PAGES

MISSING

The Canadian Engineer

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Canada's Water Powers and Their Relation to the Fuel Situation

Canada Abounds in Valuable Water Powers—Location of Waterfalls Admirably Suited to Commercial Centres and Related Raw Materials—Paper Read Before the First General Professional Meeting of the Canadian Society of Civil Engineers, Toronto, March 26-27, 1918

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THE subject assigned to me in connection with this fuel-power symposium meeting of the Canadian Society of Civil Engineers is the relation of water power to the fuel situation in Canada. At first "blush" it might appear that water power has only an indirect and limited connection with the recent critical fuel shortage which through suspended effort has caused temporary industrial stagnation and local domestic hardships of enormous extent and involving great financial loss. Even a casual general survey of our fuel-power requirements, however, will indicate that not only has water power a very direct and important bearing on the present situation, but that water power must, in the future, take a very much greater share in our fuel-power burdens.

Heat, Light and Power Needs—One Problem

It is axiomatic that our heat, light and power needs must be considered as one great national problem, and also that Canada's domestic and industrial development depends primarily on the co-ordinated use of all the fuel-power resources of the Dominion.

Development along independent and divergent lines has, in the past, prevented adequate correlation of the great Canadian industries of fuel production and hydro power supply. There is now, however, as a result of the fuel shortage, developed a consensus of opinion among men familiar with fuel and hydro power matters in Canada, that there is between these allied industries, enormous scope for national co-operation which would be conducive to their mutual advantage, as well as to the common weal.

I propose to show: First, that water power must take a very prominent part, if the best use of the varied fuel-power resources of Canada is to be achieved; and second, that there must be evolved a national master fuel-power policy which will realize the best possible co-ordinated and concomitant development and use of all the fuel-power resources of the Dominion.

Interdependence of Water Power, Coal, Wood, Peat, Oil and Gas

Within the last two days we have had recognized experts describe the possibilities and proper functions of our different available fuels—coal, wood, peat, oil and gas.

CONSUMPTION	BRITISH COLUMBIA	ALBERTA	SASKATCHEWAN	MANITOBA	ONTARIO	QUEBEC	PRINCE EDWARD ID	NEW BRUNSWICK	NOVA SCOTIA	GRAND TOTALS
Domestic										
Anthracite	10,544 (1)	113,130 (2)	28,197 (1)	1,658 (7)	—	—	—	—	—	
Bituminous	1,311,433 (2)	1,951,833 (2)	140,413 (2)	17,719 (1)	—	994,944 (1)	82,924 (1)	891,031 (1)	2,826,300 (1)	
Lignites	21,143 (2)	959,526 (2)	1,134,346 (2)	79,252 (2)	—	—	—	—	—	
Total Domestic	1,343,120	3,024,489	1,302,956	98,629	—	994,944	82,924	891,031	2,826,300	10,701,530
Imported										
Anthracite	—	Small	208,000 (3)	325,000 (3)	2,242,874 (3)	1,794,410 (3)	—	Small	Small	
Bituminous	—	Small	718,879 (3)	1,627,998 (3)	6,459,105 (3)	4,174,850 (3)	—	—	—	
Total Imported	—	Small	926,879	1,952,998	8,701,979	5,969,260	—	Small	Small	17,580,603
Total Consumption	1,343,120	3,034,489	2,229,835	2,051,627	8,701,979	6,964,204	82,924	891,031	2,826,300	28,282,133
Total Production	2,584,061	4,559,054	281,300	—	—	—	—	143,540	6,912,140	14,480,095
Production over consumption	1,240,941	1,534,565	—	—	—	—	—	—	4,085,840	
Consumption over production	—	—	1,948,535	—	—	—	—	747,491	—	
Consumption no production	—	—	—	2,051,627	8,701,979	6,964,204	82,924	—	—	
	BRITISH COLUMBIA	ALBERTA	SASKATCHEWAN	MANITOBA	ONTARIO	QUEBEC	PRINCE EDWARD ID	NEW BRUNSWICK	NOVA SCOTIA	

SOURCES OF DATA

This data obtained from.
Alberta. Dept. of Public Works, Annual Report, 1916.
Albert[a] Dept. of Mines, Quarterly Bulletin, 1917.
British Columbia. Bureau of Mines, Annual Report, 1916.
Canada. Dept. of Mines, Mines Branch, Production of Coal & Coke in Canada, 1916.
Canada. Dept. of Customs, Annual Report, 1915-16.
New Brunswick. Crown Land Dept., Annual Report, 1915-16.
Nova Scotia. Dept. of Public Works and Mines, Annual Report of the Mines, 1915-16.
U S Geological Survey, The Coal Fields of the United States, 1917. (Professional Paper 100-A)
U S Geological Survey, Coal in 1915 (Part A, Production) (Part B, Distribution and Consumption,) 1916.

REMARKS

This compilation is based on 1916 figures. Consumption areas become somewhat distorted because 7,000,000 tons, or about ¼ of the consumption is railway coal, and as such is carried from province to province as traffic necessitates.

Tonnages. (1) Are from Mines and other reports of provinces concerned.
(2) Are from combinations of reports of provinces concerned.
(3) Are calculated, allocating the tonnage according to population and known consumption, both imported and domestic; deductions and additions being made accordingly for domestic and imported tonnages in order to arrive at a reasonable figure. These figures cannot be obtained direct from any Government report.

Differences in totals are accounted for partly by taking arbitrary figures in some cases for purposes of calculation and by different methods of tabulation and statistics.

NOTE Source data compiled and tabulated by Mr. J. F. K. Brown, Mining Engineer

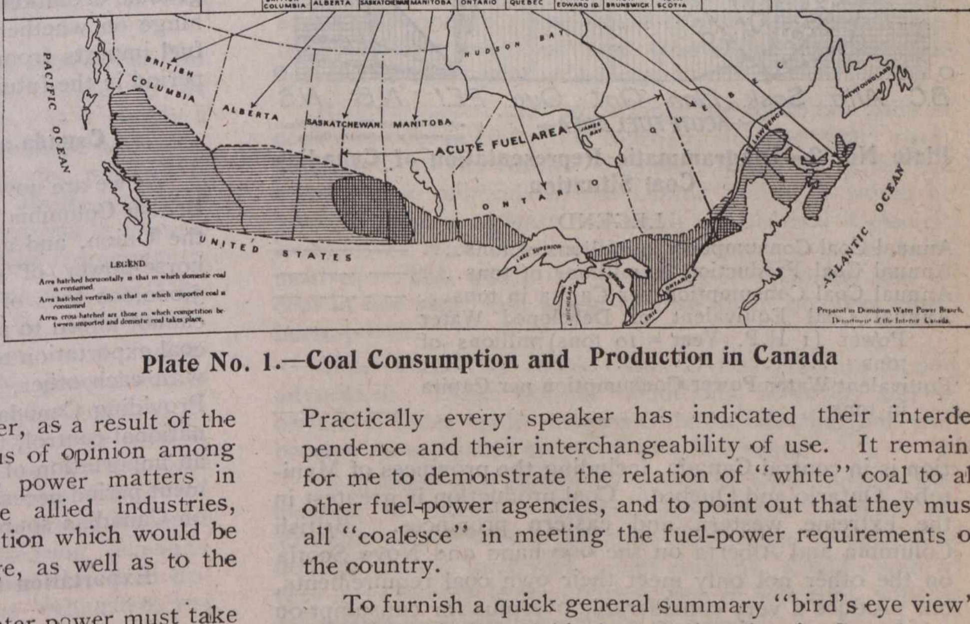


Plate No. 1.—Coal Consumption and Production in Canada

Practically every speaker has indicated their interdependence and their interchangeability of use. It remains for me to demonstrate the relation of "white" coal to all other fuel-power agencies, and to point out that they must all "coalesce" in meeting the fuel-power requirements of the country.

To furnish a quick general summary "bird's eye view" of the "white" and black coal situation in Canada, and to indicate their integrality, I have had several maps and diagrammatic statements specially prepared for submission at this meeting.

Pacific and Atlantic Provinces Self-Sustaining, But Central Provinces Dependent for Coal

Plate No. 1 represents the coal consumption and production in Canada. The tabulated statement on the top of the plate summarizes the consumption in the various provinces of the different classes of coals, both domestic and imported. You will observe the greatest consumption is in central Canada, including the provinces of Manitoba, Ontario and Quebec. Coal production is greatest in the extreme western and eastern provinces. British Columbia and Alberta on the one hand and Nova Scotia on the other not only meet their own coal requirements, but produce a very considerable overplus for consumption in the contiguous portions of central Canada. The central provinces—Manitoba, Ontario and Quebec—are almost wholly dependent on outside sources, mainly imported coals. This is clearly shown by the hatched areas on the map, the horizontal hatching covering the areas which produce their own needs, the vertical hatching covering the areas which are dependent. Where there is cross-hatching both Canadian and imported coals are consumed. It is to be observed that central Canada, where consumption is greatest, is non-productive. This I have termed the "acute fuel area" of Canada.

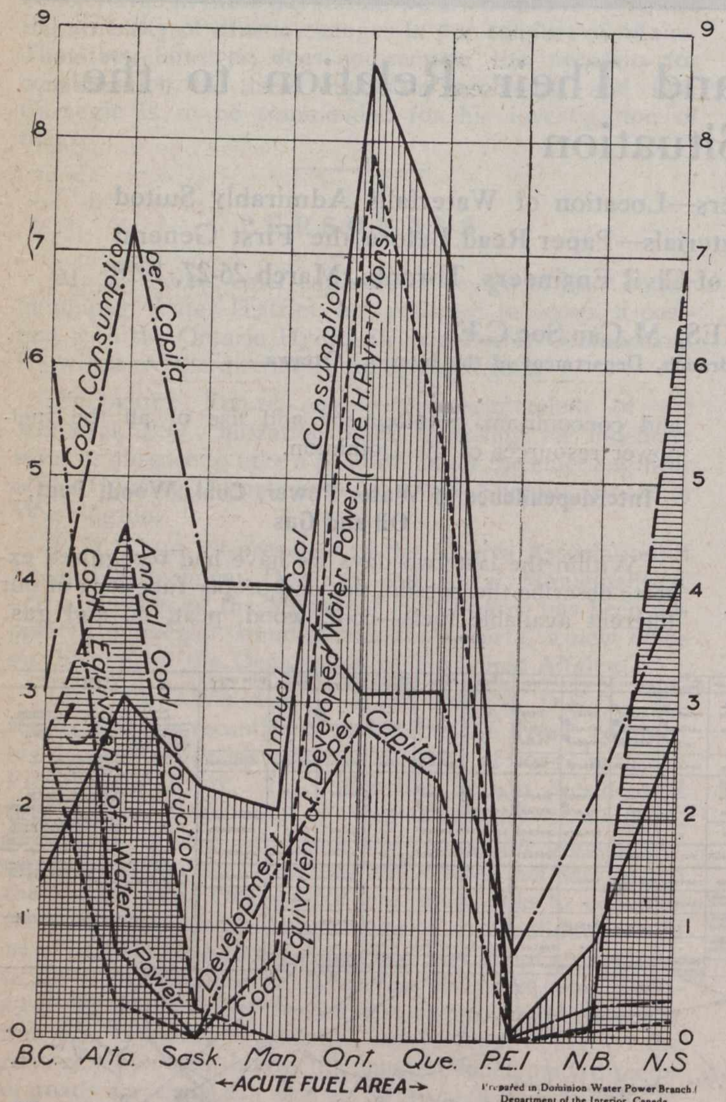


Plate No. 2—Diagrammatic Representation of Canadian Coal Situation

LEGEND

Annual Coal Consumption in millions of tons.... ————

Annual Coal Production in millions of tons.... — — —

Annual Coal Consumption per Capita in tons... —·—·—

Annual Coal Equivalent of Developed Water Power (1 H.P. Year = 10 tons) millions of tons .... - - - - - -

Equivalent Water Power Consumption per Capita in tons .... —-—-—

An Acute Fuel Area in Canada Largely Dependent on Imported Coal

This "acute fuel area" is now dependent for domestic requirements mainly upon Pennsylvania anthracite and for industrial needs upon Pennsylvania bituminous coals, as well as upon Canadian water power. So far as domestic heating requirements are concerned, Mr. Dick, the consulting mining engineer of the Conservation Commission, in his paper on the "Rational Development of Canadian Coal Resources," has pointed out the possibilities of the western portion of the "acute fuel area" being furnished with briquetted lignite from the prairie provinces. Mr. Stansfield, of the Dominion Mines Branch, in his paper on "The Low Temperature Carbonization and Briquetting of Bituminous Coal," has pointed out the possibilities of meeting the domestic heating requirements of the eastern portion of the "acute fuel area" by the product from the low temperature carbonization of Nova Scotia bituminous coals. Although both these processes are proven to be practicable, they are as yet in their formative or agitational stage and some considerable time must elapse before they can be placed on a commercial basis to furnish sufficient fuel to substitute for any large portion of the Pennsylvania anthracite now imported for domestic heating. There is at the present time no available supply, even in small quantities of a Canadian coal fuel to take the place of imported anthracite. Nevertheless, this "acute fuel area" can eventually be made independent of foreign fuel imports and Canada can become self-sustaining, at any rate, in respect of her domestic heating requirements. There must, as a necessary preliminary, be a national, co-ordinated development and use of all the available fuel and power-producing agencies in the Dominion. Such a co-ordination must be a matter of gradual evolution and adoption, and will, to a great extent hinge on whether Canada can reasonably expect assured fuel imports from the United States for a considerable period in the future.

Canada an Exporter of Electrical Energy

As we are now exporting large quantities of coals from British Columbia and Nova Scotia into adjacent States of the Union, and as we are also exporting about 275,000 horse-power of electric energy, equal in value to about 3,000,000 tons of coal, it is obvious the United States cannot afford to place a sudden and complete embargo on coal exportation to Canada. The two countries must deal with each other, at least, upon a basis of *quid pro quo*. Providing Canada has her own fuel resources under strict national control, this power exportation should assure her an importation of sufficient coal to tide over any readjustment period necessary to permit of an ultimate dependence on Canadian sources of fuel and power.

Exportation of Electrical Energy and Assurance for Fuel Needs

The exportation in the past of Canadian electric energy has not been without compensating advantages. An assured United States market for Canadian power loads has enabled the financing and completion of several hydro-electric projects, the construction of which, so far as domestic markets alone are concerned, would not have been warranted at the time. The initial United States power load has, therefore, made it possible for the domestic market to reap all the benefits of available hydro-electric energy many years sooner than otherwise would have been possible.

While Canada has been receiving far more value in her coal importation than she has given in her power exportation, the advantage is rapidly disappearing. It is reasonable to expect that the tendency will be for hydro-power exportation to increase and for coal importation to decrease. The time may come, and in the near future, when the balance will be against Canada.

It is, therefore, imperative that every proposal for increase in the exportation of power be carefully considered from a broad national standpoint. Such consideration involves the evolution of a formula with regard to power exportations which will have cognizance of Canada's fuel-power needs generally.

We must face the fact that for some time to come we shall require to import United States coal, and that in turn therefor we can, under proper conditions of recovery safely and profitably export some of our surplus hydro-electric energy.

Canada, to Become Self-Sustaining, Must Use All Her Fuel-Power Resources According to Their Particular Adaptability

B. F. Haanel, chief of the fuel testing division, Department of Mines, in his clear and comprehensive paper on the "Fuels of Canada," describes the nature, location and extent of our varied, available fuel resources. Mr. Haanel affirms that, while the problems associated with the distribution of fuel to the various parts of Canada are exceedingly complex and the strictest conservation must be practiced, the Dominion is endowed with fuel deposits on such a magnificent scale that all that is necessary is their proper exploitation and economic use for the country to be eventually practically independent of foreign sources of fuel. Mr. Haanel is particularly emphatic that Canada need not go abroad for fuel for household use, if her own fuel resources are properly exploited.

The problem of Canada's fuel needs outside of the "acute fuel area" offers little difficulty, owing to an abundance of both coal and water power. It is simply a matter of efficient and effective use of available resources. Within the "acute fuel area," however, the problem is pressing and prodigious. It resolves itself into two parts; first, provision for domestic or household heating consumption, second, provision for industrial requirements.

1—Domestic requirements of "acute fuel area" involves production of suitable substitute for anthracite.

Domestic needs involve the production of a fuel or fuels which will meet the requirements for general household use. At the present time this need is furnished by American anthracite; over 4,000,000 tons were used in 1916. Competent experts declare the anthracite coal fields of the United States are in measurable distance of exhaustion and that the supply will not last a hundred years. Having in mind the ever-increasing demands within their own borders for this fuel and the rapid decrease in quality as the supply becomes exhausted, responsible fuel advisers of the United States government have seriously urged the establishment of an embargo against exportation of anthracite. We in Canada must realize that our supply of this fuel may be gradually restricted. It is, therefore, essential that we, without delay, consider what can be accomplished in the production of a suitable substitute for United States anthracite.

2—Industrial requirements of "acute fuel area" involve (*a*) more efficient use of soft coal in central heating stations, (*b*) construction of super-power plants to serve contiguous industrial areas, (*c*) substitution of hydro power for steam-produced power wherever possible, (*d*) use of hydro power for all new industries wherever practicable.

The second part of the "acute fuel area" problem and the one with which water power is most intimately connected is the fuel necessity of the industrial or manufacturing world.

The industrial requirements are now met by Canadian hydro power and United States bituminous coal—about 14,000,000 tons consumed in 1916 for this purpose in the "acute fuel area."

Owing to the large reserves of bituminous coal in Pennsylvania, this class of fuel will probably be available

WATER POWER IN EUROPE AND NORTH AMERICA

Dominion Water Power Branch Estimate 1915 (slightly revised)

Country	Area Sq. miles.	Population latest available figures.	H.P. Available	H.P. Developed	Per cent utilized	H.P. Available per sq.mi.	H.P. Developed per sq.mi.	H.P. Per Capita Available	H.P. Per Capita Developed
U.S.A.	2,973,890	98,783,300	28,100,000	7,000,000	24.9	9.4	2.35	0.28	0.071
Canada "A"	2,000,000	8,033,500	18,803,000	1,735,000	9.2	9.4	0.87	2.34	0.216
Canada "B" Populated	927,800	8,000,000	8,094,000	1,725,000	21.3	8.7	1.86	1.01	0.216
Austria-Hungary	261,260	51,173,800	6,460,000	566,000	8.8	24.8	2.17	0.13	0.011
France	207,500	39,601,500	5,587,000	1,100,000	11.6	26.8	3.14	0.14	0.016
Norway	124,130	2,391,780	5,500,000	1,120,000	20.4	44.3	9.02	2.30	0.468
Spain	190,401	19,588,700	5,000,000	440,000	8.8	26.3	2.31	0.26	0.022
Sweden	172,960	5,522,400	4,500,000	704,500	15.6	26.0	4.08	0.81	0.127
Italy	91,400	28,601,600	4,000,000	976,300	24.4	43.8	10.7	0.14	0.034
Switzerland	15,976	3,781,500	2,000,000	511,000	25.5	125.2	32.0	0.53	0.135
Germany	208,800	64,926,000	1,425,000	618,100	43.4	6.8	2.96	0.02	0.010
Great Britain	88,729	40,831,400	963,000	80,000	8.3	10.9	0.91	0.02	0.002

"A" excludes Yukon and Northern Area incapable of immediate development. "B" included in "A" is area actually settled.

Plate No. 3—Water Power in Europe and North America

to the "acute fuel area" of Canada for many years. Although not immediately necessary, the ultimate substitution of bituminous coals must, nevertheless, be seriously considered. Water power will be the main means of such substitution. The industrial fuel problem, therefore, in the "acute fuel area" becomes largely a matter of substitution of hydro power for fuel power.

Electrification of railways, especially terminals with adjacent engine divisions, would save enormous consumption of bituminous coal and relieve our transportation systems of their greatest burden.

It is estimated that something like 9,000,000 tons of coal was consumed by our railroads in the year 1917. Judging from the results obtained from the electrical operation of railroads in the United States, it would be possible to save at least two-thirds of this coal if electric locomotives were substituted for the present steam locomotives. This would be a saving of 6,000,000 tons of coal in one year, and would require about 900,000 water horse-power.

Electrification of steam roads at this juncture is not advocated. Under normal conditions, however, and in certain districts, as in western Ontario, electrification will become an economic necessity in a few years.

In districts that cannot be served by water power, the location of modern, efficient, super-power stations at strategic points, with a resultant elimination, or combination, of many inefficient, small stations, would cause a very large saving in the consumption of soft coal, with a concurrent increased production of power.

The substitution in industry generally of hydro power for steam fuel power, would also result in a tremendous relief. There are many plants where such an exchange would be possible now. Future manufacturing plants should be encouraged to locate where hydro power is available.

Water power must be depended upon very largely to serve the industrial fuel-power situation in the "acute fuel area" of Canada.

The relation between developed water power and the coal production and consumption in the various provinces is represented on Plate 2. It is interesting to note that in the "acute fuel area" there is about as much water power developed, so far as coal value is concerned, as there is coal consumed. It is portentous that the bulk of our water power production at the present time is within the "acute fuel area," and it is reassuring to know that our largest and most important potential water powers are located within transmission range of present congested industrial districts within the "acute fuel area."

Canada is Exceedingly Fortunate in the Extent and Location of Her Water Powers

When considered in retrospect, the production of hydro power in Canada has undoubtedly been an industrial achievement and an engineering triumph worthy our nation. In the short space of about twenty-five years, there has been developed and put in use, nearly 1,800,000 water horse-power. A tabulated statement (see Plate No. 3) of the water power development in other countries, compiled recently from all available data, shows the universal importance of this resource and indicates the splendid comparative position Canada enjoys in both potential and developed water power. The present per capita power development in Canada is larger than all other countries except Norway. It is the same with respect to our known undeveloped water power. No country enjoys to a greater degree the benefits of cheap, dependable hydro power, and no country has had these benefits more universally applied for municipal, industrial and domestic use. That Canada is recognized as one of the great water power countries in the world is due largely to:

(1) The nature and extent of our water resources—abundance and seasonable distribution of rainfall; the regimen of our rivers—upper waters well forested with large lakes, suitable for regulation—rivers flowing through valleys with well concentrated falls.

(2) The fortunate location of the waterfalls with respect to existing commercial centres, and related raw materials.

(3) The consistent endeavors of governments, Dominion and provincial, in having water powers thoroughly investigated and intelligently administered.

(4) The business acumen and foresight of the capitalist, and the professional skill and courage of the engineer, in blazing the trail of pioneer water power development and use.

(5) The almost universal adaptation of electric energy for municipal, industrial and domestic purposes.

Fortunate Location of Water Powers

The outstanding feature of the water powers of Canada is their fortunate location with respect to existing commercial centres. Within economic transmission range of practically every important city from the Atlantic to the Pacific, except those in the central western prairies, there are clustered water power sites, which will meet the probable demands for hydro power for generations. The following table, prepared by the Dominion Water Power Branch, indicates, reasonably accurately, the provincial distribution of the developed and undeveloped water powers within the settled portions of the Dominion.

Province.	Power available.	Power developed.
Ontario	5,800,000	789,466
Quebec	6,000,000	520,000
Nova Scotia	100,000	21,412
New Brunswick	300,000	13,390
Prince Edward Island	3,000	500
Manitoba	3,500,000	76,250
Saskatchewan		100
Alberta		32,860
British Columbia	3,000,000	269,620
Yukon	100,000	12,000
Total	18,803,000	1,735,598

Small Portion (Not 10 Per Cent.) of Canada's Available Water Powers Developed

In general, the use of water power in Canada may be briefly described as follows:—

(*a*) For municipal, including domestic and ordinary industrial purposes, about 78 per cent. of total developed or 1,348,490 horse-power.

So far as these uses are concerned, further requirements will probably be met for some years by additional installations at, and increased storage for, existing plants. In certain centres, however, as for instance the Niagara power zones, growing requirements can only be met by new water power developments.

(*b*) Pulp and paper, about 14 per cent. of total developed or 248,075 horse-power.

Further pulp and paper plant requirements can probably be met for some time by additional installations to present plants, although the tremendous growth of this industry will necessitate the development of new water powers in different parts of the Dominion. There are now 54 pulp and paper plants scattered throughout Canada and several new plants have been under serious contemplation, some of which would be in use now had it not been for the difficulty of financing due to war conditions.

On account of the isolated nature of the industry—away from commercial centres—power requirements for pulp and paper need not conflict with other demands upon hydro power.

(*c*) Electro-chemical and similar processes, about 8 per cent. of total developed, or 140,000 horse-power.

While the United States have achieved almost a world supremacy in electro-chemistry, this industry in Canada is of very recent growth. It has, however, expanded at an enormous rate, entailing recent extensive additional installation in present plants, and requiring in the near future the development of additional water power sites. Our propinquity to the United States, and our abundance of essential raw material will compel the migration to the Dominion of many new electro-chemical plants of importance and value.

The products of the electro-chemical industry are extremely diversified. They include aluminum, silicon, calcium-carbide, cyanamid, ferro-alloys, graphite, carborundum, chlorine, etc., many of which are indispensable in the arts and in manufacture. Without aluminum the modern high-speed scout airplane would not exist; without electro-chemical abrasives and ferro-alloys manufacturing processes would be lengthened many-fold. Our industrial supremacy in times of peace is dependent upon these products to a very considerable extent.

One of the most important electro-chemical processes is the fixation of nitrogen. About 30,000 h.p. is used for this purpose at Niagara by the American Cyanamid Company, and while other plants of this kind have so far not been put into operation commercially in this country, they have been seriously contemplated, and await only a sufficient source of low-price power for realization.

The electro-metallurgical industry is in its infancy, but promises great expansion, especially in the production of nicu-steel in Canada. Few people appreciate the rapid growth during the last two years in the use of electric furnaces for the production of the highest grades of steel.

By proper foresight the demand for hydro power for these industries need not conflict with other demands, as, for instance, municipal, domestic and ordinary industrial uses.

Total developed power, about 1,735,598 h.p.

Further Use of Hydro-Electric Power

In considering the future of water power development in Canada, it is important to note that it means the use of a non-expendible resource, and in many cases represents the substitution of an inexhaustible resource for an exhaustible one. For this reason, the use of hydro-electric energy should be encouraged in every reasonable way.

Further development of water power in Canada will, undoubtedly, be extensive and must depend very largely on:

(1) Additional requirements for municipal, industrial and domestic use.

(2) Growth of pulp and paper industry.

(3) New electro-chemical and electro-metallurgical processes.

(4) Electrification of steam roads, especially terminals and adjacent engine divisions.

(5) Substitution of hydro-electric power for fuel power in manufacturing and industry.

In the rapid development within a short space of time of our water powers to the extent of nearly 1,800,000 horse-power, it is natural to expect that there has been some misconception in design, in construction, in conservation of opportunity, in overlapping of service, and even in governmental administration, although as to the latter it is an axiom in British jurisprudence that "the King can do no wrong." If we were starting *de novo* to develop our water powers, with our present knowledge of what is essential in government investigation and administration, of what is really basic in conservation of resource, of the present practice of the art of hydraulic and electric engineering, and last, but by no means least, of what is the most important or prior market demand, from a national standpoint, from particular power sites, whether general municipal requirements should precede electro-chemical and allied industrial requirements, we would, for instance, most assuredly produce a very different power situation at Niagara. At the same time, this most important and world-famous source of our electric energy has well served us. Generally speaking, our water powers have undoubtedly proven to be one of Canada's most valuable assets.

Looking to the future in power development, if Canada is to reap full benefit from her heritage in white coal, there must be a constructive liaison between (*a*) the various Dominion and provincial government administrative departments concerned in water power matters; (*b*) the producing corporation or commission, and (*c*) between the consuming public. Concurrently with such a liaison there must also be an adequate co-ordination of the development and use of water power with that of all other power-producing agencies.

Anyone who has listened attentively to the very able presentation of the various elements in the fuel situation during the last two days, must realize that there is a prodigious field for such co-ordination in the development and use of our varied power and heat-producing resources which will combine the effective use of all, along lines for which each is best adapted, and which will, by avoiding duplication or misdirection of effort, promote the efficiency of both individual and conjoint use.

The necessity for the correlated development and use of all our fuel-power resources has surely passed the agitational or educational stage. The many urgent reasons for such correlated use are stressed a hundred-fold by the coal shortage experience of this winter.

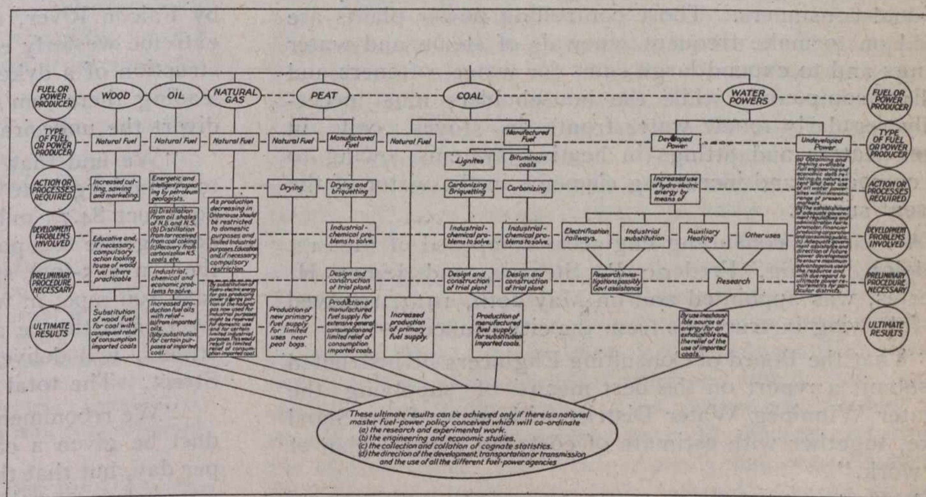


Plate No. 4—The Fuel-Power Resources of Canada

To visualize the interdependence and interrelation of all the fuel-power agencies available in Canada, and to offer something as a basis for general discussion, I have prepared a chart (Plate No. 4), which if it indicates any one thing it conclusively proves the immensity and complexity of the problems involved in effecting the co-ordinated, concomitant development and use of all our fuel-power resources. The chart shows that this can be best realized following the evolution of a national master fuel-power policy for all of Canada.

Gentlemen of the Canadian Society of Civil Engineers, are we going to leave this great problem in "the laps of the gods"? It is not one of peculiar concern to engineers, and of such timely and pressing importance to Canada that we, as a society, would be warranted in attempting a solution? Should we not mark the enlargement of the scope, influence and prestige of our society (which, we hope, is being exemplified by its transition to the Engineering Institute of Canada) by an earnest effort to evolve, in general terms, the basic principles of a national master fuel-power policy for Canada?

Cheap power promises to be one of this country's greatest assets in the post-bellum industrial rivalry of nations for world trade. Our great fuel reserves, supported by our water power resources, represent a sure source of cheap power, and should guarantee Canada her share in world trade, if our varied fuel-power resources are availed of to their maximum possible advantage.

THE GREATER WINNIPEG WATER DISTRICT

By C. S. C. Landon, A.M.Can.Soc.C.E.

THE Greater Winnipeg Aqueduct ranks as a major engineering undertaking, the scheme in the main consisting of the bringing of water from Indian Bay, a part of Shoal Lake, which is an arm of the Lake of the Woods. The water will be delivered to the city of Winnipeg and to the surrounding municipalities. This is to be accomplished by means of gravity flow, taking advantage of a difference in elevation of about 300 feet, the distance between the two points being 96.5 miles.

The question of a suitable water supply had been for some time a vexed one, both because of the uncertainty of quantity of the supply and because of the quality of the water. The purity of the present supply for domestic purposes is unquestioned, and is rarely equalled in public water service, but because of the extreme degree of hardness a great deal of expense is incurred not only by corporations and manufacturing industries, but also by individual consumers. Those controlling power plants are called on to make frequent renewals of steam and water fittings and to expend large sums for water softeners and scaling compounds while the householders must necessarily regularly renew water fronts in stoves, coils in water-heaters and fittings in heating systems, owing to the corroding and incrusting elements in the water of the present supply.

A board of consulting engineers composed of Messrs. Rudolph Hering, Frederic P. Stearns, and James H. Fuertes, was appointed and on May 20th, 1913, received the following instructions from the city council:—

"That the Board of Consulting Engineers be instructed to submit a report on the best means of supplying the Greater Winnipeg Water District with water from Shoal Lake, together with estimate of cost and general plan of the work."

After an exhaustive study of the question the consulting engineers reported as follows:—

"Shoal Lake, without help from the main Lake of the Woods, can be depended upon to furnish, even in the driest years, a large part, if not all, of the water needed for Winnipeg until the population shall have reached about 850,000, and with the help of the Lake of the Woods can furnish a practically inexhaustible supply.

"The water of Shoal Lake was, when we examined it, of excellent quality for domestic and manufacturing purposes, being soft, practically free from contamination, without noticeable color, free from odors and of an agreeable taste. The results of recent examination of the Shoal Lake water, and all of the local conditions, indicate that the occurrence of bad tastes and odors in the water, from growths therein, should be infrequent, and may never occur at all."

Should such troubles occur in the future the opportunity to correct them by suitable treatment may be availed of when necessary without interrupting the supply of water to the city or making expensive changes in the works as built.

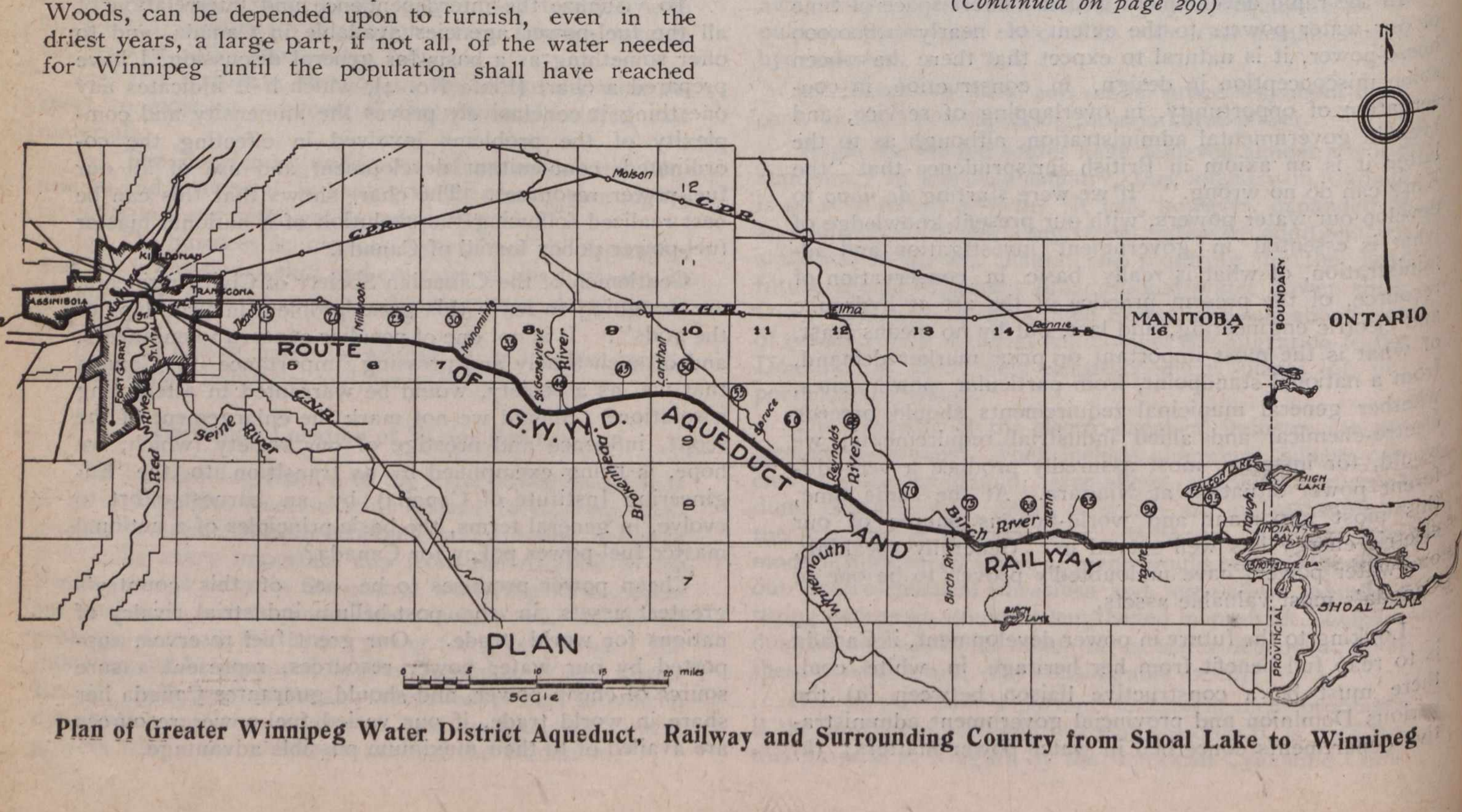
"The best point to take the water is from near the west end of Indian Bay, an arm of Shoal Lake, as the depth of the water and the configurations of the bottom and shores in this neighborhood are favorable.

"In order to avoid the dark colored water discharged by Falcon River, and cut off the shallow flowage at the extreme westerly end of Indian Bay, we propose the construction of a dyke across the end of the bay and a canal leading therefrom to Snowshoe Bay, through which to divert the undesirable waters.

"We find that the best way to get Shoal Lake water to Winnipeg is to bring it down first through a concrete aqueduct 84.75 miles in length, laid with a continuous down grade to a point about a mile east of Transcona, and then in a 5-foot steel pipe to the Red River. A 5-foot cast-iron pipe, in tunnel, is to convey the water under the river, and thence a 4-foot cast-iron pipe, laid in the city streets, will deliver it to the reservoirs at McPhillips Street. The total length of the aqueduct is 95.35 miles.

"We recommend that the concrete portion of the aqueduct be given a capacity of 85,000,000 Imperial gallons per day, but that the pipe line portion be given the smaller sizes above stated, capable of discharging 25,000,000 gallons per day by gravity into the McPhillips Street reservoirs.

(Continued on page 299)



Plan of Greater Winnipeg Water District Aqueduct, Railway and Surrounding Country from Shoal Lake to Winnipeg

RAILWAY ELECTRIFICATION*

By John Murphy

Chief Electrical Engineer, Department of Railways and Canals.

NOTE.—The writer wishes to acknowledge his indebtedness and to publicly return his thanks to officials of the railways below-mentioned, and of the manufacturers of the apparatus referred to, as well as to the technical press, from which much of the following material has been gleaned.

STILL smarting from the sufferings of two successive winters' fuel shortages, caused by inadequate transportation facilities, we are foregathered to see what can and should be done to prevent, if possible, recurrences of such serious and trying experiences.

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 incidentally 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 last month, made the following statement:—

"It is really terrifying to realize that 25 per cent. 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 per cent., of all the coal mined in the United States, were consumed in steam locomotives last year.

Here in Canada, steam locomotives also did their bit and consumed about 9,000,000 tons—30 per cent. 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 per cent. of the total output) are not included.

The 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 would save from 50 per cent. to 66 per cent. of the coal now used in steam locomotives if the latter were 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 begin?"

It is said that 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 and haulage; 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 and Pacific Railroad, by electrification, increased its ton-mileage 35 per cent. and at the same time decreased the number of trains, and their incidental expenses, 25 per cent. The time per trip was decreased 27 per cent. It is said their savings in the first year's operation, after electrification, amounted to 20 per cent. of the total cost of electrification. They buy power from water power plants.

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 per cent. Electrification obviated the necessity for double-tracking. The salvage value of the released steam engines was 45 per cent. of the cost of electrification. Electric locomotives make eight times as many miles-per-train-minute-delay as the steam engines. Their terminal lay-overs average 45 minutes and they are double-crewed every 24 hours. Pusher engine crews have been reduced from eight steam to four electric. Pusher engines or locomotives have been reduced from seven steam to two electric. Steam locomotives used to "fall down" in cold weather—the electrics always "stand up," are really more efficient in cold weather. At the New York Railroad Club meeting last year their electrical engineer stated that "coal wharves, spark pits, water tanks and pumps, as well as roundhouses and turntables, have all 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 the regenerative electric braking of their system, he 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." Another official, referring to the same subject, made the following statement: "Trains of 103 cars are taken over the summit twelve to twenty times every day, down the 2.4 per cent. grade, without ever 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."

The 440 route miles of the Chicago, Milwaukee & St. Paul Railway which have been electrified will soon be augmented by 450 miles more. Nearly 900 route miles and about 33 per cent. 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. Subdivisional points, where freight crews and steam locomotives were formerly changed, have been abolished; the passenger crews' runs are now 220 miles instead of 110. For railway purposes, these stations do not now exist; seven or eight miles of track have been taken up; through freights do not leave the main line track at all; shops and

*Paper read before the first general professional meeting of the Canadian Society of Civil Engineers, held at Toronto, March 26-27, 1918.

roundhouses have disappeared along with their staffs, and one electrician replaces the whole old force. An electric locomotive has made 9,052 miles in one month. Although schedules have been reduced the electrics have made up more than two and one-half times as many minutes as steam engines—time which had been lost on other divisions; 29 per cent. of electric passenger trains made up time in this manner. On a mileage basis alone the operating costs of the electrics are less than one-half the steam engine costs. Freight traffic increased 40 per cent. shortly after electrification—double-tracking would have been necessary to handle such increased business under steam operation. An average increase of 22 per cent. in freight tonnage per train has taken place. One electric handles about three and one-half times as many ton-miles as a steam engine; the reduction in time in handling a ton-mile is 30 per cent.; faster and heavier trains have accomplished these results, the number of trains has not been increased. About 11½ per cent. 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 1,910 minutes, or seven and one-half times as long. Extra cars on trains only delayed electrics one-ninth 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—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. Railway and it is especially interesting because it was made more than one year ago.

The foregoing experiences of men who are actually operating 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."

The limitations of the steam locomotive are due to the fact that it is a mobile steam power plant of very limited capacity, compelled to carry its own supply of coal and water, and 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 gigantic stationary steam or water power plants and the train to which it is connected. The "Electrical World" summed up the situation a short 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?"

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 may ensue in all the great industries now engaged in war work as soon as peace is declared; the multitude of people thus thrown out of work in addition to the men of the returning armies would 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 our organization a couple of weeks ago, spoke of the necessity of 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 and rebuild other countries when peace comes. How nicely these two ideas, water power development and railway electrification, work together if properly carried out.

With the view of securing something really worthy of presentation to this important meeting, I recently wrote 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: "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 his 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, is 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 E. 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 present fuel shortage questions have made us look to railway electrification for relief, I feel such a project on a large scale can only follow or go hand in hand with 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 feature in connection with any large railway electrification project.

The 99-year contract of the Chicago, Milwaukee & St. Paul Railway 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 country parallel to the railway. The railway owns its sub-stations and secondary lines, but is not concerned with the high-tension lines or power plants of the power company. A reasonable rate for power, arranged between a willing purchaser and a willing seller—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-supply situations as those outlined above, backed by abundant supplies of power, in order to foster and encourage early railway electrification work in this country.

Railway electrification is, in my opinion, a very pressing financial, economic and engineering problem—a problem worthy of the best attention of the most highly trained and experienced specialists.

THE AIR-LIFT PUMPING SYSTEM

By A. W. Swan
Canadian Ingersoll-Rand Co., Limited

TWENTY-FIVE years ago Dr. Julius Pohlé made his first successful experiments on pumping from deep wells, using compressed air, and the air-lift system as it is to-day is, with the exception of detail in design, the same as the Pohlé. Contrary to what one might expect, the compressed air is not used to force the water upward; air is led downward in the well and released in the rising main. Here the compressed air mixes thoroughly with the water and forms a froth, which, being lighter than the body of water in the surrounding rock, is naturally forced upward. All that is necessary for an air-lift system is an air compressor—which is housed, of course, in an engine room which may be any convenient distance from the well, an air pipe and a delivery pipe. It is evident that the air-lift system is simplicity itself—and it has other advantages.

In city water supply the problem of filtration is acute; slow sand filtration is expensive to instal and maintain, and at the best does not absolutely sterilize the water, and for complete sterilization the unpleasant chlorine process or the expensive ozone or ultra-violet ray process must be installed. It is well known that aeration of water has a strong sterilizing effect, and the city of New York has installed special aerating ponds as part of the Catskill project. Now, in the air-lift system aeration is entirely automatic, and as the water and air flow upward impurities are thrown off. That this is no mere claim is shown by the case of the Asbury, N.J., waterworks, where the air-lift rendered iron-impregnated water as clear as spring water.

Although the principle of the air-lift system is simple, it does not follow that careful design is not necessary. In the earlier Pohlé pumps the air was admitted to the water pipe by a simple bend in the air pipe. However, it was discovered that the chief cause of loss of efficiency in the air lift was air-bubble slippage; the larger the bubbles the greater the loss in efficiency. Hence, design tended to the improvement of the mixing chamber, and in the standard air-lift pumps of the present day, this mixing chamber is carefully designed to divide the air into very fine streams, thus preventing the formation of large bubbles.

Owing to the fact that in the well proper there are only the two pipes, for air and water, the capacity of flow is limited only by the capacity of the well, and as there are no moving parts in the well, wear and depreciation are almost negligible where they would be greatest with the plunger type of pump. Further, one compressor can be used to supply the air for several wells, and the flow of water is regulated from the power house by controlling the air pressure. Among other advantages of the air-lift system may be mentioned the fact that sand or gravel have no effect on the operation of the pump, being simply carried along with the air and water and deposited at the top of the well. The scouring action of the pump in removing sand or gravel generally increases the flow by widening the area from which water is drawn.

In respect to economy, this varies with the size of installation and submergence. Larger installations are, of course, more economical, and for a flow over 300 gallons a minute the air-lift pump will usually be less expensive than the plunger type. In the case of smaller pumps, the actual cost will be about the same for the two types, provided there is sufficient submergence for the air-lift pump. By submergence is meant the ratio of the depth of the mixing chamber below the pumping water-level to the total height pumped. The air-lift is not advisable where the submergence is below 35 per cent., and the best condition for this type of pump is from 45 per cent. to 60 per cent. submergence. The actual cost runs from 1¼ to 2 cents per thousand gallons pumped. The air pressure necessary to run an air-lift pumping system is steady once the water has started to flow, but some provision should be made for extra pressure to start the pump. According to Kent, the compressor should provide one cubic foot of air for each gallon and a half pumped, but this will vary with the depth of the well. Kent also gives the formula $A = \frac{LC}{16{,}824}$ where A = cubic feet of air, L = lift, C = cubic feet of water pumped.

The air-lift is not very well adapted to pumping horizontally, owing to the fact that the air tends to separate from the water and collect along the top of the pipe. Hence, where water is to be pumped from the top of the well a "booster" is used. This consists simply of a tank in which the air is separated from the water, the pressure of the air being used to pump the water on the rest of its journey by displacement.

In addition to pumping water, the air-lift has a wide field of application for pumping acids, brine, pulp, etc. In ore-leaching, the air-lift has been used to great advantage, and in some of the western oil fields oil has been pumped by this method from wells 800 feet deep.

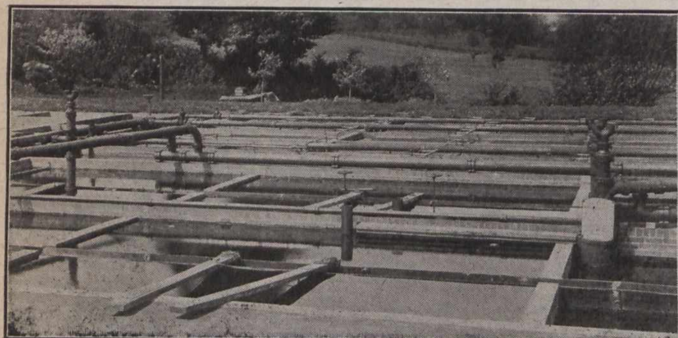
The February statement of Southern Canada Power Company, Limited, gives gross of $39,326, an increase of $6,368, and net of $18,235, an increase of $3,382. For the month of the current fiscal year gross earnings at $194,860 are $41,518 higher than in the previous year, and net at $88,103 are $11,284 higher

During the first half of last year 289,000 tons of steel were produced in Japan exclusive of her colonies. The largest producer was the Government Steel Works, with 200,000 tons. The Japan Steel Tube Company came next with 22,000 tons, and the Japan Steel Works with 14,000 tons, while the two smallest producers, the Kawasaki Dockyard Company and the Kamaishi Steel Works, turned out 12,000 and 10,000 tons respectively. It is estimated that the year's output of those mills will reach at least 570,000 tons, an increase of 50 per cent. over 1916.

ACTIVATED SLUDGE DEVELOPMENTS

THE Manchester (England) Corporation have approved of a scheme for converting part of one of their large settlement tanks at Davyhulme, Manchester's main sewage outfall works, into an activated sludge tank capable of treating a million Imperial gallons per day of strong sewage.

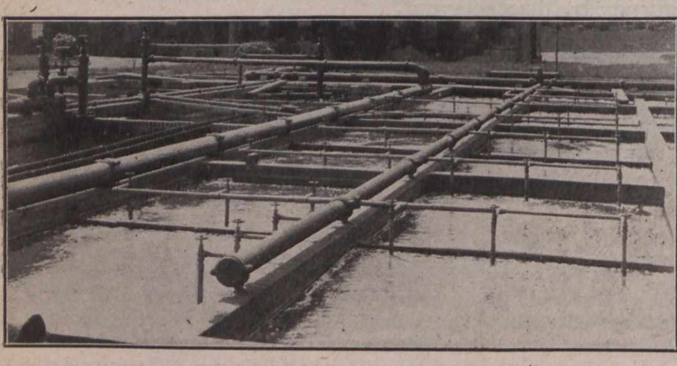
The activated sludge plant at the Withington outfall, which was designed to treat 250,000 gallons of sewage per day, was first put into operation last September, and the new features introduced, including the Clifford settling tank inlet apparatus, have so far exceeded expectations



View Across Activated Sludge Plant; Settlement Tanks in Foreground

that the volume treated had reached 400,000 gallons per day early in January and is still being increased. Both the Davyhulme and the Withington works are in charge of E. Ardern, M.Sc., who has been so intimately linked with the development of the activated sludge process from its early stages. Both the Davyhulme and the Withington installations are fitted with Jones and Atwood equipment.

The Worcester (England) Corporation have applied to the minister of munitions for a permit to extend their sewage works for the purpose of putting into operation an option given them by Jones & Atwood, Limited, when the original contract for activated sludge plant was signed to extend their plant to treat 3,000,000 gallons per day.



Aeration Tank in Use at Worcester, England

The first trial plant for dealing with 750,000 gallons per day has now been in operation since April, 1916, and Mr. Caink, the city engineer of Worcester, wrote a letter to the Royal Sanitary Institute meeting held January 12th, 1918, to the effect that "The installation of the process at Worcester has in every respect fulfilled my expectations."

UNIFORM ROAD ACCOUNTING*

By Edward N. Hines
Chairman, Board of County Road Commissioners, Wayne County, Michigan.

IN advancing a plan of obtaining costs on highway construction and maintenance, there are certain features which must be noted as essential in order to arrive at dependable costs.

First in importance is the adoption and use of a satisfactory means of controlling the items of labor and materials as they enter into the construction of the road.

Second in order is the division of the work into such groups as will agree most naturally with the character of operations performed, and at the same time readily admit of a classification which will apply to road work in general.

Finally, it is necessary to provide means for checking the results on the various operations during the progress of the work—in other words, to obtain cost figures on the different portions of the work in time to cut off waste and speed up efforts where necessary on the balance of the work still remaining.

As a means of controlling the labor item, the first detail to be considered is the use of the workman's time card. The timekeeper on the job is made responsible for the issuing of one of these cards every payroll period for each man on the payroll. He must record thereon daily the nature of the labor performed and the number of hours in each case, and at the end of the weekly period summarize in the proper space the total hours spent by the man on each class of work. After being approved by the foremen, all the cards thus made up are sent into the main office where the rates are verified, the extensions proven and the amounts due each man entered on the payroll distribution sheet. From this payroll sheet the total labor is distributed to the construction cost ledger and maintenance and indirect expense accounts.

In controlling the stock used in connection with road construction, provision is made for charging each item of material as it is used. All material which on its receipt is used directly on the road without any attempt at storage is charged directly from the voucher record through the distribution ledger to the road in question. To take care of materials, supplies and repair parts which are carried in stock, a series of stores accounts are set up. These stores accounts cover separately the different types of materials used in road construction and are made up as follows: Tiling, brick, cement, pebbles, sand, limestone, granite, trap rock, tarvia, gravel, road oil, armor plate, expansion felt, spiling lumber, coal and general stores. As a means of controlling the issuing of stock from these stores, a suitable form of stores requisition is used. This requisition is issued in triplicate, one copy being retained by the foreman having authority for its issuance; the second copy is kept by the storekeeper having charge of the stores, while the third copy is sent to the main office. This third or office copy is authority for charging the material in question to the proper account through the transfer journal. The operation of such a plan of stores control naturally requires the supervision of this stock by a competent storekeeper with adequate space and suitable conditions for proper storage.

*Abstracted from paper presented at the fourth annual short course in highway engineering at the University of Michigan, February 25-March 1, 1918.

FUEL FROM A TRANSPORTATION STANDPOINT*

By W. M. Neal
Canadian Railway War Board

NO gentleman in this room needs to be reminded of the close and intimate connection between the humble coal pile in his cellar and the pride and comfort of the loftier apartments in his house. We may in the past have treated the coal bin as a mere poor relation or humble servant. We gave it the poorest room in the house. We even hired other people to attend to it so as not to have to soil our fingers by contact with the fuel problem, but nowadays I think one can observe a much more kindly attitude toward this humble factor in our domestic arrangements. We have been forced, as it were, to enter into diplomatic relations with the coal bin and to treat it with consideration and very great respect.

The greatest coal bin in the Dominion of Canada is the coal bin of the railway companies. Many of you gentlemen have seen some of the young mountains of coal which the transportation companies are forced to maintain at their terminal points. There are in Canada over 5,000 locomotives whose appetites require an average ration of from 100 to 160 pounds of coal for every mile run. The engine which drew some of you gentlemen from Montreal to Toronto last night burned not less than sixteen and a half tons of bituminous coal. If we allow that the average tender on the average engine holds ten tons of coal, then the requirements of the railways for a single loading of their tenders amount to over fifty thousand tons. The total coal consumption of the railways of Canada in the last year for which Ottawa gives official figures (1916) was 8,995,123 tons, which cost them $27,961,186. This was almost as much as the total Canadian import of bituminous coal and slack in the same year.

But, of course, what the railways themselves consume is only the beginning of the coal problem for the railway managers. Although we imported only about 9,000,000 tons of bituminous coal and slack in 1916, the railways hauled that year 18,122,835 tons. In addition to this they hauled 7,057,628 tons of anthracite coal and 1,772,854 tons of coke. The hauling of fuel both for themselves and the public amounted to approximately 25,000,000 tons, or over one-fifth of the total freight tonnage carried by all the railways of Canada that year. It was four times the weight of the ore carried and twice the weight of the total products of manufacture which were carried by the railways. It required the service of 29,948 trains of 23 cars per train, or the exclusive service for one year of approximately 1,000 freight engines and 23,000 freight cars.

The weight of bituminous coal carried by the railways runs, as a rule, just a trifle less than the weight of all the grain produced in the Dominion.

I give you these figures to impress upon you the extraordinarily intimate connection between the coal situation and the railways of Canada. I cannot refrain from remarking, just in passing, that although coal carrying represents such a great part of railway work, it does not represent a proportionate part of railway earnings. Coal is carried farther in Canada for less money than in any other country in the world. It costs the coal dealer less for the freight on a ton of coal transported sixty miles than to team that same ton one mile in the city of Montreal or Toronto. The recent rail rate increases give the railway about 15 cents per ton more than before on an average anthracite shipment from the mines to Toronto. One hears a great deal about this increase, yet the general increase of 66⅔ per cent. in teaming costs due to increased price of oats, labor and horseflesh has scarcely been mentioned in the public press.

Now, I intend first of all to outline roughly the machinery of coal distribution in Canada as it existed before the war. It is necessary to divide the country into five districts, according to the fuel situation in each. I will then try to show what each district used, where it obtained its supply and how.

Starting in the east, let us define District No. 1. It reached from Halifax to, say, Montreal. It was supplied with bituminous coal from the Nova Scotia and Cape Breton mines. This coal was distributed partly by rail, but chiefly by boat. In 1913, the last normal year, the Dominion Coal Company distributed 1¾ million tons by boat in the St. Lawrence alone, and the Nova Scotia Steel Company another ½ million. The famous, or infamous, "Storstadt" which sank the "Empress of Ireland," was one of the fleet of vessels distributing this coal. Very little of it, I might say, was consumed farther west than Montreal. Nova Scotia and New Brunswick consumed quantities in addition to the St. Lawrence requirements. Much of this, also, before the war was carried by steamer or by the humbler but more picturesque schooners of this region.

District 2, overlapping District 1 to some extent, reached, one might say, from Quebec City and towns like Sherbrooke, P.Q., and St. Johns, P.Q., west to Windsor and Sarnia and north to Sudbury, North Bay and Cochrane. This was, and is, the great coal importing area of Canada. It is here that the major portion of our anthracite coal was consumed and the chief share of bituminous coal was converted into energy and manufactured goods. It came by three different means— (1) by rail, (2) by water, and (3) by car-ferry. The chief rail points from which coal passed directly into Ontario were Black Rock, Victoria Park, Suspension Bridge, Niagara Falls and Bridgeburg. These are the points we call the Niagara Frontier—where special precautions had to be taken this past winter, as I shall describe later on.

Another direct rail connection from District 2 to the United States is, of course, at the Soo, but no coal of any account passes here.

Of the car ferry connections the largest are at Sarnia-Port Huron and Windsor-Detroit. A considerable amount of Illinois coal passes here. Much more crosses Lake Erie from Cleveland to Port Stanley; Ashtabula to Port Dover; Ashtabula to Port Burwell; and Lake Ontario from Ogdensburg to Prescott and Charlotte to Cobourg. I might say that practically the only traffic from Port Burwell is empty coal cars southbound and loaded coal cars north. This one little port accounts for 54 cars of coal per day in good weather.

So much for the direct rail connections and the car ferries. There is still a traffic in coal schooners and steamers of a sort plying on Lake Ontario from Oswego to Kingston or Toronto, and on Lake Erie from the American coal ports to the Canadian ports I have just named.

These are the coal-carrying connections between District 2 and the American coal fields. The coal thus received is distributed chiefly from Toronto, Hamilton and London to the rest of the older parts of the province.

In District No. 3 let us place all the north shore of Lake Superior west to the eastern boundary of Manitoba. In this region, Port Arthur and Fort William are the

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*Paper read before the first general professional meeting of the Canadian Society of Civil Engineers, held at Toronto, March 26-27, 1918.

central points. Another port of which little is heard is Jackfish, a C.P.R. point where this company obtains enough coal by water during the summer to supply the North Shore divisions all year round, without having to burden the line itself by hauling coal via Toronto and Sudbury. That, of course, is a digression from my point. The centres of public distribution are the Twin Cities. Many of the vessels which come north for cargoes of eastbound grain bring coal on the up voyage. This coal is scattered westward by the returning empty grain cars from Fort William to Winnipeg. How far west of Winnipeg this movement goes I cannot say definitely, as it depends upon the production and movement of Western coal. Here the American coal coming up the lakes begins to come in competition with the coal from our Western foothills. The greater the production of Western coal the farther east it comes.

District No. 4 might be said to include Winnipeg and the eastern portion of British Columbia, overlapping District 3 to some extent. In its most westerly extension it is fed almost exclusively from the Alberta coal fields.

Of District No. 5 I need only say a word. This takes in the western slope of British Columbia. The railways here use coal and oil fuel. The supplies of coal were and are from Washington and Nanaimo. The consumption is not large and the problem of distribution is not great.

There, Mr. Chairman and gentlemen, you have the outlines of the fuel situation from a transportation viewpoint as it existed before the war. I will take now only a few moments to explain the changes which war has brought about in each district.

In District 1, the steamers plying from Sydney to St. John, Halifax, Quebec and Montreal, have, so to speak, enlisted. The distribution of coal from these mines falls entirely, therefore, upon the railways. The two million tons distributed by boat in the St. Lawrence are now carried by rail. The schooners on the coasts of Nova Scotia and New Brunswick continue to do their share, but even there the railways have had to assume an extra burden. I might add that this Eastern Canadian bituminous coal is now moving into District 2 as far as Ottawa and Cornwall. The increased consumption of coal in District 1 has made necessary the use of American coal here too, which is hauled north via Montreal and then east.

In Districts 2 and 3 there have been two changes: 1st, a falling off of water-carriage of coal on the lakes, and 2nd, the congestion of the American roads which made it impossible to send the proper number of coal cars south for coal on account of the danger that they would be lost down there even before they could be loaded at the mines. The loss of the water-carriers was perhaps the more serious of these two considerations. From these three districts a tremendous proportion of the water-carriers have disappeared. Practically the entire burden—amounting, as I said, to 2,000,000 tons or 50,000 carloads for St. Lawrence points alone—has been forced upon the railways. They met this condition by (1st) building more coal cars, (2nd) by converting sand and gravel cars for coal use, (3rd) by enforcing economy in their own use of coal, (4th) by pressing box cars into the coal-carrying service, and (5th) by trying to move as much coal as possible in the summer season when the traffic may take advantage of easier transportation conditions. By a campaign among the big shippers asking them to accept coal deliveries last summer instead of in the fall, much good was accomplished. With respect to the danger of losing our coal cars in the United States, thousands of tons of coal were worked through the American tangle in returning Canadian "empty" box cars. The use of box cars for coal carrying can only be applied from mines and docks where there are devices for loading and unloading these cars with coal. Fortunately, these devices are already established in the West, *i.e.*, Districts 3 and 4, otherwise we should have had a lot of trouble sending to Winnipeg special coal cars instead of using the westbound empty box cars.

I must make special reference to the work done on the Niagara frontier this winter by the administrative committee of the Canadian Railway War Board. In this work all roads co-operated to the fullest extent. The incoming coal cars at Black Rock, Bridgeburg, Victoria Park, Niagara Falls and Suspension Bridge were forwarded rapidly to Hamilton, Toronto, London and other points without respect to what road they were routed by. In spite of blizzards and exceptional weather conditions about 5,000 cars (chiefly coal) were put through in a period of two months over and above what would have been regarded as a normal movement. This meant to the Canadian consumers about 150,000 tons of coal extra.

So much for Districts 1, 2 and 3. In District 4, that is, from Winnipeg to the eastern half of British Columbia, the question is now being discussed whether the Western bituminous mines could not look after the bituminous requirements of that district while the lignite, being compressed into briquettes, might replace the anthracite. This is a consummation devoutly to be desired and members of the Canadian Railway War Board have already taken up the question with a view to being ready, as far as transportation is concerned, to make Western Canada, by the winter of 1919-20, as nearly self-sufficient as possible. How far this is possible I cannot even guess, although one might mention some of the factors governing the situation.

First, as to production of both bituminous and lignite coal, the mines have never been able to turn out maximum quantities (*a*) because of labor troubles. High rates of pay enable men to take time off with impunity (*b*) because of lack of storage facilities for lignite coal.

But even with these, much might be done, so far as the railways are concerned, by a concerted effort on the part of the mines, the railways and the public to persuade the consumers to place their orders for delivery during the slack months.

Conditions in District 5 have not changed. There is some talk of having the Californian supply of oil fuel for railway locomotives cut off. This would be very serious for the railways, as the following figures show: Fuel oil consumed in British Columbia, 1917—Canadian Pacific received 48,763,554 gallons and consumed 46,608,660 gallons; Grand Trunk Pacific received 6,350,840 gallons and consumed 6,303,500 gallons; Esquimalt and Nanaimo Railway used 2,646,400 gallons; Pacific Great Eastern Railway used 1,638,000 gallons.

I have described briefly the changed conditions of the Canadian fuel traffic and how the railways have met these changes.

Just one word now about the special means of internal economy which the railways have undertaken with a view to economizing in their own use of coal. I might mention that in Districts 1 and 2 the coal is poorer in quality (and higher in price) than ever before. This is due to the labor scarcity at the American mines where the product is no longer picked over as it used to be.

First, regarding passenger trains, the Canadian Railwar War Board, and the individual railways before the Board was formed, have cut off trains whose total yearly mileage would amount to 12,000,000 miles. Assuming an average of one hundred pounds of coal per passenger train mile, this means 600,000 tons saved.

Parlor and observation cars have been eliminated, except in cases where there are combinations of dining cars or sleepers.

Fewer sleepers are attached to night trains, thus a greater use of upper berths is made and the wheel resistance of extra coaches is done away with.

The speed of all trains has been reduced to the point where a maximum of effort is obtained from a given amount of fuel. No train is allowed to run at excessive speed to make up time. This has always been a practice very hard on coal economy.

Special trains and the hauling of private cars, except at the request of government officials have been done away with.

Even more important economies have been made in connection with the freight services. A campaign for heavier loading resulted in a great improvement. For example, in the movement of freight to St. John during the month of January, 1918, as compared with January, 1917, the average load per car rose from 26.4 tons to 32.3, an increase per car of 5.9 tons. The saving from this improvement on this traffic alone that month was 1,313 cars and over 7,300 tons of coal. There was also a saving of the time of eleven locomotives and fifty-five engine and train men for that month, besides a great many shopmen, yardmen, car checkers, repairmen, etc.

The handling of less than carload lots of freight has been so rearranged as to load the cars more heavily.

We are thus able to reduce the ratio between net weight and tare weight in any given train. The wheel resistance is lowered. The train is made shorter and can therefore be handled more promptly.

In the actual firing of the engines, further economies have been effected in spite of the lower grade of coal available in Districts 2 and 3. Expert firemen are sent out to show the less experienced men the best way of dressing the fires.

I might say that the old practice of burning worn-out ties on the sides of the railways has been discontinued since the war. In some districts it does not pay to haul these ties to places where the railway can use them. In these cases the farmers alongside the track or the railway trackmen are being given the ties for firewood. The greater proportion of them, however, are taken to the shops and roundhouses. It was found impossible to saw these ties owing to the amount of gravel and grit with which they were impregnated. A device has been made which breaks the ties into appropriate lengths and they are now used under the boilers.

I do not think, Mr. Chairman, that there is anything that I can add to what I have already said. As a railway man, I may as well tell you frankly that I take great pride, along with my fellow railroad men, in the record which the Canadian railways have established, not merely in the handling of fuel, but in the handling of food, munitions and domestic traffic. We have had two exceptionally severe winters. We have had labor shortage. Fuel has been scarce and of low quality. The nature of traffic and the direction of traffic has shifted and changed overnight in a manner sufficient to strain the resourcefulness of even the most alert railroad men in the world. Changes which I have indicated with regard to the movement of coal in Canada apply even with greater force to the movement of other commodities. The Canadian railways have moved hundreds of thousands of soldiers, eastbound and westbound; they have handled 75,000 foreign laborers passing from Vancouver across the continent enroute to France. There have been some difficulties, but on the whole I think there have been fewer railway troubles in Canada since the war than in any other country in the world. It is perhaps unfair of me to take advantage of your good nature to add this word of praise for the railroaders, but I should be a very poor spirited and unenthusiastic railroader myself if I failed to mention it.

I thank you for your very kind and attentive hearing.

NOVA SCOTIA STEEL AND COAL COMPANY

The annual statement of the Nova Scotia Steel and Coal Company is issued this year to cover the operations of the parent company and all its subsidiaries, thus a consolidated balance statement is issued to cover both the Nova Scotia Steel and Coal Company and the Eastern Car Company. On this account, comparisons with previous years cannot be made satisfactorily. The change has evidently been made at the suggestion of the auditors of the company, as the Scotia Company has guaranteed the bonds of the subsidiary and owns all the common stock. An analysis of the general consolidated balance sheet indicates that Scotia is now in a strong financial position, the total current assets being over $10,000,000 in excess of current liabilities. The combined profits from operations, after providing for maintenance and renewal expenditures, but before deducting depreciation, interest charges, etc., for the year ended December last was $3,069,449.23, before deducting proportion of commissions and discounts on securities written off, provision for depreciation, income tax, etc., which amounted to $976,113.20, leaving profits of $2,093,336.03. Deductions included interest on the 5 per cent. mortgage bonds of the Nova Scotia Steel and Coal Company, Limited, $287,121.13; on the 6 per cent. debenture stock of the Nova Scotia Steel and Coal Company, Limited, $263,296.87; on the 6 per cent. mortgage bonds of the Eastern Car Company, Limited, $58,401; on bank loans and advances, $144,040.20; total, $752,858.20, leaving total net profits of $1,340,477.83, which, added to the surplus on January, 1917, of $3,532,114.63, made an amount for distribution of $4,872,592.46. Other deductions included dividends on the 8 per cent. cumulative preference stock of the Nova Scotia Steel and Coal Company, Limited, $80,000; cash dividend declared on the ordinary stock of the Nova Scotia Steel and Coal Company, Limited, $562,500; stock dividends declared on the ordinary stock of the Nova Scotia Steel and Coal Company, Limited, $2,500,000, totalling $3,142,500, leaving the surplus carried forward $1,730,092.46.

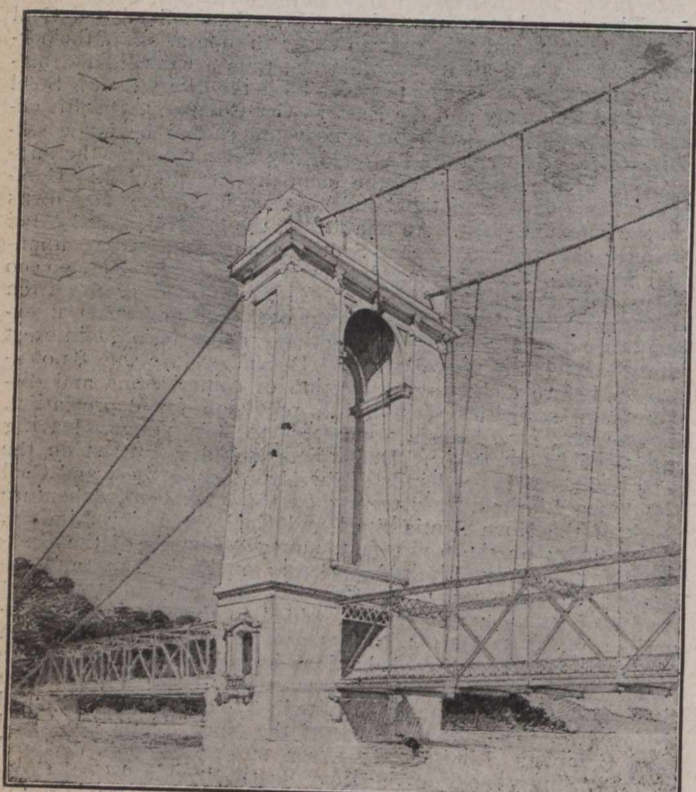
The company is in a strong financial position and has a splendid future. The work of Mr. Frank H. Crockard, the general manager, has proved very effective, but its full value will be demonstrated after the war, when financial and general conditions are again normal. Mr. Crockard's ability and experience are assets of considerable importance to the company. Mr. Thomas Cantley remains as chairman of the board and his counsels have been of great use during the past year. The company has an influential directorate, Mr. W. D. Ross looking after the financial affairs of the corporation.

Rope strain is a factor that often occasions considerable controversy regarding the actual tension upon the rope when loaded. This subject has frequently been the basis of lengthy discussions, but the difference of opinion invariably arises from the lack of sufficient knowledge respecting the fundamental principles of forces in action. To fully understand the question of rope strain it is necessary to familiarize one's self with the third law of motion—namely, "action and reaction are equal and opposite"; that is, when a force is applied, a corresponding force is exerted in the opposite direction. One of the apparently debatable points in connection with the strain upon a rope, is the different ways in which this reaction takes place. If a rope is secure at one end to a hook in the wall and a man pulls on the other end with a force of 100 lbs., it is obvious that the rope is under a tension of 100 lbs. However, if the rope is removed from the hook and a man is placed to oppose the pull of the other, some persons are under the impression that the rope is under a strain of 200 lbs., due to the pull of 100 lbs. at each end of the rope.

SUSPENSION BRIDGE FOR GRAND'MERE, P.Q.

By Romeo Morrissette
Three Rivers, Quebec

GRAND'MERE is fast becoming the centre towards which are converging several growing municipalities, including Lac a la Tortue, Turcotteville and Grandes Piles. Before entering Grand'Mere, it is necessary to cross the River St. Maurice, a few hundred feet above the power plant of the Laurentide Power Co. Heretofore access has been secured by means of a ferry, consisting of a large scow moved by hand, but latterly by gasoline launch.



Proposed Suspension Bridge at Grand'Mere

This means of transportation being slow, the construction of a bridge has become a necessity. The Laurentide Co., Limited, which has a large paper plant there, and also other interests on the eastern shore, have decided to erect the suspension bridge illustrated herewith.

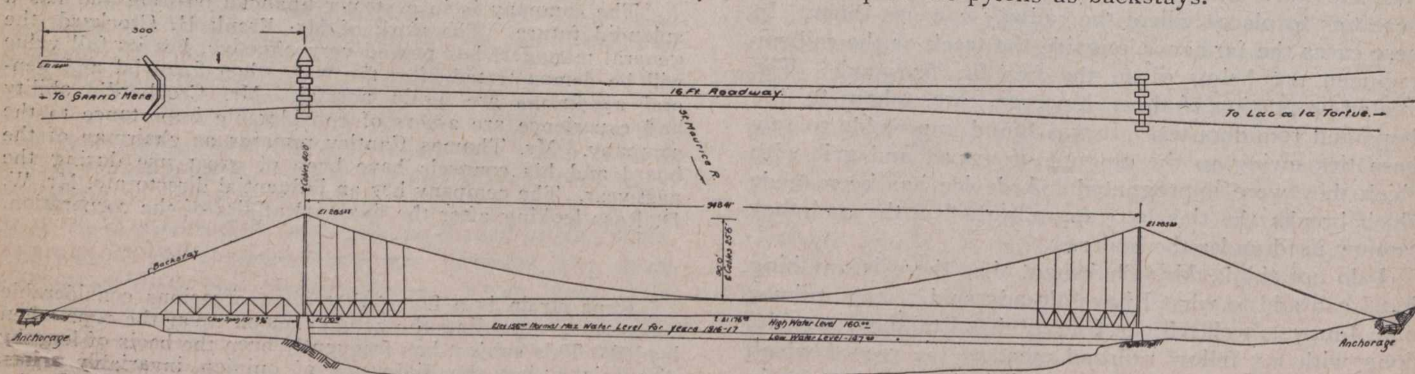
The concrete abutments are completed; they are 28 feet wide, 20 feet deep with two wings of 33 feet each. The piers are also finished to elevation 160. Each will carry a concrete pylon, as shown on the accompanying sketch. The top of the pylon will reach elevation 285.33, giving a height of 115.33 feet above the bridge floor.

The 151-foot 9¾-inch span, situated on the side of the town of Grand'Mere, and extending from the bank to the western pier, is in place, and is used temporarily as an approach to the ferry which runs between the piers and the eastern abutment. The span is designed with a 16-foot roadway and the truss is 20 feet high.

At present the work is temporarily suspended due to war conditions, but it is the intention of the company to resume construction just as soon as conditions warrant it.

Last year, they applied and got from the Federal Government, permission to erect the bridge. The details of the central truss are not completely defined yet, but a general idea of the project follows: The central span will be 948.41 feet long with a roadway of 16 feet. It will be of the Howe type, bearing on steel cross-ties, fastened to vertical wire, probably 6 inches in diameter; floor beams will run longitudinally and will be covered with two laying of planks. The truss will be approximately 18 feet high and will be suspended from a series of vertical steel wires attached to a cable on both sides of the bridge, the diameter of this cable will be 8 inches. The deflection of the cable is estimated at 25 feet 6 inches and the difference in floor elevation between the piers and the centre of the span 6 feet. This has been estimated in order to meet with any future developments due to live load.

Two concrete anchorage piers will be built and will be solidly fixed to the rock by iron bars. Eight-inch steel wire will run on each side of the bridge from these points to the top of the pylons as backstays.



Plan and Elevation of Suspension Bridge at Grand'Mere, Que.

According to the French "Gasworks Journal," sawdust and wood are to be used in Switzerland and France as substitutes for coal. In Geneva 10 per cent. of sawdust is added to the coal in vertical retorts; as an alternative, logs of wood, 3-ft. in length, are placed in the retorts, which then contain only charges of 260 lbs., instead of 1,240 lbs. of coal. Wood and coal are worked alternately on two benches, and the gases not being kept separate, the resulting tars are not acid. At La Chaux de Fonds, in the Jura, 375 lbs. of sawdust are mixed with 66 lbs. of coal in horizontal retorts, which take 990 lbs. of coal. In Neuchatel the coal is mined with 28 per cent. of coal.

According to official information, the County of Northumberland and Durham has come into the good roads system of the province. This means that an additional 375 miles of roads comes into the good roads system.

The total length of the Australian Transcontinental Railway is 3,489 miles, of which 729½ miles are of 3-ft. 6-in. gauge, 1,946 miles of 4-ft. 8½-in. gauge, and 813½ miles of 5-ft. 3-in. gauge. Western Australia, owing to financial difficulties, has not yet been able to change the 3-ft. 6-in. gauge from Freemantle to Kalgoorlie to standard gauge, and there are two more breaks of gauge in South Australia before Adelaide is reached.

THE GREATER WINNIPEG WATER DISTRICT

(*Continued from page 290*)

"We recommend taking the water out of Shoal Lake by gravity rather than pumping it over the summit in pipe lines.

"We estimate that the total cost to the Greater Winnipeg Water District of building the intake, Falcon River diversion works, concrete aqueduct and steel and cast-iron pipe lines, including crossings of streams and rivers, waste weirs, and other appurtenant works, will be $13,045,600."

This estimate does not include the cost of acquiring land, or of branch pipes to the different communities; neither does it include any allowance for water damages, nor for interest charges.

"We recommend as a part of the plan, but not for immediate construction, that a new storage reservoir, holding about 250,000,000 gallons, and estimated to cost between $300,000 and $400,000, be built at a point about a mile east of Transcona, and that a main pumping station be there established to force the water to the city through the 5-foot pipe, and through branches to be laid to the different sections of the city and district requiring the water. This reservoir and pumping station should be completed and ready for use before the demands for water shall have reached the capacity of the pipe line."

In order to establish the route line it was necessary to run 362 miles of transit lines, 1,317 miles of levels, 95 miles of precise levels, 360 square miles of topography.

In addition to the above, 12,000 feet of borings were made and recorded.

The difference in elevation between Indian Bay and the McPhillips Street reservoir in Winnipeg is 293 feet and the length of the line is 97 miles approximately, so that the average drop in the slope is slightly greater than ½ foot in 1,000 feet. The aqueduct as finally designed is a horseshoe-shaped concrete conduit to be built in place in two sections, invert and arch; the sizes of section and slopes on which each is constructed are given below:—

Slope of aqueduct.	Dimensions of sections.
0.11 inches per 100 feet	10′ 9″ x 9′ 0″
0.279 inches per 100 feet	10′ 9″ x 9′ 0″
0.300 inches per 100 feet	8′ 9″ x 7′ 4⅝″
0.382 inches per 100 feet	8′ 3¾″ x 7′ 0″
0.480 inches per 100 feet	7′ 11½″ x 6′ 8½″
0.600 inches per 100 feet	7′ 7½″ x 6′ 5¼″
0.684 inches per 100 feet	7′ 5½″ x 6′ 3½″
0.744 inches per 100 feet	7′ 4″ x 6′ 2¼″
1.290 inches per 100 feet	6′ 7″ x 5′ 6⅛″
1.537 inches per 100 feet	6′ 4¾″ x 5′ 4¾″

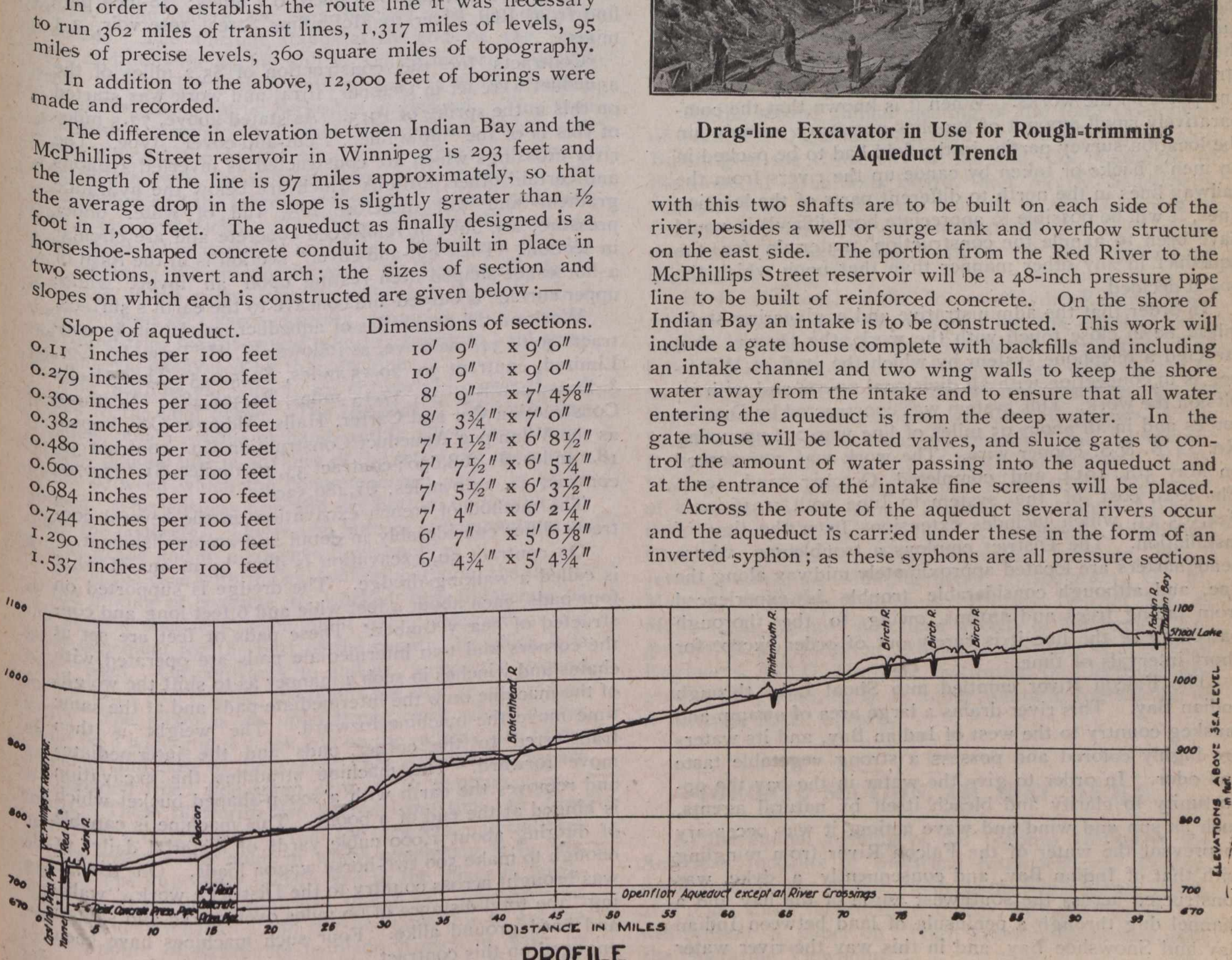
The dimensions, as stated above, are for one—the major—section of the work only, namely, that portion from the intake on the shores of Indian Bay to a point four miles east of the proposed reservoir site at Deacon. This section is approximately 81 miles in length and is constructed as a cut and cover "flow line" aqueduct. A cut and cover "flow line" aqueduct is one which is so built, in a comparatively shallow trench requiring embankment to provide the necessary covering, as to follow the slope of the country. It therefore does not run full nor under pressure, but the water flows with a free surface as it would in a ditch or channel or other similar structures. From a point four miles east of Deacon to McPhillips Street reservoir in Winnipeg the structure will be a circular pipe operating under pressure across the Red River Valley. This pipe will be constructed of reinforced concrete 8 feet in diameter and from Deacon to the Red River is 5 feet 6 inches in diameter.

At the Red River crossing will be a cast-iron lined tunnel under the river 5 feet in diameter and in connection

Drag-line Excavator in Use for Rough-trimming Aqueduct Trench

with this two shafts are to be built on each side of the river, besides a well or surge tank and overflow structure on the east side. The portion from the Red River to the McPhillips Street reservoir will be a 48-inch pressure pipe line to be built of reinforced concrete. On the shore of Indian Bay an intake is to be constructed. This work will include a gate house complete with backfills and including an intake channel and two wing walls to keep the shore water away from the intake and to ensure that all water entering the aqueduct is from the deep water. In the gate house will be located valves, and sluice gates to control the amount of water passing into the aqueduct and at the entrance of the intake fine screens will be placed.

Across the route of the aqueduct several rivers occur and the aqueduct is carried under these in the form of an inverted syphon; as these syphons are all pressure sections



PROFILE

they are circular in shape and are built of reinforced concrete.

The policy of the District has been to let contracts progressively. As the organization proceeded, tenders were invited and contracts for separate portions awarded. The total number of contracts let thus far is 69 and the amounts involved in these range from a few hundreds of dollars in some cases to considerably over a million dollars in others. Owing to the magnitude of the undertaking it would be impossible to make other than an approximate estimate of the quantities of construction involved, consequently each tenderer is asked to put in separate bids for the different items included in the contract and therefore should the actual quantities differ from those estimated the District has a fixed basis for settlement, paying only for work actually done.

Work to be performed, but not covered specifically by contract, is done under extra work orders. In each case these must be recommended by the chief engineer and approved by the board of commissioners and by the board of administration. The District places an inspector on each job and an accurate record of the cost of labor and materials is obtained. Payment for work done under "extra work" orders is made on a basis of 5 per cent. profit to the contractor on material, and 15 per cent. on labor, to care for his overhead and plant charge and his profit.

Owing to the inaccessible nature of the greater portion of the country through which the aqueduct was to be built the decision was early made to construct a standard-gauge railroad parallel to the line of the aqueduct in order that the immense amount of material necessary for the construction could be quickly and efficiently transferred to any point on the works. When it is known that the comparatively small amount of supplies necessary to maintain the location survey parties in the field had to be packed in on men's backs or taken by canoe up the rivers from the railway lines in the north to different parts of the location lines, it will be possible to appreciate how difficult it would have been to handle the construction materials for the aqueduct in any other manner than that upon which the board decided.

In order that the administrative and engineering staffs might be in close touch with the work, the District constructed a telephone system by which the staff at Winnipeg is in connection with all divisional points and with its pits on the work. This system was constructed by District forces and in all about 95 miles of line was put up, using No. 14 B. & S. copper wire. The work was commenced on May 5th, 1914, and completed October 22nd, 1914. The total cost of the system to June 30th, 1916, was $32,505.23, which includes extensions from the time of installation. The District employs a troubleman, whose headquarters are located approximately midway along the line, and although considerable trouble is experienced from falling trees and storms, owing to the thorough patrolling of the line it is rarely out of order except for short intervals of time.

The Falcon River emptied into Shoal Lake through Indian Bay. This river drains a large area of swamp and muskeg country to the west of Indian Bay, and its waters are highly colored and possess a strong vegetable taste and odor. In order to give the water in the bay the opportunity to clarify and bleach itself by natural agents, such as sun and wind and wave action, it was necessary to prevent the water of the Falcon River from mingling with that of Indian Bay, and consequently a dyke was constructed across the southwest angle of the bay and a channel dug through a peninsula of land between Indian Bay and Snowshoe Bay, and in this way the river water is shut off from the bay, flows through the channel and empties into Snowshoe Bay.

From observation made on both sides of the dyke it has been established that the color factor of the water on the aqueduct intake side is only one-ninth of that of the water upon the side on which the Falcon River empties. Comparison of water from the intake with water now supplied the citizens from city wells, show that the new supply of soft water will not differ in color from that to which all are accustomed.

The dyke was constructed during the year 1914 by Messrs. Tomlinson and Fleming, of Toronto, for $87,327. It is 7,000 feet long and contains 230,000 yards of material.

The material of which the dyke is built was obtained from a sand and gravel pit opened up nearby. From a rock outcropping on the shore of the bay near the intake site, the dyke was rip-rapped to protect it against wave action. The top is dressed with clay and sown with grass seed.

The total length of the conduit from the intake at Indian Bay to the McPhillips Street reservoir in Winnipeg is 96.5 miles and is made up as follows: Cut-and-cover concrete aqueduct with capacity of 85,000,000 Imperial gallons per day, 77.5 miles; river syphons and pressure sections of concrete aqueduct of same capacity, 7.1 miles; reinforced concrete pressure pipe (lock joint type) with capacity of 50,000,000 Imperial gallons daily, 9.4 miles; Red River tunnel, cast-iron lined, 0.2 miles; 48-inch pipe line from Red River to McPhillips Street reservoir, 2.3 miles.

Contracts for the construction of 85.2 miles of the aqueduct were let in October, 1914, and work was started on this in the spring of 1915. As stated above, 77.5 miles of this is of the "flow line," "cut-and-cover" type. The river crossings which are constructed as inverted syphons and certain other portions which are below the hydraulic gradient and will therefore flow full of water under pressure, are built of reinforced concrete and are circular in section. The "cut-and-cover" section is in the form of a horseshoe-shaped arch resting upon an invert whose upper surface is curved and concave to the earth's surface.

Work on the 85.2 miles of aqueduct was let under contracts 30 to 34, inclusive, as follows: J. H. Tremblay Co., Limited, contract 30, 20.15 miles, $945,945; Thos. Kelly & Sons, contract 31, 17.15 miles, $1,301,485; Northern Construction Co. and Carter, Halls, Aldinger Co., known as the Winnipeg Aqueduct Construction Co., contract 32, 18.2 miles, $1,268,650; contract 33, 16.1 miles, $1,137,070; contract 34, 13.0 miles, $1,489,520.

The method of trench excavation on the several contracts differ considerably in detail and accomplishment.

On contract 30, excavation is done by means of what is called a walking dredge. The dredge is supported on four pads, each about 4 feet wide and 6 feet long and constructed of heavy timber. These pads or feet are set at the corners and two intermediate pads are operated with chains and winches in such a manner as to shift the weight of the machine onto the intermediate pads and at the same time move the machine forward. The weight is then transferred to the corner pads and the intermediates move forward. The machine straddles the excavation and removes the earth with a scoop-shaped bucket which is hinged at the end of a boom. This machine is capable of digging about 1,000 cubic yards of material daily, or enough to make 500 two-horse wagon loads. One dredge was brought across country to the District's work, "walking" the total distance of 60 miles over marsh and slough and hard ground alike. Four such machines have been engaged on this contract.

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On contract 31, part of the trench to be cut is deep and consequently wide. The excavation at these points is being done with drag lines. Thew shovels have been used in the shallow cuts. Where boulders are encountered these are blasted in place and the broken pieces are removed by the shovel. When the cubical dimensions of the boulders exceed one-third of a yard the removal is paid for as rock excavation, otherwise the work is classed as earth excavation. Part of the work on this contract is through soft and boggy country and the contractors are using a drag-line excavator which type machine is particularly adaptable for work in swampy country.

On contracts 32, 33 and 34, drag-line excavators are being used for trench excavation and for backfilling of earth over the finished aqueduct. These machines are equipped with a trestled boom which is lowered or raised by a special engine located in the housing as are the engines controlling the bucket and swinging gearing. The upper structure of these excavators, including the bucket, boom, engine and housing, and the boiler, may be swung around the full circle on rollers set upon a frame. This frame is carried on wooden rollers set upon rectangular pads made of heavy timber. The pads rest upon the ground and the area of these depend upon the weight of the machine to be carried and the nature of the ground. When a move is necessary the pad nearest the excavation is picked up and swung around to the rear, the bucket is then anchored and the machine pulled backwards over the rollers. The rollers are then blocked and the digging proceeds. The machine stands at the end of the open ditch and pulls the bucket and excavated material towards itself. The bucket is then elevated and the whole machine swings and the material deposited as desired. This type of machine excavator will work in ground which will barely support the weight of a man. There are several sizes on the work, the smallest being equipped with a 1¾-yard bucket and the largest, weighing 150 tons, equipped with a 3½-yard bucket. The large machine will excavate 5,000 yards of material in 20 hours. To give a popular illustration of the amount of earth handled by this large drag-line, if the supposition is made that teams, hauling dump wagons of 2 yards capacity, require 1 hour to make the round trip, then it would take 125 teams to haul away the material excavated by this machine.

The machine excavation is not carried closer than 6 inches to the final grade. The removal of the remaining 6 inches, which is done by hand, and is called "hand trimming," is done just in advance of the setting of the profile forms between which the concrete invert pads are to be poured. This ensures firm and dry bottom upon which to place the concrete. The trench bottom is trimmed out to a neat grade and to a concave cross-section.

As is the case with the excavation methods, the details of the mixing of concrete are worked out differently on the several contracts, each plant being designed as the most expedient for the part of the country in which it is being used. On contracts 30 and 31, where the ground for the most part is solid, the plants are similar in arrangement. The mixer is set upon frame work which moves along on a wide-gauge track laid on the railway side of the aqueduct and close to the trench. The concrete aggregate is unloaded from side-dump cars on to temporary platforms. These platforms are moved from time to time as the work progresses, so that the concrete materials are always opposite the point at which concreting is in progress. The aggregate is delivered to the mixer in large-sized wheelbarrows on contracts 30 and 31. The barrows are previously measured and thus it is possible to get the exact amount of aggregate to place in each in order to have the correct amount for every batch. One man stands at the mixer, whose duty it is to add the cement.

The average time of mixing of each batch is 2 minutes, depending, however, upon the speed at which the mixer revolves. The time of mixing is under the control of the inspector on the work, who may require the continuation of the mixing until he is satisfied that the batch is thoroughly mixed and that there is no segregation of material. Continuous or gravity mixers are not allowed and each batch must be mixed separately. No concrete is allowed to drop free in air more than one foot and any chute or other means of conveying the concrete direct from the mixer or from a container into the work must not set at an angle which would cause segregation of the material in the mixed concrete.

Part of the material from the excavation is placed on the railway side of the trench, forming a levelled dump, and upon this a narrow gauge track is laid. A track upon an elevated trestle leads both ways from the mixer and is connected by switches to the track laid along the trench. The concrete is carried in small dump cars drawn by gasoline dinky engines to the work and is poured into the forms through spouts or chutes. As a rule, concrete is not hauled farther than one-half mile on either side of the mixer and when the work has progressed so that the distance for hauling exceeds one-half mile, the mixer is moved and the plant is re-established farther along the work.

(Concluded in the next issue.)

SECOND ANNUAL MEETING OF THE JOINT COMMITTEE OF TECHNICAL ORGANIZATIONS

At the second annual meeting of the Joint Committee of Technical Organizations, held last week in the Mining Building of the University of Toronto, Col. Carnegie, of the Imperial Munitions Board, and W. E. Segsworth, administrator of vocational training in the Dominion of Canada, expressed the opinion that the vital need of the day was technical training, both for the workingman and the soldier.

H. H. Couzens, of the Toronto Hydro-Electric Commission, was appointed chairman for the ensuing year, and Wills Maclachlan was re-elected secretary. The following representatives of organizations were elected to the joint committee: Canadian Mining Institute, W. E. Segsworth; Canadian Society of Civil Engineers, Prof. L. M. Arkley; Association of Ontario Land Surveyors, Russell R. Grant; Society of Chemical Industry, E. P. Mathewson; Engineering Alumni Association, University of Toronto, H. G. Acres; Engineering Alumni Association, Queen's University, Alex. C. Longwell; Engineers' Club, W. A. Bucke; Royal Canadian Institute, Harry Jewell; Canadian Manufacturers' Association, G. M. Murray; Canadian Engineers, Military District No. 2, Major L. L. Anthes; American Society of Mechanical Engineers, C. B. Hamilton; American Institute of Electrical Engineers, W. G. Gordon; Institution of Electrical Engineers (England), S. L. B. Lines; Ontario Association of Architects, R. K. Sheard.

TORONTO SECTION, AM. INST. OF E.E.

At the annual meeting of the Toronto Section of the American Institute of Electrical Engineers on Friday, April 19th, in the lecture room at 96 King Street West, at 8 p.m., Paul Ackerman, engineer, Toronto Power Co., will present a paper on "High Tension Insulators from the Operating Viewpoint."

Election of officers will take place at this meeting.

LIBRARY

Canadian Society of Civil Engineers Discusses Fuel Problem

First General Professional Meeting of the Canadian Society of Civil Engineers a Pronounced Success.—Fuel and Power Situation Exhaustively Discussed

THE first serious attempt to thoroughly investigate the fuel situation in the Dominion took place at the Physics Building of the University of Toronto at the initial general professional meeting of the Canadian Society of Civil Engineers on March 26th and 27th.

About one hundred members of the society were in attendance at the opening meeting on Tuesday afternoon when the fuels, their transportation and development were considered.

B. F. Haanel, chief of the fuel division of the Department of Mines, Ottawa, opened the meeting with a paper on the fuels of Canada. The situation obtaining in Canada to-day, he attributed to conditions in the United States, the ease with which fuels are imported from that country, and the apathy displayed towards the exploitation of certain of our own fuel resources. While not wholly dependent on the United States for her fuel supply, Canada imports from her neighbor 55 per cent. of her total coal requirements and 91 per cent. of the crude and refined oil products used. In analyzing the fuel resources, their location and extent, he stated that in addition to the coal reserves, there are 37,000 square miles covered with peat bogs, 12,000 square miles of which lie in the central provinces. He dealt with the preparation of lignite and peat for economic use and expressed the opinion that only a small amount of money would be necessary, compared with the immense value which the solution of this vexed question would be to the country. In this connection, he stated that there were seven bogs convenient to Toronto which could supply the city with 26,500,000 tons of fuel.

Transportation from the fuel viewpoint was dealt with by W. M. Neal, general secretary of the Canadian Railway Association for National Defence, Montreal. Referring to the bituminous and lignite mines of the West, he said that they had never been able to turn out a maximum on account of labor conditions. A tribute to the records the railways have made was paid by Mr. Neal, who stated that one-fifth of the total tonnage carried by them is coal.

Sir William Hearst extended a hearty welcome to the engineers and assured the meeting that the government was ready to assist and anxious to co-operate with them.

In speaking on the rational development of Canada's coal resources, W. J. Dick, mining engineer of the Commission of Conservation, Ottawa, said that the future of Canada was not in the hands of her statesmen but in those of her miners. He argued that the scarcity of coal would force many European industries to Canada after the war and suggested the formation of trade boards to regulate mining and to prevent wasteful methods. He expressed the opinion that the final solution of the scarcity of anthracite would be the manufacture of artificial anthracite by municipal gas plants. "It is not beyond the bounds of reason to foresee a condition whereby a householder in the place of his ton of anthracite will receive a ton of smokeless coal, without slate, a month's supply of cooking gas, 40 miles of motor fuel, enough fertilizer to start a small garden, and tar sufficient to allay the dust in front of his house,—all for less money than he now pays for inferior coal." He claimed that any reform in the cost of fuel in central Canada should see a reduction in the cost of domestic heating and a mitigation of the smoke nuisance.

"The Utilization of Peat," was taken up by John Blizard, technical engineer of the division of fuels and fuel-testing of the Mines Branch, Department of Mines, Ottawa, who predicted a speedy inauguration of the peat fuel industry in Canada, and a paper on "The Low Temperature Carbonization of Fuels" was read by E. Stanfield, of the same department.

In reviewing the papers, the chairman, H. H. Vaughan, president of the society, referred to the importance of not only discussing the fuel situation in Canada and the use of the present fuels as well as others which were advocated, but also of promoting economy in the use of them. By the use of certain devices it was possible to save thousands of tons of fuel and so to help minimize the difficulties. Mr. Vaughan referred to the fact that the Canadian Pacific Railway was the first railway company in North America to adopt superheaters on locomotives and thus to effect a considerable fuel economy. The papers read, he held, were of great value because the authors had presented information on definite work already accomplished or on certain practicable lines of research.

L. M. Arkley, assistant professor of mechanical engineering, University of Toronto, led the debate on the fuels of Canada. He contended that it was possible to save one million tons of coal annually in Canada by adopting reasonable measures, such as the installation in steam plants of necessary and inexpensive equipment for regulating the volume of air admitted into the furnace and sampling the waste gases as they pass out the flue to determine the proper adjustment.

James Milne, mechanical and electrical engineer of the Department of Public Works, city of Toronto, leader of the discussion on the utilization of peat, stated that he carried out investigations in 1902 in connection with the development of peat as fuel and had arrived at the conclusion that it could be prepared for about $2.75 per ton and that five tons of peat were about equivalent in heat value to three tons of coal.

James White, of the Commission of Conservation, said that the regulation compelling the railway companies to provide spark arresters on locomotives employed in the prairie provinces had done much to reduce the fire risks there. Owing to the fact that lignite coal disintegrated on exposure to the atmosphere, the mining of it was carried on in the autumn and winter and the fuel had to be delivered to the consumers at once. For this reason, he considered that Mr. Magrath's suggestion that lignite might be stored under ground or, if necessary, submerged in water, was most practical. He pointed out that the Canadian Pacific Railway was using oil as fuel because it was found to be cheaper than coal and it removed the risks due to strikes.

Mr. Dowling referred to the use of natural gas in the West. Calgary, he said, was consuming about thirty million cubic feet per day. The possibility of extracting gasoline out of natural gas opened a tempting opportunity for serious waste which should be prevented. The most important item in connection with peat from the viewpoint of George W. Allen, secretary-treasurer of the Canadian Gas Association, was that peat could be used for producing gas and many useful by-products.

To summarize the day's work, suggestions as to the development of Canada's coal resources were: (1) Substitution of coke for anthracite; (2) the introduction of by-product coke ovens, and the transformation of gas plants to include more thorough by-product recovery; (3) carbonization and briquetting of low-grade fuels; (4) the use of pulverized coal as a locomotive fuel; (5) the elimination of waste in mining; (6) greater use of eastern coals to replace imported coal in the area west of Port Arthur, which includes avoiding the use of fuel requiring a long haul wherever it is possible to procure a suitable substitute requiring only a short haul; (7) by the earliest exploitation of our own resources to aim at limiting the necessity for importing fuel from other countries.

The evening session was occupied by a most interesting illustrated address on "The Erection of the Quebec Bridge," by George F. Porter, engineer of construction for the St. Lawrence Bridge Co., Montreal.

On the second day of the session, the efforts made to relieve the fuel situation in Ontario, wood as an emergency fuel, gas for light, heat and power, oil fuel, hydro-electric energy and water powers with relation to the situation were treated.

Albert Grigg, deputy minister of lands and forests, Ontario, outlined the steps taken by the government to place a large supply of wood at the disposal of the municipalities of the province. E. J. Zavitz, provincial forester for Ontario, dealt with the subject of wood as an emergency fuel and Arthur Hewitt, general manager of the Consumers' Gas Co., Toronto, discussed the value of gas for lighting, heating and power purposes.

The possibilities of central heating for the future was the foundation for a most interesting paper by F. G. Clark, chief engineer of the Toronto Electric Light Co. Within ten years, he prophesies, the heating system in large cities will be revolutionized and transportation congestion very considerably relieved by the general use of central heating and of gas and briquettes made from powdered coal piped from the mines to the manufacturing centres as fuel.

Oil fuel and its possibilities was discussed by R. W. Caldwell, chief mechanical engineer of the Imperial Oil Company.

In his address upon "Canada's Water Powers and Their Relation to the Fuel Situation," J. B. Challies, superintendent of the Dominion Water Power Branch of the Department of the Interior, Ottawa, stated that only 10 per cent. of Ontario's available hydro-electric power had been developed. "It is axiomatic," said Mr. Challies, "that our heat, light and power needs must be considered as one great national problem, and also that Canada's domestic and industrial development depends primarily on the co-ordinated use of all the fuel-power resources of the Dominion. Water power," he added, "must take a very prominent part, if the best use of the varied fuel-power resources of Canada is to be achieved."

In his paper on "Railway Electrification," John Murphy, chief electrical engineer of the Department of Railways and Canals, Ottawa, declared that the electrification of railways, especially terminals, with adjacent engine divisions, would save an enormous consumption of bituminous coal and relieve the transportation system. Something like 9,000,000 tons of coal were consumed by our railroads in 1917. It would be possible to save two-thirds, at least, of this coal by the use of electric locomotives. The present per capita hydro power development in Canada is larger than all other countries except Norway. The speaker gave a number of concrete instances to show how electrification of railways in mountain sections, where railroading is most strenuous, had increased their efficiency.

J. M. Robertson, Montreal, director of the Southern Canada Power Company, spoke of the possibilities of relieving the fuel consumption by industries by using more electricity. The consensus of opinion, he said, was that hydro power would be the force which in after years would bring industries to this country from Europe and even from the United States.

The closing address of the day was that by P. H. Mitchell, consulting engineer, of Toronto, on "The Possibilities of Lessening Fuel Consumption in Canada by the Adoption of Electrical Heating." The speaker did not believe this method of heating practicable at present because of its expensiveness, but considered it one of the possibilities of the future.

W. A. McLean, commenting on the papers on the use of wood as fuel, strongly advocated that the timber areas should be systematically reforested so that the future supply might be assured. Speaking on the same subject, James White also supported the regulation of timber-cutting, so that the supply might be conserved. At the present time, he believed, the problem of how to increase production on the land and yet secure a supply of wood by next winter without robbing the farms was extremely important.

W. P. Brereton, city engineer of Winnipeg, stated that the problem of that city was how best to utilize slack obtained by screening at the mines. He considered that the questions of the installation of gas producers and the use of powdered fuel should be carefully studied.

B. F. Haanel stated that certain lignites of the West were suitable for use in their raw state, but others broke up on exposure. The principal trouble was in the furnaces, where the lignite decrepitated under heat and choked the bars. Lignite, however, was eminently suitable for gas producers, especially if the by-products were recovered. The gas was, unfortunately, low in heat value and the cost of distribution was high because much greater volume was required to provide the same heat as, say, coal gas. Central heating will be a factor in the saving of coal and large central plants for producing gas such as the Mond gas plant in Staffordshire, England, would be an advantage if a market for the gas could be found. He also pointed out that when fuel contains a high per cent. of nitrogen, it will pay to recover the same.

W. F. Mickle, Toronto, stated that natural gas had been supplied in Ontario in quantities which, when converted into their equivalent heat values, would be equal to 800,000 tons of coal per year.

Prof. R. W. Angus referred to the fact that neither the producer gas plants nor the Diesel engine had ever had a strong footing in Canada as yet. The fuel question resolved itself into one of educating the public and, he believed, if the Toronto Branch of the Canadian Society of Civil Engineers would co-operate with the other technical societies, it would be possible to show the public how to use fuel economically. Waste should be reduced and thus transportation difficulties minimized.

E. Stansfield, Ottawa, called attention to the absence of information on the surface combustion method of using gas and the effect of preheating of gas on its value for different purposes.

P. H. Mitchell stated that, from his experience with a housing company in Toronto with which he was connected, central heating would be a success economically if meters were installed to insure payment for the quantity of heat used.

H. G. Acres, Toronto, in discussing the heating of houses by electricity, mentioned that if Toronto, with its 80,000 houses, depended upon hydro-electricity for heat, about 1,750,000 horse-power would be required on the coldest days. This was evidently an impossible scheme inasmuch as this quantity of electricity could not be applied to other uses when less heating was necessary. Moreover, the available water power in Canada was insufficient to heat the houses in the country, apart from the demands for power. It was, of course, possible to use electricity to supplement other heating apparatus during the very cold periods. Mr. Acres did not consider that the aesthetical preservation of the Niagara Falls should be considered to the detriment of the development of power. He thought that the water power at Niagara was an instrument placed by Divine Providence to enable us to raise the scale of living and to promote the welfare of the people.

Dr. T. K. Thomson, of New York, advocated the fuller development of the Niagara River water power, and stated that it was quite feasible to throw a dam across to impound water to a depth of 100 feet at a cost of $100,000,000 to develop about 2,000,000 horse power. He said that capital was available for this purpose whenever the authorities would consent to the scheme. The demand for electrical power was increasing at an enormous rate. For example, New York State now had about 3,000,000 horsepower and the annual increase was about 300,000 horsepower.

Arthur V. White, Toronto, wished to safeguard the public in the matter of electric heating. So much had been stated to lead the people to believe that it was both feasible and economical that he believed the meeting should place on record the opinion that it was not so. Toronto alone would require all the power that is now available for heating alone.

H. R. Safford, Montreal, in discussing John Murphy's paper on railway electrification, expressed the opinion that the facts presented were both important and deserving of greater consideration. The electrification of railways is carried out because of certain local reasons. In New York it was a matter of the abolition of smoke and other civic causes. Other lines were new and some were specially adapted for electrification. So that the question should be considered in each case upon its merits and not on general principles.

J. Blizard, Ottawa, thought the whole question of fuel deserved a fuller and more carefully considered investigation. A census of fuel requirements and resources should be made. Before we could intelligently apply adequate remedies it was necessary, in his opinion, to collect every possible fact, so that the problems might be attacked in a comprehensive and scientific manner.

A committee of the council of the society was appointed to consider the conditions existing in Canada. They will have access to all the papers and discussions. and will digest them. The report of the committee will go forward to the government.

The final meeting of the session took the form of a smoker at the rooms of the Toronto branch of the society.

The last pier of the Central Canada Railway bridge over the Peace River at Peace River, has been set up. When completed, the Peace River Railway bridge will be one of the largest in Western Canada, being 1,735 feet long from abutment to abutment and 77 feet above low water level. The three central piers in mid-channel were built in 40 feet of running water, at low water mark.

GARBAGE AS FEED FOR HOGS

The Commission of Conservation, Canada, has recently issued a most interesting and comprehensive pamphlet on the methods and success of feeding garbage to hogs, employed in the cities of Saskatoon, Sask., Worcester, Mass., and Grand Rapids, Mich.

The two American cities were visited during the summer of 1917 by Prof. G. E. Day, of Guelph. In both plants the garbage is fed raw. In the Saskatoon plant, however, the garbage is boiled and mixed with a small amount of grain. This is probably the best plan of procedure in Canada where sterilization is required and the feeding of garbage to swine is conducted under license and inspection. These licenses are issued through the Veterinary Director-General at Ottawa.

Arthur Wilson, medical health officer at Saskatoon, states that a conservative estimate would be at least 1,600 hogs fattened and marketed during the year.

In that city the feeding of boiled garbage to hogs according to by-law has proven eminently successful, he reports.

At Worcester, Mass., a city of about 170,000 inhabitants, the garbage is fed at the home farm, an institution for the city's indigent poor, which contains about 600 acres, and is situated about three miles from the city.

In 1917 the home farm was getting only about 60 per cent. of the garbage, the remainder being handled by private individuals who had been granted licenses by the city. These private collectors were getting the best of the garbage, and the part most cheaply collected, because they took it from hotels, restaurants, and large boarding houses.

The superintendent, Thos. Horne, stated that fifteen tons of garbage per day would maintain three thousand pigs of all ages. According to his calculation, one ton per day would be sufficient for ninety fattening pigs. This is nearly three times as high a valuation of garbage as was made by Messrs. Brown and Hartman, at Grand Rapids. The method of feeding may partly account for the discrepancy.

The pens are floored with cement and about half of each pen has a plank over-lay for the bed. The garbage is fed on the cement floor next to the feed passage and there is also a cement trough for water. For out-door feeding, wooden platforms, built on runners, are used.

Mr. Horne claims that garbage, few raw, is a perfectly balanced food for pigs. The herd was destroyed by foot-and-mouth disease in 1915, but cholera is prevented by immunization.

Alvah Brown was the pioneer in garbage feeding at Grand Rapids, Mich. The farm where the garbage is fed is about 30 miles from the city, of sandy soil, in a thinly settled district. The present stock on the farm comprises 300 cattle, 400 sheep, and 700 pigs. There is not quite enough garbage to supply the requirements of all the stock on hand, and a certain amount of hay has been purchased for the cattle and sheep, though it is claimed they prefer garbage.

The garbage is fed raw. Mr. Brown attempted to cook it, but claims he found it decreased the value of the garbage as food, and increased the cost. The company is satisfied, therefore, that it pays better to feed the garbage raw and treat the hogs as a precaution against cholera. In summer, Mr. Hartman, who is managing the farm, recommends feeding pigs on the ground, and shifting their location occasionally so that there is no chance for any considerable fermentation of the material on the

(Continued on page 306)

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Principal Contents of this Issue

THE CONSERVATION OF WATER POWER

THE question of conservation has to do with the policy not only of the governments, federal and provincial, but also of the people at large, with regard to those resources, useful to man, which are supplied by nature in form easily adaptable to immediate utilization, and particularly with regard to those natural resources, not uniformly distributed, which are limited in extent or in quantity.

Among such natural resources are the minerals in the earth, the forests growing upon the earth, and the waters flowing over the earth. Whether applied to any or all of these, a policy of conservation should manifestly be directed neither to a locking up or withdrawal from use on the one hand, nor to an indiscriminate or wasteful utilization upon the other hand. Economy in its best sense should prevail, but an economy which has regard for both the present and the coming generations. These natural resources are placed by nature for the use of man—the man of to-day and the man of the future. Where present and future interests conflict, those of the present are paramount. It is not justifiable unduly to place burdens and restrictions upon the present generation out of regard for those to come after us nor unduly, by present extravagance, to impose unnecessary burdens upon the future. More than that, neither desires for the present nor for the future should be made the justification or pretext for measures in conflict with the fundamental laws of personal and property rights which are, under our constitutional government, the safeguards of our free constitutions.

Conservation, then, should denote the policy of the economical utilization of these natural resources, and of the utmost protection, within the law, of such economy, consistent with the needs of the present and of fuure generations.

The two great natural sources of energy available are coal deposits and water powers. The known supply of coal, while sufficient for a few centuries to come, assuming that the present rate of consumption continues, is in fact limited, as its cost to the consumer gradually increases as the supply diminishes. While the cost of developing water power is considerable, the development and transmission of electrical energy has made water power development feasible as a business proposition, as against the cost of steam power, to the extent that the amount of water power which is still undeveloped, but which could be economically developed at the present time, amounts to millions of horse-power. As fuel grows scarcer and as the science of electrical generation and transmission progresses, further water powers, now merely potential, will be available for the market.

Because it is inexhaustible and because its use replaces that of another and exhaustible natural source of energy, water power is the most potent of all natural resources, as a subject and agency for conservation. In the case of a limited, exhaustible, and rapidly diminishing supply of a natural resource, such as coal deposits, the forces of conservation should be directed to the prevention of use as far as consistently possible. But the correct view of conservation inevitably leads to the demand that, in the case of water powers, there shall be encouraged and promoted the greatest and most immediate use possible.

ONTARIO'S MINERAL PRODUCTION

THE statistics in the preliminary statement of Ontario's mineral production for 1917, cover the output of metallic and non-metallic mines, quarries and other excavations, and also the primary products of works and plants treating materials of provincial origin. The figures are subject to revision, and are issued as soon after the completion of the year as possible, for the information of the mining community and the public generally. Mr. T. W. Gibson, deputy minister of mines, Ontario, and his staff are to be commended for the rapid and careful collection and prompt publication of their statistics. Such action materially enhances the value of the figures. The total production last year, having a value of $71,060,942, shows an increase of $5,757,120 compared with that of 1916, and marks a new high point in the record of Ontario's mining industry. As Mr. Gibson says, "an expression of satisfaction may be permitted in this successful effort to bring the minerals of the province to bear with added weight in the great struggle of Britain and her Allies for justice and freedom."

Some interesting particulars are given in the preliminary statement regarding nickel and copper. The output of nickel-copper matte in 1917 was 78,897 tons as compared with 80,010 tons in 1916. The nickel content, 41,887 tons, was greater, but the copper content, 21,997 tons, less than in that year, which may be explained by the fact that the bulk of the Canadian Copper Company's production was from the Creighton mine, the ore of which is well known to contain much more nickel than copper. During the year, 1,453,661 tons of ore were smelted at the Copper Cliff and Coniston smelters.

The Royal Ontario Nickel Commission in its report on the nickel industry, issued early last year, estimated the known reserves of nickel ore as 70 million tons, but it is believed that the results of diamond drilling since the issue of the report have added nearly 100 per cent. to the quantity. Explorations at the Levack, Frood Extension, Murray and Falconbridge deposits has much extended the limits of the ore bodies. The refinery of the International Nickel Company of Canada at Port Colborne is well on the way to completion. It will have a capacity of about 10,000 tons of nickel per annum, and a relative quantity of copper.

Although the nickel-copper mines of Sudbury are the chief source of copper in Ontario, there are other deposits of non-nickeliferous copper ore from which shipments of ore and concentrates were made in 1917 to the extent of 4,173 tons, containing 431,402 pounds of copper, valued at $89,380. In addition, 110,476 pounds were recovered from silver ore and gold slag treated in United States refineries. On the Hudson Copper Company's property in Galbraith township a handsome showing of copper glance has been uncovered. The average price of copper in 1917 was 27.18 cents as compared with 27.20 cents in 1916. Since September 21st the price has been, as fixed by the United States government, 23½ cents per pound f.o.b. New York. Ontario's mineral production, large as it is, will increase rapidly as the undeveloped resources are harnessed with capital and labor.

PERSONALS

Lieut. E. M. Royce, formerly of the Canadian Artillery, now of the Royal Engineers, is gazetted deputy assistant director of inland waterways with the Imperials.

W. H. Winterrowd, formerly assistant chief mechanical engineer of the Canadian Pacific Railway, has been appointed chief mechanical engineer to succeed W. E. Woodhouse, who has resigned.

Lieut. A. H. Parker, who before going overseas was on the staff of the Good Roads Department at the Parliament Buildings, Toronto, Ont., is now serving with the Royal Engineers, working on the lines of communication on the Macedonian front. He graduated in civil engineering from the University of Toronto with class '14, and had qualified as a lieutenant in the Canadian Expeditionary Force before training in England for an Imperial commission. On completing the course he was one of three Canadians chosen out of a class of 80 for service in the East, and went out to Saloniki with the 37th Army Troop Company, R.E., in December, 1916.

OBITUARIES

Edward Fraser, superintendent of the St. James sub-station for the Winnipeg Electric Railway Company, was electrocuted while at work on March 24th.

E. S. Prentice, who passed away at the Royal Jubilee Hospital, Victoria, B.C., on March 12th, after an operation, was at one time consulting engineer to the Transvaal government and member of the Institute of Civil Engineers. He was 58 years of age and the eldest son of the late Judge Prentice of the Middle Temple, and Mrs. Prentice, Surbiton, Surrey, England. For the last six years he has resided at Ganges Harbor, Salt Spring Island. He leaves a widow and two sons.

Flight-Lieut. C. G. Wheelock, son of C. R. Wheelock, president of the Ontario Good Roads Association, was drowned at Dartford, England, on March 19th as the result of a Flying Corps accident. He enlisted as gunner in the 14th Battery, Toronto, in April, 1914, leaving the University of Toronto, where he was just completing his fourth year in the civil engineering course. He reached France in September, was promoted to bombardier, and served about twenty months at the front there and in Belgium. He then returned to England to train for a commission in the Flying Corps and was awaiting orders to return to France in the 63rd Squadron, R.F.C.

W. F. TYE WINS GZOWSKI MEDAL

An interesting ceremony took place at the meeting of the Canadian Society of Civil Engineers at Montreal on March 28th, when the Gzowski medal for the best contribution to Canadian engineering literature during the year was presented to William Francis Tye, a past president of the society, and late chief engineer of the Canadian Pacific Railway, for his recent paper on "Canada's Railway Problems." The presentation of the medal was made by another past president of the society, Sir John Kennedy.

OTTAWA BRANCH, CAN. SOC. C.E.

The year book of the Ottawa Branch of the Canadian Society of Civil Engineers has just been issued. The proceedings committee announces that through the courtesy of J. B. McRae, who designed and superintended the construction of the new pumping plant of the city of Ottawa water supply system, a visit to these works will be made on May 18th. The publicity committee announce that special arrangements have been made for fuller press publicity through reports of meetings, special news write-ups, etc.

GARBAGE AS FEED FOR HOGS

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feeding grounds. Mr. Hartman claims that he has bought thin hogs at twelve cents per pound and sold them finished at eight cents per pound and still made a good profit on the operation.

The city has made certain rules defining what is meant by garbage, and the method which the householder is required to follow in his disposal of it. Citizens are prohibited from disposing of garbage to any person or persons other than the city. The city collects the garbage by means of nine wagons equipped with covered steel tanks and one auto truck. The tanks are approximately ten feet long, four feet wide, and two feet deep.

Quite a number of cities in the United States dispose of their garbage by a method similar to the one described.

Messrs. Hooper and Miller, 40th Street Station, Denver, Col., are looked upon as about the oldest and most successful men in this business.

The Department of Agriculture of the United States has under way a study of the situation, including the best methods of handling, the feeding and fattening of stock, the most efficient and sanitary arrangement of equipment, the comparative value of garbage as a hog ration, and the economy of garbage disposal by feeding to hogs compared with systems of disposal by incineration, rendering, dumping, or burying. The investigation will extend to all parts of the United States.