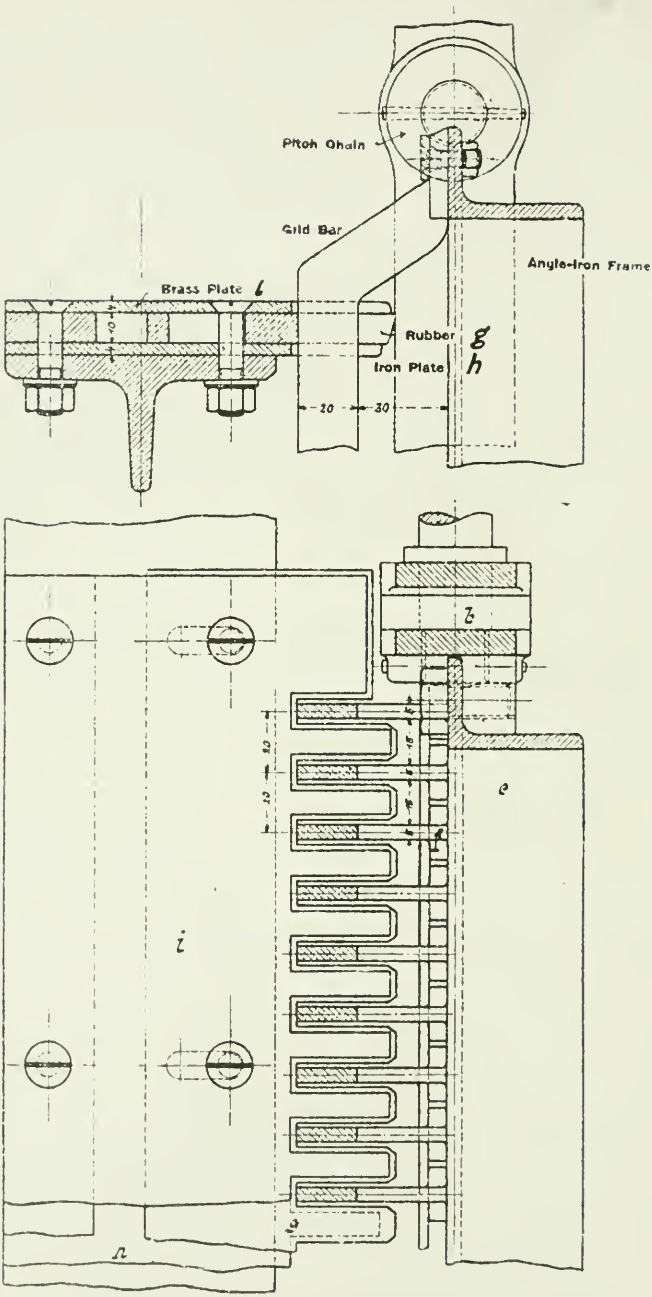


Fig. 3—The Cleaning Comb

that little of the arrested material can get pressed through the grid, that each screen bar is cleaned on three surfaces—front and two sides, that general freedom from choking is attained, that all parts may be made accessible for alterations and repairs above water and that the power consumption for operation is quite small.

The Riensch-Wurl screen is a combintaion of an annular plate and a frustum of a cone the plane of the former being inclined upward from the horizontal at from 10° to 30° and the whole being installed in the screen chamber as indicated in the diagrammatic sketch, Fig. 4. Both annular plate and frustum are made of brass perforated sections. The perforations are usually elongated rather than circular and have a width varying from 1-32 to 7-32 inch, as desired. The sewage flows through these perforations and the

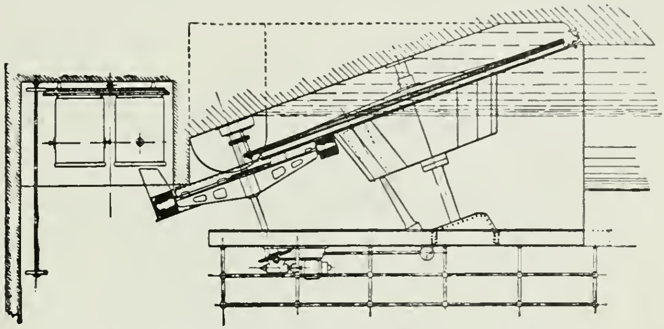


Fig. 4—Diagram of the Riensch-Wurl Sewage Screen

solids are arrested and remain upon the upstream side of the plate. The slots are made tapered, with the widened opening below, so that fine matter passing through is thereby less likely to adhere to the plates on their under sides.

The screen is revolved on its inclined shaft and as the normal flow-line is ordinarily well below the highest point of the plate,

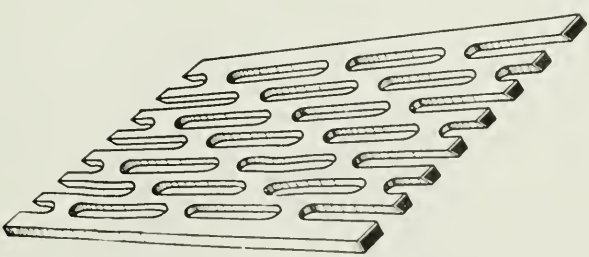


Fig. 5—Tapered Slots in Screen Plate

all parts of the submerged portion are successively brought by rotation above the water level. The loss in head is quite small. The sides of the screen chamber are accurately fitted to the shape of the screen so that escape of sewage at the junction is well nigh practically prevented.

Cleaning is accomplished by a series of rotating cylindrical brushes attached to the extremities of the radiating arms of a revolving star-shaped spider. The sense of rotation of this spider is the same as that of the screen so that the motion of the arms while cleaning the plates of the screen is opposite to that of the plates themselves. The cleaning brushes are faced with bristles as shown in figures 6 and 7 and their sense of rotation is upward from the screen on the advancing side. These brushes are suspended from the carrying arms and each is driven through a pair of spur gears, one on the extremity of the carrying arm and the other centric with the axis of the brush itself as shown in figure 6. A little consideration will show that the operation of the driving spur A tends to

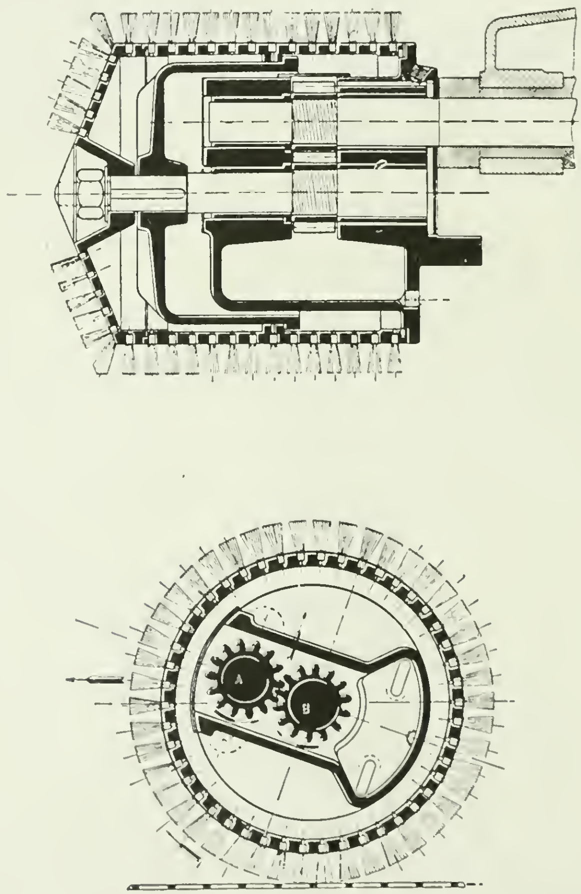


Fig. 6—The Gear Driving Mechanism of the Rotating Brushes

diminish the weight supported by the screen plates. The brushes in consequence move lightly and silently over the screen. It will be apparent also that, owing to the simultaneous motion of screen and brushes, the paths of the latter intersect each other and that each portion of the screen is brushed several times between leaving the water level and returning thereto again. The individual plates are interchangeable and easily removed so that repairs are readily made. The screenings are said to have a water content of 65% and are disposed of on land or otherwise as seems most suitable.

The city of Dresden, Germany, possesses the largest installation of Riensch-Wurl screens yet erected. This city is situated on the Elbe River and the sewage is brought to the works, in the municipality of Kadiz on the right bank of the river a few miles below the city proper, by two interceptors, each serving one side of the river. A hopper-shaped detritus tank entraps the grit which is dredged periodically therefrom by a mechanical dredger. The

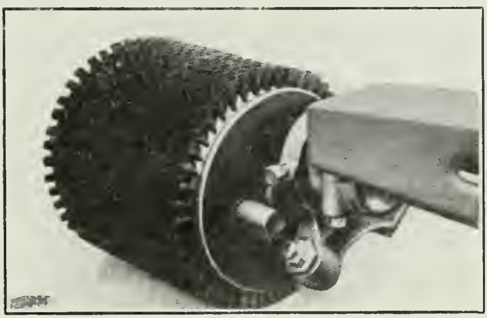


Fig. 7—Riensch-Wurl Brush Suspension

sewage is then passed through a battery of four Riensch-Wurl rotating screens each of diameter 26 feet. These may be operated in series or parallel as desired. The slots in the plates are 2 mm. x 30 mm. (1-12 x 1 1-5 in.) The plates are cleansed from time to time with a solution of soda. The arrangements provide that when the flow exceeds the capacity of one machine, a second is automatically thrown into service. A third and a fourth are similarly successively added as the volume of sewage to be treated increases. Provision is also made for by-passing to the river, the flow in excess of a pre-determined maximum in times of unusual storm. The entire installation is electrically operated.

To the visitor, the operation of this plant appears almost faultless The mechanical equipment seems perfect and the cleanliness is all that the most exacting could desire. The Sanitation Company of New York are the American representatives for these screens and to them the thanks of the writer in permitting the use of several illustrations are due. Over forty different installations to date of the Riensch-Wurl screen have been made not only in Germany but in Russia, France and Scandinavia also.

THN JUNGLE JOB

I said to myself, "I am through pioneering,
I'm sick of the wilderness, lonely and rough,
I'm sick of the graders' camp, built in a clearing,
I'm weary of laborers, hairy and tough;
I'm tired of the outfit, the bed and the ration,
The steam shovel's puffing, the shock of the blast—
I want to go back where there's civilization,
The fun and the frolic I knew in the past.

"The life that has savor and vim in,
The sights and the noises of towns,
The laughter and lure of the women,
The glitter of jewels and gowns;
I'm done with this business forever,
I'm off to see 'cities and men,'
And once I have landed, I'll never
Come back to the 'Jungle' again."

So I made for the city of wonder and glamor
The city whose glory had shone in my dreams,
I plunged with delight in its hurry and clamor,
Its welter of hopes and ambitions and schemes,
I reveled again in the food and the raiment,
The music and lights and the movement and mirth,
And I said to myself, "There is no form of payment
Can tempt me again to the outposts of earth."

But in spite of the pleasuring places,
In spite of the vast city's thrill,
The spell of the unconquered spaces
Came following after me still;
At night it would suddenly wake me
By day it would whisper and then
I knew it was trying to make me
Come back to the Jungle again.

I had thought that the softness of cities would tame me
I fought with the thrall of a life I reviled,
But the lure of the game I had played overcame me
—The struggle with Nature far out in the wild.
The flesh-pots were sweet, but they never could hold me,
I packed up my kit and I made for the trail,
And now I believe what the Old Timers told me,
"The spell of the wilderness never can fail."

I'm back to the "furthermost farness,"
I'm way, way "ahead of the steel,"
I'm wearing my engineer's harness,
The gravel is under my heel;
The dreams of the city still bind me,
The call of it comes to my ken,
But somehow I left it behind me,
I'm back to the "Jungle" again.

By Berton Brayley, in "Power."

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance $2.00
Single copies 20

Advertising rates on application.

Address all communications:

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL

It is with an unrestrainable feeling of profound sorrow that we go to press with this issue of Applied Science. It conveys to our readers the very regrettable announcement of the death of their most cherished friend, our Beloved Dean Galbraith, whose heart had a resting place for every student and graduate who had come in contact with his benign influence either in the "School" or in their professional work. We are unable to express in words the feeling of loss that we have experienced in the departure to the Beyond, of our chief advisor and our kindest friend, whose large and sympathetic heart had enthroned him in the mind and heart of every "School" man.

Since the birth of APPLIED SCIENCE, he has been our constant guardian and helper, to whom we always felt free to go for counsel. The Dean's keen interest in his graduates no doubt accounted in some degree, for the interest which he took in the "School" journal, since it was the one medium of keeping them in touch with each other and with the institution of their early training.

When we say that APPLIED SCIENCE has kept the graduates in touch with the "School," we might better say that it has kept them in touch with the Dean, for his whole life and energy was centred in the institution of his founding and building, and we trust that in future it will serve to keep them in touch with the monument which he has raised in the record of engineering education, and which will stand throughout the future eras of history as a monument to the unsurpassed and indefatigable work which he has accomplished in the interest of the profession, the School, and the members of the student family.

Not only has Dean Galbraith always manifested a kindly interest in the School journal, but in spite of the fact that his many duties demanded so much of his attention, he has contributed freely toward material for publication therein. In Volume III, No. 5, dated March 1910, appears an extensive article by him, on "The Elastic Arch."

In the issue of December, 1908, appears an address by Mr. E. W. Stern, C.E., '84, delivered on the occasion of the presentation of Dean Galbraith's portrait to the University of Toronto. In it is portrayed the respect which the early graduates hold for their beloved preceptor.

Without our leader, it is incumbent upon the graduates, and upon our earlier graduates in particular, to be constantly alert, always watchful of the union which our Dean has so proudly and so successfully effected, lest the glory which is due him through its continued growth and stability, should lose any of its rightful brilliance and effectiveness as a result of thoughtless neglect. The "School" will always mark the life of our late Dean in the pages of history, and if we are true to the debt which we owe him, we will not allow the growth of the "School" to be stunted, nor the union among "School" men to be weakened, but will converge our energies toward keeping bright and prominent, the monument of his building.

He has made the upbuilding of the engineering course in the University and the unification of the graduate body, his life work. It was his desire to see both prosper, and if we do our utmost to continue the good work from which death called him away, we will accede to his most ardent wish.

SEDGEWICK-SCOTT

On July 1st at noon, Mr. A. Sedgwick, '09, of the Department of Public Works of Ontario, was married to Miss Annie Irene Scott of Inglewood, Ont. After September 1st, Mr. and Mrs. Sedgwick will reside at 67 Fulton Ave., Toronto. APPLIED SCIENCE joins in extending congratulations.

OBITUARY

FREDERICK J. BEDFORD, '08

It was with regret that we learned of the sudden death of one of our graduates, Mr. Frederick J. Bedford, of class '08, son of Rev. J. Bedford, of Pickering. Mr. Bedford, was in the employ of the Canadian Copper Co. at Copper Cliff, Ont. On June 25th, while he was repairing some machinery at the ninth level in one of

F. J. BEDFORD, '08

the mines, a car was accidentally lowered, which struck the deceased's head, killing him almost instantly.

Mr. Bedford was born at Thessalon on May 30th, 1885. After receiving a public school education he came to Harboard Collegiate. He afterwards attended Albert College and later enrolled in the Faculty of Applied Science and Engineering at the University of Toronto, where he took a course in mining engineering with class '08.

For some time after graduating he was employed at Creighton Mine, near Sudbury, and later became superintendent of the Crane Hill Mine, also near Sudbury. For some time he was engineer for the Dome Mine at Porcupine before going to Copper Cliff, where he was engaged with the Canadian Copper Co. until the time of his death.

In his demise the engineering profession has lost a man whose diligent application to his work had won him much success and his friends have lost a fellow worker whose worthy attributes have proven him a true friend.

He is survived by his wife, who was Miss Pearl Clark, of Souris, P.E.I., his father and mother and one sister, to whom we extend our most heartfelt sympathy.

W. N. ALLAN, '15

A very sad death occurred at Oakville, Ont., on Sunday, July 19th, when Mr. W. N. Allan, son of Mr. and Mrs. J. S. Allan, of Nelson, B.C., who had just completed his third year in mining engineering at the "School," was drowned at the age of twenty-six years in the heroic attempt to rescue a man and two children, who had been precipitated into the lake from a capsized canoe.

There was a strong wind blowing of a rather squally nature, and while Mr. Allan, who was on the shore, was watching the man put up a sail, the canoe suddenly upset, throwing the occupants into the lake. Forgetful of himself and thinking only for the safety of the struggling trio, Mr. Allan, without even taking time to remove his shoes, plunged into the water and began to swim to their rescue. Before the young hero had reached them, the occupants of a near-by boat, who had observed their plight, at once went to their rescue.

Upon seeing that they were all safely aboard, the swimmer started back to the shore, but when he was about 150 feet from land he was seen to falter and he went down. The boat which had already effected the triple rescue was soon upon the spot and the body was recovered, but although an attempt at resuscitation was made immediately, all efforts proved of no avail. A physician who had been summoned as soon as the boat reached shore, made an examination, and found that death had been due to excitement and shock which had effected the heart of the swimmer, already under the extra strain of swimming, fully attired.

Mr. Allan was of quiet and unassuming nature, but underneath the quiet surface there flourished a true-hearted manhood, pillared with qualities of character which prompted him to an action of undaunted bravery, resulting in the sacrifice of his own life in an attempt to save others, and placing his name in the annals of history among those whose largeness of heart and whose thought for their fellow-men has led them to suffer death that others might be saved.

The circumstances surrounding his demise are indeed very sad. His heroic efforts deserve the attention of everyone and it will be with a feeling of profound regret that his fellow-students will learn of his death. The remains were interred in the cemetery at Oakville on Wednesday, July 22nd. Professor Haultain and Mr. W. A. MacLean were the official representatives of the University of Toronto and the Public Roads and Highways Department of the Provincial Government, respectively, at the funeral. We extend to the relatives of the deceased our sincerest condolence in their very sad bereavement.

ROBERT G. M. STRATHEARN, '13

On Tuesday afternoon, July 7th, about three o'clock, Mr. R. G. M. Strathearn met death when he was overcome by gases in a sewer on Argyle St., Toronto. Mr. Strathearn, who had always taken particular pains with his work, wished to verify some measurements which he had already made, and entered the sewer for that purpose. While making the measurements he felt the opression from the gases and attempted to reach the manhole through which he had entered, but was overcome and expired before a rescue could be effected.

Deceased, who was twenty-three years of age, was the son of Mr. George Strathearn, of Midland. He received his Public School and High School education in the northern town and entered the University in the department of civil engineering in 1909, with class '13. Upon the completion of his second year he was appointed to the staff of the sewer department, City Hall, which position he occupied until the time of his death. He had always exercised exceeding care with his work, and it was that careful sense of duty that prompted him to accept a risk, which unfortunately resulted in his death.

The body was sent to Midland on Thursday, July 9th, for interment. Deceased is survived by his father, three brothers and two sisters, to whom we extend our sincere sympathy in their bereavement.

The following "In Memoriam" was written by a close friend of the deceased:

He died, doing what he believed to be his duty, and where it called he was not found wanting. One of the keynotes of his life was thoroughness, and accuracy possessed him. He was not, therefore, lacking in those qualities that go to make up a hero.

"Come on my lads, let us descend!" so spake Bob to his men,
He led the way where DUTY called; there was no flinching then:
But human skill could not foretell the issue of that act,
For when he reached the air above, the spark divine he lacked.

Ne'er mind, 'tis well, for God doth know, he died with a good name,
Nipped in the bud—before his life had blossomed into fame:
Though few his years of service were, their quality was high
And with a record such as that, no man's ashamed to die.

Some thoughts from Holy Writ may here, be counted apt and right.
Whate'er his hand found well to do, he did with all his might,
He who'd have friends must friendly be to those he meets, and kind;
This of our Bob was also true,—he had a willing mind.

His life though short, we know, dear friend, has not been lived in
vain,
God suns and waters precious seed; Behold it lives again:
By His good grace we hope to meet our much loved boy once more
O may we all a mansion have, where Christ has gone before.

MacLean, B.A., '09, is engaged in switchboard and power plant designing, with the Canadian General Electric Co., at Peterboro, Ont. His permanent address is Orillia, Ont.

MacLennan, A. L., '02, has 115 Avenue Road, Toronto, as his address.

MacLennan, G. G., '10, formerly with the Foundation Co. Limited, at Smith's Cove, N.S., is at present on a trip through Western Canada.

MacLeod, G., '07. No record.

MacLeod, D. D., '10, is with the Department of Interior, at Calgary, Alta.

MacMillan, G., '01, is with the Topographical Surveys Branch of the Department of Interior at Moose Jaw, Sask.

MacMurchy, J. A., '96, is chief draftsman in the turbine department of the Westinghouse Machine Co.

MacMurchy, H. G., '10, is employed as generating and sub-station designer for the Toronto Power Co.

MacPherson, A. R., '13, is with P. H. Secord & Sons, contractors, of Brantford, Ont.

MacPherson, N. W., '09. No record.

MacTavish, H. J. '10 is with the Transmisson and Power Co., at Hamilton, Ont. His address is Terminal Station, Hamilton, Ont.

MacTavish, W. H., '13, is with the International Boundary Surveys Branch, Department of Interior, Ottawa. He is at present in Alaska in charge of a party on boundary survey work.

Mc

McAllister, J. E., '91, has a practice as consulting engineer at 15 King St. W., Toronto, Can.

McAllister, A. L., '93, has a practice as consulting engineer. His office address is 612 Continental Life Building, Toronto.

McAlpine, D. D., '09, is with the Canadian General Electric Co., Toronto.

McAndrews, J. B., '11, has 70 Church St., St. Catharines, for his address.

McAree, J., 82. Deceased.

McArthur, R. E., '00. We do not know his address.

McArthur, A. S., '09. His address is 54 Rathnally Ave., Toronto.

McAuslan, H. J., '03, is on the staff of the T. & N. O. Railway at North Bay, Ont.

McBride, A. H., '02, is with the Hydro Electric Power Commission, Continental Life Building, Toronto.

McBride, T. C., '10, is with the Western Construction Co., at Regina, Sask.

McCollum, C. R., '09, is with the Toronto Hydro Electric system. His address is 77 Roper Ave., Toronto.

McConnell, A. W., '06, is lecturer in architectural design at the University of Toronto, Toronto, Ont. He has been in Paris, France, during the past year, taking a post graduate course in architecture.

McCordick, A. S., '09, is assistant to the city engineer, Sault Ste. Marie, Ont.

McCuaig, O. B., '04, is superintendent of the Entiat Light & Power Co., Wenatchee, Wash.

McCuaig, P. J., '09, is with the Westinghouse Machine Co., Pittsburg, Pa.

McCulloch, A. L., '87, has a practice as engineer and surveyor at Nelson, B.C.

McCurdy, J. A. D., '07. His last address with us is Baddeck, N.S., where he was with Graham Bell, Esq.

McDougall, J., '84. Deceased.

McDougall, S. G., '10. We have not his present address.

McDowall, R., '88, is city engineer for Owen Sound, Ont.

McEachern, J. A., '11, has Strathburn, Ont., as his home address.

McElhanney, T. A., '10, is in Vancouver, B.C.

McElroy, R. W., '11. No record.

McEntee, B., '92, has a stationery store at 38 Queen St. E., Toronto.

McEwen, G. G., '04, is with T. H. Dunn, O.L.S., Winchester, Ont.

McEwen, H. J., '11. No record.

McFayden, A. J., '11, has 12 Lee St., Quebec, as his address.

McFarlen, G. W., '88, is on the city

engineer's staff, roadways department, Toronto, Ont.

McFarlen, T. J., '93, is chemist for the Antikokan Iron Co., Port Arthur, Ont.

McFarlane, J. A., '03, is chief draftsman with the Hamilton Bridge Works, Hamilton, Ont.

McFarlane, W. G., '04, is engineer and surveyor in the Peace River District.

McFarlane, J. B., is a Dominion land surveyor. His address is 60 Lonsdale Rd., Toronto, Ont.

McFaul, W. L., '13, is in the city engineer's office, Port Arthur, Ont.

McGarry, P. G., '10, has Merritton, Ont., for his home address.

McGeorge, W. G., '08, has a practice as civil engineer and land surveyor at Chatham, Ont.

McGhie, W. G., '11, is with the Canadian Crocker-Wheeler Co., St. Catharines, Ont.

McGibbon, C. P., '04, is with the Canadian Westinghouse Co., Hamilton.

McGorman, S. E., '06, has Box 393 Walkerville, Ont., for his address. He is assistant engineer, Canadian Bridge Co. Limited, Walkerville, Ont.

McGowan, J., '95, is associate professor of Applied Mechanics at University of Toronto, Toronto, Ont.

McGregor, W. W., '05. Deceased.

McGregor, J. M., '08, has Ridgetown, Ont., for his home address.

McGugan, D. J., '07, is a member of the firm, Burnett & McGugan, civil engineers and land surveyors, New Westminster, B.C.

McIlwraith, D. G., '06, is chief draftsman for the Goldie & McCulloch Co., Limited, Galt, Ont.

McIntosh, A. H., '07, is with the Illinois Steel Co., Chicago, Ill.

McIntosh, W. G., '09, is with the Herbert Morris-Crane at Hoist Co., Toronto.

McKay, O., '85, has a practice as civil engineer and surveyor at Waterville, Ont.

McKay, C., '04, deceased.

McKay, W. N., '95, is manager of the Bank of Hamilton at Georgetown, Ont.

McKechnie, F. H., '09, has for his address 303 McKay St., Montreal, P.Q.

McKenzie, D. A., '11, is meter inspector with the Toronto Hydro Electric system.

McKenzie, D. W., '05, is draftsman in the engineering department of C. N. Railway, Winnipeg, Man.

McKenzie, J. A., '06, is a member of the firm of McKenzie, Broadfoot & Johnston, Vancouver, B.C.

McKim, L. R., '10, has Wyecombe, Ont., as his permanent address.

McKinnon, H. L., '95, is vice-president of the C. O. Bartlett & Snow Co., Cleveland, Ohio.

McLaren, A. J., '11, has 221 Home St., Winnipeg, Man., as his address.

McLean, C. A., '05, is with the Canadian Westinghouse Co., Limited, at Toronto, Ont.

McLean, W. N., '05, has Erin, Ont., as his home address.

McLean, L. A., '08. Deceased.

McLeish, A. G., '11, is with the Canada Crude Oil Co., 507 Lumsden Bldg., Toronto.

McLellan, R. A., '11. No record.

McLennan, A. L., '02, is in the office of the York County engineer.

McLeod, G., '09, is electrician for the Electric Light & Railway Co., Waupaca, Wis.

McMaster, A. T. C., '01, is practicing as engineer and contractor, Toronto, Ont.

McMaster, W. A. A., '08, is a member of the firm, McMaster & Christie, land surveyors, McKay & Adam Block, Prince Albert, Sask.

McMillan, J. G., '00, of Box 431, New Liskeard, Ont., is inspector of Mines, Cobalt and Porcupine Districts, Ont.

McMillan, D., '04. No address on fyle.

McMillan, V., '09, is branch manager, Trussed Concrete Steel Co., at Fort William, Ont. (Kahn System of Reinforcement); head office, Walkerville, Ont.

McMordie, H. C., '08.

McNab, J. V., '06, is resident engineer with C. P. Railway at Moose Jaw, Sask.

McNaughton, A. L., '03, is with the Grand Trunk Pacific Railway Co., at Prince Rupert, B.C.

McNaughton, F. W., '98, is Deputy

Minister of Public Works, at Winnipeg, Man.

McNeill, F. W., '07, is with the Canadian General Electric Co., at Peterboro, Ont.

McNiven, J., '10, is government inspector on elevator construction at Moose Jaw, Sask.

McPherson, A. J., '93, is Deputy Minister of Public Works for Saskatchewan, at Regina, Sask.

McPherson, J. A., '06, is a student in the faculty of medicine, University of Toronto.

McPherson, W. B., '11, is a student at law, Osgoode Hall, Toronto.

McQuarrie, M. K., '07, is resident engineer for the C. P. Railway, at Revelstoke, B.C.

McQueen, A. A., '11, is assistant manager of the Winnipeg Hydro Electric system, Winnipeg, Man.

McRoberts, A. A., '08, is with the T. & N. O. Ry. at North Bay, Ont.

McSloy, J. I., '10, is textile manufacturer, St. Catharines, Ont.

McTaggart, A. L., '94, is in the office of A. G. McKie, consulting engineer, Rockefeller Building, Cleveland, Ohio.

McVean, H. G., '01, has a practice as contractor and engineer at Regina, Sask.

M

Mace, F. G., '05, was patent examiner in the Department of Agriculture, at Ottawa, Ont., when last heard from.

Madden, J. F. S., '02, is on the staff of the erecting engineering department for the Canadian General Electric Co., at Winnipeg, Man.

Madge, N. G., '08, is chief chemist for the Continental Rubber Co., of New York.

Madill, H. H., '11, is a member of the firm, Craig & Madill, architects, Manning Chambers, Toronto. He is also lecturer in architecture at the University of Toronto.

Main, W. T., '93. His last address on our fyle is Silverton, Oregon.

Maisonville, A. W. R., '10, was on the designing staff of the Dominion Bridge Co. when last heard from.

Malcolmson, W. S., '07. His last address with us is Haileybury, Ont. We do not know his present occupation.

Malone, J. E., '08, has Brechin, Ont., for his home address.

Manning, N. H., '09, is district manager for the Canadian Inspection and Test Laboratories, Limited, Toronto.

Manson, G. J., '04, is engineer for the Grenville Board Co., Penetang, Ont.

Manson, A. B., '09, is city engineer for Stratford, Ont.

Marani, C. J., '88, has a private practice as consulting structural engineer at Anacortes, Wash. He is also Pacific Coast manager for the Russia Cement Co., of Anacortes.

Marani, V. G., '93, is city building inspector, City Hall, Cleveland, Ohio.

Marlatt, K. D., '08, is chemist and tannery superintendent for the Marlatt & Armstrong Co. Ltd., Oakville, Ont.

Marr, N., '10, is at Campbellford, Ont., employed on the Trent Valley Canal work.

Marriott, F. G., '03, is chemist and engineer of tests at the Department of Works, foot of Princess St., Toronto.

Marrs, C. H., '02, is designing engineer for the Hamilton Bridge Works, Hamilton, Ont.

Marrs, D. W., '06, is designer and estimator for the Riter-Conley Mfg. Co., Pittsburgh, Pa. His address is 732 Summerlea Ave.

Marshall, R. J., '08, is town engineer for Trenton, Ont.

Marshall, S. A., '07, of 44 Eleventh Ave., Lachine, P.Q., is with the Dominion Bridge Co.

Martin, F., '87, is a practising physician. We have not his present address.

Martin, J. C., '11. We do not know his address.

Martin, W. H., '10, is in the city architect's department, City Hall, Toronto.

Martin, T., '96. We have not his present address on fyle.

Martindale, E. S., '09, has a practice as land surveyor at Aylmer, Ont.

Martyn, O. W., '09, is engaged in survey work at Swift Current, Sask.

Mason, D. H. C., '07, is a member of the firm, Akers, Mason & Bonnington, chemical engineers, Toronto.

Matheson, W. C., '01. We have not his address.

Mathison, P., '01, has 607 Jones Ave., Braddock, Pa., as his address.

Matthews, A. C., '10. His address is 89 St. George St., Toronto.

Maus, C. A., '03. We have not his address on fyle.

Maxwell, W. A., '06. We have not his address on fyle.

Maynard, H. V., '07, is with the Canadian General Electric Co. at Toronto, Ont.

Meader, C. H., '10, is engineer for the Colonization Roads Branch of the Department of Public Works of Ontario.

Meadows, C. A., '11, who took a post graduate course last year in structural engineering is now in Europe on a few months' holiday.

Meadows, W. W., '95, is with the Department of Public Works at Maple Creek, Sask.

Melson, J. W., '07, is in the employ of the Department of Works, City of Toronto, on sewer construction.

Menzies, J. M., '06, is engaged in missionary work at Wei An Hsien, North Honan, China.

Mennie, R. S., '02, was with the Crucible Steel Co. of America, at Pittsburgh, Pa., when last heard from.

Merrill, E. B., '91, has a consulting engineering practice at Moosejaw, Sask.

Merriman, H. O., '10, who until recently was first assistant engineer for the Hamilton Hydro Electric System, has severed his connections with that department. We do not know the nature of his employment at present.

Middleton, H. T., '01, has Palisade, N.J., as his address.

Mickle, G. R., '88, is mine assessor for the province of Ontario. His office is in the Parliament Buildings, Toronto.

Mickleborough, K. F., '13, is assistant engineer in the superintending engineer's office, department of railways and canals, Cornwall, Ont.

Mickler, G. J., '13, is sales engineer for the Ontario Hydro-Electric Power Commission.

Mill, F. X., '89—deceased.

Miller, D. J., '10. We do not know his address

Miller, L. H., '00, is sales agent for the Bethlehem Steel Co., Cleveland, Ohio. His address is 10218 Hampden Ave., Cleveland.

Miller, M. L., '03. His address is 845 Canton Ave., Detroit, Mich.

Miller, L. R., '06, is superintendent of the Watrous Electric Light, Power & Traction Co., Watrous, Sask.

Milligan, G. L., '08. The only address we have on fyle is Brampton, Ont.

Milligan, F. S., '10, is on the city engineering staff, Saskatoon, Sask.

Millman, N. C., '13, is with the Ontario Hydro-Electric Power Commission, Toronto.

Mills, G. G., '07, and Mills, L. G., '11, are in the contractors' equipment business at 809 Lumsden Building, Toronto.

Mills, P. E., '10, has charge of the drafting department of the Eisman Magneto Co., New York. His address is 320 West 56th Street, New York.

Minns, J. B., '07, is with the Canadian General Electric Co., at Winnipeg, Man., as sales manager.

Minty, W., '94, is with Messrs. Yates and Thom, Limited, Blackburn, Lancashire, England.

Milne, C. G., '92—deceased.

Mines, W., '93, is mechanical engineer for Hoover & Mason, contracting engineers, Chicago, Ill.

Mitchell, P. H., '03, and Mitchell, C. H., '92, have a practice as consulting engineers under the firm name of C. H. & P. H. Mitchell, consulting and supervising engineers, Traders Bank Bldg., Toronto.

Mitchell, L. C., '11. We do not know his address.

Mitchell, B. F., '06, is on the city engineer's staff, at Edmonton, Alta.

Mitchell, A. B., '08. We do not know his address.

Moberly, H. K., '89, has an engineering and surveying practice at Yorkton, Sask.

Moffatt, R. W., '05, is instructor in the University of Manitoba, Winnipeg, Man.

Molesworth, G. N., '07, has a practice as architect at 2 College St., Toronto.

Molesworth, J. C. P., '08—deceased.

Monds, W., '99, is a member of the firm Clark & Monds, contractors and engineers, 88 St. David St., Toronto.

Monk, E. D., '08, is district transformers specialist, with the General Electric Co., Cincinnati, Ohio.

Moody, F. H., '08, is mechanical editor of the *Canadian Railway and Marine World*, Toronto.

Montague, F. F., '06. We do not know his address.

Montgomery, R. H., '03, has a practice as engineer and surveyor at Prince Albert, Sask.

Moore, H. H., '02, has a practice as engineer and land surveyor, at Calgary, Alta.

Moore, E. E., '04, is with the Ontario Hydro-Electric Power Commission, Continental Life Bldg., Toronto, Ont.

Moore, J. H., '88, is town engineer at Smith's Falls, Ont.

Moore, J. E. A., '91, is chief engineer to the C. O. Bartlett & Snow Co., Cleveland, Ohio.

Moore, F. A., '03. We do not know his address.

Moore, W. J., '06, formerly a member of the firm Morris & Moore, land surveyors and architects, Pembroke, Ont., has been appointed town engineer of Pembroke.

Moore, J. M., '07, is engineer for the McClary Mfg. Co., London, Ont.

Moore, T. R., '13, is employed at St. Catharines, Ont., as draftsman of the new Welland Ship Canal.

Moorhouse, W. N., '04, is designer for the Sproatt & Rolph, architects, Toronto.

Morden, L. W., '05. We do not know his address.

Morgan, J. P., '10, is cost engineer with the Orpen Construction Co., Toronto.

Morice, J. H., '08, is switchboard proposal engineer for the General Electric Co. at Schnectady, N.Y.

Morley, P. F., '07, is at the Meteorological Office, Toronto.

Morley, R. W., '04, is in the Topographical Surveys Branch, Department of Interior, Ottawa, Can.

Morphy, J. A., '11. His last address with us is Oshawa, Ont.

Mortimer, F. R., '10, is with the Hydrographic Surveys Branch of the Naval Service Department, at Ottawa.

Morris, J. L., '81, has a private practice as civil engineer and land surveyor at Pembroke, Ont.

Morris, C. A., '09, is with the Canadian Copper Co. at Copper Cliff, Ont.

Morton, G., '09, is city salesman for the Canadian Westinghouse Co., at Calgary, Alta.

Mowbray, F. E. H., '08, is with the Canadian Westinghouse Co., at Hamilton, Ont.

Mullins, E. E., '03, is superintendent of motive power for the Northern Railway Co., at Port Limon, Costa Rica, C.A.

Mulqueen, F. J., '13, is with the Sao Paulo Light & Power Co., Sao Paulo, Brazil, S.A.

Munro, A. H., '10, is employed on the Trent Valley Canal at Campbellford, Ont.

Munro, W. H., '04, is in the engineering department of the Peterboro Radial Ry., Peterboro, Ont.

Munro, G. R., '05, is with the Wm. Hamilton Co., at Peterboro, Ont.

The following were awarded the professional degree of C.E. (Civil Engineer) by the University of Toronto at the Convocation in June; C. R. Young, '03, P. Gillespie, '03, T. H. Hogg, '07, and S. N. Hill, '04. The professional degree E. E. (Electrical Engineer) was awarded to R. A. Sara, '09.

N. G. Keefer, B.A.Sc., '14, is with the Glass Garden Builders Co., 43 Scott St., Toronto.

H. M. Smith, B.A.Sc., '14, is with Frank Barker, bridge engineer, 57 Adelaide St. E., Toronto.

H. D. Rothwell, B.A.Sc., '14, is with the Hydro Electric Power Commission, Toronto.

W. P. Dobson, B.A.Sc., '10, who has just completed eighteen months on research scholarship work for the Engineering Alumni Association, is now in charge of the testing department of the Hydro-Electric Power Commission, at their plant on Strachan Ave., Toronto.

E. T. Ireson, B.A.Sc., '13, is with Geo. Abrey,, surveyor, Toronto.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, AUG., 1914 New Series Vol. IX. No. 4

ROOF COVERINGS

R. E. Lindsay, B.A.Sc.

The builder of to-day realizes more and more the necessity of permanent construction. To obtain this end he must give careful consideration to the selection and application of those parts which are to protect the building and its contents from the action of the elements.

In the selection of materials, the elements of chief consideration are:

1. Resistance to Weather. The primary essential of roof coverings is that they successfully withstand the attacks of rain, wind, heat, cold, snow and ice.

The joints of the covering material should be so constructed as to permit of all expansion and contraction consequent upon variations of temperature. They also should not be retainers of water, since this on freezing would cause their rupture.

The roofing material should not absorb too much moisture for if frozen in this condition, it would mean its failure.

To satisfy all these conditions not only must the surface be impervious but the joints must be constructed in such a way as to prevent the failure of the covering at its connections.

2. Strength and Rigidity. In addition to acting as a covering and enclosure, the roofing material should be capable of bearing its part of the imposed loads and transfer them by arch or bending action to the trusses or walls. Under ordinary conditions the covering should be strong enough to withstand without excessive deflection, the wind pressure, snow load and any accidental liveload which it may from time to time have to endure. The wind load on roofs varies for different pitches and with the amount of exposure of the roof. The snow load depends upon the latitude of the place where the building is located, the pitch of roof, and to a certain extent on the kind of covering.

In addition to carrying the imposed loads the covering should, if necessary, be capable of contributing to the lateral stiffness of the building.

The connection of the covering to the purlins or rafters should possess sufficient resistance to prevent its bodily displacement by the wind and such other qualities of resistance as the conditions may necessitate.

3. Fireproof. While resistance to fire is a requirement which varies somewhat with the character of the buliding and its location, the importance of it generally may be more forcibly impressed by the treatment under this heading. Moreover, nearly all roofs are more or less subjected to the action of fire and the use of a fire resisting roof on any building will affect a saving in the matter of insurance.

A large percentage of the enormous fire losses on this continent are due to exposure, that is the fire is spread from one building to another. One of the most important factors contributing to the spread of such fires is the combustible roof. The report of the National Board of Fire Underwriters on the San Francisco conflagration emphasized strongly "the importance of fire-resisting roofs" and similar comments may be noted in reports on other conflagration. As a result, the use of fire resisting roofs in the central parts of many cities is now obligatory.

In designing a standard to afford a means of classifying roof coverings independently of the roof structure upon which they are applied and according to their fire resisting value, the National Fire Protection Association has considered the following (1) inflammability of the roof covering; (2) fire retardent properties, (a) ability to resist spread of fire on the surface, (b) protection afforded the roof structure against exposure to high temperatures; (3) Blanketing effect upon fires within buildings; (4) Flying brand hazard of the covering.

Outside of the ordinary dangers from fire some roofs possess an advantage over others in the case of lightning. "Roofs constructed of good conductors of electricity do not require any other protection against lightning as they serve to scatter the currents and thus dissipate their energies without danger of actual ignition."

4. Durability. A good roof should last without repair as long as the building it covers stands without repair. It should wear well, resisting abrasion from weather. Thoroughness in the preparation of the flashings, around openings and other parts subjected to special wear is of vital importance. The thickness of material used at these points should be such as to provide sufficient resistance.

5. Least Expense. The roof covering chosen for a certain building should be that which in the ultimate analysis gives the greatest service for the longest time at the least expenditure, including original cost and maintenance. Herein lies the necessity of careful selection. The first cost may be low and the maintenance cost high. "The annoyance and indirect expense occasioned by leaky and short lived roofs is rarely compensated for, by any possible saving in first cost. It is the duty of the builder to balance the factors of first cost and maintenance computed on the probable life and service of the structure.

Character of the Building. It is obvious that no one roofing material will be satisfactory to cover all classes of buildings. Attention must be paid to the uses for which the structure is intended and to its temporary or permanent use.

Architectural and aesthetic considerations will have considerable weight in some cases. The roofing of monumental structures and also of small dwellings have considerable effect on the appearance of the building. The construction of the roof has a marked influence on the temperature within the building. Some coverings conduct heat very rapidly and some insulating method must be used.

"The radiation from roofs is without doubt a very serious problem in the designing of any building, especially of a concrete building."

Akin to the prevention of radiation is that of insulating against condensation. In some cases it is of utmost importance that no moisture drip upon machines of various kinds, their products, or the operators. Again, if under surface of the roof be of metallic nature, the formation of moisture on it may cause its rapid deterioration.

There are certain methods of insulating roofs which necessarily add to the expenditure for the covering.

In fireproof buildings special consideration should be given to the roof. To confine internal fire the roof must act as a perfect barrier to the outbusrt of the flame, for when it is once broken through, the intensity of the fire is rapidly increased by the resulting draught and suction. In buildings as ordinarily constructed, the under surface of the roof will receive a greater concentration of heat than any other surface of the structure.

Roof Pitch and Framing

Some roofing materials may be laid on any pitch except flat ones while others are limited in use to nearly flat surfaces. It is highly important that the choice of covering be adapted to the pitch of the roof or vice versa. The lack of this adaptation is a prolific cause of leaky roofs. The selection of a certain pitch limits to a certain extent the number of possible materials that may be applied to it and any consequent effect on expenditure must be borne as a result.

Location and atmospheric conditions. The type of roof to be used is very often settled by the location of the building with reference to the source of supply and the familiarity of the artisans with the material in hand. In this case the costs of securing and applying the material are the deciding factors.

Materials which are affected by corrosive gases should not be used without protection where they would be subjected to the action of these gases. Unusual climatic conditions may subject the covering to severe tests and hence should receive careful consideration.

If the building be so located that the walls of adjacent buildings extend higher than the roof to be constructed, the possibility of falling walls or debris should be considered. The Baltimore conflagration showed the necessity of this consideration.

Materials of Composition and Their Use

There are a large number of materials that are employed in the composition of roof coverings both singly and in combinations, and there is probably no roof made out of good materials in a workmanlike manner which does not find a satisfactory field for its use.

In the following discussion under the heading of the respective materials commonly employed in coverings, their use, application and characteristics will be briefly considered.

Wood

(a) Shingles—Long service has shown wooden shingles to have many good qualities for roofing purposes. However, the growing scarcity of good material for their manufacture is making it difficult to secure those of good quality. In some localities they can still be obtained but their cost has advanced very rapidly.

The durability of shingles is sometimes increased by dipping them in linseed oil or creosote. Efforts to do this by painting after laying have been made. It is true paint somewhat protects the surface of the shingle from cracking and warping, but it encourages decay below by closing the pores of the wood and preventing quick drying after exposure to rain or snow.

The chief disadvantage of shingles is their ignitability. In this connection the report of the National Fire Protection Association comments as follows:—"Wooden shingles are the principal American conflagration breeders."

On account of the fire hazard of this roofing material their use in central parts of many cities is prohibited. In other parts the chief factors in their selection are their low cost and adaptability to small and isolated buildings.

(b) Sheathing—Of late the chief use of wood in roofs has been in the body of the covering or as a sheathing material. Being very adaptable, it is employed to suit many requirements.

Sheathing is usually made of a single thickness of planks, 1 to 3 inches thick laid close together. Matched and dressed lumber is used under all waterproofing materials except shingles and it should be covered with some impervious material under metal, slate and tiles. The method of applying depends on the roof frame work and whether the space directly under the roof is to be occupied or visible or not. When the conditions of loading and span are known the thickness required to carry the loads without excess deflection can be determined from fundamental principles or by use of a simplified formula such as is given by Ricker.

The matter of deflection should receive careful consideration because not only is excessive springing unsightly, but it generally means interfering with the stability of the waterproofing material.

The following table gives the safe load in pounds per square foot for spruce plank of various spans and thickness for limited deflections.

Load per sq. ft. superficial	Span in feet 4	5	6	7	8
30	0.9	1.2	1.4	1.7	1.9
40	1.1	1.4	1.6	1.9	2.2
50	1.2	1.5	1.8	2.1	2.4

For Yellow Pine take 9-10 of thickness given above.

The inflammability of the material prevents its use in fireproof buildings. "The burning of wooden roof boards alone has proved sufficient heat to cause the collapse of steel roof trusses."

Attempts have been made to use fireproof wood as a sheathing material. The igniting point of the wood is raised slightly by impregnating its fibre with chemical compounds of which chloride of zinc, tungstate and silicate of soda are the most common. However, by this treatment the strength of the wood is sometimes affected. It is made more difficult to work with and the increased cost as estimated by Woolson is from $35 to $65 per thousand feet. Moreover, the presence of any perceptible amount of moisture, which is very likely to occur on the sheathing, induces the chemicals to have a corrosive action on metallic materials with which the sheathing may have connection.

Slate

Slates are manufactured in various sizes, shapes and colors, and have a wide application. The best quality of slate has a hard surface, a bright lustre, and when struck with the knuckles has a clear ring. Softer slates give a dull sound when struck, absorb water and hence are liable to break in frosty weather and the nail holes wear, causing the slates to loosen. The color of the slate does not appear to indicate the quality.

The chief merit of slates is their durability. They are fireproof as far as the flying brand is concerned at least, and do not collect dust or dirt.

The various colors and sizes can be utilized to produce good architectural effects. The largest size usually means the cheaper roof, but the smaller ones give the best appearance.

The main disadvantages to slate are its tendency to crack when walked upon or subjected to excessive heat, its conductance of heat and cold, its weight and expense. The last mentioned is usually the most important of these.

Slates may be laid directly on boards, battens, or on purlins. The punching of holes for fastening should be carefully done and copper wire nails should be used, for fastening. The lap is a very important part of slating and should be selected to suit the gradient of the roof. The standard lap for suitable pitches for slate roofs is three inches.

Clay Tiles

Waterproof roofing tile is made in a great variety of shapes and colors. Those of good quality are substantial and fireproof, require no painting and are non-conductors of heat and electricity. They should be well burned and be so made that they will not absorb moisture. Semi-vitrified or glazed tiles are the most durable and impervious. Glazing consists of giving the exterior surface a coating which at the temperature required for burning is converted into a glass like mass. In addition to rendering the tile more impervious, it serves to decorate it. A combination of ornamental shapes and colors can be used to present a more pleasing appearance than can be secured with other coverings.

There are two general types of tiles, flat and interlocking, the former being laid in cement and sheathing, while the latter frequently is laid directly on purlins. Of these two kinds, those which interlock are considered to give the most satisfactory roof from a practical standpoint.

Glass tiles are made in the same shape and size as the usual ones and can be used where skylight is desired without breaking the uniformity of the roof surface.

Tile roofs are costly not only in regard to the tiles but also in regard to to the additional strength required in the supporting trusses or frame work by reason of their weight. However, tiles are becoming much cheaper and a better grade is being produced, so that an increase in their use may be anticipated.

Non-waterproof hollow burnt clay blocks or tiles are sometimes used as a base for some waterproofing material.

A kind of hollow book tile (so called because of their shape) is used. They are supported by inverted tees set as rafters, embedded in mortar between the tiles. They are heavy and expensive but give a good type of fireproof construction.

In addition to the above uses of clay tile, those of the ordinary soft clay variety are sometimes used in insulating roofs. They are hollow, two or three inches thick, and assist in giving a very good type of insulation.

Again, ordinary clay tiles are used as a protection to what is called built-up roofs. They do this to good effect, affording a high resistance to fire.

Metallic Materials

In this discussion metallic roofing will be classified and treated according to the metal which forms the base or body of the roofing sheet. It may or may not have a protective coating or some other metal or substance. (a) Iron or steel is an excellent material for using as a base in the manufacture of roofing sheets in as much as it has in itself nearly all the properties required for roofing material. It is corrodible and must be protected or its deterioration will be rapid. However, it should be borne in mind that the qualtiy of the iron or steel used in the manufacture has considerable to do with the longevity of the sheet. If durability is to be attained, the base metal should be free from those properties which accelerate corrosion.

The nature of the protective coating used gives use to four distinct types of sheets.

I. **Painted black sheets,** as the name indicates, are made up as black sheets of steel covered with a coating of paint before leaving the mill.

II. **Galvanized sheets** are made by passing thoroughly cleaned black sheets through molten zinc. The surfaces are covered with an adherent coating of zinc which excludes moisture from the iron. Since the corrodibility of zinc is low, the life of such a sheet is considerably lengthened. This process makes the sheets heavier by about one third of a pound per square foot and adds from 30 to 40 per cent to the first cost of the material.

Galvanized, painted or black sheets unpainted are made in standard sizes or gages in various forms.

The most practical form is that of corrugated iron which for most permanent use, although more expensive, should be made from muck bar iron. The corrugating is done to give the sheets longitudinal strength and incidentally improve the appearance of the sheets. The smaller corrugations are more pleasing to the eye, while the larger ones give greater stiffness to the sheet. The additional strength imparted to the sheets by the corrugations makes it possible to use this form without any underlying sheathing or support except the purlins or rafters. The following table which gives the safe and crippling loads in pounds per square foot for different gauges on different spans shows the strength of these sheets.

Gage	Safe Load Span in feet				Crippling Load Span in feet			
	3	4	5	6	3	4	5	6
26	31	23	18	16	69	52	41	24
24	37	28	22	19	84	63	51	42
22	48	36	29	24	107	80	64	54
20	59	44	36	30	134	100	80	67

Galvanizing seems to be the most satisfactory preservative for this form of metallic roofing. It should be applied to the sheets after corrugating so that the process of stamping will not injure the coating. When the corrugated iron is not galvanized it should receive two coats of iron ore paint on both sides before laying.

Plain sheets, roll roofing, V crimped and metal shingles are all forms of sheet metal which differ mainly in the form of application. The V crimped forms and plain sheets can be laid without sheathing, are easily applied, and give one of the cheapest coverings to be had. The other forms are made in a variety of styles and patterns, some of which present a very attractive appearance. All these steel forms of roofing can be obtained plain or galvanized in standard sizes. They are not so durable as iron sheets and hence require more frequent painting.

III. **Terne plate** is made by passing steel plates through a molten terne mixture. This mixture is an alloy of tin and lead in varying proportions, the most common mixture being 27% tin and 73% lead.

IV. **Tin plate** is similar to terne plate. Sheets of light iron or steel are coated with tin and passed between adjustable rollers which regulate the thickness of the coating. In both cases the finished sheets look alike but those having the thickest coating are the most durable and most expensive. The extra cost of a good plate is in the coating, and coating means protection of the plate.

Since pure or commercially pure tin is expensive and difficult to obtain, the tendency of manufacturers of tin and terne plates has been to skimp the coating of these plates. The result of having a very thin coating is that they do not give good satisfaction. The life of the sheets is not long and they require frequent painting, consequently their maintenance cost is high.

The question of the proper paint to use is a very important one since it has definitely been proven by recent investigations that some paints have an injurious action upon tin roofs, notably the graphite paints and those containing tar, pitch and similar bituminous substances.

The National Association of Sheet Metal Workers specify the use of pure metallic brown iron oxide or Venetian red as a pigment, mixed with pure linseed oil.

In general, metallic roofing materials of iron and steel have many good points in favor of their use. They are light yet strong enough as applied in most cases, and they possess sufficient resistance to fire to suit many buildings, are lightning proof and are easily applied.

Against these factors is their unpleasant connection with lack of durability. Not only must they be protected by some coating when first laid, but at frequent intervals during their life, the frequency depending on the material itself and the atmospheric conditions. That sheet metal is actively attacked by soot and smoke is shown by the tests recently conducted by the Industrial Research Department of the University of Pittsburg. The results indicate that painting must be done about twice as often as when the materials are not subjected to the action of smoke, etc.

Iron or steel is unsuitable for use in proximity to industrial plants which produce destructvie fumes or gases as the thin metal is quickly destroyed by corrosion and leaks develop.

Another disadvantage of iron and steel roofing sheets as ordinarily applied, is their transmission of heat and cold. Metal roofed buildings are harder to heat in winter, and in summer are uncomfortably warm.

When condensation is likely to occur to even a small extent, corrosion has another chance to do its work on the underside of the sheets. A fairly cheap method of insulation to prevent condensation may be applied, by placing a layer of tar paper immediately underneath the metal roofing and a layer of asbestos paper underneath the tar paper, the whole being supported by wire netting.

(b) Copper is the most durable metal that may be used for roofing. It is light and strong and weathers a fine tone. However, its high cost prevents its use on any but expensive or monumental buildings. It is laid on wooden sheathing in flat sheets and provision is made for the small amount of expansion and contraction that is necessary. Its heat conducting properties require it to be well insulated.

(c) Lead, the excellent and probably most durable roof covering used in England, is not suitable for this climate, the extremes of heat and cold causing too much expansion and contraction in the material.

(d) Zinc is used extensively as a roofing material in Europe. Its properties of strength and durability are probably more balanced than those of any other material. However, it has a high coefficient of expansion and failure to use it extensively on this continent is probably due to this and the difficulty of getting good material.

Reinforced Concrete

The use of concrete in coverings may be divided into two classes.

(a) Reinforced concrete plates (sometimes called tiles) or slabs, are moulded at a factory, delivered at the building and attached to the framing as a covering.

The tiles or plates are made in standard sizes which may be laid without sheathing. They interlock and are rendered impervious by being made dense and treated with a water proofing compound. The reinforcing of expanded metal gives them considerable strength and allows a purlin spacing of about four feet. Their cost, compared to other fireproof roofs is quite low.

Slabs are made in various thicknesses and lengths to suit the distance between rafters or purlins. As the lengths increase considerable provision must be made for expansion and contraction. This necessitates open joints which must be protected from the penetration of water. Moreover, the concrete itself must be made waterproof. Hence, the general practice is to lay some of the ordinary roofing materials over these slabs to keep out water, etc.

(b) Concrete roofs may be monolithic in construction. In this method the covering is made by spreading concrete either on reinforcing, supported by temporary wood forms or on some kind of self supporting expanded metal which requires no forms.

There is a great variety of reinforcing systems and the variety widens the type of monolithic construction, so that it is applicable to all forms of roofs from simple peaked to arched roofs and domes of elaborate composition.

When forms are used, any of the ordinary reinforcing may be employed. The thickness of slab depends upon the span. It is very desirable to have this thickness and consequently the dead weight of the slab of minimum value. For ordinary roofs a thickness of greater than 3 inches should not be used and this thickness according to Tyrrell, when properly reinforced, is strong enough for lengths up to 8 feet."

The use of combination forms and reinforcing is particularly well adapted to the construction of roof slabs. The reinforcing gives the slabs ample strength to carry the loads to which roofs are subjected and at the same time keeps down the thickness and consequently the dead weight of the roof.

These light concrete slabs not only make the amount of concrete required less but also permit the use of a lighter frame than other slabs and aid in lessening the disadvantage of weight that concrete roofs have.

In this construction the concrete does not surround and grip the metal. The only protection given to the under side of the reinforcement is a coat of plaster. This should be applied very carefully and given plenty of time to set or it may soon fall off. Intermediate supports to the reinforcement in case of long spans are necessary to bear the additional weight when the concrete has been placed, due to its being wet.

Monolithic concrete construction as compared to the other method has the objection to its use of the dripping from the wet concrete which sometimes makes it impossible to carry on other work in the building. Moreover, it is necessary to wait until the concrete has set.

Concrete roofs in general are durable, fireproof in the reinforcing is properly protected, and can be devised to give any desired amount of strength at the expense of increase in dead weight. If the great disadvantage of dead weight is not objectionable, concrete may be used for many buildings.

One objection to the use of concrete roofs on some buildings in Northern latitudes is the necessity for insulation to prevent condensation and heat radiation. Generally speaking, concrete is known as a poor conductor of heat but when compared with wood, especially in the case of thin construction such as is ordinarily employed in roof slabs of concrete, it is a relatively good conductor of heat and cold.

In winter uninsulated concrete roofs radiate heat rapidly and much more heat may be required in the building, or if warm moist air strikes it, condensation takes place on the lower surface of the slab and drops to the floor below. If this is objectionable, a means of prevention must be devised.

There are certain methods of insulating which in combination with adequate ventilation will prevent condensation and heat radiation.

There are seven types of insulation. (1) Roofing felts and quilts; (2) Cinder fill (with cement finish upon which the roofing is laid); (3) Cinder concrete fill (covered with roofing); (4) Hollow Tile (with mortar top coat upon which roofing is laid); (5) Combination hollow tile and cinder fill; (6) Double concrete roof (light concrete slab above main concrete roof); (7) Suspended ceilings.

In deciding upon the type of insulation to be used for any particular building it is necessary to study the conditions and requirements for that building. As both cost and weight are very important factors, the problem resolves itself mainly into that of finding a type of insulation which will be economical for the building considered. It would be a distinct waste to provide a type of insulation which would absolutely prevent radiation and condensation if a small amount of this was not objectionable.

Fibre and Materials Necessary for Its Use

Fibrous roofings may be divided into two classes.

(I) Built-up roofs. (II) Ready roofings.

Among these two general types there are many varieties which generally take their name from the kind of protective coating or waterproofing compound used for the fibre. While many materials are in the composition of both of the above types, the methods in which they are employed are quite different.

Built-up roofs, as the name indicates are made from various materials directly on the roof. They consist of from three to six layers of saturated felt laid on the roof, cemented together and coated with some kind of pitch and protected by slag, gravel, tile, or cinders embedded in the coating.

There are two kinds of pitch used for coating and cementing which give use to two types of built-up roofs, (1) Tar. (II) Asphalt.

Coal tar pitch from the distillation of bituminous coal is considered the best of the tars for roofing use. It contains some water, various impurities and free carbon, which after the water has been removed, is ordinarily from 5% to 35% of the total. The percentage varies with the method of manufacture and the coal used.

Free carbon is generally considered to be a valuable adjunct to roofing tars as it renders the material less affected by changes in temperature and it does not interfere with the saturating power of the felt.

Commenting on the matter of tars, the report of the A. R. and M. W. A. states—The best practice allows the use of nothing but "straight run" pitch.

Asphalts as found naturally are not suitable, even after the impurities are removed, being too hard and brittle. This is ordinarily remedied by softening or fluxing with various oils.

The fluxes should be sufficiently staple to insure against too rapid hardening of the fluxed asphalt. They should be free from deleterious constituents and should be of such character that they will combine with the asphalt to be fluxed so as to make a homogeneous and perfect solution. Poor fluxing hastens the loss of the elasticity and bending power of the compounds and with age allows them to become brittle and hard.

With skill in compounding, based on a thorough working knowledge of the materials used, asphaltic compounds can be prepared of natural asphalt and oil residuals with valuable qualities for roofing purposes.

A brief comparison of these two bituminous roofing materials might here be made.

Both can easily suffer from adulteration and poor preparation, but the asphalt seems to be more liable to this. From the chemist's view point asphalt is the safer material because it is less subject to changes when exposed to weather. However, the use of some oils for fluxing may make the asphalt more liable to internal changes. The coal tar pitch is cheaper, can be depended on for better results, and hence is more extensively used.

Felts

The felts used in built up roofs simply constitute a medium for holding the pitch material in place. Nearly all felts are made of rag stock and should have a certain amount of wool to give them saturating power. In using asphalt absorbent power is the main thing desired, while in using coal tar pitch, this quality is not so necessary. Very good results are obtained by using about five thicknesses of felt if the other materials are up to the mark. They are used in various proportions to get different results and to meet variations in the materials used.

Top Finish or Protective Coating.—A coating of some material is necessary to hold the top mopping of pitch in place, to protect it from the sun and from the action of the elements, and to give the covering some fire resisting value. Gravel, slag or crushed stone is commonly used for this purpose. It should not be too coarse or too fine or contain sand or dirt, to give the best results. Where the roof is to be subjected to wear, high fire resistance is required; and where the character of the construction warrants the expense, flat tiles or brick should be used.

As the materials used for cementing and coating will melt and run under the heat of the sun, the use of this type of covering is limited to flat or nearly flat surfaces. If used for steep slopes greater thickness of materials is required and they consequently necessitate greater expense.

Skilled workmen are necessary for the application of these roofs, and as the chances of poor workmanship are many, thorough inspection is required.

Ready Roofings

There are innumerable prepared or ready roofings which ordinarily are obtained in rolls with the cement and nails necessary to apply them. They vary from a very light felt with the cheapest possible saturant and enough sand or soapstone coating to prevent sticking in the rolls, to a sheet so heavy, that it cannot be rolled, built up of heavy felts and strengthening materials and saturated and protected also by carefully prepared compounds, and possibly protected also by a coating of crushed stone. Their durabilities and fire resisting values vary to as great a degree.

Prepared roofings may be divided into two general classes: (1) stone surfaced; (2) smooth surfaced.

The stone surfaced are to a certain extent an adaptation of the built-up roof. The protective coating must be of materials uniform in size. The amount that can be used is limited to the amount that can be rolled or that can be held on a certain pitch of roof.

The smooth surfaced roofings are usually coated with some finely divided material to prevent sticking in the roll. This must be stable and not easily effected by changes of temperature. Blown oils are frequently used for this purpose. To get the best life frequent recoating or painting is necessary.

Asbestos, magnesia, asphalt rubber, felt or some similar material, forms the basis of both these types. Many of the roofings made from these materials make excellent coverings. They can be placed quickly by unskilled labor and on almost any slope of roof.

They are of value for small and isolated buildings and for temporary structures where a roof of long life is not necessary. They are weak in that with narrow lap and a large part of the roof covered with but one layer of material a single defect can cause a leak. Another chance for trouble is their tendency to stretch and wrinkle and the difficulty of laying them absolutely tight and flat.

In making selections the reliability of the manufacturers, service tests, and cost should be the governing factors. To depend on guarantees does not give satisfactory results.

Miscellaneous Fibrous Products

(1) Sheathing paper is manufactured by impregnating straw, wood pulp or mineral fibre with hydrocarbons or some cementing compound. It is used under many of the common roofing materials to assist in keeping out moisture, heat, cold, wind, etc., and in some cases to assist in preventing radiation and condensation. Good paper should be tough, impenetrable by air or water, of uniform quality and be clean to handle.

(II) Insulating quilts are of the same general composition but are much heavier. They usually consist of two plies with some fibrous material between the plies. These quilts are laid between the sheathing and the waterproofinig materials. They are not positive insulators but afford a cheap means of fulfilling the requirements of insulation for some cases.

(III) Asbestos sheathing and protective metal are products which in properties somewhat resemble corrugated iron. They are made up of cement, asbestos and some reinforcing mesh or sheet metal. The product has considerable fire resistant value, is durable and waterproof and has in its composition materials which are generally considered necessary to give wood characteristics to a material. They are light and strong, have a high first cost, but no maintenance expense. The materials are laid in the same way as corrugated iron.

(IV) Asbestos shingles are made of asbestos and cement by means of a press. The materials used give them some of the characteristics of wooden shingles and make them durable and fireproof. They seem to have most of the qualities necessary for a roofing material and appear to render good service. They have a high first cost, but no maintenance.

(V) General Notes on Roof Coverings. (a) The following table compiled from various sources gives the latest desirable pitch for different roofing materials:

Material	Rise in 12 in.
Wooden Shingles	6 in.
Slates, ordinary	6 in.
Clay Tiles (interlocking pattern)	7 in.
Clay Tiles (ordinary)	$3\frac{1}{2}$ in.

Corrugated Iron	4½ in.
The Crimped Steel	2
Steel Roll Roofing	2
Tin and Terne Plate	1
Copper	1½
Lead and Zinc	1
Concrete	Flat
Built-up Roof—	
Tar and Gravel	½
Asphalt	½
Ready Roofing	1
Asbestos Shingles	3

(b) Weights. The following table from Tyrrell's Mill Buildings gives the total loads per square foot of roof surface for different kinds of roofing.

Roof Covering	Lbs. per sq. ft.
Corrugated iron, unboarded	8 to 10
Corrugated iron, on boards	10 to 12
Slate on laths	12 to 15
Slate on 1½ in. boards	15 to 18
Tar and gravel	10 to 12
Shingles on laths	8 to 10
Tile on plank	20 to 30
Tile laid in mortar	25 to 35
Sheet metal on boards	7 to 9
3 in. reinforced concrete	40 to 45

(c) Costs. The great variety of roofing materials and different qualities of these makes possible wide differences in the cost of a covering for a building. Moreover, the requirements of the building and the extent of the fulfilment of these have direct effects on the costs. Consequently any cost data that might be given would only be approximate and this can be obtained in cost data handbooks.

A general but brief account of the cost of coverings will be given.

Some of the various prepared roofings are the cheapest having low first cost and being cheaply laid. Other kinds in order of cost are wood shingles, tar and gravel, corrugated iron, sheet steel, metal shingles, slate, tin plate, asbestos shingles and tile.

For the base of the covering, wood is, of course, the cheapest. The other materials in order of cost are concrete, asbestos, board and tile.

C. E. B. Corbould, B.A. Sc., '14, is in the Engineering Department of the Hydrographic Survey Branch, Department of Interior, at Kamloops, B.C.

In the July issue we erred in stating that Mr. A. W. J. Stewart, '08, was general manager of the Toronto Hydro-Electric System. Mr. Stewart holds the position of assistant engineer of the Hydro-Electric system.

"A DESIGN OF A POWER PLANT"

F. Alport, B.A.Sc., '06

Part I—Preliminary Considerations

In the development of a water power, the engineer must do more than merely design and construct the power plant. The stability of the dam, size and strength of penstock or flume, choice of turbines and generators, and the design of the power house in which the turbines and generators are placed, are really a secondary consideration. The adequacy of the supply of water, head and power available at different seasons, conditions affecting these, and the advisability of the investment, occupy the premier position. A knowledge of these most important factors is more essential than a knowledge of design and construction, for a competent designer may be hired any day for $100 or $150 per month. Therefore, to ensure success, a study of the entire project becomes necessary.

Unfortunately, at the present time, the engineer is very greatly handicapped when called upon to consider the development of a water power in Canada. Not enough data is known on which to base calculations, so in every case many assumptions and deductions must be made. For instance the water available for power depends upon the amount that runs off of the watershed, the run-off depends on the precipitation, so a knowledge of the annual precipitation over a term of years should be known. At the present time this is unknown in the majority of cases and must be estimated. However, the Hydro Electric Power Commission for Ontario, and the Commission of Conservation for the remainder of Canada, have started to collect data relative to the rainfall, and to meter the rivers, establishing the relation between precipitation and flow on each watershed, so that, in the future, we will have to do much less estimating.

When called on to look into the possibilities for power development, the first step is to examine the various falls on the river, in order to decide, where there is any choice in the matter, which will give the required power most economically. This, in the majority of cases, can be decided by merely seeing the various falls. If there is sufficient water in the river for the required amount of power, at any two or more possible selections, the one that can be developed with the least expensive head works and shortest flume, will naturally be the choice. Proximity to the market is also an important factor, but is not likely to be the predominating one, for power can be transmitted very efficiently, and in many cases it is possible to bring the market to the power.

If it is not possible to decide the point of development by looking over the possibilities, a rough survey can be made by means of the hand level. The heads can be determined with this and the flow can also be found out by using a rod float. This will give sufficient data to definitely decide which fall is the better for the purpose required.

The point of development having been decided on, an accurate topographical survey must be made. The topography is taken and plotted in two foot contours and accurate notes made of the kind of material, whether rock, clay, sand, etc. If necessary, borings must be made to ascertain the depth of the strata overlying the rock. This can be very easily done by means of an ordinary auger welded to a length of inch or inch and a half iron pipe. Soundings must be made on regular cross sections of the river so that the contours can be plotted over the river bed. The elevation of the water at the top and bottom of the fall must be very carefully obtained, as well as the elevation of the high and low water. Frequently the inhabitants of the vicinity can give much valuable information as to the high and low water elevations and, although this information is not altogether dependable, it is often the best that is available.

The stream must also be carefully metered. If possible, it should be metered at high and low water, but this generally cannot be done, on account of the time that would elapse between meterings, so the engineer must estimate the high and low water flow. This is generally done by plotting a cross section of the river, finding the areas of the water at high and low water elevations and assuming that the velocity is constant for all seasons. It is advisable to add ten per cent. to the high water and deduct it from the low water flow, to give a good margin of safety.

The extent of the watershed and its physical characteristics, must be known. If no other information is available, it is necessary for the engineer to travel through it and make a rough survey of it. This will never be necessary in Ontario for maps of the whole Province can be had that give sufficient information. From them the area of land and lakes in each watershed may be computed. The physical characteristics of the watershed, such as soil, forest land, cleared land, cultivated land and prairie land, affect the annual run off and a knowledge of the extent of each is necessary. This information would not be necessary if the gauging of the stream and the annual precipitation were known over a term of years, but in nearly every case no such information can be had, so the engineer must resort to estimating.

The description of the river follows naturally that of the watershed and also must be known. The velocity of water is affected by the condition of the banks, the straightness, depth, character of the river bed, fall and number of rapids. This information is interesting but really does not affect the proposition enough to make it an important factor.

The discharge of the river, along with the head obtainable, really are the predominating factors in considering plans for the development of any water power. The head is obtained by the survey, but not the discharge. It varies in most rivers from year to year and even from day to day. If each river had a constant discharge things would be very easy for the engineer indeed. Unfortunately, they have not, and it is here that the blame for most of the failures can be laid.

If daily gaugings of the stream are known over a term of years, they form the very best kind of information on the discharge. From them hydrographs may be plotted. Horizontally the twelve months may be shown and vertically may be shown the discharge in cubic feet per second per square mile of drainage area. By changing the scale, we may also get the discharge in cubic feet per second and the horse power. If a hydrograph like this is available for one part of a river, it may be applied to other parts of the same river by changing the vertical scale. If the area of watershed above the point where the hydrograph is known is "x" square miles, and a hydrograph is required at a point above which the drainage area is "y" square miles, the scale is simply multiplied by $\frac{\text{"y"}}{\text{x}}$. These comparisons, however, hold good only if the conditions are similar at the various points compared.

If hydrographs are available, the engineer need not consider the relation of rainfall to run off, speculate on the effects of the physical characteristics of the watershed, evaporation, temperature and other factors, or compare the relative flow with that of other streams.

Unfortunately, data from which hydrographs may be plotted, is almost never available, or if available, does not cover a long enough term of years to be of any great value. Therefore, it is necessary to resort to estimating.

It is often possible to completely change the aspect of the proposition by regulating the discharge of the stream. The discharge varies with the character of the country through which the river flows. In the case of a river flowing through forest country the hydrograph is much flatter than in prairie or farm land. The forest gives up the water that falls on it, very much more slowly than the prairie land. In the case of prairie land a considerable amount of rainfall runs directly into the waterways, while in bush country, the water percolates through the soil and finds its way into the rivers as sub-surface run-off. It naturally takes the water a much longer time to percolate through the top soil and run through the sub-soil to the rivers, than it does to run directly off the surface of the ground. These facts account for the very high water in the prairie rivers in the spring which usually occurs in May. It also gives the reason why the maximum high water in the bush rivers does not occur until July. There is usually another period of high water about the end of August, due to the rains in July and August. The maximum low water season is in February.

The following table gives the percolation in percentages of the rainfall:

	Percentage of percolation
Ordinary ground, bare	29%
Wheat land	25%
Ordinary soil with sod	33%
Mixed forest	74%
Spruce forest	91%

The temperature, of course, has a great deal to do with the run

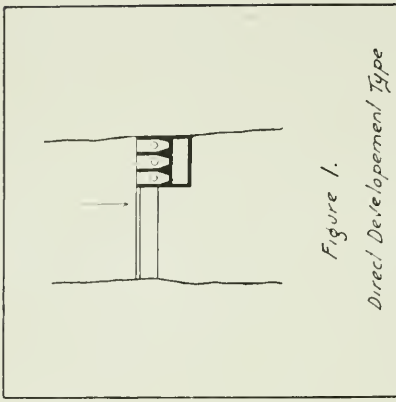


Figure 1.
Direct Developement Type

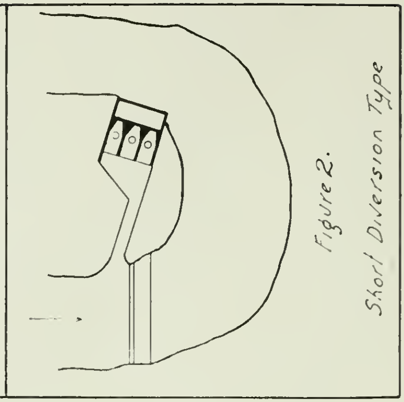


Figure 2.
Short Diversion Type

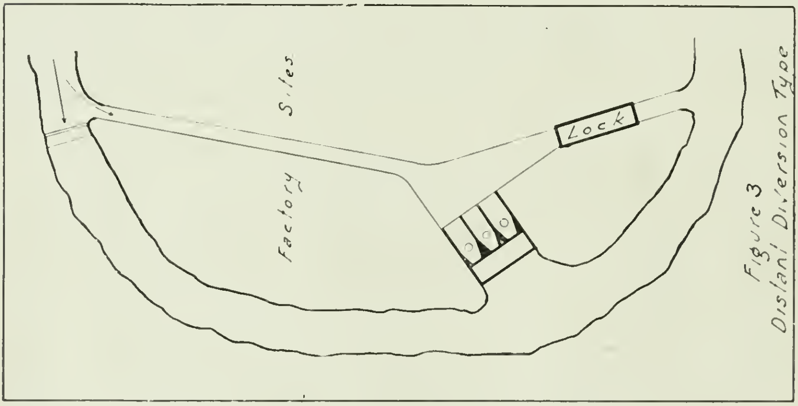


Figure 3
Distant Diversion Type

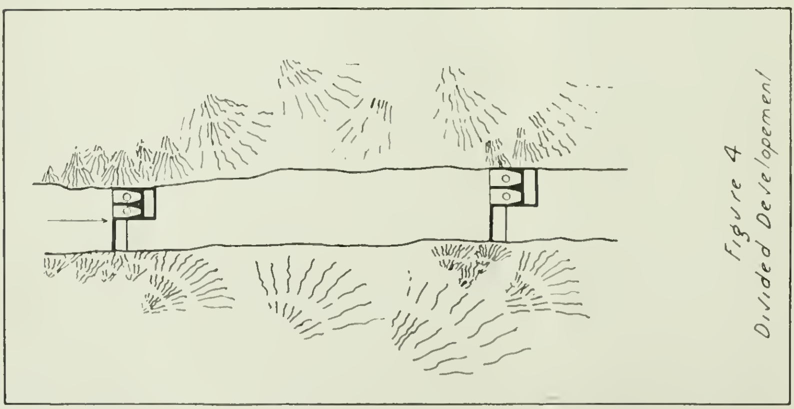


Figure 4
Divided Developement

off. In the coldest weather, most of the precipitation is frozen and retained until the warm weather comes in the spring. Thus, we have in the spring the flood time, due in part to the precipitation being retained and also to the ground being frozen, allowing the water to run directly into the rivers.

Therefore, it can be seen that a study of the physical characteristics of the watershed gives some interesting information about the steadiness of the flow, and in many cases, reforestration has been resorted to, in order to increase the steadiness. The Ontario Government, at the present time, in the laws relating to lumbering, limit the size of the tree that may be cut. This is to prevent total deforestration and preserve the rivers.

The storing facilities of the river should be looked into with a view to regulating the high and low water. Most rivers have quite large lakes at their head waters in which the high water can often be stored by putting in a small dam at the outlet. By this means the minimum flow can be increased and consequently the power. It is nearly always impossible to get the company who are developing the power to see the economy of putting in a storage system, so it is very seldom done. At the same time, in his report the engineer should mention the possibilities and cost of a storage system.

Ice is the worst enemy of the engineer in our climate, and to get rid of it, much money is spent. The top covering of ice on a river is not detrimental to power development at all. On the contrary, it is a very great help. It is the frazil and anchor ice that does all the harm. The anchor ice forms at the bottom of the river through radiation. Through a rise in temperature or other causes it is loosened from the bottom and on account of the velocity of the stream, does not get any chance to rise to the surface. The frazil ice is formed wherever there is sufficient velocity to leave open water. It forms as long needle-like crystals generally about a straw or twig is taken to the bottom of the river by eddies, and adheres to the anchor ice or is carried down by the current to still water, where it rises and adheres to the under side of the surface ice.

If great care is not taken with the head works, the frazil and anchor ice will get into the flumes and turbines in large quantities. It will cut the vanes of the turbine to pieces in a very short time.

If, in the head race, a small velocity can be obtained the very best protection against ice will be secured. On account of the small velocity the whole surface of the river will be coated with a thick covering of ice, effectually sealing it from the cold atmosphere, and the frazil and anchor formation will be reduced to a minimum. In the quiet water, the frazil ice will slowly rise and adhere to the underside of the ice sheet and thus become harmless.

If comparatively quiet water cannot be secured on the head race, mechanical means must be employed to get rid of the frazil ice. In some cases a boiler is installed and steam pipes are run to the screens to melt the ice that reaches them. Other methods of getting rid of it, in common use, are series of submerged arches, and screens. The Ontario Power Company at Niagara has very extensive head works of this nature. The water there passes into the outer forebay under submerged arches with a surface flow along the wall. From the outer forebay it passes under other submerged arches to the screens. There is surface flow along these screens to carry anything that might rise to the surface, away from them. From the screens it passes to the inner forebay and under other submerged arches to the flume. The Niagara River is, of course, unique, in that it is absolutely impossible to secure even comparatively still water near the head races.

Having gathered all the information possible the plan of development must next be considered. This is not a very difficult thing to decide as the topography of the country plainly places the development in its proper place.

The direct development (see Fig. 1) is, of course, the most efficient. In this plan the power house is placed at, or in, the dam. The head race and tail race are both very short, and consequently the losses due to friction in the races are at a minimum. Also, the plant can be operated more cheaply because it is so concentrated.

The factors which determine this choice are the relative cost of this and any other scheme, the flood flow conditions as effecting the stability of the power house, the rise in the tail race and the fluctuation in the working head. Floating timber and ice also affect the choice, as they are very dangerous to the power house, which must be protected.

The short diversion (see Fig. 2) plan is used where the dam location of the power house is not feasible, either on account of contraction of the river channel or the dam not being high enough to accommodate the machinery. By this plan the water either is carried to the power house by means of a short diversion for a head race, or is carried away from the power house by a short diverted tail race. By diversion is not necessarily meant canal. Diversion is only used to express the general idea. The water might be carried to the machinery either by a canal flume or tunnel or a combination, and away from it in the same way.

The distant diversion (see Fig. 3) program is applicable only when the concentration of the fall at one point, is impossible either on account of physical characteristics or cost. The dam is located at the best possible point and the water conducted to the power house by a flume or canal. This plan differs very little from the short diversion type but frequently offers problems not encountered in it. The plant of the Lake Superior Power Company is a well known example of this type and the canal passes through the town of Sault Ste. Marie. There are mill sites and water shipping facilities along the banks of the canal. These had to be provided for in the development scheme, as were special screens in front of the penstocks.

It sometimes happens that neither of the preceding plans are feasible. The rapids to be developed may be a mile or more long and topographical or right of way limitations prohibit them. In a case of this kind the divided (see Fig. 4) development is sometimes possible. This simply means two or more dams and power houses instead of having only the one. This plan can only be carried out when the market conditions are the best and will warrant the double operating expenses as well as the increased first cost.

It is easily obvious that each particular location is a problem in itself. The general plans, however, form a basis from which each particular plan may be selected with of course modifications to suit particular topographical or other controlling conditions.

The scope of the development must be carefully considered before the actual design is proceeded with. The total power that can be obtained at a fall or rapids may not be required for the present markets. In some cases, it may not be required for many years and to fully develop the power obtainable means tying up capital without any earning capacity.

Two courses could be followed—either to develop part of the fall or part of the flow. The government regulations now require that any company or municipality developing a portion of the power available at a fall, must have their plant so designed that any other company can develop the remaining power. This prevents any company from blanketing a fall and so designing their plant that no one else can utilize the remaining power. In view of this it is impossible to develop part of the fall. So the full fall must be used but only part of the water need be. In general, however, it is always advisable to develop the total power available, for the market can be created and the greater the output the more economical will be the unit development and operating cost.

In a few cases, the market exceeds the low water capacity before development. Then an auxiliary steam plant may be installed and the estimates for the cost of this must be provided for in the development estimate.

(*To be Continued.*)

M. E. Crouch, B.A. Sc., '11, formerly with H. J. Beatty, Pembroke, Ont., is at present engaged on re-survey work for the city of Port Arthur, Ont.

E. L. Bedard, B.A., Sc., '14, is making a survey of Stag Island, situated in the St. Clair River, six miles below Port Huron.

D. L. H. Forbes, '02, who for several years has conducted a private business as mining and metallurgical engineer, Manning Chambers, Toronto, has been appointed chief construction engineer for the Chile Exploration Co. His address is Chuquicamata (via Antofagasta), Chile, South America.

H. G. MacMurchy, B.A.Sc.,'10, is with the Dominion Power and Transmission Co., Hamilton, Ont., and not with the Toronto Power Co., as stated in the Directory last month.

H. J. MacTavish, B.A.Sc., '10, is with the street lighting department of the Toronto Hydro-Electric system. The information in the directory last month was incorrect.

C. A. Meadows, B.A.Sc., '11, has recently returned from Europe, where he has spent three months on an investigation of improved machinery for wire and ornamental iron work.

THE POWER MAN

Beyond the "utmost purple rim"
You're certain to discover him,
All khaki-clad and lean and brown
And eager for the news of town,
But having chiefly on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

You run across the "power man"
In Arkansaw or Martaban,
Or clad in true explorer's style
And seeking sources of the Nile;
His stubborn aim, his constant dream
Is hitching up some roaring stream
And getting from its rush and roar
Ten thousand horsepower—maybe more,
Where nary horsepower was before!

He's lacking somewhat in romance
A waterfall he views askance
No matter how or where it's placed
He says—"There's power gone to waste
One hundred thousand h.p. loose
Which should be put to some good use.
Not lost in spray and roar."
A torrent tumbling o'er the brim
Is wasted energy to him,
And it is nothing more.

He breaks the trail through palm and pine
For power house and railroad line,
And on his footsteps cities press
And sweep away the wilderness,
But he goes on and on and on
Toward the sunset or the dawn
With mind and heart and soul intent
On harnessing a continent,
By turning every stream he can
To power for the use of man.
One single thought is on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

By Berton Brayley, in "Power."

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science,

Engineering Bldg., University of Toronto,

Toronto, Ont.

EDITORIAL

We are proud to know that the "School" is well represented in the contingent which is soon to leave for Europe to engage in battle for our country's cause. No doubt a great many have gone, of whom we have not been advised. We are desirous of keeping a complete list of our men who enlist for the war and hope that our readers will notify us of any others who enlist, whose names do not appear in the personal items. The 2nd Field Company of Canadian Engineers, in which there is a University Corps is under the command of Captain T. C. Irving and Lieut. H. F. H. Hertzberg. A number of our men are with this company, while others have Commissions in the 48th Highlanders and the Queen's Own Rifles. We understand that a movement is in progress to establish University Corps with the Highlanders and Queen's Own regiments.

THE GLASGOW CORPORATION TRAMWAYS

The annual report of the Glasgow Corporation Tramways for the financial year ending May 31st, 1914, has recently come to hand, and its perusal proves quite as interesting as that of its predecessors. The estimated population served is 1,150,000, which is 2.3 times that of Toronto. Glasgow operates 194 miles of single track against 120 miles operated by the Toronto Railway Company within the limits of the City of Toronto, as of 1891. The gross capital expenditure to date on permanent way, buildings, ground and equipment is £3,675,317, equivalent to $15.50 per capita of the population served. According to the Arnold-Moyes report of a year ago, the net cost to produce new, the physical assets of The Toronto Railway Company was $13,532,992 or $27.00 per person. And had the city at that time purchased the physical and intangible assets of this corporation at the price proposed, viz., $20,608,000, the cost per capita would have been $41.

The Glasgow corporation operates 852 cars of the two-story type against 865 of all classes employed by the Toronto Railway Company. The gross traffic receipts from 336,654,000 fares were £1,078,691, giving an average fare of 1.54 cents. The fares in Glasgow, it will be recalled, vary with the distance, the smallest being 1 cent (½d.), and the largest 14 cents (7d.). The average distance the passenger may travel for 1 cent is 1 1-6 miles. Sixty-three per cent. of all fares were of this class.

The ratio of operating expenses to total receipts is 58.87% against 55%, the reported ratio for the Toronto Railway Company for the year 1912. After paying interest on investment, income tax and parliamentary expenses and providing for sinking fund and depreciation, a net balance of 4.69% of total receipts (£53,892), remains which is returned to the city under the benificent designation of "The Common Good." This amount has grown progressively from £8,260 in 1895 and aggregates for the twenty years, something in excess of $2,800,000.

Motormen and conductors are paid from 25 to 35 shillings per week.

While the average per capita expenditure for car fare in the City of Toronto is said to be about $12.00 per annum, in Glasgow it is $4.60. In other words each resident of Scotland's metropolis takes 293 car rides per year. In Toronto the number is probably slightly in excess of this. In rush hours at certain points of heavy traffic, as many as 480 cars are passed per hour. Crowding is practically unknown.

P. G.

WANTED

A man who has passed his preliminary D. L. S. examination, for eight months on D. L. S. work (day work), in Manitoba, to begin immediately.

Address communications to The Employment Bureau, Engineering Society, University of Toronto.

DODDS—RUTHERFORD

On May 6th Mr. W. A. Dodds, B.A.Sc., '09, chemical engineer for the Penman Littlehales Chemical Co., of Syracuse, N.Y., was united in marriage to Miss Laura Isabel Rutherford of Bolton, Ont., at the home of the bride's parents. Mr. and Mrs. Dodds will reside in Syracuse, N.Y.

QUAIL—CHENEY

At Port Arthur, Ont., on Monday, August 3rd, Mr. J. Quail, '09, of the engineering staff of the Manitoba Bridge and Iron Works, was married to Miss Frances Grace Cheney, second daughter of Mr. A. N. Cheney, Vanleek Hill, Ont.

GALBRAITH—HANEY

On Tuesday, July 28th, Mr. John S. Galbraith, B.A.Sc., '13, was united in marriage to Miss Aileen Haney of Port Credit, Ont. On account of the recent death of the late Dean Galbraith, the ceremony took place very quietly at the home of the bride. Mr. and Mrs. Galbraith are spending the summer with the former's mother at Go-Home, Muskoka, Ont.

GIBSON—MARSH

On Wednesday, August 26th, at the home of the bride's parents, Mr. Morton Milne Gibson, B.A.Sc., '10, of Gibson & Gibson, Ontario Land Surveyors, Toronto, was married to Miss Miriam Irene Marsh, "Elms Lea," Richmond Hill, Ont.

A large number of "School" men, we understand, have enlisted for service in the pan-European war. Among them are the following: Peter Campbell, '15; F. S. Rutherford, '14; John Kay, '14; E. S. Fowlds, '13; G. G. Blackstock, '15; B. H. Hughes, '16; F. H. Marani, '16; H. A. M. Grasset, '16; G. E. D. Greene, '09; N. Lawless, '11; G. A. Bell, '13; H. F. H. Hertzberg, '07; T. C. Irving, '06; W. M. Philp, '09-'14, W. B. Redman, '15; C. H. Mitchell and R. Y. Cory, '08.

W. W. Chadwick, B.A.Sc., '11, formerly with the Chadwick Brass Co., has now a manufacturing business at 18 Park St. S., Hamilton, Ont., where he is engaged in the manufacture of electric fixtures, fire place goods, stampings, turnings, spinnings and brass goods and metal work of every description.

J. B. Nicholson, B.A.Sc., '14, has been appointed engineer for the Township of Barton, Ontario.

R. B. Chandler, B.A.Sc., '11, formerly assistant city engineer for Saskatoon, Sask., is now resident engineer with Janse Bros., Boomer, Hughes & Crain, No. 1 Mackie Block, Calgary, Alberta, on the construction of the Government Elevator at Calgary.

IT CAN BE DONE

Somebody said that it couldn't be done,
  But he, with a chuckle, replied
That "maybe it couldn't," but he would be one
  Who wouldn't say so till he'd tried.
So he buckled right in, with the trace of a grin
  On his face. If he worried, he hid it.
He started to sing as he tackled the thing
  That couldn't be done, and he did it.

Somebody scoffed: "Oh, you'll never do that;
  At least, no one ever has done it."
But he took off his coat and he took off his hat,
  And the first thing we knew he'd begun it;
With the lift of his chin, and a bit of a grin,
  Without any doubting or quiddit;
He started to sing as he tackled the thing
  That couldn't be done, and he did it.

There are thousands to tell you it cannot be done,
  There are thousands to prophesy failure;
There are thousands to point out to you, one by one,
  The dangers that wait to assail you;
But just buckle in with a bit of a grin,
  Then take off your coat and go to it;
Just start in to sing as you tackle the thing
  That "cannot be done," and you'll do it.—Chain Belt.

C. G. Titus, B.A.Sc., '10, for three years engineer and assistant manager of the Temiskaming Mines, Cobalt, Ont., has been appointed superintendent of the Renfrew Molybdenum Mines.

W. Snaith, '07, secretary-treasurer of the Thor Iron Works, Toronto, has returned from a five months' absence in California, where he was superintending for his company the construction of a number of large oil tanks at Oldfields, Cal.

W. H. Rolls, who has for several years been sales clerk in the Engineering Society Supply Department, has left with the Mississauga Horse for the training camp at Val Cartier, Quebec, where they will continue training until they receive orders to sail for Europe to take their place in the line of battle.

M (*Continued*)

Munson, A. H., is at Walkerville as bridge inspector for the Canadian Pacific Railway.

Murdie, W. C., is with the Topographical Surveys Branch, Department of Interior, Ottawa. He is at present in North Western Ontario.

Murdock, C. R., '06. We do not know his address.

Murphy, C. J., '06, is chief engineer for the Crow's Nest Pass Coal Co., at Fernie, B.C.

Murphy, M. H., '11, has a general contracting business in Toronto.

Murray, E. W., '07, is on the engineering staff of the Department of Public Works at Regina, Sask.

Murray, J. D., '07, address not known.

Murray, W. P., '08, is with the Dominion Bridge Co., of Lachine Locks, P.Q. During the summer he has been in charge of construction work at Lytton, B.C.

Murton, J. C., '11, is superintendent for the National Paving Co. at Regina, Sask.

Mutch, D. A. S., '13, was with the Dome Mines, Porcupine, when last eard from.

N

Nash, J. C., '01, is second assistant engineer, Hamilton Hydro Electric Dept., Hamilton, Ont.

Nash, T. S., '02, is with the Topographical Surveys branch of the Department of Interior, Ottawa.

Nasmith, M. E., '08, is chemist for the Commercial Engineering Co. at Turtle Creek, N.B.

Near, W. P., '06, is city engineer for St. Catharines, Ont.

Neelands, E. V., '00, is manager of the Cobalt Comet Mine, Cobalt, Ont.

Neelands, E. W., '07, is a member of the firm Sutcliffe & Neelands, consulting engineers, surveyors, and contractors, New Liskeard, Ont.

Neelands, R. E. K., '07, address not known.

Neelands, R., '06, is on the engineering staff of the bridge department at the City Hall, Toronto.

Neilly, B., '07, is manager of the Penn-Canadian Mines, Limited, Cobalt, Ont.

Neville, E. A., '09, is a member of the firm Neville & Stewart, civil engineers, Vancouver, B.C.

Nevitt, I. H., '03, is assistant engineer for the sewage disposal plant with the main drainage department of public works, City Hall, Toronto.

New, R. H., has for his address 866 Main St. E., Hamilton, Ont.

Newhall, V. A., '10, is with the Canadian Inspection and Testing Laboratories, Ltd., Edmonton, Alta.

Newman, W., '91, has a practice as engineer and contractor, at 410 Ashdown Block, Winnipeg, Man.

Newton, J., '09, is in West Toronto at present.

Newton, W. E., '10, is with the Slocan Star Mines, Sandon, B.C.

Nichol, F. T., '10, is western representative for Clarence W. Noble, contracting structural engineer, with his headquarters at 905 Electric Railway Chambers, Winnipeg.

Nicholson, C. J., '94, is assistant engineer for the Hamilton, Guelph & Waterloo Railway, at Hamilton, Ont.

Nicklin, W. G., '05, was assistant superintendent of the Dalm & Kiefer Tanning Co., Grand Rapids, Mich., when last heard from.

Nickel, E. H., '11, is in the office of the Northern Electric & Manufacturing Co. at Winnipeg. His address is 663 William Ave., Winnipeg.

W. Noble, contracting structural engineer, with his headquarters at 905 Electric Railway Chambers, Winnipeg.

Nixon, C. K., '11, His address is 18 Washington Ave., Detroit, Mich.

Noble, E. S., '11, is with the Northern Ontario Power Co., at Cobalt, Ont.

Northey, R. K., '11. His home address is 42 Forest Hill Rd., Toronto.

Nourse, A. E., '07. We do not know his address.

O

O'Brien, E. D., '05. Address not known.

Odell, L. S., '09, is in Toronto at present.

O'Donnell, V. J., '09, was with the Canadian Westinghouse, Hamilton, when last heard from. His home is at Merrickville, Ont.

O'Flynn, W. A., '11, is with the Copper Queen Smelter, at Douglas, Arizona.

O'Grady, W. deC., '08, was engineer for the Gas Traction Co., Limited, Winnipeg, Man., when last heard from.

O'Hearn, J. J., '09, is manager of the Supply department for the Canadian General Electric Co. at their Fort William office.

Oke, W. V., '11. His address is 265 Delaware Ave., Toronto.

Oliver, E. W., '03, is assistant to the chief engineer of the Canadian Northern Ry. system, Toronto, Ont.

Oliver, J. P., '03, is superintendent of construction for the American Sugar Refining Co., Arabia, La.

O'Neil, C. M., '10, has as his home address Erindale-on-Credit, Ont.

Orr, J. A., '11. His home address is Clarkson's, Ont.

O'Sullivan, J. J., '07, is superintendent and auditor for the Canada Railway News Co.

P

Pace, J. D., '03, address not known.

Pace, G., '04, is general superintendent and engineer for the Simcoe Ry. & Power Co., Midland, Ont.

Pae, A. W., '09, is a member of the real estate firm, Davidson & Pae, Calgary, Alta.

Palmer, C. E., '10, is exchange manager for the Bell Telephone Co. at Toronto.

Pardoe, W. S., '04, is assistant professor in the department of civil engineering at the University of Pennsylvania, Philadelphia, Pa.

Paris, J., '04, has for some time been engaged as steel inspector with the T. N. O. Ry in Northern Ontario. At present his address is White Lake, Ont.

Park, D. G., '06, his address is 3031 National Ave., West Allis, Wis., U.S.A.

Parke, J., '04, address not known.

Parker, G. C., '10, is associate editor of the *Motor Magazine*, Toronto. His address is 29 Dorval Rd.

Parker, J. S., '11. His address is Burk's Falls, Ont.

Parkin, J. H., '11, is demonstrator in mechanical engineering at University of Toronto.

Parkinson, N. F., '13, is on the staff of the Ontario Board of Health at their experimental station on Clifford St., Toronto.

Parsons, J. L. R., '01, has a practice as engineer and surveyor at Regina, Sask.

Paterson, G. W., '06, address not known.

Paton, T. K., '07, address not known.

Patten, B. B., '03 and '05, is a member of the firm Rutherford & Patten, engineers and surveyors, St. Catharines, Ont.

Patton, J. McD., '11. His address is 2025 Smith St., Regina, Sask.

Patterson, J., '99, is physicist at the Dominion Observatory, Toronto, Ont.

Paulin, F. W., '07, address not known.

Peaker, W. J., '04, is with the topographical surveys branch of the Department of the Interior, Ottawa, Ont. His address is 545 MacLeod St., Ottawa.

Pearce, K. K., '10, address not known.

Pearson, A. W., '11, has Weston as his address.

Peart, J. W., '13, is in the city water commissioner's office, London, Ont.

Peckover, H. J., '08, is on the designing staff at the City Hall, Toronto, Ont. His address is 205 Dunn Ave.

Pedder, J. R., '90 (deceased).

Pepler, S. J., '11, address not known.

Pequenat, M., '08, is assistant city engineer of Berlin, Ont.

Perrin, W. J., '11. We do not know his address.

Perron, J. E., '13. address not known.

Petry, A. M., '09, is assistant manager for Chas. Potter Optical Company, 85 Yonge St., Toronto.

Pettingill, R. E., '06, is chemist in charge of plant number 8 of the Canada Cement Co., Limited, at Port Colborne, Ont.

Philip, D. H., '03, is engaged on the Georgian Bay Canal survey work at Ottawa.

Phillips, E. H., '00, is a member of the firm of Phillips, Stewart & Lee, surveyors and consulting engineers, Saskatoon, Sask.

Phillips, H. G., '08, is associated with the firm Phillips, Stewart & Lee, surveyors and consulting engineers, Saskatoon, Sask.

Phillips, C. H., '10, has 85 Manchester Place, Buffalo, as his address.

Phillips, E. P. A., '05, is a member of the firm Phillips & Benner, Ontario Land Surveyors, Ruttan Block, Port Arthur.

Phillips, J. J., '13, has been with Morrow & Beatty, of Peterboro, on the construction of paper mills at Iroquois Falls, Ont.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, SEPT., 1914 New Series Vol. IX. No. 5

"A DESIGN OF A POWER PLANT"

F. Alport, B.A.Sc., '06

(Concluded from last issue)

PART II

The design of the actual plant must next be considered and the dam comes first. For power purposes, it is the structure closing the river valley so that the water may be accumulated, the fall concentrated and the flow diverted in the desired direction. It may or may not have water passing over it or through it. Generally it is provided with bays in which are stop logs that may be removed to let the flood water run away without flooding the lands above the dam by raising the water too high.

The general principles of the construction of dams are:—

1. They must have suitable foundations that prevent the passage of water under them, and are able to sustain the pressures on them due to the pressure of the water and weight of the superstructure.
2. They must be stable against sliding.
3. They must be safe against overturning.
4. They must be strong enough to withstand the shock due to ice, floating timber, etc.
5. They must be practically watertight.
6. They must have water tight connections with the river banks.
7. They must be so designed as to prevent scouring below them.

They are in general of two types—*Gravity* dams or those that depend on their weight to resist sliding and overturning, and *Reinforced concrete* or *steel* dams, that depend on their sterngth to resist stress, and their anchorage for their stability.

The Gravity dam was used at a very remote period in history for the construction of reservoirs. Ancient ruins in India and Ceylon are all that are left of the labors of the prehistoric engineers. They used walls of earth across the valleys to form their reservoirs and do not appear to have had any knowledge of the science connected with the work.

In the sixteenth century masonry dams were first used in Spain, and their great massiveness cannot but excite our admiration, yet they are decidedly faulty in design.

It was not until 1850 that the French engineers first advanced a theory on the design of the masonry dams. This theory has been somewhat modified from time to time, engineers of all nations contributing something toward our present idea of the theory involved.

Besides masonry and earth, there are dams constructed of the following materials:—Concrete, reinforced concrete, rock fill, timber, steel and also a type of movable dam constructed of steel or wood. The dams that are in general use, are those constructed of masonry, concrete and timber. Reinforced concrete is but little used at present but is becoming more popular and will in time be used to a very great extent. Only the theory of the gravity dam will be treated here.

At present, all the laws which the internal stresses in dams follow, are not known, so that assumptions are made that give approximate results. The assumptions are that all the walls of the dam are rigid and that it will resist the thrust of the water by its own weight.

There are four ways in which the dam may fail:

1. By overturning.
2. By crushing.
3. By sliding or shearing.
4. By rupture from tension in the toe or heel.

To insure safety against these, the dam must be designed to comply with the following conditions.

1. The resultant of all forces acting on the dam must lie within the middle third of the base. This precludes any possibility of tension in the base and gives a safety factor of at least two against overturning.

2. The maximum pressures in the material used, or in the foundations must never exceed certain fixed limits. These limits vary, of course, with the material of which the dam is constructed, and are found experimentally.

3. The dam must be sufficiently thick in all parts to resist the shock of the wave action and floating logs, etc.

It is impossible to obtain a formula for the thickness of a dam that will satisfy at once the above four conditions. But by designing a dam to suit the first two, the others will be fulfilled.

Evidently, at the surface of the water, the pressure of the water on the dam will be zero. The pressure "p" of the water at "h" feet below the surface = $62.5h$ or $(p - 62.5h) = 0$ which is a straight line formula. Therefore if it is assumed that the front face of the wall be vertical, the back wall will be a straight line starting at the face at the top of the dam where the pressure is zero, and gradually diverging from it as "h" increases. The dam would, therefore, have a cross section shaped like a right angled triangle with the vertical face upstream. This form of dam has the minimum area that fulfils the conditions that the resultant of all forces must be within the middle third.

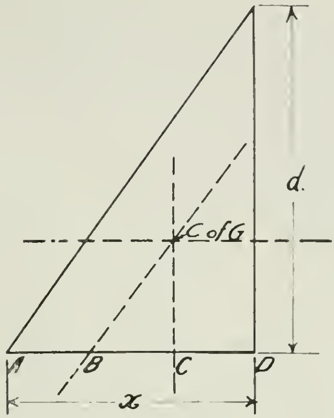


Fig. 1

Consider the ideal section. (See Fig. I.)

Let x = length of base.

d = depth of water.

w = weight of 1 cu. ft. of material of which the dam is constructed.

The maximum and minimum conditions that will occur are when the reservoir above the dam is full and when it is empty.

When it is empty the only stress acting on it is its own weight, which acts at the centre of gravity and tends to crush.

Now the centre of gravity of a triangle is $^1/_3$ of the height from the base or $^1/_3$ of "x" from "d." A dam of triangular cross section will fulfil the conditions when it is empty.

When the reservoir is full, to satisfy the condition that the resultant must be within the middle third it must lie between the points "B" and "C" on the base. Then, to find the value of "x" take moments about the point "B."

The forces acting on the dam are,—The pressure of the water on the upstream face of the dam, tending to overturn it, and its own weight, keeping it in position.

Its weight in a section 1 foot long = $\dfrac{w\,x\,d}{2}$

The moment of this about B = $\dfrac{w\,x\,d}{2} \times \dfrac{x}{3} = \dfrac{w\,x^2\,d}{6}$

The pressure at the top of the dam due to the water = 0

The pressure at the bottom of the dam due to the water = $62.5d$

The average pressure = $\dfrac{62.5d}{2}$

Then the total pressure $= \dfrac{62.5d^2}{2}$

The moment of this about $B = \dfrac{-62.5d^2}{2} \times \dfrac{d}{3} = \dfrac{-62.5d^3}{6}$

But for the equilibrium the sum of the moments = 0

$$\therefore \frac{w\,x^2\,d}{6} - \frac{62.5d^3}{6} = 0$$

$$\therefore w\,x^2 = 62.5d^2$$

$$\text{or } x = \sqrt{\frac{62.5d^2}{w}}$$

The specific gravity of the material of which the dam is constructed $= \dfrac{w}{62.5} = r$

$$\therefore \text{by substitution } x = \sqrt{\frac{d^2}{r}} = \frac{d}{\sqrt{r}}$$

In investigating the security against sliding it is assumed that no provision is made to anchor the dam other than the friction between the material of which the dam is constructed and its foundation. In every case where a dam is built in actual practice, it is anchored. The foundation is roughened by putting in a few shots of dynamite or by trenching, so that all danger of sliding is eliminated. But in investigating the case this is not considered.

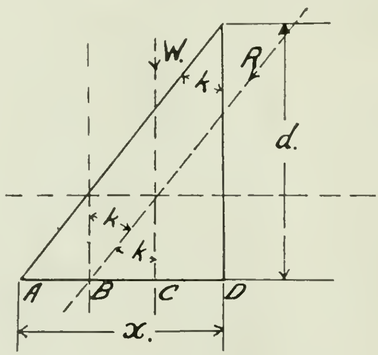


Fig. 2

If moments are taken about the point "B" (See Fig. 2) the resultant will be parallel to the inclined face of the dam.

Now suppose that the wall is cut by a horizontal plane at any point. There are two forces that keep the upper part from sliding on the lower.

1. The cohesion of the masonry.
2. Friction.

Therefore, for equilibrium $P \leq f\,w\,cl$. where "f" is the coefficient of friction of the material used, on itself.

"c" is the cohesion of the material used. It is considerable for masonry and greater for concrete.

"l" is the length of any joint

Consider cl as the factor for safety.

Then $P = f\,W$

$$f = \frac{P}{W} = \tan \text{“}k\text{”}$$

$$\text{But } P = \frac{62.5d^2}{2}$$

$$\text{and } W = \frac{w\,x\,d}{2}$$

$$\text{But } x = \sqrt{\frac{d}{r}}$$

$$\therefore W = 2\sqrt{\frac{wd^2}{r}}$$

$$\text{and } f = \frac{P}{W} = \frac{62.5d^2}{x} \times \frac{x\sqrt{r}}{wd^2} = \frac{62.5\sqrt{r}}{w}$$

$$\text{but } \frac{w}{62.5} = r \text{ the specific gravity}$$

$$\therefore f = \frac{\sqrt{r}}{r} = \frac{1}{\sqrt{r}}$$

Take 2 and 3 as the limiting values of r

$$\text{Then } f = \frac{1}{\sqrt{2}} \text{ to } \frac{1}{\sqrt{3}} = 0.577 \text{ to } 0.707.$$

But experiment proves that the limiting value of f is 0.75.

Therefore, if $x = \frac{d}{\sqrt{r}}$ the dam will be secure against sliding.

In investigating the security against crushing, it is assumed that the dam will be designed so that the resultant of all forces will lie within the middle third of the base. Then the conditions of maximum and minimum compressive stresses in the foundation, will be when the reservoir is empty and when it is full. In the one case, the resultant of all forces will be $\frac{1}{3}\,x$ from the upstream and in the other $\frac{1}{3}\,x$ from the down stream face. The maximum unit pressures will be at the two faces. In either case the condition may be represented as in Figure 3.

"$A\,D$" is the length of the foundation or joint, and "B" and "C" are points each $\frac{1}{3}\,x$ from "A" and "D."

"p" is the maximum unit pressure and is at the face. The pressure at the other end of the joint is 0.

Then the forces acting on the base = W or weight of the structure, acting at "B" and the reaction of the foundation $\frac{(p + o)}{2}\,x$.

These counter-balance one another.

Therefore $\frac{(p + o)}{2} x = W$ (weight of the structure)

$$p = \frac{2W}{x}$$

But $W = \frac{dx}{2} x w$

Where w = weight of a unit mass of the material used.

Therefore $p = 2\frac{dxw}{2x} = dw$

or $d = \frac{p}{w}$

This is the limit to the height that the dam may be built. For masonry it may be safely carried to 130 feet and higher, depending

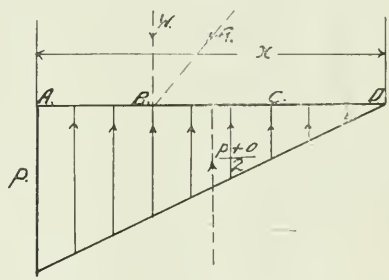


Fig. 3.

on the kind of masonry, and for concrete, to almost any height. Therefore, the design holds good against crushing for ordinary heights.

However, the design must be modified to satisfy the condition that it be able to withstand the shock due to wave action and floating bodies. This can be done quite easily by giving it sufficient width at the top. If desired, it may be made wide enough at the top to serve as a roadway and should not be narrower than four feet. A cross section of the dam will then be as in Fig. 4.

Here, "y" will be determined by conditions. "z" may be found by considering the top part as a little dam, taking the moments about the point $F = \frac{y}{3}$ from E and putting the sum of the moments $= 0$. This gives an equation in which "z" is the only unknown. Similarly "x" may be found by taking moments about "B" of all the forces acting on the dam. The only difference from the method used in the case of the triangular profile, is that the moments due to the weight of the dam, are found in two parts, the rectangular part with "y" as the top width and "d" as the depth, and the triangular part with $(x\text{-}y)$ as the base and $(d\text{-}z)$ as the height.

The condition that the resultant must lie within the middle third is thus satisfied when the reservoir is full. When it is empty it will be very slightly less than $\frac{x}{3}$ from "D." The tension in the heel thus caused is so slight that it may safely be disregarded.

The water conserved by the dam must be carried to the wheels. There are two general methods in which this can be done.

1. By means of a closed flume or penstock.
2. By means of an open flume.

In the first instance, the end of the flume or penstock must be in the wall constructed like a dam. This is called the forebay wall.

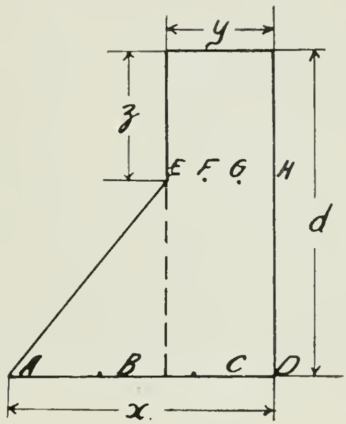


Fig 4.

There may be several forebay walls in some instances, when special protection is required against ice or other debris.

The end of this flume must be protected with racks or screens to take out any floating matter and ice. In designing them and their supporting structure it is advisable to consider them as a dam. So that, if they should ever become totally blocked with debris, they will be able to withstand the total pressure of the water. In practice the following figures are often used.

Fine Racks—Clear space between bars ¾ to 1½ inches, bars of wrought iron or steel ½ to ¾ ins., or even 1 in. thick by 4 to 5 ins. wide.

Coarse Racks—Clear space between bars, 3 ins. bars of wrought iron or steel ½ to ¾ ins. or even 1 in. thick by 4 to 5 ins. wide.

The racks must have a total clear area for the passage of water much in excess of the total area of the penstock inlets to prevent loss of head when the rack is partly clogged. To give a larger passage area and to facilitate cleaning, they are inclined.

They are best made in sections about 3 or 4 feet wide as they are then easily handled. They must be very firmly fastened in place, particularly in cold climates, where the ice freezes to them. Otherwise, any change of water level in the head race would raise them from their bases.

The head gate is provided to shut off the water from the penstock. In the past is was generally made of wood, but modern practice is to construct it of steel plates, especially if it is large. It is better to put a small bypass beside it to equalize the pressure on either side of it before opening it.

The head gate may be operated by means of racks and pinions, of screw spindles, either by hand, mechanical or electrical power or by hydraulic lifts. In cold climates the head gates must be very carefully designed so as to preclude any danger of freezing when open or closed.

Stop logs should be provided in front of them so that the water can be shut off and the gates made accessible for repairs.

After the head gate, comes the penstock. This takes the water from the head works to the turbine. In the case where the wheel is placed in an open flume, there is, of course, no penstock. The penstocks are usually made of steel with countersunk rivets to give a smooth finish. They are also constructed of reinforced concrete and wood stone. In designing them, a safety factor of not less than 4 should be used and for the lower end where the water hammer is the greatest, a safety factor of 6 is preferable.

Penstock and Draft Tube

In designing the penstock and draft tube the following formula is used.

$$t = \frac{dR}{2S}$$

Where t is the thickness of the shell

R is the unit pressure in pds. per sq. in.

d is the diameter in ins.

s is the permissible stress in the material.

Pipes carrying water for power purposes are subject to great pressure due to the quick closing of the gates by the governors. The moving water acquires a momentum proportional to the product of the weight and velocity. The penstock must be made strong enough to resist this or else some other means must be provided for the escape of the energy of the water. There are two means of providing for it.

1. By means of a surge tank.
2. By means of automatic spring valves.

The surge tank or stand pipe does two things. (1) It acts as a relief valve in case of excess pressures in the penstock. (2) It furnishes a supply of energy to take care of sudden increases of load while the water is accelerating, and dissipates the excess kinetic energy of the moving water column at the time of sudden drop in load.

The least capacity of this tank should be the amount of water the penstock will carry in twice the time it takes the governor to close the turbine gates. It should be placed as close to the turbine as possible and must be protected from freezing. The top of it should be on a level with the surface of high water at the penstock inlet. Large tanks may be constructed of steel, concrete or wood stave.

The safety valves are only used where the head is so great that the pressure on the penstock would be excessive when the surge tank is full. There should be enough of them to discharge, when open, the full flow of the penstock.

The draft tube may properly be called part of the penstock, for by it, the head between the wheel and tail water elevation can be utilized, and thus, the wheel can be placed above tail water elevation. This is possible by the action of suction, pull or draft exerted on the wheel by the water. But the draft tube must be air tight so that a vacuum is created in the tube.

It is so designed that the water, on leaving it has little or no velocity, so that the turbine uses nearly all of the head due to the velocity of the water, as well as the head due to the position above the tail water elevation.

Theoretically a draft tube of as great a length as the suction pipe of a pump, can be used, but practically it should never be longer than 20 to 25 feet and should be made as short as possible. For large turbines particularly, it is almost impossible to maintain a working head with a long draft tube.

The draft tube is made of iron, steel or concrete, and in cases where concrete is used in the construction of the power house, it may be built in with the foundation.

Machinery

The selection of the machinery is a very important part of power development and one that is very hard for an engineer to do satisfactorily. Therefore, it is generally left altogether in the hands of the manufacturers. They are given the size of the unit and the working head and are asked to submit tenders for the supplying of the machinery. This is very unsatisfactory, for it gives the engineer no check on the manufacturers. They are very apt to be much more enthusiastic than they should be over the merits of their machines, and in the competition of tendering, this is only to be expected. Therefore, more data, or rather limits must be supplied to them when calling for tenders.

The following are the various types of water wheels.

1. The Gravity Type. This type includes breast, overshot and undershot wheels. The efficiency of these is often good but the speed and power are low and they are not adapted to present day conditions. Therefore, they will not be considered further.

2. Impulse Wheels. This type includes the Pelton and Girard wheels. They are kinetic energy wheels; that is, the momentum of the mass of water in its impact on the runner buckets, is the main principle used in the transofrmation of energy into power. The impulse wheel is only used for heads of 300 feet and over. With it

there is no draft tube, consequently the head between the wheel and the tail race elevation, is lost. This is the reason the wheel cannot be used for low head developments.

3. FRANCIS TYFE OR REACTION WHEEL. This wheel rotates mostly by the pressure of the water and partly by the velocity. It is used for heads up to 300 feet. The wheel is submerged or placed in a closed flume, and the full head is utilized by means of a draft tube. The Smith, American, Holyoke, Jolly, Hercules, McCormack and Victor turbines are well known wheels of this type manufactured in America.

At Holyoke, Mass., the Holyoke Power Co. have a flume in which to test turbines. This has proved invaluable both to the manufacturers and purchasers of wheels. It has brought the American turbine practice up to its present efficiency, and in it have been tested one or more of almost every series of reaction wheels. The results of these tests reduced to unit head and power, form the basis for the selection of the turbine.

The following equations enter into the computation for the selection of the turbine.

$$K_5 = \frac{n^2 P}{\sqrt{h^5}}$$

where K_5 = the specific speed, or the speed at which the runner will operate when delivering unit horse power under unit head.

n = the number of revolutions per minute.

p = the horse power of the turbine at any given head

$$D = \sqrt{\frac{P}{k_2 \, h^{\frac{3}{2}}}}$$

Where k_2 = the constant relation of the turbine diameter to to power.

D = diameter of the wheel in inches.

h = the effective head at the wheel.

In the selection of the turbine the engineer is generally limited as to the speed. The generator or machinery may have to run at a certain speed and power, consequently the turbine speed is fixed. Also, it is better to select a wheel that will furnish essentially the amount of power required, as all machinery will work more efficiently at or near full load conditions. If possible, one turbine should be used instead of two or more because of the difficulty of keeping them in alignment.

The first step in the selection of the wheel is to determine the value of K_5 from the preceding equation. Then from the various manufacturers' catalogues select turbines having a similar value of K_5. If the computed value of K_5 greatly exceeds the values found in the catalogues, the power must be divided into two or more units. As K_5 is directly proportional to "P," by dividing K_5 by the number of units to be used, the K_5 of each can be obtained having a similar fractional value of "P" and can be used in the selection of the wheel.

Having determined from the calculated values of K_5 the different makes and types of wheels that may be used, from the catalogue, get the value of K_2 and substitute in the second turbine equation to get D.

Send to the various manufacturers, the data on the development, head, amount of water, size of unit, in fact a general description of the scheme, and invite tenders for the supplying of the wheels. These tenders should be accompanied by a report of a Holyoke test. From these tests, the values of K_2 and K_5 can be checked, also the several prospective wheels can be compared as to their operation at part gate, and the best one chosen. The selection of the generators, exciter unit, and switch board can be safely left with the manufacturers, but they should be accompanied with a written guarantee as to the efficiency. In choosing the governor, the opinion of the turbine manufacturers is of great importance and in many cases, the manufacturer furnishes both turbine and governor.

The design of the power house proper and placing of the machinery in it, will not be gone into here on account of the time required. It is generally of a very simple design, and strength is about the only consideration. In most cases it is a problem in reinforced concrete.

Velocity Considerations

A velocity diagram is of great assistance in designing. Sudden changes of velocity *must* be avoided and by plotting the velocity as a profile, the places where the design must be changed can be seen at a glance.

The velocity of the water in the head race must not be more than 3 or 4 feet per second if it is at all possible. If the speed is greater than this, there is an appreciable drop causing loss of head; also, with greater speed, the ice will not form on the surface, but will be formed as frazil, which, entering the wheel will wear out the vanes in a very short time. In Europe it is the practice to make the velocity of the water in the races not greater than 1.5 feet per sec., but here, on account of the excessive cold, a river running at 4 ft. per sec. will freeze solid.

A question on which there is a very great diversity of practice is the penstock velocity. The entrance from the forebay to the penstock should be conical so as to gradually increase the velocity from that of the head race to that of the penstock. At the lower end of the penstock the velocity should again be gradually increased or decreased so that the water will arrive at the guide buckets with the same speed that it has to enter them. At the entrance to the draft tube it should have a velocity equal to that with which it leaves the runner buckets and the velocity should be gradually decreased to little or nothing at the lower end of the draft tube. The speed of the tail race should be the same as at the outlet of the draft tube.

It is current practice to make the penstock velocity not greater than 4 feet per sec., but there is very little reason for this. In many cases, it is economical to have a much greater velocity, but each particular case must be considered by itself.

Conditions making a low speed advisable are: low head, great length of penstock, many bends in penstock, variable loads on the turbines and the regulation of the speed of the turbine by changing the amount of water used. The penstock is made large enough to give the required low speed.

Conditions making a high speed permissible are: high head, short penstock, few or no bends, constant load on the turbines and regulation of the turbine speed by a bypass.

The following table gives the highest velocity permissible in feet per sec. in penstocks of 1,000 feet or less. This table is from Modern Turbine Practice, by Thurso.

Diameter of Penstock in feet	4	5	6	7	8	9	10	11	12
Speed of water in feet per sec.	12	11.5	11	10.5	10	9.5	9	8.5	8

The losses in head while the water passes through the penstock, wheel and draft tube are as follows:

1. Entrance Loss. This can be kept low by having a taper piece at the entrance so that any change of velocity will be gradual.

2. Frictional Loss. This may be kept low by having a small velocity in the pipe and by having its interior as smooth as possible.

3. Loss due to bends. Therefore make all necessary bends as gradual as possible.

4. Loss caused by changes in the speed of the water. Therefore make any changes necessary as gradual as possible.

5. Loss due to the speed of the water while leaving the lower end of the draft tube. This loss can be kept down by making this speed as low as possible.

In conclusion, it is evident that the development of a water power involves a complete detailed investigation of the entire project and should be built on the most modern knowledge obtainable. To keep abreast of the times, requires a life of study, but the reward of the engineer is well worth the work and time spent.

Note.—In Part I, the statement that "The Hydro Electric Power Commission for Ontario, and the Commission of Conservation for the remainder of Canada, have started to collect data relative to the rainfall, and to meter the rivers, establishing the relation between the precipitation and flow on each watershed, so that, in the future, we will have to do much less estimating" is incomplete and consequently is liable to be misleading. Although the above mentioned Commissions are interested in the work, yet the work of stream measurement in Canada is being carried on by a number of departments of the Dominion Government, the Commission of Conservation probably having the least of any to do with this work.

In many parts of Canada, but chiefly the Eastern section, including Ontario, the work is carried on by the Department of

Railways and Canals, the Department of Public Works and the Department of Naval Service.

In Western Canada the work is being carried on systematically and the results are being published by two branches of the Department of the Interior, viz.: The Water Power Branch, of which Mr. J. B. Challies is superintendent, and the Irrigation Branch, Mr. F. H. Peters being commissioner. In British Columbia an arrangement has been made between the Provincial Government and the Water Power Branch by which the latter carries on the work under the name of the British Columbia Hydrographic Survey, Mr. R. G. Swan being chief engineer. In Alberta and Saskatchewan the work is under the Irrigation Branch, Mr. P. M. Sauder being chief hydrographer, and in Manitoba, the Manitoba Hydrographic Survey, Water Power Branch, is carrying on the work, Mr. M. C. Hendry being chief engineer.

With regard to the collection of data relative to rainfall, this is done almost entirely throughout the Dominion by the Meterorological Service, the head office of which is in Toronto and of which Mr. F. S. Stupart is director. While there are a great many stations established for the collection of this data, it is a well known fact that the relationship between precipitation and run-off is a very complicated one and reliance upon this relationship often leads to very serious error in the making of estimates of discharge.

BROADENING ENGINEERING COURSES

By C. R. Young, B.A.Sc., C.E.
Assistant Professor of Structural Engineering

The Function of Engineering Education

The function of engineering education is to train engineers. It is not to train men to be draughtsmen, instrument men, inspectors or technical clerks, but engineers in all that we wish the name to imply; not engineers of the past, but engineers of the future Admirable though the record of the engineer of the past has been, we must surpass it. The engineer of the future must engage in activities and assume responsibilities unknown to his professional forbears. He must concern himself quite as much with the promotion and definition of projects, and with the securing and maintaining of the support of those who pay for them as with the physical execution of the work. Along with the lawyer, the physician and the clergyman he must become a custodian of the public welfare and at the same time a loyal and active supporter of every movement for the betterment of his own profession. Through superior ability, character, personality and breadth, he must himself be the solution of the much-discussed professional problem. The bringing forth of such a man is only possible through the enlightened, persistent and concerted efforts of the engineering schools. To this work they must bring all the resources at their command.

The Equipment and Training of the Engineer of the Future

The attainment of the status for which engineers strive is only possible to a body of well-equipped, well-trained men. Heretofore, most of our attention has been directed to equipment and very little to training, regardless of the fact that weapons are useless without a knowledge of their effective use and the ability to bring about situations where they may be employed. A mental storehouse crammed with mathematical formulæ is, to an engineer who cannot formulate the problem arising from certain ascertained economic and physical conditions, quite as useless as a magazine rifle to a prehistoric savage. Equally as powerless is the engineer who can solve the scientific problem and yet lacks the art of persuading the financier or the board of works to allow him to attempt it.

In such equipment and training as has been given young engineers in the past there is much to be criticized. We have taught men how to earn a living but not how to live. We have prepared them to effectually cope with certain eventualities arising at rare intervals in the experience of most men, while we have left them unable to meet the persistent demands of everyday situations. For example, effective expression in written or spoken word, upon which the fortunes of every engineer largely depend, has gone all but unheeded. We have based the equipment and training of three upon some of the needs of one. It would be wiser to reverse the practice.

Whether he develops them through the aid of the educator or by his own efforts, the successful engineer must possess certain personal assets. These may be briefly stated as:

(1) *Technical Efficiency*;

(2) *Personal Fitness*.

(1) *Technical Efficiency*. The scientific and executive duties devolving upon the engineer can be effectively performed only by one who possesses a well-ordered knowledge of his special field, accuracy and speed. These constitute the mechanism, as it were, with which he attacks the problem. While their full development is dependent upon character and capacity, it sometimes happens that in positions of limited range a man of small capacity and weak personality may exhibit in his response something akin to mechanical perfection. No man, however, can successfully discharge a great variety of duties and adapt himself to changing conditions and positions on the basis of technical efficiency alone.

(2) *Personal Fitness*. Personal fitness in the young engineer may be said to depend upon:

(a) Character;

(b) Intellectual Capacity;

(c) Breadth;

(d) Address.

(a) Of the engineer who would succeed, the world demands unswerving integrity, a willingness to accept reponsibility for the failures of others and a rare degree of self control. No single possession contributes more to ultimate success than the power of self-detachment, or the ability to bar out anxious thought at will. There is valuable content in the remark of Cobden, made towards the close of a life of stupendous activity: "If I had not had the faculty of sleeping like a dead fish, in five minutes after the most exciting mental effort, and with the certainty of having oblivion for six consecutive hours, I should not have been alive now."

(b) The value of intellectual capacity to an engineer arises as much from alertness as from reasoning power. Much of Sir John Fowler's success was due to his ability to comprehend a situation almost instantly. Indeed, he said, somewhat facetiously, that if he did not see through a problem at once he never saw through it. In engineering, resourcefulness and originality are of much greater moment than the ability to marshal and retain a vast assemblage of facts on a given subject. The creating, rather than the absorbing, intellect is needed.

(c) To maintain pleasant relations with well-educated, vital people about him and to lay the foundations of professional eminence, the engineer must possess breadth. It is a viséed passport to the circles in which he should move. It endows his social and business life with resources and adaptability analogous to that already found indispensable in his special scientific pursuits. We must frankly admit that engineers in the past have often lacked the breadth that should characterize professional men. Says Mr. Frederick Lynch: "We turn out good engineers, but one of them—quite eminent, too—from one of our great universities asked me, myself, once, 'Who was Shelley?'" It should never be necessary for an engineer to apologize for lack of familiarity with the interests and undertakings of the general public on the ground that he is an engineer. Furthermore, such acquaintance cannot be wholly intellectual and be productive of true breadth. The engineer must feel towards the various human activities about him an enthusiasm that compels some measure of participation. He must possess breadth of sympathies as well as breadth of intellectual tastes.

(d) Since the only offering of the engineer to the world is his personal services, he must be his own ambassador. Those who entrust life and property to him must be satisfied that he personally possesses both character and ability, and on personal address their estimate will be largely formed. In commerce, an illiterate, uncouth man possessing material assets and shrewd enough to select educated, polished representatives may achieve success. In professional life such is impossible. Most engineering engagements worth while are secured through acquaintanceship, but such can be advantageous only to the one who can meet prospective clients or their relatives or friends on their own ground and maintain mutually pleasant relations easily and naturally. The young engineer must speak readily and correctly, possess pleasant manners, be neat and careful in his personl habits, enthusiastic, optimistic and physically vigorous. Sir Harry Johnston states that young men entering the British diplomatic service should be physically commanding in order to impress foreign nations with the stamina of the people whom he represents. That the value of this is by no means limited to the sphere of foreign service is indicated by a typical letter from an employer to the writer respecting applicants for the position of engineering salesman. He wrote: "What I have in mind is a good-sized fellow physically, of good family (which naturally will entail connections), and one who has the nucleus of tact, poise and shrewdness in reading men . . . . . . It is more necessary for a young man to handle himself than to attempt to handle a man on whom he is calling. He should be able to readily adapt himself to the mood in which he finds the man on whom he calls." Frequent expressions of opinion on this matter from men well qualified to judge indicate that too much importance cannot be attached to personal address.

Curricula of the Future

Having gained a clear conception of the kind of equipment and training required of an engineer, the educator must deliberately set about to devise the most effective curriculum for imparting it. In the past much damage has resulted from the effort to fully comprehend in engineering courses all the varying conditions and multiplying fields of practice. The shortening of time spent on fundamentals, the heightening of detail and the pointing out of ever-increasing applications of known principles to new problems, not only involves overloading, but connotes the development of men for immediately-remunerative, subordinate positions rather than for those of a responsible, creative, directive character. A subject, or phase of a subject, should never be featured because it may be useful to young engineers, but only because it promises to be useful to a larger number of engineers than some rival subject.

An effort is being made in many institutions to broaden and deepen engineering education by the introduction of five-or six-year courses. In some cases the plan of requiring a complete separation of professional training from general educational training as in schools of medicine, law and theology, is followed. It is believed, however, that a much better plan is to correlate the two. The first four years might, in themselves, be made to constitute a definite, limited course in fundamentals with an introduction to engineering subjects. Upon their completion the student would be allowed, if he so desired, to go out into the world and fill junior engineering positions or to proceed with another year of specialized professional study. This is the Johns Hopkins plan. Whatever the merits of five-or six-year courses may be, it is obvious that in new countries like Canada the four-year course will, for years to come, be pursued by the great majority of young men entering engineering. Our efforts must, therefore, be largely directed to the development of the best possible course covering four academic years. For this reason, such references as are made to the curricula of other institutions in what follows are limited, unless otherwise indicated, to four year courses.

The selection of subjects best calculated to impart technical efficiency and personal fitness is by no means an easy task. There is a feeling in some quarters that for the promotion of technical efficiency, subjects of an exclusively technical character, bearing as intimate a relation as possible to the student's chosen specialty, should be selected. The writer does not share this feeling. Certain non-technical, general studies can contribute valuable aid to the mastery of a technical field. "Nothing can be truly cultural which is not useful," said President-Emeritus Charles W. Eliot to a Toronto audience a few years ago. If this is true, a judicious selection of cultural subjects should promote technical attainments. For the development of professional technique, the chief reliance must, of course, be placed on technical subjects. The determination of the particular ones best calculated to serve our purposes forms no part of the present discussion.

Although technical studies have value in the attainment of personal fitness, cultural or non-technical subjects must play a more important role. It is believed that those best suited to this purpose are:

(1) *Language and Literature*;
(2) *History*;
(3) *Biography*;
(4) *Philosophy*;
(5) *Political Science and Sociology*;
(6) *Physical and Military Training*.

It may be urged that since certain of these have an important place in the curricula of preparatory schools, they might give place to an equivalent amount of technical work in engineering schools. To this, two objections arise. First, the student generally has an acquaintance with these fields gathered in immaturity and incompatible with the standard of culture demanded of a well educated professional man. Secondly, the dropping of specific instruction in them upon entering college, often means the cessation of the student's interest in these subjects. Four years of concentration upon technical studies at a time when vital changes are taking place in the student himself generally means that tastes are re-formed, or perhaps all but obliterated, and that he never fully regains his interest in literary or historical studies.

(1) *Language and Literature.* Of all the weapons placed in the hands of the engineering graduate, a vital acquaintance with language and literature most nearly approaches universal utility. Through it we gain access to all that is helpful and inspiring in the records and visionings of our own people and of those who speak alien tongues. Through it we impart such help and inspiration as we are able to give. As a means of developing in the engineer those qualities for which the company of men is most eagerly sought—lofty ambitions, refined tastes and ardent enthusiasm—language and literature are of the utmost value.

The need for special instruction of engineering students in English need not here be shown. The inability of the average engineering graduate to express himself clearly and accurately in either speech or writing has been repeatedly pointed out. It has been said that in this age the man of science appears to be the only one who has anything to say, and that he is the one that least knows how to say it. This is unfortunate, for no single circumstance predisposes an employer so much towards an applicant as the clearness and precision with which the stranger states his case. Indeed, what assurance has the prospective client that carelessness, inaccuracy and incoherence in expression will not extend to professional work? There is, too, as Professor Haultain has pointed out, the necessity of the engineer becoming, like the geologist, an effective story-teller.

English, as taught in engineering schools should not be confined to effective self-expression in speech and writing, but should increase the student's interest in reading and in some measure develop in him a standard of critical judgment. The development of appreciation and the formation of discriminating taste is entirely compatible with the perfection of an instrument for transmitting ideas with clearness, precision and brevity. It is thus desirable that any course in English should include not only composition and public speaking, but English literature as well.

English composition is now taught in very many engineering colleges. In most of them it covers not only general composition, but the specialized professional writing of the engineer. The University of Michigan offers elective courses in the Preparation and Presentation of Technical and Scientific Papers, Commercial Correspondence, Engineering Reports and Technical Journalism. Third and fourth year students in the University of Wisconsin may select as one of their subjects a course in Advanced Technical Writing with the study of scientific and technical models. An elective course in technical writing is about to be offered at the University of Minnesota. At the Massachusetts Institute of Technology a feature of the instruction in English is the training of students in the taking of lecture notes. Exercises of great value, closely paralleling much work to be subsequently encountered by the engineer, might be given in the abridgment and presentation in condensed, or perhaps semi-popular, form of professional reports and papers.

No one who aspires to professional status should pass four years of the most impressionable period of his life without enlarging his acquaintance with the best literature. As a source of enrichment of his mental and spiritual life he should develop or preserve an appreciation of the literary treasures of his language. The hazard of atrophied taste should not be invited. The professional school must keep open all avenues to the understanding of life.

Already instruction in literature is given in a number of engineering schools. At the Massachusetts Institute of Technology, elective work is offered in Eighteenth and Nineteenth Century English Literature and the English Bible. The University of Michigan gives a place to studies in Criticism of Prose Fiction and in Criticism of the Drama. The University of Pennsylvania provides courses in the History of English Literature and Language, Nineteenth Century Novelists, English Essayists, Elizabethan and Seventeenth Century Dramatists and the English Bible.

Concurrent with, or subsequent to, the formal course in English literature, a certain amount of supplementary reading should be required. No technical course purporting to train professional men should be allowed to wholly displace the habit of general reading. In order to avoid haste and congestion during the session, and to take advantage of those conditions most favorable to the growth of appreciation, several institutions have adopted the plan of prescribing summer reading. At the Massachusetts Institute of Technology and at the University of Illinois courses of summer reading of a literary, historical and general scientific character are required between the first and second and second and third years. The purposes of these courses are "to increase the acquaintance of the student with literature, history and general science, to develop in him a taste for such reading, and to impress him with the importance of general culture, not only as a source of individual enjoyment, but as a practical aid to professional men in their social and business relations." McGill University requires all students entering the second year, except those in architecture, to have read five specified books and to pass an examination based upon such reading at the beginning of the session. Students entering the third year, except those in architecture, must either have followed a course of summer reading or have prepared a 2,000-word essay. If the former has been selected, an examination must be passed before proceeding with the year. Special assignments involving less reading are made to architectural students.

In addition to providing instruction in the writing of English, several engineering schools give attention to the speaking of it. Certainly nothing is more important to the engineer than the ability to present a case clearly and concisely in the committee room, on the platform, or in the witness box. Nothing so much predisposes a client to give an engineer a chance to appear in these places as the possession of ready, expressive, restrained conversational powers. Courses in public speaking, either obligatory or optional, are provided in Cornell University, the Johns Hopkins University, the Massachusetts Institute of Technology, the University of Michigan and Union College. These generally include extemporaneous speaking from outlines and the preparation and delivery of at least one original address. At Union College, public speaking is obligatory for all second and third year students.

A valuable aid in the preparation and presentation of cases is offered in properly-directed engineering society meetings. On a purely voluntary basis, the benefits derived are limited to the comparatively few who prepare papers and take part in the discussions. If participation in the activities of the society were required by the curriculum and credit were given for it, the society might become a valued adjunct to the teaching force. An effort to realize the advantages of the engineering society more fully than is possible under a voluntary system has been made at West Virginia University. At that institution engineering society work is required of all students in the third and fourth years. Each student prepares four papers, two of which he reads and sustains and two of which he holds in readiness for presentation, should the occasion arise. Credit is given both for the papers themselves and for attendance at the society meetings.

Foreign languages are studied in most engineering schools as a means of acquiring technical information not available in English. Usually French or German is required, but Spanish is allowed in certain colleges where special attention is paid to mining and metallurgy. Courses usually cover one or two years. French is generally obligatory for students in architecture and German for those in chemistry. At the Massachusetts Institute of Technology the study of foreign languages has two objects: "that of enabling the student to make use of the languages as instruments in scientific research, and that of giving him general training and culture."

(2) *History.* One of the most potent influences for widening the horizon of the young engineer and extending his interests is the study of history. Current history is especially effective as a stimulus to participation in the activities and thought of his time and in the development of good citizenship. Recognition of the value of historical study has been accorded in a number of institutions. It is commonly given a place in combined five-and six-year courses and in the following cases, among others, has been incorporated in four-year courses. At the Massachusetts Institute of Technology, Modern History is required of all students in the first and second years. A special course in the History of European Civilization and Art is given to architectural students in the third and fourth years. Elective historical courses are provided for all departments in the third year in Colonial Systems and Current Public Problems. At Union College, American History is required of all students in the third year. For the Engineering Administration option, Medieval and Modern History are also required. In the first year at the University of Washington, United States History forms one of the cultural electives and a historical course is also permitted as a fourth year elective.

A phase of historical study that would not only be of commanding interest but, at the same time, of practical value to the young engineer is the history of engineering. An undoubted source of inspiration to those just entering upon the study of engineering, and an incentive to historical reading in this field might be afforded by a few graphic lectures outlining the beginnings of, and the notable achievements in, engineering. Isolated lectures of this kind have been given in the University of Toronto. At Cornell University, the University of Illinois and the University of Minnesota they form a regular feature of the sessional activity. A little more work of this kind would greatly heighten the enthusiasm of the student for his profession.

(3) *Biography.* As a directive influence in character-building,

no field of general reading offers more than biography. From it the student is able to supplement his own meagre experience with that of the great men of all time and to live over again with heroic souls the supreme moments that made them immortal. Beyond one or two interest-stimulating lectures each year on the lives of celebrated engineers, formal instruction is not required. It would be desirable in any course of summer reading for engineers to prescribe one or two biographies of engineers. Smiles' Lives of the Engineers, Goddard's Eminent Engineers, and Mackay's Life of Sir John Fowler, are worthy of the close study of every engineer-to-be.

(4) *Philosophy.* Apart from the personal satisfaction and self-improvement to be derived from philosophic studies, the engineering student acquires from them knowledge of immediate guiding value in professional pursuits. Logic, ethics, and psychology have a content for the engineer quite as much as for any other professional man. From logic he should derive a clearness of analysis and presentation not possible with the wholly indirect instruction afforded in technical courses. Ethical principles must form the basis of professional conduct. Psychology, through its correlation of motives and their manifestations would obviate much blind groping and friction in dealings with men. The value of these studies has already been recognized in engineering schools. At the Johns Hopkins University an obligatory course in philosophy is prescribed for all students in the fourth year, and at the University of Pennsylvania for certain departments of the fourth year. The University of Washington offers courses in philosophy as cultural electives in the first and third years. In recognition of the importance of sound professional ethics, Union College provides a course of lectures on topics pertaining to the training and qualifications of an engineer and to the engineering profession in general.

(5) *Political Science and Sociology.* A course in elementary political science and sociology should do much to promote a desire for effective citizenship among engineering students. Lively interest in public problems would arise with a careful examination of the relation of fundamental economic principles to present-day industrial and social conditions. Economic studies, of course, have a direct technical value to engineers, especially to those who are to occupy administrative positions or to undertake work involving both commercial and scientific activities.

Much attention is given by engineering colleges to instruction in this field. In addition to elective courses offered in a number of institutions, regular courses in elementary economics are provided in Cornell University, the University of Illinois, the Johns Hopkins University, the Massachusetts Institute of Technology, the University of Minnesota, Union College, the University of Toronto and the University of Washington. McGill University provides a course in engineering economics especially adapted to the needs of the engineer. The third year electives in the curriculum of the Massachusetts Institute of Technology include Economic History, Railroad Economics, Labor Problems, Municipal Government, and International Law.

The University of Minnesota provides courses in Railway Economics and American Government including, a study of the organization and present workings of the national, state and local governments. At Union College fourth year students selecting the Engineering Administration option receive instruction in Comparative Politics and International Law. In many of these institutions courses are given in Banking and Finance, Commercial Law, Accounting, Contracts and Specifications and Cost-keeping. These, however, are technical economic subjects, and as such do not enter into present consideration.

(6) *Physical and Military Training.* Nothing stands out more clearly in the careers of great engineers than the stupendous part that physical endurance has played in the winning of success. It is unkind to allow a young man who contemplates a life work demanding exceptional physical energy to neglect physical training for perhaps the four most critical years of his life. Many engineering colleges appreciate this and require physical training in at least one year of the course, generally the first year. The habit of attending to the physical well-being thus formed will probably be continued by most men. Physical training is obligatory in Cornell University, the University of Illinois, the Johns Hopkins University, the Massachusetts Institute of Technology, the University of Michigan, the University of Pennsylvania, Queen's University and Union College. At the University of Pennsylvania it is required for the entire four years. In addition, lectures on personal hygiene are given at many institut'ons, among others, McGill University, the University of Minnesota, the University of Pennsylvania, the Massachusetts Institute of Technology, and the University of Toronto. A useful aid to social service is contained in the lectures at the University of Pennsylvania, which include instruction on gymnastic systems for school, playground and college, and the application of exercise to the improvement of defectives.

While the desirability of placing military training on an obligatory basis is debatable, there can be no question as to the value of such training in setting up the student and promoting his quickness of response. The sense of citizenship established in enrolling one's self for national defence is especially compelling in those, like the student, who take the step early in life. In a number of engineering colleges of the United States military training is obligatory, as at Cornell University, the University of Illinois, the Massachusetts Institute of Technology, and the Universities of Minnesota, Washington, and Wisconsin. It is optional in McGill University and the University of Manitoba.

Experience has shown that undoubted advantages to the student attend the introduction of voluntary military training. The present war will probably bring about its establishment in many engineering schools.

Making Room for Non-Technical Subjects

Less difficulty is experienced in selecting a list of subjects of general educational value to the engineering student than in agreeing upon the subjects that they shall displace. Each member of the teaching staff is persuaded that it is not his own special work that should be reduced but that of someone else. Under these circumstances, the only possible basis of settlement is compromise. But on what basis shall it be made? It is believed that if certain broad principles were kept firmly in mind the difficulties incident to the undertaking would be considerably lessened. Some lines of policy that would probably meet with general support among engineering educators of to-day are:

(1) Curricula should be based upon the requirements of the majority of the students, not of the minority;

(2) Reading courses, that is courses requiring no elucidation by the teacher, should be reduced to a minimum;

(3) Technical detail and descriptions of the methods of practice should be limited to the minimum necessary for clear illustration of the general principles;

(4) Cultural subjects of universal utility should be obligatory and those of lesser utility, optional.

SUGGESTIONS FOR CHEMICAL ENGINEERING STUDENTS

By J. A. DeCew, B.A.Sc., '96

One of the newest branches of engineering science is that of the chemical engineer. This profession, which has evolved and established itself, is a distinct branch of engineering because of the wide field for work and the necessity for specially trained men to carry it out.

In many respects the chemical engineer may be said to be a development from the industrial chemist, as it has been found possible for the industrial chemist to so increase his experience along engineering lines that he is able to undertake and carry out such engineering work as is built up around a certain group of chemical problems. It has been more difficult for the engineer without special chemical training to carry out chemical engineering work, than for the chemist. The latter is bound to acquire certain skill and experience in manipulating apparatus and when this apparatus becomes a commercial unit, it has reached the sphere of engineering practice. At the present day, however, it is possible for men to get an excellent training in chemical engineering which includes special instruction and experience, not found in the training of either the chemist or the engineer.

Quite a little has already been written regarding the education of the chemical engineer and his function in the industrial field, and the profession is by no means as unknown or unappreciated as it was a few years ago. The suggestions I would make to students who are interested in or contemplate chemical engineering work, are not related to the courses of training which may be established in different institutions but rather to the industrial opportunities which lie open to the man who has trained his mind in the solution of chemical problems on an engineering scale. Although the field is wide from a purely professional point of view, to the man who combines this general training with a concentration upon a special series of problems of commercial importance, there is, in the opinion of the writer, a special advantage in this class of education which is now available, for general commercial work. In practically every industry there are chemical problems which must be dealt with by every executive. Where a man is engaged in a manufacturing industry or is employed as manager or superintendent for others, he must face the ever present problems which have both an engineering and chemical character. A chemical knowledge of the different materials that are being used in every walk of life has become essential to their proper manipulation and exploitation. If a man should go in for railway engineering or management, he might be called upon to deal with problems in which the chemical properties of materials such as iron, steel, wood, cement, rock, etc., would have an important bearing upon the problems. Efficient maintenance of railway lines depends upon the chemical as well as the physical properties of the materials in use. In the manufacture of many of the staple products used, such as paper, leather, rubber, soap, sugar, starch, the chemical processes involved are of basic importance and on these lie the chief responsibility for the quality of products.

When it becomes fully appreciated in trades that the engineer is better equipped to deal with problems of general management than the man with only an office training, it would also be recognized that the chemical engineer is specially qualified for the control of industrial problems of a chemical nature. From his training the chemical engineer is one who is constructive and creative rather than analytical and his knowledge is intimately related to the problems on which the conversion of materials depends. It is obvious that the better a man is trained for the kind of work he is about to follow, the easier it will be for him to advance rapidly in that work. The student who has in mind executive work in connection with manufacturing processes will appreciate that the chemical engineering course offers the best average training for many manufacturing industries in which he may find his life's work.

H. N. Macpherson, B.A.Sc., '14, is inspector for the Board of Highway Commissioners of Saskatchewan. He has been inspecting on provincial bridge work during the summer.

W. D. Walcott, B.A.Sc.,'14, is with the Public Works Department of the Jamaica Government, as surveyor on road location and other work.

C. E. Richardson, '10, is division engineer with the British Columbia Hydrographic Survey, at Nelson, B.C.

J. A. Elliott, B.A.Sc., '14, is assistant engineer with the British Columbia Hydrographic Survey, at Nelson, B.C.

N. C. Stewart, B.A.Sc., '09, is engaged on D.L.S. work near Golden, B.C.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL

DR. ELLIS IS ACTING DEAN

Dr. Ellis has been appointed Acting Dean to assume the duties from which death called away our late Dean Galbraith. In 1878, upon the organization of the School of Practical Science, Dr. Ellis became assistant to the Professor of Chemistry, Dr. H. H. Croft, and since that time has been one of the associates of the late dean in the work connected with the upbuilding of the "School." The graduates and undergraduates therefore look to him with confidence to uphold the traditions of Dr. Galbraith, whose colleague he has been for so many years.

Dr. Ellis has a host of friends among the graduates of the various years since the founding of the "School," who cherish a very high respect for him and who are glad to know that he is still able to take up the reins so long controlled by his intimate personal friend.

Thompson-Atkinson

On Tuesday, September 15th, Mr. J. M. Thompson, B.A.Sc., '13, of the staff of the Hamilton Bridge Works, Hamilton, Ont., was united in marriage to Miss Cora Blanche Atkinson, daughter of Mr. and Mrs. Robert Atkinson, Caledonia, Ont.

Huether-Wilkins

On Wednesday, September 23rd, Mr. D. J. Huether, B.A.Sc., '08, was united in marriage to Miss Etta Alderson Wilkins, daughter of Mr. and Mrs. M. Wilkins, Mount Forest, Ont.

Redfern-Kinghorn

On Wednesday, September 9th, Mr. C. R. Redfern, B.A.Sc., '09, engineer for P. Lyall & Sons Construction Co., Toronto, was united in marriage to Miss Bessie Inglis Kinghorn, daughter of the late D. W. Kinghorn and Mrs. Kinghorn, Toronto, at the home of the bride's mother on Geoffrey Street. Mr. and Mrs. Redfern will reside in the Georgian Apartments, St. George St.

The following "School" men have gone with the first Overseas Expeditionary Force from Canada to England, in addition to those mentioned in last months' issue:—P. J. McQuaig, '04; — Bevan, '05; A. J. Code, B.A.,Sc., '10; I. M. R. Sinclair, '17; E. P. Muntz. B.A.Sc., '14; J. J. Hanna, B.A.Sc., '14.

F. S. Falconer, B.A.Sc., '09, is engaged on Topographical Survey work near Revelstoke, B.C.

C. G. Hoshal, B.A.Sc., '09, and G. G. MacLennan, B.A.Sc., '10, are with the Ontario Hydro Electric Power Commission, at Eugenia, Ont., on construction work in connection with the development of electric energy at that point.

Edwin E. H. Hugli, B.A.Sc., '14, is with C. E. Deakin, Ltd., of Montreal, on the erection of the new concrete plant of the Canadian Kodak Co. at Mount Dennis, near Toronto.

S. G. Bennett, B.A.Sc., '14, has left to take a post graduate curse in Physics at Oxford University.

F. T. McPherson, '15, is in the office of the city engineer, Saskatoon, Sask.

A. C. Goodwin, '02, is in charge of testing and inspection of materials for the Ontario Hydro Electric Power Commission, Toronto.

J. N. Goodall, '04, is superintendent of the High Tension Construction department with the Ontario Hydro Electric Power Commission, Toronto, Ont.

Pick, B. W., '11, is with Smith & Phillips, engineers, at Regina.

Pickering, A. E., '04, is manager of the Tagona Light & Power Co., Sault Ste. Marie, Ont.

Piggott, R. B., '09, has as his address 157 Wentworth St. S., Hamilton, Ont.

Pinhey, C. H., '87, has a land surveying practice at Ottawa, Ont.

Pinkney, D. H., '03, is mechanical engineer and chief draftsman in the pipe mill department of the Lorain Works of the National Tube Co., at Lorain, Ohio, U.S.A. His address is 142 Princeton Ave., Elyria, Ohio, U.S.A.

Pivnick, M., '08, has a practice as dental surgeon. We do not know his address.

Playfair, N. L., '92. We understand that he is at Midland, Ont.

Plunkett, T. H., '03, is a Dominion and Ontario land surveyor at Meaford, Ont.

Ponton, G. M., '09, is consulting engineer at Calgary, Alta. His office is at 513-516 Beveridge Building, Calgary.

Pope, A. S. H., '99. When last heard from he was a member of the firm Pope & Wilcox, electrical and mechanical engineers, Portland, Oregon.

Porte, E. H., '11. Address not known.

Porte, W. B., '06, has Brown's Corners, Ont., as his home address.

Porter, C. J., '09, is with the Texas Power & Light Co., Dallas, Texas.

Potter, R. B., '07, is assistant engineer in the roadways department at the City Hall, Toronto. His address is 235 Garden Ave., Toronto.

Powell, G. G., '02, of 129 Springhurst Ave., is assistant city engineer for Toronto.

Power, G. H., '01, is consulting engineer with Chipman & Power at 47 Canada Life Building, Winnipeg, Man.

Prentice, J. M., '92 (deceased).

Price, H. W., '01, is associate professor of electrical engineering at the University of Toronto.

Pratt, F. M., '11. His address is 343 Nepean St., Ottawa, Ont. He is resident engineer in the construction department of the E. B. Eddy Co. at Hull, P.Q.

Porchnow, F. E., '07, of 506 Ellicott Square, Buffalo, N.Y., is with Wilhelm, Parker & Ward, patent attorneys, of that city.

Proctor, A. I., '09, lives on King St. E., Hamilton, Ont. We do not know his occupation.

Proctor, E. M., '08, is designing engineer in the department of railways and bridges at the City Hall, Toronto.

Procunier, J. F., '07. His home address is Bayham, Ont.

Proudfoot, H. W., '97 (deceased).

Publow, C. F., '08, is on the staff of the Toronto Hydro Electric System, Toronto, Ont.

Pullan, H., '11, is in business with his father at 490 Adelaide St. W., Toronto.

Pullan, E. F., '05, manager of the Alexo Mine, Iroquois Falls, Ont.

Purser, R. C., '06. His address is 32 Glengarry Ave., Windsor, Ont. He has been engaged on D.L.S. work in the West during the last three years.

Pye, D. E., '10. His address is Cranbrook, B.C.

Q

Quail, J., '09, is with the Manitoba Bridge and Iron Works.

Quail, H. C., '13, is in the high tension construction department, with the Ontario Hydro Electric Commission, Toronto, Ont.

Quance, G. E., '07, is secretary-treasurer of the Delhi Light & Power Co., Limited, Delhi, Ont.

Quinlan, L. J., '11, is in the topographical surveys branch of the Department of Interior at Ottawa, Can.

R

Railton, L. W., '11, is with the P. G. E. Railway, Cheakamus, B.C.

Raine, H., '07. His address is 197 Fulton Ave., Toronto, Ont. He is structural engineer with Prack & Perrine, architects and engineers, Toronto.

Ramsay, W. S., '10. Address not known.

Ramsay, G. L., '05, has an Ontario land surveying practice at Sault Ste. Marie, Ont.

Ramsperger, A. F., '09, of 22 Callender St., Toronto, is with the Dominion Bridge Company on the designing staff.

Rannie, J. L., '07, is with the Geodetic Survey branch at the Dominion Observatory, Ottawa, Ont.

Ranson, J. T., '08, of 128 Grenadier Rd., Toronto, has a practice as land-surveyor with offices at 2 Temperance St. He is also demonstrator in surveying at the University of Toronto.

Ratz., E. G., '13, was with the Canadian Westinghouse Co. at Hamilton, Ont., when last heard from.

Ratz., J. E., '11, is with the Geodetic Survey branch of the Department of Interior at the Dominion Observatory, Ottawa.

Ratz., W. F., '02. Deceased.

Raymer, A. R., '84, is assistant chief engineer, P. &. L. E. Ry., Pittsburg, Pa.

Rayner, G. W., '05, is with the Ontario Rock Co., Lumsden Building, Toronto.

Raymond. D.L.C., '04, is with the Bishop Construction Co., 614 Traders Bank Building, Toronto.

Read, F. N., '11, is with the Department of Public Works, Regina, Sask.

Redfern, B. J., '10. Deceased.

Redfern, W. B., '08, is town engineer at Steelton, Ont.

Redfern, C. R., '09, is engineer for P. Lyall & Sons Construction Co.

Reid, E. V., '11, is with Ross & Macdonald, architects, 1 Belmont St., Montreal, and Traders Bank Bldg., Toronto.

Reid, F. B., '04. Address not known.

Revell, G. E., '99, is engineer with Green Bros. & Burden, at Nelson, B.C.

Richardson, C. E., '10, is Division Engineer with the B.C. Hydrographic Survey, at Nelson, B.C.

Richards, E., '99, is Dominion appraiser, in the customs department at Ottawa.

Richardson, F. L., '08, is construction superintendent for Miller, Cumming & Robertson, contractors, 50 Front St. E., Toronto.

Richardson, G. H., '88, is managing director of the Yellowhead Pass Coal & Coke Co. His business address is 24 Credit Foncier Building, Edmonton. Alta.

Richardson, C. W. B., '07, was with the Dominion Bridge Co. at Ottawa, when last heard from.

Richardson, W. A., '11, is with Bates & Roger Construction Co., of Chicago, and Spokane, U.S.A. During the summer he has been engineer for that firm on the erection of a half-mile bridge across the Fraser River at Fort George, B.C.

Richardson, W. L., '05. His address is 2303 Mercil St., Fresno, Cal.

Ricker, H. A., '08, is with the Canadian Westinghouse Co. at Hamilton. His address is 93 Sanford Ave., Hamilton, Ont.

Riddell, J. M., '13, is at present at St. Obert, Que., where he is engaged on work for the Topographical Surveys branch, Department of Interior, Ottawa.

Riddell, M. R., '04. His address is 86 Spadina Rd., Toronto.

Ridler, A. A., '07, is superintendent of the Constructing & Paving Company Limited, Toronto.

Rigsby, J. P., '01, is with the Turnbull Elevator Works, Toronto.

Ritchie, H. C., '10, was with the Department of Public Works at Calgary, Alta., when last heard from.

Ritchie, J. E., '13, is secretary of the University of Toronto Engineering Society.

Roaf, J. R., '00, is with the Yellowhead Pass Coal & Coke Co., at Bickerdike, Alta.

Robertson, A. R., '08, is sales engineer with McGregor & McIntyre, Toronto.

Robertson, C. S., '13, is with the Provincial Board of Health of Ontario, at their experimental plant, Clifford St., Toronto.

Robertson, F. A., '08, of Meldrum Apts., Toronto, is in the publicity and sales engineering department of the Toronto office of the Canada Cement Co., Limited.

Robertson, H. D., '02, is associated with Miller, Cumming & Robertson, engineers and contractors, 50 Front St. E., Toronto.

Robertson, J., '84, of 531 Palmerston Boulevard, Toronto, is commissioner of The Canada Co.

Robertson, J. M., '93, has a practice as consulting engineer at 14 Board of Trade Building, Montreal, P.Q.

Robertson, N. R., '06. His address is 415 Winch Building, Vancouver, B.C.

Robertson, D. F., '03. Address not known.

Robinson, J., '91. Deceased.

Robinson, F. J., '95, is deputy minister of public works at Regina, Sask. His address is 2839 Angus St., Regina.

Robinson, A. H. A., '97. His last address on our records is 497 Gilmour St., Peterboro, Ont.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, OCT., 1914 New Series Vol. IX. No. 6

WIND BRACING IN TALL BUILDINGS

By R. S. Patterson, B.A., Sc.

The question of wind bracing in tall steel buildings of the skeleton type has evoked considerable discussion as to methods and design in the last few years. One class of structural designers has made ample provision in the steel frame for lateral stiffness based upon direct computations of wind stresses; while on the other hand, another class has ridiculed all mathematical treatment, and used "rule of thumb" methods for design. The exact treatment of this part of building design would lead to hopeless intricacy whether diagonals, knees, or portals are empolyed to transmit the lateral wind pressures. Although an exact determination of stresses is difficult, if not impossible, it does not follow that a mathematical analysis is useless and without any rational basis. The investigation of the stability of a steel frame building subjected to wind pressures must be solved in accordance with the fundamental laws of mechanics and strength of materials as determined from the theory of flexure.

In very tall buildings the calculation of wind stresses and the design of frame work to afford the most rigid and economical resistance to them, while conforming to architectural requirements, are matters which sometimes have relatively large dimensions in both directions, the inertia of the building, the stiffness of walls and floors and the inherent strength of the beam and column connections generally used, may afford sufficient rigidity, and precise calculations are often omitted.

When the building is comparatively tall and narrow the elasticity of the steel frame makes it necessary to make definite provision against horizontal forces in at least one direction, the steel skeleton being usually considered as a vertical cantilever exposed to horizontal wind forces in every direction, in the upper part at least, and sometimes for the entire height of one or more sides not protected by adjacent buildings.

In the usual case of a transverse bent of several columns it is impossible with the means of analysis at present available to determine how much of the vertical loading on these columns is transferred by the wind pressure from each column at windward side to each column on leeward side, although it is absolutely certain that such a redistribution takes place.

This condition makes it impossible to determine with certainty both the horizontal shears transmitted through the columns, and the bending moments to which columns and girders are subjected.

The design of the steel frame of high buildings must certainly include as one of its main features suitable effective provisions for wind loads whose effects run through the entire height of the structure and by which the transferred loads influence materially the foundation pressures.

Wind Pressures

Wind pressures on small surfaces have been recorded as high as 50 pounds per square foot, but it is doubtful if such pressures exist on large surfaces, as sides of buildings. A few of the influences which affect the intensity of wind pressures will be summarized briefly.

Effect of Altitude on Wind Pressures.—Since air is lighter in greater altitudes the wind pressure will also be less. In addition to and quite distinct from this, it is also clearly recognized that the pressure varies as the distance above the general level of the surrounding territory, increasing towards the top of the structure.

Effect of Temperate Changes.—Mr. W. H. Whitten made a careful study of the effect of temperature changes, and his conclusions were:

(1) That the pressure increases as the temperature drops, if the velocity is constant and barometer readings normal.

(2) That the pressure increases and diminishes as the barometer rises and falls.

Effect of suction.—Rapidly moving air produces a suction on the leeward side, there being a partial vacuum developed in the constant vortex or eddy on this side. Professor Albert Smith reduces the following laws with regard to suction.

(1) Increase in height tends to increase relatively the average amount of suction on the leeward wall.

(2) The relative amount of air flowing around the end of building increases as the height increases.

Effect of Gusts.—The maximum wind pressures are of short duration, probably only for a second, but sometimes occur at intervals, and thereby tend to set up an oscillation in structures they are capable of influencing. To some extent the wind impulses are absorbed in overcoming the inertia of the structure, being exhausted in internal work. Should the wind come in gusts, overcoming the inertia of the building, and causing the building to oscillate, and if the oscillations and wind impulses act together, the vibration would be increased and there would be danger of the building collapsing. Existing experiments tend to indicate the period of vibration of a tall building is several seconds (about 2 to 4 seconds) and thus the likelihood of such an agreement taking place does not seem possible.

It seems advisable that the increased pressure due to gusts should be considered in designing tall building frames.

Effect of Wind on Buildings

The effect of wind pressure tends to overturn the building on its base. In tall narrow buildings this overturning effect must be investigated, and if necessary, provision made for it by anchoring the columns of the foundations. Common specifications state that if the overturning moment exceeds 75 per cent. of the moment of stability, anchorage for the columns must be provided. From the footing plan the column loads and their point of application can be taken off and by the principle of moments the point of application of the resultant weight can be found. Knowing the magnitude and point of application of the resultant weight, the moment of stability can be readily computed.

It may give way in a horizontal direction under the influence of shearing forces either by lateral displacement from its foundations or by buckling of its various members on account of their weakness to resist these forces. If the buildings were safe against overturning it would ordinarily be safe against sliding bodily, and for the sliding tendency to be considered the width of the base must be two-fifths or more of the height. The tendency to shear the connections is one of the most important features of wind pressure. Special attention should be given the column splices and the connections of floor girders to columns. The details should be sufficient to develop the strength of the main part of the member and to give the required rigidity at the joints.

Deflection in a bent to leeward due to wind pressure will be the result of a combination of three actions—first, the elongation of the tension columns and the shortening of the compression columns; second, the deflection of the floor girders; third, the deflection in the columns. Factors affecting the amount of deflection are the sizes of the columns, their unsupported heights, and the number of columns in a cross section.

In buildings in which the ordinary beam connections are used with no special bracing, as the connections are capable of transferring only small bending moments, the deflections will be large. It will be seen that if the girders cannot take care of any bending at the connections, and there is no other factor to resist distortion, then the frame must simply close upon itself under lateral forces.

The few experiments on the deflection of tall buildings seem to reveal the fact that the actual deflection is less than the computed. Experiments on a seventeen story building by Dr. Melick show that walls and partitions reduce the deflection about 40 per cent., and they seem to be secondary and not primary agencies in resisting distortion to wind. His conclusions were that, when proper account is taken of the velocity and pressure of the wind, vibrations and deflections computed on the basis of the steel frame resisting all the pressure, will be only slightly in excess of those actually existing.

A twisting as well as a direct deflection will be induced in the building if the bracing is not symmetrically disposed with respect to the centre line of the building.

Necessity of Wind Bracing

The New York building by-law requires that all buildings exposed to the wind (except those under 100 feet. in height in which the height does not exceed four times the average width of the base) be designed to resist wind pressure. This may be regarded as representative of the type of building requiring no bracing.

In structures of the skeleton type which have relatively large dimensions, the dead weight of the building, the stiffness of the walls, partitions and floors, and inherent strength of column and girder connections may afford sufficient rigidity, and precise calculations are often omitted. The relative merits of each of the elements mentioned in the above statement for resisting wind pressures will be discussed in detail.

The stability of a steel frame building must depend upon its dead weight or its steel framework. The weight of the building affords some resistance but it is not altogether a dependable quantity. The greater the weight the greater the moment of stability. The moment of stability may be computed as previously outlined under "Effect of Wind on Buildings."

Distortion may be resisted by the compressive strength of the curtain walls, but as they are usually cut up by numerous windows they cannot be relied upon to act in conjunction with the steel frame.

Partitions as ordinarily constructed are too thin to resist shearing stresses, and their location is never definitely and finally known to the designer, in as much as they are liable to removal at the will of the tenant. They are often omitted permanently on the first floor and in many cases are not put in the upper floors until rented, when the tenants' wishes as to subdivision can be learned. Mr. Purdy states that if partitions be omitted on one floor it is nearly as bad as if they were omitted on several. It is doubtful if much reliance can be placed upon partitions for cross framing to transfer shearing stresses into vertical reactions.

Floors are effective in producing a redistribution on wind stresses from the windward to the interior and leeward columns. Tile arches assist the wind bracing of the structures because they fill the total depth of the steel beams, and act as horizontal bracing for the entire structure. In comparison with this, concrete floor slabs rest only upon the upper third of the beams and are usually one-third the depth of tile arches. They cannot efficiently transmit the horizontal stresses, and, by reducing the efficiency of the floors as braces, increase the amount of steel necessary to provide against horizontal stresses.

There is also some resistance to lateral strains combined through the various connections of the beams, girders and columns, but it is proportional to the details employed in such connections.

The above considerations will not readily admit of calculations and in using them much will depend upon the experience and judgment of the designer.

It may be said that partitions, walls, floors, etc., as ordinarily constructed, cannot be relied upon to act in conjunction with the steel frame in resisting wind forces, and there will be a limit beyond which the steel frame can take up such forces. Modern steel office buildings as built to such great heights, especially in proportion to their width, are so destitute of the ordinary means of resisting wind forces that it is necessary to give the subject much more consideration. The designer cannot rely upon the elements of strength, uncertain in value and irreducible to calculation. He must make provision in his design of the steel frame to resist these horizontal forces and reliance must be placed upon some form of metal bracing to carry wind stresses. This may be obtained by means of rigid connections and special bracing members. In many high buildings, for example, the Woolworth Building, the entire wind stresses are carried by the wind bracing, no reliance being placed upon walls or partitions, except parallel to the long side of the building. The tower was designed independently as if standing alone.

The steel frame is generally run up ahead of the walls and partitions. In several instances the frame work has been wrecked during erection; in other cases it was found to sway under wind pressure, making it necessary to put in temporary bracing to stiffen the framework. The steel frame of a building should be treated as an independent structure the same as the towers of a viaduct, and should be able to resist the wind forces on all surfaces exposed during erection. This should be accomplished by substantial bracing or by designing the column and girder connections so that they may be able to resist the bending stresses produced by wind pressure. Mr. C. C. Schneider specifies that the steel frame work shall be designed for a wind pressure of 30 lbs. per sq. ft. on all exposed surfaces composing it, and the frame work shall be considered as an independent structure without walls, partitions or floors. In proportioning the members of the structure for these temporary wind strains it is permissible to use higher unit stresses than for permanent work, *e. g.*, 20,000 lbs. per sq. in.

The Municipal Building, New York, is 25 stories high and has large lateral dimensions. No special bracing was used but reliance for resistance to wind pressure was placed on its inertia, the stiffness of its girder connections, and the strength of its hollow tile floors. The curtain walls were begun several stories up from the curb. After the curtain walls had been placed in for a few stories above this level the framework began to sway under wind pressure and it was necessary to fill in the lower stories before erection could be continued. This shows that the steel framework must be proportioned for wind stresses during erection.

Observers will have noticed cross sections of buildings of similar dimensions and almost identical in character and general planning—where one structure is made to depend upon cross-partitions, end walls and the ordinary girder connections, with columns for trans-

Plate-I

Typical Framing Plans Showing Plan Layout of Wind Bracing

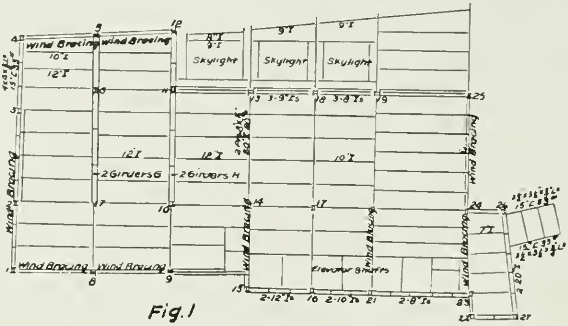


Fig. 1

Third Floor Beam of the Trust Company of America Building showing plan layout of Wind Bracing.

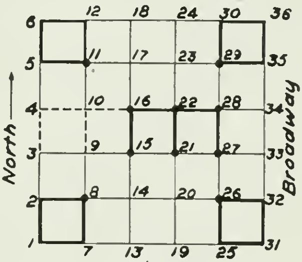


Fig. 2

Plan of Wind Bracing in Singer Bldg.
Heavy full lines wind bracing to 33^{rd} story on corners, to 36^{th} story on interior. Heavy dotted lines indicate wind bracing to 14^{th} story (main bldg.) Fine lines indicate no diagonal wind bracing. Circles on column intersections indicate anchor bolts.

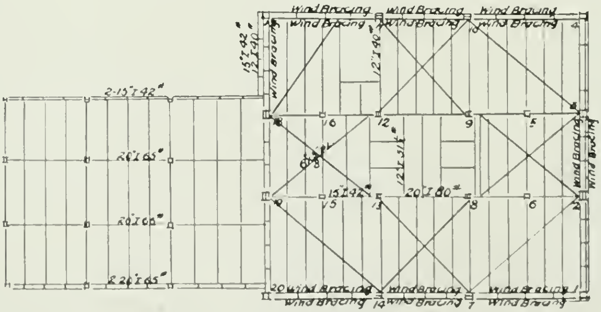


Fig. 3 Beam Plan of Metropolitan Tower

ferring horizontal stresses to the foundations, while the other has a distinct system of structural bracing capable of caring for similar forces. It would seem that either one owner was put to unnecessary expense or that the other has not proper insurance on his structure. The question naturally presents itself, whether modern steel buildings are being constructed with the same factor of safety against the various forces to which they are subjected, whether vertical, horizontal, or otherwise. From an engineering standpoint it seems reasonable to provide for each of the destructive forces to which it is subjected to a degree at least proportionate to their probabilities.

Disposition of Wind Bracing

The bracing, no matter which type is used, should be vertical and reaching down to some solid connection at the ground. It should be arranged in some symmetrical relation to the outlines of the building. For example if the building is narrow and is braced crosswise with one system of bracing it should be braced midway between ends of the building. If two systems are used they should be equidistant from the ends. The symmetrical arrangement is necessary to secure an equal service of the systems and prevent a tendency to twist.

It is believed to be economical to brace each transverse bent. The girders must be designed to act as wind bracing and the columns proportioned for both axial and bending stresses from wind. If the ordinary girder connections are used in a transverse bent, it does not seem likely that the columns on these sections can receive any appreciable wind stress, either axial or bending. Each braced bent must be designed for the full force of the wind contributory to the area under its influence. The proper selection of sections for the economical disposition of wind bracing must remain a matter of judgment.

In Plate I. some typical framing plans, showing plan lay out of wind bracing, are shown. *Fig.* 1 shows plans of bracing in the Trust Company of America Building. The bracing is symmetrically arranged, and as knee bracing is used it is mainly placed in the exterior walls so as not to interfere with the floor space. *Fig. 2* shows plan of bracing in the Singer Building. The wind stresses are resisted by 25 panels of vertical diagonal bracing between pairs of columns. A continuous system is used in the interior, while each corner has four braced panels. *Fig. 3* shows the disposition of the bracing in the Metropolitan tower. A continuous system of detached and solid web knees were used and placed entirely in the exterior walls. Horizontal X bracing was placed in the floors to distribute the wind loads to the interior columns.

Wind Bracing by Rigid Connections without Diagonals, Knees, Gussets or Portals

In buildings of relatively large dimensions, in which the ratio of height to width is small, sufficient lateral stiffness to wind pressure may be secured through rigid column and girder connections without introducing special wind bracing in the steel frame.

The following types are effective in producing greater rigidity at the joints and connections.

Type 1.—Continuous column splices. — Considerable stiffness may be secured by using continuous column splices, where the columns are made in two story lengths and staggered as to splices, i.e., only every alternate column is spliced at a floor. In present practice, however, all columns are usually spliced at the same floor, thus facilitating erection. When column splices are properly made they may be considered stronger than the main section of the column. The splice should be of sufficient strength to take the shear and flange tension due to bending.

Type 2.—The use of beam connections in framing beams and girders to columns.—The ordinary method of framing beams and girders is by means of shelf angles and column brackets. This does not stiffen the frame to any extent. A much more effective method is secured by using the ordinary beam connections in framing the beams and girders to the columns. This type of bracing was used in the upper eight stories of the Dominion Bank Building, Toronto. The beam connections stiffen the frame during erection as well as after the building has been completed. A stiffer frame will result if the beams run transverse to and the girders parallel to the longest dimension of the building. A beam should come at each column in order to give lateral stiffness to the frame.

Type 3.—Greater rigidity may be secured by using beam connections and also rivetting the flanges of girders and beams to the columns by means of corner angles. The usual corner angles are 8 x 6 in. or 8 x 8 in. Buildings are not ordinarily figured for wind longitudinally; this type seems to be amply suited for bracing the building in that direction. This method has been employed in the United Fire Companies building, New York, and the Continental and Commercial National Bank Bldg., Chicago.

It is known that beam connections are capable of transferring only small bending moments and that the columns can take only a small wind stress, either axial or bending. Mr. Forchhammer states that beam connections are not rigid but flexible. As to whether rigid or flexible connections are preferable in steel frameworks is a matter of some importance. The rigidity obtained by rigid connections is followed by the uncertainty of statically indeterminate structures. The stresses due to uneven settlement of columns for instance, may run very high in rigidly connected frameworks. Mr. Forchhammer favors the use of rigid connections at the side columns and flexible connections at the inside columns. However, to concentrate all the wind resistance in the outside columns does not seem advisable as the effect of uneven settlement might be more serious in this case, for in the outside, columns in which the whole stiffness of the frame lies might be seriously over strained. It would seem that a stiff connected frame is the only proper and practical solution of the problem.

Type 4.—By deep web connection angles.—Sometimes it is advantageous to obviate special bracing as diagonals or knees, which tend to obstruct the clear floor space and which require difficult connections. A good substitute may be had if floor girders and beams are web-connected to the columns so as to give very deep and rigid joints that can be relied upon to develop sufficient stiffness to resist distortion from wind pressure. In the City Investment Building, New York, deep heavy connection angles were shop-rivetted to the columns and field rivetted to the webs of the I beams.

Type 4.—Continuous wall girders.—In this type the wall girders are made continuous across the face of the column for the whole length of the building. The webs of the girders are carried past the flanges of the columns, the inner flanges being cut flush with the web. The connection between the wall and the girder is made by a deep gusset plate rivetted across the face of the column and serving both as a splice plate and a knee brace against wind stresses. The gusset plates are usually connected by heavy connection angles to the outside of the column flange, the gusset plate being parallel with the column web.

This style of wind bracing has the advantage of avoiding all tension on the head of the rivets and transmits the stress entirely through direct rivet shear. It is, therefore, theoretically advantageous and proves easy and cheap in construction and erection. In a 35 story office building in Seattle, rigidity against wind stresses is given to the building by a continuous belt of 30 in. wall girders running around the entire building. The gusset plate is field-rivetted to the girder webs and field connected to the flanges of the columns by heavy connection angles shop-rivetted on the outside of both the column flanges.

Type 6.—Horizontal X bracing or trussing in the floors is sometimes used to distribute the stresses among the interior columns, particularly if the vertical wind bracing is placed entirely in the exterior walls. The horizontal bracing used on the 4th and the 6th floors of the Commercial Bank Building, Chicago, consists of single and double angles laid above the floor beams and rivetted to connection plates at the columns. In most cases the gussets or connection plates cannot extend through to the columns, and are rivetted, therefore, to the connection plates on the 15 in. channels forming the lines of spandrel bracing at these points.

Vertical X Bracing

The simplest form of bracing is by a system of vertical X bracing in the panels between the columns and floor girders to transmit the pressures developed by the wind pressure to the foundations. The rectangular shape of a building can be effectively and economically preserved against distortion from wind pressure by means of diagonals. For this type of bracing the stresses are statically determinate and the ease with which the stresses may be computed and the design facilitated makes this type very desirable.

Advantages and Disadvantages.—Diagonal braces of structural shapes, either angles or channels, make the stiffest bracing and should be used in a few bents of a tall building. Metal rods with pin connections have been used but modern practise shows a preference for structural shapes with rivetted connections. If metal rods are used they should be tight in every connection for if there is any play or movement possible between members it cannot be very efficient.

Architectural requirements limit the use of diagonal bracing, as it interferes materially with the window and door spaces, corridors and other features. A complete system of diagonal braces cannot be placed in the outside walls on account of the numerous windows. It can often be arranged in the interior walls and partitions with no inconvenience to the design of the building.

Diagonal bracing imposes the condition that a comparatively thick partition be placed in the plane of the bracing for cover and protection of the steel. In the ordinary office building this condition divides the floor surface into box-like suites, usually of the same shape and size. No large opening, no freedom in the selection of a position for an opening or corridor—in short, no effective architectural medium—can be used for joining adjacent suites through such a partition. Usually the doors must be small and also in the centre of a panel or in one side, according to the type of diagonal bracing used. Corridors must either extend along the wall, thus cutting off a great deal of window light or down the centre of a panel, creating a row of offices on each side of the hall. These limitations will often result in very shallow offices and sometimes in no direct communication between suites.

Analysis of Stresses

Diagonal bracing is essentially a two column or single panel type of bracing, the usual practice being to brace odd panels rather than a continuous system. Such a braced frame is usually regarded as a cantilever truss fixed at the ground by its own weight. The diagonal members are similar to the web members of a truss and the columns act as the chords of the wind truss. The columns may be either in tension or compression, according to the direction of the wind and in the latter case it is added to the static load.

The wind pressure is assumed to act horizontally and applied at the panel points.

The exposed area tributary to a panel point is equal to the sum of one-half the story height at the point plus one-half the height of the story below, multiplied by the width of the area affecting the bracing in the panel under consideration.

From a study of a stress diagram it will be seen:

(1) That the compression (or shear as it is commonly called) in any floor girder is equal to the load at that point plus all of the panel loads above.

(2) The stress in any diagonal is equal to the shear in the floor girder above multiplied by the secant of the angle which the diagonal makes with the horizontal.

(3) The compression in the upper story leeward column is

equal to the vertical component of the stress in the diagonal. The compression in the leeward column of any story is equal to the vertical component of the stress in the diagonal in that story plus the compression in the column of the story above. The vertical component of the stress in the diagonal is equal to the shear in the floor girder at the top of the story multiplied by tan of the angle between the diagonal and the horizontal. If we denote this vertical component by the term increment, then the compression in the leeward column equals the increment for that story plus the compression in the story above.

(4) It can be seen that the tension in the windward column in any story is equal to the compression in the leeward column in the story above.

(5) The uplift at the base of the windward column is the quotient of the moment of the resultant wind and the distance centre to centre of the columns. If this uplift exceeds the weight of the frame and its loads, anchorage of the column to the foundation will be necessary.

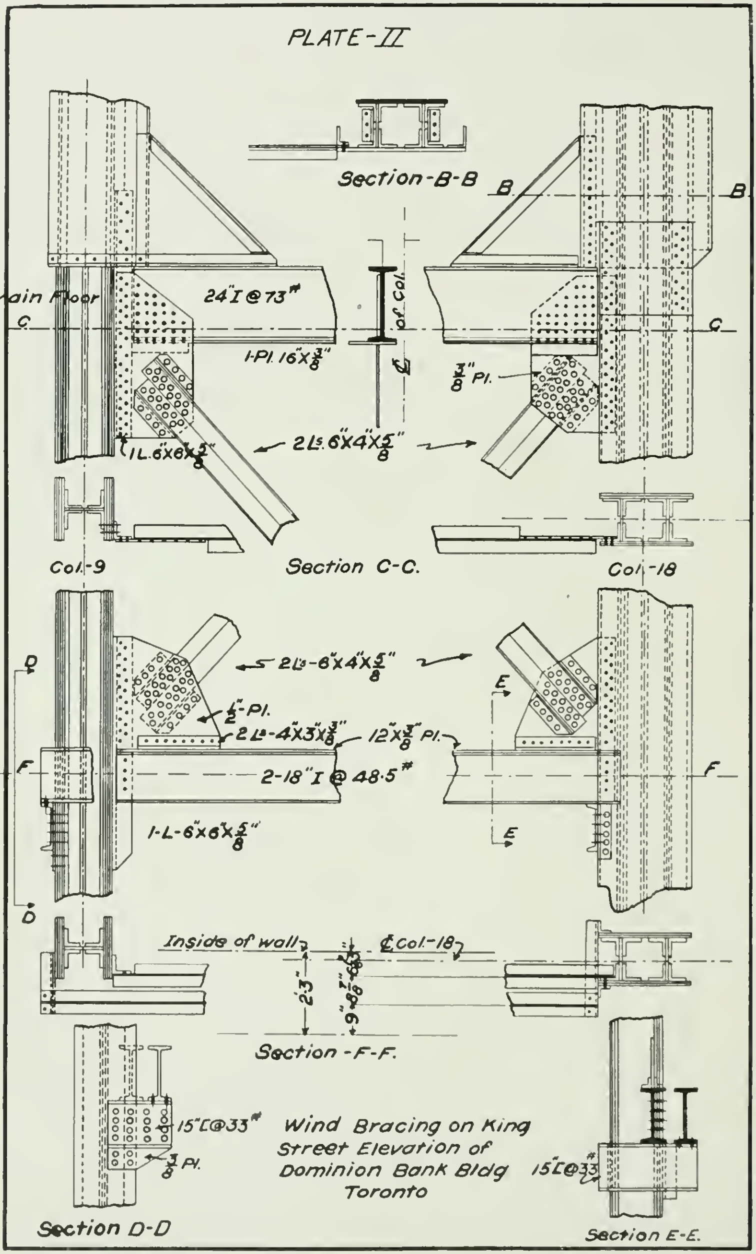
Plate II shows typical details of diagonal bracing in the Dominion Bank Building, Toronto.

The column stresses from wind on this type of bracing are direct and statically determinate. In practice the diagonal members frequently cannot be designed so as to have the gravity axis of the columns, girders and diagonal members meet in a common point and some bending stresses result in the columns and girders. The floor girders are usually shallow and though the connections are rivetted they cannot be said to be rigidly connected, and the bending moments in the columns and girders due to whatever rigidity these connections may have are neglected. With diagonals, the stresses in theory are all direct, and there is no bending, with rivetted connections. However, as is usually the case in buildings, there will be secondary stresses due to the elongating and shortening of the members that take direct stresses.

The tensile stress in the windward column must not exceed the dead load plus a small live load; otherwise anchorage must be provided to resist the upward reaction, and the column spliced for tension. When this occurs the limit of efficiency of the bracing is reached, as it is impracticable to anchor or splice the columns. The dimensions and weight of a building are usually such that, considered as a whole, its moment is sufficient to give it stability against overturning, but in rare cases the margin has been so small that additional security has been provided by anchoring some of the columns to the foundations, notably in the case of The Singer Tower in New York.

Wind Bracing without Diagonals

In a steel frame building with rectangular panels, i. e., without diagonals, its stability is dependent on the bending resistance of its various members. A correct determination of the stresses due to vertical floor loads as well as to horizontal wind forces, requires a consideration of the deformations of all the members of the frame.



Wind Bracing on King Street Elevation of Dominion Bank Bldg Toronto

Hence, the stresses are statically indeterminate and the stresses in each member are functions of all those in all the other members.

The rigid solution is too long and cumbersome for practical use in actual designing and approximate methods must be resorted to. For simplicity it is customary to figure the wind stresses independent of the direct stresses from vertical loads. This practise has led to the development of several approximate methods each with specific assumptions as to distribution of direct stresses and column shears. Some of the assumptions made for determining wind stresses will not hold under vertical loads. No assumptions that can be made will give correct stresses when the columns and girders are proportioned for direct loads and bear little or no relation to the stresses induced by the wind.

It is common to consider a transverse bent of a steel frame building as a cantilever beam, uniformly loaded, the columns acting as flanges and taking a part of the vertical reaction proportional to their distance from the neutral axis.

Location of the Neutral Axis

Before the direct stresses in the columns can be determined it is necessary to locate the neutral axis of the bent.

The neutral axis is determined by the column spacing and their sectional areas, and it is found independent of vertical loads. It can be readily computed, if we consider vertical loads, when we know the magnitude and point of application of column loads on the footings. This neutral axis will not be coincident with the centre line of the building, unless the loads are symmetrically applied to the footings. In a steel frame building this is but seldom the case. A heavy spandrel wall on one side and a curtain wall on the other, unequal loading due to elevator framing, stairways, vaults, etc., are some of the things which make it necessary to determine the neutral axis for each bent by independent calculations. Since the sectional areas of the columns may be taken as proportional to their loads it will be sufficiently accurate for all practical purposes to locate the neutral axis independent of column loads.

Direct Stresses in Columns

When the neutral axis has been located then the direct stresses in the columns can be determined. As in a beam under flexure the fibre stresses vary directly as their distance from the neutral axis, so in a transverse bent the direct stresses in the columns will be proportional to their distances from the neutral axis. It is assumed that all columns on the windward side of the neutral axis take a direct stress of tension and those on the leeward side a direct stress of compression.

Column Shears.—A common assumption is that the horizontal shear on any plane is equally distributed among the columns cut by that plane. This is true if each column has the same moment of inertia, but if the moments of inertia are different the horizontal shears taken from the columns will vary as their moments of inertia.

Wind Stresses in Rectangular Building Frames

The common methods for computing the wind stresses in the main members of a steel frame building with rectangular panels will be given and the method modified later where knees, plate girder, or portal bracing are used.

Cantilever Method.—This method was developed by A. C. Wilson and explained in detail in the *Eng. Record*, Sept. 5, 1908. It is slightly modified by R. Fleming in *Eng. News*, Mar. 13, 1913. The following statements are taken from Mr. Wilson's article entitled, "Wind Bracing with Knee Braces or Gusset Plates."

"If a beam of rectangular section be loaded as a cantilever with concentratedl oads, it is possible by the theory of flexure to find the internal stresses at any point. If, however, rectangles be cut out of the beam between the loads, there will be a different condition of stress. What was the horizontal shear of the beam will now be a shear at the point of the contra-flexure of the floor girders, causing bending, and, as in the beam, the nearer the neurtal axis the greater the shear. The vertical shear in the beam would be taken up by the columns as a shear at the points of contra-flexure and the amount of shear taken by each column would, as in the beam, increase towards the neutral axis. The direct stress of tension or compression in the beam would act on the columns as a direct load of either tension or compression, and, as in the beam, would decrease towards the neutral axis.

"Each intersection of column with floor girders would be held in equilibrium by forces acting at the points of contra-flexure; and to find all the forces acting around a joint at any floor the bending moments of the building at the points of contra-flexure of the columns above and below the floor in question are found as will be explained later.

"It is assumed that if a beam of constant, symmetrical cross-section and homogeneous material is fixed at both ends, and that if forces tend to move those ends from a position in the same straight line to a position to one side with the ends still parallel, reverse bending will occur with the point of contra-flexure in the centre of the unsupported span. And since this condition exists in all columns and floor girders it will be necessary to find the shears at the points of contra-flexure as well as the direct stresses in all the members."

In order to find all the internal stresses it is necessary to find the total horizontal shear and overturning moment of the wind at the line of contra-flexure of each story columns.

After finding the position of the neutral axis and the direct stresses in the columns, the method of finding the column and girder shears and moments will be the same for the general as for the special case in which the sectional areas and column spacing are equal.

Portal Method "A" (Column Shears Equal)

Assumptions:—(1) The bent is assumed to be a series of independent portals.

(2) The shears taken by each column are proportional to their moments of inertia.

For equal column spacing and assumed equal moments of inertia, the interior columns have their vertical components neutralized by the equal stress of opposite direction caused by the contra-flexure of the columns, and the outside columns take all of the vertical reaction of the bent. If the spacing between columns is unequal, the direct stresses from adjacent panels are unequal. The resultant is a direct stress between the two portals considered.

The direct stresses in the interior columns are zero and outside columns only have direct stresses. The direct stress in the outside columns at any story is equal to the overturning moment about its point of contra-flexure divided by the width of the bent.

Portal Method "B"

It is assumed that the interior columns take twice as much horizontal shear as the outside columns. This assumption gives a much better distribution of metal and seems to be a more rational assumption than that of method "A."

If the building has self supporting walls and the outer columns carry floor loads only, assuming the moments of inertia of the outside columns to be one-half that of the interior columns, the shear taken by the outside column will be half of that of the interior columns and the problem is similar to the preceding one. It will be observed the moments calculated by this method compare favorably with those calculated by the cantilever method.

A justification of the assumption made in this method is herewith given. In a rolled beam or plate girder it is common to assume the shear as uniformily distributed over the entire cross section. The intensity of the shear at any point is equal to the total shear divided by the area of the web plate. The portion of the total shear taken by any section of the plate would then be equal to its depth divided by the depth of the girder.

Knee Bracing

Types.—1. Detached Knee Braces.

2. Solid web knee braces, brackets, or gusset plates as they are commonly called.

Detached Knees.—Detached knees are usually built of structural shapes, either angles or channels. Where the stresses are small the brace may consist of a single angle or two angles back to back as in the Dominion Bank Building. For moderate stresses a single channel or two channels back to back may be sufficient. In the lower stories of tall buildings where the stresses are large, very deep and heavy knees must be used if there is to be any considerable reduction in bending stresses.

Solid Web Knees.—A very efficient wind brace member is a deep plate girder at each floor level with a special end connection either by means of large gusset plates or an extension of the column web.

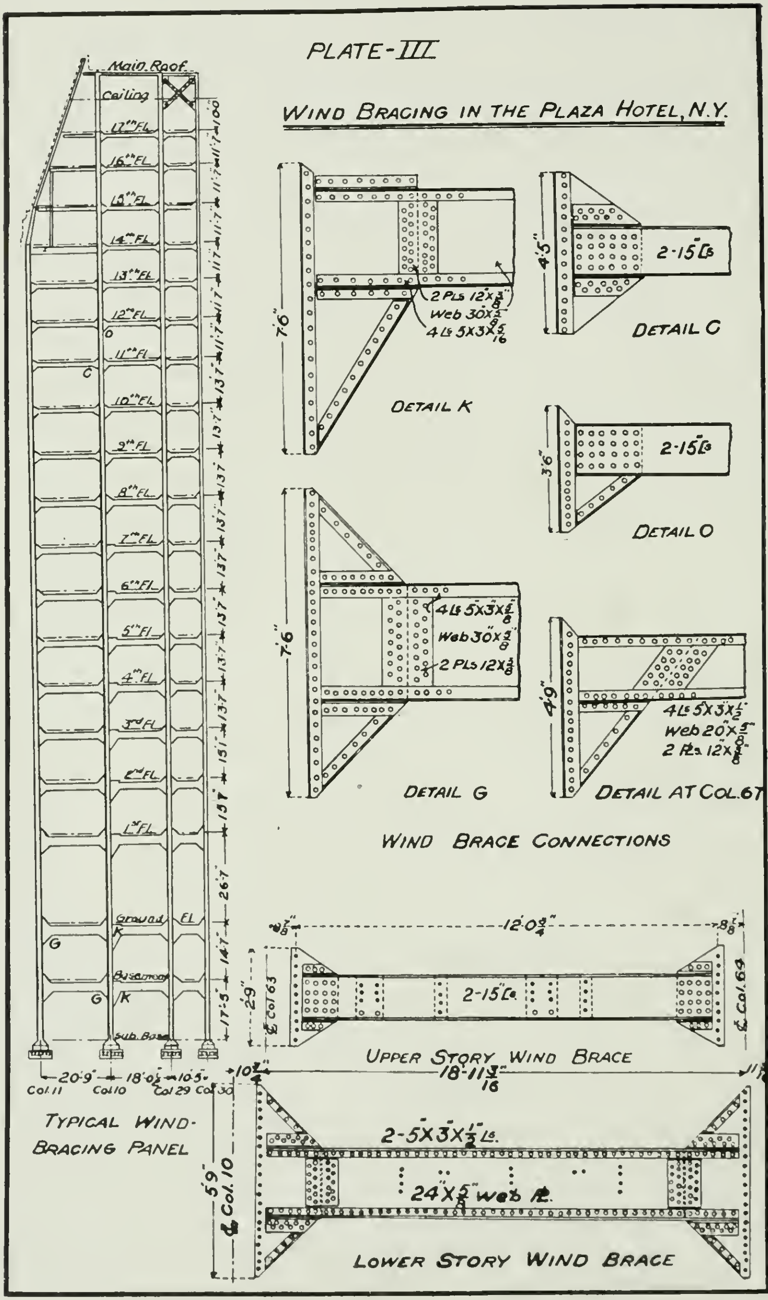


PLATE-III
WIND BRACING IN THE PLAZA HOTEL, N.Y.
DETAIL K
DETAIL C
DETAIL O
DETAIL G
DETAIL AT COL. 67
WIND BRACE CONNECTIONS
UPPER STORY WIND BRACE
TYPICAL WIND-BRACING PANEL
LOWER STORY WIND BRACE
Main Roof
Ceiling
2-15" [s
24"X5/8" web Pl.

The gusset plate is well illustrated in the Plaza Hotel, New York on Plate III. The girder web is cut short at each end and a special end connection made with a large gusset plate shop-spliced with double splice plates to the girder web. The gusset plate extends above and below the top and bottom flange of the girder forming double knee braces integral with the girder. The gusset plate may be field-rivetted, either directly or by means of connection angles, to the column flange. The gusset plate is usually stiffened with 3 x 3 in. angles, and the upper and lower flanges of the girder are shop-rivetted with connection angles to it.

In the Woolworth Building, New York (see Plate IV, Figs.4 and 5) the gusset plate is shop-rivetted to the columns and field-rivetted with double splice plates to the girder web. The bottom flanges of the girders are field-rivetted both to gusset plates and to horizontal shelf angles shop-rivetted to the gusset plate. This arrangement provides for convenient support and assembling during erection and makes all the field-driven rivets accessible.

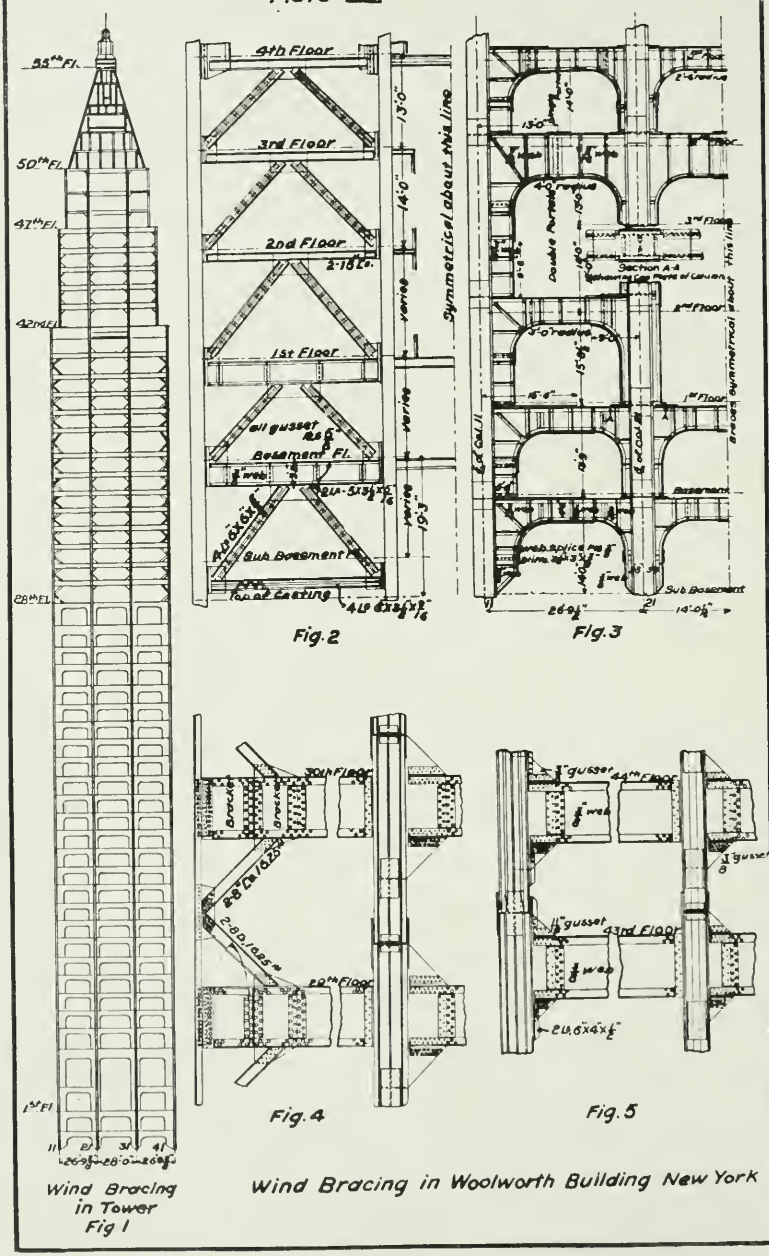
In the Union Central Life Insurance Building, Cincinnati, the column web is extended to make the connection. The girder web is cut short to clear the projecting section of the column web which is field-rivetted to it through double splice plates. The upper flange of the girder is connected to the column web by connection angles, shop-rivetted to the flange and field-rivetted to the column web. The lower flange engages the column web through connection angles, field-rivetted to the flange-angles and shop-rivetted to the column web. These horizontal angles serve as brackets for the girders during erection.

When the solid web type of knee brace with deep plate girders is used the girders must be rigidly connected to the columns. This can only be accomplished by properly connecting the flange angles as well as the girder web to the column. The large bending moments at the connection require an extension of the column web to make the connection properly. This type of connection is expensive and difficult to make in the field. The best substitute is the gusset plate connection, but this is not as satisfactory as an extension of the column web.

Discussion on Knee Bracing.—Knee bracing, whether detached or solid web knees, while an effective and efficient method, is not often a practical method of bracing a building, except in the end or wall sections of a building because of the interference of the knee with the floor space.

Knee braces do not appreciably diminish the bending in the columns unless placed both at top and bottom of girder; and for economy double knees should be used. In general no advantage is gained by making top and bottom knees of different depths. If knees are used only at top of story they should be deep and heavy. The deeper the bracing the greater will be the reduction in bending stresses. If the double knees be deep enough to intersect the column at mid-story height, the bend ng in the columns will be reduced to

Plate-IV



Wind Bracing in Woolworth Building New York zero. The same is true of the girders if the knees intersect the girder at mid-span.

When the solid web knee brace is used, the bending stresses will be carried mainly by the stiffening angles. Although the solid web knees are not usually deep, they are usually stiffened by 3 x 3 in. angles; it is recommended that if the knees are made deep, the angle stiffeners should be made about half as heavy as when they compose the entire brace. The extra cost of the solid web knee brace is warranted, as the extra metal is not lost; it gives a very rigid joint, takes care of the large bending moments at the connections, and besides per orms the function of a knee brace.

Portal Arch.—Where exceptional stresses require heavy bracing the portal arch has been used, notably in the Woolworth Building.

The Portal Arch consists of a solid web plate out of which the arched opening is deducted, stiffened by angles bent to the curve of the opening. The bracing is field-rivetted by means of connection angles to the flanges of columns and girders. In the Woolworth Building (see Plate IV, Fig. 3) the portals were proportioned for the combined stresses due to live and dead and wind load. The portal webs were field-rivetted to the columns through the projecting cover plates of the latter.

Working Stresses for Wind Pressure and Specifications

The impracticability of using diagonal braces in the majority of buildings makes it necessary to have recourse to solid web or detached knee braces, and deep plate girders to provide the requisite lateral stiffness in at least some directions. When the diagonal is removed its stress is taken up by bending in the columns and floor girders. The columns and floor girders must be designed to carry the resulting and combined stresses.

The method of combining bending with direct stress in such members as columns and floor girders is not simple, involving as it does functions of the correct section (section modulus) and is necessarily a matter of trial. It is difficult to assign judicious working stresses in such a combination especially as there are practically no experimental data to guide the judgment. It is practically certain that the greatest permissible stress where bending is involved may be greater in a member than where a stress in a member is all direct, for in the former case the greatest stress exists along a line and not uniformly over the entire cross section. It is an open question that an excess of 10 to 20 per cent. may be permitted.

Most building by-laws have the common specification of 30 lbs. per sq. ft. for wind pressure, on the actually exposed surface and permit an increase of 20 to 50 per cent. in working stresses for combined stresses due to wind, live and dead loads; but the section shall not be less than if the wind forces be neglected. Chicago and San Francisco specify 20 lbs. per sq. ft. with an increase of 50 per cent. in working stresses. C. C. Schneider in his "General Specifications for Structural Work of Buildings," calls for a wind load of 20 lbs. per sq. ft., and allows an increase of 25 per cent. for bracing and combined stresses due to wind and loading. Ketchum's specifications for "Steel Frame Buildings" perm't an increase of 50 per cent. in working stresses for combined stresses.

GEAR MATERIALS

C. B. HAMILTON, B.A.Sc. '06.

Some of the data which has been prepared for publication in the hand book of the Hamilton Gear and Machine Co., is of a nature to be of general interest to engineers. An intelligent choice of proper materials may, and often does, make the difference between success and failure. This applies with especial force to elements of machines which must resist two or more kinds of hard usage. Gears, for example, must resist static loads, shocks and also surface wear.

The whole tendency of modern practice is towards the use of high grade materials and better workmanship. In gears this means a smaller size for the same power with a consequent lowering of pitch line velocity. From this directly follows a reduction in noise and wear. Often it is possible thus to increase the speed of revolution of the whole mechanism and save doubly on the size of the various parts.

Cast Iron is the commonest material for gears. Its weak point is lack of toughness which makes it unsuitable for pinions. Steel pinions are frequently used to mate with cast iron gears. The teeth of the pinion are subjected to much greater stress than those of the gear. Semi-Steel is cast iron with the addition of a percentage of steel. It is stronger than cast iron.

Steel Castings make the strongest gears for large work but care must be taken to secure sound blanks as this material is subject to blow holes and shrinkage strains. Careful foundry work and annealing of the castings will overcome these difficulties. Open Hearth Steel should be used for gear work.

Steel Forgings are superior to steel castings both as to quality of metal and certainty of freedom from unseen defects. They can be made in a wide range of carbon contents giving a choice of hardness. This material is the best at moderate price for pinions.

Machinery Steel is similar material to that in steel forgings but is commonly finished in rolling mills instead of under a steam hammer or hydraulic press. Bessemer steel is not usually considered good enough for gears. Open Hearth should be used unless the job warrants the expense of crucible steel.

Alloy steels containing various percentages of metal such as nickel, chrome, vanadium, etc., are in common use for automobile and other high grade gears. They are produced by both the open hearth and crucible processes and are usually drop forgings. This material is expensive but of high quality, and is always heat treated to develop its superior qualities. There are two classes according to method of heat treating. First, case hardening steels which only harden after being pack carbonized and remain soft at the core. Second, tempering steels which, when heated and quenched will harden clear through and should have the temper drawn down afterwards to give toughness. The former are used for rear axle bevel gears and the latter for transmission and clash gears.

Bronze is a good and reliable material. Brass is of very little use except for the flanges of rawhide pinions. For this work a good red brass is suitable. For gears or pinions it is best to pay a few cents more per pound for No. 1 Government Bronze, 88 C, 10 T, 2 Z, or a phosphor bronze of similar proportions.

For worm wheels the 2 Z is sometimes replaced with 1% Zinc and 1% Lead. Cheap worm wheels are made of C. I. and driven by steel worms. High grade work calls for bronze wheels and case hardened steel worms. The best worms are hardened and ground.

For silent drives, rawhide, fibre or cotton is used for the smaller gear. These materials are held between flanges, riveted or bolted together. Rawhide or Cotton is about equal in strength to Cast Iron, while fibre is about half as strong.

Large gears, especially bevels, are sometimes made with wooden teeth for smooth running. The smaller gear would be cast iron with the teeth about 35% of the circular pitch in thickness. The larger gear would have maple cogs set in mortices in the cast iron body and fastened with keys on the back.

Gears running together of like material, especially if it be soft, wear rapidly, just as in the case of a journal and bearing. This does not apply to cast iron, which forms a glaze or skin in service.

On October 8th Mr. W. G. Chace, B.A.Sc. '01, Chi f Engineer of the Greater Winnipeg Water District, addressed a meeting of the Manitoba Branch of the Canadian Society of Civil Engineers. He explained many of the features of the Shoal Lake water project, now under way and traced the efforts of the city of Winnipeg to obtain an adequate water supply, leading up to the adoption of the present undertaking.

Mr. C. H. Mitchell, C.E., '92, who is with the first contingent, has been promoted to the rank of Lieutenant-Colonel. He has also received an appointment to the position of General Staff Officer on the Headquarters' staff of the first contingent, which is one of the highest appointments given to a militia officer in Canada.

B. H. Hughes, '16, on account of illness, was unable to sail with the first contingent, but will accompany the second contingent when they leave for Europe.

We understand that Messrs. H. A. Heaton, '15, G. B. Taylor, '14, and L. C. M. Baldwin, B.A.Sc. '13, who were in England when war was declared, have enlisted with the forces there.

SWORD-ISMOND

On Monday, October 12th, Mr. A. D. Sword, B.A.Sc., '08-'09, of the engineering staff of C. W. Noble, Toronto, was married to Miss Lillian Fredericka Ismond, Toronto. Mr. and Mrs. Sword will reside at Clarkson, Ont.

WILSON-BARBER

On Thursday, October 15th, Mr. H. P. Wilson, B.A.Sc., '14, superintendent of construction for the Elias Rogers Company, was married to Miss Eleanor Mae Barber, youngest daughter of Mr. and Mrs. Timothy Barber, Toronto.

Mr. T. Kennard Thomson, D. Sc., '86, has been appointed by Governor Glynn, of New York state, a member of the Atlantic Deeper Waterways Commission. This commission has under investigation a system of canals to extend from Florida to Maine, with a total length of between seven and eight hundred miles and at a probable cost of $35,000,000.

J. B. Challies, B.A.Sc., '04, superintendent Water Power Branch, Department of Interior, Ottawa, recently was elected an associate member of the American Society of Civil Engineers.

J. M. Duncan, B.A.Sc., '10, has been commissioned engineer-lieutenant, R.N. on H.M.S. Victory for the duration of the war.

E. A. Twidale, B.A.Sc., '14, who is color-sergeant, F Company, 44th Regiment, is at Allanburg, Ont., with the guard on the Welland Canal.

C. C. Rous, B.A. Sc., '13, is with the corps of engineers, established by the Canadian General Electric Co. for service at Quebec, Can.

R. A. Campbell, '09, has resigned his position as superintendent of the Tagona Water & Light Company, Sault Ste. Marie, Ont. We understand that he is succeeded by Mr. R. D. S. Beckstedt, B.A.Sc., '09, who was formerly sales agent for the same company.

M. C. Hendry, B.A.Sc., '05, chief engineer Manitoba Hydrographic Survey, Water Power Branch, Department of Interior, addressed the recent Irrigation Congress in Calgary on the power and storage investigations of the Department on the Bow River, west of Calgary.

S. A. Hustwitt, B.A.Sc. '14, is employed at Homer, Ont., on Section No. 2 of the Welland Ship Canal.

The following "School" men, in addition to those mentioned heretofore in "Applied Science," accompanied the first Canadian Overseas Expeditionary Force: N. R. Robertson, B.A.Sc. '06, M. B. Watson, B.A.Sc. '10, R. V. Macauley, B.A.Sc. '11, A. G. Gray, B.A.Sc. '13, C. B. Ferris, '13, W. W. Code, '15, D. H. Storms, '15, C. P. Cotton, '15, G. L. Magann, '15, Hal. Wallace, '15, Hugh D. Wallace, '16, R. W. Harris, '16, A. P. MacLean, '17, T. S. Glover, '17, F. L. Eardley-Wilmot, '17, P. C. De Gruchy, '17.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL

THE WAR AND THE ENGINEER

War has an interest for the engineer which it cannot have for the layman or for men of other professions. Engineering is a profession on which the country relies, alike for its machines of war and of peace, from a battleship to a barbed wire entanglement on the one hand, and from a power station and manufactories to a plough-share on the other. It suffers perhaps more severely than any other profession from the decreased activity in commercial enterprises and the cessation of construction and progressive improvement, caused by the great international conflict. The engineer has reason to be, and is as eager as anyone to avert war, but now that the machines and implements of his making have been brought into action in defensive and offensive capacities, the great struggle affords him a field for study which does not present itself to the other professions.

The four chief elements which make for success or failure in war are, (1) The resources of the country concerned; (2) The materials and implements of warfare used; (3) The officers and men engaged; (4) The statesmen who control the policy. To the engineer falls the duty of developing the natural resources of the country and the machines of warfare are the finished product of his efforts to render those resources of greatest service. He also contributes his share toward the latter two elements which play so important a part in determining the destiny of a nation.

The engineer was originally a soldier, the builder and destroyer of fortresses, the maker and user of cannons, and to him war has always presented a distinctive field for scientific study regarding the efficiency of his productions, and for a scientific test of the theories applied in the embodying of new materials in new offensive and defensive machines of war.

In the short interval that has elapsed since the South African war, he has given many new things to the army and navy, and while entertaining a horror for the destructive operations of such a gigantic conflict, he seizes the opportunity to learn where weaknesses are to be found, to compare the strength and value of different machines, and to determine where improvements can be made. The South African war has taught us many things about field artillery and those lessons are embodied in our new 18 lb. field piece which we believe is superior to any others in the world. It will be determined during the war whether the smaller field gun, which throws a 15 pound shell, makes up in muzzle velocity for what it lacks in weight. The carriages for the field guns have also been greatly modified during the last few years. The old form of carriage that recoiled with the gun has given way to the modern field gun-carriage, which is an elaborate structure with recoil cylinders and running-out springs. The gun runs back with but little movement of the carriage and the rapidity of fire is greatly increased. Engineers are waiting anxiously to know how great a part this highly developed weapon will play in deciding the issue of battle. The value of the airship as a machine of war will now be decided once and for all. Mechanical transport is also undergoing its first real test in the actual theatre of war.

So far our fleet has not had an opportunity of determining what value should be placed on new designs or whether the theories upon which they are based are well founded. Before hostilities have ceased we will know whether the subtlety and secrecy of the attack of the submarine will render it the dangerous factor which we believe it to be. We will find out whether the ingenuity of the engineer has made the torpedo as formidable as it seems, the deadliest and most fearful of naval arms. It will be of interest to know whether the turbines in use will be as reliable as the old reciprocating engines. In fact, there are hundreds of things which now have the keenest attention of the engineer, including the new uses of electricity, the development of wireless signalling, the new system of laying mines, and the relative strength of armour and guns.

There are other means by which the engineer can do much for the Empire. This present conflict is in reality a two-fold war. One is a war of arms and men on the battlefield; the other is a "Trade" war. The latter may yet prove to be the deciding factor in the final outcome of the struggle, and we are proud to know that while our armies have been doing such valiant service on the battlefield, our fleet has maintained supreme control of the highways of commerce. German and Austrian trade has been cut off from many countries and those markets are open to us now. We should act quickly and seize the opportunity before they have been supplied by other countries which are also on the alert. Every manufacturer desiring foreign trade should send out the best agents at his command to-day, for this is undoubtedly the psychological time.

The doctrine that we should use British-made goods has been preached rather than practised during the last few years. The policy of inter-purchasing between manufacturers in this country should be developed. One effect of the war will be to prompt engineers to specify and purchase more British-made materials than heretofore. The various municipalities of the country should assume the lead in this direction. The makers of such materials should do their share to reduce the cost as much as possible so that a continuance of the business will be assured. The policy of British-made goods for British firms can not be carried out in its entirety, but it can to a much greater extent than heretofore. So far as it is impossible to use British-made materials, we should show a marked preference toward friendly countries, including the kindred republic to the South of us.

When the war is over we will find ourselves in a new world; and Canada will emerge fresh and strong from an ordeal more severe than she has experienced before. New activity will assert itself in commerce and industry and we will have no more to do with people grown fat and listless from a long unbroken period of peace and plenty. The engineers who can maintain activity now will have a decided advantage when hostilities cease and the wheels of progressive industry and construction again assume a renewed vigor and unabated impulse. Manufacturers who keep their products before the public to-day while others are allowed to recede to the background and out of the mind of the consumer, will reap a rich return upon the resumption of industrial progress.

MILITARY ACTIVITIES AT THE SCHOOL

While men of all stations in life throughout the Dominion are eagerly enlisting to serve their flag and country, the men of our University are not idle. The same patriotic impulses and the same love of flag and freedom, actuates them. The spirit of unbounded patriotism prevades the atmosphere of the University, and the students and professors alike are eagerly preparing themselves for service if they are needed.

An application was made to the militia authorities for permission to form a Canadian Officers' Training Corps in connection with the University. At a mass meeting in Convocation Hall on Wednesday, October 21st, President Falconer read a communication from the Acting Adjutant-General at Ottawa authorizing the formation of such a corps. The object of the organization is to give the men a military training, sufficient to allow each man to qualify, if not as a commissioned officer, at least for service as a non-commissioned officer or private. No obligation to go to the front is entailed but if the opportunity comes, the men in training will be ready to respond. Over 1,500 men have already enlisted and new recruits are being added to the ranks daily.

The Engineering students are taking a very active part in the formation of the corps. On Wednesday, October 7th, a meeting of the Engineering Society was held in Convocation Hall to discuss what steps they should take toward preparing themselves for active service. Much enthusiasm was manifested and a great deal of discussion was indulged in. Colonel Lang explained the requirements in connection with the training corps if it should be authorized by the militiia authorities. On Friday afternoon, October 9th, another meeting of the Engineering Society was called. It was arranged that the recruiting of the students in Applied Science and Engineering should be left in the hands of the Engineering Society. Of a total enrolment of 525 students, over 450 have enlisted for drill. The companies of the "School" are in charge of Captain A. D. LePan, B.A.Sc. '07, who has given a great deal of his time toward the organization of these companies. Drill has been in progress for over two weeks and marked progress has been made.

A course of lectures on military engineering will be given to the engineering students, including a study of the International Morse Code used by the signalling corps. This code besides being used in wireless telegraphy, is also employed in military signalling by lamp and heliograph, and forms the basis of signalling by flags.

All lectures and laboratory work throughout the University after 4 p.m. has been cancelled, to afford the staff and students an opportunity to take the drill. A great deal of assistance is given by officers from the Barracks, who assist daily in training the recruits.

OBITUARY

A. R. CAMPBELL, '02.

The sad news was received of the death of one of our graduates, Mr. A. R. Campbell, '02, on August 20th, when he was accidentally drowned in the Rideau Canal near Ottawa. Mr. Campbell was Senior Major in the 105th Fusiliers, Saskatoon, Sask., and was in Ottawa for the purpose of offering his services to the Government when the fatal accident befell him.

Deceased was widely and well known throughout Ontario, as well as Saskatchewan. After graduating in 1902 Mr. Campbell was located in Collingwood and Sault Ste Marie, Ont. In 1903 he became resident engineer for Mr. Willis Chipman of Toronto, and was employed in that capacity until the end of March, 1907. During 1904 he was located at Lethbridge, Alta.; in 1905 he was at Strathroy, Ont., Moose Jaw and Saskatoon, Sask., and during the remainder of his association with Mr. Chipman, he was stationed at Saskatoon. He afterwards started a general Contracting and Engineering business in Saskatoon and secured several large contracts in that city.

A widow and two children at Saskatoon survive to mourn his loss. We extend our sincerest sympathy in their sad bereavement.

H. H. Brown, B.A.Sc., '14, is with the Lackawana Steele Co. at Buffalo, N.Y.

E. S. Noble, B.A.Sc., '11, is with the Northern Ontario Light and Power Co. at Cobalt, Ont.

A. G. Christie, '01, formerly Associate Professor of Steam Engineering at the University of Wisconsin, Madison, has resigned and received an appointment as Associate Professor of Mechanical Engineering, in the new Engineering Department of Johns Hopkins University, Baltimore, Md.

C. S. Clendenning is in the Engineering Department of the Pacific Great Eastern Railway, at Quesnel, B.C.

DIRECTORY OF THE ALUMNI

Robinson, L. H., '04, was resident engineer for the T. C. Ry, at Superior Junction, Ont., when last heard from.

Robinson, W. A., '08. His address is 259 Young St., Winnipeg, Man. We understand that he is right of way surveyor for the C.P. Railway.

Robinson, R. C., '08. His address is 173 Yale Ave., Winnipeg, Man. He is assistant engineer in the Canadian Northern Railway Bridge Department, in that city.

Robinson, W. E., '11. His home address is Beathton, Ont.

Roblin, H. L., '11, is assistant engineer in the Cranbrook office of the Water Right branch of the British Columbia Government.

Roddick, J. O., '06, is assistant engineer in the department of public works of Canada.

Rogers, J., '87, is town engineer at Mitchell, Ont.

Rogers, C. H., '06, is with the Peterboro Canoe Co., Peterboro, Ont.

Rogers, L. J., '08, is demonstrator in chemistry, at the University of Toronto, in the Faculty of Applied Science and Engineering.

Rolph, H., '94, is secretary to John S. Metcalf Co. Limited, Montreal, Que.

Rolfson, O., '06, is taking a post graduate course in astronomy at the University of Toronto.

Rose, K., '88, is manager of the Evans Rotary Engine Co. of Canada, Curry Building, Toronto.

Rose, R. R., '08. His home address is 65 Paisley St., Guelph, Ont. When last heard from he was in the Lands Department, Lake Superior Corporation, Sault Ste. Marie, Ont.

Rosebrugh, T. R., '89, is Professor of Electrical Engineering at the University of Toronto, Toronto, Ont.

Ross, J. A., '92, is designer in the engineering office of the L. S. & M. S. railway at Cleveland, Ohio.

Ross, J. E., '88, is on a surveying staff of the Department of Interior at Kamloops, B.C.

Ross, D., '08, is on the staff of the Toronto Power Co., 10 Adelaide St. E., Toronto.

Ross, R. A., '90, is consulting electrical and mechanical engineer at 80 St. Francois Xavier St., Montreal, Que.

Ross, K. G., '06, is with Lang & Keys, engineers and surveyors, Sault Ste. Marie, Ont.

Ross, R. B., '05, deceased.

Ross, R. C., '06. We understand he is with the Department of Interior, Ottawa, Can.

Ross, O. W., '10, has been engaged on the Welland Canal survey. His address on our fyle is 56 Chestnut Ave., Brantford.

Rothery, L. W., '11, is with the Westinghouse Machine Co., at Turtle Creek, Pa.

Rothwell, T. E., '05, is in the provincial assay office at Toronto, Ont.

Rothwell, H. E., '07, is assistant chemist with the Standard Varnish Works, at Port Richmond, N.Y.

Rowe, T. L. F., '11. His address is 57 Hallam Ave., Toronto. He is engaged as structural engineer on the Hospital for the Insane, Whitby, Ont.

Roxburgh, G. S., '04, of 252 Portage Ave., Winnipeg, is manager of Featherstonhaugh & Co., patent solicitors and engineers, Winnipeg, Man.

Rounthwaite, C. H. E., '00, was with the Algoma Central & Hudson Bay Railway at Sault Ste. Marie, Ont., when last heard from.

Rous, C. C., '13, is at Quebec with the corps of engineers established by the Canadian General Electric Co. for service.

Routley, H. T., '06, is a member of the firm "Routley & Summers," Haileybury, Ont., and Huntingdon, Que., contractors for various municipal construction works, with macadam roads a specialty.

Rubidge, W. F. B., '10, is with the erection department of the Dominion Bridge Co., Montreal, Que., as resident engineer. His address is 318 Old Orchard Ave., Montreal.

Runciman, A. S., '11, is with the city electric light department, Prince Albert, Sask.

Russell, W. B., '91, has a practice as civil engineer and contractor, 1037 Traders' Bank Building, Toronto, Ont.

Russell, R. K., '93, has a practice as civil engineer and contractor, 1001 Traders' Bank Building, Toronto, Ont.

Rust, H. P., '01. His address is 49 Wall St., New York, U.S.A. He is with the firm, Viele, Blackwell & Buck, consulting engineers.

Rust, F. C., '11, is with the Vancouver Island Power Co., Victoria, B.C.

Rutherford, F. N., '04, is a member of the firm Rutherford & Patten, surveyors and engineers, St. Catharines, Ont.

Rutledge, L. T., '09, is demonstrator in drawing at the University of Toronto.

Rutley, F. G., '11, was engineer on the new plant of the Calgary Power Co. at Kananaskis, Alta., when last heard from.

Ryckman, J. H., '06, is on the designing staff of the railway and bridge department, City Hall, Toronto.

S

Salter, E. M., '11, is with the Greater Winnipeg Water Supply. His address is Canora, Man.

Sanders, W. K. D., '06, address not known.

Sanderson, A. U., '09, his address is 31 Alvin Ave., Toronto. He is with the Water Supply Section, Department of Works, Toronto.

Sara, R. A., '09, is sales manager for the Light and Power Department in the city of Winnipeg, Man.

Sauder, P. M., '04, we understand is with the Department of Interior, at Calgary, Alta.

Sauer, M. V., '01, is on the engineering staff of the Greater Winnipeg Water District, Winnipeg, Man.

Saunders, G. A., '99, is on the engineering staff of the Hydro-Electric Commission, Toronto, Ont. His address is 42 Major Street.

Saunders, H. W., '00, is Division engineer for the U.S. Coal and Coke Co., at Gary W Va.

Scandrett, F. C., '11, is fellow in surveying at the University of Toronto.

Scarlett, A. A., '13, is in the test department of the Ontario Hydro Electric Commission, Toronto.

Scheibe, H. M., '03, is factory manager for E. F. Scheibe, Cambridge, Mass. His address is 10 Bellevue Ave.

Scheibe, R. R., '96, is sales manager for Bridgens Limited, Toronto, Ont. His address is 11 Rowanwood Ave., Toronto.

Schlarbaum, A., '09, is with the department of Interior, Ottawa, Ont.

Schofield, C. A., '07, is chemist for the Schoell-Kopf-Hartford & Hanna Co., Buffalo, N.Y. His address is 226 Anderson Place, Buffalo.

Schwenger, C. E., '09, is in the distribution department of the Toronto Hydro Electric System at 226 Yonge Street, Toronto.

Scott, C. A., '09, is assistant engineer in the roadways department at the City Hall, Toronto. His house address is 96 Glendale Ave.

Scott, G. S., '05, his address is 215 84th Street, Brooklyn, N.Y.

Scott, W. A., '06, has a practice as land surveyor and engineer, Calgary, Alta.

Scott, W. F., '97, is structural engineer at Dunnville, Ont.

Scott, J. W., '11, of 576 Church Street, Toronto, is in the Medical Health Department, Toronto.

Seaton, N. D., '11, 96 Bismarck St., London, Ont.

Secord, A. O., '08, is in the contracting business at 8 Temple Building, Brantford.

Sedgewick, A., '09, is assistant provincial highway engineer in the Ontario Department of Public Works, His address is 64 Wellesley St., Toronto.

Segre, B. H., '09, is a Dominion Land Surveyor with the Department of the Interior, Ottawa, Can.

Seibert, F. V., '09, is with the Topographical Survey Branch of the Department of Interior, at Edmonton, Alta.

Serson, H. V., '05, is engineer for Snare & Triest Co., Limited, 143 Liberty Street, New York.

Sewell, L., '13, is with the Topographical Surveys Branch, Department of Interior, Ottawa.

Seymour, H. L., '03, is a member of the firm Sanders & Seymour, civil engineers and Dominion Land Surveyors, at Red Deer, Calgary and Medicine Hat.

Shanks, T., '99, is chief draughtsman in the Topographical Surveys Branch of the Department of Interior, at Ottawa, Ont.

Sharp, M. C., '13. His address on our fyle is 814 Ossington Ave., Toronto.

Sharpe, N., '11. Address not known.

Shaw, J. H., '98, is surveyor and engineer at North Bay, Ont.

Shaw, K. E., '13, is draftsman with the Canadian Bridge Company, Walkerville, Ont.

Shaw, W. E. V., '08, is assistant engineer in the electrical distribution dept. of the Milwaukee Electric Ry. & Light Co., Milwaukee, Wis. His address is 187 12th Street.

Shaw, M. R., '09, is chemist with the Muskogee Refining Co., Muskogee, Oklahama, U.S.A.

Shaw, W. C., '10. His home is at 114 Park Rd., Toronto.

Sheard, P., '11, is with Geo. W. Gouinlock, architect, Temple Building, Toronto.

Shearer, H. F., '08, is power engineer for the Toronto Hydro Electric System, 226 Yonge Street, Toronto.

Shepley, J. D., '04, is district surveyor and engineer, at North Battleford, Sask.

Sheppard, A. C. T., '07, is assistant topographer in the Geological Survey Branch of the Department of Mines, Ottawa, Can.

Sherman, (Capt.) N. C., '10, is at the Ordnance Office at Esquimalt, B.C.

Shields, J. D., '94, of Hampton Court Apartments, has a private engineering practice in Toronto.

Shipley, A. E., '98, is manager of the Nelson Coke & Gas Co., Nelson B.C.

Shirriff, C. H., '05, is chemist for the Imperial Extract Co., Toronto.

Sibbett, W. A., '11, is division surveyor for the C.P.R. at North Bay, Ont.

Sills, C. P., '11, is with the Dept. of Interior, Ottawa, Ont.

INDEX TO OUR ADVERTISERS

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO NOV., 1914 New Series Vol. IX. No. 7

WORK OF THE ONTARIO HYDRO-ELECTRIC POWER COMMISSION

President Gray and the Executive of the Engineering Society are to be congratulated on securing Sir Adam Beck to address a meeting of the Society in Convocation Hall, on Wednesday afternoon, November 18th. On several occasions has Sir Adam previously been approached with a view to having him address a meeting of the Society, but, owing to the many responsible duties devolving upon him, he was unable to heretofore grant our request. The meeting was largely attended, not only by the undergraduate body, but also by the graduates and other members of the Canadian Society of Civil Engineers.

Sir Adam's lecture was exceedingly instructive and interesting, covering the work of the Commission from its inception until the present. He not only outlined what the Commission has done, but explained why it had done it and reviewed the advantages which had resulted to the people of Ontario.

He was followed by Mr. F. A. Gaby, B.A. Sc., '03, Chief Engineer of the Commission, who gave an illustrated description of the construction of the system, its transmission lines and stations.

Honorable W. H. Hearst, Premier of Ontario, spoke briefly. He has always been a warm supporter of the Hydro-Electric scheme, and in referring to Sir Adam Beck and his work he said that apart from the great engineering skill and knowledge required in carrying out such a project, there is another phase which is of vast importance—that of organization—and to Sir Adam must fall the credit for bearing the weight and responsibility of initiating and developing the organization of the greatest co-operative commercial system of its kind in the world.

In his opening remarks Mr. Gray expressed the pleasure of the Society in being so fortunate as to have Sir Adam Beck address us at the first general meeting of the year which had been devoted to engineering work. The first general meeting had been given over to military work and he was glad to report that over 97 per cent. of the undergraduates in engineering are now participating in military drill, either with the Canadian Officers Training Corps at the University, or with some other regiments. This is a better military showing than is made by any other faculty of any university or college in Canada with the exception of the Royal Military College. He remembered that on one occasion when he was in Berlin, he saw a large sign which read, "We are proud of Adam Beck." To-day the whole

Sir Adam Beck, Chairman, Hydro-Electric Power Commission of Ontario

province is proud of him because of the work which he has done in the interests of her people and his worth has received recognition from His Majesty, King George V., who lately honored him with a knighthood.

After the Science Octette rendered a selection Sir Adam gave his address, an extract of which follows:—

"The first thing that I feel like asking myself is, 'Why am

I here?' In answer I can only say that I must have been overawed by the deputation that came to interview me, and in a moment of weakness I yielded. It appears to me that I am about to speak on a subject which is worn almost threadbare; it has been talked of so much that it sounds like ancient history. However, I have promised to give you a practical talk this afternoon on the project, in the accomplishment and achievements of which we take considerable pride.

"The fundamental principle of the whole scheme is really Public Ownership, or the utilization of the resources of the province by the people, for the people, and it originated in the City of Toronto, which fourteen years ago appointed a committee to report as to the feasibility of transmitting electrical energy from Niagara Falls.

"Other municipalities took the matter up and appointed committees to investigate and report. In 1903 the City of Toronto made application to the Legislature for the right to develop and transmit power from Niagara Falls to that city. Deputations waited upon the Government, and on June 12th, 1903, the Legislature passed an Act authorizing any two or more municipalities to appoint commissioners to inquire into, construct and finance works for the development and transmission of eletrical energy. Acting under this Act, a commission was appointed by seven interested municipalities in August, 1903, which commission later submitted to the Government a very comprehensive report, as a result of which, on July 5th, 1905, the Legislature appointed the Hydro-Electric Power Commission of the Province of Ontario to investigate the water powers of the province, their development and the transmission of electrical energy. This Commission made a very exhaustive study of the subject, and following the publication of its reports a very large deputation waited upon the Government, with the result that in May, 1906, the present Hydro-Electric Power Commission of the Province of Ontario was appointed to supply and transmit electrical energy from Niagara Falls and other sources of power to municipalities throughout the province.

"The Commission encountered much opposition at the outset, chiefly from private interests, which declared that its policy would render the province bankrupt and ruin its financial credit; instead the credit of the Commission is so good as to enable it to borrow money at a much lower rate of interest than can be secured by private corporations.

"At first twelve municipalities came into the scheme. Estimates submitted by the Commission showed that $4,000,000 would be necessary for the carrying out of the scheme as planned. Certain 'experts' warned the people that the project would cost at least $12,000,000 instead of $4,000,000. As a matter of fact the municipalities built their lines and stations, bought their rights-of-way and all necessary apparatus at a cost considerably below the estimated $4,000,000.

"In order to help vested interests, negotiations were entered into with existing power companies and a contract was finally entered into with the Ontario Power Company at the rate of

Hon. W. H. Hearst, Premier of Ontario

$9.00 per h.p., which is considered one of the most favorable ever made.

"Mr. Gaby, the Chief Engineer of the Commission, is a graduate of 'The School.' He is possessed of more than technical and mechanical knowledge—he is reliable and has the integrity of character so essential in the administration of a work of this nature. The Commission has proved that men of honesty and integrity can be secured for the administration of provincial affairs, as well as by private interests.

"At the end of the present year ninety-two municipalities will be taking power from the Hydro-Electric Power Commission. The investment of the province at present is $9,100,000; the municipalities have invested over $11,000,000, making a total outlay of over $20,100,000 on the scheme. The net profit in the municipalities during the past year has been over $1,000,000, which, on an investment of $11,000,000, must be considered very encouraging.

"Every day we are finding some new uses for electricity in lightening the burdens of the toiler and notably in improving rural conditions. The effect of the co-operative system is to continually reduce the cost of power to the consumer and consequently the costs of manufacturing processes. In speaking with a railway magnate regarding the work of the Commission he told me that the industrial commissioner of his company had said that the greatest drawing card he could offer to industrial concerns was the cheap electric motive power available through the efforts of the Commission in many parts of the province. Another direct benefit to the people which results from the Commission's policy of constantly extending, is the establishment in the province of branches by many United States and other manufacturers.

"At one time the engineering graduates of our universities were obliged to go to other countries to seek employment worthy of their abilities. The Commission has changed this; it has in its employ over 150 graduates of Canadian universities, and constantly receives applications for employment from graduates of universities in the United States and other countries.

"Toronto has special reason to welcome the extension of the Hydro-Electric scheme, because of the large projects which she has in view. Cheap and reliable electric power will be of immense value to her a few years hence, when she begins negotiation for the acquirement of the Street Railway Co. upon the expiration of its franchise, and also in the development of her vast harbor projects.

"The aim of the Commission does not end at the furnishing of cheap light and power throughout the length and breadth of the province; it recently has undertaken the development of a system of hydro-radial railways which will afford cheaper and more expeditious travelling and transportation of manufactures and products. As in the case of power the profits from the operation of these railways will go to the people of the province and not to shareholders of private corporations. We have every reason to believe that they will prove economically successful from the beginning. Lectures and addresses are being given throughout the province where sufficient interest can be aroused to assure well-attended meetings. The scheme is meeting with much success and the indications are that before many years South-western Ontario will possess a network of radial railways. It is doubtful if any other phase of the work of the Commission will be of greater value to the province at large than that of hydro radials, the benefits from which will be enjoyed by rural dwellers and not only by the centres of population.

"The municipalities interested in these radial railways are sending a deputation to the Government to present their claim for a sudsidy, and there seems to be no reason why the Dominion

F. A. Gaby, B.A. Sc., Chief Engineer for Hydro-Electric Power Commission

should not grant such a subsidy, especially in view of the liberal assistance which has been given to railway companies in the past.

"We have now 433 miles of 110,000 volt lines in the Niagara Peninsula. Power had not previously been transmitted at so great a voltage and we were charged with foolish experimenting, but the work was undertaken only after most careful study by our engineers, the accuracy of whose judgment is testified to by the present developments of the system, which would not have been economically possible at a lower voltage.

"The Niagara Falls system is comparatively familiar to you and I have not sufficient time at my command to describe

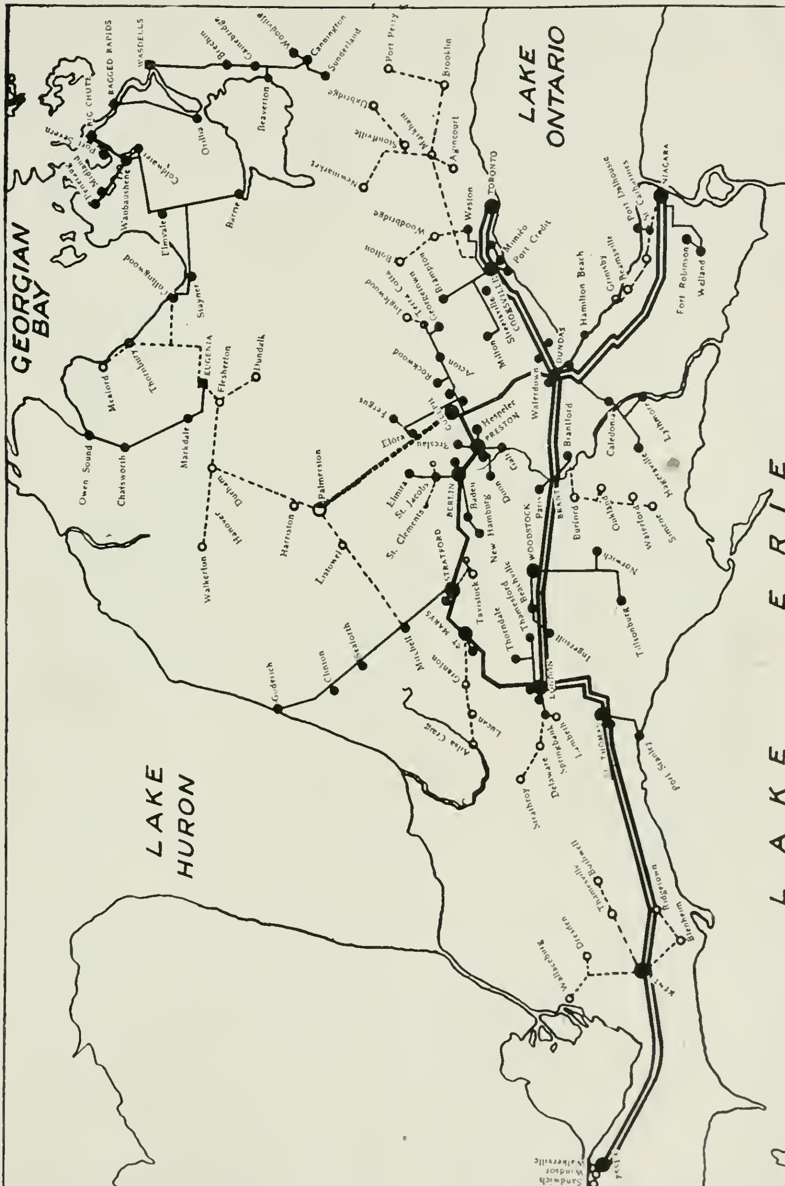


Fig. 1—Map showing the extent of the area served by the distribution systems of the Ontario Power Commission from Niagara Falls, Severn River and Eugenia Falls.

it in detail, but an idea of its extent may be had from a study of the map shown in Figure 1. We have several other systems which I will describe briefly, namely—the Severn system, the Wasdell's Falls system, the St. Lawrence sytem, the Port Arthur system, the Ottawa system, and the Eugenia Falls system which is now under development.

Severn System

"On the 10th of February, 1911, the Hydro-Electric Power Commission of Ontario entered into an agreement with the Simcoe Railway and Power Co., which had a generating plant at Big Chute on the Severn River, to supply power to be delivered by the Commission to Port Severn, Waubaushene, Cold-

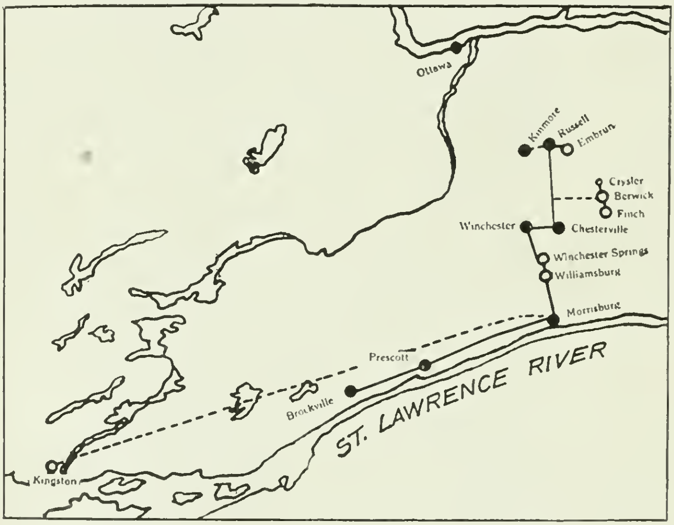


Fig. 2—Eastern section of Hydro distribution system.

water, Penetang, Midland, Elmvale, Barrie, Stayner and Collingwood at 25,000 volts. A transmission line has been constructed connecting the Big Chute plant with another plant at Ragged Rapids, owned by the town of Orillia. The extent of the system is shown on the map, Figure 1. It is the intention to ultimately connect the Big Chute plant with Wasdell's Falls on the east and Eugenia Falls on the west and through Eugenia Falls with the most northerly section of the Niagara Falls system.

Wasdell's Falls System

"Wasdell's Falls is situate on the Severn River just where the river leaves Lake Couchiching, the northern arm of Lake Simcoe. This is the first place at which the Commission has undertaken to generate power on its own account by the development of a water-fall. The station here may be operated in two parts if required since each bus is divided by disconnecting switches into two sections with one exciter, one generator, one bank of transformers and one transmission line on each section. The head is twelve feet. The present installation constitutes the total capacity of the fall. The Commission intends ultimately to connect this system up with the two other generating plants on the Severn River, viz., the Big Chute, and the Ragged Rapids. In the meantime power will be supplied to Woodville, Sunderland, Cannington, Beaverton, Gamebridge and Brechin, at each of which points there will be a station to step the current down from 25,000 volts to 2,200 volts for local distribution.

St. Lawrence System

The Commission has entered into an agreement with the Rapids Power Co., of Morrisburg, for the supply of a quantity

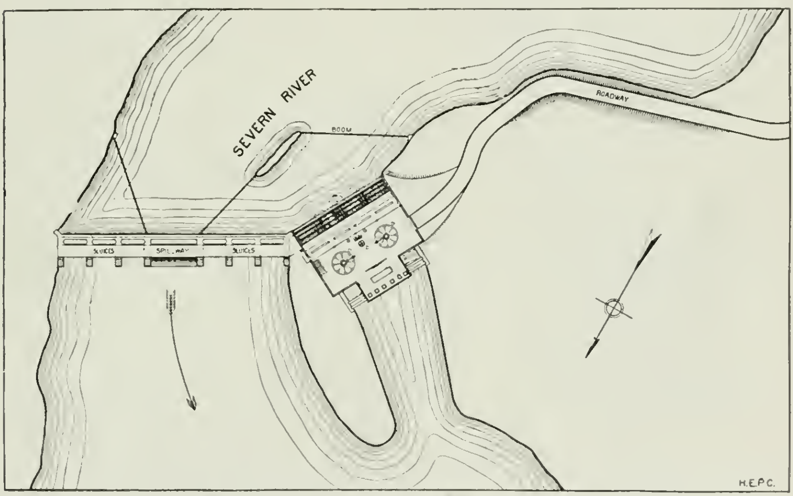


Fig. 3—Wasdell's Falls Development—General Lay-out

of power to be distributed by the Commission at 26,400 volts potential to different points in eastern Ontario. Power lines of this voltage have been constructed to Prescott and Brockville in a westerly direction and to a number of smaller towns due north of Morrisburg as far as Russell. The probable extent of the operations in this district in the near future are indicated on the map shown in Figure 2.

"A contract has been closed by the Commission to obtain a further supply from a new plant at Waddington, N.Y., as it was evident that the supply available at the plant of the Rapids

Power Company would soon be inadequate. The generating company agreed to deliver the power to the national boundary, at which point the Commission will become responsible. It is thought that the power obtained in this way will be sufficient for considerable time, or at least until some larger scheme of development of the St. Lawrence River has been decided upon.

Port Arthur System

"Power is purchased by the Ontario Commission from the Kaministiquia Power Company and supplied to the City of Port Arthur. It has constructed a 22,000 volt line and a 22,000/2,300

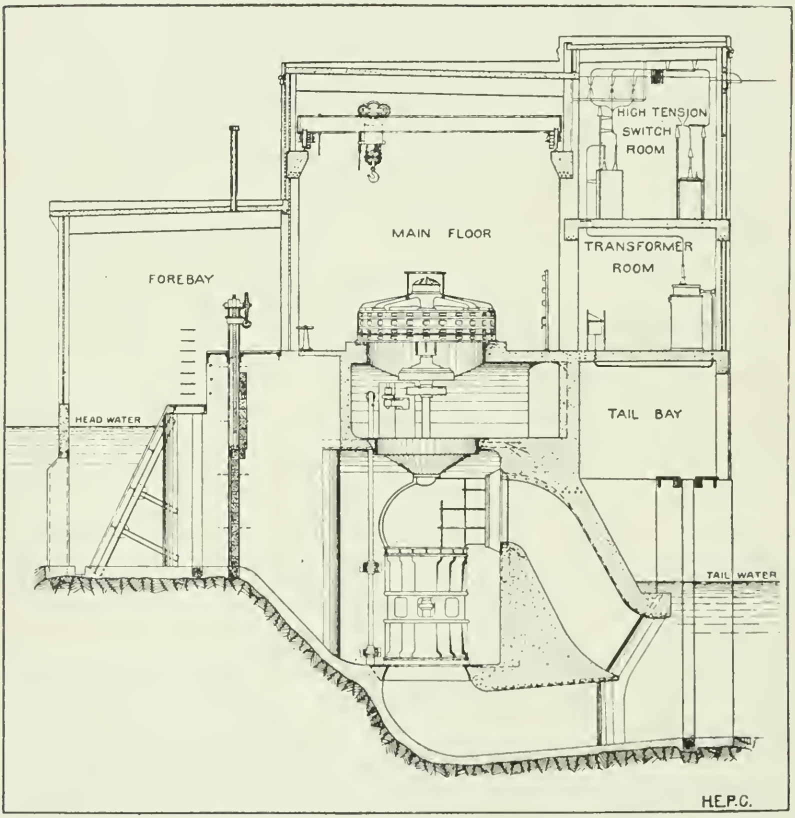


Fig. 4—Wasdell's Falls, Development—Cross Section through Power House

volt station. The original equipment had a capacity of 2,250 k.w. Port Arthur has two local sub-stations and has erected a new pumping station in connection with the municipal water-works plant.

"The rate for the purchase of power from the Kaministiquia Power Company is $16.00, which makes the power, adding transmission charges, cost the municipality $19.50 per h.p.

Ottawa System

"In Ottawa, power is purchased by the Ontario Commission from the Ottawa and Hull Power Co., which operates within the Corporation limits. The rate paid to this company is $15 per h.p. year. New consumers are being added in this city at a rapid rate and it is likely that in the near future additional power will be obtained for Ottawa, possibly at Chats Falls.

Eugenia Falls System

"The source of power for this system is Eugenia Falls on the Beaver River, which was formerly owned by the Georgian Bay Power Co. It is intended to supply power and light to Owen Sound and the surrounding district.

"There was at first some uncertainty as to the minimum waterflow measurements of the Beaver River, and in order to eliminate this a sharp crested weir was built at Eugenia Falls and a recorder was employed for the purpose of making continuous flow measurements during the summer of 1913. The results of this investigation were satisfactory to the Commission and to the Town of Owen Sound, and a contract was entered into by which Owen Sound is to be supplied with 1,200 h.p. The initial development will be approximately 4,000 h.p. in generating capacity and the station will be planned for an ultimate 8,000 h.p. capacity. The head will be about 540 feet, the highest east of the Rocky Mountains. The work here is now well under way and it is expected that it will be completed early in 1915."

Sir Adam closed by saying that great as have been the achievements of the Commission in the past, even greater things may be looked for in the future.

The following have registered in the fourth year at the "School" after an absence of a year or more:—R. H. H. Blackwell, '10, H. P. Frid, '11, C. W. B. Richardson, '07, H. B. Thompson, '10, H. K. Wyman, '11, P. J. Relyea, '13, R. A. Paul, '13, H. O. Leach, '14, and J. C. Christner, '14.

R. A. Ross, E.E., '90, has been retained by the city of Peterborough, Ont., as its representative in the settlement of the taking over of the plant of the Peterborough Light and Power Co. by that city.

A. E. Pickering, '04, formerly manager of the Tagona Light and Power Co., Sault Ste. Marie, Ont., has been retained as manager of the same concern since it has been taken over by the city.

NEW WESTON INSTRUMENT TRANSFORMERS

Two new bulletins announcing and describing switchboard and portable instrument transformers of an exceptionally high order of merit have just been issued by the Weston Electrical Instrument Co. of Newark, N.J.

It has, of course, been recognized that instrument transformers should be designed and made with a much greater degree of refine-

ment than is necessary in commercial lighting and power transformers, and as might have been anticipated, these new contributions to the art of electrical measurement by the Weston Company are worthy of recognition as standards of excellence.

They represent the results of several years' careful and most thorough analytical study and experimental investigation of the many factors involved in developing and making instrument transformers capable of giving the highest degree of precision under the widely varying conditions incidental to their practical use.

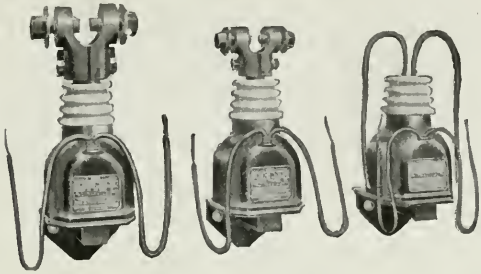
Two different Models of Portable Current Transformer are listed. One type has three self-contained primary windings and the other is of the inserted primary type, the ratio depending upon the number of turns of the primary that are passed through the aperture.

There is also a portable potential transformer which is made in various ranges.

The Switchboard Models are made in several different types, which vary in appearance with the ratio, the volt-ampere capacity and with the potential of the circuit.

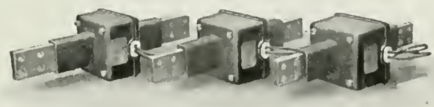
The manufacturer emphasizes the point that these transformers are unequalled in precision, in design, in workmanship and reliability in service.

Indeed, special stress is laid upon the accuracy, the ratios of transformation, and upon the fact that the design and proportions of the transformers are such that it is unnecessary to have instruments specially calibrated with the transformers in order to obtain



the degree of accuracy to which high grade instruments are guaranteed when used without transformers.

This feature is of special interest in connection with tests with portable instruments, because in many quarters the impression has prevailed that no transformers could be made that would assure the users of the degree of accuracy for which a high grade portable



instrument is designed, unless special precaution had been taken to calibrate a particular instrument with a particular transformer.

These new Bulletins are numbered 1501 and 2001, the former dealing with Switchboard Instrument Transformers and the latter with Portable Types.

O. W. N. Charlton, '11, formerly with the Department of Interior, Ottawa, is now associated with W. T. Haring, general contractor, 100 Washington street, New York, N.Y.

R. P. Johnston, B.A. Sc., '14, is on the designing staff of the Welland ship canal at St. Catharines, Ont.

D. B. Cole, B.A. Sc., '11, formerly smelter maintenance engineer for the Canadian Copper Co. at Copper Cliff, Ont., is now with the Cleveland Cadillac Co., Cleveland, Ohio.

Hugh Wallace, B.A.Sc., '14, is inspector on the construction of the Welland ship canal at Port Weller, Ont.

V. S. Chestnut, B.A. Sc., '09, is assistant to the resident engineer, section 1, Welland canal, at Port Weller, Ont.

C. N. Temes, B.A. Sc., '14, is in the draughting office of the Ontario Hydro-Electric Commission, Continental Life Building, Toronto.

"THE WIELDER OF THE WEAPON"*

By Professor H. E. T. Haultain, C.E., '89

Mr. Chairman and Gentlemen:—

The majority of the papers read before this Society are descriptions of work accomplished, descriptions of successful results, accompanied by detailed plans and specifications. This effort of mine is as far removed from this type of paper as it is possible to go. It is but a groping. Perhaps it would be more becoming the dignity of this meeting if it were referred to as a reconnaissance, but the region of the survey is not new. It is one we have all looked at, but by most of us it is passed by as being unfruitful or unpleasant. Safety and success are the prime essentials for much of the work of the engineer, with the result that where he cannot see clearly, he is the more timid. He avoids doubtful material; where he cannot avoid he raises his factor of safety. He will rarely talk of his mistakes, though they may be of much greater educational value than his successes. In fact, he will rarely talk about his work except in the form of plans and specifications. Yet I am venturing before you with my groping. One reason for this is that of late I have viewed the subject from a new standpoint, one far removed from that of the field engineer.

Last year the president of the Institution of Mining and Metallurgy said to me, "You are at a gate of the profession, what are you doing to guard it?" Part of my function as a teacher is to guard the profession as is also part of the functions of this Society. If I am at a gateway you are at the citadel. I submit that it is probable that the activity of this part of our functions might with advantage be very materially increased. Perhaps it is still more important that the range of this activity should be widened. Many will say that the profession is being well guarded, that the standard is high, is in fact very much higher than is generally realized. With this I would agree, more particularly with the last part. Is it not possible that this is a point that we have been neglecting.

A recent editorial in the University Monthly contained a reference to "the feud in Medicine and Applied Science between the practical and the genuinely University conception of training."

I do not think that the word feud expressed the idea satisfactorily, but the condition referred to, has impressed me more strongly than any other academic condition in the six years I have been in the

*A paper read before the Canadian Society of Civil Engineers in Montreal, Nov. 5th, 1914

* The paper was preceded by some slides, one of which showed clause 2 of the Engineering Ethics section of the By-laws of the Can. Soc. C.E. Mr. Haultain said that he sought a broad interpretation of the last part of that clause, viz.—"The surest way for an engineer to obtain such necessary consideration and deference from the public will be found in his manner of carrying himself." Another slide showed the man of Coreze with his two weapons, the club and the stone.

University. There seems to be a wide gulf between the older faculty of Arts, and the faculty of Applied Science and Engineering. In the picture as it appears to many observers, the bright light and the high land is on that side of the gulf away from the engineers. In fact in a general view, there is not a gulf which betokens an equality of level between the two shores, there is rather the appearance of high mountains and valleys. There is no doubt that there is a haze of misunderstanding between the two. I do not know that this atmosphere does any harm or causes any more unpleasantness than does occasional bad weather. I sometimes think it may be a sign of health. Perhaps if it were intensified it might stir up some healthy activity. I bring it in only as an illustration. It is not exactly the same way out in the field, though the picture may be obscured by many conditions absent in the smaller academic world. Are not the engineers in the eyes of the public but hewers of wood and drawers of water?

Possibly it is sufficient that we remain so and confine our attention to the wood and the water as becometh men of low degree. Without doubt the general attitude of the engineer is one of indifference in this regard.

Is it not possible that this is the real problem before the engineering societies. Is not this really the whole of which the other problems are but parts?

If this condition is to be changed, how is it to be accomplished and who should attempt it? Engineers do not talk about engineering, except to themselves and in their own language. It is nobody's business to talk about it for us. Others misunderstand us because they do not know us. They recognize that we are different from them. We must be either inferior or superior. Naturally they think we are inferior. Can you blame them? We take the trouble neither to dress nor speak the part.

One reason, without doubt, is that our work is intensely interesting and we are so busy with it that we have neither the time nor the energy to pay attention to anything but our work. Probably another reason lies in the fact that we are so accustomed to putting our ideas in the form of plans and specifications, that not only do we find other language difficult, but we avoid expressing ourselves on any subject that has not formed itself in our minds clearly and distinctly. An elaboration of details which the engineer's mind demands, only befogs the public or robs them of their interest. Broad impressions, sometimes purposely distorted to what the engineer would consider inaccuracy, attract and educate the public.

We all shy from the question, "What is Engineering?" It appears an unprofitable and tiresome subject. I am inclined to submit, however, that some of us at least should tackle it and keep on tackling it. It is neither possible nor necessary to draw complete plans and specifications, but we must produce a general view that will convey correct impressions, not only to ourselves and to those entering at the gate, but also to the outside public. Do we think the lawyer or the business man, or the man about town has anything like a true understanding of the engineer, and his ideals? Are we not quite sure in our own minds that their ideas on the subject are very far from the truth. I am perfectly sure that the ideas concerning the engineer and engineering held by the University Senate are very materially different from those held by the teachers in the Engineering faculty. An Arts professor once said to me, "I have no patience with your ideas of education. Your only reason for wanting analytical geometry is to enable you to cut out boiler plates." I could hardly frame a statement that would be further from my ideas of education and yet I failed completely to convey this to my colleague. The association in his mind between the high mental training of such a subject and the engineer reached only to the cutting of boiler plates.

Another colleague inferred that the difference between Science and Applied Science was something like the difference between wall paper in the roll and on the wall. All the great art and skill lay in the roll. The applying it to the wall was a simple matter; a matter of low degree.

What, then, is engineering and who is the engineer? If he is not simply a hewer of wood, what is he? Does he belong to any specified herd or are we all mavericks? Is there a distinguishable brand on our hide or are there only irregular and uncertain marks proving only that we are not exactly wild beasts. Are we sufficiently gregarious to constitute a herd, or is it that there are only a few of this kind and do they only herd from fear. Evidently the simile is badly taken.

Are we a tribe—if so wherein do we differ from those outside the tribe? Have we inherent characteristics? Are we differentiated from other tribes? Have we any tribal pride and of what are we proud? Or are we simply content to be the vassals of the community? Are we leaders or simply workers?

I am inclined to think that the simile of the hewer of wood is at the base of most of the misunderstanding. Let us go back to the beginning of things, to the dim red dawn of man. Did not the man of Coreze represent at his time the greatest force in the world? Was he not above all the animals? Wherein was he different from them? Was it not probably in the fact that he used forces outside of himself to win from nature. Was he not the inventor and the first user of the weapon. Was not the wielded club or thrown stone the first step towards the separation from the brute. From then until now who has always been the greatest man? Let me quote from my paper, "The Geologist." a paper read before the Canadian Mining Institute in March, 1913, and published in the Annual Volume for that year No. XVI, and also published in The Canadian Mining Journal, March 15th, 1913. "When we go back to the beginning of things, that it is to the beginning of things for man, to about the times, let us say, of pithecanthropus erectus, the story-teller was beginning. He was almost the first luxury. Possibly man's first distinction was that he was a fire-using animal. Certainly about the same stage of his development he became a story telling and story hearing animal, and the story telling part was certainly more removed from mere animal than any other phase of his activities. Progress in all stages has been based largely on co-operative organization and this came first with the fighting animal, but organization alone did not win out from the animal stage. Organization could and does exist without language and without man, but we departed from the animal through language and progressed through language. Language was produced by and for the story-teller. For his purpose was language developed and without language we would have had no modern man. The neolithic scriber on bone that 'mamothistic etcher at Grenelle' was a later development of the story-teller, who told stories in pictures and was not only the forerunner of the comic supplement, but of all that we understand in modern pictorial art. Later he told stories in song and in mimicry so that all our art, which represents our greatest departure from the anthropoid ape, is the work of the story-teller.

"Now the story-teller is still the greatest man among us. What does Kipling get per word? And has he not had the refusal of the high honours of the realm? Theodore Roosevelt received $350,000 for seven years' work as President of the United States, but received a million dollars for the story of his African holiday."

Man was a weapon wielder before he was a story teller. The weapon wielder was the real leader. We always have and always will look up to the story-teller, but we bow down to the successful wielder of the weapon. He has had more of the world's real adulation. Though he may use the same weapon he is the antithesis of the hewer of wood. The conquered slaves, the weak and the imbeciles were the hewers of wood and the drawers of water. It is true that they won something from nature, but they made no progress and they risked nothing in the effort. Man's struggles against man has been only a small part of the sum total of his effort as compared with his struggle with nature and the struggle with nature to-day is more universal, more rapid, more intense and more successful than ever before. The man in the forefront of the struggle, he who is forcing nature to the use and convenience of man as never before is the engineer and the reason that he progresses more rapidly and more successfully than ever before is largely on account of his new weapons, but still more on account of himself and his methods. His weapons are drawn from the sciences but the wielding is his own. The choosing of the weapon and the plan of campaign are his. But he is in the thick of the fight and there are no war correspondents. He makes no effort to hold communication with non-combatants. He is busy for results, and to him nothing but results counts. He has not yet got to the stage of holding communication with the public through means of show and parade, of brass bands and uniforms. No slave toiling at the wood pile ever shrank from the public gaze more carefully than does many an engineer from publicity. He is content to stand behind his wood pile and the public thinking that the pile arrived by a simple process of hewing give as little attention to the man as to the slave. Nobody tells the public that to produce the modern pile there has been a struggle calling upon higher standards than ever before in the struggle with nature; that the men who are winning in this struggle are men of as high a calibre in mental effort and moral fibre as in any other branch of human affairs. and very much higher than in most other callings.

We do not dress the part. To the public eye dignity and weight of personal character are intimately associated with gown and wig, and valour and worth with uniform and decorations. We have neither religion nor law nor military without their wrappages which tell to the ordinary man plainer than any words that the man within is of high worth in the general scheme of things. We neither talk nor dress the part. We are pleased to say that we work and that workers don't talk. As a matter of fact we fight. The word work only covers a part of our efforts. We wield weapons and plan campaigns and we risk personal safety in reputation if not in limb and life. Some will say that the fighter also doesn't talk. No, he does not talk the part, he dresses it. I can't imagine Lord Roberts liking the fuss and the feathers, but he was punctilious to a degree in such matters. And we engineers, with the exception of a few whom we rather blame for "advertising," do nothing—absolutely nothing to tell our fellows what manner of men we are. Is it not possible that this is the real problem before this Society. We cannot wear a uniform either in the shape of a helmet and tunic or of wig and gown, nor can we have parades and brass bands.

Publicity of some kind we need more than anything else, but it must be of the right kind and apparently the right kind has still to be discovered. We must recognize that there are innumerable kinds of useful publicity and that many, very many most extraordinary ones are really good form. General French can wear white feathers in his hat. A judge is never so impressive as when garbed in his wig and gown which look only absurd under other circumstances. But these are all hallowed by time and are denied to us. We are so young that language itself is denied to us. Our very name is without meaning or what amounts to the same thing, has many meanings. And so with many other words connected with us, technical, practical scientific, theoretical and so on. But the means of publicity, though many, may still be added to. The magnificent home of the Institution of Civil Engineers must by its dignified appearance alone be of great educative importance. The knighting of Sanford Fleming was not without its value, but needs repetition as does all publicity. "There are certain conditions of intimacy, continuance and repetition which are necessary if an idea or feeling is to gain a foothold in the mind and remain." At the celebration this year of the addition of the word Royal to the name of the Canadian Institute an organization founded by Fleming sixty odd years ago, a speaker of the evening, not content with Sir Sanford's reputation as an engineer, laboured to show that he was a scientific man, a geologist forsooth, because he had published the fact that the sands of Toronto Island had come by wave action from Scarborough bluffs, and as a scientific man was worthy to have been a founder of a society honored by the word Royal in its title.

The pitiful position held by many of the municipal engineers is a publicity of the opposite kind that is doing us much harm. On the other hand the good citizen activities of some of our engineers who are energetic on Civic Guilds and other public committees is of the right kind. To a few it is given to be presidents and vice-presidents of large commercial organizations. Their presence in our council is good publicity. There are many avenues closed to us, however. The engineer is too direct and too, what-shall-I-say, to be a successful politician. We study our men but not our fellow man. The settlement of labor troubles comes more and more to the engineer, but we will not succeed in persuading our fellow man to elect us to office for a long time to come. The study of our fellow man may be the first step to a successful publicity.

Am I stumbling too much in my groping over this idea of publicity. Many of you, especially those who have made your mark and your assured income may say that the last thing you want is publicity. But surely you will agree that the proper kind of publicity, the kind that will educate the public to a better appreciation of the engineer would be a great help and benefit to those coming in at the gate of the profession, and is not this Society a guardian of all the best interests of those entering the gate as well as a guard against incompetents and wrong doers. The fact that ordinary methods of publicity offend us is no reason why we should avoid all publicity. The problem that is before us is to find suitable publicity. Without presuming to do other than grope, might I suggest that legislation that would compel municipal engineering work to be under the control of engineers of the rank of members of this society would be very good publicity. The publication of a comprehensive code of ethics might also be good publicity. The expulsion of some of our members might be as good as any other form. Possibly we have not guarded the citadel so carefully but that some have entered who are not fit company for decent men, much less for engineers.

In our publicity direct attack will not do. We are not good enough as story-tellers. It may be thus that all that counts for health and prosperity is based on the work of the engineer, but the story or the picture of our work shows to the public but a pile of wood or a calabash of water. Larger or smaller but still the same. We must exhibit the man—we must show that it is not the slave and the imbecile accomplishing only through toil. We are wielders of the weapon and we must show that the wielding calls for all the best there is in a man by any count you choose. We must emphasize the man. The weapon has been glorified—the forger of the modern weapon of the engineer is a trained story-teller—the story-telling is a part of his training that accomplished his education as a maker of weapons. The modern worker in science not applied is fully one half story-teller and often the scientific half exists primarily for the story telling half. Just as there are many alleged weapons wonderful in their gilt and filagree whose only use is that of adornment so is much of science polished and attenuated for purposes of exhibition rather than of use.

But polished or unpolished, modern science is so wonderful and the story of it is told so well and so often that the forger of this weapon appears on a very much higher plane than the wielder of it. As usual, truth is at the bottom of the well and search shows that the reverse is the truth. The man who can choose his weapon—who can see so broadly and so clearly in the complexities of local conditions that he can select the weapon to fit his campaign and then with skill and moral fibre wield the weapon, is not less worthy of high place in the community than the maker of weapons no matter how wonderful or polished they may be.

This simile will offend by its incompleteness and apparent weakness. Is the gun-layer greater than the designer and constructor of the modern 13-inch rifle. This simile seems in error. I use it in an attempt at a broad impression—a parallel to the hewer of wood and drawer of water, not as a definition. The man from Coreze used the club and the stone and won thereby progress for the race—it was the wielding of these weapons that won. The modern weapons developed by science have given man much greater power over nature but it is still the wielding of these weapons that makes them of benefit.

The doctor and the engineer are the wielders of these modern weapons in the struggle against nature. The gun-layer taking orders from the fire control in order to destroy his fellow man is not a parallel with our man of Coreze.

This wielding of the engineer is new, is so very new and is growing so rapidly that we have no comprehensive view of it. It is not part of the so-called sciences, it is not applied science, it is man in action, using the sciences—in the most complex and the most useful action progress has had. If we simply refer to this action as work, the mind of the public will simply follow the old nerve path and associate it with toil, with the slave and the wood and the water. Do we need anything different, do we require the higher approval of our fellow man? Some of us, perhaps, are not interested.

What about our duty to those entering the gate?

What about our tribal pride?

THE RHYMES OF THE RE-SURVEY

By R. Sidney Bartram

(With apologies to Robert W. Service)

PART I

Now this is the tale of the labours performed by a survey gang
  Away in the back of the wild lands, where nobody cares a hang;
Where the brown bear prowls in the thicket, and the screech owl
    splits the night,
  And skunks and other blossoms sweet, yield scents of rare delight.

When grey the dawn is breaking, your duties are begun,
  Throughout the hours of daylight you labor with the sun;
And when the shadows lengthen, and the stars are shining bright,
  You take a shot at the polar star in the middle of the night.

You sleep in a dis-used box car, on a bed of boughs of spruce,
  But there's nothing to get by kicking, so what in hell's the use?
You dine on pork and cabbage, on pork and beans you sup,
  And there's pork next day for a breakfast dish, to clear the remnants up.

You pump a rusty hand-car for seven miles down the track,
  And the sweat runs into your eyebrows, and you long to ease your back.
With picket, chain and transit, you run the traverse through
  For seven miles, or maybe ten; as much as you can do.

You sit on a rotting deadfall, and open a can of pork,
  And eat a hasty dinner, with fingers for a fork;
Then on you go with the traverse, as hard as you can push,
  Till the shades of night are falling fast, o'er swamp and track and bush.

And then you hurry homeward, to the supper waiting there,
  And think of your lowsy spruce-bunk, and the sleep that knows no care;
But, swinging round a rock-cut, you "make a meet" with a freight,
  And "Safety First" is a maxim sound, so you leave the car to its fate.

The car is smashed to splinters, which pleases the engineer,
  While you stand and swear in chorus, but only the night winds hear.
So you shoulder the blasted transit, the picket, axe and chain,
  And start to tramp it homewards, a dozen miles in the rain.

At last, when the stars are shining, and the moon is swinging low,
  You reach the cars on the siding, foot-sore and full of woe;
You kick while you eat your supper, you grouse when you go to bed,
  And curse all night at the chap who snores, and wish that you were dead.

But somehow, in the morning, you wake as fresh as paint,
  Although last night you thought the life would demoralzie a saint;
And you gather the junk together, and out on the line you go,
  For another day's hard labour, in rain, or sun, or snow.

But to-day is not track traverse, it's Township lines in the bush,
  And your axe bites deep of the cedar, and down she comes with a rush.
You splash your way through the muskeg, you flounder across the creek,
  And flies and "skeeters" drink their fill till you feel too mad to speak.

But it's not bad work in the summer, it's rather fine in the fall,
But in the good old winter it's the greatest job of all;
With frozen ears and fingers, and nose that you cannot feel,
You laugh aloud with your stiffened lips, for you're doing the work that's real.

-- -- -- -- -- -- --

And so it was in the Beginning, and so it is to-day,
And so shall it be to the end of things, when you are taken away;
Until you are made into Angels, with transit, and tape and chain,
You will work for the darned old C.P.R., World without End,
Amen.

PART II

"THE NEXT WORLD"

Now this is the fate of surveyors, who love their beer too well,
They must do their work in Hades, surveying the bounds of hell;
They must blaze their trail through the darkness, they must run the Line of Regret,
Till the Hubs of Hell are planted well, and the Devil's Corners set.

And this is the fate of the Draughtsman, a red hot compass and pen,
And a red hot draughting table, for ever and ever. Amen.
He must draw the Thing as he sees It, with a Flag on every Hub,
Till a white hot print of the Bounds of Hell is passed by Baalzebub.

And the Picketmen and Chainmen must set a witness stake,
Well squared and truly numbered, in the midst of the Burning Lake
They must drag the chain forever, and measure every lot
Through bush that burns but never wastes, and swamp that's always hot.

And the Cook who cooked their dinner, oh! what shall be his fate?
Shall he stand beside the furnace door, and fill a fiery plate?
Oh no, he shall stand in the corner, away from the furnace heat.
He had it hot in the cook car, so now he shall cool his feet.

For surveyors and all their outfit are sinners beyond recall,
They hold no law but the law of might, which gives to the might est all.
So he who has learned his lesson, who has served his year and a day
May sin to the full of his heart's content, and none shall say him "Nay."

But the Devil stands in the Gates of Hell, to see who each may be,
When an O. L. S. is sighted, he rubs his hands with glee,
He calls aloud to his stokers, "Ha, stoke the furnace well,
Here's another surveyor coming along, we must make him hot in hell!"

Nipigon and Schreiber subdivisions, C.P.R.,
October 27th, 1913.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science,

Engineering Bldg., University of Toronto,

Toronto, Ont.

EDITORIAL

THE SMOKING ROOM

After many years of practically uninterrupted agitation among the undergraduates for a smoking room, the Engineering Society executive is to be congratulated on at last securing Room 18 in the Engineering Building to be used as a shrine to "My Lady Nicotine." Thereby will be supplied a long felt need, as the existence of a common lounging room where the students can meet, read and smoke, and be congenial, will afford another medium of fostering unity among the men, and keeping alive the esprit-de-corps which has always been characteristic of the Faculty of Applied Science and Engineering.

It is already popular with the members of the society, even though there are as yet only bare undecorated walls, curtainless windows, imaginary cuspidors, and chairs with the same kind of cushions. Reading tables and paper racks and some furniture have already been provided and it is intended that after some time we will have a comfortable and attractive reading room, where the students will have free access to the daily papers and journals and periodicals of interest to them.

A few members, it is said, are contemplating giving donations when they graduate, toward the appropriate furnishing of this room. Professor Haultain, the first student president of the Society and the senior living president of the Society, has given concrete expression to his interest in the student organization by offering as a gift, an enlarged photograph of the late Dean Galbraith, to be hung in this "common room" for the students. His action merits the gratitude of the men of the "School," and will have its elevating influence in keeping before the minds of the students of future years, the honored, respected, and much revered late Dean Galbraith, who was the founder of the "School" and the founder and first president of the Engineering Society.

No doubt there are many others who, having felt the need of such an accommodation for the students during their undergraduate days, will be pleased to know that the long sought treasure has been found, and will take the opportunity to contribute in some way toward rendering the room appropriate and attractive.

TRIP TO THE WELLAND SHIP CANAL

On October 31st the Toronto Branch of the Canadian Society of Civil Engineers conducted an excursion to the Welland ship canal and were accompanied by a large number of the members of the University of Toronto Engineering Society as their guests. Many, taking advantage of this opportunity to visit the vast and varied work on the canal, left the Union station at 8.10 a.m. on a special train and were joined at Merritton by about thirty-five undergraduates who had, on the previous day, been on an inspection tour of the power plants at Niagara Falls.

When the party reached Thorold it was divided into smaller sections, each section being directed by a member of Mr. Weller's staff. Section 3 of the canal and also the Government stone crushing plant were inspected on foot and the various phases of the work were fully explained by the men in charge. Sections 1 and 2 and Port Weller harbor were traversed in open cars hauled over the construction railway. After the work had been all covered, special cars conveyed the party to the Welland House, St. Catharines, where appetites whetted by the day's outing were fully satisfied.

The day was profitably spent, as the work presented many phases which were of great value, especially to the undergraduate, who in particular feels the need of greater familiarity with the practical side of engineering. The party was most royally treated by Mr. Weller and his staff, and a cordial invitation was extended by Mr. Weller to the men to return again on a similar excursion. Another trip in the spring when the work is further advanced would prove a valuable supplement to the academic instruction received by the students, and it is possible that such a trip will materialize.

MEETING OF CLASS '09

On the evening of November 10th, thirty members of class '09, resident in Toronto, had a dinner at the Strollers' Club, on Yonge St. Mr. H. Irwin gave a talk on "The Engineer on the Battlefield." A number of the men present are taking a course with the Royal Canadian Engineers, and Messrs. W. T. Carlyle, B. Langmuir and others took part in a lengthy discussion of the engineer's work in operations of warfare. About eight o'clock the party dispersed, a large number of them joining in a theatre party at the Gayety, the guests of Bert Alison. The probable date of the next meeting will be Tuesday, December 15th. The details of the programme have not yet been arranged, but further notice will be sent out by the secretary, Mr. R. Workman. If there are any '09 men in or near Toronto who are not receiving notice of the meetings, Mr. Workman would be glad to have them communicate with him at the Engineering Building, University of Toronto.

MINING AND METALLURGICAL CLUB

At its meeting on November 11th the Mining and Metallurgical Club was fortunate enough to have Mr. George G. S. Lindsey, K.C., President of the Canadian Mining Institute, to address it, his topic being "Canadian Mining, its Needs and Difficulties."

Mr. Lindsey introduced his subject by showing how much the existence of mining owes to the prospector, but on the other hand, how the profession is being held back by the difficulty of the prospector and the capitalist or engineer in meeting on a common basis concerning the value of the claim. The prospector wants to be paid for enduring loneliness and suffering hardships while searching for the elusive vein, and the mining man wishes some tangible value in return for his purchase price.

The speaker next uttered a warning concerning a certain type of mining broker who floats companies without any visible indication of a mine and whose chief object is to line his own pocket.

Turning to the more prominent mineral productions of Canada, Mr. Lindsey gave figures to show the wide variation in costs and profits and pointed out the need in many cases of care at every turn in order to declare dividends. In the case of iron the profits are very low and have to be supplemented by combining allied industries such as railways, power plants, etc., with that of iron and steel. An interesting fact pointed out was that there is a distinct shrinkage in the demands for iron and steel on account of the fact that our railway construction is reaching its completeness.

In conclusion Mr. Lindsey pointed out that although Canada's mineral resources were vast in extent, the sources of capital for development were equally extensive, and predicted that mining in the future would be much less "happy-go-lucky" in nature as the prospector's attitude changes, and expressed the hope that mining boards of directors would soon see the advisability of including a technical mining man in their number. As a parting word, the speaker admonished the coming mining engineers to maintain a high standard of integrity and to raise the dignity of the profession by meeting the public in an honest and open manner.

Harvey-Butters

On Wednesday, November 18th, at Niagara Falls, Ont., Mr. D. W. Harvey, B.A. Sc., '09, was married to Miss Catherine Lowell Butters, daughter of Mr. and Mrs. James Butters, by Rev. W. B. Findlay, of Toronto.

McQueen—Christie

On Wednesday, October 28th, Mr. P. H. McQueen, '14, of the editorial staff of the Maclean Publishing Co., Toronto, was united in marriage to Miss Mamie E. Christie, of Toronto.

Hopkins—Parker

On November 9th, 1914, Mr. Percy E. Hopkins, B.A. Sc., '10, was united in marriage to Miss Charlotte H. Parker, daughter of Mr. and Mrs. Thos. Parker, 142 Browning avenue, Toronto.

Huether-Forsyth

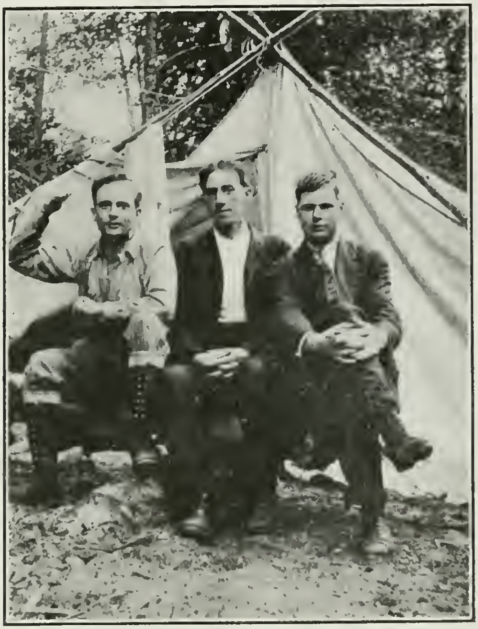
On Wednesday, November 25th, Mr. A. D. Huether, B.A.Sc., '08, was married to Miss Jean Barrie Forsyth, daughter of Mrs. Thomas Forsyth, Berlin, Ont. Mr. and Mrs. Huether will reside at 47 Highview Crescent, Toronto.

C. F. Szammers, '11, is employed with Sherwood & Sherwood, general contractors, Toronto, Ont.

M. E. Nasmith, '08, went to Kristianssands, Norway, in January of this year to make a study of a nickel refining process in operation there, and returned the latter part of July. We undertand that the work which he was doing in Norway was done for Canadian interests which expect ultimately to establish a nickel refinery in Canada.

WHAT OUR GRADUATES ARE DOING

The accompanying illustration shows a trio of "School" graduates in British Columbia. On the right is Mr. A. M. West, B.A. Sc., '08, city engineer of North Vancouver; in the centre is Mr. G. S. Hanes, B.A.Sc., O.L.S., '03, mayor of North Vancouver and formerly city engineer of that city; on the left is Mr. W. Chester Smith, B.A. Sc., '10, district engineer, Water Rights



A trio of "School" men in British Columbia

Branch, Department of Lands, British Columbia. The photograph was taken at Mr. Smith's camp on the Seymour River, where he was in charge of work in connection with hydrographic surveys on which was based his report on Greater Vancouver's water supply, which appeared in the annual report of the Minister of Lands for the Province of British Columbia for the year ending 31st December, 1913.

Bruce McKendrick, B.A. Sc., '14, is with the Dominion Dredging Co. at Port Weller, Ont.

E. P. Muntz is inspector on section 2, Welland ship canal, at Homer, Ont.

P. T. Kirwan, B.A. Sc., '10, is chemist with the Inland Revenue Department, Ottawa.

H. D. Davidson, B.A. Sc., '13, is employed as inspector on section No. 1, Welland ship canal, at St. Catharines, Ont.

J. H. Billings, B.A. Sc., who last year was instructor in mechanical engineering at the University of Missouri, Columbia, Miss., left in July for Germany, intending to study for a year in Berlin. While he was still in London, Eng., the war cloud appeared and it was necessary for him to change has plans. Mr. Billings is now a candidate for master's degree in the Massachuetts Institute of Technology, Boston, U.S.A., studying machine design and heat engineering.

There have been a few errors in connection with some former lists of "School" men who have enlisted for active service. The following is a list, corrected so far as we have been able to get information—enlisted with first contingent in Canada:—C. H. Mitchell, '92, W. H. B. Bevan, '05, T. C. Irving, '06, N. R. Robertson, '06, H. F. H. Hertzberg, '07, R. Y. Cory, '08, G. E. D. Greene, '09, H. N. Klotz, '09, P. J. McQuaig, '09, W. M. Philp,

A Group of Canadians at Salisbury Plains. (In centre is W. J. Baird, B.A. Sc. '10)

'09, W. J. Baird, '10, A. G. Code, '10, J. M. Duncan, '10, M. B. Watson, '10, N. Lawless, '11, R. V. McCauley, '11, C. A. Bell, '13, C. B. Ferris, '13, E. S. Fowlds, '13, A. G. Gray, '13, J. J. Hanna, '14, J. Kay, '14, W. E. Phillips, '14, A. C. Oxley (?), F. S. Rutherford, '14, P. G. C. Campbell, '15, C. P. Cotton, '15, G. L. Magann, '15, D. H. Storms, '15, Hal Wallace, '15, R. W. Downie, '16, H. A. M. Grassett, '16, F. H. Marani, '16, K. E. Tobin, '16, R. W. Harris, '16, Hugh D. Wallace, '16, P. C. DeGruchy, '17, F. L. Eardley-Wilmot, '17, T. S. Glover, '17, I. M. R. Sinclair, '17; enlisted in England:—L. C. M. Baldwin, '13, F. C. Andrews, '14, G. B. Taylor, '14, G. B. Macauley, '14, G. G. Blackstock, '15, H. A. Heaton, '15. Among those who have enlisted for active service with the second contingent are the following:—Harold M. Campbell, 14, L. E. Jones, '11, W. E. Lockhart, '15, C. E. MacDonald, '16. F. D. Austin, '15, J. M. Strathy, '13, A. W. Crawford, '14.

Harold Campbell, B.A. Sc., '14, and J. G. Scott, B.A. Sc., '14, are at St. Catharines, Ont., employed on mechanical design for the construction of the Welland ship canal.

C. H. Eckert, B.A. Sc., '11, is in charge of laboratory work at nights for the Dominion Sugar Company, Limited, Wallaceburg, Ont., for the present beet season.

G. B. MacAuley, '14, who was in California when war was declared, sailed at once for England and enlisted with a regiment of British cavalry. He has been at the front now for some time.

W. T. Curtis, B.A. Sc., '13, formerly with the Dominion Reduction Co. at Cobalt, is now with the Hollinger Mine, Porcupine, Ont.

K. H. Smith, '11, engineer in charge of Canadian Water Power Exhibit at Panama-Pacific Exposition, San Francisco, is temporarily located in Toronto.

C. W. Cornell, '11, of the firm of Jones-Cornell Construction Co., Limited, of New Westminster, B.C., is on a short visit to points in Ontario.

K. A. MacKenzie, B.A. Sc., '06, formerly secretary of the University of Toronto Engineering Society, is in Toronto at present. He will likely remain here for the winter, after which he will return to British Columbia, where he has been located during the last few years.

S. A. Hustwitt, B.A. Sc., '14, is engaged on work on section 2, Welland ship canal, Homer, Ont.

J. A. Yarker, '11, is on the business staff of the "Saturday Sunset," Vancouver, B.C. He is on a visit to Toronto at present.

In the Alumni Directory of the October issue of "Applied Science" it was incorrectly stated that Mr. K. G. Ross, '06, is with Lang & Keys, Saut Ste. Marie, Ont. Mr. Ross has for the last three years been a member of the firm Lang & Ross (J. L. Lang, '06), engineers and surveyors, Sault Ste. Marie, Ont.

D. G. Ferguson, B.A. Sc., '14, is on the engineering staff of the Hydro-Electric Power Commission of Ontario, Continental Life Building, Toronto.

H. S. Clark, '10, is engaged on work on Section 2, Welland Ship Canal, at Homer, Ont.

I. R. Strome, B.A.Sc., '14, is in the irrigation office, Department of Interior, at Calgary, Alta. He is at present of the staff employed on the re-classification of C.P.R. irrigated lands.

C. I. Grierson, B.A.Sc., '14, is employed as electrical engineer for the Wabamun Power and Coal Company, Edmonton, Alta.

Capt. L. E. Jones, '11, was in Toronto for a few days recently. He will accompany the Second Contingent to Europe with the Western Ontario Division, and is now in camp at London, Ont.

A. W. Crawford, B.A.Sc., '14, will accompany the Second Contingent to Europe, as corporal, 2nd Field Company, Canadian Engineers.

Silvester, G. E., '91, is chief engineer for the Canadian Copper Co., at Copper Cliff, Ont.

Sims, F. R., '13, is appraiser, Department of Customs, Ottawa, Ont.

Sinclair, D., '02, deceased.

Sinclair, D. G., '13, is with the Canadian Co., Copper Cliff, Ont.

Sisson, C. E., '05, is with the Canadian General Electric Co. at Peterboro, Ont., as transformer, estimating, designing and supervising engineer.

Slater, F. W., '04, is with the General Electric Co. at Schenectady, N.Y., as commercial engineer in the Turbine Sales Department.

Smallpiece, F. C., '98, is with the General Supplies Co., Calgary, Alta., as chief engineer and assistant manager.

Smart, R. S., '04, is manager of Featherstonhaugh & Co., patent solicitors and engineers, Ottawa, Ont.

Smiley, R. W., '97, address not known.

Smith, A. N., '92, is engineer for Wm. B. Pollock & Co., Youngstown, Ohio.

Smith, A., '94, is city engineer, North Vancouver, B.C.

Smith, H. G., '03, deceased.

Smith, Alex. H., '00, is manager of the Teck-Hughes Mine, Swastika, Ont.

Smith, R. W., '98, has a surveying practice at Revelstoke, B.C.

Smith, J. H., '03, address not known.

Smith, D. A., '04, is a member of the firm Smith & Phillips, civil engineers, and land surveyors, 1855 Scarth St., Regina.

Smith, K. H., '11, is with the Water Power Branch, Department of Interior, Ottawa, Ont.

Smith, M. L., '11, is associate editor with the Maclean Publishing Co., 143 University Ave., Toronto.

Smith, W. C., '10, is in the city engineer's office at Victoria, B.C.

Smith, G. E., '10, took a post-graduate course in Analytical and Applied Chemistry at the "School" last year. We believe he is at Bozeman, Montana, now.

Smith, F. L., '10, is superintendent of the Queen Victoria Mine, Nelson, B.C.

Smith, F. R., '07. Address not known.

Smither, W. J., '04, is demonstrator in drawing at the University of Toronto.

Smithrim, E. R., '07, is at Strathroy, Ont.

Snaith, W., '07, is secretary-treasurer and engineer of the Thor Iron Works, Ltd., Toronto, Ont. He is also secretary-treasurer of the Canada Cement and Concrete Association.

Sneath, R. G., '11, is engaged on the Welland Canal survey at Thorold, Ont.

Sparling, M., W. '09, is with the Seymour Power & Electric Co., Ltd., Campbellford, Ont.

Speller, F. N., '93, is metallurgical engineer for the National Tube Co., Pittsburg, Penn.

Spellman, W. A., '13, is in Hastings, Ont.

Spence, J. J., '08, is with the Sovereign Construction Co. Ltd., Lumsden Building, Toronto.

Spencer, A. C., '07, is mechanical engineer for the Hamilton Stove & Heater Co., Hamilton, Ont.

Spotton, A. K., '94, is chief engineer for Goldie & McCulloch Engine Works, Galt, Ont.

Spry, R. J., '10, is, we understand, in London, Ont., at present.

Squire, G. E., '11. We do not know how he is engaged at present.

Squire, R. H., '93, deceased.

Stamford, W. L., '08, was on the engineering staff of the Hydro Electric Power Co. at Pointe Du Bois, Man., when last heard from.

Starr, R. H., '08, is estimating engineer for the Toronto Hydro Electric system. His address is 670 Indian Rd., Toronto.

Stayner, D. S., '09, of 201 Heath St., W., Toronto, is resident engineer for the Harbor Commission, Toronto.

Steele, I. J., '02, is in the topographical surveys branch of the Department of Interior at Ottawa, Ont.

Steele, A. L., '10, is demonstrator in mining engineering, University of Toronto.

Steele, W. S., '11, is with the Brooklyn Rapid Transit Co., Brooklyn, N.Y.

Stern, E. W., '84, is consulting engineer at 101 Park Avenue, New York, N.Y.

Steven, H. M., '10, is mining engineer for the Canadian Mining and Finance Co., Timmins, Ont.

Stevenson, W. H., '01, address not known.

Stewart, A. E., '11, is in Toronto at present.

Stewart, J. A., '98, is engineer and contractor, 67 Federal Life Bldg., Hamilton, Ont.

Stewart, D. L. N., '05. We understand that he has been at Fort Francis, Ont., during the summer, with the Department of Lands, Forests and Mines.

Stewart, M. A., '05, is assistant engineer in the roadway department at the City Hall, Toronto.

Stewart, R. O., '11, is in the bridge department of the I. R. Co. at Moncton, N.B.

Stewart, W. M., '06, is a member of the firm Phillips, Stewart & Lee, engineers and surveyors, Saskatoon, Sask.

Stewart, G. S., '07, is sales engineer for the Toronto General Electric Co., Toronto.

Stewart, A. W. J., '08, is assistant engineer of the Hydro-Electric system, 226 Yonge St., Toronto.

Stewart, N. C., '09, is at Nelson, B.C.

Stiles, J. A., '07, is professor of civil engineering at University of New Brunswick, Fredericton, N.B.

Stirret, G. P., '08, was resident engineer for C. N. P. Ry., at Henningville, B.C., when last heard from.

Stiver, J. L., '07, is inspector of gas and electricity with the Department of Inland Revenue, Toronto, Ont.

St. Lawrence, J., '08, is superintendent of engine shops, Erie City Iron Works, Erie, Pa.

Stock, J. J., '08, is Dominion Land Survey contractor in the Edmonton district. His address is 448 Cooper St., Ottawa.

Stock, P. H., '09, is assistant engineer for the N. St. C. & T. R. railway. His address is 26 Chestnut St., St. Catharines, Ont.

Stocking, F. T., '95, of 74 Kendal Ave., Toronto, is with the Hydro Electric Commission.

Stone, L. I., '10, is resident engineer for the G. T. Railway at London, Ont.

Story, R. A., '11., is on the engineering staff of the B.C. Telephone Co., Vancouver, B.C.

Strathy, J. M., '13, is corporal with the 2nd Field Company, 2nd contingent Canadian engineers.

Street, J. C., '09, is in charge of survey of the Welland Ship Canal. Address is, care of Welland Ship Canal, St. Catharines.

Stroud, S., '09, is sales engineer for the Canadian Westinghouse at Toronto, Ont.

Stuart, H. B., '08, is designer and estimator for the Hamilton Bridge Works Co. Ltd., Hamilton, Ont.

Stuart, J. L. G., '07, '08, has been on an extended trip through Europe during the summer. We do not know how he has been engaged since his return.

Stubbs, W. F., '05, is assistant engineer for Goldie & McCulloch Co., Galt, Ont.

Stull, W. W., '97, is surveyor and mining engineer at Sudbury, Ont.

Sturdy, N. H., '05, is engineer for the Trussed Concrete Steel Co., at Youngstown, Ohio.

Summers, G. F., '07, is a member of the firm Routley & Summers, Ontario land surveyors and contractors, Haileybury, Ont.

Sutcliffe, H. W., '07, is a member of the firm Sutcliffe & Neelands, engineers and surveyors, New Liskeard and Cochrane.

Sutherland, A. L., '10. His last address on our fyle is 87 Cowan Ave., Toronto.

Sutherland, W. H., '02, is assistant engineer for the Montreal Water & Power Co. His address is 384 Grosvenor Ave., Westmount, Que.

Sutherland, C. C., '09, is assistant roadways engineer on the city engineering staff, Edmonton, Alta.

Sutherland, D., '13, is in the roadways department, City Hall, Toronto.

Swan, W. G., '05, formerly division engineer for the Canadian Northern Railway at New Westminster, B.C., is now with the artillery at Duncan's, Vancouver Island, B.C.

Swan, R. G., '09, is chief engineer of the British Columbia Hydrographic survey, New Westminster, B.C.

Sword, A. D., '08, '09, is concrete designer for Clarence W. Noble, concrete reinforcement and fire-proofing specialties, Home Life Building, Toronto.

Sykes, F. H., '05, is chief plan examiner in the city architect's department at the City Hall, Toronto, Ont.

Symmes, H. D., '91, has a practice as engineer and contractor at Niagara Falls S., Ont.

Sylvester, K. B., '10, is with the Sylvester Mfg. Co. at Lindsay Ont.

Szammers, C. F., '11, of 10 Callender St., Toronto, is with Sherwood & Sherwood, contractors, Toronto.

INDEX TO OUR ADVERTISERS

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO DEC., 1914 New Series Vol. IX. No. 8

THE ST. CLAIR AVENUE BRIDGE*

†E. M. PROCTOR, B.A. Sc., '08

Prior to 1909 there existed on St. Clair Avenue, between Bathurst Street and Spadina Road, a small wooden bridge which spanned Black Creek. In 1909 a reinforced concrete culvert (6 ft. x 6 ft.) was built at this location, and an earth embankment twenty feet in height was constructed across the ravine. In 1911 it was decided to regrade and widen St. Clair Avenue and to build the now existing St. Clair Avenue Civic Car Line. The width of the street was fixed at one hundred feet, and at Black Creek the height of the embankment was raised from twenty to fifty feet, which necessitated the extension of the culvert to a total length of two hundred and seventy-two feet. This extension was made from the same design as was used for the portion then existing.

In January, 1912, a temporary trestle was built upon the old embankment and a burrow pit opened up, just west of the ravine. Two steam shovels and a work train were used. This filling, being nearly all done during cold weather, was in a more or less frozen condition. On June 26th, 1912, it was discovered that portions of the culvert had failed, the roof having fallen in. The collapsed portions were in the newly constructed culvert, the older part remaining intact. The probable reason for failure was, that the earth, as it thawed out, settled on the top of the culvert without arching itself over the culvert, as the design, no doubt, intended that it should do. The older part of the culvert, with the previously placed fill not collapsing, bears out this theory.

The failure of the culvert and its necessary repair re-opened the question of providing an opening for a driveway in the ravine. Several conditions favored this proposition. Sir Henry M. Pellatt had donated a one hundred foot strip of land in the ravine for this purpose and there was no means of continuing this proposed driveway to the north without constructing a bridge in the embankment at St. Clair Avenue. The owners of the flats to the north were claiming heavy land damages on account of the embankment cutting off their ingress and egress. The construction of a bridge and the building of a road in the ravine would combat these damage claims to a great extent.

In the summer of 1912 the City Council decided to construct a bridge with an opening of one hundred feet. The Railway and

† Structural Designer, Bridge Dept., City Hall, Toronto.

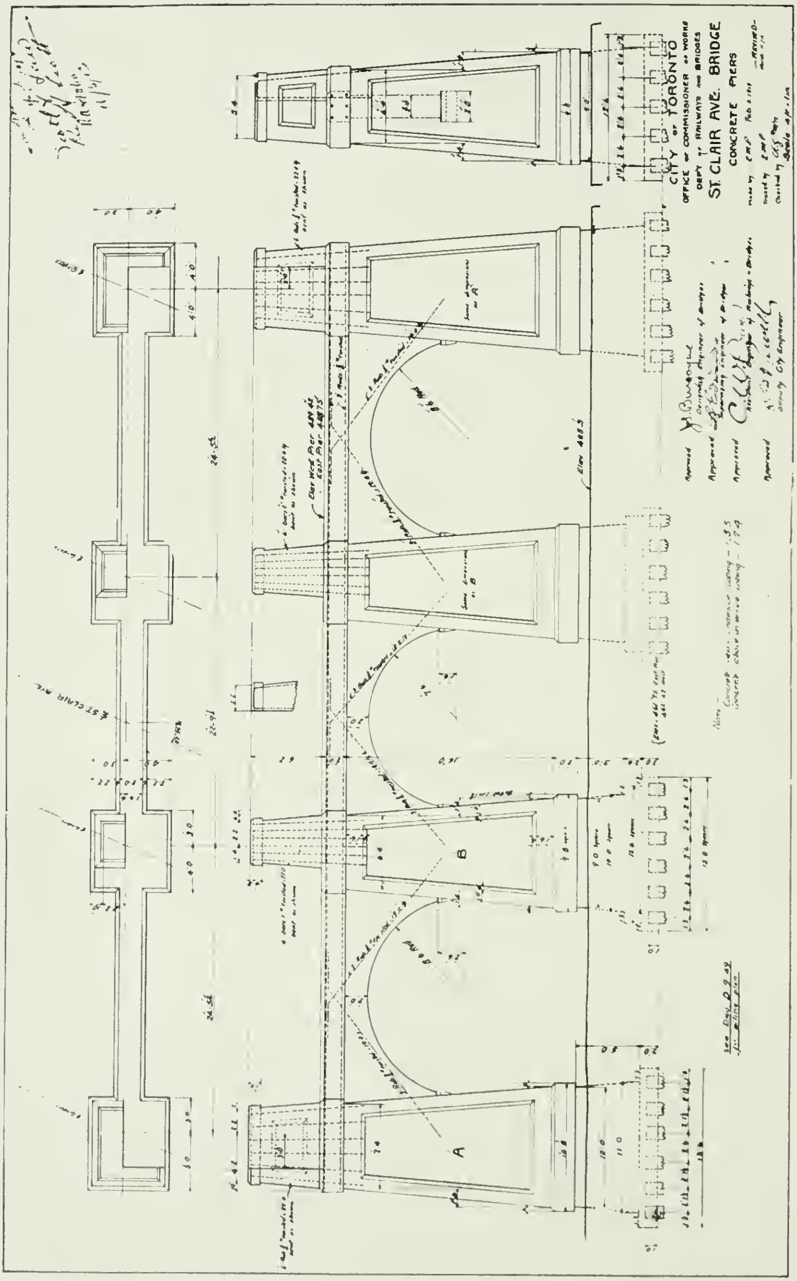

CITY OF TORONTO
OFFICE OF COMMISSIONER OF WORKS
DEPT. OF RAILWAYS AND BRIDGES
ST. CLAIR AVE. BRIDGE
CONCRETE PIERS
D-9-46
A
B

Fig. 1

Bridge Department prepared plans for a deck plate girder bridge with a concrete span of 100 feet and two approach spans of 40 feet, with a total deck width of 90 feet (handrail to handrail) and a clear distance between curbs of 69 feet, the substructure to be composed of concrete piers and abutments bearing on pile foundations. The bridge is skewed at an angle of 23° to the centre line of St. Clair Avenue and is on a .67 per cent grade.

The plans were approved and contracts let in the early summer of 1913 to the McGregor & McIntyre Company for the structural steel work, and to Scott & Law for the piling and concrete work.

The first work to be done was to repair the culvert and excavate a site in the embankment for the bridge. When the excavation was completed a temporary timber trestle was built to accommodate

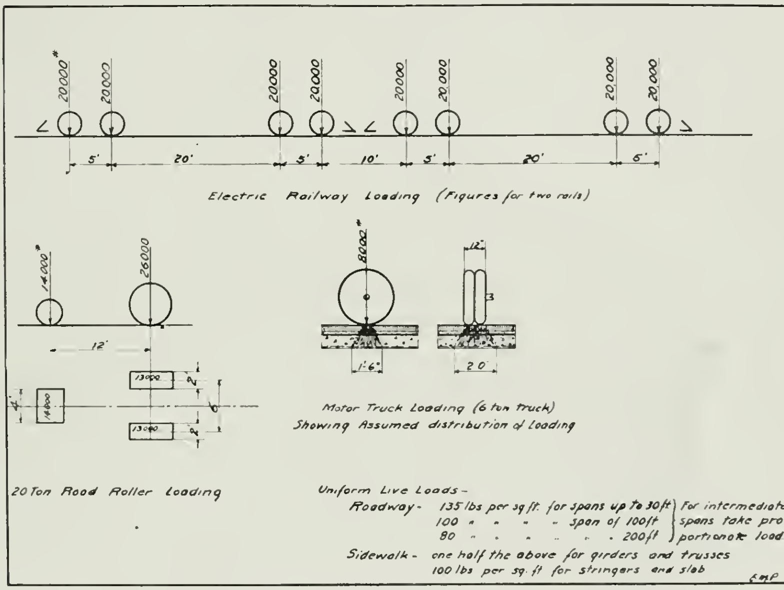


Fig. 2—Loading Specifications

the Civic Street Railway and pedestrian traffic. The Civic Street Railway was not ready to operate till several weeks after the trestle was completed. This trestle was so constructed that the new bridge could be built without interfering with the street railway traffic. This was accomplished by bridging over the spaces occupied by the piers and abutments with steel beams, which could be easily removed when it was necessary for the pile driver to pass through: this was always done at night when few cars were running. The two street railway tracks were merged into a gauntlet track on the trestle. This construction did away with the necessity of the cars stopping and turning a switch at the ends of the trestle, and brought the cost of the trestle down to a minimum. The operation of this gauntlet proved very satisfactory, very little inconvenience resulting

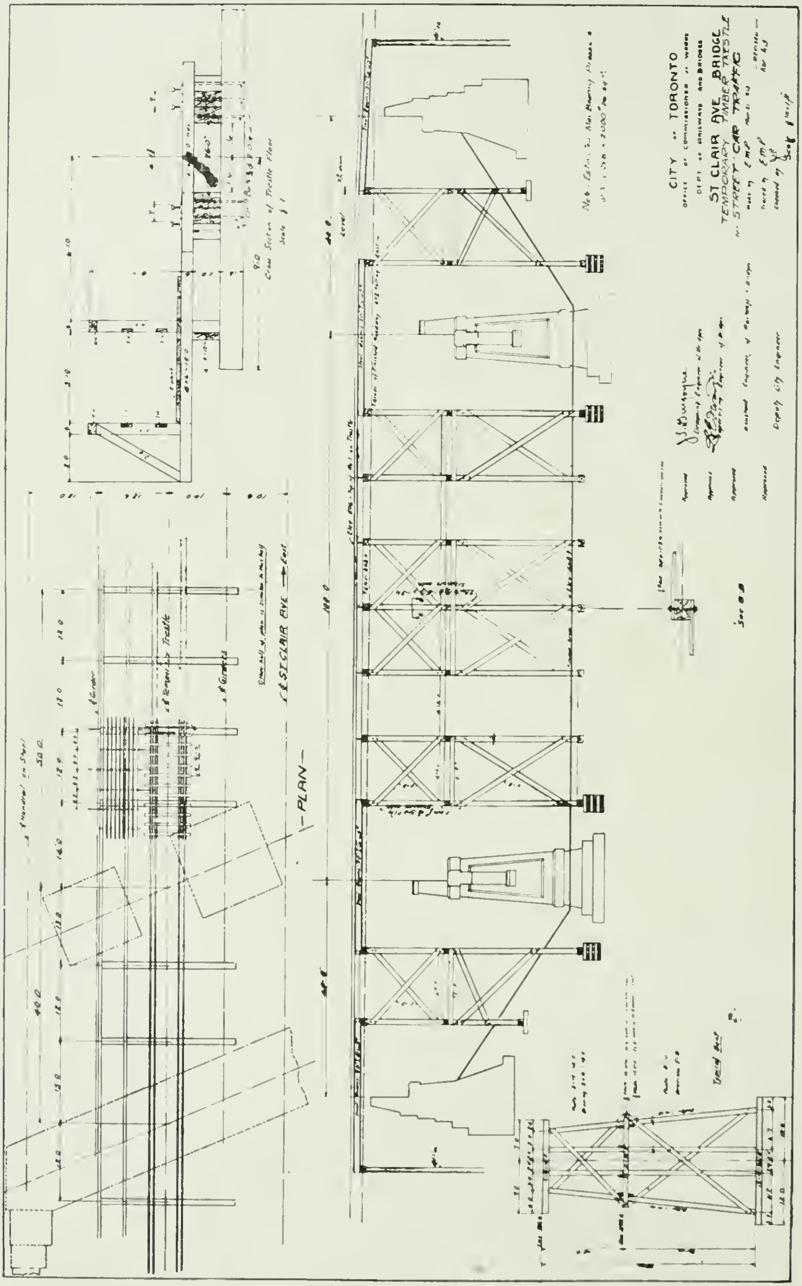

CITY OF TORONTO
ST CLAIR AVE. BRIDGE
TEMPORARY TIMBER TRESTLE
FOR STREET CAR TRAFFIC
D. 9. 52
-PLAN-
ST CLAIR AVE

Fig. 3

to the operation of the Civic Car Line. The City did all this repliminary construction by day labor.

The specifications for the permanent bridge were the City of Toronto's and Ontario Railway and Municipal Board's specifications. The item of most interest in the specifications is the loadings assumed. See Fig. 2.

The ground on which the permanent bridge was to be built is all filled-in-material and below that rather soft soil, it was necessary, therefore, to resort to piling for a proper foundation. Piles were supplied according to the following specifications:—"Piles shall be of white oak, of straight, live timber, free from cracks, shakes, rotten knots, or other blemishes. They shall be so straight that a straight line taken in any direction and run the length of the pile

Fig. 4—General View of Finished Bridge.

shall show that its centre is at no point over four inches out of a straight line. They shall show an even, gradual taper from end to end and must not be in diameter less than eight inches at the point and not less than sixteen inches at the butt. The ends shall be cut square, the body barked and all knots trimmed smooth."

The pile driver used was an Arnott four-ton double acting steam hammer, with the following dimensions:—stroke 21″, diameter of piston 9½″, steam pressure (working) 60 pds. per sq. in., the energy of each blow figures out to be 10,000 ft. pds., 110 blows per minute were delivered to the pile. Most of the piles were driven to refusal. An idea of the force of the blow of the hammer can be obtained from the following incident. A ⅜″ bolt broke, somewhere

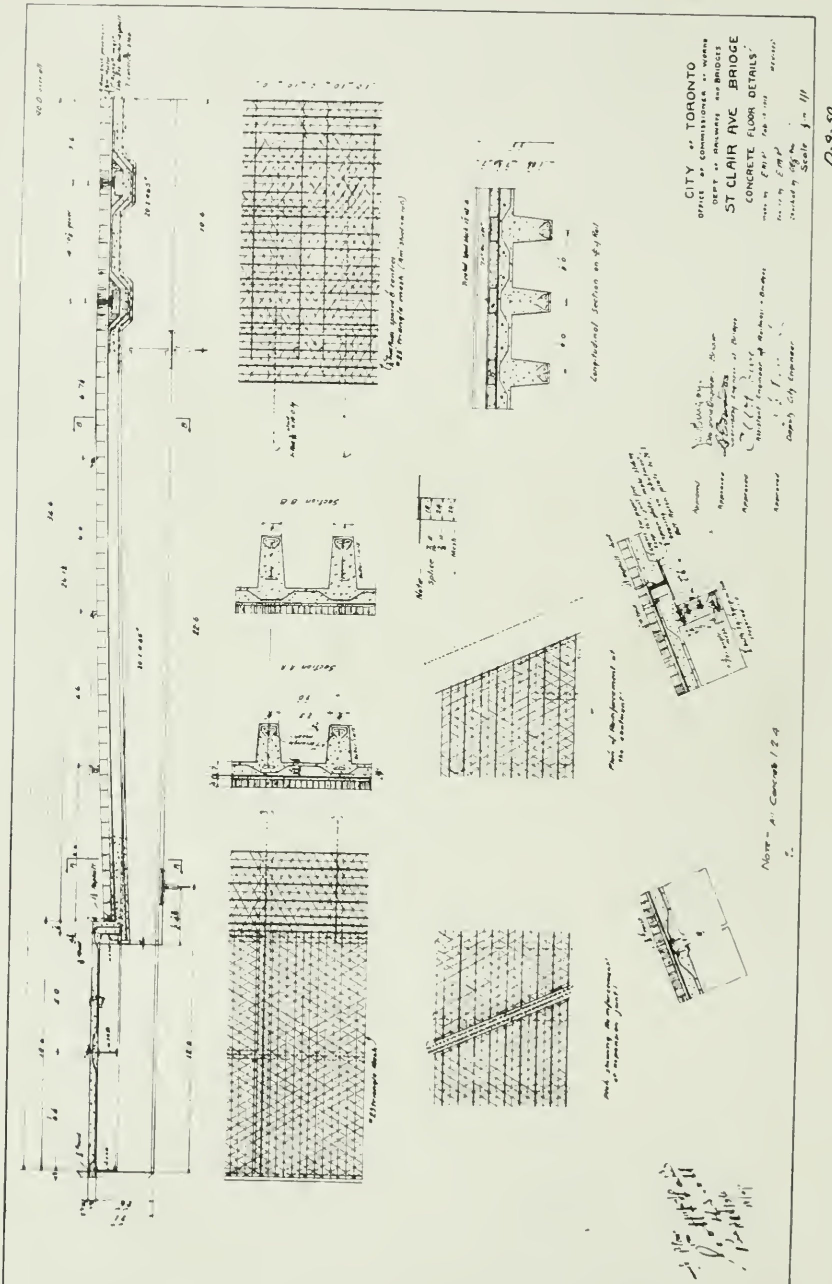

CITY OF TORONTO
ST CLAIR AVE BRIDGE
CONCRETE FLOOR DETAILS
Longitudinal Section on £ of Rail
Section A A
Section B B
D-9-50

Fig. 5

on the hammer, and the nut and a part of the bolt dropped onto the plate at the head of the pile and before the steam could be shut off, the hammer struck it one blow, flattening the bolt and nut to ⅛″ thick. Although the tops of the piles are not below water level yet the perpetual dampness of the clay soil keeps the piles wet and prevents decay. The calculated loading for each pile was fifteen tons.

The abutments and piers are built of mass concrete with local reinforcement. The concrete mix was 1:3:5 below underside of coping and 1:2:4 above. The abutments are 26 feet high and 100 feet long with 20-foot wing walls parallel with the street line. The base of the main wall is 13′ 3″ wide. Reinforcing steel (square twisted rods) is supplied in the base over the piles, under the bridge

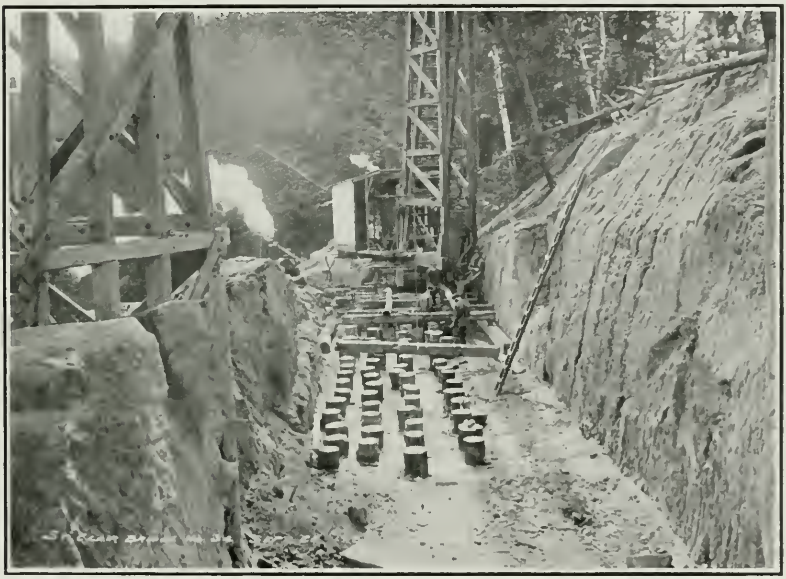


Fig. 6—Piling in west abutment showing piles " cut off."

seat, at the rear of the back wall and around the corners. No expansion joints were used.

The piers are about 10 feet square at the ground line and taper up at a batter of 1 in 12. They are 15 feet square at the top of the piling. From base of piers to roadway is about 40 feet. The piers are panelled on four sides and are joined transversely by means of a concrete strut which is constructed in the shape of an arch. On top of the piers is a concrete pedestal 6′ 2″ high on which rest the 40-foot girders. These pedestals are doubly reinforced by 6-1″ sq. twisted rods bent in the form of an inverted U, the assumption in the design being, that the pedestal has to withstand the expansion and contraction forces of the 40-foot girders caused by the friction between the

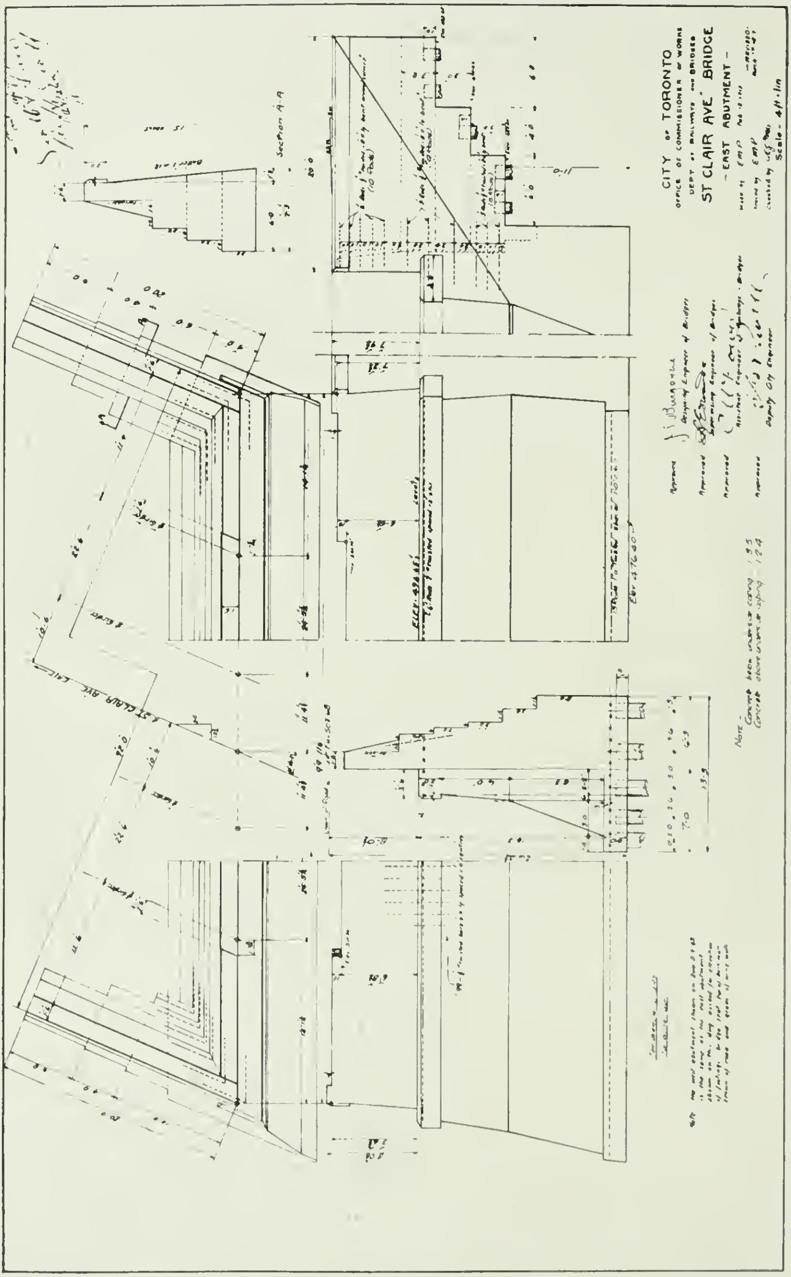

CITY OF TORONTO
ST CLAIR AVE BRIDGE
- EAST ABUTMENT -
Section A-A

Fig. 7

bearing plates. Reinforcing steel is also supplied along the top of the piers and struts and diagonally through the arched portions of the struts.

The finishing of the exposed concrete surfaces is best described by quoting an extract from the specifications, "As soon as the forms are removed and all cavities filled, the concrete surfaces shall be thoroughly rubbed with cement grout compound of one part cement to two parts fine sand until all irregularities in the surface are filled, after which the whole surface shall be gone over with a piece of sandstone or carborundum brick and ground down sufficiently to remove all irregularities. The grout surfacing herein specified shall, in no case, be used for the purpose of producing a plaster coating to cover irregularities in the surface, produced by sagging or similar defects

Fig. 8—Showing Method of Laying Tracks on Bridge Floor.

in the forms. Care must be taken that the surfaces so treated shall be thoroughly wet before the grout is applied."

The steel work of the bridge consists of four rows of girders, the centre span 100 ft. and the two outer spans 40′; 20″ I beams at 65 lbs. spaced 3 ft. centres rest directly on top of these girders. Every fifth beam cantilevers out to carry the fence and sidewalk stringers. An ornamental iron fence extends from end to end of wing walls on each side of the bridge. The girders are the common plate and angle type; the flange of the inside 100-ft. girder is made up of 2 angles 8″ x 8″ x ¾″ and 4 cover plates 19″ x ¾″ which with one eighth of the web gives a net flange area of 76.88 sq. in. This particular girder weighs 40 tons. Cross frames composed of angles

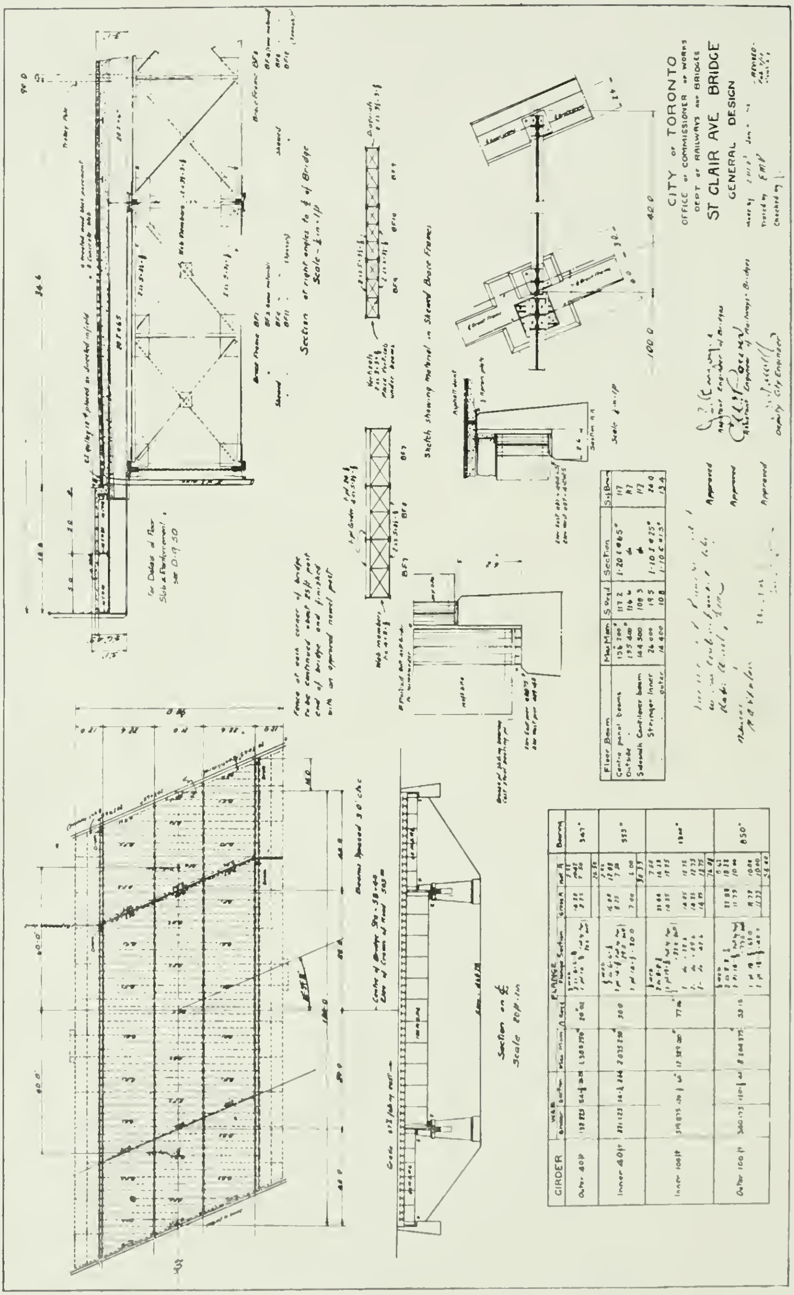

CITY OF TORONTO
OFFICE OF COMMISSIONER OF WORKS
DEPT OF RAILWAYS AND BRIDGES
ST CLAIR AVE. BRIDGE
GENERAL DESIGN
D·9·40
Section on ℄
Scale 20 ft.-in
Sketch showing material in Skewed Brace Frames
Section at right angles to ℄ of Bridge
GIRDER
Approved

Fig. 9

are placed about every 18 feet centres between the girders. No horizontal diagonal bracing was used, the great width of the bridge and also the solid type of reinforced concrete floor used making this type of bracing unnecessary. The trolley poles are placed in the centre of the roadway and are carried in an 8″ diam. iron pipe socket about 3 feet deep, which is supported on beams between the floor beams. This construction permits the easy removal of the trolley pole when necessary, the pole being merely wedged in the socket and a cast iron wheel guard placed around the base.

The expansion joints are so arranged as to be invisible from the finished bridge floor, the paving and waterproofing being carried

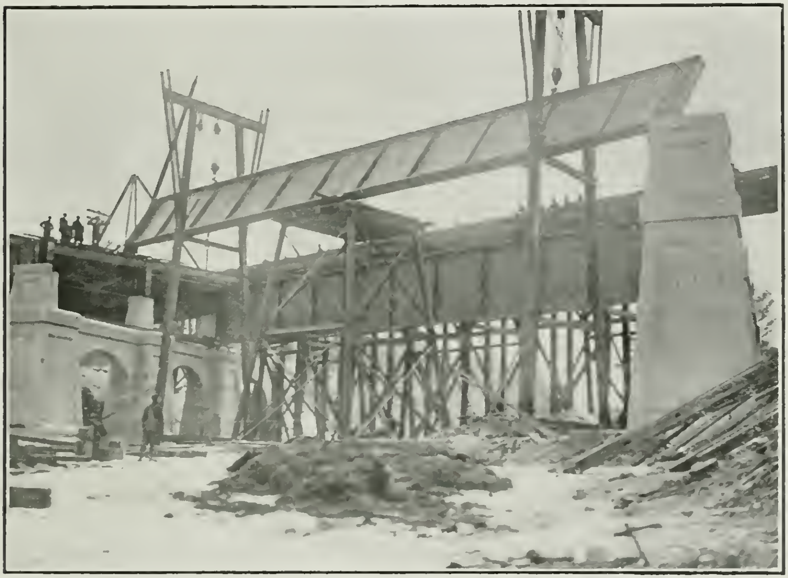


Fig. 10—Erection of One of Inner 100 ft. Plate Girders.

right over the joint. The expansion joint in the bridge floor is constructed of two vertical web plates, cut on top to the curve of the roadway and fastened at the base by means of an angle to the floor beams. To the top of each of these plates is riveted an angle also bent to the curve of the roadway, a cover plate riveted to one of these angles and free to slide over the top of the other completes the expansion joint. On account of the skew of the bridge and the fact that the street railway rails had to pass through the expansion joint, the detailing of this joint proved a little intricate. The expansion joints at the abutments are the usual apron plate type, with an asphalt joint between the concrete of the bridge floor and the concrete base for the pavement of the approach.

Structural steel catch basins are provided at various points in the bridge floor, these are connected to the creek below by four inch drain pipes. The sides of these catch basins have a batter of 3 in 12 to destroy the expanding force of ice, if the basin happened to be full of water in cold weather.

The pier members of the 100-foot girders at the sliding ends consist of a cast steel bed plate with a phosphor bronze plate inset into the top of it, while another bronze plate inset into the under side of the bearing plate of the girder completes the expansion bearing. At the fixed ends the bronze plates are omitted. The bearings for the 40 ft. girders are the ordinary steel plate type. This type of bronze plate expansion joint has given very good satisfaction so far.

In the design of the fence we were confronted with these two conditions; to make a strong fence and to make it pleasing in appearance. There have been several accidents lately in which the bridge

Fig. 11—View Showing Construction of Fence and Method of Reinforcing Sidewalk Slab.

fence was the only thing between a motor car and the ravine below, and the policy of the city now is, to build good stout fences on their bridges. The fence, as built, consists of 18 inches at the top of scroll work made of 1¼″ x ¼″ bars and 27″ of 45° lattice work at the base, made of 1¼″ x ¼″ bars, and is 4 feet high. A Carnegie handrail tee section No. 154 with one 1¼″ x 1¼″ x ¼″ angle underneath to connect the scroll work to, composes the top chord, a 2½″ x 2″ x ¼″ angle separates the scroll from the lattice work and a 2½″ x 2″ x ¼″ angle three inches from the sidewalk slab completes the fence. 5″ x 3″ tees at 13.6 lbs. at 7′ 6″ centres are used for fence posts. The scroll work and latticing were so designed as to be continuous in appearance at the fence posts.

The steel work was fabricated and erected by the McGregor & McIntyre Company. The transportation of this heavy steel from their plant on Shaw Street to the bridge site over the city streets, a distance of two miles, was admirably solved by the presence of good sleighing. The 100-ft. girders were loaded, flatwise, on two heavy sleighs, the tractive force being supplied by a large six-ton motor truck and a hoisting engine. When the motor truck could not start the load or when the grade was too steep, the hoisting engine, which was on skids, was snubbed to a telephone pole ahead of the load and a wire cable attached to the load; then with both the truck and hoisting engine no difficulty was experienced in moving the load. In this manner a grade as high as 7½ per cent. was successfully negotiated. On flat grades and generally on light grades the

Fig. 12. Showing the three stages of waterproofing.

motor truck had no difficulty in "walking right along" with its 40-ton load. It took, on an average, a day to transport one of those big girders to the site, the many corners to turn and the numerous heavy grades to go up and down occupying most of the time. Every time the sleighs stopped for any length of time the runners would freeze tight, necessitating the use of jacks to get started again.

The erection of the small steel was mostly done by means of a hand derrick and gin pole. The 100-ft. girders were erected in the following manner:—The girder was laid down flat and hauled, by means of two gallows frames, into position where it was supported, upon its side, on a platform. The girder was then lifted up till it was standing vertical, and then, after taking away the platform, was lowered into place. Two hoisting engines were used in this work, one for each gallows frame.

After the steel was in place and riveted up, the concrete floor, consisting of a 7-inch reinforced concrete slab, was laid. The reinforcing used was, one layer No. 23 triangle mesh and 7-16″ square twisted rods at 8-inch centres. The sidewalk slab is 4 inches thick with one layer of No. 23 triangle mesh reinforcing. The floor beams with the exception of the cantilevered portions and the sidewalk stringers are encased in concrete. 1:2:4 concrete was used in this work.

The concrete floor slab was waterproofed in the following manner:—

First—The surface was thoroughly cleaned by means of a hose and brooms.

Second—The surface was well swabbed over with hot asphalt.

Third—Three layers of 8-oz. burlap were well swabbed on with hot asphalt, the burlap being laid shingle fashion.

Fourth—One inch asphalt mastic was spread on top of the burlap. At the expansion joints the burlap was doubled upon itself to allow for expansion.

On top of the asphalt mastic was spread one inch of sand and cement mixed dry on which base a four inch creosoted wood block pavement was laid.

The rails were fastened to creosoted wood blocks 12″ x 12″ x 4″ laid 3 ft. centres. The method of fastening was by means of 4-7/8″ screw spikes, screwed into holes that had been bored into the blocks before creosoting. These blocks rest in a trough provided in the concrete floor which, after the rails had been properly lined up, was filled in with concrete.

The paint used was as follows: 1 shop coat red lead mixed with 22 lbs. red lead (94 per cent. pure) to one gallon pure raw linseed oil. 1st, field coat of superior graphite natural color; 2nd, field coat of No. 72 superior grey paint. The steel encased in the concrete was not painted.

The contract for the structural steel work was let to the McGregor & McIntyre Company at the following prices:—

836,346 lbs. steel at 4.3c per lb.	$35,962.88
455 lin. ft. handrail at $3.25 per ft.	1,478.75
	$37,441.63

The contract was let for the substructure and floor, exclusive of paving, to Scott & Law for $27,000.00, piling at 40c per ft. and extra concrete at $9.00 per yd. and extra excavation at 50c per cubic yard. The waterproofing, included in the $27,000.00 contract, was laid by the Canada Floors Company, Ltd., "Sarco" waterproofing being the brand used. The price paid for this work was $2,450.00, being at the rate of $1.75 per sq. yd. The concrete quantities were as follows:—

2 abutments	1,566 cu. yds.
2 piers	710 cu. yds.
Floor	629 cu. yds.
	2,905 cu. yds.

Reinforcing steel—53,400 lbs.
Piling—596 piles—15,542 lin. ft.
Summary of cost:—

Steelwork	$37,441.63
Concrete	27,000.00
Piling	6,216.80
Engineering, extras, etc	9,341.57
Total	$80,000.00

The designing, supervision and inspection of all the work was done by the staff of the railway and bridge section of the Works Department of the City of Toronto. R. C. Harris is Works Commissioner.

* Read before the University of Toronto Engineering Society, Dec. 2nd, 1914.

ENGINEERING SOCIETY MEETING
Dedicated to
The Memory of the late Dean John Galbraith, M.A., LL.D.

On Wednesday evening, December 9th, an open meeting of the Engineering Society was held in Convocation Hall. This meeting was dedicated to the memory of the late Dean Galbraith and was addressed by Mr. G. H. Duggan, '83, Dr. T. Kennard Thomson, '86, President Falconer and Dean Ellis.

President Gray in his introductory remarks referred briefly to the work which Dr. Galbraith had accomplished by virtue of his remarkable ability, his diligent application to his duties, and his faithful adherence to his high ideals. He said, "If at this meeting we will instil in our own minds and hearts some of the ideals which the late Dean so worthily upheld, then the meeting shall not have been in vain. The members of the Society are grateful indeed to Mr. Duggan and Dr. Thomson for their kindness in coming so far to help the students and graduates in handing down to posterity the memory of the man, who had merited and won the esteem and affection of all those who were so fortunate as to have him as a teacher or friend.

Mr. Duggan was one of the late Dean's early students, graduating in 1883. After graduation he was assistant to Dr. Galbraith for some time and so had come to know him very well indeed. His close association with him had given him an exceptionally good opportunity to realize the sterling qualities of the man whom he had always held in the most profound respect.

Mr. Duggan was followed by Dr. Thomson, an extract of whose address follows:—

"I thoroughly appreciate the honor of being invited to say to you to-night what we all think of our late beloved Dean, John Galbraith, but it is to be regretted that an orator was not selected, for there are many such among our graduates.

When your able professor, Mr. C. H. C. Wright, whom I remember as a freshman at the head of his class, brought me your extremely flattering invitation, I explained to him that I was not big enough a man for the purpose. He said that he knew it, having known me for nearly thirty years, but that he also knew that there was not a man in the world who could do justice to the memory of Dean Galbraith.

Montreal has the honor of being the birthplace of our late Dean, who was born of Scotch parents in 1846. He obtained his early education at the Port Hope Grammar School, and as a boy worked for Mr. George A. Stewart, the father of our genial and able professor.

Mr. Stewart lent him a copy of Rankine's 'Civil Engineering.' This book was a revelation to young Galbraith, who began to realize what a deep subject engineering was; having determined to study that profession at the University of Toronto, he was very much disappointed to find that the course existed here only on paper.

Not being able to get an education as a civil engineer in Canada, he decided to take an Arts course. He was graduated from the University of Toronto in 1868, when he won the Prince of Wales Prize for General Proficiency, the gold medal and other prizes for mathematics.

In the meantime, as Col. Ponton told you last winter, young Galbraith was out on a survey when the call came for volunteers to quell the Fenian Raid. Both he and his chief wanted to enlist, but both could not go without breaking up the party, so it was decided that the best fighter should go to war.

The future Dean left for the front after a conference in an open space that evening.

On leaving the University he apprenticed himself at once to Mr. Stewart, who qualified him as a Provincial and Dominion Land Surveyor in 1871. Thus he acquired the best education and training then obtainable in Canada, for an engineer.

From 1871 to 1878 young Galbraith worked hard and gained much experience in the practice of engineering on the Midland, Intercolonial and Canadian Pacific Railroads, as well as in private practice.

During the latter part of his railroad work, he came much in contact with the late Mr. James Ross, a very successful engineer, manager, and then financier on a large scale.

Mr. Ross was an exceptional judge of character, and in 1883 said that he considered Professor Galbraith to be an unusually capable engineer and that he would not advise any boy who was fortunate enough to be graduated by him to strive for any further University education—though he thought a year or so of travel in Europe would be time well spent.

The ten years in the active practice of his profession convinced

Mr. Galbraith, all the more, of the great necessity of an engineering school in Canada, and his cherished ambition was finally attained in 1878, when he, with the aid of Dr. Ellis, his lifelong friend and fellow teacher, to whom we owe so much, founded the School of Practical Science. He also had the hearty co-operation of Professors Loudon, Baker and Chapman of the University proper.

We can scarcely realize the many and enormous difficulties with which we had to contend, one of which was the ignorance of the public—an obstacle to all great undertakings. This was exemplified, as he used to enjoy telling, by the fact that a would-be pugilist called to enquire about the terms for a course in practical science, which he assumed meant boxing.

In those days he had no precedents to guide him. He was a pioneer in every sense of the word; studying each day the subjects in which he was to instruct the students in his lectures—since that time was practically before the days of text books.

Even without knowing this, however, one must marvel at his keen foresight, from the very beginning, in laying out the courses.

In those early days Professor Galbraith gave the lectures on all the engineering subjects, which wide range could only have been accomplished successfully by a man of extraordinary ability.

His success was such that there is not one of the early graduates who, after twenty-five years and more in the practice of his profession, does not feel that the instruction received from Professor Galbraith was of far greater value than could be obtained from any course in the best modern university, where the larger classes prevent the professors from giving so much personal attention to each student.

He told us from the start that he was not turning out full fledged engineers; that it was farcical to give a boy a degree of C. E. the day he was graduated: that he could only teach us how to study, so that, years afterward, by dint of careful study and hard practical experience, we could teach ourselves to become capable engineers.

Another piece of good advice he gave to many, was not to try to secure a permanent position on the day of graduation, but to move around from one kind of engineering work to another, for some ten years or so, until we found what we were best fitted for. There is nothing so sad as "a square peg in a round hole." It is also advisable to secure an increase in salary with every change, on the principle that the higher the salary the better the experience, since the employer can be depended on to give the most important work to the best paid men.

I never heard of the Dean's telling any one to be honest, truthful, and faithful to his employers, employees, family and friends, and yet, somehow, he made every one of us feel that he wished this, and that he hoped we would be able to live up to his high standard as nearly as our ability permitted.

For instance, I have heard him entertain a small child by quoting verses from 'Pinafore,' to show how industry might be rewarded in the 'Queen's Navy.' No trace of a moral was even hinted at, nor did the adults who heard him at the time suspect one; and, just so, the older boys and men received the inspiration from him without knowing it at the time.

A year or two ago I asked the Dean how it was that he had given up his canoe cruises in the wilds of the North, of which I knew he was very fond, for I had the pleasure of making from his very careful and complete notes, a map of his trip of 1881.

On this trip, which covered about three hundred and fifty miles, from Rupert's House (St. James Bay) to Lake Mistassini, he noted the great disturbance of the magnetic needle at certain places, indicating the presence of metal, where much has since been found.

He did not answer my question directly, but gave me a long account of how two of his friends had taken a similar trip and had been delayed several months on their return journey; and then he described minutely how worried and alarmed their families and friends had become. The inference was that he did not wish to give his wife and children cause for anxiety.

The Dean was exceptionally fortunate and remarkably few of the great men of the world have been so blessed, when he married the beautiful and capable sister of his friend, Mr. R. J. Stupart.

On the twenty-second day of last July, in the early hours of the morning, he peacefully passed away in that beautiful spot on the Georgian Bay, well named by him 'Go Home,' near to Nature, which he loved so well. His actions to the very last showed one of his dominant characteristics—consideration for those about him.

While he is greatly missed by family and friends, we all know that the work of his lifetime was completed in a manner seldom granted to man, and that he would have much preferred to have died in harness than to have lived on in enforced leisure due to impaired health.

I have referred to this as the oldest engineering society in Canada, and might remind you that this organization was formed in 1885, one year earlier than the Canadian Society of Civil Engineers. It was due to Professor Galbraith; and this is how it came about:

When we of the Second Year Class were discussing the idea of an Engineering Society, we were told that the Third Year men had thoroughly considered the matter the year before, and had abandoned it as hopeless for such a young School; for, even in 1885 there were only twelve graduates of the S.P.S., and only sixteen students then in the School who afterwards were graduated, so the subject was dropped.

A few weeks later I invited Professor Galbraith, Dr. Ellis, the Third and Second Year boys, as well as a few outside friends, such as the now eminent Toronto attorney, Mr. David T. Symons, the late medical genius, Dr. James D. Thorburn—to dinner, and after we had finished our coffee, I asked why we could not form an Engineering Society. Professor Galbraith rose immediately, settled the question at once and for all, and advised us to appoint a committee then and there to draw up a constitution and by-laws. His suggestions were carried out without delay.

As it was realized that it was necessary to start right, Professor Galbraith was persuaded to take the presidency for the first three years. Then he saw and recognized the merit of young Haultain, now your distinguished professor and one of the foremost mining engineers in America, and insisted on retiring in his favor.

His interest, however, never flagged, and more than once his assistance prevented disaster. One of these occasions was when he saved the society from a very serious financial difficulty, by undertaking to have one dollar a year collected from every student of the school.

I do not believe that ex-President Galbraith ever missed one of our annual banquets. This is quite a record for such a busy man and he was too modest to realize how much his absence would have been felt.

At one of these banquets some twelve years ago, I heard him address the boys, who had been at 'Loggerheads' with the faculty —I have forgotten what 'the tempest in the teapot' was about— but Principal Galbraith explained it in his usual clear-cut, manly, straightforward fashion, and then told the story of the Irishman who was riding a mule, which had tried every conceivable trick to get rid of him. Finally the mule got one of its hind feet caught in the stirrup. Pat looked down and said, 'Begorra, if you are going to get up, I think that I had better get off.' Dr. Galbraith then continued, 'but I would like to assure the students that the faculty is not going to get off.'

He had struck the right chord, as usual, and when the echo of the whole-souled applause had ceased, the friction was over.

The next annual dinner which I had the honor of attending was that great banquet of 1909, at which 830 were present. That was the time when you had invited the members of the Canadian Society of Civil Engineers, of which organization our Dean was a founder, councillor for many years, and, at that time, an honored president. This was in the second year of the presidency of Dr. Falconer.

We older boys had been quite worried for fear that the Senate might go outside of Canada for a president, but, thank God, they did not. Be well advised and always insist on having a native born Canadian for the presidency of this great University; and let me tell you that it is so considered by all Americans, the degrees granted here being highly esteemed in the United States.

Also insist, and this is of vital importance, that the future Deans shall be **native born Canadians and engineers.**

Many were the graduates who took long trips to attend that banquet, for the pleasure of meeting Dr. Falconer and, at the same time, showing him what we thought of Dean Galbraith.

The students that night were certainly 'feeling their oats;' they were not silent, but it was a sincere pleasure to us all to see how well the new president of our Alma Mater stood the ordeal—and won out. A weaker man, in his place, and the pleasure of the evening would have spoiled. I do not believe that even our former president, Sir Daniel Wilson, who, as you all know, was an exceptionally strong character, could have held these boys in check. The students had simply 'sized up' the new President and, instinctively had given him their respect and loyalty.

After the feast was over—and it was well on in the morning—a group of us were still discussing the great success, when a graduate of another university asked why his college could not give such an entertainment. He was answered by one of his fellow graduates, that it was merely because they had no Galbraith.

The only other of our annual reunions which I was fortunate enough to attend was that of December fifth, last year; having left a conference in Richmond, Virginia, and missed a hearing before the Senate in Washington, to get here—though that was nothing more than what many another graduate had done for the same purpose.

Most of you know what a treat it was to see and hear our Dean that night. As usual, he had not prepared a speech. That he was touched to the bottom of his heart was obvious to all. He told us the history of his life work, his early struggles to start and build up the School of Practical Science—our dear old S. P. S.

We had the good fortune that evening, to be able to watch his strong, kindly face, while he was speaking, and at the same time see what an impression that life story of his work made on President Falconer, and we realized that our president knew and appreciated the greatness of our dean.

It was also a source of much gratification to hear Sir Edmund Walker, Dr. J. A. Macdonald, Col. Ponton and the others, and to know that they, the great Canadian bankers, editors, military men and others, also appreciated the sterling worth of the most modest great man we have ever known.

Although the graduates and students knew how the Dean was loved, revered and respected, the demonstration given that night was music in the ears of all.

A fitting climax to that memorable evening, which we fondly hoped would be followed by many another, when we would again and again be able to attend to hear our dear Dean and let him know we still valued his friendship, was the reception he gave to us in the Old School, on the following afternoon, when we saw him in the midst of his charming family and friends.

It was always a pleasure when attending these functions, Mr. President Gray, to see how well they were presided over, and with what care the big and little matters were attended to, one of the most graceful incidents being the presentation of a beautiful basket of flowers to Mrs. Galbraith last December. Verily the founders of this Engineering Society "builded better than they knew."

The Canadian Club of New York and the University of Toronto Club of the same city, never lost an opportunity to invite Dean Galbraith to their banquets, and he never attended without giving pleasure to all; and when he sat at the table with the great financiers, statesmen, and other strong men of affairs, he was surpassed by none.

The Dean, like all true Canadians and Scotchmen, was loyal to the land of his birth and the land of his ancestors, and devoted to his parents. He was also devoted to his wife and children, and as true a friend as man, woman or child ever had.

He knew and appreciated the Indians and French Canadians, and was adopted into several Indian tribes, as a mark of their esteem and friendship.

On his last trip to the North he was the first white man to run the falls and rapids, then named after him, La Grande Chaudiere de Galbraith, Riviere Achamonchonan.

He had such a keen and genial humor and never tired of telling and hearing good stories.

He was such a hard worker that we never understood how he got asleep enough to keep his health.

As a student he was one of the organizers of the first Science Club of the University of Toronto.

In later years he was a vice-president of: The Ontario Land Surveyors Association, The Canadian Institute, the British Association for the Advancement of Science, and so on.

Many, if not all, the Dean's writings, such as 'The Function of the School of Applied Science in the Education of the Engineer,' should be republished in the Applied Science.

On the collapse of the Quebec Bridge, he was one of the three commissioners selected by the Canadian Government to make a report on the accident. Seven months of the most careful investigation and study resulted in what is considered one of the ablest, fairest and most scientific, as well as most humane reports ever made.

He considered it his duty to the Government and the University to accept this honor. As a rule, however, he refused all private practice that might possibly interfere with his work for 'The School.'

Some years ago he discussed the remuneration in the American Universities, and to the engineering profession generally, and though he fully realized that he could have made far more money (he would have made ten times as much) by going to the United States or entering private practice, he said that nothing could ever compensate him for what he would lose if he left the S.P.S., which he loved so well.

In brains, heart, faithfulness, industry, intuition of character, keen foresight, and executive ability, he was second to none, and he had the admiration, respect and love of all who were fortunate enough to know him, in a measure seldom granted to man."

In his remarks President Falconer said:—"The first occasion on which I met the late Dean Galbraith for the purpose of any conversation was in a class-room of the Faculty of Applied Science in June, 1907. Dean Ellis was also present. Our conversation turned upon the methods by which science should be taught to engineers. While he maintained strongly that the engineer should be turned out scientifically expert, he held that the teaching of science should be made as concrete as possible, and that it should be done by men who were acquainted with the practical problems that face the engineer. I realised soon that the method that Dr.

Galbraith held and very ably maintained, was a view that is wide-spread among schools of engineering. He also spoke to me again and again, during these last seven years, of his conviction that the course of Applied Science should not be regarded as producing engineers. Its whole purpose was to train men scientifically, to make them thinkers, so that they may become engineers afterwards when they get out into the practical life of the world. He also lamented constantly the number of subjects that were placed in the course, holding that a few subjects well mastered give a man thinking power and offer him the best training. In this he showed himself the right kind of teacher.

Dr. Galbraith's method in the direction and upbuilding of the School of Practical Science bore the imprint of his own sincere character. He did not copy other places, taking for example the calendars of the Massachusetts Institute of Technology or Cornell, and repeating in Toronto their arrangements. He studied the local situation and provided for emergent needs. When the mining development of the North required mining engineers he strengthened that department. For the demands of the workers in clay products he sought to provide instruction in ceramics. The result of this procedure has been that there is nothing useless to be cut out of the present Faculty of Applied Science. It was established upon the needs of the Province by a man who was both reasonable and independent. He would listen to new proposals, weigh and accept or dismiss them with exceedingly good judgment arising from a wide experience. The successor of Dean Galbraith has a solid foundation on which to build.

"It is not necessary for me to say anything further as to his character. He got his reward not in wealth, which is ephermeal, but in the affection of his students which is permanent. He was the centre of the annual dinner of the Engineering Society. Old graduates came back to it year after year because the Dean was there."

Dean Ellis followed President Falconer with an interesting address in which he recalled many incidents in the life of Dr. Galbraith, whom he had always considered a most cherished companion and friend. Many obstacles of considerable magnitude had confronted the late Dean in the accomplishment of his work, but his persistent perseverance and his unity of purpose had earned for him a reward such as few men attain.

A. J. Dates, B.A.Sc., '13, is in Detroit, U.S.A., with the State Railway Commission of Michigan.

Fred. Alport, B.A.Sc., '06, is with the second Canadian contingent, in the Third Field Troops, Royal Canadian Engineers.

F. C. DeGuerre, B.A.Sc., '11, is assistant to the city engineer, North Vancouver, B.C.

Major J. L. R. Parsons, '01, of Regina, Sask., is in training with the second contingent, which he intends to accompany to Europe.

D. A. Smith, B.A.Sc., '04, is at Salisbury Plain, England with the first Canadian contingent.

BOOK REVIEW

Structural Engineers' Handbook. Data for the Design and Construction of Steel Bridges and Buildings. By Milo S. Ketchum, C.E. Leather, 6½ x 9 inches; 916 pages; 260 tables; 400 illustrtaions. New York, McGraw-Hill Book Company Inc. $5.00 net.

The author of this book presupposes a knowledge of mechanics and of the methods employed in calculating stresses in members of structures. It is sub-divided into Part I and Part II, the former containing a wealth of data and details for the construction of steel bridges and buildings and the latter consisting of 280 pages of tables, a number of which were compiled specially for this book.

The book is intended for the structural engineer and for the student in engineering who has had a thorough course in applied mechanics, and will prove of immense value to graduates who are engaged in structural work, especially on steel bridges and buildings. No reference, however, is made to swing and movable bridges or cantilever and suspension bridges. Chapter VII is devoted to a study of timber bridges and trestles such as are temporarily required during the erection of steel structures. Chapter VI treats of the design and construction of foundations for bridges.

Details and data selected from a wide range, many of which have not heretofore been accessible to the public, are furnished for the designer and the draftsman. Chapter XIV on the erection of steel structures contains a great deal of valuable information and the greater part of this chapter is now available to the public for the first time. Part I also contains chapters on retaining walls, steel bins, steel grain elevators, steel head frames and coal tipples, steel stand-pipes and elevated tanks on towers as well as chapters on bridges, buildings, estimating, detailing and general designing.

One desirable thing which it appears to us to lack is a chapter on steel power-transmission towers, especially in view of the fact that so much work of that nature is being carried on now. However, the fields of work which have been treated are most thoroughly covered and the book will prove exceedingly valuable to those interested in structural engineering.

THE O.T.C. SONG

Tune—"Solomon Levi."

The warlike spirit has entered the professors of the "School,"
They will soon want the college run by military rule.
Three nights a week they're out to drill; it's a glorious sight to see,
They're out getting ready for a trip to Germany.

CHORUS—Oh! Our professors, what an army they will make,
Poor old Kaiser William, how his knees will shake.
When he sees this regiment advancing, through the Fatherland,
Marching to the music of a captured German band.

Professor Loudon takes a gang to Buffalo every year
To give the third year man a taste of American lager beer—
They go to see the rolling mill and to watch the white hot steel
And raise the roof at Statler's, where they go to get a meal.

Oh! Tommie Loudon, he sure is a popular chap.
He'll lead our professors, when they push Germany off the map.
For he'll soon have the rank of General in the Officers' Training Corps,
Then he'll give up teaching Statics, and go to run the war.

Professor Cockburn built a tug down on Toronto Bay
And now he'd like to arm it with guns and let it sail away,
Away across the ocean to fight with Germany,
And he'd put the Kaiser cruisers to the bottom of the sea.

Oh! J. Roy Cockburn, what a clever man is he,
He'll take our professors on his tug to Germany.
He'll take the rank of Admiral away from Fisher and Jellicoe
And show by Descriptive Geometry the way to sink the foe.

E. V. D.

O. G. Lye, B.A.Sc., '14, is with the Provincial Board of Health of Ontario at the Experimental Station on Clifford St., Toronto.

H. S. Kerby, B.A.Sc., '14, is in charge of a party doing hydrographic survey work in Alberta. His address is Mount Royal College, Calgary, Alta. Mr. Kerby intends to accompany the second contingent with the Canadian Aviation Corps.

A. J. Gray, B.A.Sc., '13, accompanied the first contingent as lieutenant with the 50th Highlanders.

J. H. Lindsay, '07, is district surveyor and engineer for the Public Works Department, District of Prince Albert.

J. R. Gill, B.A.Sc., '14, has a practice as an Ontario land surveyor and engineer, at Sudbury, Ont.

J. B. Goodwin, B.A.Sc., '92, is assistant hydraulic engineer, Hydro-Electric Power Commission of Ontario, Toronto.

A. W. Lamont, B.A.Sc., '09, is sales engineer, Canadian Westinghouse Co., Winnipeg, Man.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science,

Engineering Bldg., University of Toronto,

Toronto, Ont.

EDITORIAL

MONTREAL TOIKE OIKE CLUB

The Montreal Toike Oikes held the first dinner of the season at the University Club on the evening of the 17th inst. The guest of honor was Professor Gillespie. The chair was occupied by the president, Walter J. Francis. The two past presidents, G. H. Duggan and R. A. Ross occupied seats at the head table. There were thirty-one Toike Oikes present, among whom were J. M. R. Fairbairn, H. Rolph, J. A. DeCew, D. C. Tennant, W. D. Black and H. W. Sutherland. A most enjoyable evening was spent at the club, where Professor Gillespie gave a twenty minute chat on current events at the School since the last Montreal dinner. At 8 o'clock the party adjourned to the rooms of the Canadian Society of Civil Engineers directly opposite, to hear Professor Gillespie deliver an illustrated address on Two-Storey Sewage Treatment Plants. H. W. Sutherland was elected secretary-treasurer in place of E. R. Watts, who has removed from Montreal. The gathering was a most enjoyable one.

OBITUARY

Charles W. Dobbin

It was with deep regret that the many friends of Mr. Charlie Dobbin, son of Mr. and Mrs. R. O. Dobbin, Waterloo, learned of his demise at his home on Sunday morning, November 22nd. Deceased, who was a member of Class '15, in electrical engineering,

Charles W. Dobbin

was obliged to discontinue his studies about a year ago, owing to ill health, and although he took a complete rest he failed to regain his former vitality. He fell a prey to tuberculosis of the lungs and spent some time at the Sanitarium, Muskoka, but returned later to his home where he was confined to his bed for seven weeks before the time of his death.

Mr. Dobbin was born in Breslau in February, 1888, where his parents then resided, the family removing to Waterloo about a year later. After matriculating from the Berlin Collegiate Institute, he was engaged for three years at the waterworks as engineer. Being naturally inclined toward matters of a practical nature, he decided to take a course in engineering and he gave much promise of a successful future in his profession if he had been spared to realize his ambitions.

Deceased was very fond of music and devoted a good deal of his time to it, his favorite instruments being the piano and the violin. For several years he sang in the Waterloo Methodist Choir, and while at the University he was a member of the Univeristy Glee Club and a member of the Orchestra of the "School."

The funeral was conducted from the family residence on Tuesday afternoon, December 24th, to Mount Hope Cemetery, where interment took place.

A feeling of sadness comes over us at the termination of so promising a young life, and we extend to his parents and brothers our sincere sympathy in their bereavement.

MARRIAGES

Isbister-Lamont

On Wednesday, November 25th, Mr. J. Isbister, B.A.Sc., '09, was married to Miss Margaret Lamont, daughter of Mr. and Mrs. Donald Lamont, Gravenhurst, Ont., at the home of her parents. Mr. and Mrs. Isbister will reside in Onaway, Mich., where Mr. Isbister is now located.

Kinghorn-Zollner

On Saturday afternoon, December 19th, Mr. A. A. Kinghorn, B.A.Sc., '07, president and general manager of the Asphaltic Concrete Co. of Toronto, was united in marriage to Miss Valborg Martine Zollner, daughter of Mr. A. Zollner, in Trinity Methodist Church by Rev. Dr. W. H. Hincks. After their return from a trip to points in the States, Mr. and Mrs. Kinghorn will reside on Westminster Avenue.

Bain-Davidson

On Tuesday, December 29th, at the home of the bride's parents. Mr. James Watson Bain, B.A.Sc., '96, Associate Professor of Applied Chemistry, was united in marriage to Miss Margaret Garden Davidson, daughter of Mr. and Mrs. William Davidson, Toronto. Mr. and Mrs. Bain left later for a trip to Atlantic City and New York.

DIRECTORY OF THE ALUMNI

T

Tasker, R., '13. We do not know how he is employed.

Tate, H. W., '09, is director of surveys for the Ottawa and Hull civic planning commission. Address Y.M.C.A., Ottawa.

Taylor, R., '11, is demonstrator in electrical engineering at University of Toronto

Taylor, T. F., '02, is designing engineer for the city of Toronto on the Bloor St. Viaduct, Toronto. Address is 494 Concord Ave.

Taylor, W. V., '93, address not known.

Taylor, A., '00, has a practice as engineer and surveyor, Box 555, Portage La Prairie, Man.

Taylor, J. W. R., '08, is erecting engineer for the Canadian Westinghouse Co.

Taylor, W. E., '08, is engaged in contracting in Toronto.

Teasdale, C. M., '02, has a private practice as surveyor at Concord, Ont.

Teeter, W. M., '10, is with the Jefferson Glass Co., Carlaw Avenue, Toronto.

Temple, J. B., '11, his address is 238 Gladstone Ave., Toronto. He is structural engineer for the Toronto Iron Works, Toronto, Ont.

Tennant, D. C., '99, is chief draughtsman with Dominion Bridge Co., Lachine Locks, P.Q.

Tennant, W. C., '00 (deceased).

Teran, E. A., '10, his home address is Arthur, Ont. He is construction engineer for the Canadian General Electric Co.

Thom, W. H., '10, is factory manager Lyman's Drug & Chemical Co., Toronto, Ont.

Thomas, G. C., '11, his address is 167 College St., Toronto. He is in the employ of the Hydro Electric Power Commission of Ontario.

Thomas, V. C., '08. His address is 28 Langley Ave., Toronto.

Thompson, P. M., '07, his address is 54 Thorold St., Toronto.

Thompson, E. A., '09, is with the Dominion Bridge Co., Lachine Locks, P.Q.

Thompson, J. M., '13, is with the Hamilton Bridge Works Co., Hamilton, Ont.

Thompson, H. B., '10, is taking a post-graduate course in structural engineering at the University of Toronto.

Thompson, W. K., '13. We do not know how he is engaged.

Thompson, R. M. A., '10, is with the Hydro Electric Power Commission of Ontario, Continental Life Building, Toronto.

Thomson, D. J., '13, is demonstrator in mechanical engineering, University of Toronto.

Thomson, T. K., '86, is consulting engineer at 50 Church St., New York.

Thomson, R. W., '92, is in Vancouver, B.C., where he has a practice as mining engineer.

Thomson, S. E., '04, address not known.

Thomson, L. R., '05-'07, is with the Dominion Bridge Co. at Montreal, P.Q.

Thomson, J. E., '06, his last address on our fyles is 57 Queen's Park, Toronto.

Thomson, O. R., '07, is superintendent of the Sidney Electric Power Co. Limited, and superintendent of sub-stations for the Electric Power Co. Limited. Address is care of Electric Power Co., Trenton.

Thorne, S. M., '00, is manager of Preston East Dome Mines, Cobalt, Ont.

Thornley, J. H., '08, his address is 843 Dundas St., London, Ont.

Thorold, F. W., '00, is a member of the firm F. W. Thorold Co., Limited, consulting engineers and contractors, 2 Toronto St., Toronto. Special attention is given to sewage disposal and water supply problems.

Tillson, E. D., '05, his address is Hotel Albert, New York, N.Y.

Tipper, G. A., '09, has a practice as contracting surveyor at Brantford, Ont.

Titus, C. G., '10, address not known.

Toms, C. G., '08, of 12 Rusholme Rd. Cres., Toronto, is general manager of the Toms Contracting Co. Limited, Toronto.

Torrance, R. D., '11, is with Frid Lewis Co. Limited, contractors, 901 Somerset Block, Winnipeg, Man.

Torrance, T. E., '13, is with the Bell Telephone Co., Toronto.

Tough, W. G., '11, is sales engineer for the Roman Stone Co., Limited, Toronto.

Townsend, C. J., '04, is a member of the firm Wilson, Townsend & Saunders, engineers and contractors, 78 Spadina Ave., Toronto.

Townsend, D. T., '04, is chief surveyor in the department of natural resources for the Canadian Pacific Ry. Co., at Calgary, Alta.

Train, C. N., '09, is with the Nipissing Mine, Cobalt, Ont.

J. J. Traill, '05, is lecturer in hydraulics at University of Toronto.

Treadgold, W. M., '05, is assistant professor in surveying at University of Toronto. He is also town engineer, Brampton, Ont.

Trees, S. L., '03, is manager of the Whitby factory for S. L. Trees Co. Limited.

Trees, A. G., '09, is superintendent of the factory of S. Trees Co. Limited, at 42 Wellington St. E., Toronto.

Tremaine, R. C. C., '95 (deceased).

Trimble, A. V., '04, is with the Hydro Electric Power Commission Toronto.

Tucker, B. B., '04, is with the Rapids Power Co. at Morrisburg, Ont.

Turnbull, W. G., '09, is chief engineer for the Turnbull Elevator Co., Toronto, Ont.

Turner, W. E., '05, is with the Utah Light & Ry. Co., Salt Lake City, Utah.

Tye, H. W., '08, is in the C.P.R. construction department, Winnipeg Man.

Tyrrell, J. W., '83, is a member of the firm Tyrrell & McKay, consulting engineers and surveyors, Hamilton, Ont.

Tyrrell, H. G., '86, is consulting engineer at 817 Hinman Ave., Evanston, Ill.

U

Umbach, J. E., '03, is chief draughtsman in the lands department at Victoria, B.C.

Underwood, J. E., '09, is a member of the firm McArthur, Murphy & Underwood, Saskatoon, Sask.

Ure, W. G., '13, is assistant to the city engineer at Stratford, Ont.

Uren, A. E., '05, is editor, with the Acton Publishing Co. Limited, Toronto.

V

VanAllen, K. M., '10, was engaged in fruit ranching at Summerland, B.C., when last heard from.

Van Every, W. W., '99, is city engineer at Sault Ste. Marie, Ont.

Van Norman, C. P., '08-'09, of 282 Carlton St., Toronto, is resident engineer for the Toronto and York Radial Ry. Co.

Van Nostrand, J., '09, is a member of the firm Speight & Van Nostrand, Temple Building, Toronto.

Vatcher, A., '09, is with the Reid Newfoundland Co., Freshwater, Bay de Verde, Nfld.

Vaughan, J. M., '05, of 58 Melville St., Toronto, has a business as a contractor.

Venney, L. T., '10, his last address on our fyle is 156 Garry Ave., Winnipeg, Man.

Vercoe, H. L., '98, his last address on our fyle is 109 McCaul St., Toronto.

Vickers, N., '11, is with the Highway Commission of Saskatchewan at North Battleford, Sask.

Vickery, C. L., '06, is chief engineer for the American Thread Co., Fall River, Mass.

Villeneuve, T. L., '08, address unknown.

Von Gunten, C. F., '13. His home address is Blenheim, Ont.

W

Wade, E., '04, is a building contractor at Welland, Ont.

Wagner, N., '10, is in the Bridge Department of the Canada Foundry Co., Toronto.

Wagner, W. E., '99, of 21 Gerrard St. E., Toronto, has a practice as engineer and contractor.

Wagner, H. L., '05, is chief draughtsman for the Toronto Structural Steel Co. Limited, Toronto.

Waite, J. H. C., '11, is surveyor for the Cobalt Comet Mine, Cobalt, Ont.

Walcott, W. D., '11, is with the Public Works Department of the Jamaica Government, as surveyor on road location and other miscellaneous survey work. His address is Savanna-la-mar, Jamaica.

Waldron, J., '03, has a practice as civil engineer and surveyor at Moose Jaw, Sask.

Walker, E. W., '04, deceased.

Walker, R. M., '10, is with W. J. Francis & Co., 232 St. James St., Montreal, P.Q.

Walker, W. J., '07, is with T.C.R., at Grant, Ont.

Walker, J. A., '08, has a practice as civil engineer and surveyor at McBride, B.C.

Walker, C. M., '09, is engaged in Dominion land survey work at Banff, Alta.

Wallace, G. L., '11, is demonstrator in physics at the University of Toronto.

Walton, T., '10, deceased.

Wanless, A. A., '02, is assistant engineer and shop superintendent for the Nova Scotia Steel & Coal Co., Sydney Mines, N.S.

Wardell, A., '11, is on the designing staff of the Toronto Iron Works, Toronto.

Warrington, G. A., '10, his address is Cornwall, Ont.

Wass, S. B., '03, is chief engineer for the St. John & Quebec Ry., and also chief engineer for the Quebec Extension Railroad at Fredericton, N.B.

Watson, F. E., '11, of 447 Manning Ave., Toronto, is demonstrator in drawing at the University of Toronto.

Watson, M. B., '10, assistant engineer with the Public Roads and Highways Commission of Ontario at the Parliament Buildings, Toronto, is with the first Canadian contingent in Europe.

Watson, R. B., '93, deceased.

Watson, J. P., '04, is on the staff of the St. Lawrence Bridge Co., Limited, Beardmore Building, Montreal.

Watt, G. H., '99, has a practice as Dominion land surveyor, Ottawa, Ont.

Watts, R. E., '13, is with the Dominion Bridge Co., Montreal, Que.

Waugh, B. W., '08, is with the Department of Interior, Ottawa, Ont.

Webb, C. E., '09, his address is 227 Spadina Rd., Toronto.

Webb, E. E., '09, has a contracting practice at Orillia, Ont.

Webster, C. A., '14, is with Sheldon's Limited, Galt, Ont., manufacturers of heating and ventilating equipment.

Wedlake, R. M., '08, is with the Cockshutt Plow Co. Limited, Brantford, Ont.

Weeks, M. B., '97, is with the Department of Public Works at Regina, Sask.

Weir, H. M., '00, address not known.

Weir, J. M., '04, of 6 Fairview Blvd., Toronto, is secretary-treasurer of the Toronto Plate Glass Importing Co., Limited, 91 Don Roadway, Toronto.

Weir, R. P., '08, of 170 Geoffrey St., Toronto, is the Canadian manager for Cutter Electrical & Manufacturing Co., Philadelphia, Pa.

Weldon, E. A., '97, is in business as investment broker, 711 McIntyre Block, Winnipeg.

Welford, P. G., '11, is with the Hyatt Roller Bearing Co., Newark, N.J.

Wells, A. F., '04, is a member of the firm Wells & Gray, engineers and contractors, Confederation Life Bldg., Toronto.

West, A. M., '08, is city engineer, North Vancouver, B.C.

Wheler, A. G., '11. His address is Norfolk, Va.

White, E. V. H., '08, is contractor on docks and wharves at Burlington, Ont.

Whelihan, J. A., '03, address not known.

White, A. V., '92, whose address is 2 Earl St., Toronto, is consulting engineer, engaged upon work for Commission of Conservation, Ottawa, and for International Joint Commission.

White H. F., '03, address not known.

White, W. R., '08, address not known.

White, W. J., '08, address not known.

White, F. C., '09, is on the staff of the Canadian Bridge Co., at Walkerville, Ont.

White, H. M. '10, is in charge of one of the drafting rooms for the Dominion Bridge Co. at Montreal, Que.

Whitelaw, A. R., '09. His address is 10720 103rd St., Edmonton, Alta.

Whiteside, J. L., '10, address not known.

Wickens, W. S., '10, is demonstrator in drawing at University of Toronto.

Wickett, T., '89, is a physician, 25 Nightingale St., Hamilton, Ont.

Wickett, W. E., '06, deceased.

Wiggins, T. H., '90, is civil engineer and Dominion land surveyor, Saskatoon, Sask.

Wilkes, E. D., '07, is in the main drainage department at the City Hall, Toronto.

Wilkes, G. H., '11, is in Winnipeg, Manitoba.

Wilkinson, T. A., '98, is statistician for the Westinghouse Church Kerr Co., New York, N.Y.

Wilkinson, R. G., '09, his address is Aberader, Ont.

Williams, C. G., '03, is at Cobalt with the Deister Machine Co. of Fort Wayne, Ind.

Williams, E. R., '11, is at Shawinigan Falls, Que., with the Northern Aluminum Co.

Williams, J. A., McK., '09, is with A. E. Ames & Co., bankers and brokers, Toronto.

Williams, G. K., '10, is demonstrator in drawing at the University of Toronto, Toronto, Ont.

Williamson, O. T. G., '09, is with James Stewart & Co., Westminster Building, Chicago.

Williamson, D. A., '98. The last address on our fyle is care of Y.M.C.A., Ottawa, Ont.

Wilson, H. A., '11, is assistant superintendent for J. C. Wilson & Co., manufacturers of water turbines and power transmission machinery, Glenora, Ont.

Wilson, R. D., '01, deceased.

Wilson, N. D., '03, of 128 Glen Rd., is surveys engineer for the Toronto Harbor Commissioners, Toronto.

Wilson, J. N., '00, is with the Hydro Electric Power Commission, of Ontario, Continental Life Building, Toronto.

Wilson, A. F., '07, address not known.

Wilson, F. D., '08, is located in Toronto at present.

Wilson, J. M., '08, is resident engineer at Toronto for the Department of Public Works, Canada.

Wilson, L. R., '09, is engineer for the St. Lawrence Bridge Co. Limited, Montreal.

Wilson, F. F., '09, his address is 124 Geoffrey St., Toronto.

Wilson, W. H., '10, address not known.

Wing, D. O., '08, is engaged in land surveying. His address is 1001 Rogers Building, Vancouver, B.C.

Winters, W. S., '13, is with Speight & Van Nostrand, surveyors, Temple Bldg., Toronto.

Withrow, W. J., '90. Address not known.

Withrow, F. D., '00, is examiner of patents in the Patent Office, Ottawa. His address is 283 Stewart St., Ottawa.

Wood, C. S., '11. His last address on our fyle is Courtenay, B.C.

Wood, E. M., '06, is assistant to chief engineer, Canadian General Electric Co., Toronto.

Woodley, G. E., '10, is in charge of central station work in the coal fields of W. Virginia, Kentucky and Tennessee. His address is Box 1235, Charleston, W. Va.

Woods, M. H.,'07, his home address is Aylmer W., Ont.

Wookey, S. A., '09, is field engineer for the Dominion Mineral Exploration Syndicate, Timmins, Ont.

Worden, W. G., '11, is resident engineer for the Godson Contracting Co., Toronto, on the Moore Park sewer system

Workman, G. R., '10, is demonstrator in drawing at University of Toronto.

Worthington, W. R., '04, is engineer in charge of the sewer section of the works department, Toronto.

Wright, A. J., '13, is with the Toronto Hydro Electric System in charge of line records.

Wright, C. H. C., '88, is professor of architecture at the University of Toronto.

Wright, R. T., '94, was in the engineering department of the Westinghouse Machine Co., East Pittsburg, Pa., when last heard from.

Wright, W. F., '04, is manager of the motor sales department for the Canadian General Electric Co. Address 130 Hazelton Ave., Toronto.

Wright, L. A., '10, is assistant engineer on grade separation, North Toronto, for C. P. Ry. His address is 278 Jarvis St., Toronto.

Wright, G. W. A., '07, was with the Warren Bituminous Paving Co., London, Ont., when last heard from.

Wright, W. J. T., '11, is demonstrator in drawing at the University of Toronto.

Wrong, F. H., '11, has been engaged in survey work in Western Canada.

Wylie, W. H., '11, was engaged in mine surveying with the Hollinger Mine, Timmins, Ont., when last heard from.

Wyman, H. K., '11, is taking post-graduate work in the Faculty of Applied Science and Engineering, University of Toronto.

Y

Yeates, E., '99, is with the London Machine Tool Co., Hamilton, Ont.

Yorke, L. P., '11, is wiring inspector for the city of Edmonton, Alta. His address is 21 Boyle St.

Youell, A. W., '10, is with the Canadian Ingersoll Rand Co., Sherbrooke, Que.

Young, C. R., '03, is assistant professor of structural engineering, University of Toronto.

Young, W. S., '10, his address is Guelph, Ont.

Young, W. H., '05, was a member of the firm Hamilton & Young, Dominion land surveyors, and engineers, Lethbridge, Alta., when last heard from.

Young, R., '08, is electrical superintendent of construction for the B.C. Electric Railway Co., at Vancouver, B.C.

Young, J., '07, is with the Western Canada Fire Underwriters' Association, 283 Bannatyne Ave. W., Winnipeg. P.O. Box 2973.

Young, A., '11, is instructor at the Technical School, Toronto.

Young, R. B., '13, is with the Hydro Electric Power Commission in their test department on Strachan Ave., Toronto.

Young, S., '11, is surveyor and engineer for the Board of Highway Commissioners of Saskatchewan at Regina.

Z

Zahn, H. J., '02, his address is 48 Monterey St., Detroit, Mich.

Zimmer, A. R., '07, is demonstrator in electrical engineering at University of Toronto.

Zinkan, W. E., '11, is Dominion land surveyor, 865 24th St., Edmonton, Alta.

INDEX TO OUR ADVERTISERS

APPLIED SCIENCE

BOUND VOLUMES I to VIII

PRICE $1.25 Per Vol. **Supply Dept. Engineering Society**

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

Old Series Vol. 27 TORONTO, JAN., 1915 New Series Vol. IX. No. 9

*ROAD ADMINISTRATION AND CONSTRUCTION

†W. A. McLean, M. Can. Soc. C.E.

Road-building and romance, one would suppose, are as far apart as the poles. To the great majority of us, the subject of roads is a very prosaic one indeed. What of interest can there possibly be in an occupation that centres around that most commonplace object —the country road.

With thoughts only of the country road, as we too often know it in Canada, in an undescribable condition of mud, dust, or roughness, according to the season, an attitude of mental indifference is no doubt justifiable.

And yet, if we could, by some magic gift, transform all the roads of Canada from their present condition to a state equal to the roads of England, or Scotland, or France, of what more desirable change for our material welfare, comfort, and happiness, can we conceive?

When we compare Canada with the advanced countries of the Old World, the unfavorable distinctions are not in the character of the people, nor in the wealth of the soil, nor in the beauty of landscape—but above all in the condition of the roads. No country ever looked well when viewed from a road axle-deep in mud.

And so, having before us the ideal of Canada, reached in every part, and transformed by a completed system of good roads, the picture becomes one of absorbing interest and its every detail gathers around it as we go on, something of the romance that pertains to the finished work.

It is desirable that every worker, and particularly the engineer, should keep before him, the full perspective of the field in which he is engaged, in order that his efforts may be turned from ways that are too narrow. The work of constructing and maintaining 250,000 miles of existing country roads in Canada (50,000 miles in Ontario alone) to an adequate standard, is an end that may well inspire us.

Invention and Communication

The present era is remarkable as one of rapid and convenient travel, transportation and communication. In this it is distinguished

* Read before the University of Toronto Engineering Society on Wednesday, January 13th, 1915.

† Engineer of Highways, Department of Public Works, Ontario.

from all preceding ages. Invention has shown more marked advance in this phase of modern civilization than in any other. Every refinement has been sought, and vast expenditures have been made on steam and electric railways, ocean and lake steamship lines, harbors and canals, express, postal, telephone, telegraph and cable services. The motor vehicle is becoming a necessity for the transaction of business and even the air has been conquered as a practical medium for human locomotion. All these have not lessened, but rather have increased the need for better common roads, and the demand for their improvement is accumulating with marked intensity.

Changed Traffic Conditions

Until the last ten or fifteen years, road construction in the open country was well served by waterbound stone and gravel, and was governed by established practice. Roads were built for horse-drawn traffic only, and the weight of loads was comparatively light. With the general use of rapid motor vehicles an entirely new form of wear has been added to that of steel tires and steel-shod horses; the weight of loads has largely increased, placing a much greater demand on road foundations and on bridges; the use of roads has greatly increased, especially on highways carrying suburban and interurban traffic. Road building is in a reformative stage, and the annual accumulation of experience is steadily shedding new light on a very complex problem.

The road situation of to-day presents many problems. It is doubtful if road conditions will ever be without their problems, for changes are constantly taking place, requiring an equivalent adjustment in methods of dealing with them. But it is also true that the present generation has opportunity to advance in this regard far beyond reasonable heritage or desires—for in general common road construction has been neglected, has been side-tracked and forgotten in the hurry of railroad construction.

New demands are pressing; advanced methods of construction are needed; old systems of organization are inadequate; old abuses and prejudices are persistent; opportunity for reform and progress is abundant and urgent.

Increasing Usefulness of Roads

The growing difficulties of road construction and maintenance are not without their reward. The increased *use* of the roads means their increased *usefulness*. The possible service that may be performed by the common road is in proportion to the efficiency of the vehicle. The motor passenger vehicle and the motor truck have greatly advanced the general public value of the common road; and whereas good roads were regarded, a few years ago, as solely of rural concern, urban centres have become keenly alive to their value, and are willing to bear a fair proportion of the cost. The value of roads as a means of travel and transportation has increased many fold. Instead of the farming population being expected as in the past, to meet the entire cost, it is now fully conceded that, as regards main roads, cities must share the *burden as with any other* department of transportation of the future.

Ontario Road Policy

The Province of Ontario for over sixteen years, has been carrying on an aggressive road policy of education in road matters. In the beginning, the object was an educational one. Statistics had shown that the townships of the province were annually spending on their roads, about $1,400,000 in cash, and over 1,100,000 days of labor, with very unsatisfactory results. It was felt that, by a process of education, much could be done to make this annual outlay, valued at $2,500,000, of much more benefit in road improvement.

The result has been largely accomplished, and in matters of grading, drainage, and bridge construction, there has been much good derived from the educational work. The control of all roads, however, was still in the hands of township councils, and the entire cost was being borne by the rural districts, or about half the population. There was no classification, no sub-division for purposes of construction and finance, such as has been found essential in the development of adequate systems of public highways.

County Roads

In 1901, a more advanced step was taken when a plan of provincial (or state) aid was created. Under this scheme each County Council was empowered to take over, from the township authorities within the county, for construction and maintenance, a system of main, or market roads. The county, as a separate corporation, assumed full ownership and control of these roads. Unlike many systems of state aid, the County System is not a plan of disconnected patches designated from year to year, but must be fully mapped out at the inception, so as to secure proper connection as far as possible, throughout the county as a unit.

To the work of constructing these county systems, for the most part gravel and water-bound macadam roads, the province grants annually one-third of the expenditure About $1,000,000 is now being spent annually on this work, by the Government and County municipalities.

Commission Proposals

It has become apparent however, that a still more advanced policy is necessary, and last year the Government of the province appointed a commission to go fully into the matter and make such recommendations as they thought advisable.

The report of the commission points out the value of good main roads to cities; showing that cities are largely benefitted; and that they should share in the cost. It is also proposed that motorists and railway corporations should contribute to the expense. From these sources the rural districts will be relieved from their present heavy charges for market and main roads.

MAKING A STONE ROAD—FIVE STAGES

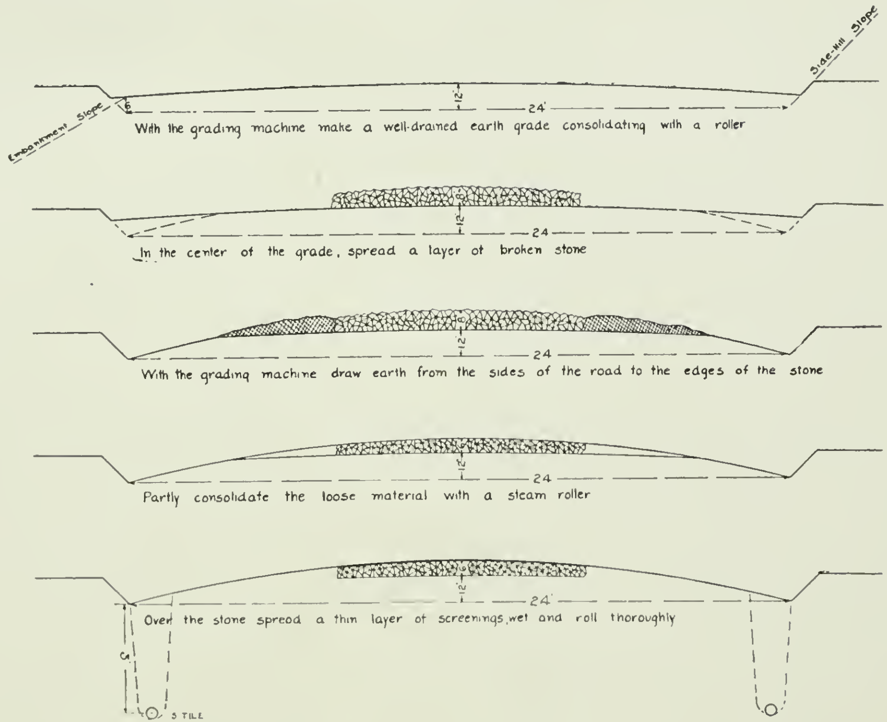
1. If a roller is not used make the crown higher to provide for settlement.

2. The dotted lines show the earth to be drawn in with the grading machine to hold the stone in place.

3. The gutters have been deepened by drawing the earth to the edges of the stone.

4. When partly consolidated less screenings are needed.

5. The complete road; care should be taken not to use too much screenings; and the open drains should be deepened as required. Tile are needed in wet soils only.



The above cross-sections show five stages in the construction of a single track road, built in the simplest possible way, suitable for the great majority of farm roads in Ontario. Open drains should have greater capacity in most cases to carry away freshets.

Roads are broadly classified as main, county and township. County roads are expected to include the chief market roads of each locality.

The Government contribution for county roads is to be increased to 40 per cent. Cities will be required to contribute to the upkeep of adjacent roads of a "suburban" class; while the province, out of part of the revenue from the motor vehicle fund, will give special assistance to the construction of heavily travelled main or "inter-urban" roads, so that the townships through which such roads pass, will not have to carry a burdensome charge for traffic originating outside of their boundaries.

Aid for maintenance will be given, in the same proportion as for construction, viz.: 40 per cent. It is regarded as a wasteful and useless expenditure to build good roads and thereafter neglect to keep them in repair. For this reason the resources of the province are drawn upon, in order that a good standard of maintenance may be reached.

Township roads are also regarded as deserving of special attention, in order that not merely a few market roads may be brought to a high standard; but that all may be raised to a standard suited to the traffic over them and that every farmer will reap the benefit. To this end, instead of a large grant to county roads alone, a grant of 20 per cent is to be made for township road improvement.

Special grants are to be made to villages having a large area and small population; while townships having an excessive number of bridges will be given Government aid so as to more nearly equalize the burden.

A plan of short term loans, without interest, to townships, is recommended. This is similar to the method followed in England, and it is anticipated, will enable municipalities and progressive communities to finance such substantial work as they may desire with economy, and under a system of easy payments.

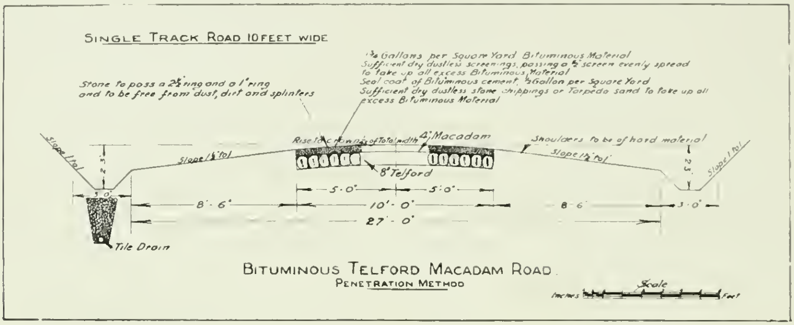
With 50,000 miles of rural roads in Old Ontario, it is anticipated that 7,500 miles will be constructed as first-class main or market roads, and that the remaining 42,500 miles will be brought to a fair standard, as good gravel roads or well-drained earth roads. On construction, a total expenditure of $30,000,000 is proposed, for work extending over a period of 15 years. Of this it is estimated that the province will pay $12,000,000; cities $6,000,000; and the counties $12,000,000. In addition to its share of construction, the province will also pay 40 per cent of the cost of maintaining market (or county) roads.

Under such a plan of encouragement to road construction, it is believed that the system proposed for Ontario will prove a decided advantage, and will create a type of road fully adequate to the needs of the province.

And that there will gradually be developed a system of main roads joining the chief cities of the province; that good systems of market roads for farm traffic will be built up; and that the more local feeders will be improved so as to meet the needs of traffic over them.

Municipal Authority

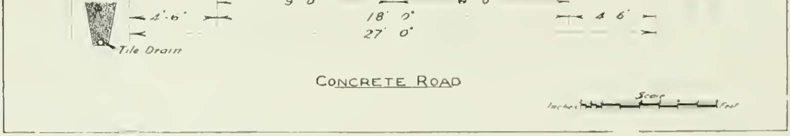
Local self-government through mun cipal organization is in the highest degree desirable in nurturing an intelligent, progressive, self-reliant people. A lively interest in their local affairs of roads, drainage, education, creates a sense of responsibility and a knowledge of government, that shows itself in the home life and in the



Bituminous Telford Macadam Road

higher statesmanship of a people. It is my personal observation under many conditions, on this continent and in Europe, that the fullest responsibility for local self-government meets a ready response from all the best citizenship, and its reward in the greater dignity of the individual and of the nation.

A central government of province or nation, therefore, should not do for the people what the people can do for themselves. A



Concrete Road

central government has enough to do with its revenues in ways that local self-government cannot, without diffusing its energies upon matters which private enterprise or local organization should control.

It follows that the central administration should, within bounds of equity and magnitude, allot to municipal bodies the necessary authority to control matters within municipal scope, rather than to retain or absorb them. By giving to local authorities the means of organization, they can do much in the way of raising money, and directing the expenditure toward effective road maintenance and betterment. It is primarily the business of a central government to see that local authorities are provided with the most efficiency means of organization possible, for road purposes.

Centralized Authority

On the other hand, experience in our own and other countries has indicated that a complete system of good roads cannot be created by local organization alone. In older portions of Canada the main roads (though they have suffered by a long period of neglect) were opened and improved by the central governments, or were constructed by toll roads companies. The same was true in the Eastern States, and in the revival of road building there, roads are being built, or are being largely subsidized by State Governments. In the United Kingdom of Great Britain and Ireland the existing main roads were constructed by turnpike trusts; they later passed to counties with an Imperial subsidy for maintenance, but national influence is now being restored. In France the great system of National Highways was built and is maintained by the state; while through subsidies, the influence of the Department de Ponts et Chaussees, is extended to the departmental and communal roads. In Germany the roads were built as military highways by the central government.

The maintenance of main roads, as with construction, has received and is receiving the support of the central governments. In the older countries of England, France, Italy and Germany, the main roads have long since been built, and the present large expenditures of central authorities is almost entirely for maintenance, and it is for road maintenance that their finely organized engineering corps are retained. Central governments should exercise a controlling hand in the maintenance of main roads, which they have built or largely subsidized.

Traffic

It is an axiom that "roads must be built according to the traffic over them"—not the traffic before improvement, but the traffic that will be developed by the improvement, and the potential traffic of expending local conditions.

For the purpose of this address, traffic may be broadly divided into— (1) Horse-drawn vehicles, (2) Fast motor vehicles, and (3) Heavy motor or horse-drawn wagons or trucks.

The traffic of a few farms, all or nearly all horse-drawn, may be sufficiently served by an earth road or light gravel or macadam road. The traffic of a larger district uniting on a single road should have a heavier gravel or macadam surface. As fast motor traffic accumulates, the need for the resistent surface of a high-class pavement becomes necessary. Heavy truck traffic of any kind increases the need for greater strength and mass in the foundation. Such conditions as the foregoing indicate the general basis upon which the type of surface for any road may be selected. It is not good economy to place a pavement at $10,000 a mile where a light gravel road at

$1,000 a mile will serve the traffic; nor is it economically sound to try to keep a light gravel road where traffic demands a heavy permanent.

Construction

Broadly, roads may be divided, for a consideration of construction, into two general classes:

First. Roads for local farm and light market traffic—such as may be drawn from a six or eight mile radius to small towns and shipping points; and

Secondly: Roads adjacent to cities, or which are main routes between large centres of population.

The first of these carry a limited horse-drawn traffic with few automobiles; the second a greater horse-drawn traffic, more heavily loaded wagons and drays, with a considerable proportion of heavy and fast motor vehicles—such roads as those adjacent to Toronto or London, or running from Toronto to Hamilton.

By far the greater part of the country is served by roads of the first mentioned class—probably 90 or 95 per cent.; while about five or ten per cent. will comprise roads of the second class.

Light Traffic Roads

It is characteristic of roads of this class that dependence for foundation is placed almost wholly on the earth sub-grade. To this end, there must be thorough drainage of the soil underlying the road surface. This is the elementary principle of the Macadam road—a dry sub-soil. It is the principle that has so greatly simplified the modern method of roadmaking as compared with the heavy construction of the ancient Romans.

At each side of the road there should be an ample open drain. The roadway, from ditch to ditch should be given a crown or camber. The road surface and sides should be smooth and, if possible, hard, so as to shed water quickly to the side drains. The material used for the travelled surface, gravel or stone, should be so compacted and bonded, that it forms a water-proof cover to prevent moisture passing through it to the earth sub-soil; this, in addition to its service in distributing a concentrated wheel-load over a greater area of sub-soil.

The open drains at the side should ordinarily have a depth of about two feet below the crown of the road. Or the principle of tile under-drainage may be applied, and the need for deep open drains largely done away with. These simple principles, applied with good judgment, are at the basis of all modern road-making.

Roads of Heavy Traffic

Roads adjacent to the larger cities, or roads such as that now being built from Toronto to Hamilton, require a heavier type of construction with a more durable surface, to carry the larger number of vehicles, more heavily loaded, and moving rapidly. The more frequent and faster traffic demands the resistent surface; and added to this the heavily loaded vehicles require a stronger form of foundation. Into this field enters the Telford foundation, and the concrete foundation, with surface treatment of tar, asphalt, or other binding agents.

The Telford Road, as originally applied, consisted of a hand-laid foundation of stone. These stones of somewhat irregular depth, usually about eight inches, are not laid flat—but stand on edge across the road. Irregular projections are chipped off by workmen with stone hammers; these spalls are wedged into the interstices to strengthen the bond, and over the top is spread a layer of broken stone, the surface being finished in the same way as an ordinary Macadam road.

The bituminous surface is a development of what was originally known as "tar macadam." There are two standard types of construction—"bituminous Macadam" constructed by the penetration method; and "bituminous concrete," constructed by the mixing method.

"Bituminous macadam" as the name indicates, may be described as a macadam road, bonded with tar or asphalt, the bituminous material being poured hot into the interstices of the stone. A four inch layer of stone (such as is retained by a 1½ inch ring will pass a 2½ inch ring) is first spread evenly over the foundation, and rolled to an even surface. Into this the heated bitumen is poured. The pouring may be done either from small cans or from large tank wagons from which it is sprayed under pressure. A penetration of about 2½ inches is usually sought, using about ¾ gallon of bitumen to the square yard. Over this is spread a light coat of stone chips, and the surface is then thoroughly consolidated by a steam roller. It is good practice to then give a paint or squegee coat of bitumen (about ¼ gal. to the square yard), adding another sprinkling of stone chips to dry the surface which is again finally rolled.

The "Bituminous Concrete" is a surface made by the mixing method. Over a layer of broken stone is first sprinkled a light coat of tar as a "binder coat," to unite the surface to the foundation. On this is spread a layer of stone with which hot asphalt or tar has been previously mixed. Mixing was first done by hand, but the practice is now to pass the material through a plant which heats and dries the stone, and in a revolving process similar to the concrete mixer, coats all particles of stone with the bitumen. The coated material is then conveyed to the road, spread and rolled to a depth of 2½ to 3 inches. This is treated with a squegee surface, as in the case of the penetration method.

The mixing method is more expensive than the penetration method; but bituminous concrete is more certain in its results, is more desirable, and will support heavier traffic than will bituminous macadam. In the mixing process, a maximum density of aggregate is sought, using stone carefully graded from fine to large.

One method of proportioning aggregate for maximum density was patented, but similar results are now obtained under what have become known as the Topeka and other Specifications. Another proprietary form of bituminous pavement is mixed with stone at a central quarry and is shipped by rail for cold construction. Another uses iron slag as the aggregate. Sand in some cases is mixed with the bitumen for use in the penetration process. A variety of minor distinctions might be enumerated.

Ordinary sheet asphalt consists of about 10% bitumen and 90% sand; laid two inches in thickness on a concrete foundation. This material has not been used for roads in the open country; but a concrete foundation with a bituminous concrete surface has been employed in some cases. The latter construction is successfully used in city paving.

There is no hard and fast line between roads in the open country, and city pavements. It is all a matter of traffic and ability to meet the cost. In most cases, the two parallel one another, or by properly applied taxation should be made to do so.

Brick pavements are used largely for roads of the open country in the State of Ohio—where they are manufactured, and the cost is proportionately low. This material has also been largely used in the state roads of New York.

More recently the value of cement concrete as a road surface has been advocated. This is largely due to experience in Wayne County adjacent to the city of Detroit, where a considerable mileage has been laid. Some of the chief characteristics of this pavement are:—A one course mix, about seven inches in thickness; a mixture rich in cement, about 1 : 1½ : 3; thoroughly clean and well proportioned gravel; and the tar coating of joints or cracks to prevent wear.

A Formative Stage

Much of the present practice, in construction for modern conditions of heavy traffic, is in a formative, almost an experimental stage.

The number of elementary materials used or dealt with in roadmaking is strikingly few, and, with minor exceptions, materials are included in a brief list—sand, clay, gravel, broken stone, asphalt, tar, oils, vitrified brick, creosoted wood, stone setts, and Portland cement.

To these may be added a few materials of local service, such as oyster shells; or proprietary binders, such as Roemac or Glutrin. While the elementary materials are few in number, the range in quality is wide, their combinations are many, conditions of traffic are of varying degree, and such factors as climate, workmanship and cost must be considered.

In the solution of road problems, at the present time, effort is being given by scientific engineers to the accumulation of facts respecting road materials and their action under climate and traffic. Much has been done in the past five years in this regard, and it is confidently expected that the next five will do more. Experience will then more nearly approximate the anticipated life of new materials and new methods. The status of knowledge respecting road construction in the next five years will largely depend on the care and thought with which any users at the present time, assemble facts, and correlate them with definite standards of traffic.

Road construction and maintenance to a high standard of efficiency is being found in all countries, a matter of much expense and the cause of increased taxation. England, France, the United States, are all seeking means less costly than are now available. A road of satisfactory quality, which can be laid for one dollar a square yard, is an ideal towards which we may well strive; a road for instance, to consist of a concrete foundation, with a bituminous or similar surface, the latter to have a life, with reasonable repair, of ten years. Such a road, if attainable, would go far to solve the road problem of to-day.

THE ATLANTIC AND INTRACOASTAL WATERWAYS

By T. Kennard Thomson, '86, D.Sc.

A glance at the coast line of the United States from Maine to Florida will show that Nature has made the construction of inland waterways along the coast wonderfully simple, having by means of sand banks, rivers and bays, performed most of the work for man, making it possible by means of artificial canals here and there—with more or less dredging in existing waterways—to obtain sufficient water for safe passage of barges from Maine to Florida.

This kindness of Nature was seen and taken advantage of by Congressman J. Hampton Moore, and others, and resulted in the organization of The Atlantic Deeper Waterways Association in 1907, to promote the construction of the series of canals linking the natural bays, rivers and sounds along the Atlantic seabord in order to provide a modern protected free waterway, admitting heavy traffic, owned and operated by the United States Government, between New England and Florida.

The Association has succeeded by getting various acts through Congress, in having a complete survey of the proposed routes made by the United States Government Engineers.

The East Coast of Florida has already a chain of natural protected waterways connected by canals constructed by corporations. In the southern portion, the State is now constructing a series of canals in order to drain the Everglades. Connection will undoubtedly be made between Jacksonville, Florida, on the Atlantic coast, with the Gulf of Mexico, via the magnificent St. Johns River and a connecting canal.

A seven foot deep canal is already under construction from Jacksonville, Florida, to Charleston, South Carolina. From Charleston, South Carolina, to Beaufort, North Carolina, a seven foot canal is recommended.

From Beaufort, North Carolina, to Norfolk, Virginia, a twelve foot depth is desired—via a short canal from Beaufort to Pamlico Sound; another canal to connect Pamlico with Albermarle Sounds and then to Norfolk and up the Chesapeake Bay to Baltimore and Chesapeake City, and by the Chesapeake and Delaware Canals


THE ATLANTIC
INTRA-COASTAL WATERWAY
SHOWING INTERCONNECTED BAYS AND RIVERS
AND INLAND CONNECTIONS
SCALE OF MILES
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ONTARIO
LAKE ERIE
GEORGIAN BAY
ST MARY'S FALLS CANAL
QUEBEC
MONTREAL
OTTAWA
PLATTSBURG
BURLINGTON
BANGOR
BAR HARBOR
EASTPORT
PORTLAND
PORTSMOUTH N.H.
GLOUCESTER
LYNN
BOSTON
CAPE COD
PLYMOUTH MASS
NEW BEDFORD
ESCANABA
HOUGHTON
MILWAUKEE
CHICAGO
GARY
TORONTO
ROCHESTER
LOCKPORT
BUFFALO
OSWEGO
ROME
UTICA
SYRACUSE
SCHENECTADY
SENECA FALLS
WATERTOWN
WHITEHALL
GLENS FALLS
SCHUYLERVILLE
BINGHAMTON
ELMIRA
DETROIT
ERIE
ASHTABULA
TOLEDO
CLEVELAND
HUDSON
KINGSTON
POUGHKEEPSIE
NEWBURGH
HARTFORD
NEW LONDON
NEW HAVEN
BRIDGEPORT
SCRANTON
WILKESBARRE
WILLIAMSPORT
LOCK HAVEN
BELLEFONTE
PATERSON
HACKENSACK
NEWARK
NEW YORK
PERTH AMBOY
NEW BRUNSWICK
BETHLEHEM
EASTON
TRENTON
BRISTOL
BORDENTOWN
BURLINGTON
BARNEGAT
HARRISBURG
PHILADELPHIA
CHESTER
WILMINGTON DEL
NEW CASTLE
SALEM
BRIDGETON
HAVRE DE GRACE
CUMBERLAND
BALTIMORE
ANNAPOLIS
WASHINGTON
LEWES
CAPE MAY
CAPE HENLOPEN
FREDERICKSBURG
CRISFIELD
RICHMOND
LYNCHBURG
NEWPORT NEWS
PORTSMOUTH
NORFOLK
CAPE CHARLES
CAPE HENRY
ELIZABETH CITY
DANVILLE
WELDON
EDENTON
PLYMOUTH N.C.
WASHINGTON N.C.
CAPE HATTERAS
RALEIGH
GOLDSBORO
NEWBERN
BEAUFORT N.C.
FAYETTEVILLE
ELIZABETHTOWN
WILMINGTON N.C.
SOUTHPORT
CAPE FEAR
CONWAY
COLUMBIA
GEORGETOWN
ATLANTA
AUGUSTA
CHARLESTON
BIRMINGHAM
TUSCALOOSA
MILLEDGEVILLE
MACON
DUBLIN
BEAUFORT S.C.
SAVANNAH
COLUMBUS
HAWKINSVILLE
SELMA
MONTGOMERY
JACKSON
EUFAULA
ALBANY
DARIEN
BRUNSWICK
FERNANDINA
BAINBRIDGE
JACKSONVILLE
MOBILE
GULFPORT
PENSACOLA
GREEN COVE SPRINGS
ST AUGUSTINE
PALATKA
ORMOND
DAYTONA
NEW SMYRNA
APALACHICOLA
CEDAR KEYS
NEW ORLEANS
DE LAND
SANFORD
TITUSVILLE
CAPE CANAVERAL
KISSIMMEE
ST PETERSBURG
ST LUCIE
PUNTA GORDA
PALM BEACH
FT MYERS
FT LAUDERDALE
MIAMI
KEY WEST

(to be enlarged) to Delaware City on the Delaware River; another short canal will connect the Delaware River with South Amboy, N.J., near the end of Staten Island, New York, connecting there with Kill von Kull and then with the Hudson River to Albany, thence via the New Barge Canal to Oswego on Lake Ontario and Tonawanda, on the Niagara River; and also via the Hudson River and Champlain Canal to Lake Champlain, which will eventually be connected with the St. Lawrence River below Montreal.

From New York safe passage can also be had along the Long Island Sound and through the recently completed Cape Cod Canal.

Two other projects are being considered—one a protected waterway through the lagoons of Rhode Island, and the other a waterway connecting Narragansett Bay with Massachusetts Bay and Boston Harbor.

Summary

St. Johns River, Fla., to Fernandina, Fla., 7 feet depth. Work under way	$251,726
Fernandina, Fla., to Savannah River, Ga., 7 feet depth. Work under way	195,000
Savannah River, Ga., to Charleston Harbor, S.C., 7 feet depth. Work under way	427,400
Charleston Harbor, S.C., Winyah Bay, S.C., 7 feet depth. Construction recommended	1,227,800
Winyah Bay, S.C., to Little River, S.C., 7 feet depth. Construction recommended	5,677,800
Little River, S.C., to Cape Fear, N.C., 7 feet depth. Construction recommended	3,724,219
Cape Fear, N.C., to Beaufort, N.C., 7 feet depth. Construction recommended	2,872,111
Total Southern Section Atlantic Intracoastal Waterway, St. Johns River, Fla., to Beaufort Inlet, N.C., in round numbers	$14,400,000
Beaufort Inlet, N.C., to Norfolk, Va., 12 feet depth. Project approved by Congress; work partly completed. Chesapeake and Albermarle Canal purchased. Much of the route lies in Pamlico and Albermarle Sounds, natural waterways requiring no improvement	$ 5,400,000
Norfolk, Va., to head of Chesapeake Bay, Md. Natural waterways requiring no improvement.	
Chesapeake Bay to Delaware River, 12 feet depth. Recommended for immediate action, including purchase or condemnation of existing Chesapeake and Delaware Canal	10,514,290
Delaware City, Del., to Bordentown, N.J. Route follows channel of the Delaware River, for which present depth is sufficient over the entire distance, assuming a 12 feet project.	

Bordentown, N.J., to South Amboy, N.J., 12 feet depth. Immediate construction recommended......	20,000,000
South Amboy, N.J., to New York Bay (and thence to Hudson River and Long Island Sound). Natural waterways requiring no improvement for a 12 foot project.	———
Total Northern Section Atlantic Intracoastal Waterway, Beaufort Inlet, N.C., to New York Bay, in round numbers..................................	36,000,000
Total cost, Atlantic Intracoastal Waterway, as recommended by the Army Engineers..................	50,400,000

The following sections of the Intracoastal Waterway route have been surveyed by the Army Engineers, and, while not adversely reported, consideration is postponed until more progress has been made on the foregoing sections:

Key West, Fla., to Indian River, Fla., 7 feet depth..	$2,127,950
Indian River, Fla., to St. Johns River, Fla., 7 feet depth	2,491,056
Fisher's Island Sound, Conn., to Narragansett Bay, R.I., 18 feet depth..............................	12,322,000
Narragansett Bay, R.I., to Boston Harbor, Mass., 18 feet depth...	29,590,000

Connected Projects

In New York Harbor, the East River and the Bronx Kills, improvements recommended by the Engineers will facilitate barge traffic from the Intracoastal Waterway and the Upper Hudson to Long Island Sound..	$13,400,000
New York City to Troy, N.Y. Route follows the Hudson River; a natural waterway undergoing improvement between Hudson and Troy, 12 feet depth (but a greater depth advisable). Work under way..	5,000,000
New York State Barge Canal, Troy, N.Y., to Tonawanda, N.Y., and Troy, N.Y., to Lake Champlain, N.Y., 12 feet depth........................... State project, rapidly approaching completion.	126,000,000
Cape Cod Canal; Buzzards Bay, Mass., to Barnstable Bay, Mass., 25 feet depth .... Constructed by a private corporation; completed.	12,000,000

Length of Connecting Canals, Atlantic Intracoastal Waterway

	Length of Excavation
1. New Jersey Canal (new project)...................	33.7 miles
2. Chesapeake and Delaware (existing canal to be enlarged)..	13.7 miles
3. Chesapeake and Albermarle (project adopted; existing canal being enlarged)............................	11.4 miles
4. Albermarle and Pamlico (Alligator River and Rose Bay) project adopted............................	26.3 miles
5. Beaufort Cut (project adopted; existing canal to be enlarged)......................................	6 miles
6. Beaufort to Cape Fear River, N.C., (new project)	

about	5 miles
7. Cape Fear River to Little River, S.C., (new project) about	20 miles
8. Little River, S.C., to Winyah Bay, S.C. (new project) about	15 miles
Total Intracoastal Waterway links	131.1 miles
Total length of continuous navigation made possible by above canals connecting existing waterways (about)	1800 miles
Mileage of 148 rivers interconnected by Intracoastal Waterway	5365 miles
New York Barge Canal System, including Central Lakes	500 miles
Total length of Great Lakes, which will connect with Intracoastal Waterway	1489 miles
Lake Champlain, 126 miles; Richelieu River, 65 miles	191 miles
St. Lawrence River (about)	1000 miles
Canadian Inland Waterway (Georgian Bay Canal)	400 miles

Average Tariff per Ton Mile

Earthen Roads by animal power	25 cents
Steam railroads	7.8 mills
Canals	2 to 3 mills
Rivers, sounds, etc	1 mill
Lakes and ocean	0.5 mill

This wonderful length of inland waterways can thus be obtained for the depth specified, for the extremely small amount of fifty million dollars, which looks like a small outlay for the United States Government, when compared with one-hundred-and-fifty million dollars spent by New York State alone, on its waterways; or with the fifty million dollars for a New Welland Canal.

The saving in life and property will amount to enormous figures annually, and in addition the Government will have safe channels for submarines and other war vessels.

Sooner or later the whole system will be deepened and widened, where necessary, for boats of 30 feet draft or more.

In order to ensure this good work by educating the public to the necessity thereof, the Atlantic Deeper Waterways Association has held conventions in the following cities, starting in 1907 at Philadelphia, then at Baltimore, Md., Norfolk, Va., Providence, R.I., Richmond, Va., New London, Conn., Jacksonville, Fla., and this year starting at New York City and spending five days on the Hudson River.

The convention this year was held on the "Berkshire," the largest river boat afloat, with 700 delegates and guests. Stops were made at Newburgh, West Point, Poughkeepsie, Kingston, Hudson, Albany and Troy, and the enthusiasm aroused along the entire route was certainly inspiring, and it was estimated that the people of these cities must have spent over $50,000 in entertaining our party.

In recognition of his project for a really greater New York, Governor Glynn appointed the writer a delegate to represent the State of New York at this convention.

The convention in the fall of 1915 will be held at Savannah, Ga.

VALVE DIAGRAMS AND THEIR APPLICATION

Part I.

By M. L. Smith, B.A. Sc., '11

Associate Editor "*The Power House*"

To the man who is constantly employed about steam engines the solution of valve problems by means of diagrams is a matter that is easily understood. The technical student, however, will be much helped if he will take the trouble to lay out a properly proportioned valve seat upon one piece of paper and the corresponding valve on another. By moving this model valve upon its seat as the engine cycle is studied by means of the diagram, the relation of all the events of the revolution to each other at any time will be more easily grasped.

Most of the calculations pertaining to valves and their relation to the other parts of the engine involve difficult mathematics. For this and other reasons it is usual to obtain results graphically by means of diagrams—that is by drawing all parts full size or to a scale and actually measuring lengths with a rule. Valve diagrams then are employed in general practice as follows:

(1) To determine lap, displacement, angular advance and other facts in connection with existing valves.

(2) To design and proportion certain parts of new valves and their gearing.

A number of different diagrams are employed for this purpose, chief of which are the Zeuner, which is used mostly in Europe, and the Bilgram, which is quite popular in America. For a number of reasons the latter is easier for mechanics to understand and apply, and so we will confine ourselves largely to it.

The Bilgram Diagram

This diagram was devised by Hugo Bilgram, of Philadelphia, and depends for its proof upon a geometrical proposition which says that if two angles and a side of one triangle be respectively equal to the corresponding two angles and side of another triangle, the two triangles are equal in every respect. This is seen in Fig. 1. In the triangles bBO and QOq, the side BO is equal to QO, as they are radii of the same circle. The angle QOq has been made equal to the angle BOb and the angles BbO and QqO are equal, because they are right angles. Now according to geometry, the two triangles are equal in every way —that is, the line bB is equal to Qq.

The angle of advance may be determined by drawing from (b) a line bB equal to the lap plus lead and joining BO, the angle of advance being bOB. We have just seen that the lap plus lead can just as well be measured up from (q), and can be represented by the line qQ. The angle of advance now is QOq instead of BOb. This is what is done in the Bilgram diagram.

In connection with the designing of valves, all or some of the following facts are easily obtained:—

(1) The throw of the crank may be determined from the stroke of the engine.

(2) The maximum port opening is usually determined by calculation, or, if the same as the port, its width can be measured.

(3) The throw of eccentric and travel of valve can be measured.

(4) The lead is determined by judgment and practice of the designer.

(5) The point of cut-off—that is, the proportion of the

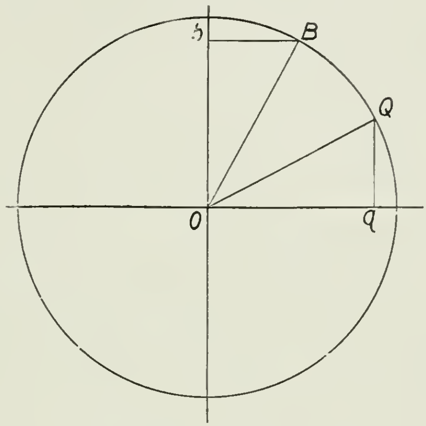


Fig. 1—Simple proof of the principle of the Bilgram Diagram

stroke at which cut-off takes place, is usually a matter for the designer's judgment.

(6) The point of compression or the point in the stroke at which exhaust closes.

It may be required to find, by means of the diagram, some of the above and any other information, such as inside and outside lap, angle of advance, crank positions for the different events of the engine stroke, positions of the valve corresponding to various positions of the crank, width of port opening at any point in the stroke, etc.

The Complete Diagram

The diagram must be accurately drawn to some scale. Either full size or an enlarged scale is best. The crank pin circle with its diameters may be drawn to a different scale from the rest of the diagram, thus in the illustration Fig. 2 the stroke is represented half size and the valve diagram is drawn full size. Proceed as follows:

(1) Draw a horizontal centre line AH to represent the engine stroke, and, using this line as a diameter, draw the crank pin circle as shown to the predetermined scale.

(2) From the same centre and with a diameter equal to the travel of the valve construct the valve travel circle. Its radius will, of course, be equal to the eccentricity.

(3) Still using the same centre, draw the maximum port opening circle with a radius equal to the greatest port opening.

(4) Assuming that the cylinder is to the left of the crank,

Fig. 2—Complete Bilgram Diagram

and that we are considering the forward stroke, measure off from A the proportion of the stroke at which cut-off is to take place—namely, Aw, which is 5/8 of the stroke, and, therefore, 5/8 of the distance AH. From (w) draw a vertical line to cut the crank pin circle at C. This point C represents the position of the crank pin when cut-off occurs. Through C draw a crank line CN. By a crank line is meant a diameter of the crank pin circle through any crank position.

(5) From the dead centre crank line measure upwards a distance (qa) equal to the lead, and through (a) draw a short horizontal line. Call this the lead line.

(6) Draw in the steam lap circle. Its centre must be on the valve travel circle, and it must touch three points—namely, the lead line at (a), the M.P.O. circle, and the cut-off crank line.

(7) In the same way as the point of cut-off was determined, measure from A a distance Ax representing the proportion of the stroke at which compression is to take place. Through (x)

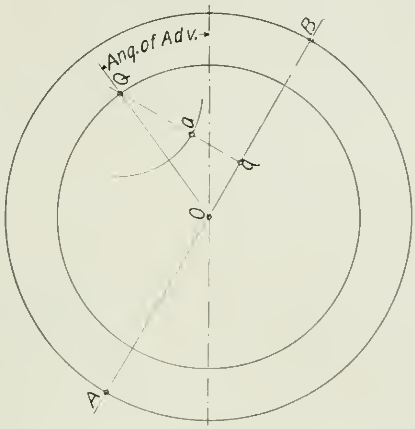


Fig. 3—Use of Bilgram Diagram to determine displacement and port opening.

draw a vertical line cutting the crank circle at D. This is the crank position for compression in the other end of the cylinder. For head end compression, draw a crank line through D, which will cut the crank circle at the desired crank position M.

(8) From the same centre as the steam lap circle draw the exhaust lap circle so that it will just touch the compression crank line. The exhaust lap is represented by the radius of this circle. Draw a crank line F K so as to touch the other side of the exhaust lap circle. This gives the two crank pin positions for release—namely, F and K. The crank position for admission depends upon the lead; hence, draw a crank line through the lead line at the point (a) and the centre of the crank circle C. This gives the two points of admission G and I. Providing that the ports, lap, etc., are the same for both ends of the valve, the crank positions for similar events in opposite ends of the cylinder will be found at opposite ends of diameters of the crank pin circle.

Studying the diagram, Fig. 2, a number of facts will be understood. The crank pin circle, crank lines and all lines pertaining to the crank are drawn to a certain scale. All other lines relate to the valve, and, therefore, should be drawn to a uniform scale, which may be the same as for the crank parts or different. Throw of the eccentric or valve displacement is represented by the radius of the valve travel circle, and the travel of the valve is represented by its diameter. By displacement of the valve is meant the distance it moves in either direction from its mid-position. The maximum port opening is represented by the radius of the M.P.O. circle.

The maximum port opening is always less than the width of the cylinder port in good design as the latter must be wide enough to accommodate the exhaust steam.

Steam lap is represented by the radius of the steam lap circle and exhaust lap by the radius of the exhaust lap circle. Lead is represented by the distance of the lead line above the horizontal diameter or base line. Note carefully that the radius of the valve travel circle is equal to the radius of the M.P.O.

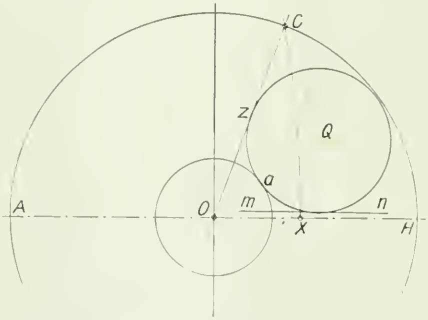


Fig. 4—Use of Bilgram Diagram to determine point of cut off.

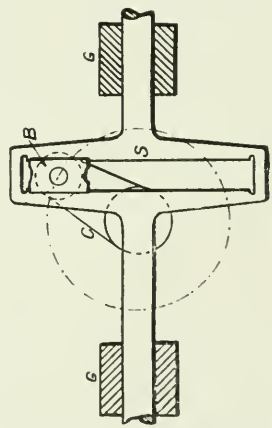


Fig. 5—Scotch yoke or slotted cross head in which there is no angularity of connecting rod.

circle plus the radius of the steam lap circle. The travel of the valve is, therefore, equal to twice the lap plus the maximum port opening.

The displacement of the valve when the crank is at A or on dead centre, is equal to the distance Qq or the lap plus the lead. The line Qq is a vertical from the centre of the steam lap circle to the crank line for the above crank position. Qa represents the lap, while (aq) represents the port opening, which in this case is equal to the lead. For any other crank position, such as A[1], the displacement is equal to the vertical Qq[1] on the crank line as before. The lead is Qa[1] and the amount of port opening is (aq).

At the crank position B, the vertical QO on the crank line reaches its greatest length; hence, the crank position B is the position for maximum port opening. At C the vertical distance is equal to Qz, Fig. 4, which is the same as the lap, therefore, there is no port opening, and C is the point of cut-off. This same reasoning can be carried out in connection with the exhaust lap, but is never required.

In the cut, Fig. 2, the complete diagram is represented. This, however, is rarely required. For instance, if the port opening or displacement only is required for a given crank position, such as A, Fig. 3, all that is required is to draw the crank line for this position, lay off the angle of advance by the line OQ as shown, draw in a small section of the valve travel circle, and draw the line Qq vertical to AB. Draw a small section of the steam lap circle as shown. The part Qa is the lap, (aq) is the port opening, and Qq is the displacement.

Again, suppose an engineer requires to find the exact point at which cut-off takes place. He draws the base line and the crank pin circle, as in Fig. 4. Next comes the M.P.O. circle and the steam lap circle. The crank line can now be drawn, touching the steam lap circle at (z). This will give the crank pin position C for cut-off, from which the piston position can be found by drawing the arc as shown from a centre on the base line and with a radius equal to the length of the connecting rod to the scale of the crank pin circle. The position of the piston will be at (x). The distance Ax can now be measured, and the percentage of the stroke which it represents is easily calculated.

These statements are correct only in cases where a Scotch yoke or similar form of cross head, as in Fig. 5, is used. The effect of the connecting rod will be dealt with in the next number of this series.

---

* THE WORK OF OUR LATE DEAN GALBRAITH

By G. H. Duggan, '83

I am deeply sensible of the honor of being asked to address you on the subject uppermost in our thoughts to-night, the work of Dean Galbraith: our School, this Society and I think I may include to a large extent the present standing of the Engineering profession. Everyone interested in engineering in Canada to-day knows full well the influence of the School and the large part it has played in the development of the country and every member of it, graduate or undergraduate, must be proud of its position, but particularly we who joined the School in its early days, when the world of engineering was young, when the engineer was of no account, scorned by the captains of industry, when his technical education was rather a handicap and on graduation he was often glad to take a job of pulling a

* Extract of address delivered at a meeting of the Engineering Society in Convocation Hall on Dec. 9th, 1914, dedicated to the memory of our late Dean John Galbraith.

chain, holding a rod or of even driving stakes. To us it is a revelation to see what has been accomplished in less than a generation. In that short space of time the whole status of engineering and of the School has undergone a wonderful change; the engineer has arrived. he is sought by corporations, our great railways and our great industrial companies are manned by engineers, many of them to the very top. The older professions now recognize that we hold an important place in the community and I confidently expect many of the present members of this society will see engineers occupying the highest positions in the gift of the nation.

In the elevation of the engineer in the community there have, of course, been other factors as well as the School, but I think we can fairly claim that in the number and the influence of our graduates our School has by far the leading place. It is a proud position, but at the same time it brings with it the responsibility of maintaining this position and we must do some hard thinking and planning to discharge it. Before laying out plans for the future, it is always well to examine the ground, survey the situation and ascertain how the position has been attained. It seems that there is not likely to be much difference in the actual technical instructions imparted by first class schools and so far as this is concerned, we are without sensible advantage or disadvantage compared to other like institutions. If that be so, our standing is not due only to the excellence of our instruction and we must look farther for the real cause. To my mind we owe it to the spirit which seized the School in its early days, the loyalty, the esprit de corps, the pride which each has in his alma mater and in the achievements of other members of the School; in fact, to that something that is difficult to define which seems to me to be akin to the patriotism that makes a nation great. All of us know how this spirit came to the School. The School was started and fostered and built up by a man of wonderful personality, revered and loved by all, with the rare gift of inspiring others with his enthusiasm—a very leader of men, Dean Galbraith.

No eulogy can add lustre to the name of Dean Galbraith or to the reverence in which it is held, but because I have known him for so long and so intimately I cannot refrain from giving something of my own experience.

We were very few in those days, only three graduating in my year, and we were fortunate in getting much of the Dean's time. Later, when I became his assistant for a short time, I shared his office and knew him even better. We all admired the Dean and were hopeful with him for the future of the School, but I do not think anyone in those days, even the Dean himself in his most sanguine hopes, imagined it would come to the strength and power it has. As years went on I marvelled at his success, recognized more and more his sterling qualities and valued his friendship the more highly.

I want to pause for a moment to refer to this Society because I see in it a strong evidence of the Dean's ability as an organizer, and I know he valued it greatly as an educational aid and for the influence it has upon the life of the School. In my time we were, unfortunately, too few to organize an Engineering Society, and we were thus debarred its benefits, but I feel that this Society is by far the most helpful single influence in the success of the School and particularly in the after success of its graduates. Under its auspices men get away to some extent from the hard facts of technical instruction; they learn to know each other outside the classroom, friendships are made, and the traditions are created which have held the graduates together, and established the esprit de corps before referred to.

It is rather typical of the Dean's methods that he should nominally have retired from direction of the Society, which he was so interested in starting, as soon as it could stand on its feet but at the same time continue to watch it with fatherly care and I am sure he carefully guided its work to the last.

To revert to our loss; it is staggering and seems almost irreparable but it is not the spirit of the Canadian engineer or that which the Dean imbued, to halt or be dismayed by seeming disaster, and "the good men do, lives after them." Materially we have the consolation of knowing that Dean Galbraith has left us well organized to carry on the work so well started and we have the good fortune to have a man thoroughly equipped and capable of leading us to further achievements. My old friend Dr. Ellis is particularly fitted for that task; through all the years of the School from its very beginning he has stood shoulder to shoulder with Dean Galbraith, sharing much of his actual work, and I do not doubt, giving inspiration and unostentatiously contributing to our success. Still with all his qualifications, Dr. Ellis' task is an arduous and difficult one, and we of this Society owe it to the memory of Dean Galbraith and to the School to assist Dr. Ellis and lighten his labours to the best of our ability. It seems to me we can best do this and at the same time pay tribute to the memory of Dean Galbraith by keeping his example before us and conducting affairs as if he were still guiding.

To us who have worked with Dean Galbraith, no other course seems possible, but there are many more to come who will not have had that privilege and we, too, must pass on. To those following let us hold up the ideal of Dean Galbraith. I am at a loss to suggest how this should be done, but I know there are many actively in touch with School affairs, imbued with the spirit of Dean Galbraith who will make it their interest and pleasure to plan the practical details for carrying on the work of the Society and to keep his memory green before the future graduates and the profession.

Watson-Lockwood

On December 25th, Mr. F. E. Watson, B.A.Sc., '11, demonstrator in drawing, University of Toronto, was united in marriage to Miss A. R. Lockwood, daughter of Mrs. C. K. Lockwood, Brighton, Ont.

Sheppard-Meservey

On Monday, November 30th, 1914, Mr. A. C. T. Sheppard, D.L.S., '07, topographer with Geological Survey of Canada, was united in marriage to Miss Lillian Hamilton Meservey, only daughter of Mr. and Mrs. M. C. Meservey, of Montreal. After a trip to Boston and New York Mr. and Mrs. Sheppard returned to Ottawa, where they will reside until Mr. Sheppard's departure with the second overseas contingent.

Harris-Mitchell

Mr. Joseph H. Harris, B.A.Sc., '10, son of Mr. and Mrs. John B. Harris, Toronto, was united in marriage to Miss Helen E. Mitchell, daughter of the late Mr. and Mrs. Robert Mitchell, on Saturday, January 2nd.

The following "School" men have volunteered for active service with the Canadian Engineers of the Second Contingent and are now encamped at Ottawa with the 6th Field Company:—Lieutenant C. Hughes, '09; with the 5th Field Company:—Sergt. W. B. Redman, '15; B. H. Hughes, '16; W. G. Brown, '16; F. Alport, '06; H. W. Frogley, '11; C. H. Hopkins, '09; H. R. Jardine, '09; A. H. Munroe, '10; with the 4th Field Company:—Lieutenant D. J. Miller, '10; Corporal A. C. T. Sheppard; with the Signal Company:—Sergt. C. E. MacDonald, '16; A. E. Stewart, '11; A. W. Crawford, '14; J. M. Strathy, '13; W. E. Lockhart, '15; F. D. Austin, '15; and J. J. Stock, '08.

Eugene W. Stern, '84, who has a practice as consulting engineer in New York and is secretary of the American Institute of Consulting Engineers, has been appointed chief engineer of the Bureau of Highways, Borough of Manhattan, New York city.

W. C. Murdie, M.A.Sc., '13, is with the Geodetic Survey of Canada, Department of Interior, Ottawa.

Mr. A. C. T. Sheppard, D.L.S., '07, of the Geological Survey of Canada, is with the second overseas contingent in the 4th Field Company of Canadian Engineers, at Lansdowne Park, Ottawa, Mr. Sheppard holds the rank of corporal in this company.

W. A. Richardson, B.A.Sc., '11, is with the headquarters staff, 3rd Brigade, Canadian Field Artillery, 1st Contingent. R. V. Macaulay, B.A.Sc., '11, is with the 5th Battery, 2nd Brigade, Canadian Field Artillery, 1st Contingent.

J. L. Whitside, B.A.Sc., '10, is bridge engineer, office of Highway Commissioner, Provincial Government, Winnipeg, Man.

G. F. Dalton, B.A.Sc., '14, is with the Geodetic Survey of Canada, Department of Interior, Ottawa.

J. L. G. Stuart, B.A.Sc., '07-'08, has been appointed resident engineer for the Burlington section of the Toronto-Hamilton highway.

A. B. Mitchell, '08, is engineer in charge of construction on the waterworks extensions for the town of Orillia, Ont.

Geo. T. Clarke, '06, vice-president of Richardson Bros., Limited, of Saskatoon and Winnipeg, has been appointed by the department of Public Works, Ottawa, to superintend excavation for the foundation work of the new Saskatoon post-office.

A. M. MacKenzie, B.A.Sc., '14, is wire-chief, Bell Telephone Co., Guelph, Ont.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications:

Applied Science,

Engineering Bldg., University of Toronto,

Toronto, Ont.

EDITORIAL

The Twenty-sixth Annual Dinner of the Engineering Society will be held on Friday, February 12th, at 8 p.m., in the Prince George Hotel.

Among the speakers of the evening will be Mr. Thos. R. Deacon, '91, President and General Manager, Manitoba Bridge and Iron Works, Limited, and ex-Mayor of Winnipeg; Hon. W. H. Hearst, Premier of Ontario; and Mayor T. L. Church, Toronto. A good entertaining programme and a particularly good menu has been arranged for. The price of tickets will be $1.75.

"SCHOOL" MEN REPRESENTED AT McGILL SCIENCE DINNER

The Fifth Annual Dinner of the Science Undergraduate Society of McGill University was held on Friday, January 22, 1915, in the McGill Union, Montreal. Mr. C. R. McCort, Chairman of the Civil Club, was present as a Representative of the Engineering Society of the University of Toronto, and responded to the toast to Sister Universities. This toast was also responded to by representatives from Queen's and Laval. The principal speakers of the evening were Principal Peterson and Dean Adams of McGill, Dean Goodwin of Queen's, Mr. H. F. Meurling, M.Can.Soc.C.E., Lieut.-Col. Starke of McGill C.O.T.C., Prof. John McNaughton, Dean Walter of Arts, Dean Berkett of Medicine, and Dean Lee of the Faculty of Law.

Although the attendance was not quite so large as at some similar functions in the past, the dinner was a decided success, and thoroughly enjoyed by all. Dean Adams, in replying to the toast to the Faculty, congratulated the men on the excellent work being done in the C.O.T.C. and mentioned the fact that 78 of their Undergraduates in Science are already on their way or at the front. Owing to the great amount of time required for military work, it had been decided by the Faculty to grant each man a bonus of 10 per cent. on each subject, at the Annual Examinations. Dean Goodwin of Queen's, spoke highly of the work being done at McGill, and said that they were labouring under difficulties at Queen's, due to the fact that so many of their men had gone to the front.

After many words of wisdom spoken and humorous touches given by the several speakers, the banquet came to a close, by all joining hands and singing "Auld Lang Syne," followed by the McGill yell.

OTTAWA GRADUATES ENTERTAIN SCHOOL MEN OF THE SECOND CONTINGENT

On Wednesday evening, January 14, at the Univeristy Club, Ottawa, the graduates who are residents of the Capital City, entertained the School men who have enlisted with the Second Contingent and who are now in barracks at Lansdowne Park, Ottawa. Sixty four were present, of whom sixteen were guests of the evening. Mr. R. A. A. Johnston, '88, of the Geological Survey, presided, and the following members of the executive of the Ottawa branch of the Engineering Alumni Association occupied seats at the head table: Thomas Shanks, '99, president; J. B. Challies, '03, secretary; W. F. M. Bryce, '08, treasurer, and Messrs. R. S. Smart, G. E. Stacey, F. Withrow, G. H. Ferguson and R. W. Morley.

Telegrams of congratulations and best wishes were read from the

Calgary, Winnipeg and Vancouver branches of the Engineering Alumni Association, the Toike Oike Club of Montreal, Prof. C. H. C. Wright and Mr. H. Irwin of Toronto and Dr. T. Kennard Thomson, of New York. The trim military uniforms, the tastefully arranged bunting and the patriotic songs and speeches harmonized with the other outward and visible signs of a loyalty to country and an enthusiasm for the cause of empire which were in constant evidence during the meeting. The toasts to "The King," "The School," and "Our Guests" were honored in the traditional school spirit and the insistent demand for speeches drew from the boys in khaki many responses expressive of gratitude for the brotherly regard of their Ottawa friends.

The musical programme which was under the direction of Mr. Alan Fraser, '10, came in for deservedly favorable mention and was one of the most enjoyable features of a decidedly pleasant reunion.

At the close of the dinner the rooms of the club were placed at the disposal of the party and an opportunity was given to make new acquaintances and to renew old friendships. The guests of the evening, members of the Second Contingent, were: F. Alport, '06; A. C. T. Sheppard, '07; J. J. Stock, '08; C. H. Hopkins, '09; C. Hughes, '09; D. J. Miller, '10; G. H. Munro, '10; H. W. Frogley, '11; J. W. V. Strathy, '13; A. W. Crawford, '14; W. G. Brown, '16; W. E. Lockhart, '15; W. B. Redman, '15; C. E. Macdonald, '16; B. H. Hughes, '16.

H. M. Weir, B.A.Sc., '00, is employed in the city engineer's office, Saskatoon, Sask.

C. W. Hookway, B.A.Sc., '06, is with the Westinghouse Manufacturing Co., Hamilton, Ont.

J. W. Withrow, '90, is in the Patents Office, Department of Agriculture, Ottawa.

D. G. Munroe, '07, is resident engineer, Lake Erie & Northern Ry., Brantford, Ont.

O. L. Flanigan, B.A.Sc., '08, is in charge of construction work for C. H. and P. H. Mitchell in connection with the Cobalt Lake Drainage Scheme, Cobalt, Ont.

F. S. Falconer, B.A.Sc., '09, is with the Geological Surveys, Department of Interior, O tawa, Ont.

R. H. Hall, '09, is with the Customs Department, Ottawa, Ont.

N. C. A. Lloyd, '09, is with Brown & Brown, surveyors, 2 Toronto St., Toronto.

G. L. Kirwan, B.A.Sc., '10, is with the Topographical Surveys Branch, Department of Interior, Ottawa.

M. B. Bonnell, '04, is in the Patents Office, Department of Agriculture, Ottawa.

R. Neelands, '06, is with the Topographical Surveys Branch, Department of Interior, Ottawa.

J. O. Roddick, B.A.Sc., '06, has a contracting practice at Brantford, Ont.

A. M. Carroll, '08, is with the Sovereign Construction Co., Toronto, Ont.

R. E. K. Neelands, B.A.Sc., '07, is surveyor at the Coniagas Mine, Cobalt, Ont.

P. E. Hopkins, B.A.Sc., '10, is geologist with the Bureau of Mines, Ottawa.

C. A. Morris, B.A.Sc., '09, formerly with the Canadian Copper Co., is now with the Hollinger Mine, Timmins Ont.

W. Hutchings, B.A.Sc., '14, is assayer, O'Brien Mine, Cobalt, Ont.

P. W. Meahan, B.A.Sc., '14, is employed in the cyanide plant, O'Brien Mine, Cobalt, Ont.

J. Carter, B.A.Sc., '14, is in the cyanide plant, Nipissing Mines, Cobalt, Ont.

W. A. O'Flynn, B.A.Sc., '11, is with the Temiskaming Mine, Cobalt, Ont.

At the annual meeting of the Toronto Branch of the Canadian Society of Civil Engineers the following officers were elected for the ensuing year:—Chairman, J. W. R. Ambrose; council, J. G. G. Kerry, W. A. Bucke, Geo. A. McCarthy, A. F. Stewart (ex-officio); secretary, C. H. R. Fuller; Library committee, A. L. Mudge, W. A. Hare, J. R. Cockburn, H. J. Bowman.

DIRECTORY OF THE ALUMNI

A

Acres, H. G., '03, is associated with the Hydro Electric Power Commission, Toronto, as hydraulic engineer. He is now engaged in work at Kenora, Ont.

Adams, J. H., '10. His home address is 25 Maynard Ave., Toronto. He is a member of the Adams Mfg Co., 300 Yonge St., Toronto.

Adams, O F., '10 is with the Hydro Electric Power Commission of Ontario at Toronto.

Adsett. F. C '14, is engineer for the Light and Heat Commissioners, Guelph, Ont.

Agnew N. J. '10, has 56 Victoria Ave. S., Hamilton, as his address.

Aitken, J., '11. We do not know his address

Akers, H. G., '08, is a member of the firm of Akers, Mason & Bonnington, chemical engineers, Confederation Life Building, Toronto.

Alexander, J. H., '04. His address is not known.

Alison, T. H. '92, is with the Bergen Point Iron Works, Bayonne, N.J. as chief engineer and secretary of the firm.

Alison, J. G. R., '03. His address is 50 Murray St., Toronto. He has recently been engaged in engineering work at Lorne Park, Ont.

Allan, J. R., '92. is in Renfrew Ont., carrying on a general engineering and surveying practice.

Allan, J. L., '00, is in Dartmouth, N.S., on Government service, as office engineer on the construction of a branch line from Dartmouth to Dean, N.S.

Allan, L. B , '11 is in the Roadways Department, City Hall, Toronto.

Allan, L. F., '08. His address is 362 Dupont St., Toronto.

Allen, F. G., '07. We do not know his present address.

Allen, R. J., '13, is demonstrator in electrical engineering at the University of Toronto.

Allison, C. B., '08, is engaged in Dominion and Ontario land surveying. His address is South Woodslee, Ont.

Alport, F., '08, is with the 5th Field Company, Canadian Engineers, 2nd Canadian Contingent, at Ottawa.

Alton, J. L., '14. His home address is Lucknow, Ont.

Amos, W. L., '06, is in the engineering department of the Hydro Electric Power Commission, Toronto.

Amsden, W. G , '10, is with the Consolidated Optical Co., Toronto.

Anderson, A. G., '92, is a hardware merchant at Port Dover, Ont.

Anderson, A. S., '13. His home address is 455 Hunter St., Peterboro, Ont.

Anderson, F. J., '07, is at Niagara Falls, Ont., with Anderson & Barry, engineers and surveyors.

Anderson, R. M., '08, is a member of the firm of Speight & Van Nostrand, engineers and surveyors, Toronto.

Andrewes, E., '97, is business manager for the Maenofferen Slate Quarry Co., of Portmadoc, North Wales.

Angus, H. H., '03, is on the staff of the Canadian Domestic Engineering Co., Toronto.

Angus, R. W., '94, is Professor of Mechanical Engineering, University of Toronto.

Apsey, J. F., '88, has a practice as civil engineer in Baltimore, Md. His address is 3 N. Calvert St.

Archer, E. G., '11, is in the estimating department of the Hydro Electric Power Commission, Toronto.

Ardagh, A. G., '93, has a private practice in Barrie, Ont., land surveying and engineering.

Ardagh, E. G. R., '00, is assistant Professor of Chemistry, University of Toronto.

Arens, A. H., '06, is resident engineer and mine surveyor for the Inverness (N.S.) Railway & Coal Co.

Arens, E. G., '09, is with the Calgary Iron Works, Calgary, Alta.

Arens, H.W., '03, deceased.

Arens, R. J., '08, is assistant superintendent of the Firestone Tire & Rubber Co., at Akron, Ohio.

Armer, J. C., '06, is manager of the *Canadian Manufacturer* Publishing Co., and secretary-treasurer of the Commercial Press, Limited, Toronto.

Armour, R. H., '05. His present address is not known.

Armstrong, H. V., '09, is town engineer, Estevan, Sask.

Armstrong, J., '95, is chief engineer for the Hudson Bay Railway. His headquarters are at Le Pas, Man.

Ashbridge, W T., '88, of the Ashbridge Brick Co., 1444 Queen St. W., Toronto, lives at 195 Silver Beach Ave.

Augustine, A. P., '07, is in Vancouver, B.C., and is engaged in land surveying.

Austin, E. T., '09, is in the employ of the Mond Nickel Co., at Coniston, Ont., as superintendent.

Avery, C. R., '13, is on the staff of the Provincial Board of Health at the experimental station on Clifford St., Toronto.

Aylesworth, C. B., '05, is with the Canadian Westinghouse Co. at Hamilton

B

Badgley, L. A., '11, is a demonstrator in drawing, University of Toronto.

Bain, J. A., '00, is in Ottawa, as structural engineer, Department of Public Works.

Bain, J. W., '96, is Associate Professor of Applied Chemistry, University of Toronto.

Baird, J. A. '10, is in practice in surveying and general engineering, Leamington, Ont.

Baird, W. J., '10, is with No. 2 Company, Divisional Train, 1st Canadian Contingent, Salisbury Plain, England.

Baker, M. H., '06, is city engineer for Prince Albert, Sask.

Baldwin, F. W., '06, is engaged with Graham Bell, Esq., Hammondsport, N.Y., and Baddeck, N.S., in experimentation and manufacture of aeroplanes.

Baldwin, L. C. M., '13. His address is Forest Hill Rd., Toronto. He is now in active service in France.

Ball, E. F., '88, is chief assistant engineer of resurveys, N.Y.C. & H.R. R.R. Co., New York city. His address is 335 Warburton Ave., Yonkers, N.Y.

Ballantyne, H. F., '93, is in New York, where he has for some years been carrying on an architectural practice at 2 West 47th Street.

Banks, H. R., '14, is engaged in mining work at Gowganda, Ont.

Banting, E. W., '06, is a lecturer in surveying, University of Toronto.

Barber, Frank, '06, is engineer for York county, and is carrying on a consulting practice in bridge and concrete engineering at 57 Adelaide St. E., Toronto.

Barber, H. C., '08, is with The Standard Underground and Cable Co., Hamilton, Ont.

Barber, H. G., '02, is with the Department of the Interior, Topographical Surveys Branch, Ottawa.

Barber, T., '09, is hydraulic engineer for Chas. Barber & Sons, manufacturers of turbine water wheels and accessories, Meaford, Ont.

Barber, W., '05, is with the city of Toronto, in the roadways department.

Barker, H. F., '94, is in the city. He is a member of the firm of Godson Paving Co.

Barley, J. H., '00, is in the engineering department, Canadian Westinghouse Co., Hamilton, Ont.

Barnett, H. A., '10, is with the Canada Pacific Railway Co., construction department, Toronto.

Barrett, J. H., '04, is with the Wm. Davies Co., Limited, Toronto, as superintendent.

Barry, W. H., '09, is a member of the firm Anderson & Barry, engineers and surveyors, Niagara Falls, Ont.

Bartlett, E., '08, is a member of the firm Bartlett & Grassie, engineers and surveyors, in Medicine Hat, Alta.

Bartley, T. H., '11. His address is 464 Gladstone Ave., Toronto.

Bates, M., '06, deceased.

Batten, H. L., '11, is engineer for the Consolidated Mining & Smelting Co. of Canada Ltd., Traill, B.C., at their Centre Star Mine, Rossland, B.C.

Beatty, F. R. '07, is assistant manager of the architectural bronze and iron department of the Canada Foundry Co., Toronto.

Beatty, F. W., '13. His home address is Pembroke, Ont. He had been engaged on D.L.S. work in Western Canada.

Beatty, H. E., '04. His address is Pembroke, Ont.

Beatty, H. J., '91, resides in Pembroke, Ont., as an engineer and surveyor.

Beatty, J. A., '03, is a member of the firm of Morrow & Beatty, contractors, Peterboro, Ont. They have been for some time engaged at Iroquois Falls, Ont., on the construction of the Abitibi Paper & Pulp plant.

Beatty, W. B., '13, is at Sarnia, Ont.

Beatty, W. G., '01. His last address on our fyle is Fergus, Ont.

Beauregard, A. T., '94, is at Darien, Conn., U.S.A.

Beckstedt, R. D. S., '09.

Bedford, F. J., '08. Deceased.

Bedard, E. L., '14. His home is at Lambton, Ont.

Bedard, H. J., '14. His home is at Lambton, Ont.

Begg, W. A., '05, is townsite inspector for the Department of Public Works, at Regina, Sask.

Beith, R. E., '09, is in the employ of the Department of Public Works, Sault Ste. Marie, Ont.

Belcher, J. T., '14. His home address is at 536 Clendenan Ave., Toronto.

Bell, C. A., '13, is sergeant with the Canadian Engineers, 1st Contingent, at Salisbury Plain, Eng.

Bell, G. G., '05. We do not know his present address.

Bell, R. S., '13. His address is 10 Starr Ave., Toronto.

Bennett, G. A., '09. His last address on our file is Tillsonburg, Ont.

Bennett, S. G., '14, is engaged in active service with the British Army at Rouen, France. He had, previous to Dec. 1st, 1914, been taking a course at Oxford University.

Bergey, A. E., '94, is associate professor of constructive design in the Carnegie Institute of Technology, at Pittsburgh, Pa.

Berkeley, G. L., '11, is assistant engineer in the Surveys Department for the Toronto Harbor Commission.

Berry, E. W., '10, is on Dominion land survey work, Department of the Interior, Ottawa. He is a D.L.S. man.

Bertram, G. M., '01, is manager of the Joplin, Mo., branch of the Sullivan Machinery Co., manufacturers of mining and quarrying equipment.

Betts, H. H., '06, is in Rio de Janeiro, Brazil, for the Rio de Janeiro Tramway, Light & Power Co.

Beynon, D. E., '06, is general superintendent of the Dunlop Tire & Rubber Goods Co., Toronto, as superintendent.

Billings, J. H., '11, is a candidate for Master's degree at Massachusetts Institute of Technology, Boston, Mass., where he is taking a special course in mechanical engineering.

Bingham, H. C., '10, is engineer and land surveyor, New Grayson Bldg., Moose Jaw, Sask.

Binns, R. E., '13. His address is not on our fyle.

Birchard, E. R., '09, is with the second contingent at Exhibition Park as sergeant-major with the Eaton battery.

Bissett, D. C., '10, is engineer for the Dome Mines, Porcupine, Ont.

Bissett, G. W., '06, is mill superintendent for the Canadian Exploration Co., Limited, at Naughton, Ont.

Bissett, J. R., '11, is in the Water Power Branch of the Department of the Interior, Ottawa.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO
ENGINEERING SOCIETY

VOL. IX. TORONTO, FEB., 1915 No. 10

REPORT OF THE OFFICIAL DUTY TRIAL OF THE DE LAVAL PUMPING UNIT AT THE JOHN STREET STATION OF THE TORONTO WATER WORKS.

By Professor Robert W. Angus, '94.

Description of the Machine.

The unit consists of a 1,400 H.P. steam turbine, designed for a speed of 3,600 revolutions per minute and a steam pressure of 150 pounds. It is connected by gears with two centrifugal pumps so that the latter run at 600 revolutions per minute, the gears having a speed ratio of 6 to 1. The whole unit was built by the DeLaval Steam Turbine Company, Trenton, New Jersey, and furnished to the City by the Turbine Equipment Company, Toronto.

The Turbine.

The turbine is of the compound impulse type, built on similar lines to the Rateau and other machines of the same principle. The following details are taken from the general drawing furnished the City by the builders, only a few of the outside dimensions being checked.

The steam supply to the turbine is 6 inch diameter and passes through a Schutte steam operated trip throttle valve, thence through the governor direct to the steam chest of the turbine, from which it enters the turbine nozzles. The governor is of the John's type, and acts on a pilot valve, which in turn admits steam to a piston controlling the governor valve, the latter being a balanced double seated valve; the control of the turbine is by throttling.

In addition to the main governor, an emergency governor is connected with the Schutte trip valve already mentioned, which trips and closes the steam off when the turbine speed reaches 3,840 revolutions per minute.

The turbine has 14 wheels of blades in two groups, the first one consisting of five wheels and the second and larger group, of nine wheels with a small receiver space between the groups. The wheels in the smaller group have a mean diameter of approximately 6 inches less at the centre of the blades than the corresponding wheels in the larger group.

Where the shaft passes through the casing of the turbine, the gland is packed with carbon rings and also sealed with steam at 6 pounds pressure; the condensation from these glands being drained away. The rotor is carried on two bearings, these bearings being entirely free of the turbine casing and being carried on the bed plate of the machine. A small thrust bearing on the rotor shaft takes up any unbalanced end thrust, and the governor and oil pump are driven from this main shaft by worm and gear.

The turbine exhaust pipe is 36 inches diameter where it leaves the turbine and enters the condenser. The condenser, which was made by the C. H. Wheeler Manufacturing Company, Philadelphia, is of the water works surface type having a condensing surface of 1,500 square feet made up of 1-inch brass tubes 7 feet 2 inches long, the inside diameter of the shell being 6 feet. All of the water passing through the main pumps also pases through the condenser, the main suction passing through it. The diameter of the suction main entering the condenser is 42 inches, and that leaving it is 36 inches, while the air pump suction connection is 8 inches diameter.

The air pump is a Mullen patent wet vacuum pump built by the C. H. Wheeler Manufacturing Company, steam cylinder 8 inches diameter, pump cylinder 16 inches diameter, stroke of both pistons 12 inches. The steam end of the machine is of the ordinary slide valve type controlled by a throttling governor. The vacuum cylinder is of cast iron with a hard brass cylinder liner, and a long piston so adjusted as to open the inlet parts in the cylinder when it passes over them, the action being similar to that in two cycle double acting gas engines. The steam and pump pistons are coupled together and the stroke is governed by a crank with fly wheel.

The valve deck plates are bolted to the ends of the pump barrel and hold Gutermuth valves opening outward only, i.e., water and air are admitted to the cylinder when the piston uncovers the central port by moving past it, and then the delivery to the hotwell takes place through the valves on the deck plates. The Gutermuth valve is a coiled flexible bronze spring.

Steam for driving the air pump is taken from the main supply pipe between the separator and the steam turbine, and the exhaust from the pump passes through a steam trap and into the turbine itself where it is utilized in doing work. There was no means of obtaining during the test, the air pump exhaust pressure. The drip from the trap on the air pump exhaust passes through an oil trap and the oil is drawn off. No oil reached the inside of the turbine, and the exhaust steam from it was perfectly clean.

The speed of the air pump was about 116 revs. per minute.

The condensed steam passes into the hot well, from which it is delivered to the boilers by a Goulds triplex single-acting boiler feed pump driven by chain from the main pumping unit. Each of the three plungers is 3½ inches diameter and 6 inch stroke, and the speed is approximately 45 revolutions per minute. Owing to the great amount of condensing water and the high vacuum, the temperature of the feed water was quite low.

Returning again to the main turbine, the drive from it to the pumps is made by means of double helical gears having a speed ratio of 6 to 1 thus giving a pump speed of 600 revolutions per minute at the normal turbine speed of 3,600 revolutions per minute. The two pinions are far enough apart to place a bearing between and thus the pinion shaft has three bearings and the shaft itself is connected to the turbine shaft by a flexible coupling. The same thing applies to the gears which are connected to the pump by a flexible coupling.

The main turbine bearings and also the pinion bearings and the gears themselves are oiled by a gravity system. An oil pump is attached below the governor and the oil drains away from the bearings to the pump and is then lifted into an overhead tank, from which it runs by gravity to the bearings. The oil itself is water cooled on its way to the overhead tank and water cooling is also used on the pinion shaft bearings. The large gear bearings are ring oiling.

The pumps consist of two separate duplicate pumps connected together by piping, the shafts of both pumps being connected by flexible couplings and being in line with the large gear shafts. In this place it may be explained that the whole machine consists of four distinct units connected by flexible couplings, viz.:—the turbine, the gears with their shafts, the first pump and the second pump.

Each pump is of the single stage, double entry centrifugal type, i.e., without outside guide vanes, and has a volute casing. The inlet and outlet are each 24 inches diameter and the two ring oiling bearings on each pump are bolted to the sides of the casing. The pumps run in series, the discharge from the first pump being carried to the suction of the second by piping under the floor. The stuffing boxes are sealed by water from the pumps themselves and priming is arranged by means of a single steam ejector connected to the top of each pump casing. The impellers are of bronze.

Nominal Dimensions of the Pumping Unit.

The dimensions set down here are largely those given by the builders, and were not verified, as they were not essential to the duty trial, and are given for the sake of information only.

Steam Turbine.

Type of turbine—Compound impulse.	
Speed, revolutions per minute	3,600

Saturated steam pressure, pounds per square inch	150
Rated horse power	1,400
Number of blade wheels	14
Number of main bearings	2
Size of steam pipe, inches	6
Size of exhaust pipe, inches	36

Condenser.

Water works—Surface type.	
Diameter inside of shell, feet	6
Size of tubes, inches	1
Length of tubes, inches	86
Condensing surface, square feet	1,500
Suction pipe entering condenser, inches	42
Suction pipe leaving condenser, inches	36
Steam inlet, inches	36
Outlet to air pump, inches	8

Air Pump.

Type—Steam driven, crank and flywheel vacuum pump, wet service.	
Diameter steam cylinder, inches	8
Diameter pump cylinder, inches	16
Stroke of both cylinders, inches	12
Speed, revolutions per minute	116

Boiler Feed Pump.

Type—Belt driven, triplex, single acting.	
Number of plungers	3
Diameter of plungers, inches	3½
Stroke of plungers, inches	6
Speed, revolutions per minute	45
Driven by silent chain from main turbine shaft.	

Venturi Meter.

Diameter at each end, inches	30
Diameter at throat, inches	15

THE DUTY TRIAL.

General Conditions Governing the Trial.

The pumping unit was brought under the general specifications dated October, 1912, and these specifications provided for prices being submitted on three different machines, viz.:—(a) a self contained vertical, triple expansion, fly wheel, plunger pumping engine with jacketed steam cylinders; (b) a centrifugal pump driven by a triple expansion condensing engine running at a speed of not over 350 revolutions per minute and designated as "Alternative No. 1", and (c) a centrifugal pump driven by steam turbine, the speed of the pump not to exceed 750 revolutions per minute. This is marked "Alternative No. 2".

The capacity of the pumps as shown by Section 5 of the specifications in each case was to be "not less than 15 million Imperial gallons of water in 24 hours, against a pressure difference of 105 pounds per square inch between the suction and discharge mains, the pressures to be measured at approximately the same level".

The pump purchased was that specified under "Alternative No. 2" consisting of pumps driven by a steam turbine as described in the early part of this report. Under Section 78 the conditions for testing the pump are as follows:— "Paragraph 73 relating to 'Tests' in Alternative No. 1 to apply to Alternative No. 2 with this exception: should the contractors guarantee a duty in excess of 100,000,000 foot pounds when using saturated steam, the duty guaranteed will be substituted for this amount, and for each one million (1,000,000) foot pounds in excess of the guarantee, the Corporation shall pay to the Contractor the sum of fifteen hundred dollars ($1,500) and pro rata for fractional parts, but the total bonus shall not exceed ten thousand dollars ($10,000). Should the duty . . . . . be less than the guarantee the Commissioner shall deduct . . . . . two thousand dollars ($2,000) for each million (1,000,000) foot pounds unperformed . . . . . ". "If the duty be more than five million foot pounds below the guaranteed duty, the Commissioner may . . . . . . reject the unit."

Section 73 says:—

"This unit shall perform a duty of not less than one hundred million foot pounds for each one thousand pounds of steam, containing not more than 1½ per cent. of entrained water as determined by throttling calorimeter measurements, used by engine, and any auxiliary pumps supplied by the contractor and operating during the duty trials, when pumping not less than 15,000,000 gallons per 24 hours as per pressure, suction and speed specified.

In computing the duty the work performed shall be based upon Venturi meter measurements, and the head shall be shown by an accurate pressure gauge, attached to the discharge main (see Section 70).

All the steam used by jackets, reheaters, air pumps, air compressors, boiler feed pumps, and other auxiliaries, required for the operation of the unit, shall be charged up to the engine in computing the duty."

The conditions of the trial are further governed by Section 75 which says:—

"After the pump has been in successful operation for sixty days, a duty trial of 24 hours' duration shall be made.

The pump shall be operated continuously at its rated capacity, against a pressure of 106 pounds, as recoiding on the gauge. (See Section 70 for location of gauge.)

Engine to be supplied with steam at 150 pounds gauge pressure at the boilers."

Section 70 states in part:—

"The head for computing the duty shall be that shown by an accurate pressure gauge attached to the discharge main at a point inside the engine room and beyond the last pump, less the reading shown by a gauge attached to the supply conduit at or near entrance to pumps, an allowance being made for any difference in the level of the gauges. No allowance shall be made for friction of water between the gauge points, between which shall be situated the complete machine as supplied by the contractor.

"In computing the duty, the total steam used including that used by jackets, reheaters, air pumps, air compressor, bolier feed pump and any other auxiliary pumps? shall be charged up to the engine.

"The duty trial shall be of 24 hours' duration. The engine shall be operated continuously at its rated capacity, against a pressure difference of 105 pounds per square inch as above specified, and shall be supplied with steam of not more than 150 pounds per square inch by gauge at the boiler.

"During the trial the engine shall be operated by the regular engineers of the Station, at the speed and pressures specified, but otherwise shall be under the control of the contractor. The trial shall be conducted by the Commissioner, or person appointed by him, in the presence of a representative of the contractor."

After the specifications had been printed some correspondence took place between the Commissioner of Works and the contractors, The Turbine Equipment Company of Toronto, and on March 18th, 1913, the Commissioner wrote the contractors as follows:—

"Replying to your favor of the 13th inst., I beg to advise you that, as arranged, the official test on the turbine pump you are building for us will be made against a pressure difference of 115 pounds per square inch, while delivering about 15.5 million Imperial gallons."

The Turbine Equipment Company further stated that their pump would satisfy the City specifications in regard to quantity and pressure at a speed of 600 revolutions per minute.

In a turbine pump design it is not possible to decide in advance on the corresponding pressure, discharge and speed, and only two of these qualities can be definitely fixed and the pump designed to approximate to the third one as nearly as possible. In the present instance, at a speed of 600 revolutions per minute and a pressure difference of 115 pounds per square inch, the discharge considerably exceeded the specified quantity of 15.5 million Imperial gallons per 24 hours. In running the test, therefore, it was decided to adhere as closely as possible to the desired speed of 600 revolutions per minute and pressure difference of 115 pounds per square inch, and take the discharge as it actually occurred.

Steam Pressure.

The specifications required a gauge pressure of 150 pounds per square inch at the boiler. During the time the test was run, very extensive changes were taking place at the pumping station; a new boiler room was being constructed and some of the old buildings had been removed, so that the steam pipe to the turbine from the boilers was very long and a greater part of its length was exposed to the weather. Under such conditions it seemed unfair to adhere to this pressure at the boiler, but to make allowance for losses which would occur under fair normal conditions it was decided to carry 149 pounds per square inch at the turbine throttle. The record shows, however, that the actual pressure was somewhat lower than this. The pressure above the turbine nozzles was read on a gauge.

Quality of Steam.

The steam to be supplied was to contain not more than 1½ per cent. of entrained water as determined by throttling calorimeter measurements. The throttling calorimeter was attached to the main steam supply pipe just a few inches on the boiler side of the throttle valve. The steam separator between the turbine and the boiler worked very efficintly and the steam as measured contained only 1.05 per cent. of moisture. The pressure in the calorimeter was taken on a mercury manometer.

Vacuum.

The vacuum on the turbine was measured by means of a mercury column attached thereto.

Water Pressures.

In measuring the water pressures, the suction pressure was determined by means of a glass tube open at the top and attached to a flexible rubber hose which was connected to the suction pipe inside the engine room and within a few feet of where the water entered the condenser. The height of water in this tube above the concrete floor is called the suction pressure, the water in it always stood above the centre of the suction pipe.

The discharge gauge was attached at the discharge flange of the pump where the diameter of the pipe is 24 inches.

An accurate gauge was used, reading to ½ pound per square inch. The elevation of the centre of the discharge gauge above the datum used on the suction pressure was 13 feet.

The total pressure was found by adding the pressure equivalent of 13 feet to the discharge pressure and subtracting therefrom the suction pressure reading reduced to pounds per square inch.

Capacity of the Pump.

The capacity of the pump was determined by means of a Venturi meter, as required by the specifications. In order to eliminate any possible error from the recording mechanism, a mercury manometer was connected up so as to record the exact difference of pressure in the tube, readings on this manometer being used to compute the discharge.

The co-efficient used for the Venturi tube was that obtained from the scale furnished by the makers, The Builders Iron Foundry. The meter was 30 inches diameter at the ends, with a 15 inch throat.

Barometer.

The barometric pressure during the test was obtained from the records of the Meteorological Office on Bloor Street, a correction being made to allow for difference of level between the Observatory and the John Street Station. Both days of the test were very unpleasant, with very heavy rain on Monday and a very dense fog, for Toronto, on Tuesday. The barometer, however, stood quite high, the corrected reading for the John Street Station being 29.88 inches.

Condensed Steam.

The exhaust steam from the turbine, which included that from the air pump, was delivered by the air pump into a reservoir in the basement of the engine room. This reservoir had a quick-opening valve, by means of which the condensed steam could be delivered into a weighing tank on scales and there weighed.

The drips from the governor valve and glands, as well as the water from the separator attached to the exhaust pipe of the air pump, were collected in a barrel partly filled with cold water and weighed, the water being run out and fresh cold water introduced whenever the water in the barrel became hot.

Observers and Observations.

Observations were made by students in the fourth year in the Faculty of Engineering of the University of Toronto. These men were all skilled in such work, which forms a large part of their daily duties. They were divided into three shifts of about eight hours each, each shift overlapping the previous one by about one hour.

Observations were taken at regular intervals during the entire trial, those on the suction and discharge pressures the Venturi meter and the weight of condensed steam being taken every 7½ minutes, while those on the main steam and nozzle pressures, the vacuum, the speed and the calorimeter were taken at 15 minute intervals. The weight of steam from the drips was taken about every 45 minutes, but the intervals varied somewhat, as the weights were taken and cold water put into the barrel when necessary.

All gauges used were calibrated both immediately before and after the trial by a Crosby dead weight tester, and the scales were examined by the Government Inspector just before the trial and a certificate that they were accurate, was given by the Inspector.

During the entire trial the weight of condensed steam, along with the tank holding it, was very close to the capacity of the scales. Owing to an error of the observers in taking the time, the weight at 7.07½ exceeded the capacity of the scales and had to be estimated. In doing this the probable weight was estimated from the average of the previous six readings and would have an error not exceeding 40 pounds, which is negligible in comparison with the total weight of steam used in the trial of 370,280 pounds.

Representatives at the Trial.

The contractors were represented by their local and district Managers and by Mr. Waller, Chief Engineer of the De-Laval Company, the plant being in charge of the Chief Engineer of the station, Mr. McRae.

RESULTS OF DUTY TRIAL.

The results of the trial are given herewith.

General.

Date of trial, 3 p.m. Monday, November 30th to 3 p.m Tuesday, December 1st.

Duration of trial, hours	24

Corrected Average Pressures.

At turbine in main steam pipe, pounds per sq. in.	148.0
At turbine nozzles, pounds per sq. in.	137.4
Vacuum, inches of mercury	28.82
Barometer, inches of mercury	29.88

In discharge main at exit from pump, pounds per sq. in.	111.82
In suction main before entry to condenser, feet above datum	5.72
Elevation of discharge gauge above datum, feet	13.0
Pressure difference on pump, pounds per sq. in.	114.10
Pressure differences specified, pounds per sq. in.	115

Average Temperatures.

Of engine room, Fahrenheit	69.
Absolute pressure in condenser, inches of mercury	1.06
Corresponding temperature, degrees Fahrenheit	81.

Calorimeter.

Pressure of supply steam at calorimeter, pounds per sq. in.	148.0
Pressure in calorimeter, inches mercury	2.51
pounds per sq. in.	5.1
Temperature in calorimeter, degrees Fahrenheit	297.2
Moisture in steam, per cent.	1.05
Moisture specified not to exceed, per cent.	1.50

Speed.

Speed of turbine, revolutions per minute	599.5

Water Pumped.

Difference in pressure by manometer between entrance and throat of Venturi meter, inches mercury	11.542
Water delivered, Imperial gallons per 24 hours	18,373,000

Steam Used by Turbine During Trial.

Steam condensed in condenser, pounds	369,331
Steam from glands, etc., pounds	949
Total steam used by turbine, pounds	370,280

Horse Power Developed.

Pressure difference on pump, pounds per sq. in.	114.10
Water pumped, Imperial gallons per minute	12,759
Water Horse Power	1,016.4
Steam per water horse power per hour, pounds	15.18

Duty.

Work done by pump in 24 hours, foot pounds	48,301,255,720
Steam used by pump in 24 hours, pounds	370,280

Duty per thousand pounds of steam used, foot pounds	130,449,000
Duty guaranteed, foot pounds	118,500,000

Respectively submitted,

ROBERT W. ANGUS.

Toronto, Dec. 28th, 1914.

It will be seen that the contractor sufficiently exceeded his guaranteed duty to gain the maximum bonus allowed.

VALVE DIAGRAMS AND THEIR APPLICATION

Part II.

By M. L. Smith, B.A. Sc., '11, Associate Editor,

"*The Power House.*"

In the last number the Bilgram valve diagram, in its simplest form, was explained at length. The application of all valve diagrams is modified by a number of conditions, such as angularity of the piston and eccentric rods, the manner of transmitting the motion from the eccentric to the valve stem, etc. The effect of all such considerations should be thought out before proceeding to obtain information by means of valve diagrams. The diagrams, as explained, apply to the plain slide valve and its simpler modifications. Its application to other valve gears will be explained as these are separately taken up.

Angularity of the Connecting Rod

The crank pin does not move back and forth in a straight line as does the piston and cross-head, but must swing round in a circle. For this reason the method of determining the crank pin position which has been given is correct only for such mechanisms as the slotted cross-head, Scotch yoke, and others in which the angularity of a connecting rod can have no effect. The swinging of the connecting rod from side to side, if the engine be running over, will cause cut off to occur earlier in the return stroke and later in the forward stroke, the piston being pulled forward in proportion to the amount of sideways motion of the crank pin.

If it be required to accurately find the relative positions of the crank and piston and thus the valve and piston, the effect of the connecting rod must be taken into account. This is done, as shown in Fig. 1, by means of the arc Cx instead of the straight line Cw, as in Fig. 2. The radius of this arc is equal to the length of the connecting rod to the same scale as the crank pin circle, and its centre is located on the base line extended towards the head end of the cylinder. The eccentric rod is usually very long in proportion to the valve travel, and, for this reason, the angularity of the eccentric rod has little effect on the valve, and can, therefore, in most cases be neglected.

Equalizing the Cut-off.

In order to have the cut-off occur at similar points in both forward and return strokes, various expedients are adopted. An examination of Fig. 3 will make it plain that if cut-off is to come about at similar points in the cylinder for both strokes, the crank pin positions will have to be different on account of both being drawn towards the cylinder. It is seen that one

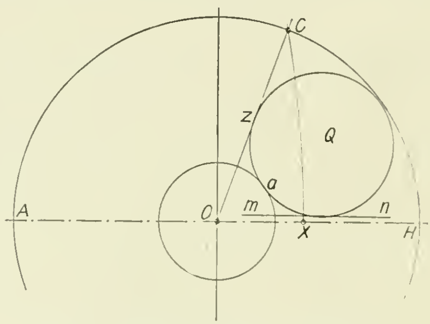


Fig. 1—Use of Bilgram Diagram to determine point of cut off.

way of overcoming the effect of this shortening of the connecting rod would be to increase the lap for the head end and to decrease it for the crank end, as shown in Fig. 3. The drawback to this method is that the lead becomes excessive for the return stroke, as shown by the distance (a_1 q_1) as compared to (a q) which represents the lead for the forward stroke. The port opening is also unequal for all parts of the stroke, which is, however, not so important.

A much better way of equalizing the cut-off is by means of a rocker arm, as shown in Fig. 4. The rocker arm, by creating similar irregularities in the valve motion serves to neutralize the effect of the connecting rod without disturbing the leads. Determine from the Bilgram diagram the travel, lap, angle of advance, etc., for one end, taking into account the effect of the connecting rod. Lay off the stroke, as at A H, and, upon it, the points where cut-off is to take place. On the same base line extended draw the crank pin circle C N and the valve travel circle (m n). Draw in the crank positions for cut-off—namely, C and N and for admission. Lay off the corresponding positions of the eccentric centre 90 degrees plus the angle of advance ahead of these. These are (n) and (m) for cut-off and (o) and (p) for admission.

We know that the valve is in the same position for both cut-off and admission—that is, for positions (o) and (n) and (p) and (m). Now, with the points (o) and (n) as centres, strike little arcs (o_1) and (n_1). Their intersection is the point

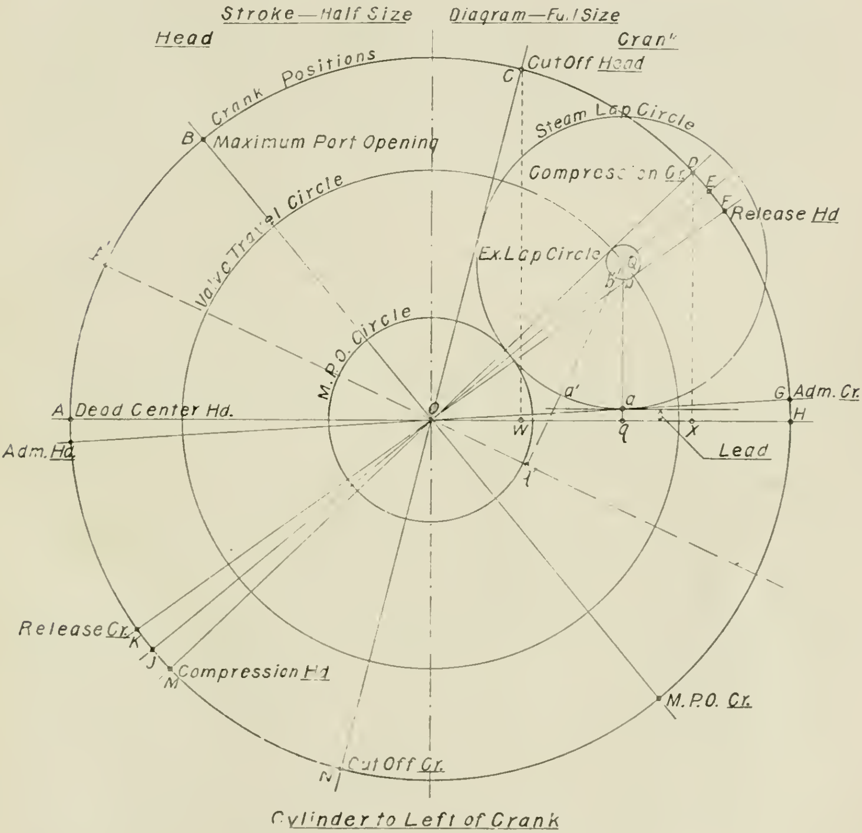


Fig. 2.—Complete Bilgram Diagram.

at which the eccentric rod pin should be for admission and cut-off on the forward stroke. In the same way the point where the arcs (m_1) and (p_1) cross will be the same pin position for the return stroke. Connect these two points with a straight line and from its centre draw a perpendicular, as shown. This line will represent the central position of one arm of the rocker. The other arm V W should be perpendicular to the valve stem at the central position, and the point of intersection W must be chosen so as to make the two lever arms proportional to the throw of the eccentric and the travel of the valve respectively. In a similar way release or compression may be equalized.

The equalization of the cut-off has more to do with the designing of the engine than with its operation; nevertheless a knowledge of the methods employed will be of great assistance in correcting troubles located by means of the steam engine indicator. Also, in attempting to obtain information by means of the Bilgram diagram care should be taken to find out previously whether means have been adopted to equalize the cut-off and other events of the stroke or not. It is well to observe also that where rocker arms are used, the throw

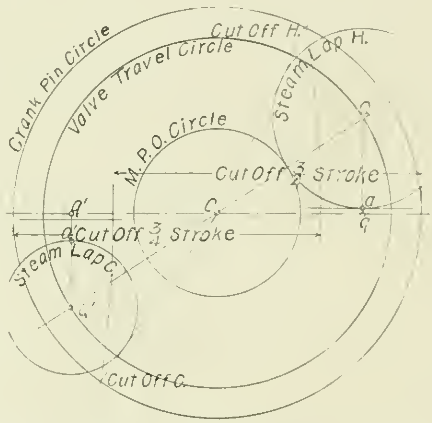


Fig. 3.—Effect of Angularity of Connecting Rod.

of the eccentric is not necessarily the same as the valve displacement.

The Zeuner Diagram.

In a large number of shops in this country where the output of engines is not great, the setting of the eccentric is usually a cut-and-try process, and no diagram is used. When questioned concerning this practice the reason often given is that the purchaser sometimes has ideas of his own regarding amount of lap, lead, etc., and that no standard can be adopted. In the British Isles where the marine engines built are no doubt the best of their kind in the world, the valve gears are made to be assembled without any trial cuts so to speak, eccentric settings, laps and port widths being calculated beforehand by means of diagrams.

Among European engineers, the diagrams devised by Dr. Zeuner are most used and, for this reason, synopsis of their main features will be dealt with here. Many points of similarity will be found between the diagrams of Zeuner and Bilgram, and if either has been well understood by the student, no trouble should be experienced in mastering the salient points of the other.

The typical feature of the Zeuner diagram is that the value displacement is represented by the length of crank radius line intercepted by the valve circles. Referring to the diagram in Fig. 5, let J be the crank position and Z the eccentric position at any instant. The outer circle J A Z is the valve travel circle, the valve travel being represented by its diameter. The two smaller circles are termed valve circles and these are drawn with a diameter equal to half the valve travel or, in other words the eccentricity.

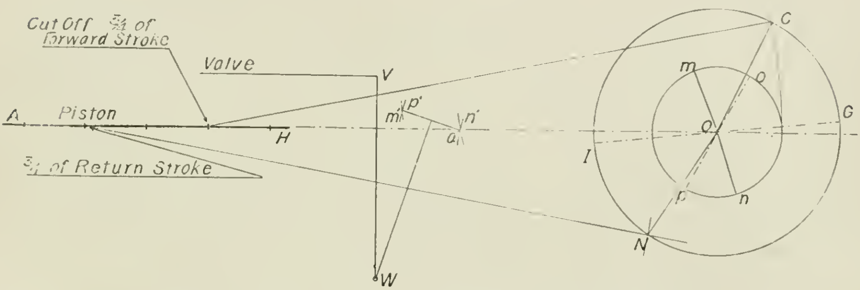


Fig. 4.—Equalizing Cut Off by means of Rocker Arm.

The part Ob of the eccentric radius which is intercepted by the valve circle ObF represents the valve displacement, that is, the amount the valve has moved from its central position. The reason for this is as follows:—We know that the valve displacement when the crank is at J and eccentric at Z is, Oa, aZ being a vertical line through Z on J F. It can be proved that, upon joining b F, the two triangles O b F and O a Z are equal in every respect, that is Ob = Oa or Ob, while the intercept of the eccentric radius by the valve circle represents the valve displacement for any position of the eccentric.

The diagram proper is shown in Fig. 6, and may be constructed in the following way: Describe a circle KXA with a diameter equal to the valve travel, and draw in the dead centre diameter KA. From O on the line KA measure off the lap OB and the lead BC. Through C draw a line at right angles to the dead centre line cutting the valve travel circle at the point F. Draw a diameter through the point F, namely F O J. Using the line O F as a diameter, describe the valve circle O F C and likewise on O J construct the valve circle W O J. With O as a centre, draw the steam lap circle W Q B and also the exhaust lap circle (w q c) with radii equal to the steam lap and exhaust lap respectively.

Where the valve circles intercept the steam lap circle, draw the crank diameters G P and R E. Also through the points where the exhaust lap circle cuts the valve circles, draw the diameters V L and H N. Through the centre O, midway between the two valve circles and at right angles to F J draw the crank diameter M T. For purposes of explanation draw any radius O Z of the valve travel circle.

Considering that the cylinder is to the right and the engine runs over, we will now locate the different points in the stroke at which the cylinder events occur. As before explained, the distance the valve has moved from its central position for any crank position is shown by the amount cut

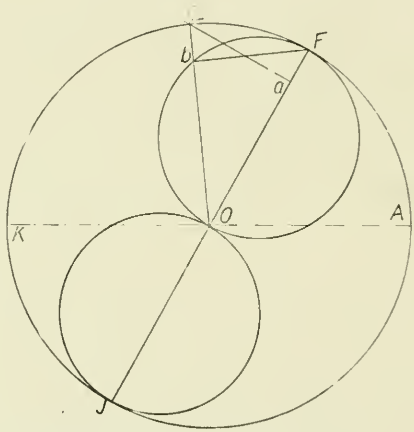


Fig. 5.—Diagram Showing Proof of Zeuner's Theory.

off the radius drawn through the point by the valve circle. At the point of admission, the displacement must equal the lap of the valve. The point of admission then, is at E because when the piston is at this point, the valve displacement or the part of the crank radius cut off by the valve circle is OD, which is equal to the radius of the steam lap circle and is, of course, the lap.

At the dead centre point A, the valve displacement is equal to O C or the lap O B plus the lead B C. When the crank reaches Z, the valve displacement is equal to Ob, therefore the port opening is (a b). At the point F the valve circle intercepts the whole radius O F which represents the eccentricity or the greatest valve displacement. The port opening is here equal to f F which is the greatest possible. The point F then, is the crank position for maximum port opening. As the crank pin moves around to G we find that the valve has moved back until the part intercepted by the valve circle is equal to O Q or the lap, and there is no port opening whatever. This point G is therefore the crank position for cut-off.

In the same way as with the steam lap circle, the part of the crank radius intercepted by the exhaust lap circle represents exhaust lap. At the point H, we find that the valve

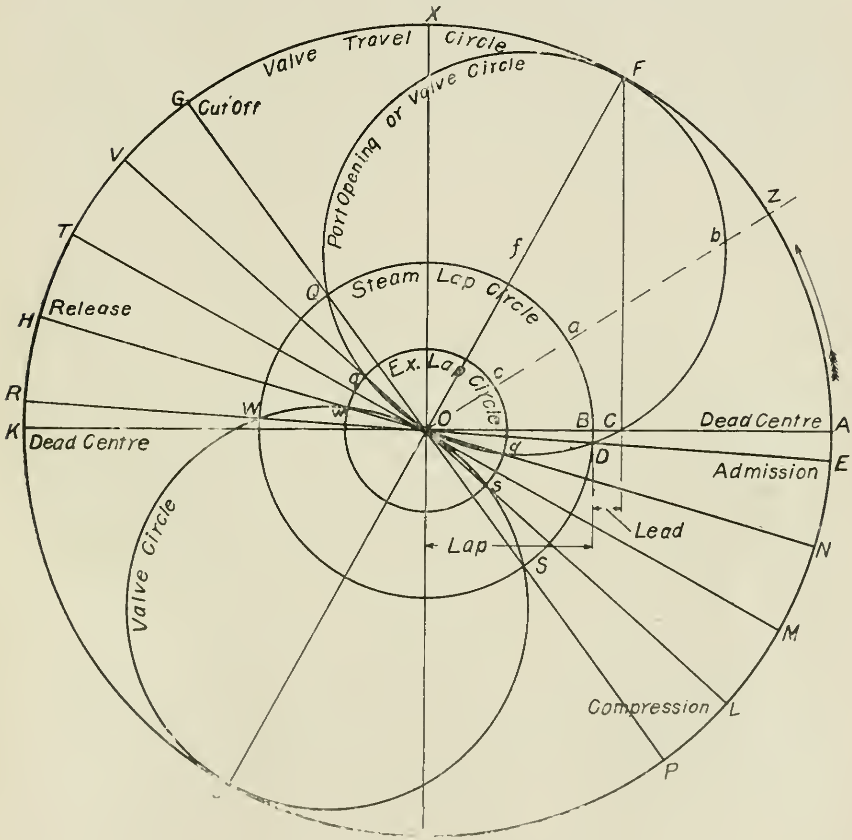


Fig. 6.—Complete Zeuner Diagram.

displacement is equal to Ow, which is the exhaust lap. That is, the port is about to open to exhaust, and H therefore is the crank position for release. This, it is seen, takes place slightly before the beginning of the return stroke just as admission takes place a little before the forward stroke. As the crank pin comes round on the return stroke, nothing particular happens until the point L is reached, when the valve displacement Os is again equal to the exhaust lap. The port is about to close to exhaust, and compression takes place.

The cycle is completed as the crank returns to E the point of admission. At the points T and M, of course, the valve is in its central position and all ports are closed.

The time occupied in or the proportion of the stroke in which the crank pin is going from E to G is called the period of admission. That used in going from G to H is known as the period of expansion. From H to L is exhaust and from M to E is the period of compression. For certain purposes it is seen that this diagram is even more simple that that of Bilgram, and a little study will show that it can be used in the same way to obtain any desired information in connection with valves and gearing provided sufficient data are given.

To determine the correct piston position for any point in the stroke, Dr. Zeuner used a supplementary diagram such

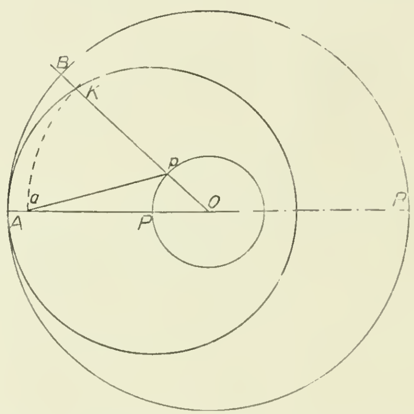


Fig. 7.—Auxiliary Diagram for Determining Piston Position.

as that shown in Fig. 7. The large circle A B R is drawn with a radius AO, representing the length of the connecting rod plus the length of the crank arm to some convenient scale. With a centre P and a radius A P equal to the connecting rod, describe another circle A K touching the larger circle at A. With a centre O, the same as the large circle, describe the small circle P P which, of course, has a radius equal to the crank arm.

The lines AP and PO represent the connecting rod and crank arm respectively when the engine is on dead centre. Let pO be any other position of the crank and produce pO to B. It is easily seen that BK is equal to Aa, and therefore, for any position of the crank the distance the piston has moved from its starting position is equal to the intercept between these two circles of the crank line produced. The value of these diagrams depends largely upon their accuracy and, for this reason it is usually best to draw them to an enlarged scale.

TWENTY-SIXTH ANNUAL DINNER.

The one function above all others which year after year emerges from the medley of University activities, enveloped in a distinctively encouraging and satiating atmosphere of pleasant recollection is the Annual Dinner of the Engineering Society. Each year the success which attends the "School" Banquet, voluntarily pronounces it as the best yet. The twenty-sixth annual dinner which was held at the Prince George Hotel on February 12th, can rightfully boast of an equal right to that of any of its predecessors to any distinction or precedence which fresh memories might give one over those which were no longer enhanced by still effervescent enthusiasm growing out of reunions and genial fellowship.

The Dinner this year was a remarkable success as a medium to afford a reunion of "School" men, and an opportunity to discuss matters relating to engineering and the "School" and cement even more firmly the bond which binds the graduates and undergraduates together as one harmonious unit. It was also unique in that unusual vent was given to patriotic expression, as about 70 of our members are either with the British Army or the First Canadian Contingent, and a large number have enlisted for active service with the Second and Third Overseas Contingents. The undergraduate members in Toronto who had enlisted for active service were guests of the Engineering Society. A pre-dominant trend of patriotic feeling pervaded the gathering, and the addresses of the evening and their reception voiced in no uncertain way the loyalty of those assembled, to the "School" and to our Country.

Over three hundred were present including Hon. W. H. Hearst, Premier of Ontario; T. R. Deacon, '91, ex-mayor of Winnipeg, and President and General Manager of the Manitoba Bridge and Iron Works; T. L. Church, mayor of Toronto; W. H. Taft, ex-president of United States; Dean Goodwin of Queen's University, President Falconer, Dean Ellis, D. Moliter, C. E., J. B. Challies, '04, Superintendent Water Power Branch, Department of Interior, Ottawa, and J. L. Morris, C.E., '81, the first graduate from the School of Practical Science, and W. J. Fitzgerald, President of the Ontario Surveyors Association.

In his opening remarks, Mr. Gray, the chairman, expressed the gratitude of the Society to those who had helped to make possible a Dinner of such promising success. When he proposed the toast to "The King" it is doubtful if ever 300 lusty voices ever sang with greater and truer meaning the National Anthem of the British Empire.

The toast to "Canada and the Empire" which was proposed by R. D. Galbraith, '15, was replied to by Premier Hearst, who was at his best. His excellent portrayal of the extent and richness of Canada's resources and the magnitude of the possibilities that lie before our Dominion evoked round after round of unrestrained applause. He appealed to Canadians to rise to their opportunities of the present time and share in the glory which will be ours when military autocracy shall have been crushed and peace again restored among the nations of the earth. We should now give all for the Empire in men and money and then devote our energies to the development of Canada until she makes her place among the confederations of the world.

Mr. Taft spoke in reply to the toast to the United States and briefly outlined the work which had been accomplished in the construction of the Panama Canal. Much of that was done by the war department while Mr. Taft was Secretary of War for United States and he consequently was well acquainted with much of the work and the difficulties which were encountered in completing so great a task. The difficulties were not all of an engineering nature, the chief problem being the necessity of making provision against fevers of the tropical country.

"Our Graduates" were toasted by E. H. Scott, '15, and T. R. Deacon, '91, replied. Mr. Deacon's address was forcibly delivered and contained very much of real interest to "School" men and to others as well, who are interested in the development of our country's resources. The wealth of our country depends not upon her tall buildings and her great areas, but upon the mettle of her manhood and the development of her natural resources. He appealed to the Dominion Parliament and to the Provincial Legislatures to give greater assistance toward technical education if they wish the wealth now dormant, to be placed at the disposal of our people.

Mr. H. O. Leach, '15, proposed the toast to "The University and the Faculty of Applied Science and Engineering." In replying, President Falconer demonstrated the deep interest which he feels toward the University and her students when he spoke as follows,—

"The Faculty of Applied Science has been remarkable for the spirit of unity with which it is pervaded. There is no other faculty in the university that exhibits such unanimity of feeling and that rallies more whole-heartedly to the interests of the faculty itself. It is a good example for the other faculties of the university in this respect. The dinners of this faculty therefore are pervaded by the best of feeling.

"A few days ago I visited some of the Eastern Universities of the United States. The impression that I received was that they are conducted on a much more elaborate scale than we have hitherto been able to approach in the University of Toronto. Their staffs are large; they have elaborate buildings and well equipped laboratories. It is our duty to follow on as closely as we can. Our people must be taught that education is the foundation of progress, and the educated man from the universities must carry this message to the people throughout the length and breadth of the land. Progress is to be measured by the way in which the people of a country prove to be masters of their environment. The educated man is one who has control of his faculties and who wherever he goes is able to turn to his use the material conditions by which he may be surrounded. The supremacy of mind over a nation's physical endowment will be the standard of their advance as compared with others. It will, therefore, become more necessary to educate our people who will occupy our own positions with satisfaction and honour.

"Turning now to the experience of the session through which we are going, it has been to me a year of deep tragedy. You have rallied in a wonderful way to the Officers' Training Corps, which has been fit and proper, and yet it is extremely sad. As I look forward to the next year I cannot say that the cloud seems to lift, for many of you will be away, and many may never return, and yet go you must if your duty calls you. This year will be a year to which our children and their children will look back as a year in which the mettle of their fathers was tested. One great satisfaction that is coming out of this sad year is the proof that our generation is as good as any generation of our fathers was. We do not need to look back to Waterloo for heroism. Nothing in British annals has surpassed the retreat from Mons. The action of our men is as heroic as it has ever been, and our Canadians are willing to do their best. There is no decline in the stamina of the race. You have come to the University at a great time, a great testing time, a sad, profoundly sad time, but when you have come through it you will realize that it has been a wonderful period. Some of you may not come through it, but I believe that there are larger issues of life than the present span of years, and in the truth of the Old Word that he who loseth his life shall find it."

Dr. Ellis also gave a very interesting address in which he congratulated the engineering students on the splendid response they were making to their country's call. The Kaiser of Germany had thrust his hand into the melting pot of international politics, and that hand being out of harmony with the contents and their purpose, had caused an explosion which had set the whole world ablaze. He regretted the necessity of the young men risking their lives for their country but was proud to know that they were so nobly answering the call of honour, freedom and liberty.

Mayor T. L. Church, K.C., President of the Union of Canadian Municipalities followed, responding to the toast to

"The City of Toronto," which was proposed by H. M. Black, '15, and said in part:—That he hoped some day in the near future a monument would be built to the memory of the late Dean Galbraith, who had done so much to build up the University of Toronto.

If they sought this monument they had just to look around them in Canada; to the various municipalities where, in many of them, the Head was a pupil of the late Dean. He was a man who had a manner which was characterized by great sociability, amiability, urbanity and great personal popularity. He was "to the faults of the students a little blind and to their virtues very kind, but always kept the padlock on the mind".

The Mayor said that there was sufficient brains in Canada without running to the United States or elsewhere for engineering ability; he advocated a policy of "Canada for the Canadians" in the engineering profession.

The Universities of Toronto, McGill and Queens had done a great deal through their Engineering Departments to build up Canada, and the time had now come for the Governments, Dominion and Provincial, to get together and capture the German trade. They should carry on in the universities, necessary investigations in every way, and secure the secrets of the industrial success of the Germans in a scientific way so that our industrial expansion may go ahead. Further, the Governments should utilize the students and the various technical departments of our universities to solve this great question. The German patents are cancelled in the British Empire, and now is the time to strike, and secure their trade. United effort and mutual benefit should be the watchword in solving it.

The Government should also restore single fare rates for the students of our universities in Canada, which the railways took away from them in 1912, and as President of the Union of Canadian Municipalities he had taken the matter up that week with the Government. A further question should also be taken up of providing work in the summer months, through the various Governments for the students of the Canadian Universities. There was plenty of work to do if the Governments would lend their active assistance in developing Canada.

"The Engineering Branch of our City is largely made up of graduates of the School of Science, as is the Engineering Department of the Harbour Board and the Hydro-Electric Commission. This School has furnished us with our best men. They are hard workers, and they are enthusiastic over their work, as well as able and capable. He wished the Engineering Society even greater success in future.

"There is no class of the community who have responded more nobly or heroically to the call of arms and to the call of

"Your country needs you" than had the students of Canada. They have enlisted in thousands and gone to the war, following the admirable example of University men of the British Isles."

"Sister Institutions" were proposed by E. M. Monteith, '15, which toast was replied to by G. J. Smith and Mr. F. C. Montgomery, representatvies from Queens and McGill respectively. Dean Goodwin of Queens also spoke for a short while and referred to the military work which was being done by the engineering students in Kingston.

Mr. R. B. Sinclair then proposed a toast to "Our Absent Members". He very appropriately made reference to those who had enlisted for active service and those who were already on the firing line. "These men," he said, "may not all come back but they are showing the mettle of which they are made and will bring honour to themselves and their Alma Mater. There is one," he said, "who has been taken from us and whom we cannot and would not forget on this occasion. For twenty-five years our late Dean had been the central figure at our annual banquets and we feel that we should pay tribute to the memory of the one who had fostered the Society for so long."

A vocal solo was rendered by W. K. Greatrex, '17, and the Science Quartette gave several selections. Music was provided by the Toike Oikestra under the leadership of G. W. F. Johnston, '15.

The following cablegram was later sent to Col. C. H. Mitchell and other members of the Engineering Society now at the front.

"Engineering Society entertained School men of the second contingent at annual banquet. Speakers were Taft, Hearst, Falconer, Ellis, Deacon and Church. All united enthusiastically in sending greetings and best wishes to all School men. Many declare they will drink health of School, Canada, and democracy with you in Berlin. Signed, President E. D. Gray."

LETTER TO THE EDITOR.

The Editor, Applied Science, Toronto University.

Sir:—

When in Montreal the other day, the Chief Engineer of one of the Departments at Ottawa, said to me—"There is one fault I have to find with your Engineering School in Toronto, you don't advertise. You are doing the best work in Canada and very few people know it."

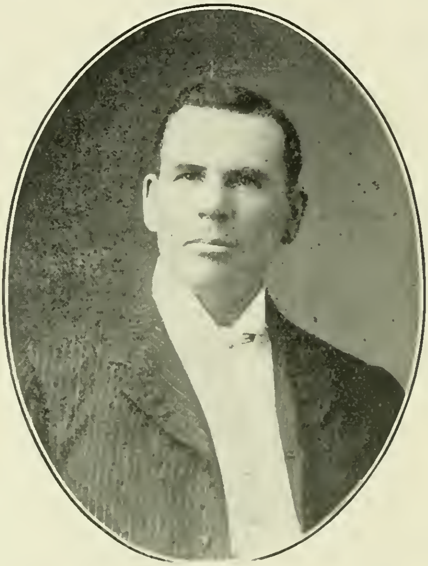
Yours faithfully,

H. E. T. HAULTAIN.

BIOGRAPHY.

Thomas Russ Deacon, '91.

This young but expansive country of ours owes much of her development to the students of Applied Science and Engineering in Canada, foremost among whom are the graduates of the School of Practical Science. It is doubtful if, among these men, there is another who has played a greater part in the upbuilding of the Dominion than has Thomas Russ Deacon, a graduate of 1891. The field of his work extends over all the provinces, while his greatest efforts were probably concentrated in the newer provinces of the West.



THOS. RUSS DEACON, '91.

Mr. Deacon was born on January 3rd, 1865, on a farm in the county of Lanark, Ont. He received his Public School education in Lanark County and attended High School in Pembroke, Ont.

After matriculating he was engaged in the Rocky Mountains, as assistant on the original survey of the Banff National Park Reserve in 1887. During the course of his work he discovered the way to ascend Cascade Peak and bears the distinction of being the first white man to reach its summit.

Upon graduating from the "School" he received employment during the summer of 1891 as instrument man on Township sub-division survey work in Algonquin National Park. He was engaged on survey work of various kinds in the Sudbury district during the following winter and during the following summer of 1892 he was engaged on the construction of the North Bay water works. In the Fall of 1892, Mr. Deacon went to Rat Portage (now Kenora), where he was engaged as town engineer and also carried on a private practice in survey work and mining engineering.

In 1897 he became manager of The Ontario Gold Concessions, Ltd., and did a large amount of prospecting on their behalf, sinking forty-seven different shafts and diamond drilling thousands of feet. In 1899 he was appointed Managing Director and Consulting Engineer of the Mikado Gold Mining Co., then operating the largest gold mine in Ontario.

He resigned this position as well as that of consulting engineer with various other companies and went to Winnipeg in 1902 to found and organize The Manitoba Bridge and Iron Works, Ltd., one of the leading manufacturing industries of Canada, west of the Great Lakes. This Company, of which Mr. Deacon is the largest shareholder, fabricated and erected the first railway bridge, the first highway bridge and the first steel building ever manufactured west of the Lakes in Canada.

He has served on the executives of all the large business organizations in Winnipeg, such as the Board of Trade, the Builders' Exchange and the Industrial Bureau and served as Provincial Vice-President of the Canadian Manufacturers' Association. He was also one of the three members of the Royal Commission on Workmen's Compensation, who drafted the present Manitoba Act "re compensation for injuries to workmen".

In 1906 he was appointed a member of a commission to inquire into the question of a permanent water supply for Winnipeg. Mr. Deacon was the first person to propose bringing water from Shoal Lake, adjoining the Lake of the Woods. He pointed out in a speech before the Board of Trade that his investigations and preliminary surveys had shown the proposition to be feasible. The Board of Consulting Engineers who had been appointed to assist in solving this serious problem were much impressed with Mr. Deacon's plan, but on account of insufficient data, they recommended getting water from the Winnipeg River. However, as the city was at that time busily occupied with its hydro-electric scheme, the water question was pushed aside until the growth of the city and the inadequacy of the artesian supply was brought sharply to attention by a severe shortage in 1912. The council submitted a by-law asking the people to spend about $2,000,000 more on the artesian supply. Mr. Deacon wrote letters to the papers advising the people to defeat the by-law and solve the problem in a proper way.

The by-law was defeated and Mr. Deacon was practically forced to be a candidate for mayor. He was elected and organized the Greater Winnipeg Water District, and after complete surveys were made he showed that the Shoal Lake scheme to bring in 100,000,000 gals. per day by gravity was quite feasible. A by-law was carried by a very large majority whereby the citizens of Winnipeg voted $13,500,000 toward the carrying out of this scheme to bring a supply of water a distance of 95 miles. The work is now under way, a standard railway having been built over the whole length this last year and the contracts for the work let at $1,600,000 below the estimate.

He held the office of mayor of Winnipeg for two years and retired voluntarily at the end of 1914, although urged by the largest petition ever presented to a mayor in Winnipeg, to accept the office for another year.

The following motion taken from the minutes of the Winnipeg Council, December 28th, 1914, portrays in some degree the appreciation with which Mayor Deacon's services were regarded by the citizens and his colleagues.

"Moved by Ald. Milton,

"Seconded by Ald. Wallace,

"The Council of the City of Winnipeg desires to place on "record its hearty acknowledgment and appreciation of the "value and efficient services rendered to the City by His Wor- "ship Mayor Deacon during his term of office as Mayor for the "years 1913 and 1914.

"The City of Winnipeg is deeply indebted to His Worship "for initiating and carrying out to a successful conclusion many "improvements and reforms adding to its prosperity and em- "bellishment, and the Council believes it is but voicing the "sentiments of all citizens in testifying to his untiring energy "and devotion to the duties of his office.

"Upon retiring from office, His Worship carries with him "the good wishes of each and every one of his associates on "the Council, and they trust that the success which he has had "in civic administration may continue in his private life.

"Be it further resolved that His Worship be presented "with the chair which he has occupied as Chief Magistrate of "the City adorned with a plate suitably inscribed, and the "Council express the sincere wish that he may long be spared "to use the same.

Carried unanimously."

Dushman-Leff.

In New York, on June 28th, 1914, Mr. Saul Dushman, B. A., Ph. D., of the General Electric Co. and formerly Lecturer in Electro-Chemistry at the University of Toronto, was united in marriage to Miss Anna Leff of New York City.

A SOUTHERN BRITISH COLUMBIA POWER SYSTEM

By VINCENT S. GOODEVE, '10.

Many people in the Eastern provinces of our Dominion are inclined to regard British Columbia as a comparatively new and undeveloped province. Yet, as far back as 1897 gold and copper mining and smelting had reached such a stage as to cause far-seeing men to begin the construction of a hydraulic power plant to supply the promised market. I refer to the West Kootenay Power & Light Co., from whose system nearly all the mining and smelting industries of what is known as the Kootenay and Boundary countries, are supplied with power. Much of the ore in these districts is of such low grade as to require a good supply of cheap power in order that the ore may be handled in sufficient quantities to render its mining and smelting profitable.

In 1908 the company were supplying power from their first plant situated at Lower Bonnington Falls on the Kootenay River about ten miles from Nelson. The available load at that time was 1,000 h.p. at the end of a 32 mile transmission line. That the venture of the company was justified is evidenced by the fact that this original plant of 4,000 h.p. capacity, is now used as a stand-by while their second plant at Upper Bonnington Falls, about one mile from the first and of 16,000 h.p. capacity, together with No. 3 plant at Cascade City on the Kettle River and of 3,900 h.p. capacity, are required to supply the present load. No. 2 plant was completed in 1907, and in the same year the company took over the system of the Cascade Water, Power and Light Co., including what is now the No. 3 plant, which was supplying power in the Boundary country but which had not the capacity to supply the increasing demand. Forthwith, the Bonnington power was extended into this country and arrangements made whereby either source may be utilised to supply a limited supply of power to the other system in the event of a breakdown or shutdown for any cause.

The transmission voltages and places supplied from the various plants are as follows:—

No. 1 plant—Dead, and its customers supplied by special transformer in No. 2 plant, transmitted at 22,000 volts to Rossland, Trail and Silver King Mine.

No. 2 plant—60,000 volts supplied to Rossland, Grand Forks, Phoenix, and Greenwood.

No. 3 plant—22,000 volts, supplied to Grand Forks, Phoenix, Greenwood and Boundary Falls.

All current is transmitted at 60 cycles and stepped down to the prevailing distribution voltage, usually 2,200 volts, at the various sub-stations.

Someone has rightly said that if the province of British

Columbia were flattened out it would have twice its present area. The building of a transmission line in such a country is not an easy task. The power must go wherever the mines and smelters are located. The smelters must be built wherever the character of the land and the railroad facilities will permit. These conditions lead the power lines over rough land to altitudes of six thousand feet and down again to two thousand feet. The patroling and repairing of such a line is an expensive matter, and the company found it better to build a line requiring very little attention but costing more than the flimsier line. The 60,000 volt line is a model in this respect and its 84 miles of duplex three phase line give remarkably little trouble. It is also remarkably straight considering the character of the country through which it passes. The heavy cedar poles are spaced only from 100 to 150 feet apart. The cross arms are heavy and the butts are often placed in blasted holes in solid rock. Only a few freak poles have shown signs of decay as yet, and only once or twice has the lightning been known to set fire to the pole or cross-arm. The line is not sectionalised. One line can carry all the load, so that as soon as trouble is found to be on either line, the entire load is thrown on the good line. Being on separate poles, trouble on one line does not cripple the other. So amply has the system been designed that it has not been found necessary to transmit at the rated voltage as yet, but current is transmitted at 40,000 volts by using taps in the windings of the transformers at the generating and receiving stations. This causes a saving in the expenses of locating and replacing broken down insulators for even the most up-to-date systems have breakdowns now and then from flaws in apparently good porcelain and stresses due to internal surges. The cables are arranged in an equilateral triangle by placing one cable at the top of the pole. The other two are on the crossarm. This formation is desirable to equalize the mutual induction of each wire on its mates and to facilitate transposition.

All the buildings and equipment of the system were designed to last and to accomodate large additional capacity. The available power at Upper Bonnington Falls is only partly developed even with the addition of another 8,000 h.p. unit, which is being installed at present. This last addition will be required to supply power for the electrification of the C. P.R. from Castlegar to Rossland. The sub-stations are all built along the same plans. Separate rooms are provided for each bank of transformers, the high tension switching equipment, and the switchboard and operating room. No provision is made for elaborate systems of relays to disconnect lines when the voltage drops or the current is interrupted. The simple inverse-time-limit overload relays afford sufficient protection on both the high tension and feeder switches.

Much difficulty was experienced in erecting Power House No. 2. Over 70,000 cubic yards of solid granite had to be excavated for the forebay, powerhouse site and tail race. The building is reinforced concrete and is not at all ugly or out of keeping with the natural beauty of its surroundings. The interior is roomy and provision is made in the present building for four units of 8,000 h.p. capacity each. Two of these are installed and in operation and a third is now being installed as mentioned before.

In this article I have endeavored to omit the quoting of capacity data and similar information as I have always found that it makes wearisome reading. Instead of detailing the equipment of the powerhouses and substations, which is pretty much standard and is familiar to most students interested in power plant construction, I have outlined some of the conditions under which this system was constructed and is now operated. Every little system has troubles all its own and it is these peculiarities which make the descriptions of plants and systems interesting.

WHAT OUR GRADUATES ARE DOING.

M. B. Watson, B.A. Sc., '10, who accompanied the First Canadian Overseas Contingent has recently been appointed Lieutenant with the Royal Canadian Engineers.

J. F. Henderson, '10, is resident engineer for Chipman and Power at Thorold, Ont.

J. H. Carter, '07, is with the Hydro-Electric Power Commission of Ontario, Continental Life Building, Toronto.

F. W. McNeill, B.A. Sc., '07, is with the Canadian General Electric Co., Ltd., at Calgary, Alta.

C. Noecker, B.A. Sc., '14, is at St. Thomas, Ont., with James A. Bell & Son, Surveyors and Engineers.

Rex P. Johnson, B.A. Sc., '14, is on the designing staff in the Welland Ship Canal office, St. Catharines, Ont.

J. H. Dawson, '09, is assistant resident engineer, section 5, Welland Ship Canal, Allanburg, Ont.

H. M. Campbell, B.A. Sc., '14, has received a commission as lieutenant with the Second Contingent and is now with the Seventh Canadian Mounted Rifles in the concentration camp at London, Ont.

C. C. Forward, '06, is analyst in charge of the laboratory of the Inland Revenue Dept., at 48-50 Bedford Row, Halifax, N. S.

Norman M. Lash, '94, formerly Assistant Chief Engineer for the Bell Telephone Company of Canada, has recently been appointed Chief Engineer of that Company, with offices in Montreal, Que.

L. W. Morden, '05, is with the Packard Electric Co., St. Catharines, Ont.

L. H. Robinson, '04, is Assistant to the Engineer of Construction, Intercolonial Railway Company, Moncton, N.B.

W. deC. O'Grady, '08, is Assistant Branch Manager, Ford Motor Car Company of Canada, Ltd., at Calgary, Alta.

T. L. F. Rowe, '11, is Superintendent of Construction on the Hospital for Insane, Whitby, Ont.

F. H. Chestnut, B.A. Sc., '08, is located in Marshfield, Oregon, U.S.A., where he is in business under the name of the "Coast Equipment Co." handling engineers' supplies and equipments.

A. W. Chestnut, B.A. Sc., '10, who was Assistant Engineer for the Foundation Company of New York, in the work of straightening up the C.P.R. elevator at North Transcona, is now at Le Pas, Man., engaged in gold mining.

J. C. Martin, B.A. Sc.,'11, is with the Northern Electric Co., Montreal, Que.

A. P. Augustine, '07, has a land surveying practice at Prince Rupert, B.C.

J. D. Shepley, B.A. Sc., '04, has a private practice in surveying and engineering at North Battleford, Sask.

H. R. Banks, B.A., Sc., '14, has accepted a position with the Consolidated Arizona Smelting Co., Humboldt, Arizona, U.S.A.

Marani and Moore

V. G. Marani, C. E., '93, and J. E. A. Moore, C. E., '91, have a practice at the Euclid Building, Cleveland, Ohio, as Consulting Civil and Mechanical Engineers under the firm name of Marani & Moore. They make a specialty of conditions and engineering features relating to the matter of reducing fire hazard, while they are engaged in a consulting capacity on almost every kind of engineering work.

Mr. Marani was Constructing Engineer for the Cleveland Gas, Light and Coke Co. from 1895 to 1906. He was Engineering Superintendent of Cuyahoga County Court House from 1906 to 1909, and during 1910-11 he was Building Commissioner of Cleveland.

Mr. Moore was Resident Engineer, Ore Dock and R. R. Terminal Construction, Duluth, Minn., 1891-94. During the following three years he was Structural Engineer, Riter Conley M'f'g. Co., Pittsburgh and afterwards was Chief Structural Engineer, Wellman, Seaver, Morgan Co., Cleveland, Ohio., until 1900 when he was appointed Chief Estimating Engineer for the same company. In 1907 he became partner with the late J. W. Seaver, Consulting Engineers. From 1911 to the date of the recent establishment of the new firm, he was Chief Engineer, C. O. Bartlett Snow Co., Cleveland, Ohio.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications;

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL.

The following "School" men, in addition to those published before, have joined the Second Overseas Contingent:—R. E. Taylor, '17; C. M. G. Purchas, '17; F. C. Mayberry, '17; J. A. Macdonald, '17; C. K. Hoag, '17 (G.G.B.G.); D. German, '17; W. D. Armstrong, '17; R. E. Williams, '16 (Intelligence Corps, Field Artillery); J. S. Panter, '16 (Field Telephone Corps); H. B. Little, '16; J. A. N. Ormsby, '16; J. P. Cavers, '16 (Machine Gun Section); L. Husband, '16; L. B. Tillson, '15 (Machine Gun Section); N. H. Daniel, '15; Lieut. H. S. Kerby, '14 (Can. Aviation Corps); Sergt. J. M. Robertson, '14 (14th Battery C.F.A.); Lieut. H. M. Campbell, '14; A. A. Swinnerton, '16; A. A. H. Vernon, '18; E. F. Norris, '17 (Machine Gun Section).

Lieut. H. H. Betts, '06, who after graduation was with the Rio de Janiero, Light and Power Company, Rio de Janiero, Brazil, S.A., and who spent the last two years on work in Spain, is now with the British Railroad Troops, Boulogne, France.

LETTER FROM A "SCHOOL" MAN AT THE FRONT.

The following letter was received by Professor Haultain from F. C. Andrews, B.A. Sc., '14, who sailed from New York after war was declared and joined the British Army.

Northern France, Jan. 13, 1915.
(I am not allowed to give any address.)

Dear Professor Haultain,—

You will perhaps be surprised to hear that I am out here in the middle of the row. I left England about Dec. 17th and my first day in the trenches was Xmas day.

This place isn't too bad only it is so confoundedly wet and muddy. The part I am in is very low lying and owing to the enormous amount of rain we are nearly drowned out. The trenches themselves are awfully wet and muddy and it is quite impossible to get a dry place to stand or sleep in, one is always wet and cold and simply covered with mud, the very wettest mud I have ever seen. The only consolation we have is that the Germans are in the same fix, and we try to imagine, worse than ourselves.

The last trenches we were in were the worst probably in our division; the mud and water was bad, but really the worst part of it was the dead Germans and our own men we uncovered when we were digging. Most of these men were killed in an advance and were buried in a most haphazard manner, especially the Germans; they simply chuck them in a shell hole, leaving a foot or an arm sticking up. Our men are awfully decent to the dead, take a lot of pains burying them and putting up crosses over them, but the Germans are most haphazard in their methods. I watched them one day.

On Xmas day we had a truce with the Saxons in front of us, purely unofficial, and talked to them between the trenches, in fact I think a photograph was taken of a mixed crowd of Germans and English. The Saxons are a very decent crowd and appear from their actions to be heartily sick of the war.

We were relieved out of the trenches a couple of days ago and went into billets; we are very comfortable, indeed, but unfortunately to-morrow at 4.30 a.m. we go into them again. The chief danger in the trenches is the sniping which goes on constantly and gets rather annoying, but one grows used to it in time. A few days ago our artillery shelled the German ternches on our left front, most wonderful signt, seeing the shells bursting several at a time, great clouds of smoke and earth and Germans running around. They shelled back but didn't do much damage.

The Canadians are, I understand, still in England, but ought to be out soon. I suppose I am about the only "School" man out here at present, there can't be many more Canadians here yet.

Yours very sincerely,

(Signed) Fred Andrews.

UNIVERSITY OF TORONTO CLUB OF NEW YORK.

The University of Toronto Club of New York held its thirteenth annual banquet on Wednesday, February 3rd, at the Hotel Astor.

President Louis L. Brown, S.P.S. '95, presided and the guests of the evening were President Falconer, the Rev. Dr. Wm. Carter of New York, Prof. McPhedron and Prof. C. H. C. Wright.

The banquet was very successful in every way, there being a large attendance of members, who were most enthusiastic in their applause of the speakers as they referred to the notable part that Canada and particularly the University of Toronto was taking in the Great War.

President Falconer stated "Canada is not in this war by force. It is not with a spirit of bravado we have sent one hundred thousand men to the front. We are proud to be able to do what we are doing". It was very evident from the applause that greeted his remarks that the graduates down in New York are very proud too of the stand Canada has taken, and also particularly proud of the showing made by their Alma Mater.

Professor Wright spoke impressively in a very touching manner to the loss of our late Dean Galbraith, who so often had attended these banquets, and the feeling of sympathy was sincere from the graduates of Arts and Medicine, as well as Science.

Among the "School" men who were present were, H. F. Ballantyne, '93, Secy. and Treas. of the Club; E. W. Stern, '84; Dr. T. K. Thomson, '86; T. H. Alison, '92, and F. W. Harrison.

The Herbert Morris Crane and Hoist Company, Limited, Peter Street, Toronto, have just issued a new bulletin on the Morris Belt-Driven Friction-Hoist, giving the prices and general particulars of the hoists for various purposes and under various conditions, in tabulated form. The hoists and the principles governing their operation are well set forth by illustrations and diagrams.

BOOK REVIEW.

American Handbook for Electrical Engineers—By Harold Pender. Leather, $4\frac{1}{4}$ inches x 7 inches, 1969 pages. Publishers—John Wiley and Sons, New York. $5.00 net.

Reviewed by Professor H. W. Price, B.A. Sc.

Every student of electrical engineering is interested in a hand book which will serve as a convenient and reliable source of information on a multitude of topics in his line of interest. This new book is the most complete electrical handbook we have yet consulted.

Dr. Pender, the editor-in-chief, is Professor of Electrical Engineering at the University of Pennsylvania, which explains the fact that so much of the material is presented in form quite as useful to students as to engineers in practice.

The American Handbook contains 2,000 pages of carefully boiled-down information and data on a very wide range of subjects. It is well bound in leather. Instead of dividing all material under fifteen to twenty general headings, such as measurements, materials, transformers, central stations, electric traction, etc., this book is arranged alphabetically somewhat like an encyclopedia. Further assistance in locating information is offered in a topical index of articles, and a large detailed index containing about 6,000 items. Both in the index and at the head of each article are given references to other articles in the book where similar information is to be found under discussion from different points of view. Subjects requiring from ten pages upwards are also briefly indexed at the beginning of the article.

In so far as possible, all subjects such as apparatus or machinery are treated in routine manner: General description and definitions; applications; principle of operation; design; testing; performance; specifications; installations; operation; dimensions, weights, and costs; bibliography. A systematic plan of this sort applied to matter assembled by twenty-five engineers and scholars of recognized ability has resulted in a remarkable collection of information and data. Nearly every subject, electrical or mechanical, of interest, directly or indirectly, to an electrical man is given attention. Many subjects are well reviewed which most other handbooks hardly mention; for example, construction data on water rheostats for test loading of high and low voltage generators covers five pages, and all this information is to the point. One inconvenience in arrangement is noted. Mathematical tables of logarithms, trigonometric functions, hyperbolic functions, differential equations, etc., are scattered alphabetically. If collected under one general head such as mathematics, they would be vastly more convenient.

The American Handbook for Electrical Engineers will make a valuable addition to any engineer's collection of data.

THE VALUE OF EXECUTIVE TRAINING ON THE ENGINEERING SOCIETY EXECUTIVE.

There are no greater oportunities than those open to the Engineer. This is true whether he desires to remain in professional work or associate himself with any of the industrial pursuits closely allied with Engineering. In either case, it is essential that the Engineer of to-day be a man of business. He must at least have an intimate knowledge of business methods and principles. While the Engineer deals with the forces of nature he has no less to do with men and organizations. There are men who shut themselves up from the world and by close study evolve some great scheme or make an important discovery, but chances of success along this line are rare. The real business is done by teamwork and not by individual play. Tasks of importance are accomplished by large organizations where many men play important parts, and in which all combine in unison to secure strength. There are students in the School to-day of the hermit type who follow some one line such as, studies, athletics or social affairs. While it is essential that the undergraduate appreciate the value of academic work, is it not of equal importance that he study men? He should endeavor to acquire that quality of mixing with his fellows which develops tact, resourcefulness and judgment and makes life more pleasant. The Engineering Society of the "School" offers greater opportunity for this development than any other academic activity. In holding office on the executive committee a man is doing valuable work for the institution and although the duties of office at times are most exacting and the work heavy, the benefit to the "School" cannot be compared to the personal benefit he receives. A well contested election is a true sign of "School" spirit, and in running for office a man gains the acquaintance of many who later become true and intimate friends. It is no disgrace to be defeated by a good man. We have only to look for examples of success among the older graduates and find that they have invariably taken a keen interest in the welfare of their alma mater and most of them have been active on various executive committees of student organizations. These men did not seek mere personal advancement; the same traits of character that made them loyal to the "School" have given them that broad vision and appreciation of men and affairs in general which distinguish them as leaders. It has been truly said "Men have developed the capacity t odirect affairs only as they have learned to understand their fellowmen".

H. F. White, '03, is Assistant Superintendent, White Manufacturing Co., London, Ont.

G. Helliwell, '10, is Lieut. with the 1st Battalion, First Canadian Overseas Contingent.

C. E. Bush, B.A. Sc., '07, is Lieut. with the cyclist corps, First Canadian Overseas Contingent.

R. D. S. Beckstedt, B.A. Sc., '09, formerly Sales Agent for the Tagona Light & Power Company, Sault Ste. Marie, Ont., has been appointed superintendent for the same company.

Geo. G. McLennan, B.A. Sc., '10, is with the Hyland Construction Co., in charge of the power house construction at Eugenia Falls, for the Hydro-Electric Power Commission.

C. H. R. Fuller, B.A. Sc., '14, has been elected Secretary of the Toronto Branch, Canadian Society of Civil Engineers, for the ensuing year.

J. A. D. McCurdy, '07, is in Toronto endeavoring to make arrangements to establish a base here for the equipping and training of an aviation corps for military purposes.

W. J. White, B.A. Sc., '08, was, until about a year ago at the Boston office of the General Electric Co. He went from there to Perth, Australia, to the office of the British Thomson-Houston Co.

Wills Maclachlan, B.A. Sc., '06, has resigned his position with the Electric Power Co., and is now inspector for the Electrical Employers' Association of Ontario, with headquarters at 10 Adelaide St. E., Toronto.

At the annual meeting of the Ontario Land Surveyors' Association, held in Toronto, on Feb. 16th, 17th and 18th, F. N. Rutherford, B.A. Sc., '04, delivered a paper on "Possessory Titles". J. S. Dobie, B.A. Sc., '95, delivered a paper on "Stone Crushing" and another on "Roads and Pavements".

C. J. Townsend, B.A. Sc., '04, will in future carry on the business of the engineering and contracting firm of Wilson, Townsend and Saunders, with headquarters at 79 Spadina Ave., Toronto, Mr. Townsend having taken over the interests of the retiring partners.

R. A. Sara, B.A. Sc., '09, Sales Manager of the Winnipeg Light and Power Department, has returned to the West after a combined holiday and business trip of two weeks in the East, on which he visited Toronto, Montreal, Detroit, Chicago and Minneapolis to investigate the accounting systems in use by the various power companies with a view to improving, if possible, the system now used by the City of Winnipeg.

W. G. McIntosh, B.A. Sc., '09, has recently been appointed Sales-engineer for Toronto by the Herbert Morris Crane and Hoist Co., Ltd., manufacturers of lifting and shifting machinery, with works on Peter Street. Mr. McIntosh has had a very varied experience in shop work, draughting office work, and field erection, having previously been with the Otis-Fensom Elevator Company, the Toronto Power Company, the Canada Foundry Company and the Dominion Power Company.

DIRECTORY OF THE ALUMNI.

Bitzer, A. M., '09, is with the Second Canadian Contingent in camp at Ottawa.

Black, B. S., 513. His address is 197 Madison Ave., Toronto.

Black, G. E., '08, is with the Ontario Government at the Ontario Prison Farm, Guelph, Ont.

Black, R. G., '95, is a member of the Toronto Hydro-Electric Commission.

Black, W. D., '09, is superintendent of the eastern branch of the Otis-Fensom Elevator Co., with headquarters in Montreal.

Blackwell, R. H. H., '10, formerly resident engineer for the Canadian Northern Ry. at Biscotasing, Ont., is taking a post-graduate coure in engineering at the University of Toronto.

Blackwood, A. E., '95, is manager of the New York office of the Sullivan Machinery Co.

Blackwood, W. C., '06, is instructor in physics, Technical High School, Toronto.

Blain, D., '13, is draftsman for the Canada Foundry Co., Toronto.

Blair, W. J., '02, was located at Provost, Alta., when last heard from.

Bleakley, J. F., '85, is engaged in a general engineering practice at Bowmanville, Ont.

Blizard, D. C., '09, is with the Canadian Inspection Company on the inspection of shrapnel shells.

Blyth, J. M., '14. His home address is R. R. No. 3, Durham, Ont.

Boeckh, J. C., '06, is in Toronto, and is with the Boeckh Brush Co. as a member of the firm.

Bonnell, M. B., '04, is in the Patents Office, Department of Agriculture, Ottawa, Ont.

Bonter, E. R., '13. His home is at Trenton, Ont. He is at present with the Canadian Crocker-Wheeler Co. at Montreal.

Boswell, E. J., '95, is on the engineering staff of the Canadian Pacific Railway Co.

Boswell, M. C., '00, is lecturer in organic chemistry, University of Toronto.

Boswell, W. O., '11, is in electro-chemical work. His home address is 25 Roxborough St. W., Toronto.

Boulton, W. J., '09, is Surveyor, Dept. of Interior, Ottawa, Ont.

Bourne, O. B., '07, is Resident Engineer, Greater Winnipeg Water District, Winnipeg, Man.

Bow, J. A., '97, is in Great Falls, Mont., with the Boston and Montana Mining and Smelting Co.

Bowen, G. H., '09, is Assistant Engineer, Distribution Dept., Toronto Hydro-Electric System, Toronto, Ont.

Bower, J. W. H., '14, has 15 Pleasant Blvd. Toronto as his address.

Bowes, H. F. '08, is superintendent of the Warren Bituminous Paving Co., Toronto.

Bowman, A. M., '86, was a member of the Pennsylvania Contracting Co., Pittsburgh, when last heard from.

Bowman, E. P., '10. His home is in West Montrose, Ont. We do not know his professional activities.

Bowman, F., '11, is draughtsman with the Dominion Bridge Company in the office at Lachine, Que.

Bowman, F. M., '90, is vice-president and director of the Blau Steel Construction Company, Pittsburgh, Pa.

Bowman, H. D., '07, his present address is E. D., Y.M.C.A., 179 Marcy Ave., Brooklyn, N.Y.

Bowman, H. J., 85, is a member of the firm of Bowman and Connor, consulting municipal and structural engineers, Toronto and Berlin, Ont. Mr. Bowman is engineer for the county of Waterloo.

Boyd, D. G., '94, is in Toronto, in the Department of Lands and Mines, Parliament Buildings.

Boyd, W. H., '98, is in the Topographical Branch, Geological Survey, Department of the Interior, Ottawa.

Brace, J. H., '08. His address is 23 Lorne Ave., St. Lambert, Que. He is with the Bell Telephone Co.

Brackenreid, T. W., '11, was in the employ of the Canadian General Electric Co., in Peterborough, Ont. when last heard from.

Brady, W. S., '07, is manager of the Madison Theatre on Bloor St. W., Toronto.

Brandon, E. T. J., '01, is assistant engineer for the Hydro-Electric Power Commission, Toronto.

Brandon, H. E., '06, is chief engineer of the Vulcan Iron Works, Winnipeg, Man.

Bray, L. T., '00, who has Amherstburg, Ont. as his permanent address is District Engineer and Surveyor for the Province of Alberta.

Brecken, P. R., '08, is secretary of the Broadview Branch of Toronto Y.M.C.A.

Brereton, W. P., '01, is City Engineer, Winnipeg, Man.

Breslove, J., '03. We do not know his present address. He was in the Westinghouse Machine Co., Pittsburg, when last heard from.

Brian, M. E., '06, is city engineer of Windsor, Ont., and also engineer for several adjacent townships.

Bristol, W. M., '05, is in the Halifax, N.S., office of the Canadian Westinghouse Co.

Broadfoot, F. C., '06. His address is 142 Hastings St., Vancouver, B.C. He is a member of the firm of Broadfoot, Johnston and Hamilton, Vancouver.

Brock, A. F., '10, is with the Canadian Copper Co., at Copper Cliff, Ont.

Brock, W. M., '11, is draftsman with [illegible] nadian Bridge Co., [illegible] Ont.

Broughton, J. T., '01, is chief engineer of the Scotdale Foundry and Machine Co., Scotdale, Pa.

Brodie, W. M., '95, is travelling salesman for the Sterling Coal Co., Ltd., 95 Bay St., Toronto. We do not know his present address.

Brouse, W. H. D., '11, is in this city, with Kerry and Chacė, Limited.

Brown, J .M., '02, was in the steam turbine department of the Westinghouse Machine Co., Pittsburgh, when we last heard from him. We do not know his present address.

Brown, T. W., '06, is a member of the firm Brown and Loucks, engineers and surveyors, Saskatoon, Sask.

Brown, D. B., '88, who was, when last heard from, locating engineer, Grand Trunk Pacific, is on our list of unknown addresses.

Brown, G. L., '93, resides in Morrisburg, Ont., and is engaged in civil engineering and surveying.

Brown, L. L., '95, is vice-president of the Foundation Company, Woolworth Building, New York.

Brown, T. D., '04, has a private engineering practice at Lethbridge, Alta.

Brown, J. A., '70, is engineer in charge for the Trussed Concrete Steel Co., Vancouver, B.C.

Brown, E. I., '08, is in the sales dept. of the Northern Electric and Manufacturing Co., Toronto.

Brown, C. E., '09, is in Hamilton, Ont., with the Canadian Westinghouse Company.

Brown, H., '11. His address is not on our files.

Browne, E. W., '09. His present address is unknown to us.

Browne, M. O., '10. His address is 313 McClellan Ave., Detroit.

Bryce, W. F. M., '08, is in the office of the city engineer, Ottawa, Ont.

Buchan, P. H., '08, is assistant engineer, construction department, British Columbia Electric Railway, Vancouver.

Buchanan, J. A., '09, is on survey work at Edmonton, Alta. His address is 140 Jasper St. W., Edmonton.

Buchanan, T. R., '13, is demonstrator in the department of electrical engineering at University of Toronto.

Bucke, W. A., '94, is manager of the Toronto district office of the Canadian General Electric Co.

Bunnell, A. E. K., '06, is assistant engineer, Federal Plan Commission of Ottawa and Hull, Booth Bulding, Ottawa, Ont.

Burd, J. H., '03, is engaged in survey work in Saskatoon, Sask. His address is P.O. Box 690.

Burgess, E. L., '03 is with the Topographical Surveys Branch, Department of the Interior. We understand that he is now located at Kamloops, B. C.

Burgess, J. R., '10, is inspector at the plant of the Algoma Steel Co., Sault Ste. Marie, for the Robert W. Hunt Co.

Burley, R. J., '04, is Division Engineer, Irrigation Office, Department of Interior, Calgary.

Burns, J. E., '09, is a member of the firm "Langrill and Burns, Advertisers' Agents," Dineen Building, Toronto.

Burnham, F. W., '04, is in the engineering department of the Canadian Westinghouse Company, Hamilton.

Burnside, J. T. M., '96. Deceased Dec. 3rd, 1914.

Burwash, L. T., '96, is manager, Western Supply Company, Winnipeg, Man.

Burrows, B. H. A., '13, is in charge of the Coleman Fare Box Co., at Tottenham, Ont.

Burwash, N. A., '03, is engaged in land surveying, Toronto.

Bush, C. E., '07, is lieutenant with the Cycle corps, First Canadian Contingent.

Byam, F. M., '06, is in the employ of McGregor and McIntyre, Toronto, as chief engineer.

C.

Cain, E. T., '11, is inspector in the Bridge Dept., I. C. Ry., Moncton, N.B.

Calder, J. W., '04, is in the city engineer's office, Port Arthur, Ont.

Cale, W. C., '10, formerly with the Stone and Webster Engineering Corporation, as engineer on transmission line construction at Keokuk, Iowa, is now with the Mississipi River Power Co. of that place.

Caldwell, W. B., '13, is with the Department of Roadways, Toronto.

Cameron, N. C., '04, is associated with the Dominion Engineering and Construction Company, of Montreal.

Cameron, A., '06, is in Winnipeg, Man., in the employ of the Vulcan Iron Works, Limited.

Cameron, M. G. '09, has no address with us at present.

Cameron, C. S., '11, has Beaverton, Ont., for his home address.

Cameron, D., '08, is with the Lake Erie and Northern Railway, Brantford, Ont.

Cameron, O. L., '13, is engaged on pitometer survey work for the city of Toronto.

Campbell, A. D., '10 is in Cobalt, Ont., as mining engineer for the O'Brien Mines.

Campbell, A. J., '04. We do not know his address.

Campbell, A. M., '04. We have not his present address.

Campbell, L. L., '13, is engaged in survey work at Berkeley, Cal His address is 2408 Fulton Street.

Campbell, W. G., is a member of the firm "Campbell and Lattimore, Railway Contractors," 2 King St. E., Toronto.

Campbell, A. R., '02. Deceased.

Campbell, D. H., '14, is with the Topographical Surveys Branch, Department of Interior, Ottawa.

Campbell, R. J., '95. We do not know his address.

Campbell, G. M., '96 was superintendent of the power apparatus shops of the Western Electric Co., at Riverside, Ill., when last heard from.

Campbell, J. J., '14, is resident engineer with Chipman and Power, Toronto.

Campbell, N. A., '08 is with the General Supplies Limited, 122-11th Ave. W., Calgary, Alta.

Campbell, R. A., '09 is engineer in charge of the Municipal Lighting Plant, Sault Ste. Marie, Ont.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

VOL. IX. TORONTO, MARCH, 1915 No. 11

BUILDING ESTIMATING.

E. E. H. Hugli, B.A.Sc.

To the architect or contractor, the matter of systematic and efficient estimating is of as great, if not greater, importance as that of efficient carrying on of the actual work of construction. The following discussion is intended to serve as a guide to the less experienced estimator on work such as is referred to, and will also provide some helpful hints for the more experienced estimator who wishes to decrease the probability of error in making estimates.

Speaking generally, the more detailed the form of estimate is made, the less likelihood there will be of error due to assumptions. Furthermore, errors, when they do occur, are more easily detected, and the estimator is able to verify his data more intelligently and systematically.

METHODS OF ESTIMATING.

The methods of estimating depend on the degree of accuracy required, and also on customs, which vary to a certain extent in different parts of the country; but we may say there are five outstanding methods of ascertaining the value of a building before erection. These methods are:

(1) **Estimating by the Cost per Cubic Foot of Similar Buildings.**—This is the best known and most usually adopted method, because of its general convenience. The dimensions are best taken by measuring the length and breadth from out to out of walls, and the height from half foundations to half-way up the roof. The cubic contents thus obtained are multiplied by the price per foot cube of some similar building. Sometimes the height is measured from the bottom of footings (i.e., top of concrete) to half-way up the roof. Cheaper attached structures, such as annexes, stables, sheds, etc., should be kept separate and priced at a lower rate; while more ornamental portions, like towers and porches, would be valued higher than the main block. Small buildings cost more, in proportion than large ones of the same type.

This cubing system is open to some objections. The lumping together of voids and solids at one rate is certainly unscientific, for the same class of building may be divided into many rooms, with numerous internal solids in the shape of walls, etc., between; while another may have comparatively few chambers, creating much empty space. In fact, the proportion of voids to the solid structure is not a fixed quantity, so that the price per cubic foot can never be exactly regulated. This requires large experience and a nicety in pricing which the estimator cannot always possess. The description and quality of materials and workmanship, too, are seldom the same; neither are the conditions of contract; and these variations are frequently overlooked when a certain rate per cubic foot is assumd.

(2) **Taking Out Rough Quantities and Pricing the Items.**— This is, of course, more exact than pricing per cubic foot because more items are considered.

(3) **Estimating per Square.**—This mode is to take the constructional shell only, and pricing it at so much per 100 square feet. Walls, for instance, are taken according to their thickness and manner of finishing, including all digging, concrete, plastering, papering, etc.; floors, including joists, struttings, ceilings, etc.; roofs, including slating, lead-work, rafters, boarding, etc.; and so on,—all being reckoned as per square complete. Such a system of superficial measurement appears to be more satisfactory than the cubing, as it takes into account the materials and labor in a more exact and definite form. Of course, a special list of prices must be compiled for each of these main superficies, and care and discrimination are certainly required.

(4) **Pricing per Unit of Accommodation.**—This is a somewhat rough-and-ready means of estimating the cost of such buildings as hospitals, schools, churches, stables, and other edifices, which may be respectively priced at per patient, per scholar, per sitting, and per horse. It is better, however, to check and approximate estimate by working out two or more styles, thereby insuring closer results.

The above methods are never used by the contractor who puts up the building, because it would be unwise, as well as unbusinesslike for him to use such loose methods. They, however, are accurate enough for architects and insurance companies, who only require an approximate figure on the value of a building.

(5) **Estimating by Accurate Quantities.**—This method is only adopted when it is intended to actually carry out the work. It is very laborious, and necessitates great skill and a thorough knowledge of building construction. This is the only method contractors can use with safety. It is intended to discuss this method fully, as it is by far the most difficult.

There are so many different trades and such a great many different kinds of material required to put up a building that, in order to make an accurate estimate, the different trades should be kept separate, as well as the different materials. There are about fourteen distinct kinds of work on a building. These are:

1. Excavation.
2. Concrete Work.
3. Masonry.
4. Brick-work.
5. Carpentry.
6. Roofing.
7. Plastering.
8. Joinery.
9. Hardware and Ironwork.
10. Heating and Ventilation.
11. Plumbing.
12. Painting.
13. Glazing.
14. Steel Work.

Space will not permit, as before stated, discussing each one of these fully, and we will therefore limit ourselves to the five of the most important kinds of work, namely: excavation, concrete work, masonry, brickwork, and carpentry. The steel work is now a very important part of the modern building, but it is such a large subject in itself that it canont be discussed here on account of lack of space.

EXCAVATION.

Before figuring on excavation, there are many things to be taken into consideration, which vary in different localities.

(a) **The Character of Material to Be Excavated.**—Where the excavation is deep, the nature of the earth's crust is liable to vary considerably, which would affect the cost of excavation to a more or less extent. Care should therefore be taken to determine the nature of the soil. If there is rock, it, of course, requires blasting. If the work is to be done in the winter, allowance should be made for blasting the frozen ground. Wet ground, which would require pumping, should not be overlooked. Sometimes it is necessary to sink caissons on account of quicksand.

(b) **The Disposition of the Material.**—The excavated material is either wasted on the premises or hauled away. If it is to be hauled away, the distance and the method of hauling should be taken into account.

(c) **Amount to Be Excavated.**—The existing levels of the ground, compared with those required, should not be forgotten. In excavating for a foundation, the excavation should be sufficiently large to give the men a chance to put up the forms.

(d) **Materials Required for Excavating.**—It is often necessary to drive piles to which to nail the lumber. The lumber and piles are to be considered in the general expense.

(e) Consider the cost of labor and the efficiency of laborers and machinery.

(f) Consider depreciation of plant.

(g) Consider office expenses.

If none of the above things are forgotten, the estimator should be able to estimate the cost of an excavation fairly accurately, with experience.

CONCRETE WORK.

The things which affect the cost of concrete work are:

1. Material.
2. Labor.
3. Overhead expenses.
4. Office expenses.

I. Material.

(a) There are five distinct types of concrete, namely: stone concrete, gravel concrete, concrete floors, concrete blocks, and reinforced concrete. In stone concrete the size of the coarse aggregate should be determined. When this is known, the cost will depend on local conditions. Sometimes the broken stone is delivered on the job at so much per cubic yard; but in some cases a stone crusher is used on the premises. The price of gravel depends on how far it has to be hauled. Frequently this can be delivered to the work for a certain price per cubic yard. For cellar floors the broken stone is first laid uniformly with a thin coating of cement on top. The cost of these floors depends on the proportion of the mixture of cement, as well as the cost of the stone. When concrete blocks are used, of course the cost of the mortar must be taken into consideration, as well as the cost of the blocks. The price of these blocks depends on the size, the composition, and whether they are moulded on the job or delivered there by the manufacturer.

(b) Another thing to be considered is the price of the lumber required to make the forms, and the centering required to support concrete slabs. If the centering can be used over again, the cost of the lumber will certainly be less than if special centering had to be constructed for each floor. The same can be said of lumber used a second or third time for simple forms. Each time the lumber is re-used, a percentage is generally deducted from the original cost. The fineness of the surface required for the concrete should not be overlooked, because this affects the price of the forms. Planed lumber is then required, when in some other cases rough lumber would do.

(c) The cost of reinforcing material depends on the kind required. If patented fabricated steel is used, the cost of same can be obtained in the catalogues. Occasionally a patent reinforcement is manufactured at the works, and a royalty is paid to the party holding the patent. The reinforcing rods, which may be round or square in section, or deformed, generally cost so much per pound. An estimator should never forget the cost of delivering these rods to the work, for the cost per pound may be the cost on the cars or at the factory.

(d) The practice regarding openings in walls, such as doorways, arches, etc., varies, and the understanding in this regard between the architect and the contractor should be observed. Small openings, however, are generally disregarded in estimating the volume of the concrete, if it is to be paid for by the cubic foot.

II. Work.

The cost of mixing concrete depends on the method, and the contractor should take into consideration whether he will use a mixer or whether the mixing should be done by hand. The concrete mixer reduces the cost of mixing per cubic yard, and if the job is large, it pays to use the mixer. All mixers, however, have not the same efficiency. Therefore, the kind used and the expense of using it, along with its capacity for work, are things to which the estimator should pay particular attention.

MASONRY.

Masonry is sometimes measured by the perch or by the cord, but the best method is by the cubic yard. In estimating by the perch, it is necessary to state how much the perch is taken at, whether $24\frac{3}{4}$ or 25 cubic feet. Note should always be made in regard to corners, and deduction for openings under a certain size. Corners are generally measured twice.

Rough stone from the quarry is generally sold under two classifications, namely: rubble and dimension stone. Rubble consists of pieces of irregular size, such as are mostly obtained from the quarry, up to 12 inches in thickness by 24 inches in length. Stone ordered of a certain size, or to square over 24 inches each way, and to be of a particular thickness, is called dimension stone.

Rubble masonry and stone backing are generally figured by the cubic yard. Dimension-stone footings are measured by the square foot, unless they are built of large irregular stone, in which case they are measured the same as rubble. Ashlar work is always figured by the superficial foot; openings are usually deducted, and the jambs are measured in with the face work. Flagging and slabs of all kinds, such as hearths, treads for steps, etc., are measured by the square foot; sills, lintels, mouldings, belt courses and cornices by the linear foot; and irregular pieces by the cubic foot. All carved work is done at an agreed price by the piece.

For estimating purposes, stone may be divided into two classes: soft stone, such as the sand stones, and hard stone, such as the granites.

Soft Stone.—Indiana limestone may be taken as an example of soft stone. The method of estimating the cost of this soft stone is to estimate so much per cubic foot for the rough blocks, and the cost of sawing, pointing, cutting, rubbing, and waste in stock is added on. If the work is tooled, which is preferable for this material, a suitable percentage should be also added.

Consoles, dentils, panellings, and similar ornamental work, mantels and exterior work, have no fixed prices, but must be governed by the estimator's knowledge of time required to cut any particular kind. If mouldings are deeply undercut, an extra price will have to be charged.

In heavy work, where the amount of stock is large, compared with the amount of dressing, deductions may be made that sometimes amount to as much as 20 per cent. Rock-face work is somewhat more expensive than plain dressed work, because the projecting rock surface requires more stock. Therefore a percentage should be added.

It is customary to leave stone roughly cut to shape for carving in the wall, and therefore the sculptor determines the value from the drawings, and includes the cost of models, which must be approved by the architect before the work is cut. Circular work, if plain, costs about the same as square work; but if fluted, as in the case of columns, it may cost as much as 50 per cent. additional.

Granite.—Final estimates of cut granite by the cubic foot are seldom made, although approximate estimates are often made in that way by comparing a proposed piece of work with a similar one already completed. The reason for not making final estimates is that every additional moulding or break in granite work affects the cost considerably, differing greatly in this respect from soft stones.

Machinery is used extensively in cutting plane faces in granite, and also to some extent for mouldings and carved work. Every line in granite is costly to cut and must be computed separately. For instance, a plane face 12 inches wide, if cut by machinery, would cost much less per square foot than if cut by hand, where the machine cannot be used. A bevel will cost so much per lineal foot additional. A scotia or other moulding will cost even more per lineal foot additional for each member. All returns, no matter how small, must be counted as not less than 1 foot. Flutes or reeds in columns are very expensive, and must be calculated in each case according to the width and depth. All notches ar rabbets are counted separately according to shape and size. Polishing plain surfaces costs so much per square foot, in addition to the cost of cutting, surfaces having widths of 4 inches and under counting as 6 inches, and those over 6 inches up to 12 inches counting as 1 foot.

Brickwork.—Brickwork is generally estimated by the thousand bricks laid in the wall, but measurements by the cubic yard and the perch are also used. The following data will be useful in calculating the number of bricks in a wall: For each superficial or square foot of wall, 4 inches (the width of one brick) in thickness, allow seven and one-half bricks; for a 9-inch (the width of two bricks) wall count 15 bricks; for a 13-inch (the width of three bricks) wall allow 22½ bricks; and so on, estimating 7½ bricks for each additional 4 inches in thickness of wall. The preceding figures are for bricks about 8½ in. x 4 in. x 2½ in. in size. If smaller bricks are used, the thickness of the walls will be decreased proportionately.

If brickwork is estimated by the cubic yard, allow 500 bricks per yard. This figure is based on the use of bricks of the size just given, and mortar joints not over ⅜ of an inch thick. If the joints are ⅛ inches thick, as in face brickwork, one cubic yard will require about 575 bricks. In making calculations of the number of bricks required, an allowance of, say 5 per cent., should be made for waste in breakage, etc.

Rubbed and ornamental brickwork should be measured separately and charged for at a special rate.

Data on Brickwork.—The following estimates on the cost of brickwork, which were very carefully compiled in the I.C.S. library, will be of value. It should be understod that the prices will vary with the cost of materials and labor; the proportions, however, will be constant. The figures are based on kiln or actual count; that is, with deduction for openings. When the work is measured with no deductions for openings, the cost per thousand may be assumed as about 15 per cent. less than the prices given, which are exclusive of scaffolding, hoisting and builder's profits. The scaffolding will cost according to the conditions of the structure and site from 5 to 7 per cent. of the prices given.

COST OF COMMON BRICKWORK PER THOUSAND BRICK, USING 1 TO 3 LIME MORTAR.

1,000 bricks	$8.00	
2 bushels of lime @ 25c. per bushel	.50	
½ cubic yard sand @ $1.50 per cu. yd	.75	
Bricklayer, 8 hrs. @ 55c. per hour	4.40	
Laborer, 8 hrs. @ 25c. per hr	2.00	
Total		$15.65

USING 1 TO 3 PORTLAND CEMENT MORTAR.

1,000 bricks	$8.00	
1 bbl. of Portland cement	2.00	
½ cubic yard of sand	.75	
Bricklayer, 8 hrs. @ 55c. per hr	4.40	
Laborer, 8 hrs. @ 25c. per hr	2.00	
Total		$17.15

USING 1 TO 4 LIME-AND-CEMENT MORTAR.

1,000 bricks	$8.00	
¾ bushel of lime @ 25c. per bu	.19	
½ cu. yd. of sand	.75	
2/3 bbl. of cement @ $2.00 per bbl	1.34	
Bricklayer, 8 hrs. @ 55c. per hr	4.40	
Laborer, 8 hrs. @ 25c. per hr	2.00	
Total		$16.68

Estimating Brickwork.—The following figures and method of estimating brickwork were supplied by an estimator of a large contracting firm. The prices given include office expenses and builder's profit. The wages per hour on which these figures were based are: Bricklayers, 65 cents; hod-carriers, 25 cents; and common laborers, 18 cents.

Following are mentioned four distinct classes of brick buildings, and in the table are given the labor prices per thousand brick for the various storeys of buildings of these classes.

1. Absolutely plain factory buildings.
2. Factory or office buildings, broken up with a few pilasters and other projections; stretcher-brick facing; neatly cleaned down and pointed.
3. Office buildings of fairly ornamental type; well broken up with pilasters, projecting courses, etc.; with pressed brick facing.
4. Highly ornamental brick buildings; moulded cornices, pilasters, raised quoins, sunk moulded panels and numerous flat and segmental arches.

LABOR PRICES PER THOUSAND BRICK FOR FOUR CLASSES OF BRICK BUILDINGS.

Part of Building.	Class 1.	Class 2.	Class 3.	Class 4.
Basement	$7.50	$7.50	$8.50	$9.50
First floor	8.00	9.00	10.50	13.50
Second floor	8.50	10.00	11.00	14.00
Third floor	9.00	10.50	11.50	14.50
Fourth floor	9.50	11.00	12.00	15.00
Fifth floor	10.00	11.50	12.50	15.50
Sixth floor	11.00	12.00	13.00	16.00

The prices in the table include the cost of mortar. If the cost of brick at building is added, the result will be the total cost of brickwork, exclusive of scaffolding.

The following miscellaneous brick prices, including labor and mortar, but not brick, are from the same source as the prices given in the above table, and are based on the same conditions, the prices being in bricks per thousand:

For heavy basement walls and similar masses of brickwork.	$7.00
For 18-inch brick walls, not over 2 or 3 storeys high, in hard brick, with struck joints	8.00
Same as above, but for 13-inch walls	9.00
For 18-inch brick walls as above, but faced on one side with pressed brick	12.00
For 18-inch brick walls as above, but faced on both sides with pressed brick	16.50
For 13-inch brick walls as above, but faced on one side with pressed brick	14.00
For 13-inch brick walls as above, but faced on both sides with pressed brick	19.00

Add to above, if of English or Flemish bond, an entire cost of wall	.50
If broken up into light piers, requiring a lot of plumbing, add to cost of wall as above........................	1.50
If a large number of segmental arches must be turned, add to the total cost of the wall........................	1.00

In addition to the preceding schedule, two useful rules to remember are: For pressed brick segmental arches, add for labor $1\frac{1}{2}$ times the cost of bricks; for pressed brick arches, requiring radial brick, add for labor twice the cost of straight pressed brick. As radial brick are shipped to the building in barrels, and have to be unpacked and laid out on the full-sized diagram on the floor, it will be found that the rate given is not excessive.

For brick vault arches, the cost of labor, exclusive of mortar, will be about $5.00 per thousand brick. If pointed underneath, 7 cents per square foot will have to be added. If the centres are left in place until the mortar has set, it will be necessary to rake out the joints and wet them before pointing. This will cost about 10 cents per square foot.

TERRA-COTTA WORK.

Terra-Cotta Floor Arches.—The cost of terra-cotta floor arches varies somewhat with the span and with the difficulties encountered in putting up and removing the centering. If the building consists of a number of storeys, the centering that is used on one floor may be used on a floor several storeys higher up, in this way decreasing the outlay for centering, as in the case of concrete. For ordinary spans, for instance, the following method is the ordinary way of estimating the cost of a 12-inch arch:

Centering......................So much per square foot of arch.
Hoisting and Laying............So much per square foot of arch.
Mortar.........................So much per square foot of arch.

If the ceiling is much broken up by girders, the price per square foot of each will of course become more than if the ceiling is flat.

Terra-Cotta Partitions—In office buildings, terra-cotta partitions are usually erected on top of a floor in order to divide the space into such rooms as will suit the tenants. This work is generally done after the work is otherwise completed. The thing to be taken into consideration in estimating the cost of such partitions are: thickness of partitions, cost of setting per square foot, including mortar, and the cost of terra-cotta per square foot.

Although not always of brick or terra-cotta nature, it will be found more convenient to consider all tiling together and at the same time that the cost of brickwork is taken up. The cost is generally taken as per square foot laid in place.

CARPENTRY.

Carpentry should include general framing, roofs, floor joists, partitions, sheathing, flooring, furring, and plastering grounds.

Studs.—To calculate the number of studs, set on 16-inch centres, the following rule may be used: From the length of the partition in feet, deduct one-fourth, and to this result add 1. Count the number of returns, or corners, on the plan, where double studding is required, and add 2 studs for each such return. (The reason for adding 1 is to include the stud at the end, which would otherwise be omitted.) The sills, plates and double studs must be measured separately.

Sheathing.—To calculate sheathing or rough flooring (not matched), find the number of feet B.M. required to cover the surface, making no deductions for door or window openings, because what is gained in openings is lost in waste. If the sheathing is laid horizontally, only the actual measurement is necessary; but if it is laid diagonally, add a certain per cent. to the actual area.

Flooring.—In estimating matched flooring, a square foot of 7/8-inch material is considered to be 1 foot B.M.. If the flooring is three inches or more in width, add one-quarter to the actual number of board feet, to allow for waste of material in forming the tongue and groove; if less than three inches wide, add one-third. Flooring of 1 1/8-inch finished thickness is considered to be 1 1/4 inches thick, and for calculating it the following rule may be used: Increase the surface measure 50%. (This consists of 25% for extra thickness over one inch and 25% for waste in tongueing and grooving.) To this amount add 5 per cent for waste in handling and fitting. In figuring the area of floors, openings for stairs, fireplaces, etc., should be deducted.

Weather Boarding or Siding.—In measuring weather boarding or siding, the superficial or square foot is usually employed. No deduction should be made for ordinary window or door openings, as these usually balance the waste in cutting and fitting.

Careful attention must be given for the allowance for lap. If 6-inch, nominal width (actual width 5 5/8 in. siding, laid with 1-inch lap, is used, add one-quarter to the actual area of the space to be covered, in order to obtain the number of square feet of siding required. If 4-inch stuff is used, add one-third to the actual area. When, as previously noted, no allowance is made for openings, the corner and baseboards need not be figured separately.

Cornices.—As a general rule, cornices are measured by the running foot, the moulded and plain members being taken separately. A good method of figuring cornices is as follows: Measure the girth or outline, and allow so much for each inch of girth per lineal foot. This price should pay for material and setting.

Cost per Square Foot.—For all classes of materials that enter into the general framing and covering of a building, a close estimate may be made by analyzing the cost per square foot of surface, that is the cost of labor and materials—studs and sheathing in walls, joists and flooring in floors, etc.—required for a definite area should be closely determined, and this cost divided by the area considered will give the price per square foot. If the corresponding whole area is multiplied by the figure thus obtained the result will, of course, be the cost of that portion of the work. While the usual custom is to adopt a uniform rate for the various grades of work, a careful analysis will show that roof sheathing, where the roof is much cut up, costs more in place than wall sheathing, owing to its position; also that the studs in walls and partitions cost more than floor joists, as they are lighter and require more handling.

Miscellaneous Carpentry Items.—There are several miscellaneous items in carpentry that require consideration. Some of these are:

Setting window panes in wooden buildings, estimated at so much apiece.

Furring brick walls, 1 in. x 2 in. strips, 16-inch centres, at so much per square foot, including labor, material and nails.

Cutting holes and fitting plugs in brick walls at so much each.

Setting window frames in brickwork at so much each.

Setting window and door frames in stonework at so much each.

Furnishing and setting trimmer-arch centres at so much, etc.

Smaller items, such as nails, etc., should also be taken into consideration.

TAKING OFF QUANTITIES.

Although the method of taking off quantities of materials from the plans have, in some cases, been explained, it may be wise to say a few general words in this regard.

Before the estimator can intelligently take off quantities from a plan, he must understand the plans perfectly. He must be thoroughly familiar with the problems of the different trades which come up in that particular building. He must know the relation of the trades to one another. In other words, while at such work, the estimator should have the exact construction of the work in his mind's eye, and must imagine the work going on, at the same time having a perspective mental view of the whole work from start to finish. The costs of material and of labor are items which change from time to time, and which, by means of a good office system, can be at the finger ends of even an inexprienced estimator; but to be able to analyze the construction of a building quickly and accurately, and to recognize the new problems which frequently come up in a building, is an asset that only the experienced builder and estimator possess.

W. F. B. Rubidge, '10, is resident engineer on the construction of the Rosedale section of the Bloor Street viaduct for the Dominion Bridge Co., who are general contractors.

CLASS OF 1910 HOLD A REUNION.

On Thursday, 26th, about forty members of Class '10 held their first reunion dinner in Toronto at the Hotel Mossop. Besides members of the class resident in the city, there were representatives from many outside points, including Winnipeg, Hamilton, Niagara Falls, St. Catharines, Campbellford, London and other places. An excedingly enjoyable time was spent, the ceremonies of the event being presided over by Geo. G. MacLennan, the President of the year. He was assisted in making arrangements for the reunion by a committee consisting of J. H. Craig and J. M. Gibson.

The guests of the evening included Lieut. E. G. MacKay, with the 38th Regiment of Brantford, with the second overseas contingent. Music was provided by Messrs. Bennett, Allen and MacLean, graduates of Toronto, and several vocal numbers were rendered by Mr. J. H. Craig.

The toast list was headed by "Our King." "The Army" was proposed by Mr. Craig, and responded to by Lieut. E. G. MacKay, who will shortly leave for the front. Reference was made to the men of the class who are now with the First Contingent, viz.: F. T. Nichol, J. G. Helliwell, W. J. Baird, A. G. Code, and M. B. Watson, and to the following men with the Second Contingent: E. G. MacKay, D. J. Miller, J. I. McSloy, A. H. Munro, and H. J. MacTavish, and also to J. M. Duncan, who has a commission on H. M. S. "Victory" in the British Navy.

The toast to the "University of Toronto" was attended to by A. V. Delaporte and J. T. King. Athletics were toasted by L. A. Wright and Hugh Gall. The health of Class '10 was proposed by Geo. G. MacLennan, and a general discussion of school affairs followed. J. M. Gibson and W. P. Dobson looked after the toast to "The Profession." Reference was made to the deaths of N. G. H. Burnham, J. N. Leitch and T. Walton since graduation.

After the welfare of the Class and the Profession had received a thorough milling, and the history of the years since graduation had been well disseminated, it was decided to hold informal luncheons each year in Toronto in October and December, to be followed by the Annual Reunion Dinner later in the winter.

A request was made that all the men who had changed their addresses since the last appearance of their names in the Directory of the Alumni in "Applied Science" should keep the President posted of new addresses in order to keep the entire year in touch with each other. The gathering dispersed with a generous rendering of "Auld Lang Syne" and "Toike Oike."

R. M. Walker, B.A.Sc., '10, formerly with Walter J. Francis & Co., Montreal, is now with G. D. Jenssen & Co., consulting engineers, Hawkesbury, Ont., who make a specialty of sulphite mills.

*FINDING THE EQUATIONS OF CURVES AND THEIR USES ON SPECIAL SLIDE RULES.

F. Gordon Reid, '15.

The end of very much mathematics, and the work of many eminent men, has been the simple and, as far as possible, accurate description of the things in the world around us.

In science there are many laws which describe the actions of certain variables with respect to others, and the actions of these variables can nearly always be shown by means of graphs or curves, which therby give us a picture of their operations which is much clearer than if we were given the actual law which described their actions.

However, it is oftentimes desirable that we know the laws which represent the actions of the variable, even if we have the exact curves of their variations given.

It is very desirable that the laws of certain phenomena be known to us, for when we have these laws in a concrete form we can apply the processes of mathematics to them, and, although mathematical processes are often mechanical, we arrive at very comprehensive, reasonable and entirely usable results which are very useful.

For instance, from knowing the laws of the universe we can predict certain future events—in fact, we may and do publish the Nautical Almanac for many years ahead of time, and thereby render invaluable aid to navigators. Similar instances may be drawn from other branches of science, and it is the method of arriving at and using this information which I wish to describe to you.

Study and the association with certain men have made me believe that problems, heretofore placed under the head of "Rule of Thumb" for solution, even by engineers, are capable of accurate solution.

In the Transactions of the American Society of Mechanical Engineers there is a paper entitled "On the Art of Cutting Metals," by Frederick W. Taylor, and also a paper entitled "The Transmission of Power by Leather Belting," by Carl G. Barth. In both of these papers a problem by many considered to be so complex and to contain so many varnables as to be completely unsolvable (accurately), is investigated and brought to a clear, accurate solution. And the solutions for the case of maximum efficiency in each case have been of great value to humanity, for you will concede that anything done efficiently is of value to humanity— that is, if the thing must be done.

Considering now one of the problems solved in the former of these papers, we will see the nature and usefulness of such an investigation.

---

*Presented before the Mechanical and Electrical Club of the University of Toronto Engineering Society, on Feb. 2nd, 1915.

The Problem of a Lathe in the Act of Cutting Metal from a Forging.

Let us assume now that all details of this lathe are known—i.e., speeds available, feeds and torque available, and that the lathe is properly proportioned for rigidity; also let us assume that we are using a tool whose properties are known to be best adapted to cutting metal from the kind of forging being used.

Then the questions which present themselves to us are: What speed, feed and depth of cut should we use to remove the metal most economically? This question has for years been answered by machinists from what they call their fund of experience—but which is really "Rule of Thumb." But since you have each seen many different answers for these problems, it must have occurred to you, "Just what is the right answer?"

These questions have been answered, and the method of arriving at these answers was as follows:—

Experiments were made to show the effect on cutting speed of the variables, depth of cut, amount of feed, and the variables which these two govern—i.e., area and thickness of the shaving, and the pressure of the chip on the tool. The results of these experiments were represented graphically by means of curves and then came the question of how to use this knowledge to obtain the answer desired.

The equations of the curves were found, so that instead of having the results in the form of curves, they were now in the form of algebraic equations, and these equations were operated upon by the processes of mathematics to show the relation of one law to another, and to finally solve these relations so as in each case to arrive at the answer fulfilling the conditions for maximum efficiency.

Algebra, without the method of "Trial and Error," would not accomplish this result, but finally Mr. Barth devised a form of special slide rule, which embodied all the laws, and which in itself embodied a visual form of "Trial and Error" method, thereby arriving at the desired answer.

This was in general the method of attacking the problem, so now let us see the details, the first of which is

The Method of Finding the Equations of Curves.

The ancient Greeks studied very carefully what we now know as conic sections, and with which all are familiar in the form of the ellipse, hyperbola, parabola, and circle.

These curves all follow the general form of the equation of the second degree, and which is for rectangular axes,

$$ax^2+bxy+cy^2+dx+ey+f=0$$

the values of the coefficients being changed to give the desired curve.

Since there has been much written about these curves, and also about that class of curves called Harmonics—a particular case of which is the "sine wave"—I will not deal with methods of finding their solution here, for one may find complete analyses of these curves in text-books.

However, another type of curve which expresses many of the phenomena of science has an exponential equation, the general form of which is

$$y = kx^n$$

and since these curves plot as a straight line on logarithmic co-ordinates their solution is comparatively easy; also this type of equation is the form most easily applied to the special slide rule, which is itself very useful, so we might say that they are among our most useful classes of curves.

Consider now a logarithmic scale—that is the, the familiar graduations of a slide rule.

The length from 1 to 10 is so divided that any length x measured from 1 on this scale reads by the graduations the value of $\log_{10} x$.

Then a straight line plotted on logarithmic co-ordinates will have its equation found as

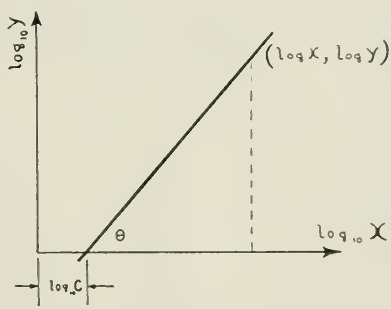


FIG. 1.

$$\frac{\log y}{\log x - \log c} = \tan \theta$$

since $\log c$ and $\tan \theta$ are constant for the curve in question

let $\tan \theta = n$

and $c^{-n} = k$

then $\log y = n \left(\text{og} \frac{x}{c} \right)$

or $y = x^n c^{-n} = k x^n$

Similarly for another case

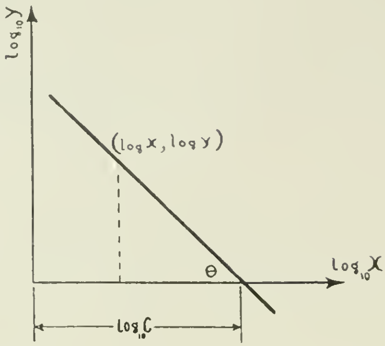


FIG. 2.

$$\frac{\log y}{\log c - \log x} = \tan \theta$$

letting $c^n = k$ and $\tan \theta = n$ then $\log y = n \left(\log \frac{c}{x} \right)$

$$\text{or } y = c^n x^{-n} = \frac{k}{x^n}$$

this method of solution has been applied to the curves whose equations are given in Figures 3, 4, and 5.

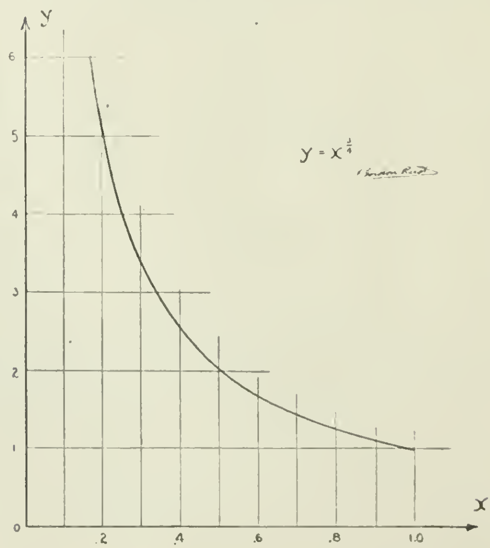


FIG. 3.

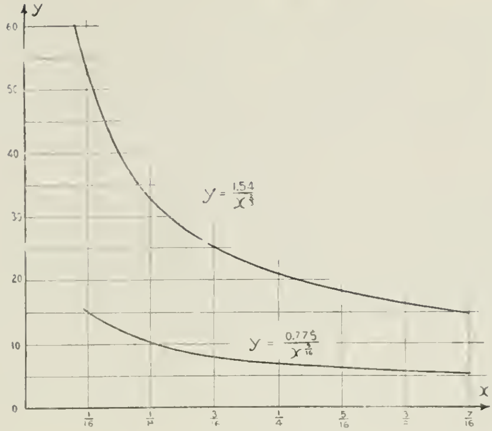


FIG. 4.

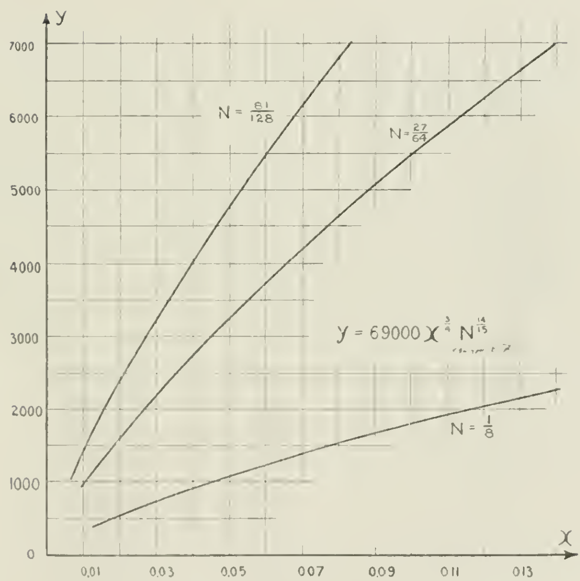


FIG. 5.

Some general headings, and points may now be laid down as follows:—

Having plotted the curve for which we desire to know the equation, we decide

1. If the curve looks at all like the expansion of steam or air adiabatically; that is, the expansion line on an indicator card, it is well to try plotting it on logarithmic paper and see if the points

lie approximately in a straight line. If so, the solution is carried out as described. Fig. 1 or Fig. 2.

If the curve when plotted on logarithmic paper forms the arc of a circle, then proceed as in above case, but from analytical geometry substitute the circle equation for that of the straight line as used above. A little study will show how this may be accomplished.

2. If the curve appears like any "conic section," i.e., hyperbola, parabola or ellipse, use the equation given earlier in the paper, and proceed as follows: For corresponding points of x and y insert their values in the equation (note, always use more than three points), and solve simultaneously for the values of the constants.

3. If the curve does not lend itself to either of the above methods, a third of this type might be tried.

Consider the general equation as

$$y = a + bx + cx^2 + dx^3 + \ldots, \text{ etc.}$$

$$\text{or } y = a + bx + c\sqrt[2]{x} + d\sqrt[3]{x} + \ldots, \text{ etc.}$$

Three terms are generally sufficient, for the equation of the cube is seldom encountered.

Using this equation, proceed as in Method 2.

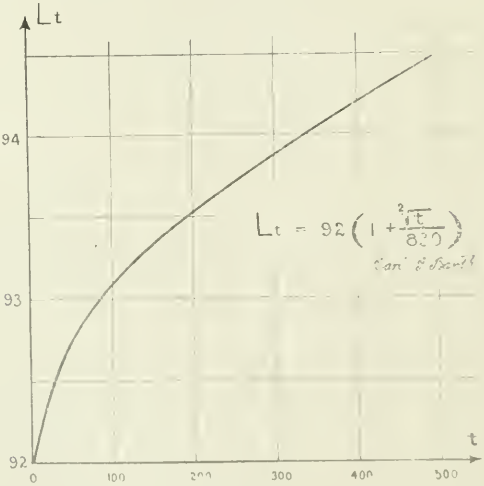


FIG. 6.

A constant factor of the value of the intercept on the axis of x or y may be brought outside a bracket in order to simplify the equation, if desired.

A practical example of this is shown from the tests on the elastic properties of leather belting by Wilfred Lewis—the equation was found by Mr. Barth, and used by him in his paper, A. S. of M. E., Trans. No. 1230, Vol. 31.

There are also other simple curves having formulae like

$$y = a - \frac{b}{c+x}$$

$$y = \frac{a}{b+x} + \frac{c}{d+x}, \text{ etc.}$$

But since I have not as yet found a general method for finding the equations of many of this type of curve, I bring it to your notice more as a suggestion for investigation in the future than as information, but since we know there is a method of finding these equations, let us hope that some of us may stumble on it in the near future and add it to the general knowledge.

There is, however, the general form of all curves, $y = f(x)$, and it would seem that this should lead us always to the result, if the following reasoning be followed:—

From the geometical significance of the derivative we know that $\frac{dy}{dx} = \tan \theta$. Now, for any curve which we have plotted we can draw the tangent at several points and find θ, and thus inserting the corresponding values of x and y we should be able to solve the equations and find what function x is of y, for in each equation the function x is of y remains constant.

However, this inverse method, which is akin to integration, is as full of difficulties as its relative, and becomes practically a "method of trial," which you will find in most cases unssuccessful.

Now, before taking up the application of these laws on the special slide rule, let us put down a few points to be borne in mind either when doing work or in reading the works of others.

Do not assume that the law derived from the curve of the experiments may be used for points outside the range of the experiment.

Always have more than three points from which to plot the curve, and it is well to use, when drawing the curve, the average of points for the same values of the variables, making the curve an average of the average points.

Do not let a theoretical perusal of the subject influence you too much in the choice of a formula to express the law shown by the curve—rather have regard to the accuracy and generality of the results.

The following is a consideration of a form of the special slide rule, which is most useful in applying the results found by the above methods—or, in fact, by any methods which lead to accurate applicable results.

The fundamental principle of a slide rule is that it algebraically adds quantities expressed by lengths on a scale. In the case of the familiar Mannheim Rule, the addition is of the logarithm of the quantity, Thus, when you perform the following:

$$3 \times 9 = 27$$

on the rule. What really is being carried out is the following:

$$\log_{10}3 + \log_{10}9 = \log_{10}27$$

With this knowledge now—consider the equation for the Specific Speed of Hydraulic Turbines

$$Ns = \frac{N P^{\frac{1}{2}}}{H^{\frac{5}{4}}}$$

in which

Ns = Specific Speed
N = Revolutions per Minute
P = Horse Power of Runner
H = Effective Head in feet on Runner.

Then a Slide Rule to embody this formula would have to perform the following

$$\log_{10}N + \tfrac{1}{2}\log_{10}P - \tfrac{5}{4}\log_{10}H = \log_{10}Ns.$$

The rule shown accomplishes the result in the following manner·

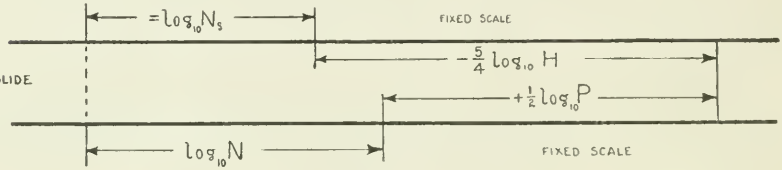
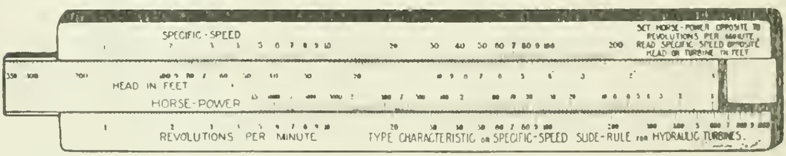


FIG. 7.

Thus, for length log n a logarithmic scale was constructed of unit length, and for length ½ log P a logarithmic scale of ½ unit length was made, etc., for H and Ns, the rule finally taking the form shown below.



Two other rules have been made, which, combined with the specific speed rule, will give—

The Type of Turbine to be Used.

The Diameter of the Reaction Runner.

The Diameter of the Impulse Runner and the corresponding diameter of the nozzle or jet to be used.

These three rules practically solve any problem in the design of an hydraulic plant, and give a fair example of the applicability of the special slide rule to engineering.

The following are illustrations of the complicated formulae which have been applied to the special slide rule.

$$\theta_2 - \theta_1 = Cv \log e \frac{p_2}{p_1} + Cp \log e \frac{v_2}{v_1}$$

This is the well known 'Change of Entrophy' formula for air.

$$P = \frac{(e^{fa}-1)\ (2A-0.00001036\,V^2)\,a}{2\,e^{fa}\ -\ 1}$$

one of Mr. Barth's formulae for the Pull of Belts.

$$V = \frac{13.4}{F^{0.5514}\left(\frac{48}{9}\,D\right)^{0.3133} + \frac{7.2}{54+48D}}$$

one of F. W. Taylor's formulae for the cutting speed of standard tools on steel.

This, I believe, will show the pettiness of crticizing formulae on account of their complicated nature—for they are still simple and useful if they are applicable to the special slide rule.

A point of perhaps no little interest in connection with the foregoing is the following method of constructing a logarithmic scale by geometry.

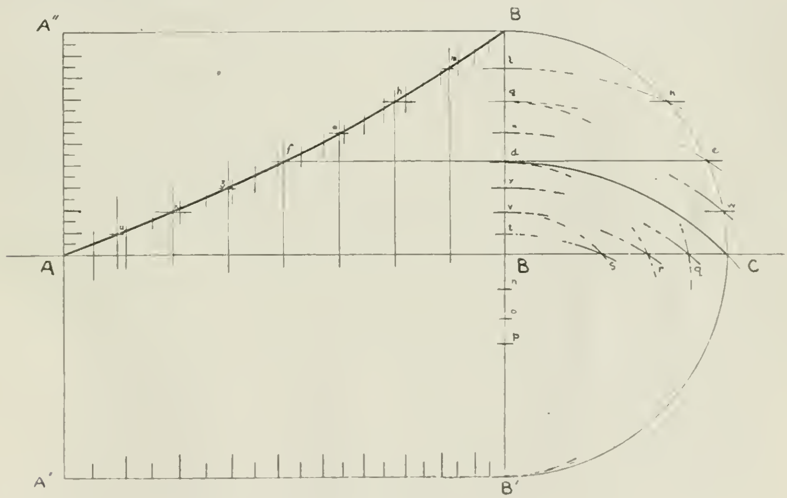


Figure illustrating the method of constructing a logarithmic curve or scale.

We have always associated the construction of logarithms with calculus, Taylor's Theorem and the value of e, but knowing the properties of a logarithmic scale should show us a method of constructing it by geometry.

For a logarithmic scale the distance from 1 to 2 equals the distance from 2 to 4, and so on, and the intermediate lengths are proportional.

We also know the simple truth that the angle in a semi-circle is a right angle, and that therefore the perpendicular from the vertex of this triangle on the base or diameter of the circle is a mean proportional between the lengths into which it divides the base or diameter.

This, then, suggests the following method of constructing a logarithmic scale. .

Take A B, the desired length, and divide into 8 equal parts: erect B″ B B′ perpendicular to A B of convenient length, and construct the semi-circle B″ C B′ as shown.

Then with centre B′ and radius C B′ cut B″ at ″d″.

Make d, e, f parallel to B C, and with centre B′ and radius B′ e cut B′ B″ at "g".

Make g, k, h parallel to B C, and with centre B′ and radius B′ k cut B′ B″ at l.

Divide g B′ at n, and with radius n g and centre n cut B C at q, then with centre B′ and radius B′ q cut B′ B″ at y.

Divide B′ d at o, and with centre o and radius o d cut B C at r, then with centre B′ and radius B′ r cut B′ B″ at v.

Make z, v, w parallel to B C, and with centre B′ and radius B′ w cut B′ B″ at $\propto$

Divide B′ v at p, and with centre p and radius B′ p cut B C at s. With centre B′ and radius B′ s cut B′ B″ at t.

Now produce the seven points, l, g, $\propto$, d, y, v and t parallel to A B C, and the points u, x, z, f, υ, h and m where the divisions of A B and B B″ intersect will lie on a logarthmic curve from A to B″—from 1 to 2.

If now A A″ be divided into ten (10) equal parts and the points be produced parallel to A B till they intersect the curve A B″ and these points be carried down to A′ B′ parallel to B′ B″, then A′ B′ is divided as a logarithmic scale from 1 to 2.

As shown in the figure, A A″ was divided into 20 equal parts, which makes the divisions of A′ B′ a more finely divided logarithmic scale—this process may be carried to the refinement desired, giving a scale divided to as any decimals as required.

The proof of this is as follows:

(1) $B'd = B'C = \sqrt{2} = 2^{\frac{1}{2}}$ if BB' is considered as length 1

(2) $B'g = BC$ and $(B'C)^2 = (B'd)^2 + (de)^2$

$$= (B'd)^2 + (BC)^2 - (Bd)^2$$

$$= (\sqrt{2})^2 + 1^2 - (\sqrt{2} - 1)^2$$

$$= 2 + 1 - 2 - 1 + 2^{\frac{3}{2}}$$

$$\text{or } B'g = \sqrt{(B'C)^2} = 2^{\frac{3}{4}}$$

similarly for $E'l$

(3) Now $(B'V)^2 = (B'r)^2 = (B'B)^2 + (Cr)^2 - (CF)^2$

$$= (B'B)^2 + \left(\frac{B'd}{2}\right)^2 - \left(B'B - \frac{B'd}{2}\right)^2$$

$$= 1 + \left(\frac{1}{\sqrt{2}}\right)^2 - \left(1 - \frac{1}{\sqrt{2}}\right)^2$$

$$= 1 + 2^{-1} - 1 - 2^{-1} + 2^{\frac{1}{2}}$$

$$\text{or } B'V = 2^{\frac{1}{4}}$$

similar proofs being had for the other points—the complete list being as

$$B'B = 2^0 \qquad B'\propto = 2^{\frac{5}{8}}$$
$$B't = 2^{\frac{1}{8}} \qquad B'g = 2^{\frac{3}{4}}$$
$$B'V = 2^{\frac{1}{4}} \qquad B'l = 2^{\frac{7}{8}}$$
$$B'y = 2^{\frac{3}{8}} \qquad B'B'' = 2^1$$
$$B'd = 2^{\frac{1}{2}}$$

these terms are in geometric progression with the general term as 2^{mn}

where $m = \frac{1}{8}$ and $n = (\text{number of term} - 1)$.

Now it is a fact that the differences of terms in geometric progression are themselves in geometric progression—so we see that the lengths Bt, tv, vy, etc., are in geometric porgression, and that the sum of the eight lengths is unity,

$$i.e., (2^1 - 2^{\frac{7}{8}}) + (2^{\frac{7}{8}} - 2^{\frac{3}{4}}) + \ldots (2^{\frac{1}{8}} - 2^0) = 1.$$

With this knowledge and also remembering that for any three terms in geometric progression the middle term is a mean proportional between the other two, it is evident that by making the value of $M = \frac{1}{10}$ and using 10 terms of the series that we can build up a logarithmic scale from the resultant scale.

Note (the length $A'B'$ is merely the series where $m = \frac{1}{10}$ considering $A'B' = 1$, transformation being made from the series with $m = \frac{1}{8}$ by the curve AB'').

With length A′ B′ as the first unit length of a logarithmic scale, i.e., from 1 to 2, we can then repeat from 2 to 4—4 to 8 and 5 to 10, making the complete scale from 1 to 10 in that manner—thus by means of geometry alone we have constructed a logarithmic scale, and if a natural scale of the same length from 1 to 10 be laid coincident with it, then the logarithm of any number shown on the graduations of the logarithmic scale may be read off the natural scale. This is the familiar method of finding logarithms on a slide rule.

The two points illustrated in this paper are the connecting links between experiments and the use of their knowledge in different branches of engineering—the solving of the curve finds the law, and the slide rule is a means of applying it handily.

We should rely upon the information gleaned from accurate tests rather than upon a theoretical consideration of the subject—and in many cases in engineering no amount of theorozing will show the way to solution.

With the complicated conditions and numerous variables present in the case mentioned—cutting metal on a lathe—no amount of theorozing would have obtained the result desired; it was by making accurate experiments and from the curves of these experiments finding the laws governing the variable and using these laws on special slide rules, that the efficiency of all metal cutting machinery throughout the world was so materially increased by Frederick W. Taylor and his associates.

This should illustrate the usefulness of methods of which the foregoing are examples.

LETTER FROM A "SCHOOL" MAN AT THE FRONT.

The following letter was received by his parents from Sergt. C. A. Bell, B.A.Sc., '14, who is with the 2nd Field Co., Canadian Engineers, in France:—

March 4, 1915.

Dear Parents:

Well, everything is going fine just at present. I received your letters of February 5th, a week or so ago, also several lots of papers dated about Feb. 10th.

Well, we have been in the trenches at last. We were employed building new ones and repairing old ones. The line was rather a quiet one where we were, only a few shots now and again. At first you duck and think rather fast, but soon it seems a normal part of your life, and the buzz and whir of a bullet does not bother one as much as the buzz of a troublesome mosquito. The big guns and shells make you start for a time, but unless they are close to you, one does not bother about them after a time. However, as long as you hear them you are safe, because if it does get you, you won't hear it.

Shells are the worst, and they have certainly wrecked some buildings in this part of the country. In the first place that we were in, the church used to get a few German shells each day or so. I don't think that it was intentional to shell the church, but the church spires form good range marks.

I have not seen any Germans yet, except some prisoners in a French town. One thing that impresses one about the English Tommy is that he is always shaved. They look as though they had their daily trip to the barber.

Up until now we have usually been billeted in a barn. The other day we moved and were billeted temporarily in an old farm house. We had three or four sheaves of straw, and the farmer wanted to charge us 8 francs, but of course one cannot draw blood out of stone. We have received 15 francs since coming here, and that was all gone to supplement our rations. Food is high over here in most places. One thing that is particularly good is the coffee, one penny a cup (10 centimes).

Our present billet is the best yet. It is a schoolhouse, and we are fixed quite comfortable. I am writing this before a fireplace while sitting in a big arm-chair. Also, four of us have one bed, some luxury. I will be very comfortable as long as the Germans don't drop a few shells into it.

I met Gordon Hughes to-day. He is keeping well, and has a good job now. He is dispatch rider for headquarters. He has a motorcycle to travel around on.

I suppose the winter will soon start to turn over there now. We had our hardest touch of winter the other day while on the march. The column had just stopped on the outskirts of a town for a few minutes, when up came a blizzard, which lasted for 15 or 20 minutes.

You might send me a few boxes of milk chocolate every week, also one pair of socks per week, heavy ones. You might also send a towel once a month. This will save washing and mending, besides rubber boots soon wear out socks.

Well, I must close now, as the candles are not very long.

With love to all,

(Signed) AUSTIN.

AFTERMATH OF THE DINNER.

In the report of the Annual Banquet last month, we unfortunately omitted to mention that the Class of '09 had a re-union that evening, about forty of them being present. This Class has always proven to be a "live wire," and the reunions of these men have helped materially toward the success of the Annual School Dinner. It is hoped that all the other years will soon follow their example, and thus be of real assistance in "boosting" the School and School men. Class '14 have made a good start, and also had a reunion on the night of the annual banquet, when a large number of them turned out to meet their former classmates.

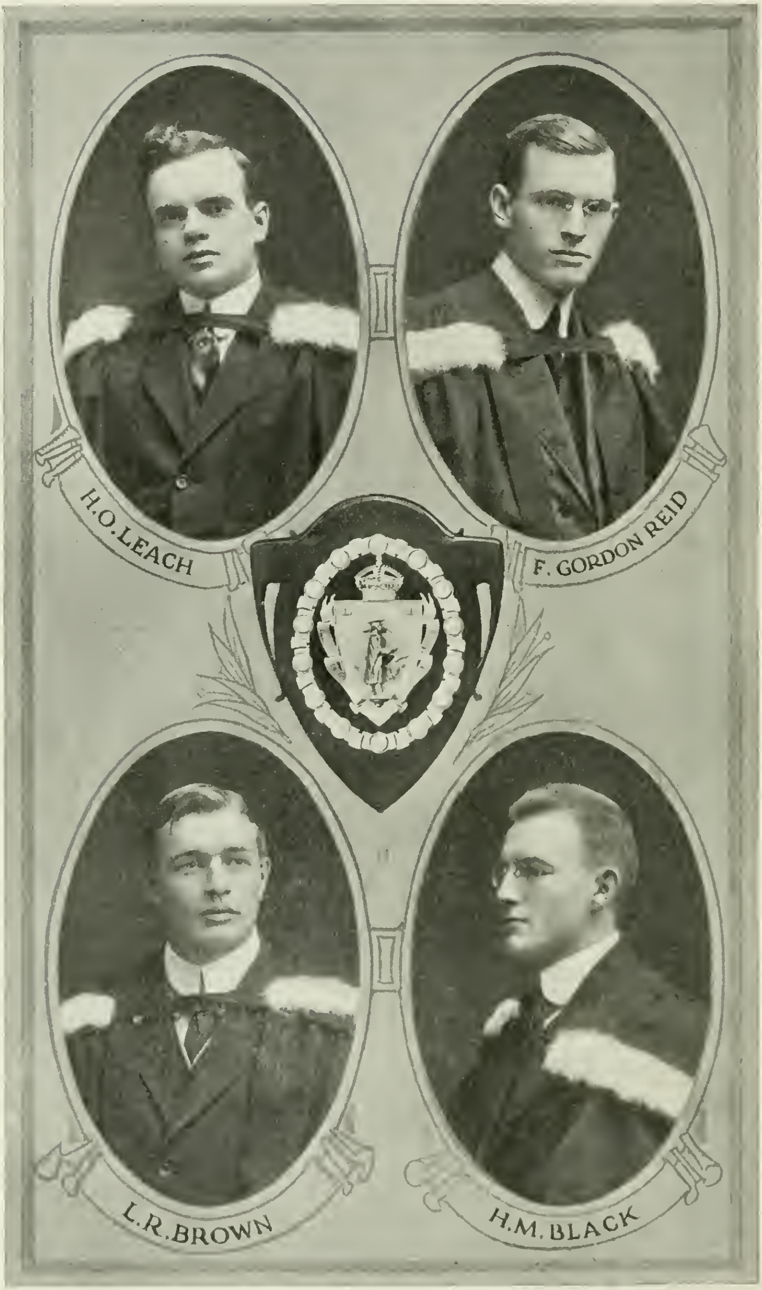
Class '10 have already had one reunion and intend to have a reunion on comparatively recent dates. The men who attend others at regular intervals. Class '08 and Class '07 have each had these reunions are unanimous in declaring that it is "worth while," and have no hesitation in recommending men of other classes to take action and get their men together.

C. C. Rous, B.A.Sc., '13, is in the Ordnance Department, 11 Haldimand Hill, Quebec, P.Q.

J. M. MacInnes, '06, is assistant engineer, Canadian Pacific Railway, Winnipeg, Man.

J. A. Mackenzie, '06, is a member of J. A. Mackenzie & Co., railroad contractors, Kerresdale, B.C.

J. C. Johnston, '00, whose home is at 1459 Mississippi Ave., Portland, Oregon, is with Warren Bros. Co., paving contractors in that city.



WINNERS OF INTER-YEAR DEBATING TROPHY, 1914-15

A TROPHY FOR DEBATING.

Mr. W. E. Segsworth, Mining Engineer, Toronto, has presented an artitically and appropriately designed shield to the Engineering Society of the University of Toronto as a trophy in inter-year debating. It has long been felt that debating and public speaking should be encouraged among engineers, so that as a result of proper training, they would be better enabled to present their views and contentions before the various boards, etc., who receive their reports. This shield, which is of sterling silver on a mahogany background, will in future be looked upon with pride by the society, and will do a very great deal to improve the training of the young engineers at the University.

The trophy was won this year by the graduating class, who were represented by Messrs. H. M. Black, H. O. Leach, F. G. Reid and L. R. Brown.

A silver cup has also been presented to the society by a number of graduates, as a trophy in public speaking. This will no doubt assist in preparing material for the debating contests and serve as an additional incentive to greater activity along the desired lines.

ADDRESSING OF MAIL TO MEN AT THE FRONT.

In order to facilitate the handling of mail at the front and to insure prompt delivery it is requested that all mail be addressed as follows:—

(a) Rank ....
(b) Name ....
(c) Regimental Number ....
(d) Company, Squadron, Battery or other unit.....
(e) Battalion ....
(f) Brigade ....
(g) First (or Second) Canadian Contingent........
(h) British Expeditionary Force ....

Army Post Office,
LONDON, ENGLAND.

R. E. Watts, B.A.Sc., is in the Welland Ship Canal Office at Allanburg, Ont.

J. B. Skaith, B.A.Sc., '14, is with the construction department, Toronto Power Co., Toronto, Ont.

T. L. F. Rowe, '11, is superintendent of construction, new Hospital for Insane, Whitby, Ont.

J. D. Peart, B.A.Sc., '14, is with the ToughOakes Gold Mines, Kirkland, Ont., installing electrical equipment for mine and mills.

E. L. Cousins, B.A.Sc., '06, chief engineer for the Toronto Board of Harbor Commissioners, has been granted a leave of absence for eight or nine months to undertake the preparation of plans for a system of radials and radial entrances for the city.

The following men, in addition to those previously announced in "Applied Science," have enlisted for active service:—

First Contingent—Lieut. G. L. Magann, '15, Dr. H. E. Cawley, '99, G. R. Dashwood, '16, R. D. Hague, '08, F. M. Perry, '98; D. Wilson, '15, A. H. Qua, '08.

Second Contingent—F. A. McKinley, '17, C. G. Hewson, '17, J. F. Young, '17, J. Ward, '17, C. H. Smith, '17, J. H. Legate, '17, E. B. Dustan, '17, E. S. Byres, '17, E. R. Dafoe, '17, W. R. Bauer, '17, W. B. Andrew, '17, W. H. Aggett, '17, H. B. Norwich, '16, A. R. Mendizabal, '16, A. B. Whaley, '16, C. E. Gage, '16, C. W. Edmonds, '16, W. G. Shier, '15, R. M. Arthur, '15, C. Smythe, '16, V. R. Pfrimmer, '16, F. S. Merry. '16, S. K. Cheney, '16, F. J. Matthews, '16, K. D. McDonald, '15, R. B. Sinclair, '15, C. E. Sinclair, '14, D. L. N. Stewart, '05, H. K. Wyman, '11, G. A. Cockburn, '15, J. N. Williams, '15.

Third Contingent—C. J. Inglis, '04, L. W. Klingner, '07, L. R. Wilson, '09, H. S. Clark, '10, A. W. Sime, '14, W. E. Raley, '15, W. W. Ritchie, '16.

The C. O. T. C. at the University has received the most of their uniforms, and it is expected that the remainder will be ready in a short while. A band, under the leadership of H. O. Leach, '15, has been organized to accompany the men at the concentration camp this spring. It made its first public appearance in the parade on March 20th, when over 9,000 men in uniform, including mounted rifles, infantry, cycle corps, artillery, etc., marched through the streets of Toronto, when, it is estimated, over 200,000 citizens turned out to view the inspiring parade.

W. E. Phillips, B.A.Sc., '14, is capitain in the 7th Battalion, Royal Lienster Regiment, at Fermoy, Ireland. At present he is at Camberlee, England, at the Staff College.

WANTED.

A "School" man who has passed his preliminary D.L.S. examination, for about 8 months, as assistant on D.L.S. work in Western Canada, to begin about April 10th. The work consists of making corrections and completting unfinished surveys in Manitoba, Saskatchewan and Alberta. Apply to "Applied Science" Employment Bureau.

WANTED.

"School" man, who has pased his preliminary D.L.S. examination—for period of probably eight or ten months on D.L.S. work in B. C. To begin immediately. Apply "Applied Science" Employment Bureau.

Born—To Mr. and Mrs. C. E. Palmer, at the Cottage Hospital, Toronto, on Saturday, March 20th, a daughter.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications;

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL.

ENGINEERING SOCIETY ELECTIONS.

The elections of the Engineering Society and the programme of entertainment with which the occasion is celebrated have always proven themselves to be a fun factory, not only for the undergraduates, but also for the graduates who are "socially" inclined and return to assist in the ceremonies. The campaign this year furnished as keen contests as has any in the past, and a particularly pleasing feature was the unusually large number of graduates who were present at the evening entertainment, which was held in the Second Year drafting room behind Convocation Hall.

A liberal supply of fruit and tobacco and pipes was distributed to the men, who always appear to possess an unusual capacity for such luxuries on these occasions. An atmosphere of energetic and unrestrained activity pervaded the entire number, and everyone contributed some share toward the enjoyment of himself and the others. The usual dress of social events was discarded for more serviceable uniforms, as forecasts had intimated that there would be considerable work of a practical nature, in which the assistance of all present might either voluntarily or forcibly be brought into play.

Apart from the spontaneous entertainment, which was always at the point of effervescence, and ready to assert itself in a multitude of forms upon the slightest indication of a calm in the proceedings, there was a very good programme of events and contests arranged by a committee, of which Mr. K. A. Jefferson, '15, was convener.

PRESIDENT-ELECT, C. E. HASTINGS

The first event was a game of broom-ball on roller skates between the Juniors and the Seniors. The play was fast and furious, but was kept well in hand by Mr. E. M. Moncith, '15, who acted as referee. Though the game was closely contested, the Seniors won by the score of 4—2, and thereby added another championship to their laurels before graduating.

The next event, a modern chariot race, in which a team of seven men from each year was entered, was perhaps the most interesting and lively of the evening. The first heat between the Second and Fourth Years was won by the Seniors by half a lap, while the second heat was annexed by the Third Year, who just managed to nose out the Freshmen. The final heat between the two winnnrs of the former heats was won by the Fourth Year, when Mr. L. S. Adlard, by clever riding won the laurels.

Another broom-ball match was staged between the Fourth Year miners and the Fourth Year men in sanitary engineering. Owing to disputes and the uncertainty of the play, no decision was announced.

By this time most of the surplus energy had been worked off by the crowd, and everyone was satisfied to take a rest and view other items of the programme in which there were fewer contestants. The gym team, under the leadership of A. R. Mendizabal, '16, gave an exhibition, and won the appreciative applause of the spectators.

A fencing contest between L. G. Glass, '15, and J. E. Breithalpt, '15, was refereed by F. C. Mechin, '14, who gave the decision in favor of Mr. Breithaupt. The next fencing bout, which was refereed by Professor C. H. C. Wright, was won by C. E. Oliver, '16, over O. D. Vaughan, '17.

Two boxing bouts were refereed by J. M. Gibson, '10, to the entire satisfaction of even the contestants. The first encounter, between "Short" Suhler, '15, and "Slim" Krug, '16, was of a whirlwind variety, in which the short end of the fighting won the long end of the decision. The next bout was a blindfold contest, in which the outstanding contestants were the referee and F. R. Allan and E. Birdsall, the heavyweights of year '18. Mr. Allan was declared to have won the decision over his opponents.

Mr. M. B. Hastings, '10, who won the first wrestling championship for the "School" in 1909, acted as referee in a wrestling bout between J. Gray, '15, and J. E. Tremayne, '16, which was won by Mr. Gray.

The last event was a pick-a-pack wrestling match between J. Ross, '16, and G. S. Stratford, '16, comprising one team, and A. H. Livingstone, '18, and G. C. Storey, '15, comprising the other team. This match was refereed by Major Heron, president of the Argonaut Club, and T. P. Galt, K.C., honorary president of the same Club, who gave the decision to Messrs. Livingtonse and Storey.

President Gray then announced the result of the election, which showed the following to have been chosen as the Executive for next year: President, C. E. Hastings; Vice-President, W. B. Honeywell; Corresponding Secretary, R. S. C. Bothwell; Recording Secretary, J. McEachren; Treasurer, G. H. Sohn; Chairman of Civil Club, H. A. Babcock; Chairman of Electrical and Mechanical Club, T. A. Daniel; Chairman of Chemical Club, D. Boyd; Chairman of Archtiectural Club, J. L. Skinner; Chairman of Mining Club, B. A. McCrodan; Fourth Year Rep., J. R. Kirby; Third Year Rep., H. R. Nicholson; Second Year Rep., J. H. McVean; Curator, J. Gardner; First Year Rep., to be elected.

After the results had been announced speeches were given by the president-elect, Mr. Hastings, and also by the other presidential candidates, Messrs. D. G. Hagarty, S. R. Ross and W. L. Dobbin.

In response to the entreaties of those present, short addresses were delivered earlier in the evening by Prof. Wright and Mayor T. L. Church, both of whom referred appropriately to the part which "School" men are taking in the present national crisis. They complimented them on the good work which they are doing in that regard, and also congratulated them on the success of the evening's programme.

The Toike Oikestra, which had so unselfishly furnished music throughout the evenig, played the National Anthem, and after it had been heartily sung by all present, the crowd dispersed.

PRESIDENT GRAY'S RETIRING ADDRESS.

Gentlemen:—

After a year so pleasant as you gentlemen have made it, one could scarcely, without a tinge of regret, bid farewell to such enjoyable duties.

It is indeed a pleasure, though, on behalf of the Engineering Society, to welcome you, Mr. Hastings, to this office.

Your fellow-students have conferred upon you not only the greatest undergraduate honor in their Faculty, but I truly believe in the entire University. I congratulate you.

Co-existant with that honor, Sir, is a responsibility none the less great. Time will not permit me to dwell in detail upon the varied maters demanding your attention. I venture to hope, however, your first aim shall be to consolidate such work of your predecessors as may be worthy of retaining. The Supply Department, Applied Science, the Employment Bureau, the furtherance of debating and public speaking, all want every attention. Detailed reports on these, as well as other matters, are compiled and await you.

Above all, I would urge that you ever remember that the Engineering Society consists not only of the President and Executive, but of every graduate as well as undergraduate of the "School." Do all in your power to preserve the traditions of the past, to tighten and strengthen the fraternal bond and make it still more true that, no matter where you find him, if the hand grips a little tighter and the smile's a little broader, then you'll know he's a "School" man.

Gentlemen, on behalf of the outgoing Executive, I wish to thank the Professors and the other members of the Engineering Society for the consideration and support you all have given us this year.

I take great pleasure in presenting Mr. Hastings, your President-elect 1915-16.

E. D. GRAY.

ROLL OF HONOR

Lieut. F. L. Eardley-Wilmot.

Lieut. F. L. Eardley-Wilmot, whose home was at Westward-Ho, Devon, England, was a son of Colonel A. Eardley-Wilmot, R.F.A., who is at present in command of one of the ammunition columns in France. He came to Canada during the summer of 1913, and entered the "School" in the department of Civil Engineering with Class '17.

F. L. EARDLEY-WILMOT, '17

During the summer of 1914 he was employed in the Public Works Department, City Hall, Toronto, and after the outbreak of the war he joined the Princess Patricia's Light Infantry, which regiment he accompanied to the front.

A letter from him, dated March 1st, stated that he had received an appointment as machine gun officer with the P.P.L.I., and that on March 4th he would be sent back from the firing line to take a two weeks' course on machine gun work. It must have been very shortly after his return to the front that he was killed in action.

Besides his father, his mother, and three sisters mourn his loss. Although he was only nineteen years of age, his worth was recognized when he received a commission with the battle-scarred soldiers of the P. P. Light Infantry.

Norman Lawless.

When the call for recruits for the First Canadian Contingent was made, among the first to enlist was Norman Lawless, who joined the 2nd Field Company, Canadian Engineers. Mr. Lawless was born in Hamilton, Ont., but his family moved to Toronto when

NORMAN LAWLESS, '11

he was quite young. He received his Public School education at Queen Victoria School, and afterwards attended Parkdale Collegiate Institute. He took a course in civil engineering at the "School" with Class '11, and since then had been employed in the sewer department at the City Hall, Toronto.

After the contingent had reached England he had been transferred to a mounted regiment on account of his knowledge of horses; but later he was again placed with the Engineers, it being felt that his engineering experience rendered him too valuabl man to be removed from the Engineers' Company.

During the transfer of the Canadian troops from England to

France, Norman contracted a cold, due to exposure, which developed into acute pneumonia. He died in a hospital in France on February 19th, at the age of twenty-seven years.

His parents are both deceased, but to his other relatives we wish to express our condolence in the loss of a brother who so nobly answered his country's call and gave all he could for the cause of honor and freedom.

Lieut. Fred. C. Andrews.

Mr. Andrews graduated from the "School" with Class '14 in mining engineering. After graduation he accepted a position as

F. C. ANDREWS, B.A.Sc., '14

engineer with the Dome Mines at Porcupine, Ont. Through an accident he had his hand injured, and as a result was at his home in Hamilton when war was declared, and was unable to accompany the First Canadian Contingent on account of the injury.

Feeling that it would be a long while before he would reach the front with another Canadian contingent, he sailed for England at his own expense. He secured a commission in the Second Leinster Regiment, and after a six weeks' course at Cork, Ireland, he left to join his regiment early in December, reaching the trenches on Christmas Day.

The many letters received from Lieut. Andrews by his parents and friends were very realistic in their description of operations in the theatre of war. He often referred to his appreciation of gifts received from home since he had reached the front, and always portrayd a cheerful confidence in the ultimate success of the work in which he was so active.

A cablegram was received by his father, Mr. C. H. Andrews, 26 Mapleside Ave., Hamilton, conveying the sad news that his only son had been killed in action on March 16th. Deceased was 25 years of age, and was a fine type of Canadian manhood. We wish to convey to his relatives our sympathy in their loss of one who so nobly gave his life for the country's cause.

PEAVIE.

We beg to acknowledge receipt of a copy of No. 3, Vol. I, of our contemporary, "Peavie," which was published by the 2nd Field Company, Canadian Engineers, when at Salisbury Plain, England. It is devoted to articles relating to the war and to personal items of interest regarding the members of the company. Captain T. C. Irving, '06, is circulation manager. The following poem is taken from this number:—

And you, a patriot in your prime,
  You waved a flag above his head,
And hoped he'd have a high old time,
  And slapped him on the back and said:

"You'll show 'em what we British are!
  Give us your hand, old pal, to shake."
And took him round from bar to bar,
  And made him drunk—for England's sake.

That's how you helped him. Yesterday,
  Clear-eyed and earnest, keen and hard,
He held himself the soldier's way—
  And now they've got him under guard.

That doesn't hurt you: you're all right:
  Your easy conscience takes no blame;
But he, poor boy, with morning's light
  He eats his heart out, sick with shame.

What's that to you? You understand
  Nothing of all his bitter pain;
You have no regiment to brand;
  You have no uniform to stain.

DIRECTORY OF THE ALUMNI.

Campbell, W. C., '05, whose home is at Keene, Ontario, was in the West, engaged in mining enginering when last heard from.

Campbell, A. W., '06, is with the Hydro-Electric Power Commission, Toronto.

Campbell, H. M., '14, is Lieut. Second Contingent in camp at London, Ont.

Campbell, H. A., '14, lives at 5 Schofield Ave., Toronto.

Campbell, J. E., '08, has no address with us at present, except his home address at Coldstream, Ont.

Campbell, C. D., '11, is town engineer of Galt, Ont.

Candee, C. N., '14, is with the Synthetic Drug Co., 352 Adelaide St. W., Toronto.

Canniff, C. M., '88, lives at 77 St. Clair Ave. E., Toronto.

Carey, B., '89, has no address with us at present.

Carlyle, W. M., '10, is secretary-treasurer of Carlyle and Sons, Ltd., concrete contractors, Toronto.

Carlyle, R. T., '14, is with Carlyle and Sons, Ltd., concrete contractors, 18 Toronto St., Toronto.

Carmichael, R. M., '13. His home address is Kenora, Ont.

Carpenter, H. S., '97, is Superintendent of Highways of the Province of Saskatchewan, Department of Public Works, Regina.

Carrie, G. M., '13, is resident engineer for Chipman and Power, Neepawa, Man. He is in Toronto at present.

Carroll, A. M., '08, is with the Sovereign Construction Company, Toronto.

Carroll, M. J., '06, is with the Department of the Interior, Ottawa, in the Topographical Survey Branch.

Carscallen, H. R., '08, is on hydrographic work in the West, with the Dept. of Interior, Calgary, Alta.

Carson, W. R., '05, is mechanical engineer in charge of plant and construction, Grasseli Chemical Co., Cleveland, O.

Carter, J. M., '14, is with the Nipissing Mines, Cobalt, Ont.

Carter, W. E. H., '98, is a member of the firm of consulting mining engineers Carter and Smith, Toronto. He is at present at Wilkie, Sask.

Caster, J. H., '07, is with the Hydro-Electric Power Commission of Ontario, Continental Life Building Toronto.

Caudwell, N. S., '10, is taking a course in law at Osgoode Hall.

Cavell, E., '07. His address is 182 Sunnyside Ave., Toronto

Chace, W. G., '01, a member of the firm of Kerry and Chace, Limited, Toronto, is chief engineer of the Greater Winnipeg Water District Winnipeg, Man.

Chadwick, R. E. C., '06, is with the Foundation Company, Limited, Montreal.

Chadwick, W. W., '11, has a manufacturing business at 18 Park St. S., Hamilton, Ont., making electric fixtures, fire-place goods, stampings, turnings, spinnings, and brass goods and metal work of every description.

Challen, G., '08. His address is Chedoke, P.O., Hamilton, Ont.

Challies, J. B., '04, is Superintendent of Water Powers, Department of the Interior, Ottawa.

Chalmers, W. J., '89, is assistant engineer, Ohio River Improvement, U. S. Government, and resides at Vanport, Pa.

Chalmers, J., '94, is city commissioner, Edmonton, Alta.

Chandler, R. B., '11, is with Janse Bros., Boomer, Hughes and Crain, on the construction of the government elevator at Calgary, Alta.

Charlesworth, L. C., '93, resides in Edmonton, and is director of Surveys for the Province of Alberta.

Charlton, H. W., '97, is on the staff of the Experimental Farm, Ottawa, as chemist.

Charlton, O. W. N., '11, formerly with Department of Interior, Ottawa, is now associated with W. T. Haring, general contractor, 100 Washington St., New York, N.Y.

Chase, A. V., '05, whose home is at Orillia, Ont., is on survey work on the Trent Canal.

Cherry, P. G., '11, is advertising salesmanager, Might Directories, Limited, Toronto.

Chestnut, A. W., '10, is at Le Pas, Man., engaged in gold mining.

Chestnut, E. F., '11, is corporal with No. 1 Company, 19th Battalion, 2nd Contingent, at Exhibition Park, Toronto.

Chestnut, F. H., '08, is at Marshfield, Oregon, where he is in business under the name of the Coast Equipment Company, handling engineers equipments and supplies.

Chestnut, V. S., '09, is assistant engineer on the construction of the Welland Ship Canal, St. Catharines, Ont.

Chewett, H. J., '88. His permanent address is Prince George Hotel, Toronto.

Chilver, C. A., '04 is Secretary-Treasurer of C. A. Chilver Co., Limited, Builders' Supplies, Walkerville, Ont.

Chilver, H. L., '04, is assistant engineer, Windsor, Ont.

Chisholm, D. C., 10. We do not know in what line of work he is engaged. He is in Winnipeg Man.

Christie, W., '02, is engaged in engineering and land surveying at Prince Albert, Sask.

Christie, A. G., '01, is Associate Professor of Mechanical Engineering at Johns Hopkins University, Baltimore, Md.

Christie, F., '06, is with the Algoma Central Railway in charge of construction.

Christie, R. M., '14, has 9847-91st Ave., Edmonton, Alta, as his address.

Christie, U. W., '04, is in Ottawa, Ont., in the Astronomical Survey Branch, Department of the Interior.

Chubbuck, L. B., '99, is with the Canadian Westinghouse Co., Hamilton, Ont., in the engineering department.

Clark, F. W., '11, is field engineer, Hydraulic Department, Ontario Hydro-Electric Power Commission, Toronto.

Clark, G. T., '06, is general manager of Richardson Bros., builders and contractors, Saskatoon.

Clark, H. J., '11 is employed on the Burlington, Division, Toronto and Hamilton Highway, Burlington, Ont. His address is 2 Markham St., Wychwood, Toronto.

Clark, H. S., '10, is lieutenant with the 36th Battalion, 3rd Contingent, at Hamilton, Ont.

Clark, H. A., '13, is with the C. P. Ry. near Chapleau, Ont.

Clark, J., '00, was, when last heard from, with the P. and L. E. R. R. at Pittsburgh, Pa., as electrician. We do not know his present address or occupation.

Clarke, F. F., '03, is divisional engineer for the Canadian Northern Railway Co. His home is at 49 Sheldrake Blvd., Toronto.

Clarke, J. E., '11. His home address is 139 Downing Ave., Toronto.

Clarkson, G. E., '13, is with the Parker Dye Works, Ltd., Toronto.

Claveau, J .A., '10, is with the Chicoutini Pulp Co., at Chicoutini, P.Q.

Cleary, F. S., '11. Deceased March 1914.

Clegg, B. D., '13. His home is at 295 Stewart St., Peterborough, Ont.

Clement, S. R. A., '05, is with the Hydro-Electric Power Commission, Toronto, Ont.

Clement, W. A., '89, is city engineer of South Vancouver, B.C.

Clendenning, C. S., is in the engineering department Pac. Gt. Eastern Railway, Quesnel, B.C.

Cline, C. G., '09, is Division Engineer, B.C. Hydrographic Survey, Water Power Branch, Department of Interior, Vancouver, B.C. His address is 249 Hastings St. E., Vancouver, B.C.

Clipsham, K. M., '14, is a member of "Clipsham and Delamere," manufacturers of motor cars, 1896 Dundas St., Toronto.

Clothier, G. A., '99 was, when last heard from at Stewart, B.C., as mining engineer and assayer.

Coates, P. C., '04, when last heard from was teaching at Oakland School, Victoria, B.C. His home was at Violet Ave., Marigold, B.C.

Cockburn, J. R., '01, is Assistant Professor of Drawing in the Faculty of Applied Science and Engineering, University of Toronto.

Cockburn, L. S., '10, is mechanical engineer for Beardmore and Co., Acton, Ont.

Code, A. G., '10, is with the First Canadian Contingent in Europe.

Code, S. B., '04, is town engineer of Smith's Falls, Ont. He has a private practice as civil engineer and surveyor.

Cole, C. R., '10. His home address is Box 606, Woodstock, Ont. We do not know what he is doing at present.

Cole, D. B., '11, formerly Smelter Maintainance Engineer for the Canadian Copper Co., at Copper Cliff, Ont., is now with the Cleveland Cadillac Co., Cleveland, Ohio.

Coleman, J. H., '13, is illuminating engineer for Toronto Electric Light Co., Toronto. His address is 17 Farnham Ave.

Coleman, R. M., '10 is assistant sales manager for the Toronto Electric Light Company, Toronto, Ont.

Colhoun, G. A., '06, is draughtsman for the Hamilton Bridge Works Co., Hamilton, Ont.

Collett, W. C., '08, has a practice as architect at 7 St. Mary St., Toronto.

Collinson, J. G., '09, has St. Thomas Ont., as his home address. He is on the engineering staff on the construction of the Welland Ship Canal.

Collinson, W. G., '09, is chief chemist for the Carborundum Co., of Niagara Falls, N.Y.

Colquhoun, G. A., '10, is with the Topographical Surveys Branch, Department of the Interior, Ottawa.

Coltham, G. W., '09, is carrying on an engineering and surveying practice at Aurora, Ont.

Connell, C. B. B., '07, is at St. Kitts, B.W.I.

Connor, A. W., '95, is a member of the engineering firm of Bowman and Connor (H. J. Bowman, '85) with offices in Toronto and Berlin, Ont.

Connor, H. V., '02, is with the Canadian Westinghouse Co., Hamilton, Ont.

Cooch, H. A., '09, is sales engineer for the Canadian Westinghouse Co., with headquarters in Toronto.

Cook, A. S., '11, is connected with the Geo. R. Cook Co., contracting engineers, Ford Building, Detroit.

Cook, G. M., '13, is designing engineer for the Trussed Concrete Steel Co., Walkerville, Ont.

Cook, W. A. M., '06, is structural engineer, city architect's department, Toronto.

Coombs, J. A., '13, is at present at 659 Bloor St. W., Toronto.

Coon, B. R., '13, is a member of the firm S. B. Coon and Son, Architects, Ryrie Building, Toronto.

Cooper, C., '99, is at Carlyle, Sask.

Corbould, C. E. B., '14, is assistant engineer, B.C. Hydrographic Survey, Dominion Water Power Branch, Dept. of Interior, Nelson, B.C.

Corman, W. E., '09, is chief draughtsman and assistant engineer on Hydro-Electric work for C. H. and P. H. Mitchell, Traders Bank Building, Toronto.

Cornell, C. W., '11, is a member of the firm, Jones, Cornell Construction Co., Limited, engineers and contractors, New Westminster, B.C.

Corrigan, T. E., '05, is electrical contractor, 34 Begbie St., New Westminster, B.C.

Applied Science

INCORPORATED WITH

TRANSACTIONS OF THE UNIVERSITY OF TORONTO ENGINEERING SOCIETY

VOL. IX. TORONTO, APRIL, 1915 No. 12

NOTES ON NAVAL ARCHITECTURE AND STEEL SHIPBUILDING.

*J. R. Cockburn, B.A.Sc., A.M. Can. Soc. C.E.

The object of this article is to outline briefly the general principle involved in the design and construction of steel vessels without attempting to go very deeply into any part of the subject.

A great many of the calculations which are made in connection with the design of ships are those dealing with the areas, centres of gravity and moments of inertia of figures bounded by curves, and the volumes and centres of gravity of solids.

There are in general use four different methods of obtaining the areas of plane figures which are bounded on one side by a curve and on the other by a straight line.

1. The first and simplest of these is the trapezoidal rule in which the area $=h\left(\frac{a}{2}+b+c+d+-\frac{z}{2}\right)$ where a, b, c, $-$ z are the ordinates and h is the common interval between them. See Fig. 1.

It is quite obvious that this method is only approximate.

2. Simpson's First Rule.

$$\text{Area} = \tfrac{1}{3}h\,(a+4b+2c+4d+2e+4f+g)$$

A simple proof for this rule is as follows. See Fig. 2.

The area below the curve is practically equal to the area of the trapezoid.

$$\text{Area} = \left(\frac{a+l}{2}\right)\tfrac{2}{3}h + \left(\frac{l+m}{2}\right)\tfrac{2}{3}h + \left(\frac{m+c}{2}\right)\tfrac{2}{3}h.$$

$$= (a+2l+2m+c)\,\tfrac{1}{3}h.$$

$$= (a+4b+c)\,\tfrac{1}{3}h.$$

A second and more exact proof is as follows.

The equation to the curve may be assumed to be $y=a_0+a_1x+a_2x^2$. See Fig. 3.

$$\text{Area of narrow strip} = y\,dx.$$

$$\text{whole area} = \int_0^{2h} y\,dx.$$

*Assistant Professor of Descriptive Geometry, University of Toronto.

$$\text{or} \int_0^{2h} (a_0+a_1x+a_2x^2)dx.$$

$$\text{which} = \left[a_0 x + \tfrac{1}{2} a_1 x^2 + \tfrac{1}{3} a_2 x^3 \right]_0^{2h}$$

which has to be evaluated between the limit $x=2h$ and $x=0$. The expression then becomes

$$a_0 2h + \tfrac{1}{2} a_1 4h^2 + \tfrac{1}{3} a_2 8h^3.$$

Now from the equation to the curve when

$$x=0 \;:\; y=a_0$$
$$x=h \;.\; y=a_0+a_1 h+a_2 h^2$$
$$x=2h \;.\; y=a_0+2a_1h+4a_2h^2$$

But calling the ordinates in the ordinary way y_1 y_2, y_3.
when $x=0$, $y=y_1$,
$x=h$, $y=y_2$,
$x=2h$, $y=y_3$,
therefore $a_0=y_1$

$$a_0+a_1h+a_2h^2=y_2$$
$$a_0+2a_1h+4a_2h^2=y_3.$$

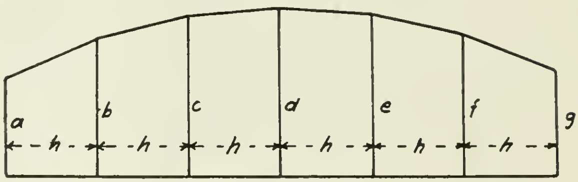


Fig. 1.

$$\therefore a_0=y_1$$
$$a_1=\frac{1}{2h}\;(4y_2-3y_1-y_3)$$
$$a_2=\frac{1}{2h^2}\;(y_3-2y_2+y_1)$$

or substituting above.

$$\text{Area}=y_1 2h+\frac{4h^2}{2}\cdot\frac{1}{2h}\;(4y_2-3y_1-y_3)+$$
$$\frac{8h^3}{3}\cdot\frac{1}{2h^2}\;(y_3-2y_2+y_1)$$
$$=\tfrac{1}{3} h\,(y_1+4y_2+y_3).$$

3. Simpson's Second Rule.

Area $= \frac{3}{8} h(a+3b+3c+2d+3e+3f+g)$.

Proof assuming that the equation to the curve is

$$y=a_0+a_1 x+a_2 x^2+a_3 x^3$$

Area of narrow strip ydx

$$\text{whole area} = \int_0^{3h} y\,d\,x$$

$$= \int_{o}^{3h} (a_0 + a_1 x + a_2 x^2 + a_3 x^3) dx$$

which equals $\left[a_0 + \frac{1}{2} a_1 x^2 + \frac{1}{3} a_2 x^3 + \frac{1}{4} a_3 x^4\right]_o^{2h}$

which has to be evaluated between the limits $x = 3h$ and $x = 0$.

The expression then becomes

$$a_0 2h + \tfrac{1}{2} a_1 9h^2 + \tfrac{1}{3} a_2 27h^3 + \tfrac{1}{4} 81h^4$$

From the equation to the curve.

When

$x = 0, \quad y = a_0 = y_1$

$x = h, \quad y = a_0 + a_1 h + a_2 h^2 + a_3 h^3 = y_2$

$x = 2h, \quad y = a_0 + 2a_1 h + 4a_2 h^2 + 8a_3 h^3 = y_3$

$x = 3h, \quad y = a_0 + 3a_1 h + 9a_2 h^2 + 27a_3 h^3 = y_4.$

Solve the above equations for values of a_0, a_1, a_2 and a_3 and substitute these values in the equation for the area and the result is area $= \frac{3}{8} h(y_1 + 3y_2 + 3y_3 + y_4)$.

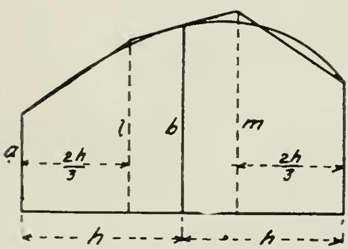


Fig. 2.

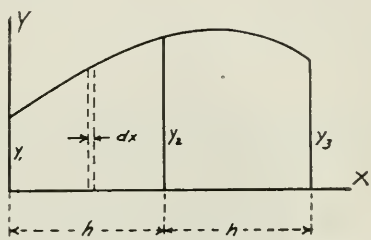


Fig. 3.

4. The Five-eight Rule or Simpson's Third Rule.

$$\text{Area} = \frac{1}{12} h(5y_1 + 8y_2 - y_3)$$

The proof of this rule follows directly from the proof of Simpson's first rule. See Fig. 5.

By Simpson's First Rule

Area of figure $AXBCD = \frac{1}{3} h\,(AD + 4XE + BC)$.

By the five-eight rule

$$\text{Area } AXED = \frac{1}{12} h\ .\ (5AD + 8XE - BC)$$

$$\text{and area } XBCE = \frac{1}{12} h(5BC + 8XE - AD)$$

Adding these two areas

$$= \frac{1}{12} h\,(4AD + 16XE - AD)$$

$$= \frac{1}{3} h(AD + 4XE + BC).$$

It should be noted that the result found by the formula is the area between two ordinates only, although three ordinates are required to find it.

The extension of the five-eight rule is as follows:

$$\frac{1}{12}h\left\{\begin{array}{cccccc} 5 & 8-1 & & & & \\ & 5 & 8-1 & & & \\ & & 5 & 8-1 & & \\ & & & 5 & 8-1 & \end{array}\right.$$

$$\frac{1}{12}h(5y_1+13y_2+12y_3+12y_4+7y_5-y_6)$$

$$\text{or} = h\left(\frac{5}{12}y_1+\frac{13}{12}y_2+y_3+y_4+\frac{7}{12}y_5-\frac{1}{12}y_6\right)$$

The trapezoidal rule is applicable when there are any number of equidistant ordinates.

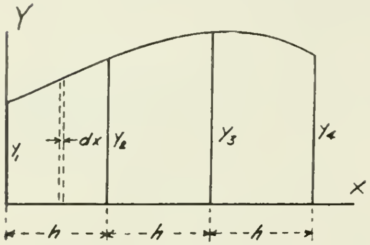


Fig. 4.

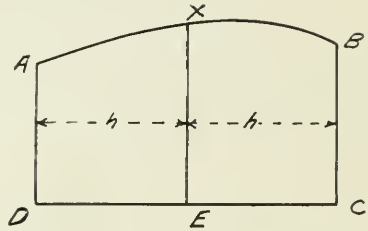


Fig. 5.

Simpson's first rule is applicable only when there are an even number of equal spaces between ordinates.

Simpson's second rule is applicable only when the number of spaces between the ordinates is divisible by three.

The five-eight rule is applicable when there are any number of equidistant ordinates, provided an ordinate beyond the area required be known.

The position of the centre of gravity of a plain figure or solid may be readily found by taking moments about any convenient axis.

The following examples illustrate the method of obtaining the area and position of the centre of gravity of a plane figure bounded on one side by a curve.

1. Solution by Simpson's First Rule.

Distance between ordinates = 2′ 0″.

No.	Length of Ordinate	Simp. Mult.	Functions of Ordinate	Levers	Products
1	1.45	1	1.45	0	0.0
2	2.65	4	10.60	1	10.60
3	4.35	2	8.70	2	17.40
4	6.45	4	25.80	3	77.40
5	8.50	2	17.00	4	68.00
6	10.40	4	41.60	5	208.00
7	11.85	1	11.85	6	71.10
			117.00		452.50

$$\text{Area} = \frac{1}{3}(117x2) = 78 \text{ sq. ft.}$$

$$\text{Distance of C of G from section No. 1} = \frac{452.50}{117} \times 2 = 7.72 \text{ ft.}$$

2. Solution by Simpson's Second Rule.

No.	Lenth of Ord.	Simp. Mult.	Functions of Ordinate	Levers	Products
1	1.45	1	1.45	0	0.0
2	2.65	3	7.95	1	7.95
3	4.35	3	13.05	2	26.10
4	6.45	2	12.90	3	38.70
5	8.50	3	25.50	4	102.00
6	10.40	3	31.20	5	156.00
7	11.85	1	11.85	6	71.10
			103.90		401.80

$$\text{Area} = \frac{3}{8}(103.90x2) = 77.925 \text{ sq. ft.}$$

$$\text{Distance of C of G from section No. 1} = \frac{401.80}{103.90} \times 2 = 7.71 \text{ ft.}$$

The results obtained by the two methods are practically the same, and either result is sufficiently accurate for all practical purposes.

Displacement and Centre of Buoyancy.

The displacement of a vessel may be expressed either in units of weight or in units of volume, the weight of the vessel being equal to the weight of the water which it displaces when floating.

The centre of buoyancy of a vessel is always in the same vertical line as its centre of gravity, and may be defined as the centre of gravity of the volume of water displaced.

In order to find the volume of the underwater portion of a vessel, the body is intersected by a series of equidistant planes. The area of each section is then found by one of the rules already explained, or by means of the planimeter.

The areas thus found are treated as the ordinates of a new curve, the area of which will represent the required volume. The position of the centre of gravity may be found as previously explained.

As the hull of a vesel is symmetrical about the fore and aft central plane, it is usual to make cauculations for one side only.

The equidistant planes, which are taken to intersect the hull, may be parallel to the load water line plane, or they may be perpendicular to the load water line and fore and aft central planes.

The first series of planes will give the vertical position of the centre of buoyancy, and the second series its longitudinal position.

In calculations of displacement, three coefficients are often used. They are as follows:—

1. The Block Coefficient, or the ratio between the displacement and the product of the length between perpendiculars, the moulded beam and the moulded draft $= \dfrac{\text{displacement}}{L \times B \times D}$

2. The Prismatic Coefficient, or the ratio between the displacement and the product of the length between perpendiculars and the midship section below the load water line.

3. The Midship Section Coefficient, or the ratio between the midship section and the product of the moulded beam and draft amidships.

Tonnage.

The term "tonnage" must not be confused with the displacement in tons, as there is no relation between tonnage and displacement.

In the early days of British shipping a great deal of the trade consisted in carrying wine from France to Great Britain. The wine was carried in large casks called tuns, which were all of nearly the same size, so a handy way of reckoning the size of a ship was to state how many tuns of wine she could carry. The tun of one hundred cubic feet was finally adopted as the British unit for measuring a vessel's capacity.

The word tunnage has since been corupted into tonnage.

If the tonnage of a vessel be given as 10,000, it simply means that the internal capacity of the ship is 10,000 $\times$ 100 cubic feet.

Calculation of Weights.

It is possible to calculate from the detailed drawing the weights of the principal portions of a ship, such as shell plating, inner bottom plating, framing, steel and wood decks, platforms, beams, bulkheads, etc. There are, however, a great many parts the weight of which cannot be readily calculated, and it is usual to estimate their weights by comparison with those of existing ships. Such parts are stems, and stern frames, shaft brackets, engine and boiler foundations, rudders, paint, cement, fittings, etc.

As it is a very laborious calculation to determine the weight of a large ship in detail, it is common practice, especially in preliminary work, to estimate the weight by comparison with existing ships of nearly the same size and type, the weights of such ships being known. If two ships be of the same type and proportions, their weights must be to one another as the products of their lengths, breadths and depths.

Let $L =$ Length between perpendiculars in feet.

Let $B =$ Breadth moulded in feet.

Let $D =$ Depth moulded in feet.

Let $N = \dfrac{L \times B \times D}{100}$

Then the weight of hull = N × Ch.
the weight of steel = N × Cs.
the weight of wood and fittings = N × Cw.

The following table taken from Kemp's Engineer's Year Book (1913) gives the average values of the coefficients, Ch, Ss and Cw:—

Type of Vessel.	Cs.	Cw.	Ch.
Torpedo boat destroyer	.25	.09	.34
Cruiser	.30	.11	.41
Battleship	.33	.14	.47
River paddle steamer	.20	.10	.30
Channel steamer	.25	.13	.38
Coasting steamer	.32	.20	.52
Cargo tramp	.35	.12	.47
Intermediate liner	.42	.17	.59
Fast mail liner	.39	.14	.53

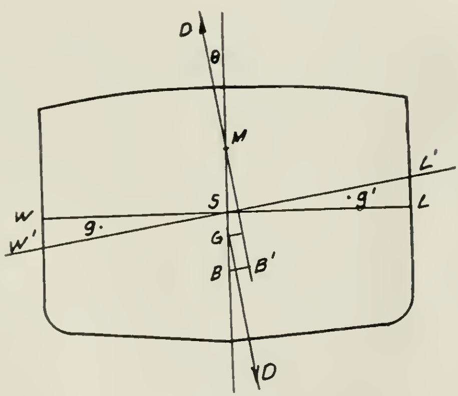


Fig. 6.

In calculating the weights of machinery the methods employed are similar to those used to obtain the weight of the hull. In preliminary estimates the weights may be taken as being proportional to power.

In addition to the weights of the hull and machinery of a vessel, it is necessary to calculate the deadweight which the ship is to carry. The deadweight consists of such things as spare gear, crews and effects, passengers, baggage, coal, and everything else not included in the estimate of the hull and machinery.

The following table, which is taken from Kemp's Engineer's

Hand Book (1913), gives coefficients for the weights of various types of machinery:—

Type of Machinery	Type of Boiler	Type of Ship	H.P per Ton	Tons of Engine per H.P.	Tons of Boiler per H.P.
RECIPROCATING ENGINES	Cylindrical	Cross Channel Str. Cruiser Battleship	9	.041	.070
	Cylindrical	Cargo Str. Forced D.	4.5	.113	.109
		Cargo Str. Nat. D.	4.2	.125	.113
		Mail Steamer	6 0	.082	.085
	Small Water Tube	Torpedo Craft	40.0	.0127	.0123
	Large Water Tube	Cross Channel Str.	11.6	.0410	.0373
		Cruiser Battleship	12.8	.0410	.0370
TURBINES	Cylindrical	Cross Channel Str.	13.0	.022	.055
		Mail Steamer	8.5	.040	.078
	Small Water Tube	Torpedo Craft	40.0	.0127	.0123
	Small Oil Fuel	" "	48.0	.01	.0104
	Large Water Tube	Cross Channel Str.	15.0	.0220	.0450
		Cruisers Battleships	13.30	.038	.037

Stability.

The Statical Stability of a vessel is the property she has of retaining an upright position, and is of the utmost importance in regard to safety.

The statical stability of a vessel remains fairly constant for all angles of heel up to between 10° and 15°, and the stability within such limits is known as the initial statical stability.

The stability of a vessel may be compared to that of a sphere in which the centre of gravity does not coincide with the centre of the sphere. When such a sphere is placed upon a horizontal plain surface it will take a position such that its centre of gravity is directly below its geometric centre, and if forced from this position by an external force, it will immediately return to it when the outside force is removed.

In the case of a vessel floating in still water, the point about which it virtually rotates when rolling from side to side is known as the transverse metacentre. In order for the vessel to be in a state of stable equilibrium, this metacentre must be above the centre of gravity.

The inclinations of a vessel in a longitudinal or fore and aft direction are of importance in determining the trim under varying conditions of loading. Such inclinations take place about a point known as the longitudinal metacentre. The principles involved in determining the positions of the two metacentres are essentially the same. It is therefore sufficient to illustrate the method of obtaining either one of these.

The distance that the metacentre is above the centre of buoyancy is usually expressed as BM, and its value may be found from the following equation:—

$$BM = \frac{I}{V}$$

where I = Moment of inertia of the figure inclosed by the load water line.

V = Volume of displacement.

The proof of the formula is as follows:—

Let Fig. 6 represent the section of a ship inclined from the upright by some external force through a small angle θ.

The wedge-shaped volume WSW′, which has come out of the water, is called the emerged wedge, and the other wedge, LSL′, is called the immersed wedge.

As the volume of displacement of the ship is the same after being inclined as it was before the volumes of the two wedges must be equal.

Let g and g^1 be the positions of the centre of gravity of the emerged and immersed wedges respectively.

Let B be the centre of buoyancy of the vessel in an upright position when floating at water line WL, and B^1 the centre of buoyancy when inclined and flating at water W^1L^1.

Let v be the volume of either of the wedges, and V the total volume of displacement.

As the change of position of the centre of gravity of the small volume v from g to g^1 is equivalent to changing the centre of gravity of the whole volume V from B to B^1, we may write $B\,B^1 \times V = g\,g^1 \times v$.

$$\text{or } BB' = \frac{v \times gg'}{V}$$

and for a very small angle of inclination

$$\frac{B'B}{BM} = \sin\theta \text{ or } B'B = BM \sin\theta.$$

If y be the half breadth of the water line we can write

$$WW' = LL' = y \sin\theta$$

and the area of the triangle WSW' or

$$LSL' = \tfrac{1}{2} y \times y \sin \theta = \tfrac{1}{2} y^2 \sin \theta.$$

As θ is very small the distance $gg' = \tfrac{4}{3} y$. Therefore the moment caused by the transference of the displacement from one side to the other

$$= \tfrac{1}{2} y^2 \sin \theta \times \tfrac{4}{3} y = \tfrac{2}{3} y^3 \sin \theta.$$

And for a very small length dx of the water line the moment is

$$\tfrac{2}{3} y^3 \sin \theta dx.$$

Making a summation for the whole length of the ship

$$\text{Moment } V \times gg' = \int \tfrac{2}{3} y^3 \sin \theta dx.$$

$$= \tfrac{2}{3} \sin \theta \int y^3 dx.$$

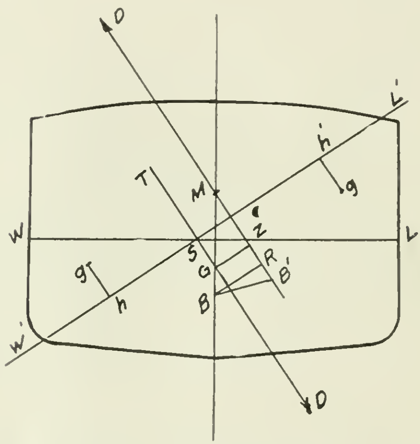


Fig. 7.

$$\therefore BB' = BM \sin \theta = \frac{V \times gg'}{V} = \frac{\tfrac{2}{3} \sin \theta \int y^3 dx}{V}$$

$$\text{or } BM = \frac{\tfrac{2}{3} \int y^3 dx}{V}$$

But $\tfrac{2}{3} \int y^3 dx$ is the expression for the moment of inertia of the load water line about its longitudinal axis.

To determine the righting moment of a vessel.

Let G be the position of the centre of gravity and D the weight of the vessel. The righting moment $= D \times GM \sin \theta$. The moment of inertia of the load water line may be calculated by applying one of Simpson's rules, the cubes of the half breadths being used instead of the half breadths as used in computing the area.

The method is illustrated in the following table:—

No.	Half Breadths	Cubes of H.B.	Simp. Mult.	Products
1			1	
2			4	
3			2	
4			4	
5			2	
6			4	
7			2	
8			4	
9			1	
				Sum of Prod. = P.

$P \times \frac{1}{3}$ common interval = area of curve of ordinates cubed, $\frac{8}{12}$ of this, or $\frac{2}{3} P \times \frac{1}{3} CI$ = moment of inertia of the load water line.

Statical Stability at large Angles of Heel.

Let Fig. 7 represent the cross section of a vessel inclined at a large angle θ.

The righting moment of the ship is $D \times GZ$

$$GZ = BR - BP$$
$$= BR - BG \sin \theta.$$

The moment of statical stability

$$= D(BR - BG \sin \theta)$$

$$\text{But } BR = \frac{V \times hh'}{V}$$

∴ Moment of statistical stability

$$= D\left(\frac{V \times hh'}{V} - BG \sin \theta\right).$$

This is known as Atwood's formula.

Dynamical Stability.

When a vessel is inclined through an angle by an external force the work done on the ship is equal to the weight of the ship multiplied by the vertical separation of its centre of gravity and centre of buoyancy The amount of this work is what is called the dynamical stability.

In Fig. 7 the vertical distance between the centres of gravity and buoyancy when the ship is inclined through an angle θ is $B'Z$

The original vertical distance is BG

$\therefore$ the vertical separation is

$$B'Z - BG$$

$\therefore$ the dynamical stability $= D(B'Z - BG)$.

Now $B'Z = B'R + RZ = B'R + BG \cos \theta$.

$$V(gh + g'h') = V \times B'R$$

$$\text{or } B'R = \frac{V(gh + g'h')}{V}$$

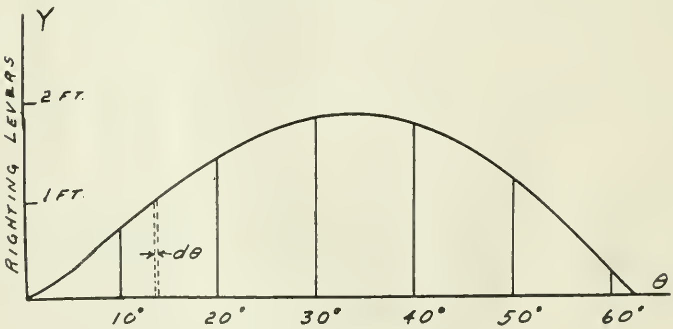
Substituting in the above value of $B'Z$, we obtain

$$B'Z = \frac{V(gh + g'h')}{V} + BG \cos \theta$$

$\therefore$ the dynamical stability

$$= D\left[\frac{V(gh + g'h')}{V} - BG(1 - \cos \theta)\right]$$

This is known as Mosley's formula.



In Fig. 8 we have the curve of statical stability of a battleship plotted for various angles of heel. The ordinates represent the righting levers on a certain scale, and the righting moments on another scale, which is equal to the scale of righting levers multiplied by the weight of the vessel.

It is interesting to note that the area of the curve of statical stability up to any given point represents the dynamical stability up to the same point. This can be readily proved as follows:—

The work done in inclining the vessel through a small angle

$d\ \theta$ is equal to the product of the moment and the angle through which the moment acts, the angle being expressed in radians.

$$= yd\theta.$$

The total work done in inclining the vessel from the upright to the angle in question, viz. $\theta\ . = \int yd\theta$ but $\int yl\theta$ equals the area of the curve.

As the righting moment of a vessel depends upon the relation of the metacentre to the centre of gravity, it is always necessary to calculate the position of the centre of gravity of the ship as a whole before any knowledge of the stability can be gained.

The following are average values of the height of transverse metacentres above the centres of gravity for different types of vessels:—

For a Battleship	3′—6″
" Cruiser	2′—6″
" Large cargo vessel	2′—0″
" Paddle steamer	2′—0″
" Cross Channel steamer	1′—6″
" Transatlantic mail steamer	1′—0″

The reason for such a great metacentric height in battleships is in order to give sufficient stability for gunfire.

The more nearly the metacentre approaches to the centre of gravity, the more slowly will the vessel roll, and for that reason a transatlantic mail steamer is given a metacentric height as small as is permissible with safety.

Structural Requirements of Ships.

The three principal classes of stresses experienced by ships are as follows:—

(1 Those caused by longitudinal bending and shearing forces.

(2) Transverse strains.

(3) Strains due to the propulsion of the vessel.

In addition to the above there are a great number of local strains due to a variety of causes, such as heavy local weights, attachment of rigging, etc.

The longitudinal bending and shearing stresses are caused by the uneven distribution of weight and buoyancy, this condition being greatly aggravated by the action of waves. When a vessel is supported upon the crest of a wave of her own length the stresses tending to produce hogging are at a maximum, and when the vessel rests across the trough of a wave upon two crests the stresses tending to produce sagging are at a maximum.

Fig. 9 shows graphically the distribution of weights and buoyancy for a ship when subjected to hogging stresses.

The curve B shows the distribution of the buoyancy or displacement.

The curve W shows the distribution of the weight of the vessel.

The curve L shows the difference between the weight and buoyancy at the various sections. It is called the curve of loads, and from it the curves of shearing forces and bending moments may be calculated by the ordinary methods of statics.

Fig. 10 shows the corresponding case for the ship when subjected to sagging strains.

In order to determine the maximum stress at any section of the ship, it is necessary to calculate the moment of inertia of the section and the position of its neutral axis. The formula $\frac{p}{y} = \frac{M}{I}$ may then be employed.

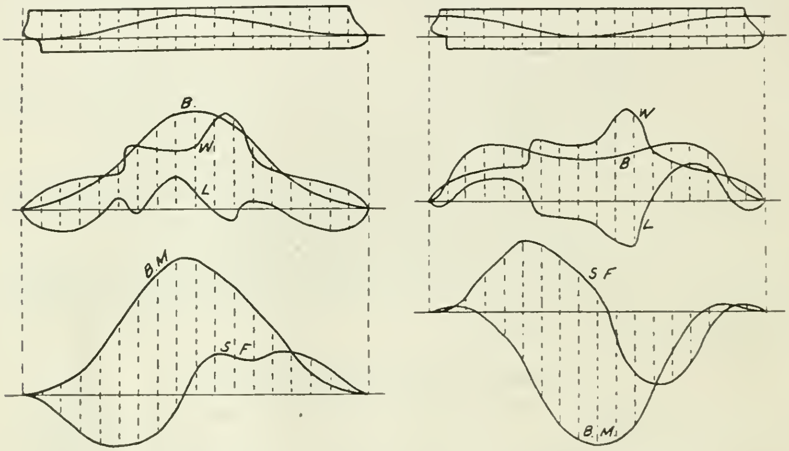


Fig. 9. Fig. 10.

In designing the cross-section of a ship the deck houses and superstructures which are liable to stress must be embodied in the design and made sufficiently heavy, or serious injury to them will result.

The maximum bending moment in foot tons for ordinary ships may be assumed to be between $\frac{1}{20}$ and $\frac{1}{30}$ of the product of the length in feet and the displacement in tons, and will usually occur in the neighborhood of the midship section.

The shearing force is usually zero at the midship section, and a maximum midway between the midship section and the ends.

The stresses caused by the action of waves are greatly influenced by the inertia of the water, and by the motion of the vessel. According to the trochoidal theory of waves, the particles of water move with a circular motion, and this motion materially modifies the supporting power of the waves.

It might be worthy of note that the maximum permissible bending stresses in a ship 500 feet long will cause the vessel to bend as much as 6 inches, and it has been found in certain cases that a change in temperature of 7° will bend the ship over 1 inch.

The longitudinal stresses are resisted principally by the shell plating and decks.

The transverse stresses are caused mostly by racking strains due to rolling and the action of waves. They are very difficult to determine, but are much smaller in amount than the longitudinal stresses. The transverse framing and blukheads are the principal members which resist transverse strains.

Resistance and Propulsion of Ships.

The resitance to be overcome by a ship passing through the water may be divided into three parts:—

1. Skin resistance, which is due to the friction of the water on the sides of the vessel.
2. Eddy-making resistance.
3. Wave-making resistance.

The first of these depends upon the length, area and nature of the surface, and upon the density of the water. It varies as the nth. power of the speed where n varies from 1.83 to 2.16.

The eddy-making resistance varies approximately as the square of the speed, but it will vary in amount according to the shape of the ship. A ship with full stern and thick stern post and rudder will have a greater eddy-making resistance than one with a fine stern and thin stern post and rudder.

The effective horse power (E.H.P.) required to overcome the frictional and eddy making resistance may be calculated from the following formula

$$\text{E.H.P.} = \frac{1}{326} f S V^{2.83}.$$

Where V is the speed in knots.

S the area of wetted surface in sq. ft.

f a coefficient, varying from 0.009 for a length of 500 ft. to 0.01 for a length of 40 ft.

The wave-making resistance of a vessel depends upon a great many variable factors, such as the size and proportions of the vessel, the speed at which the vessel is travelling, etc.

The most accurate method of estimating the wave-making resistance of a vessel is by using the results of experiments with models, or with actual ships, and comparing them by means of Froud's law, which is as follows:—

If two vessels of exactly similar form, but of different sizes, are run at speeds proportional to the square roots of their lengths, their wave-making resistances will be proportional to the products of their displacements and speeds.

An approximate formula for the effective horse power required to overcome wave making resistance is

$$\text{E.H.P.} = \frac{1}{326}\ b\ \frac{(W)^{\frac{2}{3}}}{L}\ V^5$$

where W is the displacement in tons.
L is the length in feet.
V the speed in knots.

As the coefficient b varies for different speeds in the same ship the formula is unreliable.

The ratio of the effective horse power to the indicated horse power may be expressed as follows $\frac{\text{EHP}}{\text{IHP}} = .63$ to .45.

The Admiralty coefficient of propulsion which is expressed as follows $C = \frac{W^{\frac{2}{3}} V^3}{P}$ is used to obtain the total indicated horse power required to propel a vessel at a given speed.

The total power required may be found by substituting the proper value for the coefficient in the formula $P = \frac{W^{\frac{2}{3}} V^3}{C}$.

The following table gives possible values for the admiralty coefficient c:—

Length.	Coefficient.	L.	c.	L.	c.
100	137	350	289	650	315
150	188	400	297	700	217
200	277	450	303	750	319
250	255	500	307	800	321
300	275	550	310	850	323
		600	312		

The values given in the above table apply to reciprocating machinery. For turbine propulsion the values of c are about 16% less than those given in the table.

A rough approximation to the relation between Speed and Indicated Horse Power may be expressed as follows

$$\text{I.H.P.} = \frac{S}{100} \times \left(\frac{V}{10}\right)^3 f$$

where S = wetted surface in square feet.
V = speed in knots.
f = a coefficient which varies from 5 to 7 for ordinary vessels.

The Design and Construction of a Steel Vessel.

Before the construction of a vessel is commenced, the general drawings, as well as certain detail drawings should be prepared.

The most important drawing, and in fact the drawing upon which all details of the hull are founded, is called the sheer draft, or lines of the vessel. This drawing consists of the representation of the following lines:—

1. The water lines or intersections of the hull by planes parallel to the load water line plane.

2. The cross-sections or intersections of the hull by transverse vertical planes.

3. The buttocks and bow lines or intesections of the surface of the hull by longitudinal vertical planes.

4. The diagonals or the intersection of the surface of the hull by longitudinal planes inclined to the horizontal.

· These lines are represented by their orthographic projections on the three following planes:—

1. A horizontal plane.

2. A vertical plane parallel to the longitudinal axis of the vessel.

3. A second vertical plane at right angles to the others.

In drawing the "lines" for a ship the following conditions must be complied with:—

(a) The displacement as calculated from the lines must equal the total weight of the vessel.

(b) The position of the centre of buoyancy as calculated must be in the same vertical line as the centre of gravity of the ship.

(c) The transverse metacentre must be a sufficient distance above the centre of gravity to insure safety without being so high as to cause violent rolling when subjected to the action of waves.

(d) The lines must be "fair"—that is, they must be so that the surface of the vessel will have no irregular hills or hollows.

The process of correcting the "lines" to conform to the requirements is known as "fairing" the lines. It is a fairly tedious process, and is carried out by the method of trial and error.

When the lines of a vessel are faired on a small scale drawing they must be copied full size upon the mould loft floor and carefully "faired."

The information necessary for laying off the lines on the loft floor is furnished to the loftsmen in the form of a table called the table of bodies. This table contains all necessary dimensions arranged in the most convenient form for reference.

When the lines are faired on the loft floor the next thing to do is to make what is known as a scrieve board. This consists of a floor or platform made of fairly good tongue and grooved flooring. This is in fact a large drafting board, on which the cross-sections of the vessel are drawn full size. All the lines on a scrieve board are cut or scrieved well into the board, so as to render them sufficiently permanent.

The following information must be placed on the scrieve board: The moulded shape (shape inside plating) of every frame, the positions of all shell plating edges, longitudinal stringers, decks, and everything that comes in contact with the framing of the vessel.

The scrieve board is placed in a convenient position for the furnace and platform men to refer to when turning (bending and bevelling) the frames.

Turning the Frames.

The main transverse frames of a vessel are usually of angle, bulb angle or channel section, and must be of very mild open hearth steel. Ordinary structural steel is difficult to work, and the frames are often injured while being adjusted to shape after cooling when made of hard material.

The frames are first brought to a white heat in a specially constructed furnace and then bent around a thin strip of metal which has been previously brought to the right shape and fastened by suitable dogs to the iron-bending slabs. The bevelling is done at the same time, the bevels being lifted from the scrieve board.

Lifting the bevels is a very simple matter, because the bevel of a frame at any given point is directly proportional to the distance between its projection on the scrieve board and the corresponding projection of the next frame to it. For example, if the frames in the ship be spaced 24 inches apart and the distance from a point on a frame to the nearest point on another frame, which is one space nearer the midship section, be 2 inches, the bevel of the frame at that point must be 2 in 24, or 1 in 12.

As soon as the frames, keel, stem and stern frames are completed in the shop the framing of the vessel may be set up.

A great deal of the plating of the vessel, such as bulkheads, decks and steel deck houses, may be laid out from the mould loft and scrieve board, but the only satisfactory method of plating the outside of the hull is by the templet system. The plating lines are all marked on the frames from the scrieve board, and these lines are the guides for the shell templets.

The templets for laying of the shell plates are made of thin soft lumber in strips ranging in width from 4 inches upward, and of about ¼ inch in thickness. A skeleton templet is built up in such a way that a strip of wood will cover each endge of the plate and also every frame in contact with the plate. This templet is placed in contact with the frames and the holes are marked by means of white lead. The templet is then transferred to the proper plate and the holes marked off.

In ordering the shell plating for a vessel it is usual to make a block model of one-half the ship, and draw the plating right on the model. The plates may then be traced on paper and measured.

The plating of a vessel may be arranged in three different ways.

The first and simplest method is to have all seams, both transverse and longitudinal, lap joints. This is the usual practice in the case of tugs and freighters.

The second method is to have the longitudinal seams lap and the transverse seams butt joints. This is the usual practice in the case of passenger steamers and yachts.

The third method is to have all seams butt joints. This method makes the outside surface of the vessel smooth and all seams invisible. It is, however very rarely restorted to on account of the expense involved in planing all edges of plates to an exact lines and the additional riveting required.

The plating of a vessel is rendered watertight by caulking the seams between the plates. from the outside. It is not usual to caulk the butt straps or the inside edges of the plates.

When the hull of a vessel is completey plated, caulked and painted and all underwater portions of the machinery and fittings are in place the vessel is ready for launching.

INTERNATIONAL ENGINEERING CONGRESS, 1915.

September 20-25, San Francisco, Cal., U.S.A.

Volume IV. of the transactions of the Congress will comprise an important series of papers on the general subject of Railways and Railway Engineering. This field will be treated under seven principal topics covering relation of railways to social development; present status of railways; economic factors governing building of new lines; location; physical characteristics of road, including track and roadbed; bridges; tunnels; terminals; construction methods; signals; road equipment, including motive power other than electric; rolling stock in general; floating equipment; electric motive power in general.

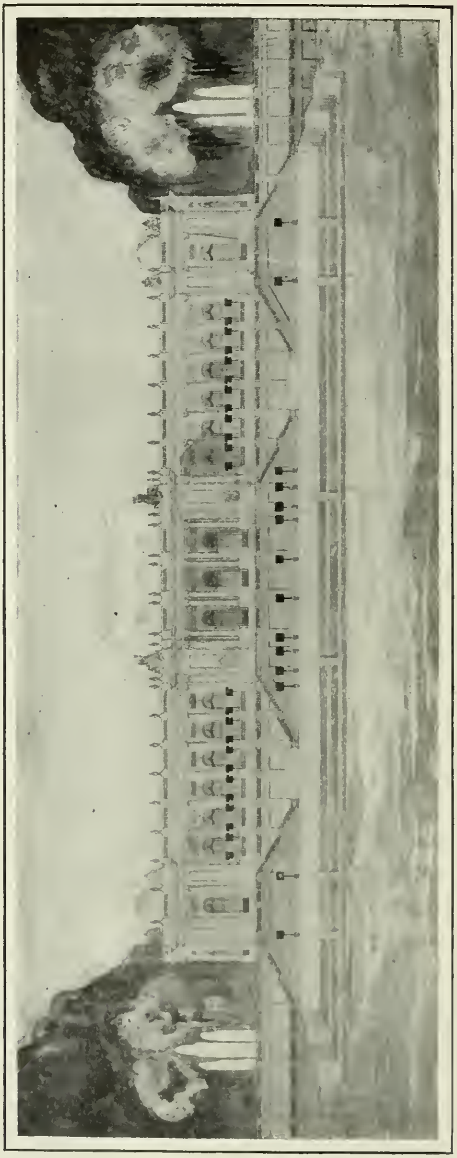
Approximately 27 papers are expected for this volume, prepared by authors representing 9 different countries. The list of authors includes many of the most eminent names in this field of engineering work throughout the world.

The volume as a whole will be illustrated with charts, diagrams and half-tones, together with discussions contributed by leading American and foreign engineers, and will form a most valuable acquisition to the library of all engineers and others who may be interested in these phases of engineering work.

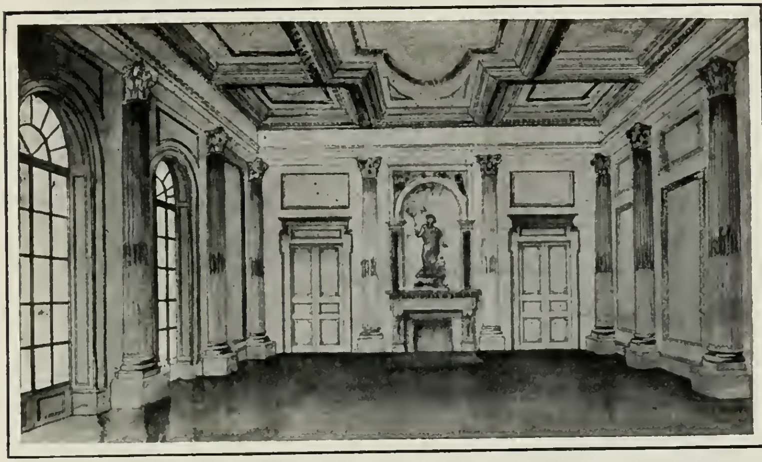
The transactions of the Congress as a whole will include nine or ten other volumes, covering the various fields of engineering work.

Membership in the Congress with the privilege of purchasing any or all of the volumes of the proceedings is open to all interested in engineering work. Those interested may secure fuller information from the Secretary, Mr. W. A. Cattell, 417 Foxcroft Building, San Francisco, Cal.

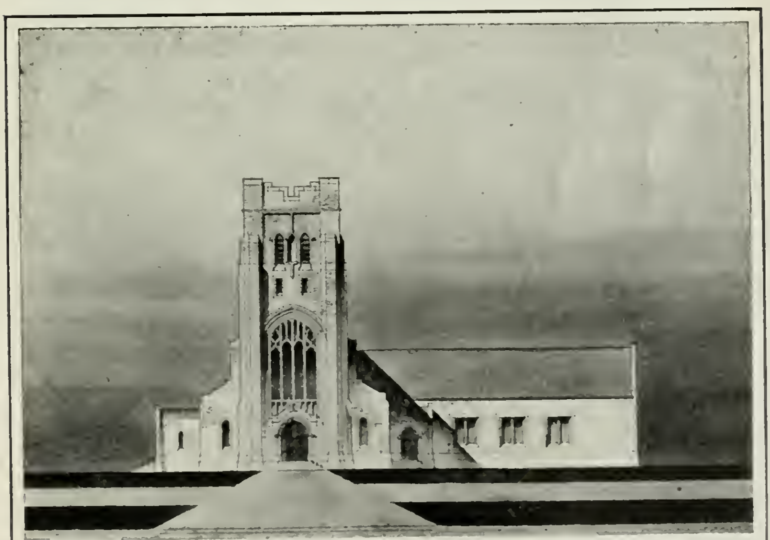
H. S. Clark, B.A.Sc., '10, who was previously engaged on the Welland Ship Canal construction, has been on military duty with the frontier guard at Niagara Falls, Ont., since August until recently, when he received a lieutenancy in the 36th Battalion of the Third Contingent. He is now at regimental headquarters, Hamilton, Ont.



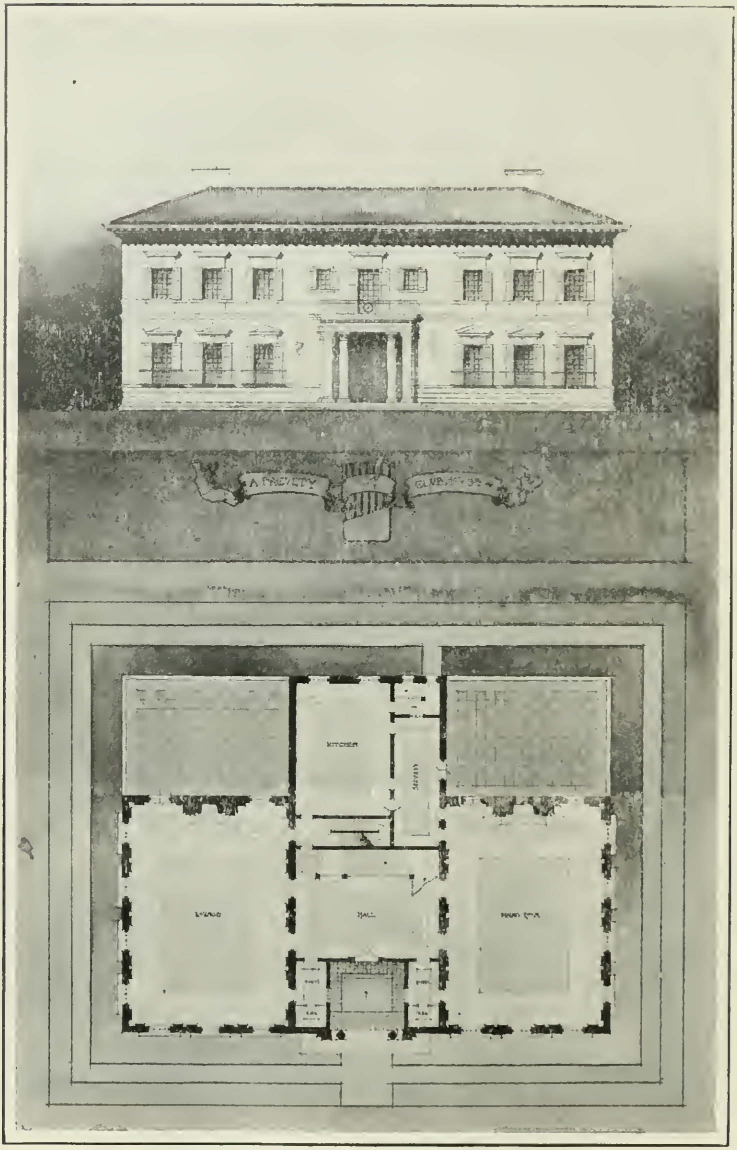
A CASINO.—K. C. Burness, 4th year.



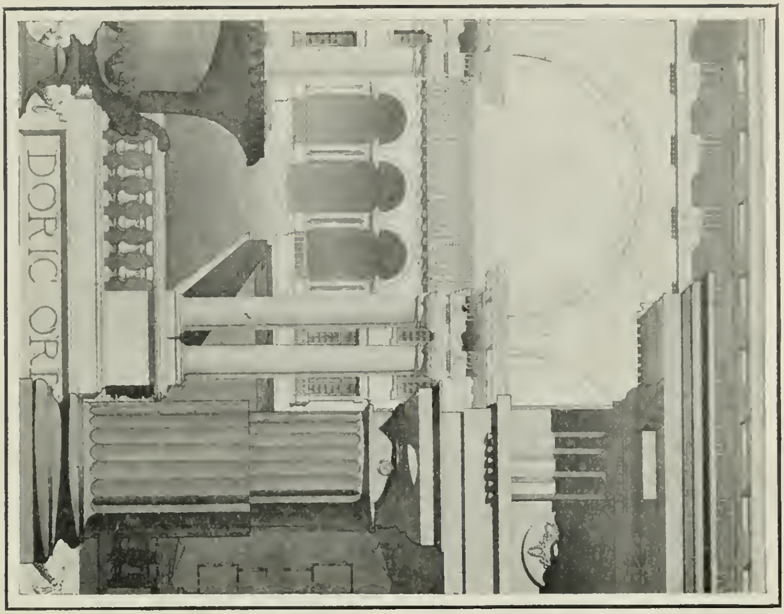
A STATE DINING ROOM.—W. S. Kidd, 3rd year.



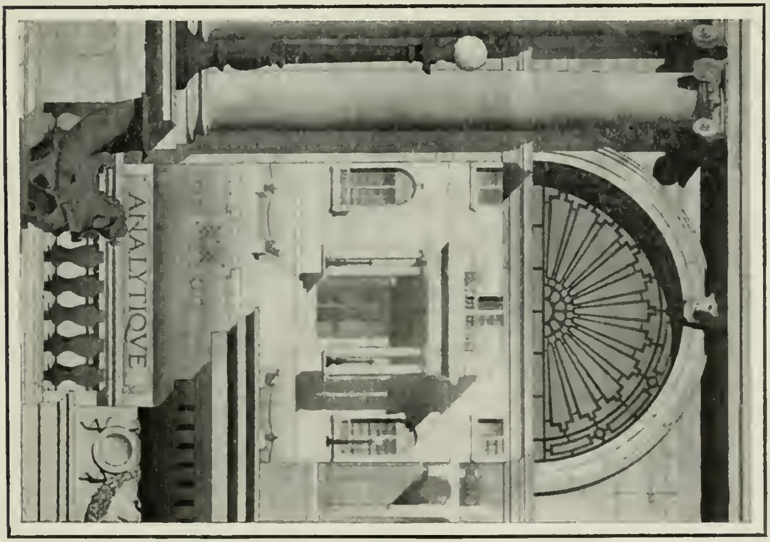
A VILLAGE CHURCH.—J. L. Skinner, 3rd year.



A FACULTY CLUB. C. C. Thompson, 2nd year.



DORIC ORDER.—G. R. Gounlock, 1st year.



ENTRANCE TO A CITY RESIDENCE.—O. H. McAvoy, 1st year.

ARCHITECTURAL CLUB EXHIBIT.

The Architectural Club of the University of Toronto Engineering Society, under the leadership of Chairman T. S. Graham, '15, and Vice-Chraiman K. C. Burness, '15, has, during the past year, enjoyed an unusually active and successful term. The third annual exhibit, which was held in Convocation Hall on March 29, 30 and 31, was the most complete and encouraging exhibit of this nature which the club has yet conducted. In addition to the more elaborate designs, it included a good display of freehand drawings and clay modelling.

A distinctive feature was the Dominion Government Power House Competition, for which first, second and third prizes of $25.00, $15.00 and $10.00 respectively, were awarded by the Water Power Branch, Department of Interior, Ottawa. First prize was awarded to H. R. Watson, '17, second prize to G. R. Edwards, '15, and third prize to H. J. Burden, '15.

About three thousand visitors, including a large representation of the profession from down town, attended the exhibit, and considerable surprise and pleasure was voiced at the high standard of the work, especially that of the junior years.

A few cuts appear in this number of "Applied Science," illustrating the work of the different years. Additional illustrations will be shown in future numbers, as we believe that our readers will be interested in the work which is being carried on by this section of the Engineering Society.

---

*INTERESTING ITEMS IN THE GROWTH OF THE STUDY OF APPLIED SCIENCE.

In seeking for the origin of the Faculty of Applied Science we must go back to Prince Albert, Consort of Queen Victoria.

That wise and good prince, deeply convinced of the benefits to be derived from the application of science to the problems of industry, exerted himself to arouse in the people of Great Britain a sense of the value of Applied Science. The first fruit of his labors was the great Exhibition of 1851, planned by him to demonstrate the advantage of science to the arts and the mutual benefits of commerce among the nations.

The Exhibition was followed by a great awakening of interest in Applied Science, which led in England to the manifold activities which are associated with the words "South Kensington." Prince Albert was not only an enlightened statesman; he was also an affectionate and careful father, and he spared no pains to fit

*Extracts from remarks of Dr. Ellis, at Engineering Society Dinner, Feb. 1915.

his children for their exalted destiny by giving them what he considered to be the best education in his power. Educated at Bonn, he had a high opinion of the value of chemistry, and a great respect for Liebig, and he secured a pupil of Liebig, Dr. Lyon Playfair, afterwards Baron Playfair of St. Andrews, the only chemist so far as I know who ever became a Cabinet Minister, as tutor for his son, his late Majesty Edward VII. Lord Playfair told me that on one occasion he took his royal pupil to visit a certain foundry. The foreman, who was showing them over the works, plunged his hand into a crucible of molten metal and withdrew it unscathed. The Prince was greatly interested in the experiment, and asked to repeat it on his own person. On Mr. Playfair enquiring of the foreman if it would be quite safe, the foreman asked leave to feel the Prince's hand, and having done so, replied that it would be quite safe, as the royal hand was just right, neither too damp nor too dry. On receiving permission, the Prince, without hesitation, performed the experiment with perfect success.

Prince Albert's eldest daughter was the Crown Princess of Prussia, the mother of the present Kaiser. She inherited a large measure of her father's ability and character, and she did her best to instil into the mind of her son the liberal principles of her father. Unfortunately, there were other influences brought to bear upon him which proved too strong for her. When he plunged his hand into the seething crucible of world politics, it was not the cool, calm hand of faith and reason, but the mailed fist of passion and the lust of power, and the explosion caused by that experiment has set the world ablaze.

The interest aroused in England in 1851 took about twenty years to reach Canada. In 1871 Mr. John Sandfield Macdonald, then Premier of Ontario, proposed the establishment of a College of Technology. The Government bought the Mechanics' Institute building at the corner of Church and Adelaide Streets, and fitted it up for this purpose. There were at that time in the Parliament of Ontario a number of brilliant University men ,such as Edward Blake, afterwards Chancellor of the University; Thomas Moss, afterwards Chief Justice and Vice-Chancellor of the University, and Adam Crooks, afterwards Minister of Education. These men viewed the proposed College of Technology with grave misgiving as a step in the wrong direction, and advocated, both on the score of economy and efficiency, the teaching of Applied Science by the Provincial University, strengthened where necessary by additional chairs and additional equipment maintained by the public funds.

When Sandfield Macdonald's government was defeated and Alexander Mackenzie came into power, Adam Crooks became Minister of Education, and a scheme was prepared for carrying out technical education in accordance with the views of himself and his advisors.

The name "College of Technology" was changed to "School of Practical Science," and a building that is now known as the Engineering Building was erected on University property, where laboratories were equipped for the teaching of science open to students of the University and of the School of Practical Science alike.

Under Sir George Ross as Minister of Education in 1889 the University Federation Act came into force, a University teaching staff was appointed and University labortories were equipped.

The School of Practical Science was separated and became an affiliated college, with Dr. John Galbraith as Principal.

Finally the University Act of 1906 formally united the School of Practical Science with the University, as its Faculty of Applied Science and Engineering, a position which it has virtually held since 1878.

EXTRACTS FROM REMARKS OF REV. DAVID M. STEELE AT A DINNER OF THE ALUMNI OF THE RENSSELAER POLYTECHNIC INSTITUTE.

Four things seem to me to mark students and faculty alike of an institution such as this. These qualities go far to mark the men in your profession even after they are out of school. All four of them are illustrated tonight in multiples of one hundred. I note here the characteristics of industry, accuracy, modesty and courage.

Industry: Of all the hard-working members of the student body of this country, I am willing to grant that your students are the most nearly overworked; while, of all the men who keep on being students after they are out of college, you men probably study the hardest. One reason for this is that your very calling requires you to think clearly—and that never was easy.

Accuracy: I feel perfectly that there is no other group of men busy at any occupation in this country, whose very business calls them to deal so in accuracies and to speak in niceties. This in the end cannot help but beget the faculty of telling the truth. And this is needed, for how few there are who have the saving grace of veracity! But you have it. And it is a saving grace: for the comment is as apt to-day as when Falstaff first made it: "Lord, how this world is given to lying!"

Modesty: Your modesty is due to the fact, not that you know so little, but that, knowing so much, you know best that there is so much more to learn. Like Sir Isaac Newton, the more you know the more you feel yourselves like children picking up pebbles on the shore of the infinite sea of knowledge, yet unknown.

Courage: Your fourth characteristic is courage, but it is of a special kind—the courage of the mind. There was a time when men built their knowledge upon their opinions and made to be a test of truth the question whether they wanted to believe so and so. You have taught them to reverse all that entirely. Your method is the opposite of my friend's, who said to me one day, he being a newspaper reporter: "Tell me what you want to prove and I will send you the statistics." You begin by saying: "What are the statistics? Let me have them first, and I will stand by what they prove." And it is safe to do this; for the universe of God is fireproof: if you are in the search of truth any time and cannot find it for the dark, it is safe anywhere to strike a match.

Being thus industrious in your work, accurate in your thinking, modest in your attitude toward knowledge and frank and fearless in facing facts in the search for truth, you are needed in this country in this generation. You are needed in politics; you are needed in religion, you are needed in society; you are needed in the realm of finance; you are needed in the realm of finance; you are needed in the field of morals. To quote a passage from the ancient story from the book of Esther, "Who can tell?" saith the Scripture, "Who can tell but that thou art come into the kingdom for just such time as this?"

THESES FOR DEGREE OF B.A.Sc.

The following is a complete list of theses presented by men of the fourth year for the degree of Bachelor of Applied Science. The bracketed figures following each name designates the course the candidate is following, thus: (1) Civil Engineering; (2) Mining Engineering; (3) Mechanical Engineering; (4) Architecture; (5) Analytical and Applied Chemistry; (6) Chemical Engineering; (7) Electrical Engineering; (8) Metallurgical Engineering.

Candidate.	Title of Thesis.
Adlard, L. S. (1)........	Water Purification.
Anderson, A. C. (1)......	Concrete Arch Dams.
Arksey, G.A. (1)........	Breakwaters Built in Open Water.
Arthur, R. M. (2)........	Roasting and Sulphuric Acid Leaching of Eustis Copper Ore.
Austin, F. D. (1)........	Chemical Purification of Water Supplies.
Ball, W. V. (7)..........	Comparison of Steam and Electrical Locomotives.
Banbury, T. R. (7).......	Step-up Transformer Stations.
Beacock, V. A. (7)......	Speed Control of Alternating Current Motors.
Bennett, P. (1).........	Concrete Roads.
Birrell, A. L. (7	High Tension Power Protection Appliances.

Black, H. M. (7).........Application of D. C. Motors to Rolling Mill Drive.
Blackwell, R. H. H. (1)...Pile Foundations.
Bonus, W. H. (7)........The Electrification of a Railway Terminus.
Breithaupt, J. E. (6).....The Manufacture of Leather.
Brouse, E. D. G. (1)......Investigation of a Watershed for Power Purposes.
Brown, L. R. (1).........Reinforced Concrete as Applied to Sewers and Sewage Disposal.
Buchanan, F. M. (1).....The Use of Bitumen as a Paving Material.
Budd, H. C. (7)..........Electrification of Steam Railroads.
Burden, H. J. (4)........An Up-town Hotel in a Large City.
Burness, K. C. (4).......Civic Planning in Canada.
Carmichael, F. N. D. (1)..Dipper Dredging.
Catto, R. W. (4).........A Gentlemen's Country Club.
Chandler, F. H. (7)......Protection of High Tension Circuits Against Static Stresses.
Christner, J. C. (1)......Concrete Piling.
Cockburn, R. M. (1).....Measurement and Computation of Flow in Streams.
Code, W. W. (7).........Single Phase Railway System.
Cook, J. D. (1)..........Concrete Abutments.
Crealock, A. B. (1)......Commercial Dock Design.
Da Costa. W. R. (1)......Water Purification.
Daniel, N. H. (1)........Grade Separation.
Davey, C. G. (3).........The Four-Cycle Gasoline Motor.
Davidson, G. P. (7)......Synchronous Converters.
Davidson, J. J. (4)......Canadian Government Building in London, Eng.
Dean, W. A. (7).........Mercury Arc Rectifiers.
Deverall, E. V. (1)......Methods of Reducing the Fire Hazard in Buildings.
Dibblee, J. (7)..........Automatic Voltage Regulation.
Dickson, W. L. (1).......Concrete as Applied to Road Building.
Downey, G. A. (1).......A Scheme for Provincial Highway Development with Special Reference to Ontario.
Edwards, G. R. (4)......A Gothic Church.
Elliot, R. V. (7).........Electric Furnace Electrodes.
Emmerson E,.R. (2).....The Hydrometallurgy of Stibnite Ores.
Evans, A. C. (1).........Plane Table and Stadia Topography. (Methods of U. S. and Canadian Geological Surveys.)
Falconer, H. S. (1).......Hydrographic Surveying—Soundings.
Flannery, D. T. (7)......Oil Circuit Breakers.
Ford, J. W. H. (1).......Reinforced Concrete Arch Bridges.
Fraser, W. R. (1)........Retaining Walls.

French, W. G. (1) .... Dry-dock Construction in Canada.
Frid, H. P. (4) .... Efficiency in Building Construction.
Fulton, W. J. (1) .... Retaining Walls.
Galbraith, R. D. (1)...... Pneumatic Caisson Practice.
Geale, C. N. (1) .... Purification of Public Water Supplies.
Glass, L. G. (6) .... Oxidation of Ammonium Sulphite to Ammonium Sulphate.
Gooderham, [illegible] (1) .... The Value of Concrete Construction as Applied to Fire-resisting Structures.
Gould, W. H. R. (7) ...... Developments in Hydraulic Turbines.
Graham, T. S. (4) .... Office Building—Eight to Ten Stories.
Grange, E. [illegible] (1) .... Reinforced Concrete Floors.
Gray, E. D. (1) .... Silica as an Effective Road Binder.
Gray, G. [illegible] (7) .... Drainage of Agricultural Lands.
Gray, J. [illegible] .... Steam Boilers.
Griffiths, G. E. (7) .... Power Factor Correction and Voltage Regulation by Synchronous Machines.
Haas, M. S. (2) .... Cupellation Losses in Silver Assaying.
Halford, D. S. (2) .... A Flotation Treatment of Gold Ores from Porcupine.
Hall, W. T. (2) .... The Cyanide Treatment of Porcupine Gold Ores.
Hanlon, J. E. (2) .... So[illegible] f "Pyritic Smelting."
Hayward, C. (1) .... Sewage Disposal for Suburban Districts.
Higgins, L. T. (2) .... A Study of Certain Aluminium-zinc Alloys.
Hogarth, C. E. (1) .... Caisson Construction for Foundations.
Ireland, T. P. (7) .... Electric Locomotives.
Ironside, A. G. (7) .... The Single Phase Railway System.
Jackson, C. W. H. (1).... Treatment and Utilization of Woollen Mill Waste.
Jefferson, K. A. (7) ...... Development of Power Plants from Storage Reservoirs.
Johnston, G. W. F. (1) ... Grade Separation.
Jones, C. M. (7) .... Induction Motors—Their Design and Commercial Applications.
Jones, R. D. (2) .... The Function of Time and the Influence of Grain Sizing on the Vitrification of Clay.
Jupp, E. H. (1) .... Water Purification for Public Use.
Keys, C. R. (7) .... Lightning and Static Arresters.
Kohl, H. (5) .... The Manufacture and Uses of Sodium Sulphite.
Laidlaw, R. E. (1) .... Sewage Sludge Disposal and Utilization.
Lamb, G. J. (1) .... Gauging of Large Rivers.
Lawrence, G. W. 7) ...... Protection Relays.
Leach, H. O. [illegible] .... The Sanitary Disposal of Refuse.
Lloyd, R. H. (3) .... Steam Turbines.

Lockhart, W. E. (1).....Railway Ballasting.
Longworthy, W. E. (1)...The Reinforced Concrete Arch.
Lount, C. T. (1).........Drainage Problems in Saskatchewan.
Lye, R. G. (1)...........Pile Foundations.
Macdonald, C.A. (1).....Municipal Water Supplies.
Macdonell, I. M. (2)......An Examination of Certain Zinc-Aluminium Alloys.
Macpherson, H. E. (1)...Reinforced Concrete Floors.
McCaffrey, W. R. (1)....Purification of Water by Ozone.
McCort, C. R. (1)........Breakwaters.
McDonald, K. D. (1).....Photographic Surveying.
McDonald, J. P. (1).....Cofferdams.
McGie, W. R. (3)........Balancing of Petrol Engines as Applied to Motor Vehicle Types.
McGugan, D. F. (1)......Irrigation.
McIntyre, J. S. (7).......Single Phase Alternating Current Distribution from Station to Consumer.
McKague, E.V. (1)......Docks, Breakwaters and Retainage Pertaining to Harbor Development.
Martin, E. T. (7)........Synchronous Motors.
Meitz, W. H. (1)........Tunnelling (Railways).
Mills, F. L. (2)..........Some Phases of Pyritic Smelting.
Mitchell, G. (1).........Earthen Dams and Embankments for Reservoirs.
Mogan, J. T. (1).........Subaqueous Construction.
Monteith, E. M. (7)......Electric Mine Hoists.
Morris, A. (4)...........Group of Modern Farm Buildings.
Morris, B. M. (1)........Cast-and-Driven Concrete Piles.
Morris, W. D. (5)........Chemistry of Foods.
Muir, J. M. (2)..........The Function of Time and the Influence of Grain Sizing on the Vitrification of Clays.
Neilson, M. A. (1).......Concrete Highway Bridges.
Nicklin, H. S. (1).........Percolating Filters.
O'Connor, E. B. (1)......Concrete Roadways.
Omand, W. M. (1).......Subaqueous Foundations for Bridges.
Paul, R. A. (1)..........The Economic Value of Fireproof Building Construction.
Payne, A. N. (3).........Mechanical Refrigeration: The Ammonia Compression System and Its Application to the Manufacture of Artificial Ice.
Pearce, L. P. (1).........The Scientific Treatment of Sewage by Sprinkling Filters.
Peck, H. M. (1)..........Topographic Surveying.
Peterkin, S. M. (1).......Highway Construction and Maintenance.
Porter, C. F. (1).........Concrete Road.
Porter, J. E. (1).........Typical Breakwaters, referring particularly to Freshwater Types.

Powell, W.D. (2)........Comparison of Agitation, Frothing and Bubble Box Methods.

Purdy, W. F. P. (7)......Interurban Railways.

Raley, W. E. (1).........Concrete Building Foundations on Earth.

Rance, C. C. (1).........Rural Highways. ....

Rankin, G. (1)...........Failures in Reinforced Concrete Building Construction.

Redman, W. B. (1)......Reinforced Concrete Docks.

Reid, F. G. (3)..........Engineering Details Concerning the Installation and Operation of "Taylor System."

Relyea, P. J. (6).........The Manufacture of Barium Salts.

Richardson, A. A. (1)....Earthen Dams.

Robertson, A. S. (3).....Subaqueous Concrete Construction.

Rose, J. T. (1)...........Public Water Supply—Purification of Water by Sedimentation and Filtration.

Ross, A. C. (7)..........Outdoor Transformer and Switching Stations.

Ross, J. (2).............Roasting and Leaching of Eustis Copper Ore, with Sulphuric Acid.

Rowe, H. M. (1).........The New Welland Ship Canal and the Proposed Georgian Bay Canal—A Discussion of the Respective Merits and Engineering Difficulties of the Two Routes.

Russell, W. E. (7).......Voltage Regulation.

Rutter, G. W. (4)........A War Memorial.

Ryan, W. . (7)...........The Relative Cost of Electrical Power as Generated by Steam and Water Power Plants.

Savage, E. W. (7).......Protection from Lightning.

Scott, A. G. (7)..........The Storage Battery as a Factor in Central Station Control.

Scott, E. H. (1)..........Construction of Railway Culverts.

Scott, R. G. (1)..........Topographical Surveying.

Seymour, N. F. (7).......Circuit Opening Devices for the Protection of Electric Circuits and Machinery.

Shaw, J. H. (1).........Irrigation.

Sheehy, J. S. (1)........Concrete Dam Construction.

Shier, W. G. (3).........The Steam Turbine and Its Accessories.

Simpson, C. N. (1).......Water Purification.

Sinclair, R. B. (1).......Tunnelling.

Smyth, A. H. (3)........The Application of Engineering to the Management of a Woodworking Plant.

Steel, W. A. (7).........Polyphase Metering.

Stitt, J. B. (2)..........An Assay Method for the Gold Silver Tellurium Ores of Kirkland Lake.
Stone, J. D. (3)..Recent Improvements in Locomotives.
Storey, G. C. (7).........Power Measurement in Three-Phase Circuits.
Stroud, J. E. C. (2)......The Electro-Analysis of Zinc.
Suhler, A. N. (7)........Motor Control.
Taylor, A. N. (7).......High Power Lamps.
Thompson, H. B. (1).....The Structural Design of Office Buildings.
Tillson, G. D. (3).......The Cupola Furnace.
Tillson, L. B. (1)........Measurement of River Discharge.
Tom, J. A. (1)..........Modern Methods of Water Purification, with Special Notes on the Ultra Violet Ray.
Uffelmann, W. (5).......The Manufacture of Gasoline.
Vezina, A. L. (7)........The Construction and Maintenance of Macadam Roads.
Ward, A. L. (7).........Commutation.
Weir, F. E. (1)..........The Use of Concrete in Piling.
West, C. W. (1).........The Canalization of Rivers (with special reference to the Trent Canal).
Williams, J. N. (1)......Timber Piling.
Wilson, J. C. (1)........Metallic Roofing.
Wood, H. A. (1).........Docks, Breakwaters and Retention Work, as Applied to Harbor Development.
Wyman, H. K. (7).......Automatic Protection of High-Voltage Systems.

T. A. McElhanney, B.A.Sc., '10, is a member of McElhanney Bros., civil engineers and land surveyors, Dominion Trust Building, Vancouver, B.C.

N. D. Seaton, B.A.Sc., '11, is at Timmins, Ont., with the Northern Canada Power Company.

M. R. Shaw, B.A.Sc., '09, is assistant secretary and chief chemist for the Export Oil Corporation at Waggaman, La.

J. M. McGregor, '08, is a member of the firm, McCubbin & McGregor, surveyors and engineers, Chatham, Ont.

W. K. Thompson, B.A.Sc., '13, is technical clerk in the Land Patents Branch, Department of Interior, Ottawa.

G. A. Warrington, B.A.Sc., '10, is employed in the Department of Public Works of Manitoba, Winnipeg, Man.

T. G. Gravely, B.A.Sc., '11, is at present on the editorial staff of "The Globe," Toronto.

E. C. R. Stoneman, B.A.Sc., '14, is assistant power engineer, Bell Telephone Company of Canada, Montreal, P.Q.

APPLIED SCIENCE

INCORPORATED WITH

Transactions of the University of Toronto Engineering Society

DEVOTED TO THE INTERESTS OF ENGINEERING, ARCHITECTURE AND APPLIED CHEMISTRY AT THE UNIVERSITY OF TORONTO

Published every month in the year by the University of Toronto Engineering Society

Subscription Rates

Per year, in advance	$2.00
Single copies	.20

Advertising rates on application.

Address all communications;

Applied Science,
Engineering Bldg., University of Toronto,
Toronto, Ont.

EDITORIAL

We beg to call the attention of our readers to the fact that after May 1st, 1915, the duties of Editor of "Applied Science" and Secretary of the Engineering Society will be assumed by Russel G. Lye, '15. We believe that the graduates will give Mr. Lye unstinted support in carrying on the work of the Society, as it is very desirable that each one should do his share, especially at the present time. It is a difficult task to keep correct records of all the "School" men, in view of the fact that the nature of their work necessitates frequent changes of addresses. We would ask every man to keep the Secretary well informed of his address and occupation, and also send in any items of news which would be of interest to his fellow alumni.

Furthermore, we know that some of our graduates who are among the most loyal of "School" men, do not realize the present necessity of concrete as well as moral support. The number of our graduates has increased to such an extent that the Engineering Society finds the publication of "Applied Science" to be a heavy burden. We do not believe that any graduate wishes the entire load to fall upon the student members of the Society. This contention is borne out by the fact that most of the graduate member have readily assumed their share of the responsibility, but we aim to have every "School" man an active participant in the work of the "School" men.

A few months ago a personal letter was sent to each of our readers, with a view to soliciting their co-operation. The response has been very encouraging, and we trust that the remaining few will do their share to maintain the esprit de corps of the "School" by helping to keep "Applied Science" among all the graduates, and so strengthen the bond which unites "School" men.

The following 'School" men have enlisted with the Canadian Overseas Railway Construction Corps for service in France and Belgium: J. A. Tilston, '14, W. G. French, '15, R. R. Hewson, '15. We understand that this corps has gone to West St. John for a month or more of training.

The following "School" men have enlisted with the Second Canadian Contingent, in addition to those previously mentioned in "Applied Science": N. A. Burwash, '03, with the Engineers; B. H. Segre, with 4th Bde., 13th Bn.; R. L. Junkin, '13, with the Engineers; C. R. Avery, '13, with 4th Bde., 13th Bn.; T. F. Howlett, '13, with the Engineers; N. F. Parkinson, with 4th Bde., 13th Bn.; H. Webster, '13, with 4th Bde., 13th Bn.; H. J. Burden, '15, with Mississauga Horse; W. E. Raley, '15, with the Engineers; W. D. Powell, '15, with the Engineers; T. A. Daniel, '16; J. S. Wilson, '16; T. E. Armstrong, '16; H. S. Gooderham, '18, with 20th Bn.; H. Stewart, '16, with Machine Gun Section, 20th Bn.; W. H. R. Gould, with Second Divisional Cycle Corps; W. F. Hadley, '15, with the Corps of Guides; T. L. Harling, '18, with the Mounted Rifles; T. B. Jack, '18; A. P. Maclean, '17; J. S. M. Wallace, '17, with 25th Battery, C.F.A.

The following men have enlisted with the Third Contingent: F. R. Allan, '18, with the Machine Gun Detachment, 35th Bn.; A. M. Thomas, '16, with Company No. 2, 35th Bn.; C. H. Wheelock, with Machine Gun Detachment, 35th Bn.; A. G. Scott, '15, with 42nd Regiment, Petawawa, Ont.

Lieut. M. S. Haas, '15, is on duty, Toronto Civic Guard, Island Post.

R. D. Galbraith, '15, and Lieut. E. V. McKague, '15, are taking a course at the Royal School of Cavalry, Stanley Barracks, Toronto.

S. A. Lang, B.A.Sc., '14, who went to Chile a year ago with the Braden Copper Company at Rancagua, has recently been promoted to head of the sampling department.

J. A. D. McCurdy, '07, will be in charge of a new aviation school at the Long Branch Rifle Ranges. Mr. McCurdy's flying school, which has recently been established by the Department of Naval Service, will be a training school for recruits for the Royal Naval Air Service. Mr. McCurdy is one of the best known aviators on this continent. His flight from Key West to Cuba about four years ago created much interest, and he has the distinction of being the first aviator to dispatch a wireless message from an aeroplane. A number of "School" men have already sent in their applications to join this corps.

TROPHY FOR PUBLIC SPEAKING

Presented to the Engineering Society by a number of graduates.

R. W. Soper, B.A.Sc., '13, has a private practice as architect at 168 Front St., Sarnia, Ont.

J. A. Coombs, '13, is employed on the construction of the Federal Railway of the United States, in Alaska.

B. W. Waugh, B.A.Sc., '08, recently returned to Ottawa, after completing a base line survey at Port Nelson, Hudson Bay, for the Dominion Department of Interior.

E. R. Gray, B.A.Sc., '13, formerly Division Engineer, Sewer Department, City Hall, Toronto, has recently received an appointment as assistant city engineer of Hamilton, Ontario.

F. T. McPherson, '15, was elected president of a recently established engineering society in Saskatoon, Sask.

C. S. Cameron, '11, has a practiee as Dominion and Saskatchewan Land Surveyor, at the Merchants Bank Building, Searth St., Regina.

MARRIAGES.

Cory—Telfer.

On April 10th, 1915, the marriage was solemnized at St. Thomas' Church, London, England, of R. Y. Cory, B.A.Sc., '08, Captain, 15th Battalion (48th Highlanders), 3rd Brigade, First Canadian Contingent, British Expeditionary Force, of 5 Deer Park Crescent, Toronto, to Miss Beatrice Edna Telfer, of Collingwood, Ont.

Nourse—Webster.

On April 10th, 1915, Mr. A. E. Nourse, B.A.Sc., '07, of Toronto, was united in marriage to Miss Kate Augusta De Neville Webster, of Toronto.

Curzon—Banks.

On Wednesday, April 14th, 1915, Mr. J. H. Curzon, '11, of the staff of the Main Drainage Department, City Hall, Toronto, was married to Miss Alva Banks, daughter of Mr. and Mrs. John L. Banks, 178 Kingston, Road, Toronto. Mr. and Mrs. Curzon left on a trip to New York and other points in the United States.

DIRECTORY OF THE ALUMNI.

Corbould, C. E. B., '14, is in the Engineering Department, Hydrographic Survey Branch, Department of Interior, Nelson, B.C.

Cory, R. Y., '08, is captain with 15th Battalion, 3rd Brigade, First Canadian Contingent, France.

Coulter, G. P., '07. We do not know his address.

Coulson, C. L., '03. His home is in Welland, Ont. We do not know the nature of his professional work.

Cousins, E. L., '06, Harbor Engineer for the city of Toronto, has been allowed eight or nine months of leave of absence to undertake the preparation of plans for a system of radials and radial entrances for the city.

Coultard, R. W., '99, is associate editor, "Mine, Quarry and Derrick," Calgary, Alta.

Conmans, O. F., '11, is Provincial Drainage Engineer, Regina, for the Saskatchewan Government.

Courtice, E. D. W., '14, is with the Waterworks Department, city of Toronto.

Cowan, W. A., '04, of Truro, N.S., is resident engineer for the Intercolonial Railway.

Cowper, G. C., '07. His home is in Welland, Ont. He is engaged on D.L.S. Topographical Surveys.

Craig, J. A., '99, is engaged in civil engineering and surveying at Prince Albert, Sask.

Coyne, H., '08, is chief draughtsman for Thomas & Thomas, Racine, Wis.

Craig, J. H., '10, is a member of the architectural firm of Craig & Madill, Manning Chambers, Toronto.

Craig, S. E., '04, is with the Canada Foundry Co., Toronto. His address is 72 Nina Ave., Toronto.

Crashley, J. W., '14, has 76 DeLisle Ave., Toronto as his address.

Crawford, A. W., '14, is with the 2nd Field Company, Canadian Engineers, Second Contingent.

Creighton, A. G., '06, is a member of the firm of Creighton & Strothers, architects and structural engineers, Prince Albert, Sask.

Crerar, S. R., '04, is lecturer in surveying, Faculty of Applied Science and Engineering, University of Toronto.

Crosby, N. L. R., '05, is contracting engineer with Toronto Structural Steel Co., Toronto, Ont.

Crosby, T. H., '09, is sales engineer with the Canadian Westinghouse Co., in the Vancouver office.

Crouch, M. E., '11, has a land-surveying practice at Port Arthur, Ont.

Cruthers, W. M., '11, is in the engineering department of the Canadian General Electric Co., at the Peterborough plant.

Culbert. J. V., '07, is with the Buffalo Mines. Cobalt, Ont.

Cumming, J. D., '08, is at Copper Cliff, Ont., with the Canadian Copper Co.

Cumming. R., '02. is a member of the contracting firm of Miller. Cumming & Robertson, Toronto.

Cunerty. T. J., '11, is with the Westinghouse Electric and Manufacturing Co., New York, in the export department.

Cunningham. C. H., '11. is designing engineer for Thor Iron Works. Toronto. of which firm he is a director.

Cunningham. R. H., '09. is at Windsor. Ont. He is sales engineer for the Hoskin Manufacturing Co., Detroit.

Currie. W. M., '04, is a member of the staff of the Canada Steel Co., Hamilton.

Curtis. W. T., '13. is with the Hollinger Mines. Timmins. Ont.

Curzon. J. H., '11. is employed in the sewer department. City Hall. Toronto.

Cuthbertson. W., '14. is employed with the Department of Public Works of Ontario, on the construction of the Toronto-Hamilton road.

Dahl. A. D., '08, has Midland. Mich., for his address. He is research chemist for the Dow Chemical Co.

Dallyn. F. A., '09. is with the Ontario Board of Health as consulting expert. in charge of the experimental station at Toronto.

Dalton. G. F., '14. is with the Geodetic Survey of Canada. Department of Interior, Ottawa.

D'Alton. F. K., '11. is on the staff of Ridley College. St. Catharines. Ont.

Daniels. W. N., '06. is at Noble Road. Jenkintown. Pa., as Superintendent of Reinforced Concrete Construction. for the Guarantee Construction Co. of New York City.

Danks. F. A., '08. is with the Waterworks Department. City of Toronto. He is at the engineer's office, filtration plant. Centre Island. Toronto.

Danks. C. N., '09. is with the Jenckes Machine Co., Sherbrooke. Que., as engineer.

Dann. E. M., '09. is District Engineer. British Columbia Hydrographic Survey. Dominion Water Power Branch. Department of Interior Kamloops. B.C.

Darling. E. H., '98, is a member of the firm. McPhie. Kelly & Darling. consulting engineers. Bank of Hamilton Building. Hamilton. Ont.

Darroch. J., '08. has no address with us at present. When last heard from him he was with the Autoparts Mfg. Co.. Detroit. Mich., as draughtsman.

Dashwood. R., '14. is on active service with the British Army.

Dates. A. J., '13. is with the State Railway Commission of Michigan. He lives at 35 Farrand Ave.. Highland Park. Mich.

Davidson. H. D., '13. is employed on the construction of the Welland Ship Canal. St. Catharines. Ont.

Davidson. R. D., '14. is engaged in land survey work with A. H. Hawkins. D.L.S., Le Pas. Man.

Davis. A. I., '09. is at Fort Dodge. Ia.

Davis. J., '09. is sales engineer for the Canada Foundry Co.. in connection with the Ottawa office.

Davis. H. W., '09. resides in Kingston. Ont., where he is in charge of the power department of the Davis Tanneries. Ltd.

Davis. H. C., '09. We do not know his present address.

Davis, R. S., '07, is manager of the Calgary office of the Canadian Westinghouse Co.

Davis. W. B., '11. is engaged on the construction of the Trent Valley Canal. Frankfort. Ont.

Davison. J. E., '00, is in the engineering department of the Canadian Northern Ry. Co., at Winnipeg. Man.

Davison. A. E., '03, is with the Hydro-Electric Power Commission. as engineer. with Toronto as headquarters.

Dawson. I. H., '09. is assistant resident engineer, section 5. Welland Ship Canal. Allanburg. Ont.

Deacon. T. R., '91. is president and general manager of the Manitoba Bridge and Iron Works.

Dean. C. D., '10. has Alexandra Apartments, Sarnia. Ont.. for his home address. We do not know his business address.

Death. N. P. F., '06. is a member of the firm of Death & Watson. electrical engineers and contractors. Toronto.

DeCew. J. A., '96. is in Montreal, Que.. where he has a consulting practice in chemical engineering.

DeGuerre. F. C., '11. We do not know his address.

Deitch. E. L., '13. is inspector with the Ontario Hydro-Electric Power Commission.

Delahaye. W. H., '09. is in the Patent Office. Dept. of Agriculture. Ottawa.

Delamere. R. D., '14. is a member of Clipsham & Delamere. manufacturers of motor cars. 1896 Dundas St.. Toronto.

De Laporte. A. V., '10. is chemist with the Provincial Board of Health. Toronto.

Depew. H. H., '04. is in Edmonton. Alta., at 649 First Street. We do not knew the nature of his employment.

Derham. W. P., '09. He has no business address on our fyles.

Diamond. R. W., '13. is with the Anaconda Copper Mining Co.. Anaconda. Montana.

Dickson. G. W., '00. is with the Laurentide Co.. Limited. Grand Mere. Que.. paper manufacturers. as superintendent of the ground wood pulp mill and the log preparing mill.

Dickenson. E. D., '00. is with the General Electric Co.. at Schenectady. N.Y.

Dill. C. W., '91. is managing director of the National Paving and Contracting Co.. Winnipeg. Man.

Dixon. H. A., '00. is at Jasper. Alta., as district engineer for Mackenzie Mann & Co.. on the C. N. R.

Dobbin. R. L., '10. is superintendent of the waterworks department for the city of Peterborough. Ont.

Dobson. W. P., '10. is in charge of the testing department of the Ontario Hydro-Electric Power Commission. at their plant on Strachan Ave.. Toronto.

Dobie. J. S., '95 resides at Thessalon. Ont. He is engaged in O.L.S. and D.L.S. work.

Dodds. W. A., '09. is chemical engineer for the Penman Littlehales Chemical Co., of Syracuse. N.Y.

Douglas. F. W., '11. of 276 Palmerston Ave.. Toronto. has been employed with Geo. B. Meadows Co.. Ltd. manufacturers of wire. iron and brass materials. Toronto.

Douglas. R. H., '08. is with the Department of Public Works. Edmonton. Alta.

INDEX TO ADVERTISERS