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The Canadian Engineer

A weekly paper for civil engineers and contractors

Empirical Column Formulae for Brick Piers

Tests at University of Toronto on Piers of Various Lengths Built of Brick of Known Strength to Determine Effect of Slenderness Ratio on Strength of the Piers—Detailed Report of Tests on 14 Piers and 62 Individual Brick

By WILLIAM WORTH PEARSE

City Architect and Superintendent of Building, Toronto

TORONTO'S Building Department is at present revising its building by-law; when the chapter on brickwork was reached, it was found that the data available on Canadian brickwork was very meagre.

The brick manufactories that supply the Toronto market kindly consented to allow the Department to visit their plants, select brick and have them tested. The results are tabulated on page 229. The numbers in the first column are the key to the manufacturers' names, which are not to be revealed. The brick selected were not the best brick manufactured by the different companies but were the types usually used as backing brick. Only in a few cases did the Department select face or very hard brick, as usually that type of brick is used only for facing.

It was found that absorption affected the strength of brick in compression. Brick having an absorption of 12% and under were on an average of about 38% stronger in compression and 85% stronger in bending than the average brick absorbing more than 12% of moisture.

After the tests summarized on page 229 had been made, it was thought advisable to try to arrive at a relation between the individual brick and brick laid up in piers, so a representative of the Department selected one of the poorest types of brick from one of the leading manufacturers, who kindly donated the brick to build fourteen piers of different heights, the object being to derive a curve, if possible, that would give the strength of brick piers for different heights.

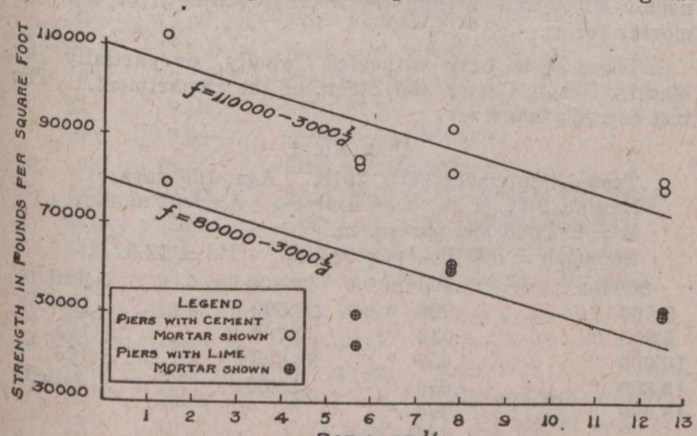


FIG. 1—LINE FORMULAE SUGGESTED BY PROF. PETER GILLESPIE AS RESULT OF TESTS ON BRICK PIERS

It as also decided to let the piers set for a period of about three months, as this was considered the least time that the walls would be called upon to take their full load. It was also decided to build the piers in both lime and cement mortar of the following mixtures:—*Lime Mortar.*—1 part lime to 3 parts sand. *Cement Mortar.*—1 part portland cement, 3 parts sand, and ¼ part hydrated lime (all by bulk).

The piers were laid up during the month of June by an experienced bricklayer. They were 8⅝ ins. square in plan and were built so as to represent a portion of an ordinary brick wall one brick thick bonded by headers every sixth course, according to common practice in Toronto.

In constructing the piers an effort was made to obtain a class of workmanship neither better nor worse than would be expected from men of ordinary skill. The crushing strengths of individual brick and of cubes of mortar 6 ins.

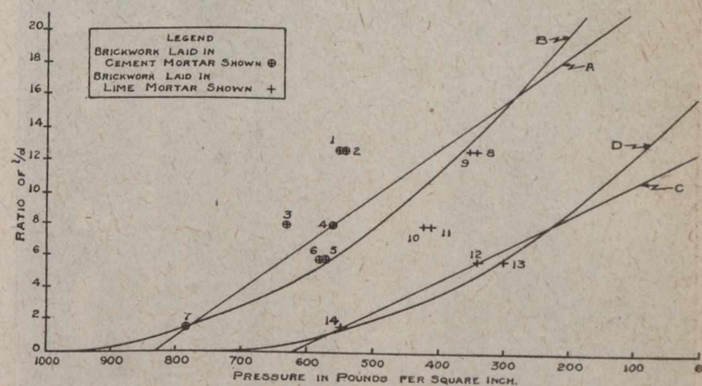


FIG. 2—FORMULAE SUGGESTED BY TORONTO BUILDING DEPT.

"A," $p = 828 - 34\, l/d$ "C," $p = 620 - 50\, l/d$

"B," $p = 1{,}000 - 180\sqrt{l/d}$ "D," $p = 760 - 190\sqrt{l/d}$

l = height of pier in inches

d = least thickness of pier in inches

to a side (the latter at an age of approximately three months), are as follows:—

Modulus of rupture of individual brick, 165 lbs. per sq. in.

Crushing strength of individual brick, 1,000 lbs. per sq. in.

Crushing strength of lime mortar, 235 lbs. per sq. in.

Crushing strength of cement cubes, 1,835 lbs. per sq. in.

The piers were constructed on the 200,000 lb. Riehlé testing machine in the Strength of Materials Laboratory at the University of Toronto, under the direction of Peter Gillespie, associate professor of applied mechanics. Each pier was build on a plate of ¼ in. steel, 13 ins. square, as a base, and capped in plaster of Paris. In addition to the crushing strength of each pier, the amount of shortening due to load and the lateral deflection, if any were obtained.

As mentioned previously, the investigation was to determine, if possible, the relation between strength and slenderness; and for that reason, values of the ratio of length to diameter lying between 1.4 and 12.5 were provided for in the program by varying the length from 1 ft. to 9 ft. A course of bricks including mortar joints averaged 3 ins. in depth.

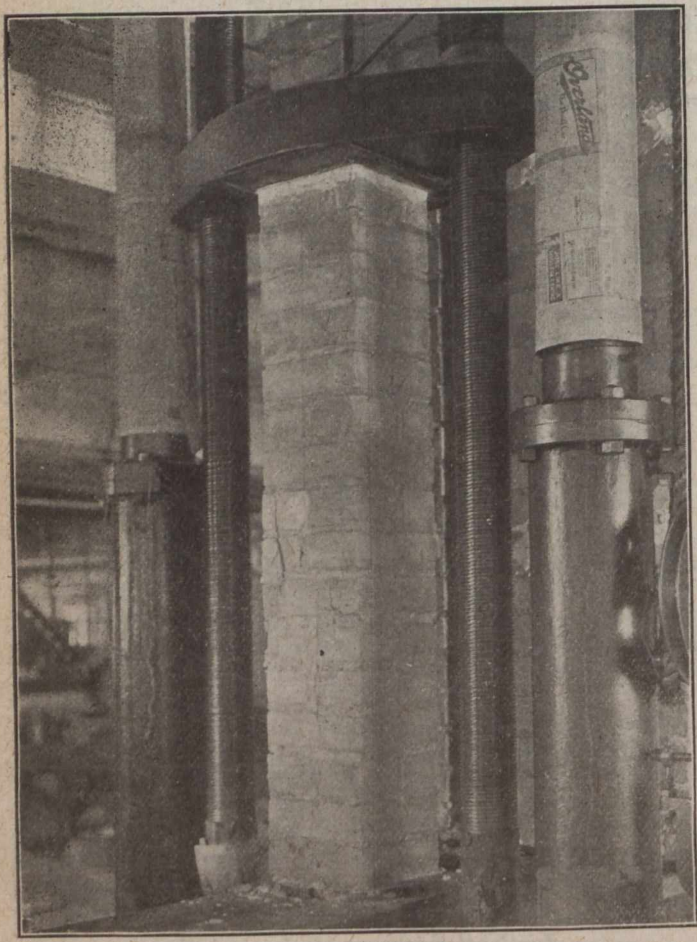
In Fig. 2, points have been plotted for different ratios of of l/d and then a straight line formula has been plotted for the cement-mortar piers, namely:—

$$p = 828 - 34\ l/d \text{ (see straight line A)},$$

where p = ultimate pressure per sq. in.
l = length of pier in ins.
d = thickness of piers in ins.

A parabolic curve has also been plotted, making the curve tangent at 1,000 lbs. (ultimate crushing strength of the individual brick) and the least crushing strength of pier No. 5 whose slenderness ratio is l/d=5.7 and crushing strength per square inch of 570 lbs., or

$$p = 1000 - 180\sqrt{l/d}. \quad \text{(See curve B).}$$



Test of Brick Pier at University of Toronto

It will be noticed that the straight line A passes through the point plotted for pier No. 4, having a crushing value of 560 lbs. per sq. in., and also through the point plotted for pier No. 7, having a crushing value of 780 lbs. per sq. in.

The piers built in lime mortar will now be considered.

Referring to Fig. 2, a straight line (C) has been drawn through the point plotted for pier No. 14, having a crushing value of 550 lbs. per sq. in., and through the point plotted for pier No. 12. The equation for this straight line is

$$p = 620 - 50\ l/d.$$

A parabolic curve, $p = 760 - 190\sqrt{l/d}$, has been passed through the points plotted for piers Nos. 14 and 13.

Johnson, Bryan and Turneaure, in "Modern Framed Structures," part III, suggest a parabolic equation for the strength of columns, and from Fig. 2 it will be seen that it agrees well with tests.

Load deformation curves have been plotted and from these the modulus of elasticity of the masonry was found.

The area beneath the curve is a measure of the work done in producing failure, and if this when done be divided by the volume of the pier, the result will be analogous to the common "co-efficients of resilience." This is used to measure the capacity of the material or structure to resist shock, or

$$R = p^2/2E,$$

where R = the ultimate resilience per unit of volume.
p = strength of the material.
E = the modulus of elasticity.

For the twelve piers observed, this co-efficient has been worked out in inch-pounds per cubic foot, with the following as the values:—

Pier	Mortar	Resistance to Shock
1	Cement	955 in.-lbs. per cu. ft.
2	Cement	950 "
3	Cement	1075 "
4	Cement	970 "
5	Cement	1215 "
6	Cement	1060 "
Average		1040 "
8	Lime	565 "
9	Lime	525 "
10	Lime	645 "
11	Lime	715 "
12	Lime	865 "
13	Lime	630 "
Average		650 "

The resistance to shock is 60% greater where cement mortar is used than where lime mortar is employed.

Crushing Strength

The following table gives the observed values of the crushing strength for the fourteen piers tested:—

Cement Mortar Pier No.	Strength	Lime Mortar Pier No.	Strength
1	550 lbs. per sq. in.	8	340 lbs. per sq. in.
2	540 " " " "	9	350 " " " "
3	630 " " " "	10	420 " " " "
4	560 " " " "	11	410 " " " "
5	570 " " " "	12	340 " " " "
6	580 " " " "	13	300 " " " "
7	780 " " " "	14	550 " " " "

The average strength of the cement mortar series is nearly 60% greater than the average strength of the lime mortar series.

These tests were witnessed wholly or partially by Messrs. Sykes, Carter and Steen, of the Department. The test records follow:—

Pier No. 1

Tested September 25th, 1918. Age, 105 days.
Height, 9 ft. ¼ in. = 36 courses. Cement mortar.
E = 294,000 lbs. per sq. in.
Strength = 550 lbs. per sq. in. l/d = 12.5.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	22,800 lbs.	.120 ins.
2,500 "	.008 "	27,600 "	.134 "
5,800 "	.032 "	32,700 "	.163 "
10,000 "	.056 "	38,600 "	.196 "
13,800 "	.079 "	41,200 "	failed
18,200 "	.094 "		

Pier No. 2

Tested September 28th, 1918. Age, 108 days.
Height, 9 ft. ¼ in. = 36 courses. Cement mortar.
E = 264,000 lbs. per sq. in.
Strength = 540 lbs. per sq. in. l/d = 12.5.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	29,400 lbs.	.160 ins.
1,200 "	.000 "	38,000 "	.208 "
10,800 "	.068 "	40,200 "	failed
20,800 "	.119 "		

(Continued on page 230)

Tests on Individual Brick

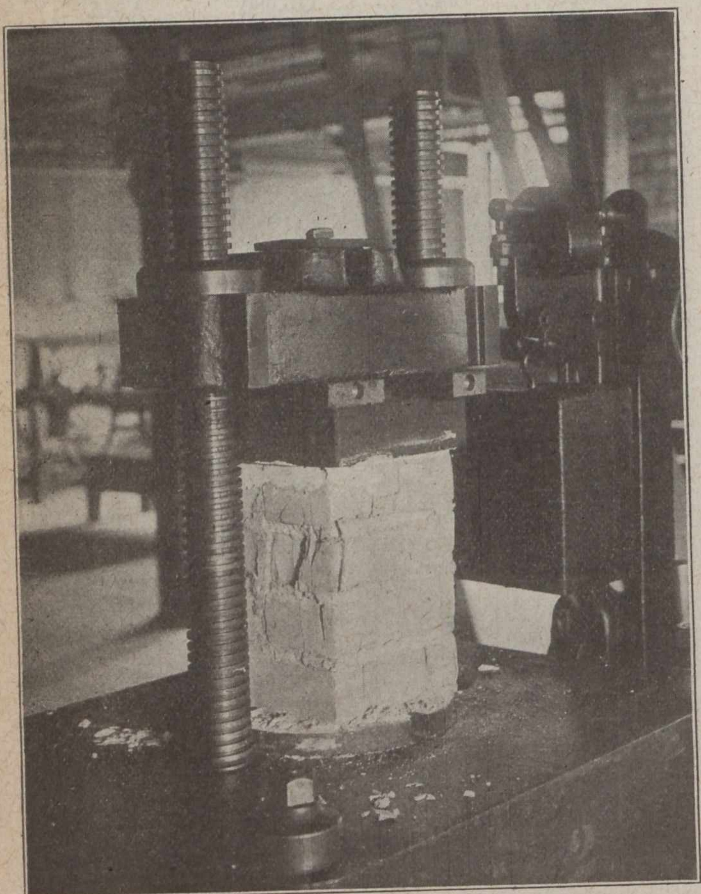
Conducted by Robert Marshall at the University of Toronto for the City Architect's Department, Toronto

No.	Absorption %	Process.	Centre load, (7" between supports).	Area, sq. in.	Crushing, lbs.	Crushing, lbs. per sq. in.
41	14.2	Soft mud, rock and pallet yard	1,215	34.1	91,700	2,690
33	13.8	Dry press	1,360	33.7	155,300	4,615
35	17.9	Dry press	1,970	34.8	159,350	4,580
38	11.53	Stiff mud setting off yard	1,945	31.4	113,600	3,610
11	11.6	Stiff mud	1,980	44.5	115,680	4,515
62	15.85	Hydrated lime	1,045	32.9	80,400	2,445
12	15.7	Stiff mud, rock and pallet yard in summer	1,470	34.4	122,600	3,565
61	20.9	Stiff mud, rock and pallet yard in summer	1,400	34.8	80,630	2,320
13	9.96	Soft mud	3,285	32.9	202,800	6,170
60	18.85	Soft mud, rock and pallet yard	1,160	36.7	82,600	2,250
14	16.4	Soft mud	1,895	34.5	106,300	3,080
58	11.2	Hydrated process	470	34.2	128,260	3,750
15.2	4.26	Stiff plastic wire cut	4,100	33.1	202,800	6,135
57	16.9	Soft mud, rock and pallet	1,160	34.9	91,400	2,620
16.2	9.9	Stiff plastic wire cut dry press	2,050	33.9	120,520	3.555
56	16.35	Soft mud, rock and pallet yard	1,180	34.2	98,510	2,875
17	6.1	Stiff plastic wire cut dry press	2,650	34.5	202,800	5,880
55	22.4	Stiff mud	2,135	36.6	99,050	2,700
18	12.95	Stiff plastic	1,945	31.3	46,200	1,476
54	14.6	Soft mud, rock and pallet yard	1,055	33.6	119,000	3,540
20.2	12.56	Stiff mud	2,020	35.	119,000	3,405
67	24.8	Soft mud, rock and pallet	1,735	37.2	100,950	2,710
22	14.52	Soft mud, rock and pallet yard	2,480	32.3	140,820	4,365
51	21.9	Stiff mud setting off yard	2,755	35.8	107,470	3,000
23	9.1	Hydrated lime process pan mixer	540	33.6	105,800	3,110
50.1	14.86	Stiff mud setting off yard	3,740	33.0	158,600	4,815
46	13.45	Stiff mud setting off yard	1,590	32.5	97,200	2,985
45	14.65	Stiff mud setting off yard	1,045	35.6	71,700	2,010
43	19.6	Stiff mud setting off yard	2,355	32.5	132,080	4,080
1	10.3	Quicklime	1,005	32.6	97,900	3,000
73	7.1	Machine mixed sand with Portland cement	1,100	34.0	82,250	2,420
2	6.4	Hydrated lime	1,610	33.2	154,200	4,640
71	17.0	Stiff plastic wire cut	3,070	35.2	169,480	4,820
3	19.6	Dry press	1,620	34.	194,600	5,720
68	13.25	Hydrated lime, pan mixed	660	35.7	58,740	1,645
70	15.81	Stiff plastic wire cut	2,640	35.6	202,800	5,700
4.2	12.4	Dry press, stiff plastic wire cut	1,620	32.4	151,600	4,680
67	9.26	Hydrated lime, pan mill mixed	845	33.7	79,960	2,375
5	19.3	Stiff plastic wire cut	2,750	33.	202,800	6,150
65	16.3	Rock and pallet yard	1,155	34.2	70,900	2,070
6	3.64	Plastic wire cut	5,320	32.7	202,800	6,215
21	9.15	Soft mud	2,220	32.6	126,940	3,890
7.1	6.06	Stiff plastic wire cut	3,760	33.9	202,800	5,980
7.2	18.5	Stiff plastic wire cut	1,170	33.1	202,800	6,135
64.3	25.35	Stiff mud, stiff plastic, dry press	1,210	34.6	157,040	4,530
64.4	12.68	Stiff mud, stiff plastic, dry press	1,935	35.1	202,800	5,780
64.5	19.0	Stiff mud, stiff plastic, dry press	1,770	34.4	93,700	2,720
64.6	20.0	Stiff mud, stiff plastic, dry press	1,150	32.8	37,300	1,145
8	12.1	Dry press	1,980	34.1	181,240	5,320
63	14.46	Dry press	1,200	34.3	117,160	3,420
10	13.86	Dry press	1,975	33.	165,900	5,020
24	12.25	Quicklime process pan mill mixed	780	35.5	80,970	2,275
25	12.5	Soft mud, rock and pallet yard	1,440	34.2	100,800	2,950
27	26.7	Soft mud, rock and pallet yard	1,335	33.1	89,400	2,700
30	14.6	Dry press	2,140	34.2	183,500	5,370
42.2	23.35	Stiff mud setting off yard	1,710	33.8	165,950	3,130
42.1	15.4	Stiff mud setting off yard	1,760	33.6	126,000	3,750
31	16.4	Dry press	2,300	34.4	202,800	5,900
32	15.15	Dry press and stiff plastic wire cut	1,895	33.9	202,800	5,980
34	15.6	Dry press	1,625	32.9	147,100	4,470
37	12.8	Stiff mud setting off yard	1,500	34.4	139,000	4,040
40	11.25	Soft mud setting off yard	1,050	34.4	80,840	2,350

Pier No. 3

Tested October 3rd, 1918. Age, 108 days.
Height, 5 ft. 7½ ins. = 22 courses. Cement mortar.
E = 330,000 lbs. per sq. in.
Strength = 630 lbs. per sq. in. l/d = 7.8.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	32,200 lbs.	.087 ins.
4,600 "	.012 "	40,800 "	.114 "
14,200 "	.036 "	47,000 "	failed
24,600 "	.066 "		



Test of Brick Pier at University of Toronto

Pier No. 4

Tested October 7th, 1918. Age, 112 days.
Height, 5 ft. 7½ ins. = 22 courses. Cement mortar.
E = 284,000 lbs. per sq. in.
Strength = 560 lbs. per sq. in. l/d = 7.8.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	29,800 lbs.	.092 ins.
1,600 "	.005 "	38,600 "	.129 "
10,700 "	.037 "	41,800 "	failed
21,600 "	.063 "		

Pier No. 5

Tested October 8th, 1918. Age, 112 days.
Height, 4 ft. 1 in. = 16 courses. Cement mortar.
E = 234,000 lbs. per sq. in.
Strength = 570 lbs. per sq. in. l/d = 5.7.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	31,000 lbs.	.084 ins.
800 "	.000 "	37,200 "	.103 "
10.400 "	.032 "	42,600 "	failed
21,000 "	.059 "		

Pier No. 6

Tested October 8th, 1918. Age, 112 days.
Height, 4 ft. 1 in. = 16 courses. Cement mortar.
E = 276,000 lbs. per sq. in.
Strength = 580 lbs. per sq. in. l/d = 5.7.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	30,000 lbs.	.071 ins.
2,200 "	.005 "	38,000 "	.090 "
13,000 "	.033 "	43,200 "	failed
20,000 "	.045 "		

Pier No. 7

Tested September 25th, 1918. Age, 107 days.
Height, 12⅛ ins. = 4 courses. Cement Mortar.
E was not determined.
Strength = 780 lbs. per sq. in. l/d = 1.4.

Pier No. 8

Tested September 26th, 1918. Age, 107 days.
Height, 9 ft. ⅛ in. = 36 courses. Lime mortar.
E = 215,000 lbs. per sq. in.
Strength = 340 lbs. per sq. in. l/d = 12.5.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	14,200 lbs.	.091 ins.
1,600 "	.012 "	17,800 "	.118 "
7,200 "	.042 "	21,600 "	.150 "
12,000 "	.073 "	25,400 "	.207 failed

Pier No. 9

Tested September 27th, 1918. Age, 108 days.
Height, 9 ft. = 36 courses. Lime mortar.
E = 208,000 lbs. per sq. in.
Strength = 350 lbs. per sq. in. l/d = 12.5.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	15,200 lbs.	.106 ins.
2,000 "	.016 "	20,000 "	.144 "
9,400 "	.062 "	25,800 "	failed

Pier No. 10

Tested October 1st, 1918. Age, 110 days.
Height, 5 ft. 7½ ins. = 23 courses. Lime mortar.
E = 242,000 lbs. per sq. in.
Strength = 420 lbs. per sq. in. l/d = 7.8.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	21,800 lbs.	.079 ins.
3,000 "	.012 "	31,200 "	.106 "
8,200 "	.030 "	31,200 "	failed
16,800 "	.054 "		

Pier No. 11

Tested October 2nd, 1918. Age, 111 days.
Height, 5 ft. 7½ ins. = 23 courses. Lime mortar.
E = 214,000 lbs. per sq. in.
Strength = 410 lbs. per sq. in. l/d = 7.8.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	19,000 lbs.	.078 ins.
4,600 "	.022 "	24,200 "	.105 "
10,600 "	.042 "	30,600 "	failed

Pier No. 12

Tested September 21st, 1918. Age, 94 days.
Height, 4 ft. ¾ in. = 16 courses. Lime mortar.
E = 119,000 lbs. per sq. in.
Strength = 340 lbs. per sq. in. l/d = 5.6.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	19,600 lbs.	.108 ins.
4,500 "	.023 "	22,200 "	.123 "
9,500 "	.048 "	25,600 "	failed
15,300 "	.088 "		

Pier No. 13

Tested September 21st, 1918. Age, 94 days.
Height, 4 ft. ⅞ ins. = 16 courses. Lime mortar.
E = 142,000 lbs. per sq. in.
Strength = 300 lbs. per sq. in. l/d = 5.6.

Load	Deformation	Load	Deformation
000 lbs.	.000 ins.	18,300 lbs.	.089 ins.
2,000 "	.010 "	21,000 "	*.119 "
9,400 "	.042 "	22,000 "	failed
14,400 "	.063 "		

*First cracks, seventh and eighth from bottom.

Pier No. 14

Tested September 21st, 1918. Age, 95 days.
Height, 12⅛ ins. = 4 courses. Lime mortar.
E was not determined.
Strength = 550 lbs. per sq. in. l/d = 1.4.

Summary

1.—The strength of the strongest pier laid in cement mortar was 78% of the strength of the individual brick.

2.—The strength of the strongest pier laid in lime mortar was 55% of the strength of the individual brick.

3.—Brick masonry laid in cement mortar is about 50% more rigid and 60% stronger than that laid in lime mortar, and the resistance to shock is 60% greater in the former than the latter.

4.—Longitudinal or vertical rupture through bonding courses occurred very frequently.

5.—No appreciable shrinkage in height could be observed during the first month after construction. After this period, measurements were discontinued.

6.—Lateral deflections under load were in most cases so small as to be almost incapable of measurement with a scale divided into 100th of an inch.

7.—As a result of the tests, the following formulae for the strength of brick piers in lbs. per sq. inch are suggested (the first being for cement and the second for lime masonry):—

P = 828—34 l/d.
P = 620—50 l/d.

Prof. Gillespie proposes the following formulæ for the strength of brick piers in lbs. per sq. ft.:—

P = 110,000—3,000 l/d (cement mortar).
P = 80,000—3,000 l/d (lime mortar).

Some very valuable tests have been made by the U. S. Department of Commerce (see technologic paper No. 111 of the Bureau of Standards, Washington, D.C.). Tests made on large brick piers were reported and a general survey made of all previous tests conducted on the subject.

In having the tests made at Toronto University, the writer had in view an attempt to get up a curve or straight line that would be reasonably safe to be used for different ratios of l/d, but the few tests made would not warrant anything definite. It is hoped to have a great number of brick piers tested this year so that a reasonable formula for brickwork may be secured.

It is also the intention to test tile piers of the same lengths as the brick piers, so as to determine their comparative or relative strengths. Other building materials will also be tested in similar manner, so that the Department may take brick as the standard, or unit, and rate the other materials higher or lower, expressing their value in terms of brick as the unit.

ONTARIO BUILDERS ELECT OFFICERS

At the annual convention of the Provincial Builders' and Supply Dealers' Association of Ontario, held last week at Chatham, Ont., the following officers were elected for the ensuing year: President, H. Elgie, Toronto; first vice-president, Col. J. L. Young, V.C., Stratford; second vice-president, John Hildreth, Chatham; secretary-treasurer, T. R. Wright, London. Board of Directors: W. H. Palmer, Chatham; L. A. Boss, London; R. M. Norton, Sarnia; G. Thomas, Galt; W. Murray, Hamilton; R. H. Nicholson, St. Catharines; and C. A. Crow, Ottawa.

THE STRENGTH OF LARGE BRICK PIERS

A final report on an investigation of the strength of large brick piers has been issued as Technologic Paper No. 111 by the U.S. Bureau of Standards, says "Engineering & Contracting." The investigation was conducted in the Pittsburgh Laboratory of the Bureau in co-operation with the National Brick Manufacturers' Association. Tests were made on 40 piers 30 in. x 30 in. x 10 ft. high, and four supplementary piers of the same cross sectional dimensions by 5 ft. high. The bricks used were representative of four districts east of the Mississippi River. The conclusions based on the results of the investigations and study of previous tests were as follows:

The primary failure of brick piers is caused by a transverse failure of the individual bricks.

The ultimate strength of the pier may be increased by any method of construction which will increase the depth of the component parts of the pier. This may be done by (1) laying the bricks on edge instead of flat, (2) breaking joints every few courses instead of every course, or (3) using bricks of more than ordinary thickness.

The strength of the pier may be increased by the introduction of wire mesh in all horizontal joints. The increase is slight, however, unless the mesh is used in every joint.

Varying the number of header courses used does not appreciably affect the ultimate strength of the pier.

The mortar joints should be made as thin as possible. They should be of uniform thickness. For this reason regularity in shape of the bricks is essential.

The ultimate strength of brick piers is proportional to the compressive and transverse strength of the bricks used in their construction.

The kind of mortar used is important in its effect on the strength of brick masonry. A pure lime mortar is inefficient when a high compressive strength is desired. In a mortar of 1 part Portland cement to 3 parts sand, 25 per cent. by volume of the cement may be replaced by hydrated lime without appreciably affecting the strength of brick piers. Higher percentages of lime up to 50 per cent. by volume may be used on piers of small cross sectional dimensions.

The following empirical formulas for use in computing the strength of brick piers are derived from the tests of the investigation:

(1) P = K p
(2) P = K R, where

P = the ultimate unit compressive strength of the pier,
p = the unit compressive strength of the single bricks.
R = the unit transverse strength or modulus of rupture of the single bricks,
K is a constant depending upon the grade of mortar used, and for which the following values are given:

Mortar.	Values to be determined by tests of individual bricks.	Value of K
15 per cent. lime; 85 per cent. cement, to 3 parts sand, by weight	Unit compressive strength flat = p	0.26
	Unit compressive strength on edge = p	.30
	Modulus of rupture from transverse test = R	1.25
1 part lime to 6 parts sand	Unit compressive strength flat = p	.11
	Unit compressive strength on edge = p	.14
	Modulus of rupture from transverse test = R	.65
1 part cement to 3 parts sand	Unit compressive strength flat = p	.27
	Unit compressive strength on edge = p	.32
	Modulus of rupture from transverse test = R	1.45

General Professional Meeting at Ottawa

Combined With Annual Meeting of the Engineering Institute of Canada—Report of Proceedings—Addresses by the Governor-General, the Minister of Public Works and Others —Discussions on Highways, Hydro-Electric Ice Troubles and Railway Electrification

MORE than 100 engineers from Montreal, Toronto and other cities and towns throughout Canada travelled to Ottawa last week and joined two hundred of their Ottawa brethren in a very successful general professional meeting, with which was combined the annual meeting of the Engineering Institute of Canada. It was the first annual meeting of the institute since its change in name and scope, and the papers and discussions were well representative of the wider activities and interests of the society, including much that was of interest to mechanical, civil, electrical and mining engineers, all of whom were present. While the interest displayed in the various papers and discussions naturally varied to a considerable extent, the attendance dwindling to barely a score upon a couple occasions, the meetings generally were very well attended, the greatest interest being shown in President Vaughan's paper on the manufacture of munitions, and in the topical discussion on railway electrification, both of these sessions being attended by fully two hundred engineers. Live interest was also displayed in the papers on "National Highways and Good Roads," by J. Duchastel, and "Design of Hydro-Electric Plants for Combatting Ice Troubles," by R. M. Wilson.

The meetings were held in the palm room of the Chateau Laurier, and the luncheons and smoker were in the dining rooms of that hotel.

Tuesday Morning's Session

The first session was called to order at ten o'clock, Tuesday morning, February 11th, by the retiring president, H. H. Vaughan. The secretary read the minutes of the last meeting, the report of council and the financial report, each of which was briefly discussed. The balance sheet showed a surplus of assets over liabilities amounting to $84,000.

It was announced that B. F. Haanel had been awarded the Gzowski medal for his paper, "Fuels of Canada," and that Ross Ross had won the student's prize for a paper describing the Abitibi Pulp & Paper Co.'s plant.

The president stated that 960 members of the institute are or were in active service. This equals 36% of the total number of members of all grades who were eligible for service. Of the 960, no less than 943 were officers, as follows:—

Brigadier-generals, 9; colonels, 9; lieutenant-colonels, 9; majors, 110; captains, 110; lieutenants, 329; non-commissioned officers, 367.

Killed in action or died from wounds, 75.

Although a complete report cannot yet be made of the honors won by members, the following decorations are known to have been awarded:—

Victoria Cross, 2; Knight of the British Empire, 1; Companion of St. Michael and St. George, 9; Companion of the Bath, 1; Distinguished Service Order, 29; Military Cross, 52; Military Medal 1; Distinguished Conduct Medal, 2; Croix de Guerre, 5; Legion of Honor, 3.

Roads and Pavements Report

George Hogarth, of Toronto, read the report of the Committee on Roads and Pavements. The specifications (for the three grades of asphaltic road oils) that were previously adopted by the institute, were revised; and specifications for asphalt binder (penetration method) and for three grades of refined coal tar, were added to the committee's report.

The reports from the branches were read, and it was announced that Ontario, Alberta and British Columbia now have "Provincial Divisions," although no reports had been received from them. The Quebec Provincial Division is now being formed.

Revisions of the by-laws were submitted to the meeting and were adopted upon assurance by Prof. Haultain that he had had a careful tabulation made of the proposed changes in order to see just how the old by-laws were being changed, and that the changes were merely matters of wording and really meant nothing at all, and that the "Montreal councillors have not slipped in a joker, as some of the members may think they have, and, indeed, as they might have done amid such a mass of changes in wording." Walter J. Francis also assured the members that there was no joker in the proposed revision of by-laws, and that it was merely an attempt to make them as near perfect as possible. Adjournment for luncheon.

ADDRESSES BY THE GOVERNOR-GENERAL, MAYOR FISHER AND SECRETARY FLINN

HIS Excellency, the Duke of Devonshire, Governor-General of Canada, was the guest of honor at the engineers' luncheon held February 11th, at Chateau Laurier, Ottawa. That he would make no attempt to deliver a technical address, said the Governor-General, was due to his experience —gained in more than 30 years of political and parliamentary life—that when in the presence of experts, one should keep the ears open and the tongue quiet. He referred in glowing terms to the part that engineers had taken in the war and expressed the hope that the great skill and capacity shown by the engineers of Canada would never again have to be turned to work of destruction. That Canada is only at the very beginning of its great future, he felt certain, and what has been accomplished in the past is merely an indication of what can be accomplished in the future.

Engineers as Viewed by a Lawyer

Another honored guest at the luncheon was Mayor Fisher, of Ottawa, who is a lawyer. In a very witty manner and in legal phraseology, he discussed the engineer's work as a source of revenue for the legal profession.

First there is the item of extras,—additional work not contemplated in the contract. Fortunately there are engineers of various kinds. All estimators are optimists. It is a good thing that they are not prophets instead of estimators, because otherwise the lawyers would lose many a job.

"Then there is the engineer who undertakes to change the plans," said Mr. Fisher. "The proper kind of an engineer, from the lawyer's view point, does this without notifying headquarters or writing the contractor.

"Then there is the engineer who makes up the itemized statement and who passes all extras as having been performed at an economical and reasonable price. If one is lucky, and dealing with governments, there is the engineer who reports favorably on the extras when fyled, and states that they are the result of an act of God. To these men the lawyer owes a great personal debt.

Water Still a Ticklish Subject

"Then there is the municipal engineer, a wonderful person, particularly if called a Commissioner of Works so that all sorts of duties can be heaped upon him, including garbage collection and even a bit of engineering. His greatest function is making explanations. He must be able to explain to council, and also if he cannot explain to the ratepayers, then the mayor and the aldermen suffer and the engineer goes on his way without interruption."

The mayor urged the engineers not to talk too much about water at the convention, because he said that Ottawa is sensitive about that subject even at this late date. The city has solved the problem so far by doing nothing. It is keeping the sewage out of the water pipes and putting in plenty of chlorine, but, he said, the engineers would have to take the street car and go to Aylmer if they desired to see water that is really clean.

He warned the engineers that when they visit the Parliament Buildings they should carefully guard their conversation, particularly in reference to gargoyles. Some gentlemen are caricatured on paper and others on stone. This is rendered necessary by art.

The third guest of honor at the luncheon was A. D. Flinn, secretary of the United Engineering Council, New York City. Mr. Flinn had time to deliver only a very brief address as he had to catch a train. He assured the convention that some joking remarks that had been made regarding the intelligence of engineers, were not at all a joke but could be substantiated by actual statistics. In the United States Army they had a system whereby they measured the fitness of men for their tasks. Two million men were measured in camps all over the country. If the mental efficiency of the best group were to be rated at 100, and the other groups based proportionately, the engineers would be rated at 100 per cent., and the next highest vocation at 66 per cent.

He invited the members to make use of the Engineering Societies Library, which has 160,000 volumes, and said that it belongs to Canadian engineers to use to any extent that they may desire. The doors of the American Societies, he said, are always open to Canadian engineers.

Affiliation Possible Says Mr. Flinn

Mr. Flinn referred to the Canadian Engineering Standards Association, and stated that in the United States also they are concerned with American and British standards, and that he suggested that all these standards associations should co-operate in establishing right and useful world standards.

The work of the Engineering Council, said Mr. Flinn, is largely non-technical, bearing upon the relation of the engineers to the government, to the community, to each other, and of one society to another. There are now five societies who are members of the council, embracing 38,000 members, and other societies are eligible and may join..

As to international affiliation, that it quite possible. There may be some way in which the Canadian engineers may be affiliated with the Engineering Council. For evident reasons, it would not be practicable for the Engineering Institute to become a member of the Engineering Council upon the same basis as the other five societies, but international co-operation would be desirable, and he would suggest that the Engineering Institute and the Engineering Council should appoint a committee for interchange of good fellowship and for active and formal co-operation. Then, if, as time goes on, further steps are mutually agreed upon, they might be undertaken or suggested either by the Institute or by the Council. He wished to assure the Canadian engineers that there is the heartiest good feeling in the hearts of the engineers of the United States for their brethren in Canada.

Tuesday Afternoon's Session

Further reports from branches and other routine business occupied about an hour's time when the meeting reassembled Tuesday afternoon. Adjournment was then announced until 4 p.m., when the retiring president's address was delivered.

Address by Mr. Vaughan

Mr. Vaughan spoke for over two hours on the manufacture of munitions in Canada, showing more than 250 lantern slides illustrating sections of shells, gauges, interior views of munition working plants, etc. He outlined the development of the industry in Canada and described various shells and the machinery required for their production.

Over 60,000,000 shells, at a cost of $1,200,000,000, was the output of 480 Canadian firms. These shells required 2,000,000 tons of steel, 18,000 tons of copper, 25,000 tons of spelter and 138,000 tons of lead, in addition to $27,000,000 worth of shell boxes and large quantities of other materials.

During the war, the Imperial Munitions Board constructed 44 steel and 46 wooden steamships at a cost of over $68,000,000, besides purchasing considerable quantities of metals, aeroplane woods and other materials required by the Imperial Government.

After Mr. Vaughan's address, the annual dinner and smoker was held under the auspices of the Ottawa branch, the entertainment including both local and professional talent.

COMMITTEE ON LEGISLATION NAMED TO PREPARE DRAFT OF A STANDARD BILL

WEDNESDAY morning's discussions were opened by J. M. Leamy, of Winnipeg, who presented the report of the "Committee on Legislation" that had been appointed by the various branches, one or two delegates from each branch having met the previous day at Ottawa. As a result of their discussion, the following resolution was introduced by Mr. Leamy:—

Whereas it seems that the wishes of the majority of the members and of the branches of the Engineering Institute of Canada are that provincial legislation should be obtained to define the status of the engineers throughout Canada; and

"Whereas the members of this annual meeting are of the opinion that this legislation should be as uniform as possible throughout the provinces;

"Be it resolved that a special committee be formed, composed of one delegate appointed by each branch, to meet at headquarters before the 15th of April, 1919, to draw up such sample legislation as it may deem necessary and advisable in order that the members of the institute throughout the different provinces may ask for legislation on the same uniform basis.

"That the secretary be instructed to call the first meeting of this committee.

"That this committee be authorized to obtain the necessary legal advice on the matter.

"That this committee shall submit the proposed legislation to the council before the 1st of May, 1919.

"That the council shall then ask by letter ballot, before the 1st of June, 1919, the opinion of all the members of the institute regarding the adoption of the proposed legislation prepared by the said special committee of the institute.

"That the council be authorized to pay all the expenses of this committee and of each delegate.

"That the council of the institute shall report the result of the ballot to the branches, and if the vote is favorable to legislation, the council of the institute shall immediately take the necessary measures, in co-operation with the branches, to have such legislation enacted."

Amendment Suggested by the President

Mr. Leamy explained that the resolution was very specific as to dates for several reasons. The Western provinces had been discussing the question of legislation for some time. Saskatchewan was about to ask for a bill at the present session of the legislature. Manitoba had drafted a tentative bill. It was thought that before any of these bills were submitted to the legislatures, efforts should be made to mould the legislation as uniformly as possible. It was not intended that the resolution should be final and unchangeable as to dates, but the idea was that work should be commenced immediately, as the western branches are anxious to have legislation closing the profession on their statute books as soon as possible.

The work of the committee, said Mr. Leamy, would lie not only along the lines of what kind of legislation is needed, but also as to the need of it. The need must be established before a standard bill is prepared.

President Vaughan objected that the resolution as submitted would take all authority in the matter away from the council of the institute. He thought that the report of the committee should be made to council for its approval and that council should not be obliged to forward the report of the committee to the membership in whatever manner the committee might frame its report. "After electing a council to conduct the affairs of the institute," said Mr. Vaughan, "you are taking away its powers to amend, which might be a vital interest to the whole membership."

Mr. Decary could not understand why Mr. Vaughan should object to the resolution. As a member of council he saw nothing objectionable.

Col. Leonard said that the principle of these matters had come up some years ago in connection with other affairs, and he questioned the right of any committee to go over the heads of the council. Some authority should be left to the council in the matter.

Walter J. Francis and Arthur Surveyer both spoke in favor of the resolution, suggesting that council might send out its own draft of proposed legislation if it did not approve of the committee's draft, and that it would then be up to the membership to decide whether they wished to adopt the committee's draft or the council's draft. They also suggested that the council is entirely free to circularize the membership with any criticism that it might desire to issue regarding the committee's draft, but they felt that the committee's report should not be altered by council before being submitted to the members.

Mr. Dodwell Discusses Legislation

C. E. W. Dodwell, of Halifax, told of the effort made over twenty years ago by the engineers of Nova Scotia to close the profession in that province. The bill passed the House of Assembly but was killed by the Legislative Council and was never again introduced.

The committee will have very responsible work to do and should not attempt to rush it too much. He questioned whether the work could be done in the time mentioned in the resolution. It would first be necessary to get a detailed report of the working of the acts which now close the profession in Quebec and Manitoba, and also regarding the acts closing the legal, medical and other professions. Mr. Dodwell felt that legislation is necessary. Without the required qualifications, no man can practice medicine or law; plumbers cannot "plumb" and veterinary surgeons cannot "vet," but anybody can hang up his shingle as an engineer.

There are, however, two sides to the argument, and while he had worked very hard for the legislation in Nova Scotia twenty years ago, his views had now modified, and while he was still in favor of legislation, he recognized that there are arguments that should be considered.

The strongest argument against legislation is that the profession is not a closed one in England, but the conditions there are different. The Institution of Civil Engineers of Great Britain is over a hundred years old, and no engineer receives recognition unless he is a member of that institution. The Institution of Civil Engineers of Great Britain is the engineering society de luxe, but here we have a young and a large country and it will be very many years before the Engineering Institute can have the standing and prestige that the institution has in Great Britain.

The committee should investigate carefully the acts under which the other professions are protected. Why is a parson or a lawyer, a parson or a lawyer? What makes a doctor different from other men, and gives him his right to practice his profession? And why is a plumber? These things must be considered by the committee in defining an engineer. The work of the committee should be done largely by correspondence.

Mr. Decary thought that the work of the committee would be much simpler than suggested by Mr. Dodwell. The questions largely to be considered in closing any profession, said Mr. Decary, are what studies are necessary to prepare a man for the profession? what examinations must be passed? and what penalties should be applied to abuses of the profession? That is all that there is to any legislation protecting any profession, said Mr. Decary.

Objects to Blank Cheque

Mr. Stead objected to the blank cheque which the resolution would hand to the committee and thought that the work might be too costly to the society. Mr. Francis thought that uniform legislation must be decided upon regardless of expense. Prof. Haultain asked Mr. Leamy whether the expense would be $1,000 or $10,000. "Somewhere between those two figures, probably," replied Mr. Leamy.

Failing to elicit any definite information regarding the expense, Prof. Haultain said that he felt that the meeting was being stampeded into the adoption of the resolution, and he thought that it should be investigated more thoroughly. The whole subject was brand new to him. He questioned the truth of the introduction to the resolution, and said that there was no evidence that the majority of the members of the institute desired legislation. At this point in his remarks he was interrupted by a number of members who pointed out that all of the branches had endorsed the idea of legislation and that the members were clearly in favor of it. Prof. Haultain still thought that it was unnecessary for the meeting to go on record to any such extent before the investigation of the whole subject by the committee, and he objected to the payment of unlimited expenses.

Mr. Mountain called the attention of the meeting to the fact that a vote had been taken twenty-five years ago on the question of legislation and that about 80 per cent. of the members of the society at that time had expressed a desire for such legislation. He personally felt that a closed corporation should be obtained, and he thought that the records of the vote twenty-five years ago should be looked up.

Mr. Vaughan drew attention to the fact that under the new by-laws adopted the previous day, an annual meeting would have no authority to appoint a committee to act independently of council, and that while those by-laws were not yet in force, the appointment of this committee in this manner would be a violation of the spirit of the revised by-laws.

Resolution Carried Without Amendment

Mr. Leamy said that the subject of legislation had been talked about for twenty years and he did not think that the council should have any right to veto the report of the committee, although they could accompany it with any letter they desire when sending it out to the membership. He did not think that the expenses could possibly be $10,000, but roughly estimated them at $3,500.

"We are hearing nothing these days but democratic control of a body of this nature," said Mr. Leamy, "and we don't want the work of this committee to be overruled by the council."

"This is not democracy," said Mr. Vaughan, "it is anarchy. The government of the province of Ontario has enacted prohibition. Suppose that the cities and towns throughout Ontario were to appoint a committee of eight people to make a report on whether the province should have prohibition, the report to be submitted directly to the people and the people then to vote on it independently of their government, and possibly overruling the government. That is what you are practically proposing in this resolution."

This view was supported by Col. Leonard, who thought that the adoption of the resolution would tend to the introduction of soviet government in the society.

At this point, the large majority of members present, being in favor of the resolution, became impatient at the discussion, and cries of "question" forced the chair to put the matter to a vote. The resolution was carried almost unanimously.

Election of Officers

The secretary read the report of the scrutineers, the following officers being elected for the coming year:—

President, Lieut.-Col. R. W. Leonard, St. Catharines, Ont.; vice-presidents, W. J. Francis, Montreal, and D. O. Lewis, Victoria; councillors, Sir Alexander Bertram and Arthur Surveyer, Montreal; J. B. Gibault, Quebec; Alex. Gray, St. John; G. Gordon Gale, Ottawa; W. A. McLean, Toronto; W. P. Brereton, Winnipeg; G. D. Mackie, Moose Jaw; A. R. Greig, Saskatoon; L. B. Elliott, Edmonton; F. H. Peters, Calgary; and R. W. McIntyre, Victoria.

Capt. Durley on "Standardization"

President Leonard was introduced by Mr. Vaughan and took the chair. Capt. R. J. Durley, chief of the Division of Gauges and Standards of the Imperial Ministry of Munitions, read a paper on "Standardization and Engineering." He referred to the Canadian Engineering Standards Association, stating that their work had dealt so far mainly with aircraft parts and screw threads.

When Capt. Durley had finished, Mr. Vaughan told of the application that has been made to the government for financial aid for the Engineering Standards Association, and asked the meeting to pass a resolution supporting the application, which was done.

M. R. Riddell, chief engineer, Canadian Aeroplanes, Ltd., Toronto, began an illustrated address on the "Development and Future of Aviation in Canada," but before he finished, it was necessary to adjourn for luncheon, Hon. Arthur Meighen and other guests having been invited for a fixed hour.

HON. ARTHUR MEIGHEN, MINISTER OF INTERIOR, ADDRESSES THE ENGINEERS

HON. Arthur Meighen, Minister of the Interior, addressed the members of the Engineering Institute of Canada at luncheon, February 12th, at the Chateau Laurier. He said that 86 men in his department belong to the engineering profession, and all but one are members of the institute. These men are engaged in the water-power branch, the surveys branch and the newly established irrigation service.

He called attention to the very high standard of efficiency and devotion to duty of the men of the civil service in general; "and without any flattery to the engineers," said Mr. Meighen, "the men of that profession stand at the head of the service for efficiency and interest in their work."

The engineering profession is as old as the world itself, said Mr. Meighen. It was born of war. Until the middle of the eighteenth century, all the engineers were military engineers, but at that time a distinction was made between military and civil engineering, and a distinct branch of the profession arose.

He welcomed the engineers to Ottawa and expressed the hope that they would join with the government in the solution of problems of an engineering nature during the period of reconstruction.

Col. Leonard, who presided at the luncheon, said that when he was chairman of the Transcontinental Railway Commission, he was much worried by his inability to get before the Exchequer Court a claim that was a very large one. The witnesses disappeared or something happened to his case every time it came up. Finally he went to Mr. Meighen, who was then solicitor-general, and requested him to handle it.

"It is most unusual for a solicitor-general to handle a case of this kind," said Mr. Meighen, "although that is what he is appointed for. However, I will have a try at it." As a result of Mr. Meighen's efforts a judgment of only $600,000 was obtained on a claim totaling $10,000,000, said Col. Leonard.

HOW CAN THE WORLD BE MADE SAFE FROM SCIENCE? ASKS DR. IRA HOLLIS

DR. IRA HOLLIS, president of the Worcester Polytechnic Institute, Worcester, Mass., and former president of the American Society of Mechanical Engineers, delivered one of the most striking addresses of the whole meeting. He referred to the slogan of the Institute, which is as follows:—

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

He said that this was a splendid statement of the aims and objects of an engineering society. He has been on a committee that has been working for a year to formulate such a statement without succeeding in such a good expression of high motives.

He felt, however, that the first part of the slogan is more or less giving away to the last part, and that the percentage of technical papers originating in engineering societies is decreasing as the percentage of papers dealing with the usefulness of the engineering profession to the public is increasing.

He was not certain whether that was the best thing for engineers or not, but he felt that it made for good citizenship at least. With regard to technical papers, however, the society should remember that its first object is education,—to teach members how to do their work better—and then to improve their relations and usefulness to the public.

He congratulated the engineers on having but one society in Canada, whereas in the United States there are four big national societies, each of which has crystallized its policies to such an extent that it is very difficult to get them together.

Mankind is entering the third period of its development, said Dr. Hollis,—the period of human control over power. The possibilities of this period are barely touched. This age in which we are now living will soon seem like the dark age to our descendants. Man can only advance through the control of power outside of himself, and therein lies the function and place of the engineer.

Yet what does the engineer's work amount to without the spirituality which makes life worth while? Science is not safe when it can be used to cover the ground with blood and to sow the bottom of the ocean with ships. How can the world be made safe from science? This is a more important question than how can the world be made safe for democracy.

Reverent Attitude Required

Dr. Hollis felt that the world would be safe only if science is approached in that reverent attitude which would prevent its use as a destructive agent. What does science amount to if it leads to control of the earth?

"God help us," exclaimed Dr. Hollis, "from that efficiency that places in the hands of a few the control of a people like the ass is controlled by man."

Engineers must prevent our patrimony being wasted or used for the destruction of mankind. "In the United States," said Dr. Hollis, "before we entered the war, we were the most wasteful people on earth; but the war has brought a different vision to our profession. One of the greatest works of the engineering profession to-day is conservation,—the saving of everything that will perpetuate the Anglo-Saxon race and that will perpetuate our ideals."

Mr. Hollis outlined the tremendous saving of coal that had been accomplished in his state, and asked whether conservation of this sort could be allowed to cease with the end of the war.

He also referred to the great conservation that could be effected by greater water power development. Next to conservation, the most important problem before the engineering profession is standardization. There is no one phase of manufacturing under the control of the engineer that is not susceptible to standardization. Articles made for like purposes must be standardized. The commercial supremacy of this continent depends upon that.

Then there is labor. No man is better fitted to take a hand in the labor question and the re-employment of soldiers than is the engineer. Not because he is an engineer; we have had much talk about the engineer in politics, said Dr. Hollis, but should he be given a political place in the life of the country? Not at all, unless he fits himself for it. The engineering profession is a great one only to the extent to which we make it so, and not merely because it is called "engineering." But the engineer has the ability to fit himself to handle labor problems and problems of state. Dr. Hollis referred to the war service statistics of the institute, and said that he was going to ask the American engineering societies to prepare the same statistics, to see how they compare with the Canadian figures.

Proposes Gigantic Engineering Convention

It is not machinery that runs the world, he said, but it is the willingness to give service, to sacrifice life for a great cause. The same truth applies to peace as to war; the willingness to give one's self in time of peace is called service. The same formula that has made the profession great in the war should make it great in peace,—service, unlimited service to the people.

Dr. Hollis again referred to the reverent spirit in which the materials of the world should be handled and protected. No league of nations can survive, he declared, if the spirit is not behind it.

Two months ago, he said, it was proposed that the American Society of Mechanical Engineers should go to London to hold a meeting, but he had opposed the idea as he hoped that a meeting could be arranged next year in London, Paris or Rome, of all the engineers of this continent,—civil, mechanical, electrical and mining—to join in a gigantic peace celebration.

Aeroplanes for Passenger Traffic

After luncheon Wednesday, M. R. Riddell finished his discussion on the "Development and Future of Aeroplanes in Canada." His lecture was illustrated with many interesting views. Mr. Riddell's company was producing 380 aeroplanes a month at the end of 1917. He prophesied a great future for aeroplanes in the carrying of mail and other light express matter, and also of passengers, stating that the machines could be equipped with stabilizers and comfortable cabins, and that flying under the conditions of passenger traffic would be very different from and materially safer than war work or stunt flying.

To Establish "Professional Division"

Major Anthes, of the Department of Soldiers' Civil Re-establishment, gave a short address on the work of that department and explained the need for a professional division similar to that which is so successful in the United States Employment Service. Major Anthes announced that a Canadian Professional Division would be organized in the immediate future and that offices would be opened at an early date at least in Montreal and Toronto. Engineers and other technically trained men who return from the front will be assisted in finding work.

GOOD ROADS ASSOCIATION'S PRESIDENT DISCUSSES FEDERAL AID LEGISLATION

J. Duchastel, honorary president of the Canadian Good Roads Association, presented a paper on "National Highways and Good Roads."

"We have to admit," said Mr. Duchastel, "that, except in a few instances, our road construction has been sadly neglected as compared to European practice. True enough, our distances are very large, our population scarcely settled, and our resources limited. Again, nature has in two ways assisted us. First, in providing a wonderful system of navigable streams and chains of lakes, which takes care of the transportation of a great number of our natural products; secondly, the cold weather we experience during several months of the year permits the transformation of many poor country roads into excellent winter roads for sleighing and in some localities a great deal of our transportation is accomplished during this period.

"Railroad companies have expanded in a wonderful manner; we have three transcontinental roads parallelling one another at close range. Many localities depend entirely on railroad facilities for all their commodities. This condition of affairs is all very well up to a certain point, but there comes a time when feeders, in the way of highways, to these railway trunk lines have to be developed. The districts situated twenty miles or more each side of the trunk lines of these railways have to be tapped, and the only way of doing so is to build good roads permitting the settlers and farmers to economically transport their produce to the railroad.

French Have Wonderful System

"A great deal of talk has recently been indulged about the help the federal government should give towards road construction. Several methods of government aid have been advocated. The French system has been advocated by some. There is no question but that it is a very wonderful one and its results clearly show its excellence. The roads of France have in a great measure helped to win the great victory of democracy over aristocracy. But unfortunately for us the French road policy is based on a different political organization to ours. In France everything is centralized. The Department of Ponts and Chaussées constructs and maintains all roads—nationales, départementales, vicinales, etc.

"Here the situation is quite different; the British North America Act has vested with the different provinces the obligation of building and maintaining public roads. We know that provincial rights are sacred and rightly so. Our situation in the road problem is very similar to that of the United States."

Mr. Duchastel then outlined the United States act by which Congress appropriated $85,000,000 to be spent in the five years prior to June 30th, 1921.

He outlined the conditions under which he thought that a highway branch of the Department of Railways and Canals should be organized, and urged that the federal government should provide 50% of the cost of national highways and that a sum of $50,000,000 should be voted immediately for this work.

He also claimed that a higher limit than $10,000 per mile should be fixed as the contribution of the federal authorities, as in the United States it is now known that that amount is not always sufficient.

"Maintenance is one of the most important problems," concluded Mr. Duchastel. "The Canadian bill should go to the limit on this score and compel each province to maintain thoroughly all highways on which the federal government has spent money."

Hon. C. A. Magrath Discusses Roads

Hon. C. A. Magrath, Canadian chairman of the International Joint Commission, formerly a member of the Ontario Highways Commission, was asked to discuss Mr. Duchastel's paper.

He said that he had never brought any technical knowledge to the good roads problem, and that he had been practically conscripted by the late Sir James Whitney for the work in Ontario. He did not pretend to be an expert in the matter, but he felt that the road problem would call for tremendous financing. This is a young country, needing many roads. Good roads cost from $5,000 to $25,000 a mile and even higher, he said, and a tremendous amount of money would be required.

He could not agree with the suggestion that the money should be apportioned according to the population of the provinces. That might be sound policy in a finished country, but not in a country that has such large areas yet to be developed as has Canada.

He pleaded that the best business brains of the country be used in administering the funds for highway work. There are many engineers, he said, who have pushed their heads through the business crust of the country, and these men should be used in an advisory capacity.

There are two main types of highways required in Canada. One is to meet the needs of the producer, primarily the agriculturist. The other type is the revenue-producing road; that is, the motor tourist road. There are many beauty spots in the Laurentian Hills and other parts of Canada through which motor roads could be built and summer resorts established which would, he thought, bring a vast amount of money into Canada through tourist traffic.

The St. Lawrence river is very attractive to tourists, said Mr. Magrath, but what are we doing to develop it? Some people object that the water of the St. Lawrence is too cold to swim in, but that is a problem for engineers to solve. The water might, perhaps, be caught at high tide and stored so that it would be heated by the sun's rays or other means and then allowed to flow out again. He also suggested a road from Ottawa 75 miles up the Gatineau, westward to Pembroke, thence through Algonquin Park to Toronto.

In locating roads, said Mr. Magrath, the maximum of traffic should be secured with the minimum of mileage.

A. W. Campbell Promises Millions

A. W. Campbell, Dominion Highways Commissioner, when called upon to discuss Mr. Duchastel's paper, said that he had come to listen to the discussion and get information rather than to give it. He was much interested in the development of our natural resources and the opening up of beautiful scenery by means of roads. The importance of considering the road problem at this time could be readily appreciated now that the motor vehicle is getting to be so very important for business and pleasure vehicles are also rapidly increasing in number.

The people of Canada have $200,000,000 invested in motors, and in the province of Ontario alone last year $1,250,000 was collected for licenses. This money, at least, should surely go toward the improvement of the roads.

How the roads should be developed is a very great question. It is going to involve millions and millions. It is largely an engineering problem, and in the expenditure of that money many engineers will be employed. Many who return from the front will have had experience in that type of work and will find a field for their activity. Maintenance is a matter of very great consequence, and he was interested in noting the idea that the provincial departments should be held entirely responsible for maintenance, but he was not clear as to just how this was going to be brought about.

Great Road-Building Era

George Hogarth, chief engineer of the Ontario Highways Department, said that it is not yet known in just what manner federal aid will be granted, but they do know that it will be adequate and that it should lead to an era of road building the like of which has never been seen in Canada in the past.

Mr. Hogarth described the three systems of provincial aid that are in force in the Province of Ontario, and said that with proper attention there is no difficulty in keeping roads smooth and efficient.

Andrew Macallum, Commissioner of Works of the city of Ottawa, drew attention to the desirability of limiting the unit weight of loads. It would be manifestly absurd, said Mr. Macallum, to allow a locomotive to travel along a road on rubber tires. On Rideau Street, in Ottawa, the pavement had to be torn up and a heavier base laid on account of the heavy motor truck loads. The 5-ton truck is the most economical. When the 7½-ton truck is reached, the elastic limit of the tires is exceeded, and if the truck is made too wide, the tires will not stay on because of the camber of the road. In the United States it was found that the roads went to pieces with the pounding of the big trucks, while steel trailers drawn behind ordinary motor trucks by a contractor in New York, broke up granite block pavements. The limit of speed might be six miles, but it is human nature to run at twenty miles if the motor will do it and the policeman is not near, so a unit limit should be put on wheel loads.

Hydro-Electric Ice Troubles

R. M. Wilson, chief engineer of the Montreal Light, Heat and Power Co., gave an illustrated talk on "The Design of Hydro-Electric Plants for Combatting Ice Troubles." He described the different forms of ice and outlined some practical suggestions as to how to cope with the evil, basing same on experience at the Cedars Rapids plant. Mr. Wilson's paper was illustrated by a number of lantern slides.

R. M. Wilson Discusses Design of Hydro-Electric Power Plants for Combatting Ice Troubles

WHEN water is sufficiently cooled, said Mr. Wilson, it loses its fluidity and becomes filled with thousands of needle-like crystals which interlace until the whole mass becomes solidified. There are three forms of ice, namely, sheet, frazil and anchor ice. The formation of sheet ice begins at the shore or upon reefs, boulders or other obstructions, and unless broken by the wind or prevented from forming by high water velocity, the sheet ice builds outward and gradually covers the whole surface of a river or power canal.

The French-Canadian term for ice that forms along the shores of rivers and around boulders is "bordage," while "frazil," also a French-Canadian term, comes from the French for forge cinders, which it is thought to resemble. When the water of a canal or river is at 32° F. or very near to that temperature, the temperature of the air needs to drop only a few degrees below 32° F. in order to form large quantities of frazil upon the surface of the water. With a temperature of 17° F. or even higher, and a little wind to create surface agitation, a great deal of frazil will be formed.

Frazil formed under these conditions is very sticky, and when it comes into contact with metal that is exposed to the air, it adheres to the metal and cannot be removed until the temperature of the water or metal is raised a fraction of a degree above freezing point. When frazil flows under surface ice, it is not so sticky, but still causes trouble, because where the volume is great it blocks up the racks and wheel entrances unless the design of the plant is such as to overcome the trouble.

Clearing Frazil by Electricity

Where frazil has accumulated under the surface ice, it will in time raise several feet above the elevation of the water surface in a river or power canal. In deep water channels that are covered with ice, and where frazil is attached to the under surface of the ice in depths varying from 1 ft. to 14 or 15 ft., it has been found that the suspended mass is of a spongy nature and passes a fair volume of water.

When this condition exists, a rise of air temperature to 33° F. or 34° F., lasting two or three days, raises the water temperature sufficiently for the greater portion of this suspended mass to disappear, although the water temperature may not be raised more than one or two hundredths of a degree F.

Frazil does not always float on the surface, said Mr. Wilson. It has been found floating at depths of several feet. Frazil suspended from surface ice can be removed by use of electric current. The small quantity of heat generated by the passage of current between electrodes inserted through the surface ice, will disintegrate the suspended spongy mass of frazil very quickly. An area of approximately 4,000 sq. ft. of this spongy ice, having an average depth of 7 ft., can be cleared in about 30 minutes by 2,750 k.w. About 6,000 volts is required with a spacing of about 32 ft. between electrodes.

Anchor Ice Carries Debris

Anchor ice is the ice which anchors to the rough, stony bottoms of rivers, and rarely forms under a layer of surface ice. The rise of a fraction of a degree in the temperature of the water will loosen it and cause it to float to the surface. It can be distinguished from other kinds of slush ice on account of its being darker in color and floating high in the water. Large quantities of anchor ice can be found in shallow rivers where high velocity prevents surface ice from forming.

From careful observations, said Mr. Wilson, we have never found anchor ice to form in water deeper than 16 to 18 ft., even in the coldest weather. Anchor ice is much more dangerous than frazil, because it carries large stones, water-logged timber, tree stumps, etc., with it into the plant. When the water in the rivers around Montreal is high during the winter, the greatest ice trouble is experienced. From the middle of December to the end of January is the time when frazil causes the most trouble, and from the middle of February to the middle of March the greatest trouble is with anchor ice.

All hydro-electric plants in northern climates are more or less troubled by ice, said Mr. Wilson. Those of early design are often either shut down entirely for short periods or else their output is reduced, and sometimes the reduction of output lasts for the whole ice season. With experience, and the improved design of hydraulic equipment, continued the speaker, plants can now be designed that will be immune from ice troubles, excepting perhaps only those depending on canals running across country where means cannot be taken to mitigate or eliminate ice difficulties.

Ice troubles come under two heads: namely, those causing damage to the outer portion of the development, such as erosion of river banks, floods, damage to dams and other structures, back water, etc.; and secondly, those which cause trouble to hydraulic equipment, such as blocking of racks, wheel chambers and wheels.

To provide against these troubles great care should be exercised in selecting the site and in the design of the head and tail-race channel. If the development makes use only of a portion of the flow of a river, and if swift water results in the river not being ice-covered, care must be taken to ascertain the prevailing wind conditions. With open water above the plant, frazil and anchor ice will be formed, and if the prevailing wind is toward the intake channel, large quantities of frazil will be forced into the canal, even if the water outside of the power canal has a velocity of from five to eight feet per second and almost at right angles to the canal.

Locating the Plant

This trouble could often be greatly reduced by properly locating the development. Power canals that are narrow and deep are preferable to those that are wide and shallow, but in any case the average velocity at the entrance should be very low.

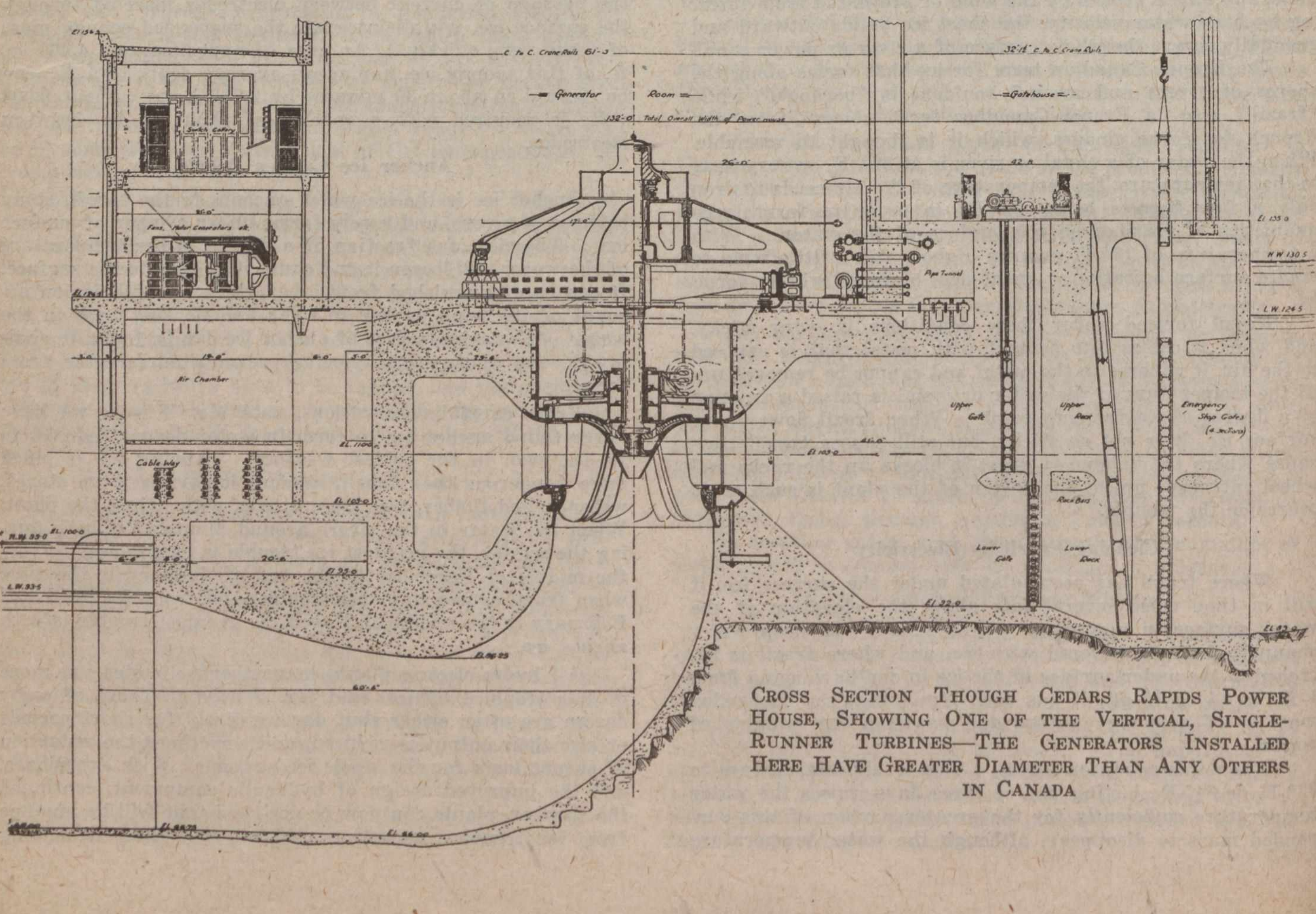
A survey of river conditions above the entrance to the canal should be made to ascertain the presence of reefs, boulders or other obstructions; because, with open water conditions, these will become coated with anchor ice so as possibly to divert the water from the entrance of the power canal sufficiently to lower the head several feet. Another source of ice trouble that should be guarded against is the lowering of the water level in the power canal due to temporary blockage of the river above the plant, caused by ice dams in the upper water during extreme cold weather. This is likely to affect seriously the plant's operation.

It is believed by many that if a large pond can be created by constructing a power canal, ice troubles can be reduced to a minimum. This is not true, said Mr. Wilson. In the case of large developments of the low or medium head class, with surface velocities of one to one and a half feet per second in the power canal or head-race, it is usually assumed that surface ice will form as soon as the water temperature reaches freezing point and the air somewhere between zero and 20° F. This condition may suit the formation of surface ice in some but not in all cases, and not with conditions that exist on the St. Lawrence. Sheet ice forms in the shallow waters and bays along the shore. When the wind breaks up its formation, and frazil is formed at the same time, the whole mass moves down, and with the aid of the wind enters the power canal, coating the whole surface with a conglomerate mass in a very short time.

The surface of the canal having been coated, sheet ice is deflected down the main channel, but the frazil continues to gather under the surface ice at the entrance to the canal, forming an underhung dam, which is serious, and unless properly handled would ultimately shut the plant down. Mr. Wilson showed a diagram prepared from actual measurements of such an underhung dam, where approximately 60% of the cross section of the power canal was closed by surface ice and the underhanging frazil that clung to it.

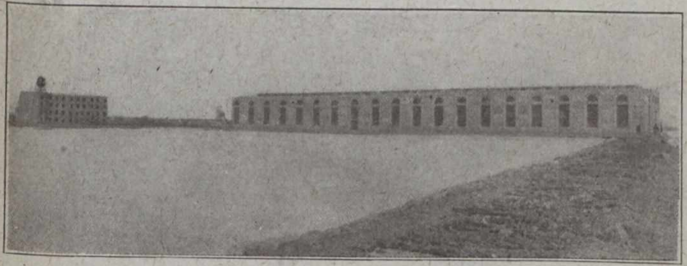
Trouble from Back Water

When rapids exist below the plant, a suitable wing dam protecting the tail race discharge should be constructed to prevent trouble from back water caused by anchor ice forming in the main channel. If the development involves damming a whole river with the power house and overflow dam, a large pond is created, backing the water up stream for a considerable distance. With a development of this sort, at times a light surface ice will undoubtedly form on the pond. But if there are rapids up the river which have not been drowned out, considerable trouble will be experienced, as frazil and anchor ice will form and float down under the surface ice on the pond, clinging to its under-side and forming an underhanging dam. The free water area will be contracted and land above the plant will be flooded and there will be considerable damage and also reduction in the capacity of the plant. If the water backed up by the under-



CROSS SECTION THOUGH CEDARS RAPIDS POWER HOUSE, SHOWING ONE OF THE VERTICAL, SINGLE-RUNNER TURBINES—THE GENERATORS INSTALLED HERE HAVE GREATER DIAMETER THAN ANY OTHERS IN CANADA hung dam can find another outlet, the reduction in capacity of the plant may be serious.

If the storage above the power house and dam is reduced 3 or 4 ft. or even less in order to carry the plant's peak load for 1½ or 2 hours daily, and if the storage builds up quickly after the peak is off, it is found that the water rises so rapidly as to over-run the surface ice along the shore and near the dam and power house, resulting in flat ice becoming very thick. By the end of winter, it may be found



HEADRACE, POWER HOUSE AND TRANSFORMER HOUSE—CEDARS PLANT OF THE MONTREAL LIGHT, HEAT & POWER CO.

to be from 2 to 3½ times as thick as the surface ice in the centre of the river or canal.

Damage is likely to be suffered from erosion and scouring of the river banks when the spring break-up occurs unless means are provided to care for same, such as facing the river banks with concrete, timber or stone riprap.

If the break-up is accompanied by heavy freshets, the ice may be shoved into the head race and carried over the dam in layers as thick as 90 ins. Considerable damage may be done, said Mr. Wilson, if the overflow dam is not properly protected, and also the front portion of the power house raised sufficiently above extremely high water to prevent the ice being carried against it. To provide against damage to the apron side of dams and by scouring at the rear of the apron, tumble ponds would be found useful if the design does not allow the ice to discharge in its normal plane and not on end.

The ice troubles affecting the operation of hydraulic equipment have been difficult to overcome with plants of multi-runner type. High specific speed runners have been so successful with modern designs of thrust bearings, that the multi-runner type turbine has passed away in favor of the vertical single runner. The majority of developments, up to 1912, of low and medium heads, consisted of horizontal installations of the multi-runner type, having two, four, six or more runners on the shaft.

The first Canadian plant of the vertical single runner type was the Cedars plant. The result of four years' operation has proven that it is possible to eliminate the ice trouble experienced in the multi-runner plant. When this plant was designed, special attention was given to ice problems, as it was known that severe ice conditions would be encountered, on account of the St. Lawrence River above and below the plant remaining open all winter.

Enclosed Gate House

Experience in the operation of other plants was of great benefit in the design in effectively overcoming the operating difficulties due to ice; for example, enclosing the gate house so that the hot air from the generator room enters the gate house, placing the screens or racks so as to keep the outside air from them, dividing the racks into six sections for each unit, installing an electric crane for handling them, installing motor-driven head gates for each unit, and installing emergency gates to cut off the water completely for examination of racks and head gates. These have all worked very efficiently. Minor changes have been made, however, in the top rack section. The original spacing between the rack bars was 2½ ins., but this was found to be too close and alternate bars were removed so that the spacing was 5 ins.

Each main unit is supplied through three openings, each 12 ft. 8 ins. by 28 ft. The water enters at about 3 ft. per second, passes through spiral concrete casing, entering the wheels at 7¼ ft. per second.

When frazil and anchor ice are running, a certain amount of fine sheet ice and debris of all kinds is mixed along with them, and when this gets onto the racks it coats them so as to block off the water from the wheels.

The ice can be put through by working ordinary rakes up and down the rack bars. The procedure, however, is to raise the top section of the racks and to hit them a slight blow with a wooden maul. The whole coating, maybe 2 or 3 ft. thick, falls away and goes through the wheels. If the ice apparently does not want to enter the spiral casing, the trouble is overcome by manipulating the head gates and changing the velocity of entrance, although this method of operating is only adopted when anchor ice is running heavily. Ordinarily the top section of the racks is allowed to remain up.

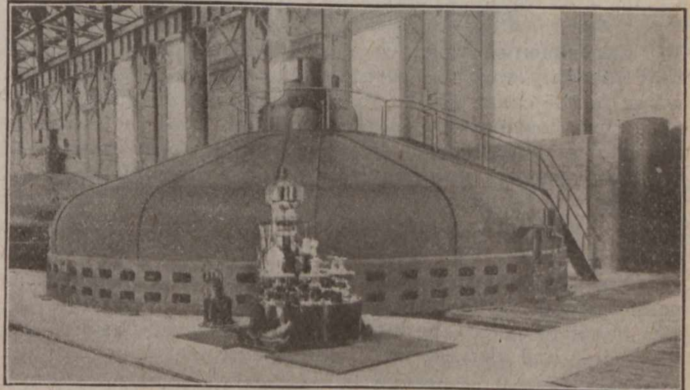
No Choke in Gates or Wheels

Four years of operation under severe winter conditions demonstrate that no matter how much anchor ice or frazil enter a plant, whether before or after the canal is coated with surface ice, no choke takes place in the guide vanes, gates or wheels. The explanation offered for this condition is that the metal parts of the wheel installation are maintained at a temperature just above freezing, causing the ice crystals to slip. The difference measured on the thermometric scale is infinitesimal, although the physical results are enormous.

Operation with the top sections of the racks up, when anchor ice is running heavily, has caused a little difficulty, as a considerable amount of debris has been carried into the runners. Timber, railroad ties, stumps of trees, stones, etc., have been removed from the runners, one stone weighing over 600 lbs.

It has been estimated that the volume of anchor ice to support this stone required between 80 and 90 cu. ft., yet with this large volume of ice no blocking occurred, the only indication that something was in the runner being a broken gate arm. The unit continued to develop its power with this large stone in one of the buckets.

Operation has demonstrated that no trouble from ice shut downs is experienced in plants having single runner



INTERIOR OF CEDARS PLANT, SHOWING ONE OF THE 10,000 H. P. GENERATORS AND GOVERNOR

units with openings in the guides, gates and wheels as large as at Cedars.

After it had been fully demonstrated that however large might be the volume of floating spongy ice entering the power house, it could be put through the wheels, attention was turned to the head-race.

The head-race is slightly over two miles long and 800 ft. wide on the surface of the water. We found, said Mr. Wilson, a considerable decrease of flow in the canal, due to the ice covering and the reduction of free water area on account of the underhung dam formed by frazil, anchor and sheet ice under the surface ice, particularly at the entrance of the canal. This is a serious condition for a plant when

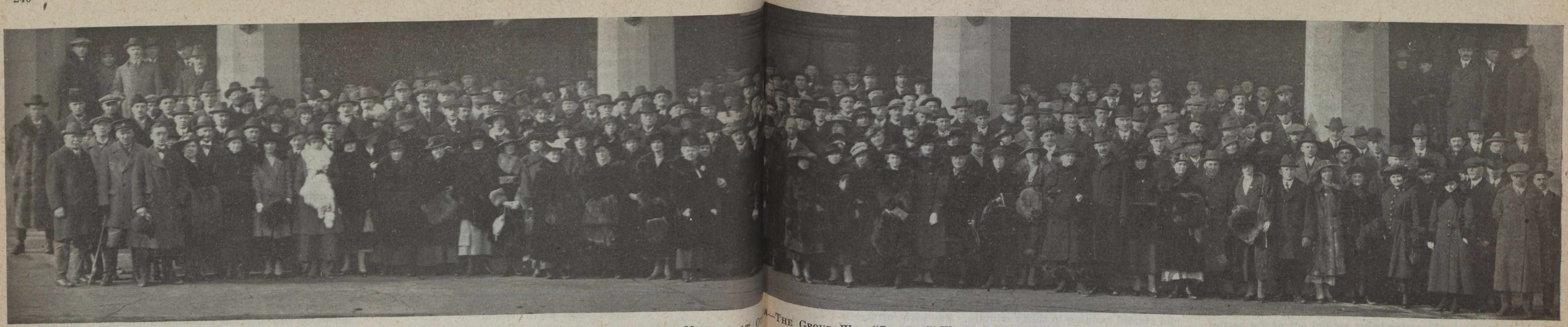


Photo Taken Last Week at the General Professional Meeting at O—The Group Was "Snapped" When on the Way to the New Parliament Buildings

the full number of units are installed. We therefore studied the conditions carefully and have adopted the method of removing approximately half the surface ice the whole length of the canal, operating with open water all winter.

By this method of operation, the sluices originally installed with 16 ft. openings for handling ice, were considerably troublesome, as they would not handle the large sheets of shore ice, 36 to 40 ins. thick, which are likely to enter the canal while it is kept open; so last summer we rebuilt our west end sluiceway, erecting two openings, each of 44 ft., with 5 to 6 ft. of water flowing over the crest. It is our intention to rebuild next summer the sluiceway next to the power house, installing two openings each 60 ft. wide.

To close these openings after the ice season, a stop-log dam has been designed, with openings for logs 15½ ft. long. The steelwork is lowered into place and the logs then inserted.

Always Open Water in Canal

Experimental work was carried out before we found that the only way to operate the plant was to keep open water in the canal all the year round. It was thought possible that floating ice could be diverted from the canal by means of a suitable boom, stretched at the proper angle from the most westerly sluiceway to the north shore of the canal, but this was found to be not the case, as the ice entered the canal in such large volumes that lighter ice went under the boom and large sheet ice ultimately broke the boom.

Next we experimented with a timber ice deflector at a point 1,500 to 1,800 ft. above the entrance to the canal, the idea being to deflect the large surface ice which breaks from the shores and also the frazil and anchor ice.

This method of protection was not found to be very efficient, when the wind condition was such as to hold all of the ice that was floating in the river above the diversion dam toward the north shore. Also during extreme cold weather the reefs in the channel outside the entrance of the canal would become heavily coated with anchor ice. With these dams and the diversion dam ice coated, only a small part of the required water entered the canal, so that we removed our diversion dam and are taking care of whatever ice enters the power canal. We are still making improvements in our canal entrance, said Mr. Wilson, by increasing the channels of supply, removing some of the reefs that have been a source of trouble during ice season. By the time our remaining units are installed, the canal will be in proper shape at the entrance. We are thoroughly satisfied that with the modifications in the sluices, and the work completed on the intake, that the plant will operate to maximum capacity all year.

In the handling of ice, one of the most important features is proper equipment. When winter sets in, the canal does not freeze over, but becomes coated with a rough surface of ice blown in by wind. The mixture, consisting of frazil, sheet ice and sometimes snow, usually takes four to six hours, with suitable wind conditions, to coat the two miles of canal with ice.

We have two ice breakers that are really reinforced tugs, and it has been found that after the surface of the canal has become coated with the conglomerate mass that it takes several days of extreme cold before it becomes consolidated to such an extent that the tugs have difficulty in breaking it up. With proper ice sluices to avoid jamming when the broken surface ice is carried down, a channel 100 to 150 ft. can be made from the power house to the entrance in a day and a half by using the two ice breakers.

At times we have resorted to the use of explosives in breaking up the jams. We have experimented with various kinds of explosives to find out which would be the most efficient in ice. We have used 60%, 40% and 30% nitro-glycerine dynamite in sticks 1½ ins. diameter, 8 ins. long, and in charges of seven to eight sticks, but they were all too fast and only pot-holed the ice.

With the aid of the Canadian Explosives Co., we obtained an explosive made from ammonium nitrate, having strength equal to 30% nitro-glycerine dynamite in sticks 3 ins. in diameter and 8 ins. long. This gives a large volume of gas, slow in action and very satisfactory. It has the advantage of not freezing unless 5° or more below zero, and if left in the water an hour or longer, it dissolves and is no longer dangerous.

In reply to a question, Mr. Wilson stated that the present installation consists of 12 units, each about 10,000 h.p., and that the ultimate installation will be 18 units.

Mr. Thornton's Discussion

K. B. Thornton, manager of the Public Service Corporation, Montreal, opened the discussion on Mr. Wilson's paper, saying that in the old days, extremely cold weather meant strenuous days and sleepless nights for the operators of hydro-electric plants, while to the man on the street it meant the stopping of street cars and the closing of works, and to the shareholders in power companies it meant a decrease in net earnings.

Mr. Wilson's paper, said Mr. Thornton, is another assurance that a power plant can be operated successfully throughout the winter. It is particularly suitable that this paper should be read in Ottawa, where experiments for the prevention of ice troubles have been carried on for twenty years by John Murphy, as duly recorded in the transactions of scientific societies and technical journals. Mr. Murphy and Dr. H. T. Barnes, of McGill University, have greatly improved the methods of combatting ice troubles, and in the future those troubles will be reduced still further and more active steps taken to prevent the formation of the ice.

The handling of ice is a problem peculiar to each plant, and any general formula is uncertain. The methods of handling ice at Cedars may be absolutely different than those required elsewhere. They have a plant of large capacity drawing water from a large intake canal.

Sluiceways Nearly Always Too Small

Mr. Thornton referred to the suggested remedial improvements, particularly in the size of the sluiceway openings. These are almost always too small as perpetrated by many designing engineers, he said. As regards protection at the intake, his idea would be to place overlapping, parallel, protecting dams at the entrance to the forebay. But the quantities of water and the size of the openings are so enormous, that he is content to let Mr. Wilson go ahead with his scheme of handling the problem.

With reference to the underhung dam shown by Mr. Wilson, where 60 per cent. of the cross section had been taken up with ice, Mr. Thornton stated that he had found that where the entrance to the forebay is adjacent to rapid running water, and where there is a canal with a forebay at the end of it, one always get an underhung dam immediately where the velocity decreases at the end of the canal and beginning of the forebay. In the plant with which Mr. Thornton is connected, this is their one and only source of ice trouble; that is, where the canal joins the forebay. They have to cut a channel across the forebay to the dam and take it out, and then their trouble is over.

Power Sites Fixed by Nature

Regarding the careful selection of power site mentioned by Mr. Wilson, Mr. Thornton thought that this is usually predetermined by nature, and that not much latitude is allowed by nature in selecting a river power-house site. The problem is generally a financial one; that is, as to whether any certain small change is warranted by the expense and by the loss or gain in head, etc. Any operating engineer always finds that there are improvements that he could make if he could design his plant all over again.

In 1906, Mr. Wilson in a paper discussing the influence of ice on operation, had said that where possible dams should be installed and the water taken out through sluices from the bottom of the dam.

In 1908, Mr. Murphy said that ice troubles could only be remedied by building dams by which an equitable flow could be secured all the year round. Before the Royal Society, Mr. Murphy said that dams would reduce frazil.

The ideal situation, said Mr. Thornton, is a completely canalized river or canal, as opposed to a partially canalized river.

The Quebec Streams Commission, the Commission of Conservation and the Dominion Power Board are all investigating storage on rivers with the idea of conserving the water, preventing floods in the spring and drought in the fall. If realized, the installation of these dams would also greatly reduce trouble due to the blocking of ice. The prevention of ice-forming conditions should be given more consideration. This is a field that up to now has been completely ignored, all efforts having been to eliminate ice troubles as found in individual plants.

Regarding the ice being thicker at the edges of the forebay than in the centre, this always happens, said Mr. Thornton, whether the elevation is varied or not. In one plant with which he is familiar, the elevation was not varied a foot, and yet the ice was two or three times as thick on the shore as in the centre, due, he believed, to difference in the velocity of the water.

Mr. Murphy's Discussion

John Murphy said that Mr. Wilson had been kind enough to submit a copy of his paper to him some days previously so that he (Mr. Murphy) would be able to discuss it, and that he noticed that in the original copy of the paper, Mr. Wilson had ascribed the ease with which the ice goes through the wheels without sticking, to the fact that the pressure on the ice generated mechanical heat sufficient to keep the ice from sticking. Mr. Murphy observed that Mr. Wilson had since deleted this sentence and had credited the non-sticking of the ice to the fact that the metal parts of the wheels were kept at a higher temperature by the heat from the generator room.

He was very glad to see that Mr. Wilson had changed that sentence, because he felt that it was very important, and that in his second explanation Mr. Wilson had arrived at the true explanation. If the metal parts of the wheels were exposed to the outer air and not kept slightly warm, the ice certainly would stick and the wheels would be frozen up. "This is a little point, but an important one, and one which should be taken up by the bodies concerned with water development, because if we dam a river like the St. Lawrence and don't take care of the ice, I don't know where we will be at," said Mr. Murphy.

Mr. Murphy declared that agitation plays an important part in the formation of ice crystals, and that where the surface is agitated by the wind or where the water forms rapids, frazil will be formed quicker and in greater quantity than in quiet water. To prove this he performed several interesting experiments. He had previously made arrangements with the management of the Chauteau Laurier to put various sized bottles of water in the hotel's ice-making plant.

The water in these bottles was chilled to 32°F., and the bottles were then carried from the basement of the hotel to the palm room on the ground floor, where the discussion was taking place. With one exception, all of the bottles were perfectly clear when they were brought into the palm room, no ice crystals being visible. "Certainly the bottles are no cooler than they were when they left the refrigerating room at 32°F.," said Mr. Murphy. "They have gained a little heat in being carried upstairs. No ice has formed in these bottles, but if we agitate them, ice will form." Mr. Murphy then shook various bottles and it was seen clearly that quantities of frazil had formed immediately upon agitation.

Experiments by Mr. Murphy

To prove his point further, Mr. Murphy poured the apparently clear water rapidly from one of the bottles into a bucket that had been covered with light netting. The agitation resulting from the water being poured out of the bottle was sufficient to cause the formation of a quantity of frazil, which was caught by the netting and showed clearly the needle-like formation of this ice.

To show the attraction that sheet or surface ice has for frazil and the way the latter clings to it, Mr. Murphy dropped a lump of ice as big as a walnut into a 5-gallon bottle of clear, chilled water. Immediately frazil formed throughout the upper half of the bottle and rose rapidly toward the chunk of ice, massing around same.

Another experiment tried by Mr. Murphy was not quite so successful. He introduced an iron rod which was supposed to have been chilled to 32° F., into one of the clear bottles to show how frazil would form and stick to the metal, but the rod had been allowed to remain too long in the room before the experiment was performed, and while frazil could be formed by agitating the water with the rod, it did not stick to the metal.

Mr. Murphy said that when liquids reach the freezing point, they have the tendency to form ice crystals and to freeze solid, but that there is a certain inertia which is not overcome until still lower temperatures are reached unless the water is agitated, but if the water be agitated and the freezing started, then, said Mr. Murphy, it continues and spreads.

He attributed the thickness of bordage ice to constant agitation along the shore.

The fact that the turbines at Cedars are of the single runner type has nothing to do with the lack of ice trouble, thought Mr. Murphy. There would have been no difference, he said, whether there was a single runner or a hundred runners, provided that they were all kept warm, like the single runner is, from the heated air of the generator room. On the other hand, if the single runner were not in the plant, it would freeze up just as tight as any multiple runner had done.

Small Boiler Keeps Plant Running

The fact that the metal parts were kept a little warmer than the ice was the reason that the ice did not stick and was the only reason, said Mr. Murphy. This had been proven in a plant that had frozen up every year for years. A very small boiler had been put in to heat it, and as a result, it had not frozen up all winter.

Mr. Murphy referred to the experiments which had been carried on in 1904 by Col. Leonard at St. Catharines to show the loss of heat in iron pipes. Col. Leonard had discovered in his experiments that if pipes are kept warm, ice would not stick to them and they will not freeze up. In 1906, Mr. Murphy had kept a plant running "with just a breath of hot air," when it had been frozen up tight right along previously. On November 26th, 1905, there were no electric light, street cars or power in Ottawa excepting from one little plant which he had thawed out at 2.30 a.m. with a small outfit generating 30 pounds of steam. This plant he had started running in thirty minutes. The plant of the Ottawa & Hull Electric Co., said Mr. Murphy, depends on a very small steam boiler.

Col. Leonard said that he had conducted experiments in 1914 at St. Catharines for the Dominion Power & Transmission Co. and found that a very small amount of heat applied to the rack bars kept them from being blocked. They made the racks of hollow bars, practically of pipe, and passed a small amount of hot water through them. They found that these bars were unnecessarily bulky, however, and that a small amount of heat applied in other ways was equally satisfactory.

A great many people, said Col. Leonard, believe that if one builds a dam and dams the rapids, that the ice is destroyed. This is not true, he said, and was a bad message to get abroad. He cited the instance of the Dominion Power & Transmission Co.'s plant, which takes water from the Welland canal. Despite the fact that the system is apparently fully canalized, there are ice troubles, and would one say that dams could be built all the way up the lakes for hundreds of miles to prevent the ice from forming?

Mr. Thornton replied that while in a case of this sort the ice could not be entirely prevented from forming, that the canal undoubtedly greatly reduces ice troubles and also is of use in connection with the formation of surface ice.

As it was 6 p.m. before the discussion was finished, Dr. Dawson's paper on "Standard Datum Planes" and Mr. Busfield's paper on "The Montreal Tunnel" were postponed to the next day.

In the evening a formal reception was tendered by the newly elected president, Col. Leonard, in the ball-room of the Chateau Laurier. Dancing continued until nearly 2 a.m., a buffet supper being served at midnight.

Railway Electrification Discussed by John Murphy, W. G. Gordon, F. H. Shepard and H. H. Vaughan

THURSDAY morning was devoted to a topical discussion on railway electrification by John Murphy, electrical engineer of the Department of Railways and Canals, Ottawa; W. G. Gordon, transportation engineer, Canadian General Electric Co., Toronto; and F. H. Shepard, director of heavy traction, Westinghouse Electric and Manufacturing Co., Pittsburgh.

Mr. Murphy stated that 106 cars are operated by the Ottawa Electric Railway, the average horse-power of each motor being 106, or a total motor installation of 11,236 h.p., but the maximum power demand is less than 7,000 h.p., or in round numbers only about 7/12 of what might be called the installed power capacity. The economy of generating the power in a central station instead of having steam engines on the cars themselves is therefore evident. At least 5/12 of the coal that would otherwise be required is saved, and, assuming that the plant is operated by water, all the coal is saved.

Mr. Murphy stated that 18% of the energy in the coal is obtainable at the switch-board in a modern pumping plant, but 97% of the energy of the coal hauled by locomotives is wasted either by loss of efficiency in the locomotive or by the power required to haul coal and water for its own purposes, and by the radiation and standing losses, etc. The locomotive cannot have the benefit of modern condensing apparatus and other fuel-saving apparatus that is available to modern central stations. Mr. Murphy's argument tended to show that it would pay to electrify railways even if the generators in central stations are steam-driven, and certainly if they are water-power driven, on account of the entire conservation of coal.

"Steam Locomotives consume 25% of all coal mined every year," he said. "Electric locomotives can save two thirds of that coal when their electrical energy comes from stationary steam plants; water power can make them save it all.

"Still smarting from the sufferings of two successive winters' fuel shortages, caused primarily by inadequate transportation facilities, we should prevent, if possible, recurrences of such serious and trying experiences.

Use 30% of Canadian Coal

"No argument is required, I think you will agree, to support the contention that eliminating the need for coal at a considerable distance from the mine is a greater measure of relief, and of true conservation, than increasing mine production and thereby adding more load to the already overburdened railways. Reducing coal consumption automatically relieves or releases men and apparatus all along the route from the mine to the consumer; it also relieves the route itself from some of its congestion.

"So eminent an authority as E. W. Rice, the president of the American Institute of Electrical Engineers, addressing that body in New York in February, 1918, made the following statement:

"'It is really terrifying to realize that 25% of the total amount of coal which we are digging from the earth is burned to operate our steam railroads—and burned under such inefficient conditions that an average of at least 6 pounds of coal is required per horse-power-hour of work performed. The same amount of coal burned in a modern central power station would produce an equivalent of three times that amount of power in the motors of an electric locomotive, even including all the losses of generation and transmission from the power station to the locomotive.'

"Mr. Rice went on to say that 150,000,000 tons of coal, nearly 25% as he said, of all the coal mined in the United States, were consumed in steam locomotives last year.

"Here in Canada steam locomotives consumed about 9,000,000 tons—30% of the 30,000,000 tons of coal imported into and mined in this country. Our 9,000,000 tons cover, I believe, wood and oil consumed on steam locomotives; some 49,000,000 gallons of oil are covered by the Canadian record. But, in the United States figures, 40,000,000 barrels of oil, 15% of the total oil output, are not included.

Of Interest to Fuel Controllers

"The total conservation of—the elimination of the necessity for mining—those great quantities of fuel would be secured if all the railways were operated electrically and if the electrical energy were generated from water power. Modern steam central stations can save from 50% to 66% of the coal now used in steam locomotives if the latter are discarded and electric locomotives used instead.

"With such possibilities for fuel conservation in sight may we not soon expect to learn that the fuel controllers in both countries have asked the railways, and that the railway managers have asked their engineers:—'How many of these millions of tons of coal can you save—when will the good work of railway electrification begin?'

"It is said our fuel shortages were due to a combination of bad weather and inadequate transportation. As we cannot control the *weather* our attention and efforts must be directed to the *transportation* portion of the difficulty. Railway electrification will reduce coal consumption, coal haulage and the mining of coal; it will also greatly improve traffic conditions; electrification, therefore, seems to be the solution of the problem. Under these circumstances it may not be out of place to recite in general terms what electrification has actually accomplished on some notable railways.

"Railroading in the mountains is the most strenuous kind of railway work. The examples which I have chosen cover mountain sections. The Butte, Anaconda & Pacific Railroad, by electrification, is said to have increased its tonmilage 35% and at the same time decreased the number of trains, and their incidental expenses, 25%. The time per trip was decreased 27%. It is said their savings in the first year's operation, after electrification, amounted to 20% of the total cost of electrification. That railway buys power from water power plants.

Regenerative Electric Braking

"On the Norfolk & Western Railway power is obtained from their own steam station. Twelve electric locomotives have replaced 33 Mallets of the most modern and powerful type. The tonnage has been increased 50%. Electrification obviated the necessity for double tracking. The salvage value of the released steam engines was 45% of the cost of electrification. Electric locomotives make 8 times as many miles per-train-minute-delay as the steam engines. Their terminal lay-overs average only 45 minutes and they are double-crewed every 24 hours. Pusher engine crews have been reduced from 8 steam to 4 electric. Pusher engines or locomotives have been reduced from 7 steam to 2 electric. Steam locomotives used to 'fall down' in cold weather—the electrics always 'stand up,' they are really more efficient, in cold weather. At the New York Railroad Club meeting last year their electrical engineers stated that:—'coal wharves, spark pits, water tanks and pumps as well as roundhouses and turntables have disappeared from the electric zone. Our track capacity has been doubled. Our operating costs have been reduced. From an engineering, an operating and a financial viewpoint our electrification has been a success.' Speaking of the value of regenerative electric braking they went on to say:—'The use of the air brake is practically eliminated, it is only used to *stop* trains; it is regrettable we are unable to put a dollars and cents value on this great asset; to appreciate it properly one must have had experience with the difficulties of handling 90 car trains with air. Trains of 103 cars are now taken over the summit, 12 to 20 times every day, down the 2.4% grade without even touching the air. We never broke a train in two or slid a wheel. It is done so nicely we wouldn't spill a drop of water out of a glass in the caboose.'

Cruising Radius Is Doubled

"The 440 route miles of Chicago, Milwaukee & St. Paul Railway which have been electrified will soon be augmented by 450 miles more. Nearly 900 miles of railway and about 33% in addition for passing-tracks, yards, industrial tracks and sidings will soon represent the extent of this great railway electrification. Among the advantages secured by this railway on its electric sections are the following:—The 'cruising radius' of each electric locomotive is twice that of the steam engine. Sub-divisional points, where freight crews and steam locomotives were formerly housed and changed, have been abolished; the passenger crews' runs are now 220 miles instead of 110. For railway purposes, these stations do not now exist; 7 or 8 miles of track at each old station have been taken up; 'through freights' do not leave the main line track at all at these points; shops and roundhouses have disappeared, along with their staffs, and one electrician replaces the whole old shop and roundhouse force. An electric locomotive has made 9,052 miles in one month. Although schedules have been reduced the electrics have 'made up' more than 2½ times as many minutes as steam engines running on the old schedules —'time' which had been lost on other divisions; 29% of electric passenger trains made up time in this manner. On a milage basis alone the operating costs of the electrics are less than one half the steam engine costs. Freight traffic increased 40% shortly after electrification—double-tracking would have been necessary to handle such increased business under steam operation. An average increase of 22% in freight tonnage, per train, has taken place. One electric handles about 3½ times as many ton-miles as a steam engine; the reduction in time in handling a ton-mile is 30%; faster and heavier trains have accomplished these results; the number of trains has not been increased. About 11½% of the energy used by the railway is returned to the line in the process of regenerative braking, and this returned-energy helps to haul other trains. While this is a very important item, and reduces the power bills, it is only regarded by the management as of secondary importance in comparison with the more safe and easy operation of trains on the grades, and the elimination of former delays for changing brake shoes and repairs to brake rigging when operating with steam locomotives. The electrics maintain their schedules much better than steam engines. In three months the electrics only waited for the right of way 254 minutes, while the steam engines in a similar period waited 1910 minutes—or 7½ times as long. Extra cars on trains only delayed electrics 1/9 of the time steam trains were delayed for a similar reason. Cold weather delayed steam trains 445 minutes in the three months under discussion, but the electrics were not delayed a minute; the latter are *more efficient* in cold weather. Many of the delayed steam trains were double-headers—but never more than one electric is hitched to a passenger train. An entire suspension of freight service, due to steam engines losing their steaming capacity and freezing up, was not an uncommon experience. Electrical energy for the operation of these trains costs considerably less than coal. This latter statement is one of the most interesting in connection with the operation of the C. M. & St. P. Ry. and it is especially interesting because it was made more than two years ago.

Electric Motor Only a Link

"The foregoing actual operating experiences on large railway electrification projects show what the electric locomotive is doing every day. As the vice-president of the last mentioned railway said 'electrification has made us forget that there is a continental divide.'

"We must remember that while a steam engine will only do the work for which it was designed, the electric motor is only a link between the central station and the load, and it will pull any train of any weight whatever that is provided with strong enough couplings. All that is necessary is to make the electric locomotive large enough and strong enough so that it will not burn out.

"The limitations of the steam locomotive are due to the fact that it is a mobile steam power plant of limited capacity; it is compelled to carry its own supply of coal and water; and, it is unable to take advantage of many of the economical refinements of the large modern stationary steam plant. On the other hand the electric locomotive has no such limitations; it merely acts as a connecting-link between efficient stationary steam or water power plants of unlimited capacities—because they may be extended indefinitely—and the train to which it is connected. The Electrical World summed up the situation some time ago when it said:—'Why continue to haul millions of tons of coal, for and by uneconomical steam locomotives, all over the country, and thus add more loads to the already over-burdened railways, when the power which they need so badly can be much more economically and efficiently transmitted to electric locomotives over a wire the size of one's little finger?'

Old Estimates Need Revision

"The continual increasing cost of coal and fuel oil will force railway managers to look more and more carefully into railway electrification. Estimates of a few years ago now need revision. Money may be hard to get but if, at times, fuel cannot be obtained at all some substitute must be obtained—if normal life is to be continued in northern latitudes.

"A representative of the National City Bank of New York, writing of the period after the war, referred to the stagnation which might ensue, in all the great industries then engaged in war work, as soon as peace is declared; the multitude of the people thus thrown out of work in addition to the men of the returning armies may create unbearable conditions unless suitable employment will have been arranged for them in advance; he referred to the economic advantages of railway electrification and was of opinion that this work might solve the whole question if soon taken up with vigor. The Minister of Public Works, Hon. F. B. Carvell, M.P., addressing the Ottawa Branch of the Engineering Institute of Canada a number of months ago, spoke of the necessity for conserving the energy of our water powers—instead of letting them run to waste—so that this great store of energy might be employed in assisting to build up our own country and to rebuild other countries when peace comes. How nicely these two ideas, water power development and railway electrification, would work together if properly carried out!

Generalization Always Dangerous

"With the view of securing something worthy of presentation to this important meeting I wrote to an eminent engineer, a man of international fame and recognized as an authority on railway electrification, requesting him to tell me his own views upon this subject. A specialist's opinion, in my opinion, is always very valuable. Here is a short extract from his interesting reply. He said:—'Generalization is always dangerous, especially in connection with electrification of railways, where so many factors such as the physical location, character of loads, the power situation, etc., come in to affect the decision if applied locally.' From this sober statement it may be seen that my correspondent is an engineer—not a politician. He proceeded as follows: '. . . with present equipment-prices the cost is absolutely prohibitive.' This opinion, let me point out, as in connection with the proposal to 'electrify everything.' Do not let it dampen our enthusiasm. Listen to this also and kindly keep it in mind; it is another extract from the address of C. W. Rice above referred to. He said:—'I think we can demonstrate that there is no other way known to us by which the railroad problem facing the country can be as quickly and as cheaply solved as by electrification.'

"While the recent fuel shortage and kindred questions have made us look to railway electrification for relief I feel such projects on a large scale can only follow or go hand in hand with water power plant development and co-operative operation of power plants. The location of a number of plants at different points—large water power plants and auxiliary steam plants—so situated and inter-connected that a failure at one plant, or the connections to it, will not jeopardize the others or completely cut off and isolate an important railway district is, in my opinion, an essential and a prime necessity in connection with any large railway electrification project.

"The 99 year power contract of the C. M. & St. P. Ry. above referred to is worthy of more than a moment's attention and consideration in this discussion. That railway has a contract with a power company which has a series of plants stretching across the whole country parallel to the railway. The railway owns its sub-stations and secondary lines but it is not concerned with the high tension lines or power plants of the power company. A reasonable and fair deal—a contract, in fact, which each party knows the other will respect—is the basis and the real reason for that great railway electrification. Neither party questions the other's integrity or financial soundness. One delivers the power it has undertaken to supply and the other uses it. The arrangement is ideal in its simplicity and entirely satisfactory to everybody concerned. It will, in my opinion, be necessary to have such attractive power conditions as those outlined above, backed by abundant supplies of power, in order to foster and encourage 'railway electrification' in this country.

"Railway electrification is a truly economic (financial and engineering) problem—a problem worthy of the best attention of the most highly trained and experienced specialists."

Discussion by W. G. Gordon

Regardless of grades, the electric locomotive can pull a train at the highest speed allowed by the alignment of the track, declared W. G. Gordon of the Canadian General Electric Co., who showed a large number of slides giving views of electric locomotives and statistics showing a saving in maintenance costs amounting to as much as 37.8%, and an increase of revenue ton miles hauled of 10.7%, or an actual saving of 44%. On one railroad 19.72 watt-hours per ton mile were required with the regenerative braking and 24 watt-hours without regenerative braking.

Mr. Gordon also showed a couple of very interesting reels of moving pictures demonstrating the operation of electric locomotives and showing a trip across the continental divide on a train hauled by an electric locomotive. The film is entitled "The King of the Rails" and is the property of the General Electric Co., Schenectady. It shows the ease with which electric locomotives handle both passenger and freight traffic.

F. H. Shepard's Address

F. H. Shepard, of the Westinghouse Electric and Manufacturing Co., said that the main point in regard to the electrification of railways is not economy in operation, but the question of the propriety of diverting from households fuel that will be urgently needed for heating and other purposes in years to come, in view of the fact that hydro-electric power can be utilized fully as well for the railway's purposes.

He referred to the electrification of the Norfolk & Western, stating that the capacity of this railroad has been doubled. On the best grades, trains of 5,000 tons are handled by a single electric locomotive, and on 2% grades, trains weighing 3,250 tons. These trains have been accelerated to full speed within a minute on a 2% grade. This road is a heavy coal carrier, and uses "Titanic" cars weighing 30 tons empty and carrying 100 tons of coal. The road also has very heavy curves.

On the St. Clair tunnel, during the first year of operation after electrification, the Grand Trunk Railway reported a total delay of only seven minutes.

Mr. Shepard also called attention to the possible saving in track and roadbed maintenance by the use of electric locomotives, the weight being divided in the electric locomotive, whereas in the steam locomotive there is a great concentration of weight and also heavier impact. The load of the electric locomotive can be divided over any desired number of driving axles. His company is now building locomotives with twelve driving axles and is contemplating a design with even a larger number. There is no difficulty, he said, in extending the locomotive to any length or power desired. There are no reciprocating parts or counter-balance, therefore he thought that the materials required for track maintenance would be reduced for the same axle weights.

The electric locomotive, said Mr. Shepard, shows no diminution in capacity. If it is in condition for service at all, it is 100% engine. The steam locomotive shows a continual reduction in efficiency, especially in cold weather.

Low Maintenance Charges

The repairs and renewals of an electric locomotive are almost insignificant and it always operates to the limit of its design and operates even better in winter than in summer, whereas the steam locomotive frequently goes out of business entirely in winter. In the Pennsylvania terminal in New York City, electric locomotives have been operated for years, and the only expense due to maintenance has been when a monkey-wrench has been dropped into the works, or on account of some similar accident, other than the purchase of a few brushes and a little paint, etc. Of course, the cost of maintenance of electrical equipment depends entirely upon the history of the handling of the equipment, said Mr. Shepard, as the motor will attempt to "carry on" under any load that is put upon it, and even though it may do the work, it may have suffered a strain that will show up later on. Careful operation of electrical equipment is required to avoid overloading. From the data available at present, however, a saving of at least 50% in maintenance is shown by the electric locomotive as compared with the steam locomotive.

High Voltage Most Economical

The overhead conductor carrying high voltage has been found to be the most economical, said Mr. Shepard, and improvements expected in these conductors will result in lowering their cost. Power prices have been kept stationary and have even decreased during the past few years.

Round-houses, division points and repair shops are reduced in number by electric locomotives, which have a cruising radius much greater than the steam locomotive. The economical operation of railroads, with increased labor costs, will require expeditious handling of traffic, said Mr. Shepard, and electrification will be the only way of increasing the capacity of the roads, increasing revenues and avoiding freight embargoes. He called attention to the locomotives now being built for the Chicago, Milwaukee & St. Paul Railway, which have six twin motors and nine operating speeds.

Comfort A. Adams, president of the American Institute of Electrical Engineers, who arrived shortly before Mr. Murphy finished his discussion, was asked to say a few words to the meeting. Mr. Adams said that the feature of electrification of railways that appeals to him the most, is the reliability of electrical apparatus and the greater certainty of its doing the work assigned to it than is found in any other type of machine.

C. A. Adams Emphasizes Conservation

He drew attention especially to the conservation that electrical locomotives would effect and said that this phase of the problem would become more and more important, and that we could look forward to the time when nearly all railroads will be operated very largely by electric power.

Changing the subject for a moment, Mr. Adams congratulated the institute upon the way in which it is interesting the electrical, mechanical and mining engineers as well as civil engineers, and said that he thought that they had taken a step in the right direction in broadening out and interesting all classes of engineers. He said that the discussion on railway electrification was an example of one of the many problems that interests all the different classes of engineers alike. It is equally electrical, mechanical and railroad engineering, and indirectly interests those who are concerned in the development of water powers.

H. H. Vaughan Presents the Other Side

H. H. Vaughan, formerly superintendent of motive power, C.P.R., discussed the problem from a viewpoint of the railroad man accustomed to handling steam locomotives throughout his lifetime. Mr. Vaughan explained that he had been out of railway work for several years past and that he was somewhat "rusty" on the progress made in railway electrification, but that from 1900 up to a few years ago he had been actively interested in discussing railway electrification, and that he had always hoped to see some portion of the C.P.R. electrified.

Electrification must have done a great deal, said Mr. Vaughan, to make railway men's lives more comfortable, because of the greater certainty of operation and the much less engine trouble. The bane of the motive power superintendent's life is the daily list of steam locomotives out of commission.

He defended the efficiency of the steam locomotive, however, and stated that he does not believe that the consumption of fuel in steam locomotives is so wasteful as had been stated. The examples shown, he claimed, were taken from lines where the conditions of operation did not make for efficiency with steam locomotives. Where the grades are good, such as from Ottawa to Winnipeg and Ottawa to Montreal, he believed that a low coal consumption would be shown per ton-mile. There is a saving in electrification, he said, but not so great as is generally supposed.

The repairs to electrical equipment must cost money, and he did not think that the comparison of maintenance costs was made upon a fair basis. The cost for electric locomotives, he maintained, had been taken for locomotives that had been in service only four or five years, whereas they had been compared with costs of operation of steam locomotives some of which had been in service for many years.

If a railroad were equipped with all new steam locomotives, he thought that the maintenance charges would be as low as electric railway maintenance charges. The steam locomotive requires little attention the first few years of operation, and after that the cost of maintenance increases steadily for ten or twelve years, when it must be rebuilt. Mr. Vaughan claimed that it had not yet been determined just how long an electric locomotive would run before being rebuilt, but he felt certain that it would play out some time or other and would have to be renewed just the same as any other engine. It is not the boiler and engine that costs all the money for repairs, he said, but the running gear and general breakages,—expenses that would be attributable alike to electric locomotives.

When he was on the C.P.R. he had investigated electrification frequently, he declared, and he was always interested in it and never opposed to it. He recognized its advantages in the way of smoke elimination and avoidance of delays. He had proposed electrification for the Quebec section of the C.P.R., intending to obtain 25-cycle power from Shawinigan; but when they estimated the cost, they found that they could strengthen their old bridges and buy more modern steam equipment at less expense, and they did that instead of electrifying.

May Electrify Smith's Falls to Ottawa

They also examined in detail the costs of electrifying from Fort William to Winnipeg, but it was difficult, said Mr. Vaughan, to show a very great saving. Other lines also were figured out but under the existing conditions of traffic, the saving shown was not as great as expected.

There is one section of the C.P.R., however, which he thought would be electrified before long, if the traffic increases, or as the Montreal terminal facilities get crowded, and that is the Smith's Falls to Ottawa division, including the Montreal terminal. He believes that the traffic there warrants electrification and that electrification would be the next move toward increasing the Montreal terminal facilities.

Railroads hesitate, said Mr. Vaughan, to tie up great investments in one specific district when they can put the same money into locomotives which can be swung from one district to another wherever the power may be needed. An earning of possibly 7½% might be shown on the cost of electrification where the same money put into modern steam plant might show earnings of 25%. Like all other business problems, said Mr. Vaughan, it is a question of dollars and cents.

In this country, however, where so much water power is available, there is another side to the question, he admitted, which cannot be ignored, and that is that electrification would avoid the burning up of a supply of coal which some day our descendants will sorely need.

Competing Systems Hampered Progress

Mr. Vaughan expressed an opinion that greater progress had not been made in railway electrification, largely because the big electrical companies in past years had competing systems. If a railroad invested millions in one system, he said, the other company would tell them that they had made a tremendous mistake, for which they would be sorry. If the chief engineer of another railroad were to report in favor of the other system, then the electrical engineers of the competing concern would intimate to the directors that their engineer was not quite fully posted on the problem.

While he understood that these matters had been adjusted now, said Mr. Vaughan, and that all electrical engineers are nearer in accord as to the proper systems to use, still these earlier disagreements had had their effect and had caused railroads to hesitate until everyone was in agreement as to the very best system of electrification. He was glad to see the electric railway engineers reaching agreements about these problems and thought that once it was mutually agreed by all engineers as to just how electrification should be accomplished, that many more railroads would take up the question and much more rapid progress would result.

First Thought of the Government Will Be To Prevent Unemployment, says Minister of Public Works

HON. Frank B. Carvell, minister of public works, was the speaker last Thursday noon at the luncheon held by the Engineering Institute of Canada in connection with the Ottawa professional meeting.

Mr. Carvell said that until the country gets back upon a normal peace basis, the first thought of the Dominion government is to provide employment where necessary. The chief need will be in the larger cities, he thinks. In the Maritime Provinces there is no unemployment, in Montreal there is some, in Toronto much more.

"I do not believe that we have Bolshevism in Canada now, but if men get hungry we will face a most unpleasant situation," he declared. "The government must spend money, and any amount necessary, to give our returned soldiers an opportunity to work."

Soldiers will be demobilized at the rate of 30,000 to 40,000 monthly from now on, and while they will not all want employment as soon as they get home, most of them will want it within a few months or a year. Mr. Carvell told how politics had been generally mixed up with the spending of public money in Canada, and promised that in the future vote-getting would not dictate the spending of public funds. Referring to highways, he said that he knew of no way in which public money could be spent to better advantage to create employment, or where the people would get better value for their money.

"The engineer will be the most important man in the working out of our road policies," said Mr. Carvell. "In the past more money has been squandered on building roads than any other public work, because the right kind of roads have not been built There is no use building roads which become mud holes in a year or two." He referred to the necessity for adequate drainage and said that it would be the federal government's policy in road work to have engineers on the job from the first to last.

"There is no reason for pessimism," declared Mr. Carvell, "because Canada has come through the ordeal of war in better shape than any other allied nation, and economically to-day is in a better position than any of them. Once we get back to a peace basis, we will experience a period of prosperity heretofore undreamed of.

"But there is another side to the question," he continued. "For months past people have been coming to Ottawa in processions pointing out to the government where money can be spent to advantage on public works. I don't object to that, for under our system of government that is the right of the people, but we must not forget that before the war we had a national debt so small that it was hardly worth considering. It was about $330,000,000, and we never counted it when considering expenditures. We had a revenue of $150,000,000 to $160,000,000 per year, and we could take care of the interest on the debt without trouble. If we wanted to spend $15,000,000 or $20,000,000 for a public work, we had the money to do it. And besides that we had a good surplus. In fact a large part of the cost of the construction of the National Transcontinental Railway was taken care of out of our surplus. As it stands to-day, or as it will stand when our men get home, the public debt of Canada is about two billions of dollars and the interest on that will be from $110,000,000 to $115,000,000 per year or almost as much as our total liquid revenue before the war.

"To this interest we must add $50,000,000 per year for pensions and that must be paid no matter what else suffers, for that is a debt we owe to the soldiers and it must be liquidated to the last dollar. Soldiers' hospitals must be maintained and there must be other expenditures in connection with the re-establishment of the fighting man which must be carried out as long as one of these men remains alive to need it. In all we will require a revenue of from $300,000,000 to $350,000,000 per year, and if any man can tell me where the last million dollars of taxation is coming from, or how we are to raise that huge amount of money, then I say that he is entitled to any position the people can give him."

"It will take a good deal of money to put the Canadian Northern where it ought to be," said Mr. Carvell, "and I think as much money will be spent on the railways as in any other department of public work.

"The government's program calls for the spending of a large amount of money this year and the program will probably be enlarged, as it usually is, by supplementary estimates.

"But there are other institutions in the the country beside the Government that have a responsibility in connection with the effort to get back to peace conditions. The great corporations, public or private, the employers of labor all have their part to play and they must not shirk it. I am not a pessimist but I want to say here and now that we have troublous times ahead unless we face them properly. We must provide employment, for if the men of the country are not employed we will have something very near to Bolshevism. Every man who has made money during the war, and most employers of labor have made money, has a duty to carry on for the next year whether he can do it at a profit or not. He must play his part in the effort to bring the country back to a peace basis. It won't be for long. In a year from to-day we will have forgotten all about it.

Will Spend the Necessary Money

"During the coming year it will be necessary to spend money to prevent unemployment, and we will spend it. We can borrow it if we have to; we have borrowed it for war purposes for the past four years and we can do it again. It isn't this year, but it is the next year, after the soldiers are home and peace conditions restored, and the year after that and after that again, that we will need to be careful about the debt."

Visit to Parliament Buildings

After luncheon Thursday, the engineers visited the new Parliament Buildings, where they were met by J. B. Hunter, deputy minister of public works, who briefly outlined the history of the new structure from the time of the fire, February 3rd, 1916.

Apart from the loss of life, there were few regrets that the old building had been destroyed, he said, as it was badly ventilated, dirty and had outgrown its usefulness. He praised the work of the architect, J. A. Pearson, and his associates, Messrs. Ewart and Marchand. Mr. Hunter stated that the building is 470 ft. long, 245 ft. wide and 90 ft. high. The tower will be 260 ft. high.

Other Papers Read

After returning from the Parliament Buildings, the technical meetings were resumed at 4.30 p.m., J. L. Busfield reading a paper on "The Montreal Tunnel," illustrated by lantern slides, and Col. Leonard presenting a paper on the "Mining and Metallurgy of Cobalt Silver Ore." A paper was also presented on the "Standard Datum Planes for Canada,'" by Dr. W. Bell Dawson, superintendent of Tidal Surveys Department of Naval Service. Dr. Dawson reviewed the efforts that had been made to secure an accurate sea level datum, and the need for uniformity in surveys throughout the country. In conclusion he said:—

Dr. Dawson Urges Uniformity

"We have at present a network of levelling in Eastern Canada, which has been built up by three systems of levelling operations since 1883, and is now correlated accurately with mean sea level. The levelling in the public works department, extending from Georgian Bay through the Montreal region, and now connected with the tidal stations on the Lower St. Lawrence and at Halifax, was finally revised in 1914.

"The lines of the geodetic survey in the Maritime Provinces, connected with the tidal station at Halifax, since 1913, extend by other routes continuously to the region of the Great Lakes.

"On the Pacific coast, the lines of levels are also beginning to form a network; and the two sides of the country are united by a through line across the continent finally connected, in 1916 and 1917, by the comprehensive work of the Geodetic Survey. There is thus at present a system of bench-marks throughout all the more inhabited parts of Canada, for reference; and the dates mentioned show that this has been quite recently accomplished.

"It is obviously desirable therefore, that all engineers should now utilize the uniform datum thus established, and that all railway profiles should be referred to it, to eliminate the confusion arising from the adoption of independent datums which are still in vogue."

Moving Pictures by Mr. Norrish

The concluding attraction on the program was the exhibition, Thursday evening, by B. E. Norrish, of moving pictures showing some of Canada's natural resources and modern industries.

Registration

The registration at the convention included 187 from Ottawa and Hull, 38 from Montreal, and 74 from other cities in the United States and Canada, as follows:—

Toronto—H. T. Hazen, J. M. Wilson, H. W. Wicksteed, E. T. Wilkie, E. M. Proctor, Geo. Hogarth, W. S. Harvey, A. H. Harkness, H. E. T. Haultain, J. Morrow Oxley, T. U. Fairlie, C. S. Gzowski, Jr., F. G. Engholm, H. W. Armstrong, W. B. Russell.

Winnipeg—B. Stuart McKenzie, Guy N. Dunn, E. Brydone-Jack, J. M. Leamy.

Quebec—A. R. Decary, A. B. Normandin, Alex. Fraser, H. E. Huestis.

New York—Alfred D. Flinn, A. B. Oatley, A. C. London, F. H. Shepard.

Vancouver—Major W. G. Swan, C. J. Moon, Lt.-Col. Montizambert, W. M. MacAndrew.

St. John—F. G. Goodspeed, A. Gray, C. C. Kirby, Gilbert G. Murdock.

Kingston—R. M. McLelland, W. L. Goodwin, G. L. Guillet.

Peterborough—A. L. Killaly, Robt. B. Rogers.

Pembroke—Jas. L. Millar, J. L. Morris.

St. Catharines—R. W. Leonard, Alex. J. Grant.

New Westminster—A. M. Worsfold, W. R. Gross.

North Bay, T. R. Courtright; Fort William, H. B. R. Craig; Chatham, N.B., Geoffrey Stead; Isle Verte, P.Q., J. T. Bertrand; Cape Tormantine, N.B., A. B. Frippe; Bathurst, N.B., W. M. Melanson; Melbourne, Ont., J. W. Harkom; Brockville, G. H. Bryson; Sherbrooke, W. E. Brooks; Windsor, Arthur F. Stevens; Amherstburg, G. S. Rutherford; Sault Ste. Marie, J. W. B. Ross; Deschenes, P.Q., C. D. Norton; Cornwall, W. H. Magwood; Belleville, G. H. Forth; Worcester, Mass., I. N. Hollis; Napanee, F. F. Miller; Outremont, J. A. Duchastel; Iroquois Falls, L. E. Kendall; Calgary, Wm. Pearce; Halifax, C. W. Dodwell; L'Original, Victor A. Belanger; Timiskaming, P.Q., R. F. Davy; Three Rivers, Romeo Morrissette; The Pas, Man., J. W. Porter; Dawson, Alfred Thompson; Medicine Hat, Lt.-Col. Nelson Spencer; Moncton, S. B. Wass.

At the meeting held last week in Ottawa, the members of the Engineering Institute of Canada adopted a design for a new emblem. A shield of the same shape and size as the present emblem will bear the name and date of incorporation, and a beaver. There will be no enamel work. The badges will be in gold for members, silver for associate members and bronze for juniors and students. Each badge will be numbered on the back and they will be sold only to members of the institute.

SPECIFICATIONS FOR ASPHALT BINDER AND REFINED AND BLENDED COAL TAR

IN the report made to the Engineering Institute of Canada by the Committee on Roads and Pavements, the following specifications are advocated for asphalt binder (penetration method) and for refined and blended coal tar:—

Specification for Asphalt Binder

Penetration Method

1. It shall be homogeneous and free from water, and shall not foam when heated to a temperature of 150°C. (302°F.).
2. It shall have a specific gravity at 25°C. (77°F.) of not less than 0.98.
3. It shall have an open flash point of not less than 190°C. (375°F.).
4. It shall have a penetration (No. 2 needle, 100 grams, 5 secs., 25°C.) of not less than 130° nor more than 180°.
5. It shall have a ductility at 25°C. (77°F.) of not less than 75 centimetres.
6. It shall be soluble at room temperature in chemically pure carbon disulphide to the extent of not less than 99.5 per cent. by weight in the case of oil asphalt, and native asphalts shall show a percentage of the products of the fields from which they come.
7. Of the material soluble in carbon disulphide not less than 14 per cent. nor more than 30 per cent. by weight shall be insoluble at room temperature in 76° Baume paraffine petroleum naphtha distilling between 60°C. and 88°C. (140°F. and 190°F.).
8. It shall show not less than 10 per cent. nor more than 18 per cent. by weight of fixed carbon on ignition.
9. When fifty grams of the material are heated in a cylindrical vessel 5.5 centimetres in diameter and 3.5 centimetres deep, for 5 hours at a temperature of 163°C. (325°F.) the loss in weight shall not exceed 5 per cent., nor shall the penetration of the residue (No. 2 needle, 100 grams, 5 secs., 25°C.) be less than 50 per cent. of the original penetration.

Specification for Refined and Blended Coal Tar

Cold Application

1. It shall be homogeneous and free from water.
2. It shall have a specific gravity at 25°C. (77°F.) of not less than 1.14 nor more than 1.18.
3. It shall have a specific viscosity for 50 cubic centimetres at 40°C. (104°F.) of not less than 20 nor more than 30.
4. On distillation the percentages by weight of distillate at the following temperatures shall be:—

To 170°C. (338°F.)	not more than	5 per cent.
" 235°C. (455°F.)	" " "	18 " "
" 270°C. (518°F.)	" " "	25 " "
" 300°C. (572°F.)	" " "	32 " "

(a) The residue from the foregoing distillation shall have a melting point of not more than 70°C. (158°F.).

(b) The distillate from the foregoing distillation shall have a specific gravity at 25°C. (77°F.) of not less than 1.01.

5. It shall be insoluble in chemically pure carbon disulphide at room temperature to the extent of not more than 15 per cent. weight.

Hot Application

1. It shall be homogeneous and free from water.
2. It shall have a specific gravity at 25°C. (77°F.) of not less than 1.20 nor more than 1.27.
3. It shall show a float test at 50°C. (122°F.) of not less than 65 seconds and not more than 85 seconds.
4. On distillation the percentages by weight of distillate at the following temperatures shall be:—

To 170°C. (338°F.)	not more than	0.0 per cent.
" 235°C. (435°F.)	" " "	10 " "
" 270°C. (518°F.)	" " "	17 " "
" 300°C. (572°F.)	" " "	22 " "

(a) The residue from the foregoing distillation shall have a melting point of not more than 75°C. (167°F.).

(b) The distillate from the foregoing distillation shall have a specific gravity at 25°C. (77°F.) of not less than 1.03.

5. It shall be insoluble in chemically pure carbon disulphide at room temperature to the extent of not more than 20 per cent.

Binder

Penetration Method

1. It shall be homogeneous and free from water.
2. It shall have a specific gravity at 25°C. (77°F.) of not less than 1.20.
3. It shall have a melting point of not less than 28°C. (83°F.) nor more than 35°C. (95°F.).
4. On distillation the percentages by weight of distillate at the following temperatures shall be:—

To 170°C. (338°F.)	not more than	0 per cent.
" 235°C. (455°F.)	" " "	3 " "
" 270°C. (518°F.)	" " "	11 " "
" 300°C. (572°F.)	" " "	15 " "

(a) The residue from the foregoing distillation shall have a melting point of not more than 75°C. (167°F.).

(b) The distillate from the foregoing distillation shall have a specific gravity at 25°C. (77°F.) of not less than 1.03.

5. It shall be insoluble in chemically pure carbon disulphide at room temperature to the extent of not more than 22 per cent. by weight.

PUBLICATIONS RECEIVED

PRODUCTION AND TREATMENT OF VEGETABLE OILS.—By T. W. Chalmers. Published by Constable & Co., Ltd., London, Eng. 152 pages, with nine folding plans and 95 illustrations; 7½ x 11 ins., cloth, $5 net. The following chapter titles indicate the scope of the work: Principal Vegetable Oils; Preparatory Machinery for Copra and Linseed; Preparatory Machinery for Palm Fruit and Palm Kernels; Preparatory Machinery for Cotton Seed and Castor Seed; Some Special Forms of Reduction Machinery; Meal Kettles, Receiving Pans and Moulding Machines; Oil Presses, Anglo-American Type; Oil Presses, Cage Type; General Arrangement of Oil Mills; Extraction of Oils by Chemical Solvents; Refining of Oils; Hydrogenation or Hardening of Oils; Generation of Hydrogen for Oil Hardening Purposes; Manufacture of Soap; Glycerine Recovery and Refining and the Splitting of Oils; Index.

AIR-LIFT SYSTEM OF PUMPING.—Catalogue No. 900 issued by the Canadian Ingersoll-Rand Co. Ltd., Sherbrooke, P.Q. 32 pages and cover, 3½ x 6 ins., coated paper. Chapters on the advantages of the air-lift, principles of operation, requirements of the wells, necessary equipment and booster pump, reports on numerous installations with photographs, and the uses of the air-lift other than for pumping water.

AIR COMPRESSORS.—Catalogue No. 14 published by Alley & MacLellan, Ltd., Glasgow, Scotland. 160 pages, 6 x 9 ins., coated paper, sewn binding, half cloth, stiff covers. A well-illustrated and fully detailed volume, with useful tables on air compressors, air reservoirs, air piping, pumping motors, after-coolers, vacuum pumps, forge hammers, water traps, air check valves and meters.

At a meeting of representatives of the Ontario Provincial Division of the Engineering Institute of Canada, held last week at Ottawa, the following officers were elected for the ensuing year: J. B. Challies, Ottawa, chairman; E. R. Gray, Hamilton, vice-chairman; George Hogarth, Toronto, secretary-treasurer.

The council of the Township of York, at a meeting held last Monday, instructed their engineers, Frank Barber and R. O. Wynne-Roberts, of Toronto, to prepare preliminary sewerage schemes for the urban portions of the township. These portions include East Toronto, Todmorden, Woodbine Heights, Oakwood, Fairbank, Silverthorne, Runneymede, Swansea, Cedar Vale, Mount Dennis and Lambton Mills.

The Canadian Engineer

Established 1893

A Weekly Paper for Civil Engineers and Contractors

Terms of Subscription, postpaid to any address:

One Year	Six Months	Three Months	Single Copies
$3.00	**$1.75**	**$1.00**	**10c.**

Published every Thursday by
The Monetary Times Printing Co. of Canada, Limited

JAMES J. SALMOND, President and General Manager
ALBERT E. JENNINGS, Assistant General Manager

HEAD OFFICE: 62 CHURCH STREET, TORONTO, ONT.
Telephone, Main 7404. Cable Address, "Engineer, Toronto."
Western Canada Office: 1208 McArthur Bldg., Winnipeg. G. W. GOODALL, Mgr.

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BRICK WALLS AND RESEARCH

THAT Canada needs a Central Research Institute similar to the United States Bureau of Standards, is again demonstrated by the article which appears on another page of this issue, on brick piers, by W. W. Pearse, city architect and superintendent of building of the city of Toronto.

When Mr. Pearse began the work of revising the building by-laws of Toronto, he found it necessary to look to the United States for all information regarding the strength of steel columns, wooden columns, wooden beams and all other structural items. There were very few available Canadian tests.

In connection with brickwork, McGill University and the University of Toronto had no data. They had tested some individual brick and a few piers, but had made no exhaustive tests of piers in relation to the individual brick of which they were composed.

The lack of Canadian data on Canadian materials made it difficult for Mr. Pearse to write an independent and original by-law based on Canadian materials and Canadian conditions. Pending the acquirement of more information, he was forced to leave many chapters remain just as they were. This was particularly true of the chapters on brickwork; but it is hoped that he will be allowed to continue his tests, because during each month in the construction season, the builders and owners in Toronto will save many times as much as the sum that he is asking as an annual grant for the tests.

Aside from the fact that the city of Toronto needs this data for its new by-law, however, there is no reason why that city should be required to pay the entire expense for work of this sort, which is of value to every city and town throughout Canada. In fact, it is not at all likely that the city of Toronto will vote any large sum of money to carry on the tests in a truly comprehensive manner. From time to time the city may vote $500 for these tests, but $10,000 would not be any too much to secure adequate data and proper research into the whole problem.

Would it not be possible to form an advisory committee consisting of all the principal city engineers throughout Canada, to undertake the general direction of these tests? Every city engineer could then include in his annual estimates a grant of a few hundred dollars toward the expense of the research.

Mr. Pearse's tests tend to put a premium on good brick, and rightly so, for there is no reason why for the same load a wall should be as thick if constructed of brick with 5,000 lbs. per sq. in. crushing strength and laid in cement mortar, as if it were built of brick of 1,200 lbs. per sq. in. crushing strength and perhaps laid in lime mortar.

In steel and most other materials, the effect of the slenderness ratio, fixed ends, etc., have been exhaustively investigated, but in brickwork we appear to be about as far advanced technically and scientifically as were the Babylonians.

The few tests conducted by the city of Toronto are not sufficient to warrant very much generalization or the derivation of very reliable formulæ, but the work is valuable and should be continued in the interest of safety and economy for the general public, in the interest of manufacturers of good brick, and above all in the interest of engineers who desire to eliminate guess-work and to make engineering as nearly as possible an exact science.

TWO CENTRAL STATION DIRECTORIES

PROBABLY the clearest instance of duplication of effort by government departments has come to light in connection with the census of central electric stations, that has been undertaken by both the Census and Statistics Office and the Commission of Conservation.

Summaries were recently given out by the Census and Statistics Office of a census that had been taken last year by that Office in conjunction with the Dominion Water Power Branch, and it was announced that there would be published at an early date a complete directory of central electric stations in Canada.

Directly upon the heels of this announcement there is issued a 300-page directory by the Commission of Conservation, covering exactly the same ground and apparently giving the same sort of information that will be given by the Census Office's directory.

Both departments claim to have started the work first, but the Commission of Conservation would at least appear to have completed it first, and their publication is in the mails while the other directory is still in the hands of the editorial committee attached to the office of the King's Printer.

The Commission of Conservation's volume arrived just as this issue was about to go to press and time is lacking to examine it in sufficient detail to offer any comments upon it other than that it appears to be a very thorough and valuable work of reference. Whether the Census Office's directory will be more complete, we do not know, but surely, there has been wasteful duplication of effort that should have been avoided.

It should not be necessary to compile and print two directories for the one purpose. Whether the publication of a directory of this kind comes within the province of the Commission of Conservation or whether it could be more rightly considered a function of the Census and Statistics Office, we do not know; but the duties, rights and fields of these two bodies should be more clearly defined.

Overlapping of this sort seems to be waste of public funds. Surely both parties who were gathering this information must have known, at least latterly, that the other was at work, and if so both are to blame if they did not make some effort to get together and merge their information into one volume. The fact that such merged effort would have resulted in greater value to the public is evidenced by the fact that the two reports differ as to the total amount of power generated in central electric stations in Canada, and the public is left at a loss to know which report is the more accurate.

PERSONALS

GEORGE A. MOUNTAIN, chief engineer of the Board of Railway Commissioners, Ottawa, has been nominated as a director of the American Railway Engineering Association.

ERNEST OLIVER, of Toronto, has been officially appointed superintendent of the Toronto, Niagara & St. Catharines electric railway by the Board of Directors of the Canadian National Railways.

J. R. W. AMBROSE, chief engineer of the Toronto Terminal Railways Co., has been elected president of the Engineers' Club, Toronto. Mr. Ambrose was born in 1878 in Wisconsin, and graduated in 1902 with the degree of Engineer of Mines from the University of Minnesota. Joining the staff of the Minneapolis and St. Louis Railway as an instrumentman, he rapidly worked his way through the construction departments of the Minneapolis, Dakota and Pacific; Chicago, Milwaukee & St. Paul and the Iowa Central. Then he returned to the Minneapolis & St. Louis Railway as Division Engineer on Maintenance of Way, which position he retained until 1907, when he was offered and accepted the position of Assistant Engineer of Construction, Grand Trunk Railway. The following year he had charge of construction of the Grand Trunk Railway System's magnificent hotel, the Chateau Laurier, and of the Central Station, Ottawa. He was next connected with the Montreal and Southern Counties electric railway enterprise, and in 1910 was appointed Resident Engineer of Grade Separation at Toronto by the Grand Trunk Railway, in charge of the extensive changes in grade between Union Station, Toronto and the western entrance to the city. When the Toronto Terminal Railways Co. was organized in 1914, Mr. Ambrose was appointed chief engineer and has been in charge of the construction of the new Union Station at Toronto. He is a councillor of the Engineering Institute of Canada and a member of the nominating committee of the American Railway Engineering Association. In 1909 he became a naturalized Canadian citizen.

LOUIS W. GAY has joined the sales engineering staff of the Texas Co., of New York, and will "cover" Ontario and western New York State, with headquarters at Buffalo. Mr. Gay resigned last summer from the late firm of John Baker, Jr., who were formerly the sales agents for the Texas Co.'s asphalts and road oils.

Auguste Tessier, M.P.P., will ask the Quebec Government to appropriate a large sum of money for the prospecting and development of Ungava. Mr. Tessier declares that some day the water powers of Ungava will be harnessed and their power transmitted far abroad, even to Europe. He quotes no engineering authority for this statement, however.

ELECTRIC GENERATION IN CANADA

UNDER the title of "Electric Generation and Distribution in Canada," the Commission of Conservation has issued a 300-page directory compiled and written by Leo. G. Denis, hydro-electric engineer of the Commission. The book is 6¾ by 9¾ ins., paper bound, and illustrated by many photographs and 12 diagrams and maps.

The data, which is confined entirely to central electric stations, is divided according to provinces and is arranged alphabetically under each province. In each case data is given regarding the ownership of the station, the price at which power is sold, complete information regarding the equipment of hydraulic plants, steam plants and sub-stations, power rates, distribution lines, etc.

Seven tables at the end of the volume tabulate the data as follows:—

Summary of power plants, giving ownership (whether municipal or private), horse-power and kind of prime movers, capacity of generators, maximum load, service conditions and general remarks regarding head, load factor, etc.

Summary of transmission lines, giving voltage, cycles, size of mileage of conductors, value, lightning protection, etc.

Consumption and rates for lighting and power, street lighting, number of consumers, power taken, etc.

Number and capacity of plants and whether hydro-electric, steam or gas, tabulated by provinces.

Ownership, prime movers and generators, with capacity, by provinces.

Load, service, etc., giving the maximum load, type of service, storage and ice conditions, etc.

Transmission lines and distribution, giving the total mileage of lines, capacity of transformers, connected load, etc.

A comprehensive index, occupying nearly 12 pages, adds to the value of the book as a work of reference.