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The Canadian Engineer

*A weekly paper for engineers and engineering-contractors*

# IMPROVEMENTS TO WATER SUPPLY AT PORT HOPE, ONT.

NOTES ON THE DESIGN AND CONSTRUCTION OF THE NEW 600,000-GALLON-PER-DAY SLOW SAND FILTRATION PLANT, INTAKE, RESERVOIR AND PUMP HOUSE, WHICH ARE NOW NEARING COMPLETION.

OWING to pollution of the infiltration wells upon which the town depended for water, Port Hope, Ontario, last fall had to consider other methods of obtaining a potable supply. Three infiltration wells and a filter gallery had been located near the shore of the lake. It was found that these were being polluted by drainage from the town site; also insufficient water was being obtained from them. Shallow trenches were dug beyond the infiltration wells and a temporary pumping station kept these trenches full. The water so supplied filtered back through the sand into the wells, and thus increased the supply. It was foreseen that this method could not be continued during the winter, because the shallow trenches would freeze, and besides, it did not remedy the serious pollution.

In October, therefore, the town called in a consulting engineer, and voted the necessary money to obtain a permanent pure supply. No other source of supply excepting Lake Ontario was considered, because the distribution system and the pumping station were arranged to receive the supply from Lake Ontario, and also because of the much greater cost involved in piping from distant sources.

The consulting engineer recommended the erection of a slow sand filtration plant, because the excavations made for the infiltration wells were admirably suited to such filters, practically no other excavation being necessary. Also, good sand and gravel were readily available, thus reducing the cost of such filters, and thereby reducing the annual interest and operating charges to such an extent as to be lower than they would be for a mechanical gravity filter.

**Intake.**—An intake pipe 14¼ inches internal diameter was laid to a point in 10 ft. of water, 1,800 ft. from the filters. By running the same length of intake into the lake at a different angle, supply could have been obtained at 20 ft. depth, but this supply would have been from the vicinity of rapidly shifting sand. The vicinity to which the intake was laid has a rock bottom, and the water was found to be much clearer there than at the 20-ft. depth. For about 900 ft. from the shore, a channel was dredged sufficient to allow a covering of 2 ft. on the pipe, and for the remainder of the distance, sufficient dredging was done to be able just to bury the pipe. The outer 900 ft. of the intake is laid partly in clay and boulders and partly in rock.

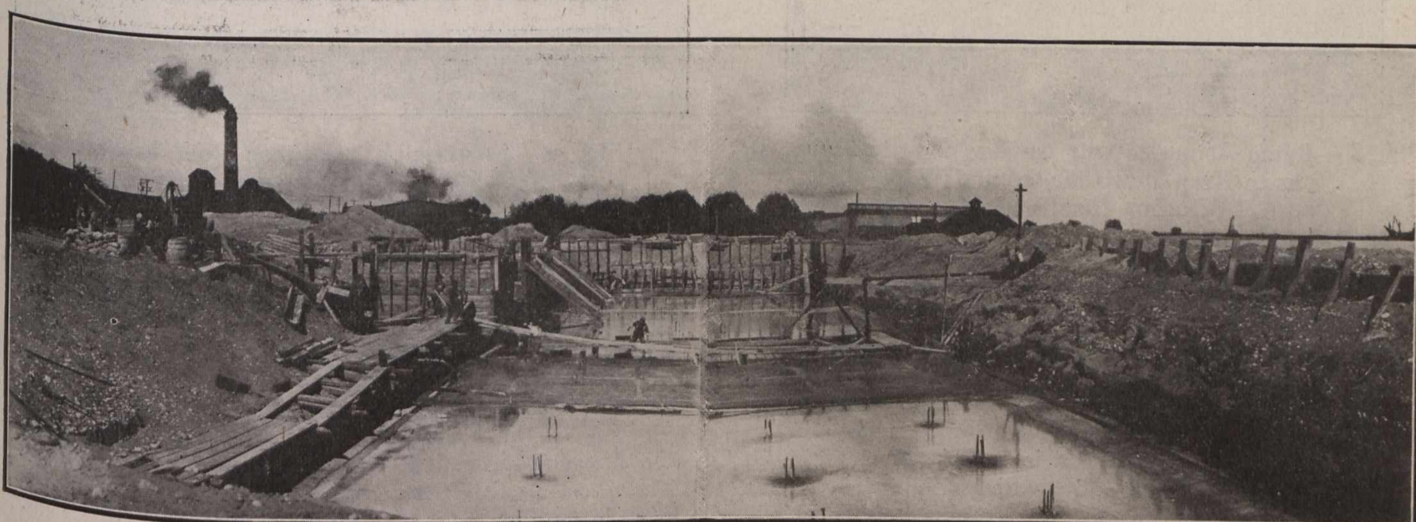

**Fig. 1.—General View of Construction of Floor of Filters, Showing Steel Dowels for Columns. The Main Pumping Station is Shown in the Background at the Left.**

The contract for laying the intake was awarded to J. F. Boyd, of Sault Ste. Marie, Ont. It will be completed in about four weeks.

The intake pipe was connected up in 90-ft. lengths, with a bulkhead at each end so as to float it. It was towed into position, sunk by admitting air, and connected by a diver. Fig. 9 is a general view of the intake work, showing a length of pipe being floated into position. The gasket used in connecting this pipe was tar mixed with a small percentage of tallow. This mixture was painted

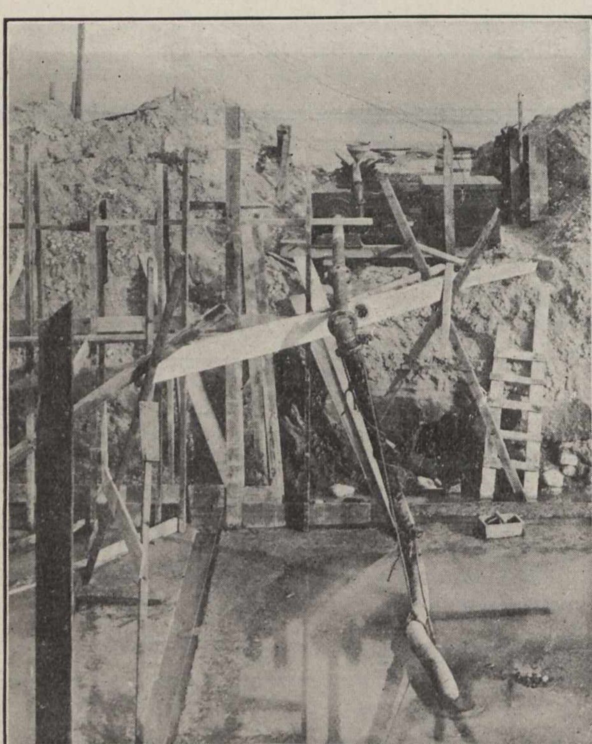

Fig. 2.—Pump Arranged with Suction Pipe in Sump, so as to Keep Down the Ground Water During Construction.

about ⅛-in. thick on the face of each flange, so that when the bolts were tightened, the tar bulged out a little all around the joint. This made a perfectly watertight and very elastic joint.

On the outer end of the intake pipe, a bend was inserted and a steel hood placed thereon each night when work was stopped. This hood is 3 ft. in diameter, built up of 1-in. x 1½-in. flats, and covered with burlap. When the intake is laid out to the proper point, this hood will be set in place permanently and the burlap removed.

**Filters.**—The filters will be completed in about two weeks. They are being constructed by Thomas Garnet & Sons, of Port Hope. Work was started about April 1st. There are four filters, each 47 ft. square, with nine 1 x 1-ft. columns, the columns being placed 11 ft. apart

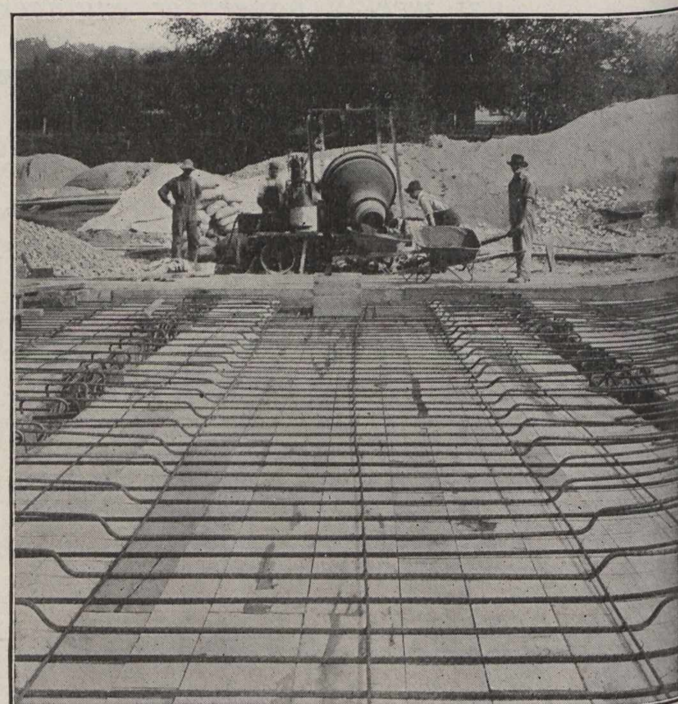

Fig. 4.—Reinforcing for Filter Roof in Place, Showing Bent Rods Between Two of the Beams.

in each direction. The floor is of monolithic construction, reinforced in both directions. It is dished away from the base of the columns to form four lines of gutters in each direction, the inverts of all these gutters being level. Figs. 5 and 7 show plan and cross-sections of the filters.

Fig. 1 shows a general view of the construction of the floor of the filters. The mixture used was 1:2:4. There are approximately only 1,200 cubic yards of concrete in the four filters and pure water reservoir. Twenty-two and a half tons of reinforced steel were used. The pure water reservoir is 35 ft. x 76 ft., reinforced concrete construction, the excavation of one of the infiltration wells proving adaptable to a reservoir of this size.

During construction of the filters, the ground water was not allowed to rise on the outside of the filters more than 3 ft. above the floor level. To keep the ground water down, a line of 12-inch tile was laid lengthwise under the floor, with a sump placed at its middle point. The suction pipe from a centrifugal pump was dropped into this sump. Considerable care was exercised in pumping promptly whenever necessary. As a result, the tendency of the filters to float was checked, thus preventing distorting stresses, and the engineer claims to have obtained a perfectly watertight structure. Fig. 2 shows the suction

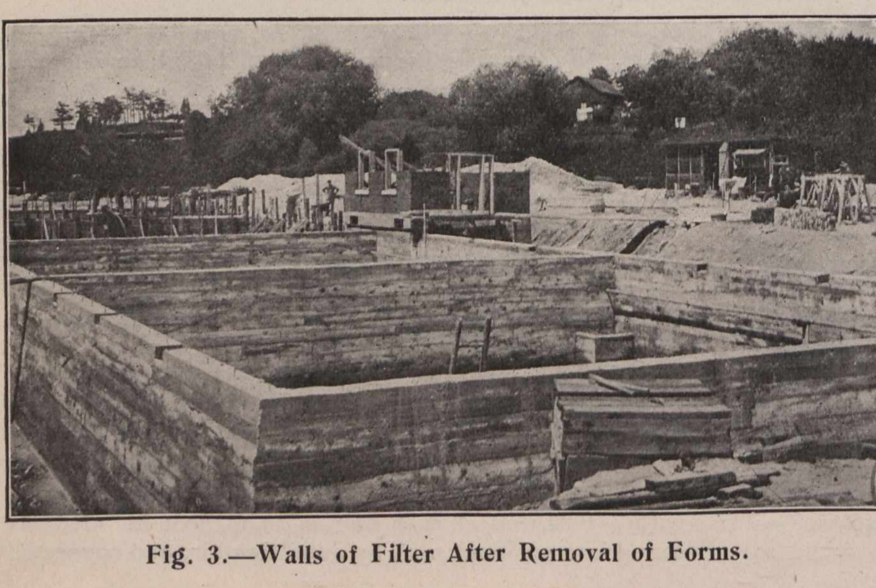

Fig. 3.—Walls of Filter After Removal of Forms.

pipe and pump which were used to handle the ground water. Fig. 3 shows the walls of the filter after removal of the forms. The column and roof forms, which were put in place after the removal of the wall forms, are shown in Fig. 6. The roof was reinforced for continuous action. Fig. 4 shows the bent rods between two of the beams. The roof will be covered with a foot of sand to prevent freezing in the filters.

Eight-inch split tile were laid in the gutters of each filter, as shown in Fig. 8. From these the filtered water is carried through Venturi meters to the pure water reservoir. The tile are covered with about 12 inches of graded gravel, the bottom 6 inches passing 1 in. to 1½ in. mesh; the next 3 inches, ¼ in. to 1 in.; the top 3 inches, 1/20 in. to ¼ in. Over this gravel there is laid 42 inches of screened, washed and graded sand.

**Operation.**—When the sand must be washed, it is planned to rake it up into piles, from which it will be shovelled into an ejector box, which will be lowered through a manhole. Water from the town distributing system will flow into the box through a hose, and will carry the sand into another hose leading from the other side of the box, which latter hose will carry it to the sand washer placed on top of the filters. The washed sand will be carried hydraulically back into the filters. There are five manholes for each filter, so there will be excellent light for the cleaning operations.

The ground covered by the filters is 1/5 acre, so their capacity is estimated at 600,000 Imperial gallons per day. The average daily consumption of the town at present is 200,000 gallons. During unusual demands, such as for fire purposes, the filters will be capable of operating for 24 hours at the rate of 1,600,000 gallons.

It is expected to obtain a bacterial efficiency of 98 per cent. At present the town

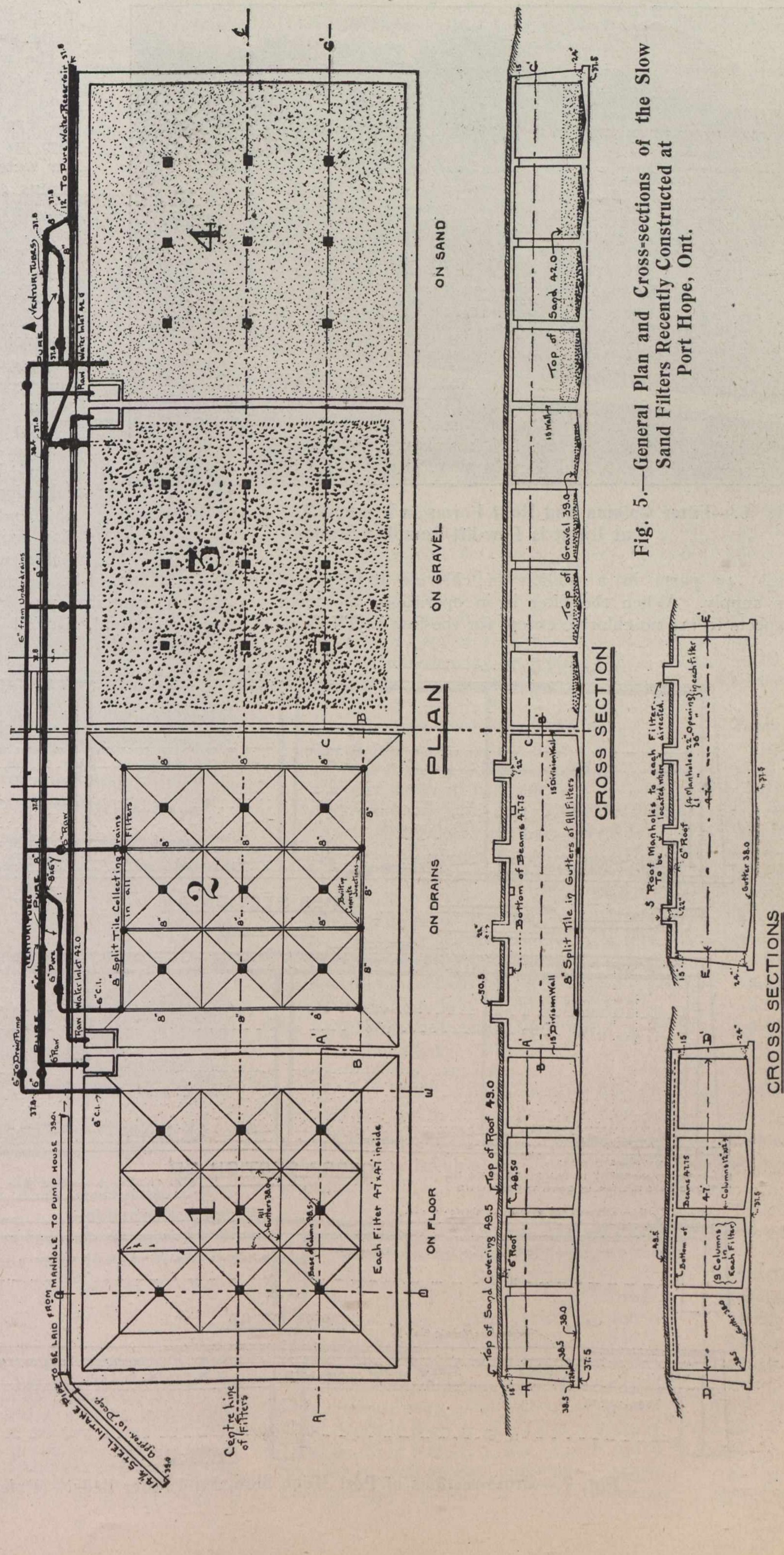


Fig. 5.—General Plan and Cross-sections of the Slow Sand Filters Recently Constructed at Port Hope, Ont.

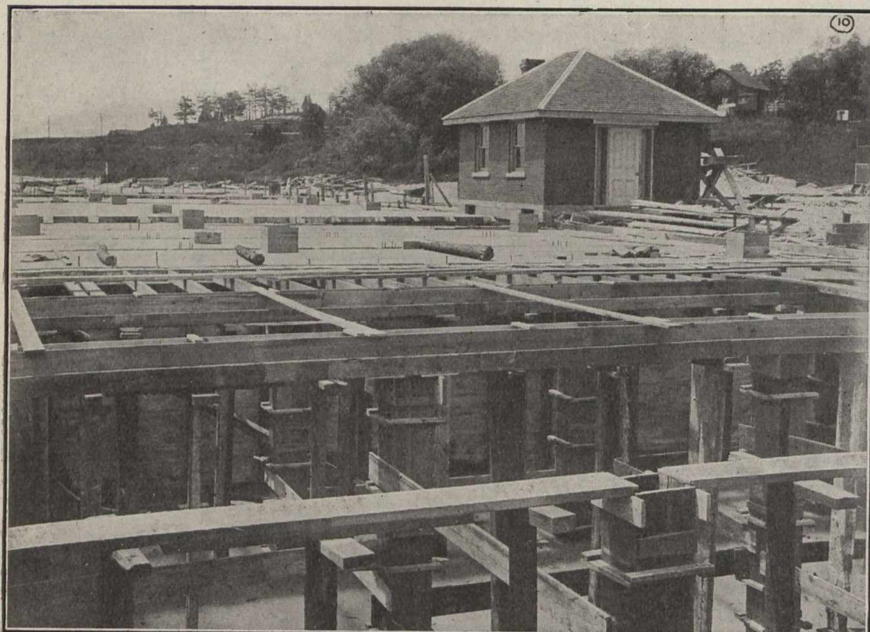


**Fig. 6.—Filter Column and Roof Forms in Place. The Small Building at Right is Low-lift Pumping Station**

uses .45 parts in a million of chlorine to disinfect its supply. When the filter is in operation, the town expects to use no chlorine except for the few days following each cleaning, when about .15 parts to the million will likely be used.

The water flows by gravity from the lake to the filters. The surface of the sand in the filters is 242.5 ft. above the sea level. The average lake level from 1871 to 1900 was 245.0, with extreme low water record of 241.36, so that the pumps at the low-lift pumping station will have to be operated only during low water. When the water is dirty, however, causing considerable loss of head in the filters, the low-lift pumps may be operated so that the elevation of the water will be higher in the pure water reservoir, and therefore higher in the pump well of the main pumping station, thus reducing the suction lift of the pumps in the main pumping station. The pump at the low-lift pumping station is motor-driven, and there is an auxiliary pump driven by oil engine.

**Equipment.**—The pumps, motor, engine and piping were supplied by Canadian Fairbanks-Morse Co. The Venturi meters were supplied by Francis Hankin & Co.; loss-of-head and elevation gauges by H. W. Cowan; cast iron pipe by National Iron Works; valves by Drummond, McCall & Co.; sluice gates by Kerr

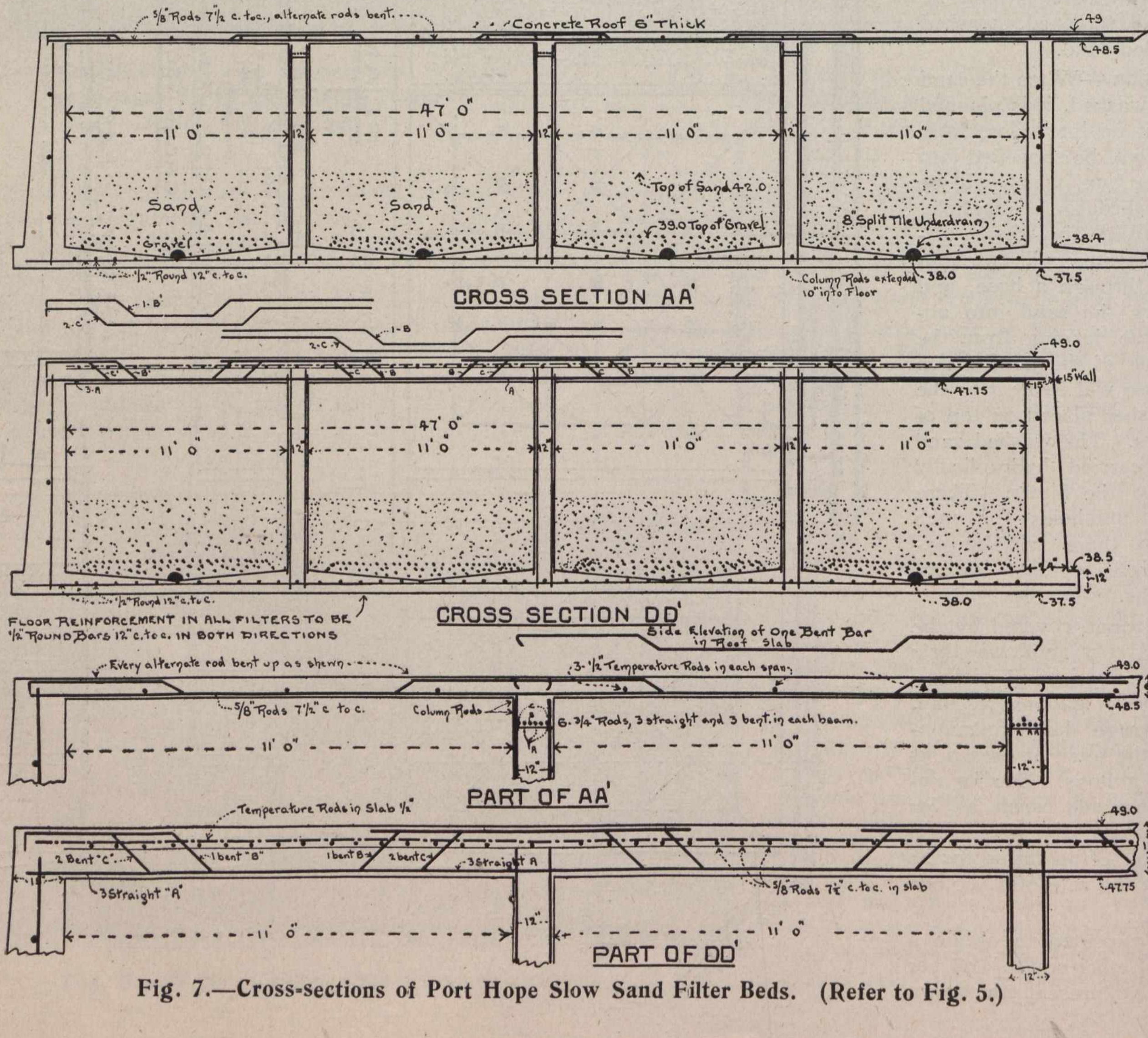


**Fig. 7.—Cross-sections of Port Hope Slow Sand Filter Beds. (Refer to Fig. 5.)**

Engine Co.; sand-washer by F. S. Henning; riveted steel intake pipe by Francis Hankin & Co.; reinforcing steel by Trussed Concrete Steel Co. The contractor used "Rogers" cement and a Wettlaufer mixer.

It is interesting to note that the actual cost of the entire work totals within a few hundred dollars less than the engineer's advance estimate.

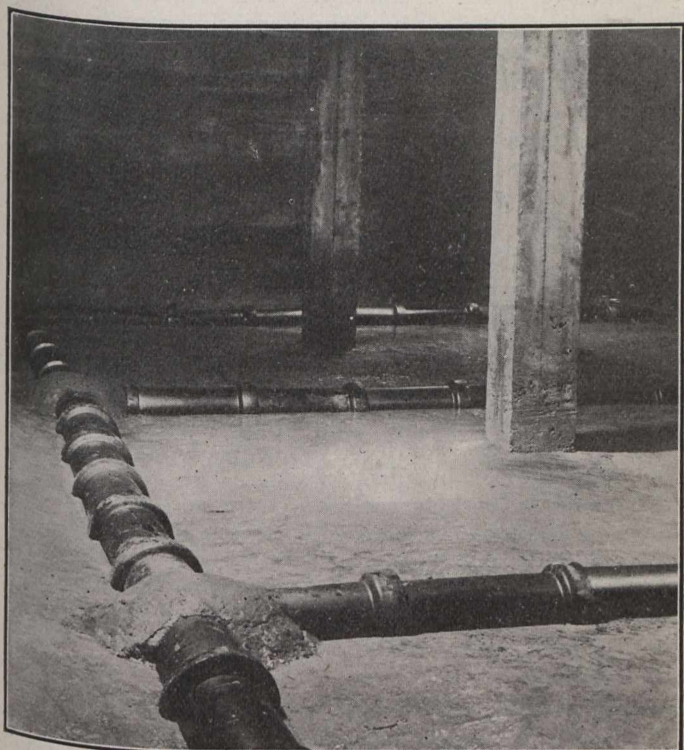

**Fig. 8.—Split Tile Laid in Gutters to Carry Filtered Water to Pure Water Reservoir.**

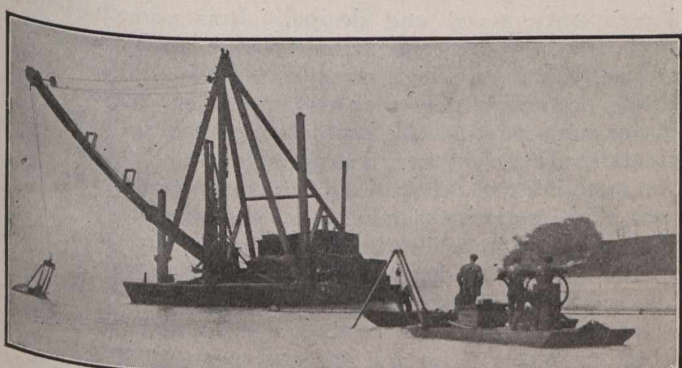

**Fig. 9.—Dredging Channel for Intake. Ninety-foot Section of Pipe Being Floated into Position.**

The plant was designed by and constructed under the supervision of F. W. Thorold & Co., consulting engineers, Toronto, to whom we are indebted for the photographs and for much of the information given in this article. H. O. Waddell, B.A.Sc., was resident engineer.

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The quantity of petroleum entering the markets of the world in 1914 amounted to 400,483,489 barrels, according to statistics compiled under the supervision of J. D. Northrop of the United States Geological Survey. Of this output the United States is credited with 66.36 per cent., representing in quantity a trifle less than double the output of all the other oil producing countries combined. Changes in rank during the year affected only Japan and Peru, the former superseding the latter by a narrow margin.

## TEST BORING DATA, SHOAL LAKE AQUEDUCT.

In our issue of August 12, 1915, the contract prices were given, together with the latest estimate of the total cost of the Winnipeg-Shoal Lake aqueduct. It was pointed out that the present computation indicates a saving of $1,860,000 over the original estimate, speaking well for the administrative and executive efficiency of the Greater Winnipeg Water District organization.

In our issue of June 4, 1914, we published some cost data relating to the equipment and operation of the wash boring parties that took to the field in November, 1913, in charge of Douglas L. McLean, under the direction of W. G. Chace, the District's chief engineer. These valuable tables of equipment and cost data, furnished by Mr. McLean, may now be supplemented by another useful classification of hand auger work as follows:—

**Table I.—Hand Auger Test Boring Cost Data.**

(Small "Empire Drill" earth auger without casing used as hand auger).

| | Totals. |
|---|---|
| Number of holes | 29.0 |
| Frost depth in feet, 1 | 55.9 |
| Peat depth in feet, 2 | 234.1 |
| Sand and gravel depth in feet, 3 | 0.9 |
| Clay depth in feet, 4 | 409.7 |
| Total depth in feet of 1, 3, 4 | 465.5 |
| Total depth in feet of 2, 3, 4 | 644.7 |
| Number of men per day or man-days | 65.8 |
| Cost per day | $208.66 |

| Work done from February 4-28, 1914— | Feet. |
|---|---|
| Average depth frost per hole | 1.93 |
| (This is frozen peat and water.) | |
| Average depth of peat per hole | 8.07 |
| Average depth sand and gravel per hole | .03 |
| Average clay depth per hole | 14.10 |
| Average total depth | 22.20 |
| Average cost per foot run, 1, 3, 4 (cts.) | 44.8 |
| Average cost per foot run, 2, 3, 4 (cts.) | 32.4 |
| Average cost per man-day | 3.175 |
| Average man-days per hole | 2.27 |
| Average man-days per foot run, 1, 3, 4 | 0.141 |
| Average man-days per foot run, 2, 3, 4 | 0.102 |
| 4-man gang— | |
| Average cost per day | 12.70 |
| Average bored, 1, 3, 4 feet per day | 28.4 |
| Average bored, 2, 3, 4 feet per day | 39.2 |

These holes were about 2,000 ft. apart and considerable time was required transporting outfit and travelling to camp.

**Table II.—Hand Auger Test Boring Cost Data.**

(Hand operated rod and pipe augers used).

| | Total. | Totals to April 22. |
|---|---|---|
| Number of holes | 396.0 | 370.0 |
| Frost depth in feet, 1 | 759.6 | 759.6 |
| Peat depth in feet, 2 | 2,608.9 | 2,490.9 |
| Sand and gravel depth in feet, 3 | 59.3 | 59.3 |
| Clay depth in feet, 4 | 3,530.8 | 3,352.3 |
| Total depth in feet, 1, 3, 4 | 4,349.7 | 4,171.2 |
| Total depth in feet, 2, 3, 4 | 6,199.0 | 5,902.5 |
| Number of men per day, man-days | 245.9 | 236.9 |
| Cost per day | $690.10 | $662.70 |

Summary of results to April 22—

| | |
|---|---|
| Average depth frost per hole, feet | 2.05 |
| Average depth of peat per hole, feet | 6.73 |
| Average depth of sand and gravel per hole, ft. | 0.16 |
| Average depth of clay per hole, feet | 9.06 |
| Average total depth, feet | 15.95 |
| Average cost per foot run of 1, 3, 4, cts. | 15.9 |
| Average cost per foot run of 2, 3, 4, cts. | 11.2 |
| Average cost per man-day | $2.80 |
| Average man-days per hole | 0.64 |
| Average man-days per foot run, 1, 3, 4 | 0.057 |
| Average man-days per foot run, 2, 3, 4 | 0.040 |
| 3-man gang— | |
| Average cost per day | $8.40 |
| Average bored, 1, 3, 4, feet per day | 52.8 |
| Average bored, 2, 3, 4, feet per day | 75.0 |
| Cost of equipment— | |
| 3 rod augers at $10.70 | $32.10 |
| 6 spanners at 20 cents | 1.20 |
| 3 monkey wrenches at 70 cents | 2.10 |
| 1 pipe auger at $15.00 | 15.00 |
| 4 10-qt. galvanized pails at 21 cents | .84 |
| 1 doz. 3½-lb. axes at $1.00 | 12.00 |
| Total | $63.24 |

Table I. gives the total and average costs for 645 feet of boring in which was used the small auger drill spoon with necessary wrenches, handles, drill rods, etc., of a Junior Empire drill set. This outfit cost $259.85 delivered at Winnipeg, and was supplied by the New York Engineering Company. The test holes put down were at 2,000-ft. intervals and averaged 22.2 ft. in depth. They cost 32.4 cents per foot run, including the peat in the depth.

In opening up the holes through frozen material axes were used on all hand auger work, and found to be more efficient than a chisel, crowbar or pick.

In Table II. is given data covering some 6,200 ft. of boring, where hand-operated rod and pipe augers were used. These hand augers give practically the same efficiencies for depths of 15 to 20 ft., but for depths under 15 ft. the pipe auger is the faster. The rod auger, consisting of 1 auger piece, 1 handle, 5 extension rods with 12 extra bolts ⅜ in. x 1¼ ins., cost $10.70. To this should be added cost of a couple of spanners and the lifting handle. The pipe auger, consisting of 1 auger piece, 5 rods with couplings and bolts, 1 handle, 1 extra set of bolts and 2 spanners, together with 2 only ⅜-in. steel chains 4 ft. long, with one grab and one side hook attached to each, cost $15.

## BIG CAR ORDERS REPORTED.

A Montreal dispatch says that Mr. W. W. Butler, vice-president of the Canadian Car and Foundry Company, states that an order for 100 box cars, valued at $100,000, had been received from the Alberta and Great Waterways Railway Company, and the Edmonton, Dunvegan and British Columbia Railway. The company also secured an order from the same source for $10,000 worth of switch and frog material, which will be manufactured by their subsidiary, the Canadian Steel Foundries.

It is understood also that the National Steel Car Company, of Hamilton, received an order from the Edmonton, Dunvegan and British Columbia Railway for ten stock cars. The value of the consignment was placed at $125,000.

## THE MODERN ELECTRIC MINE LOCOMOTIVE.*

By Graham Bright.

THE day of the small mine with small equipment is passing, and in the future most of the bituminous coal mining will be accomplished in larger mines using heavy equipment. The demand for larger capacity in equipment has been increasing rapidly of late, and owing to the restricted space available for the equipment on a mine locomotive, difficulty is being experienced in designing equipment to meet the conditions. A possible solution of the problem is in providing forced ventilation for the motors which are of a type that require very little ventilation to produce a large increase in the continuous rating. This scheme has been tried out on a large locomotive and the results indicate that forced ventilation will play a prominent part in meeting the extreme severe conditions that are frequently arising in the mine locomotive field.

Motors for mine locomotives are rated in the same manner as the railway motor, that is, the one-hour rating with a rise of 75 deg. C. This rating, unfortunately, does not determine the fitness of the motor to meet a certain set of conditions in mine service. The mine motor is essentially an entirely enclosed motor so that the losses must be dissipated by conduction through the casing. In a locomotive with a box type frame, the air about the motor is trapped in, so that very little ventilation is obtained. With the open bar type frame the conditions are not so bad, as considerable ventilation is obtained around the motor.

The continuous rating of a mine motor is generally given at a reduced voltage since the average voltage applied to the motor in service is considerably below normal. This rating will be found to range from 35 per cent. to 50 per cent. of the hour rating of the motor depending upon the capacity, speed and design. It is a much simpler proposition to design a motor to give a high one-hour rating than it is a high continuous rating. The hour rating depends largely upon the amount of material in the motor and consequently its thermal capacity. The continuous rating, however, depends upon the distribution of the material, the distribution of the losses and the ventilation. The majority of mine operators buy motors on the one-hour rating, while the real capacity of a locomotive for all-day service depends upon the continuous rating of its motors. For a given set of conditions the root-mean-squared current can be readily determined from a characteristic motor curve and this root-mean-squared current should not exceed the continuous capacity of the motor if the motor is not to be overloaded.

A number of operators and some engineers advocate a rating of so many horse-power per ton weight of locomotive. This method may meet a great many conditions, but at times fails utterly. Unless the speed is high, a high horse-power per ton cannot be utilized owing to the limited adhesion of the wheels.

The limiting dimensions, weight, gauge, and rail, greatly handicap the design of a mine locomotive, and in the last few years the operating conditions have become difficult to meet owing to the increase in length of haul, weight of cars, and number of cars to be handled per trip. Some manufacturers have endeavored to meet these conditions by increasing the one-hour rating of the motor

*From a paper to be presented at the Panama-Pacific Convention of the American Institute of Electrical Engineers, San Francisco, Cal., September 17, 1915.

while manifestly the proper thing to do is to increase the continuous rating.

About a year ago the author had occasion to estimate on a 24-ton locomotive to meet some very severe conditions. The haul was long and the grade against the loads. One manufacturer had three 85-h.p. motors as the maximum available for the equipment. According to calculations, this equipment was not large enough although on a horse-power per ton basis it seemed amply large (a little over 10 h.p. per ton). A second manufacturer offered a 25-ton locomotive equipped with three 115-h.p. motors.

The customer decided to try out both kinds and two locomotives of each make were installed.

The following tests, made some time after the locomotives were installed, clearly indicate that the high one-hour rating of 115 h.p. was obtained at the expense of the continuous rating, so that the 85-h.p. motor is really the larger of the two.

Both locomotives were operated in all-day service and a complete record kept of the cars handled, the grades, the distances and the weights. This service was, however, much lighter than was originally specified. Table I. shows the results of the test made with the locomotive equipped with three 85-h.p. motors.

The temperatures given are actual temperatures, so that the rise indicates that the equipment is working right up to the limit and any further load added would shorten the life of the motors so that satisfactory service could not be obtained. The actual number of cars handled was about 75 per cent. of the number originally specified.

Table II. shows the results with the 25-ton locomotive using three 115-h.p. motors. It will be noted from this table that the work done by the 24-ton locomotive was 42 per cent. greater than the 25-ton locomotive equipped with the larger motors. The temperature of the motors on the 25-ton locomotive will average but two degrees lower than that of the motors on the 24-ton locomotive, showing that although the latter was doing 42 per cent. more work, the temperature of its motor was practically the same as on the 25-ton locomotive, whose motors are supposed to have 37 per cent. greater capacity. No doubt some of the increase in actual capacity of the 85-h.p. over the 115-h.p. motor is due to the fact that the 24-ton locomotive is equipped with the open steel bar frame which

**Table I.—24-ton Locomotive.**

Equipment, three 85-h.p. 500-volt motors.

| Distance. | Grade. | Pull in lbs. per car. | Work done in lb.-ft. |
|---|---|---|---|
| 700 | 0 | 47.5 | 33,300 |
| 1,400 | 2.5 | 142.5 | 200,000 |
| 1,800 | 1.0 | 85.5 | 153,000 |
| 1,600 | 0.425 | 63.5 | 101,100 |
| 2,400 | 2.5 | 142.5 | 342,000 |
| 1,450 | 1.1 | 89.5 | 130,000 |
| 1,750 | 2.5 | 142.5 | 249,000 |
| 1,880 | 1.06 | 88.0 | 165,500 |
| 600 | 3.3 | 173.0 | 104,000 |

Total ....................1,477,900
Total pound-miles per car ... 279
Total pound-miles for 725 cars 202,300

Air Temperature 20 Deg. Cent.

| | Armature. | Commutator. |
|---|---|---|
| No. 1 motor | 95 deg. | 97 deg. |
| No. 3 motor | 92 deg. | 97 deg. |

allows considerable ventilation around the motor frames, while the 25-ton locomotive is equipped with a slab steel frame which pockets the air and permits of very little ventilation. The temperature of one motor of a second 24-ton locomotive, operating at the same time and doing about 10 per cent. more work than the first, was found to have practically the same rise.

As before stated, the service conditions are becoming more severe each year until conditions are sometimes submitted that cannot be met with by any of the standard equipments from a heating standpoint. The author has had in mind for the last few years that the time is coming when forced ventilation would be necessary to meet such cases. Forced ventilation has been used very successfully for the last nine or ten years on large main line locomotives. As this particular installation seemed to be such

**Table II.—25-ton Locomotive.**

Equipment, three 115-h.p. 550-volt motors.

| Distance. | Grade. | Pull in lbs. per car. | Work done in lb.-ft. |
|---|---|---|---|
| 700 | 0 | 47.5 | 33,300 |
| 1,400 | 2.5 | 142.5 | 200,000 |
| 1,800 | 1.0 | 85.5 | 153,000 |
| 1,600 | 0.425 | 63.5 | 101,000 |
| 2,400 | 2.5 | 142.5 | 342,000 |
| 600 | 1.1 | 89.5 | 54,000 |

Total ................. 883,300
Total pound-miles per car .... 167
Total pound-miles for 851 cars 142,000

Air Temperature 20 deg. Cent.

| | Armature. | Commutator. |
|---|---|---|
| No. 1 motor | 92 deg. | 95 deg. |
| No. 3 motor | 92 deg. | 95 deg. |

Rating of 25-ton locomotive ...... 345 h.p.
Rating of 24-ton locomotive ...... 252 h.p.
Work done by 25-ton locomotive ... 142,000 pound miles
Work done by 24-ton locomotive ... 202,300 pound-miles

a case, permission was requested of the operating company to allow the manufacturer to install a small fan at one end of the locomotives to blow air through a duct to be so mounted that air could be delivered to the rear end of each motor. The commutator lid was raised around the edges a small amount to permit the air to escape. From 200 to 300 cu. ft. of air per minute was supplied to each motor. The motor driving the fan required about one h.p.

Before installing the fan in the locomotive a test was made on a single motor mounted on the test floor at the factory. The result of the test showed that with about 300 cu. ft. of air per minute passing through the motor the continuous rating could be nearly doubled. Since the continuous rating of a large slow-speed motor of this type without ventilation is only about 40 per cent. of the one-hour rating it will be seen that with ventilation this continuous rating is still considerably below the one-hour rating.

Owing to the dusty condition of the mine it was thought that trouble would be experienced by the motors being filled with dirt. During the heavy pull when bringing the trip out a great deal of dust is raised and the operators decided to run the fan only while the locomotive was going in with the empty trip.

The results have been surprising, both in regard to temperature rise and the condition of the motors.

Table III. shows the result of a test made by the operating company on the locomotive with blower, and a locomotive equipped with 115-h.p. motors without a blower. The load conditions were much more severe than on the original test and the latter locomotive was doing about 5 per cent. more work than the former.

**Table III.**

| | Three 85-h.p. motors. | Three 115-h.p. motors. |
|---|---|---|
| Mine air at beginning of test | 25 deg. C. | 25 deg. C. |
| Motor frame .............. | 35 " | 35 " |
| Motor armature .......... | 42 " | 42 " |
| Mine air at end of day ...... | 25 " | 25 " |
| Motor frame at end of day .. | 75 " | 93 " |
| Motor armature at end of day | 97 " | 121 " |

The results shown in Table III. were obtained with the fan on the 24-ton locomotive operating considerably less than 50 per cent of the time. An inspection of the inside of the motors showed that they were much cleaner than the ones not using forced ventilation. The results of the tests show conclusively that the increased capacities that are being demanded can be economically met by the use of forced ventilation with standard motors if these motors are properly designed. This will prove quite a saving to the operators, since without forced ventilation new and expensive motors would have to be signed.

It is the intention now to install a blowing equipment on the other 24-ton locomotive and on both locomotives equipped with 115-h.p. motors. It is not probable that the 115-h.p. motor will receive as much benefit from forced ventilation as the 85-h.p. motor, due to the fact that the armature of the 85-h.p. motor is furnished with ventilating slots while the 115-h.p. motor is not.

## MUNICIPAL USE OF NATURAL GAS.

The United States Bureau of Mines has just issued a pamphlet dealing with the chemical and physical properties of the natural gases used in twenty-five cities. In this paper, which gives the first comparative data of this kind ever published, the authors, G. A. Burrell and G. G. Oberfell, state that five of the samples contain methane only as the combustible gas. The others contain in addition to methane, higher members of the series of paraffin hydrocarbons. The heating values range from 735 to 1,312 B.t.u. per cubic foot at 0° C. and 760 mm. pressure. Some of the natural gas used in Texas has a heating value of about 740 B.t.u. per cubic foot at 0° C. and 760 mm. pressure. The natural gas used in Pittsburgh, Columbus, Cleveland, Cincinnati and many other places in the east is quite uniform in composition.

The explosive limits of mixtures of natural gas and air lie between about 5.00 per cent. gas, low limit, and 11.50 per cent. gas, high limit. For many of the natural gases listed, there is required about 10.0 cubic feet of air per cubic foot of gas for complete combustion.

According to Cady and McFarland and to Czako, helium may be present in natural gases to the extent of from traces up to 1.84 per cent. The ignition temperature of natural gases lies between about 550° C. and 750° C. The composition of the natural gas used in any one town may remain remarkably uniform for a long period of time.

Oxygen, carbon monoxide, hydrogen and olefine hydrocarbons are not present in such gas, except possibly in negligible traces.

## COST DATA FOR ROAD WORK IN SASKATCHEWAN.

THE following tables have been carefully compiled by the Board of Highway Commissioners of the province of Saskatchewan for the use of municipalities engaged in road work By their aid it is possible with a few minutes' figuring to ascertain very closely what any particular piece of road grading should cost, and also the sizes and capacity of the culverts necessary.

**Table of Cost Data for Roads.**

1½ to 1 side slope and 16 feet road bed.

| Fill in feet | Cost per cubic yard in cents | Number of cubic yards per 100 feet length | Price per 100 feet | Length of culvert |
|---|---|---|---|---|
| 1 foot | 18 cents | 65 cubic yards | $11.70 | 19 feet |
| " | 20 " | " | 13.00 | " |
| " | 25 " | " | 16.25 | " |
| " | 30 " | " | 19.30 | " |
| " | 35 " | " | 22.75 | " |
| 2 feet | 18 cents | 141 cubic yards | $25.38 | 22 feet |
| " | 20 " | " | 28.30 | " |
| " | 25 " | " | 35.28 | " |
| " | 30 " | " | 42.30 | " |
| " | 35 " | " | 49.35 | " |
| 3 feet | 18 cents | 228 cubic yards | $41.04 | 25 feet |
| " | 20 " | " | 45.60 | " |
| " | 25 " | " | 57.00 | " |
| " | 30 " | " | 68.40 | " |
| " | 35 " | " | 79.80 | " |
| 4 feet | 18 cents | 326 cubic yards | $58.68 | 28 feet |
| " | 20 " | " | 65.20 | " |
| " | 25 " | " | 81.50 | " |
| " | 30 " | " | 97.80 | " |
| " | 35 " | " | 114.10 | " |
| 5 feet | 18 cents | 435 cubic yards | $78.30 | 32 feet |
| " | 20 " | " | 87.00 | " |
| " | 25 " | " | 108.75 | " |
| " | 30 " | " | 130.30 | " |
| " | 35 " | " | 152.25 | " |
| 6 feet | 18 cents | 556 cubic yards | $100.08 | 36 feet |
| " | 20 " | " | 111.20 | " |
| " | 25 " | " | 139.00 | " |
| " | 30 " | " | 166.80 | " |
| " | 35 " | " | 184.60 | " |
| 7 feet | 18 cents | 687 cubic yards | $123.66 | 39 feet |
| " | 20 " | " | 137.40 | " |
| " | 25 " | " | 171.75 | " |
| " | 30 " | " | 206.10 | " |
| " | 35 " | " | 234.45 | " |
| 8 feet | 18 cents | 830 cubic yards | $149.40 | 42 feet |
| " | 20 " | " | 166.00 | " |
| " | 25 " | " | 207.50 | " |
| " | 30 " | " | 249.00 | " |
| " | 35 " | " | 290.50 | " |
| 9 feet | 18 cents | 983 cubic yards | $175.94 | 45 feet |
| " | 20 " | " | 196.60 | " |
| " | 25 " | " | 245.75 | " |
| " | 30 " | " | 294.90 | " |
| " | 35 " | " | 344.05 | " |
| 10 feet | 18 cents | 1,148 cubic yards | $206.65 | 48 feet |
| " | 20 " | " | 229.60 | " |
| " | 25 " | " | 287.00 | " |
| " | 30 " | " | 344.40 | " |
| " | 35 " | " | 401.80 | " |

Culvert capacity table for corrugated iron pipe, assuming a maximum daily rainfall of 2½ inches and a slope of one in one hundred:—

| Area of Land to be drained | | Size of Culvert required. | | |
|---|---|---|---|---|
| Square miles | Acres | Diameter (inches) | Cross sectional area (in square feet) | Capacity (cubic feet per second) |
| .02 | 11 | 8 | .349 | .768 |
| .03 | 20 | 10 | .545 | 1.44 |
| .05 | 34 | 12 | .785 | 2.36 |
| .10 | 61 | 15 | 1.227 | 4.35 |
| .16 | 104 | 18 | 1.767 | 7.42 |
| .35 | 226 | 24 | 3.142 | 16.67 |
| .65 | 415 | 30 | 4.909 | 30.43 |
| 1.08 | 691 | 36 | 7.068 | 50.20 |
| 2.34 | 1,494 | 48 | 12.566 | 109.27 |
| 4.14 | 2,649 | 60 | 19.630 | 200.30 |
| 6.85 | 4,386 | 72 | 28.270 | 322.40 |
| 10.80 | 6,914 | 84 | 38.484 | 500.30 |

## ENGINEERING IN WESTERN CANADA AS THE CONGRESS ENGINEER MAY SEE IT.

A GENERAL committee, comprising representative Canadian committees of the British Columbia and Alberta members of the British Institute of Civil Engineers, the Canadian Society of Civil Engineers and the American Society of Civil Engineers, has issued an invitation to members of the national engineering societies of the United States, and others who are arranging to attend the International Engineering Congress at San Francisco, to return through Canada and enjoy the hospitality of resident members in Canada of these various societies.

Arrangements have been made with the Southern Pacific and the Canadian Pacific Railway Companies for special train and steamer facilities over these roads from San Francisco, via Victoria and Vancouver, B.C., and Calgary, Alberta, to Chicago, in order that members of the International Engineering Congress may have an opportunity of a scenic trip through the Canadian Rockies, and of visiting the many interesting engineering works along the route. The committee has issued a circular outlining the extent of these proposed tours of inspection. The following features are noticed, sufficient indeed to warrant at least further inquiry by those of our readers proposing to attend the Congress during the week of September 20th.

It is planned to leave San Francisco on September 25, in time to catch the boat for Victoria, B.C., at Seattle on September 27. Among engineering features in Victoria the Dominion Government breakwater and harbor work will certainly not be overlooked. There is at the most interesting stage of construction here a 2,500 ft. breakwater to shelter a 90-acre water area, and two large docks with berthing spaces 800 and 1,000 ft. long. Some novel methods of construction are being employed on both works, under the direction of J. S. MacLachlan, of the Department of Public Works, Ottawa, engineering staff. The Sooke Lake water supply system, recently completed under the direction of C. H. Rust, city engineer of Victoria, and similar works will make the visit to Victoria a notable one.

A day in Vancouver will be spent in a 16-mile trip up the north arm of Burrard Inlet to the power houses of the British Columbia Electric Railway Company. They are situated on the shores of the inlet at the foot of a mountain 4,000 ft. high, on the other side of which lies the Coquitlam watershed, connected to the forebay above the power houses by a tunnel 2¼ miles long. The design of the new power house has been carefully studied from an architectural standpoint and its massive proportions harmonize with the precipitous mountains which form the background. The trip will be made by water and is very picturesque. The company is generating 84,000 h.p. The generators are driven by Doble-Pelton wheels, operating under a 400-ft. head.

At Ruskin Station a stop of about seven hours will be made to view the development of the Western Canada Power Company, located at Stave Falls on the Stave River, 5 miles from the railway. The works are situated in a valley lying between mountains which rise high above the timber line and are covered with snow and small glaciers. The dam at the foot of the valley forms a lake 18 miles long with a storage capacity of 370,000 acre-feet. The plant operates under a 105-ft. minimum and a 125-ft. maximum head. The installation consists of two 10,000 k.v.a., three-phase, 60-cycle, 4,400-volt generators, driven by two 13,000-h.p. Francis type turbines.

The train, leaving Ruskin, passes through the most interesting portions of the Canadian Rockies in daylight; and arriving at Glacier, the party will remain for a day viewing the magnificent mountain and glacial scenery and the work that the Canadian Pacific Railway is carrying on in driving a five-mile tunnel through the Selkirks to reduce the grade over this divide.

A daylight run will be made from Glacier over Roger's Pass, down the valley of the Columbia River and over the Kicking Horse Divide to Lake Louise, giving an opportunity of viewing the great peaks and glaciers close to Field, as well as the famous spiral tunnel which carries the railroad over the divide between the Atlantic and Pacific Oceans.

Another daylight run through the mountains and down the valley of the Bow River brings the party to Seebe to view the water power development works of the Calgary Power Company, situated at the junction of the Kananaskis River with the Bow. From here to Calgary the train follows closely the Bow River, affording a view of several sites for future developments of a similar type to those at Kananaskis and Horseshoe Falls.

The Bow River is particularly interesting to an engineer on account of the way it is being conserved and used for the generation of electrical energy, and for the irrigation of immense tracts of prairie land further east. Its head waters have been investigated with a view to summer storage and already a regulation and storage dam has been built at the outlet of Lake Minnewanka, near Banff.

The party will leave Calgary for Bassano, 80 miles east. This district has been put under irrigation by the Canadian Pacific Railway and is the largest irrigation scheme in the world. With the two blocks they have available in irrigable land over a million acres. At Bassano the Bow River is dammed and here is situated the head works of the western block. The dam is the Ambursen type, raising the water 40 ft. The C.P.R. officials have extended an invitation to the party to view this work and a stop of sufficient duration will be made to do so. At Brooks, a little further east, the main irrigation canal crosses the railroad on a reinforced concrete aqueduct 1¼ miles long. A short stop will be made here to view this. From Bassano the route lies through the great grain-growing districts of Southern Alberta and Saskatchewan.

From the above it is evident that the committee has arranged an unprecedented opportunity to visit, without undue waste of time, some of the most noted engineering works in Canada, works the widely varying nature of which typifies in a remarkable degree the present stage of Canadian practice.

At the request of the Canadian committees, Mr. C. W. Allen, engineer of the Dominion Water Power Branch, in charge of the water power exhibit in the Canadian Pavilion at the Panama Pacific International Exposition has arranged to make the final preparations for the trip.

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## UNIQUE BRIDGE ACROSS PANAMA CANAL.

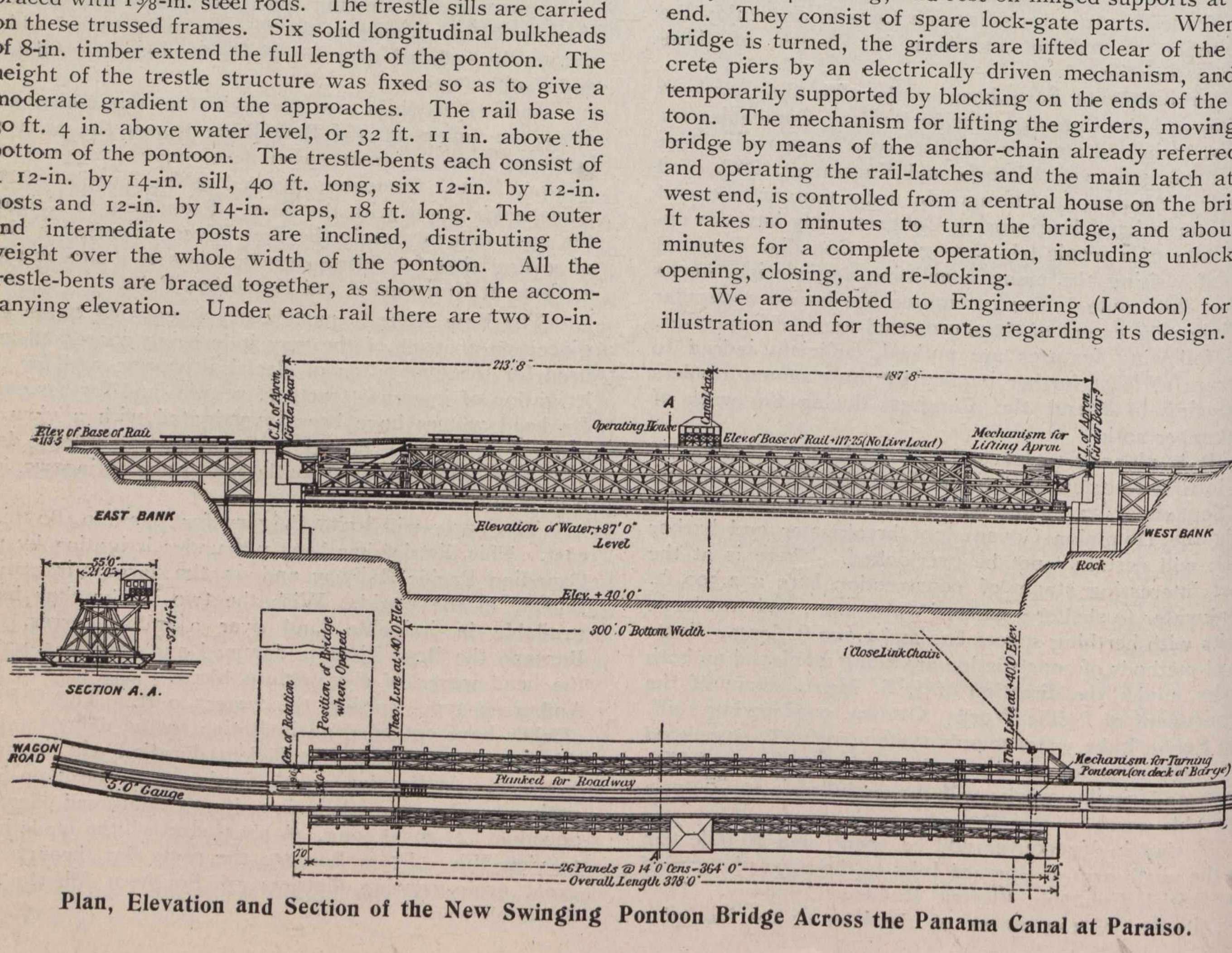
There is at Paraiso, on the Panama Canal, a swinging pontoon bridge of very interesting construction. It is used both as a railway and highway bridge, and consists of a timber barge, or pontoon, supporting a continuous framed trestle carrying the roadway. The pontoon is arranged to swing about one end, so that it may either bridge the canal or lie alongside the east bank, leaving an open waterway. Concrete piers are built at each bank of the canal, and the pontoon is pivoted about a heavy steel tube fastened to the east pier. Steel apron-girders are provided, connecting the piers with the bridge when it is closed, and the piers are connected to the banks by pile-trestle approaches. The bridge is operated by means of a 1-in. anchor-chain fastened at each bank; this passes round an electrically driven winch on the deck of the pontoon near the west end.

The pontoon is 378 ft. long over all, 55 ft. wide, and 6 ft. 3 in. deep at the centre line, and when it is open there is a clear 300-ft. channel in the canal. The frames of the pontoon are spaced 24 in. apart, the floor and rake timbers are 4 in. by 12 in., and the deck beams are 4 in. by 10 in. At intervals of 14 ft. there are trussed frames consisting of three ordinary frames bolted together, and braced with 1⅜-in. steel rods. The trestle sills are carried on these trussed frames. Six solid longitudinal bulkheads of 8-in. timber extend the full length of the pontoon. The height of the trestle structure was fixed so as to give a moderate gradient on the approaches. The rail base is 30 ft. 4 in. above water level, or 32 ft. 11 in. above the bottom of the pontoon. The trestle-bents each consist of a 12-in. by 14-in. sill, 40 ft. long, six 12-in. by 12-in. posts and 12-in. by 14-in. caps, 18 ft. long. The outer and intermediate posts are inclined, distributing the weight over the whole width of the pontoon. All the trestle-bents are braced together, as shown on the accompanying elevation. Under each rail there are two 10-in. by 16-in. and one 8-in. by 16-in. stringers, while there are additional 8-in. by 16-in. stringers on each side for carrying the roadway floor.

As the pontoon has but little longitudinal stiffness, the trestle structure was designed to act as a stiffening truss to take the bending moments and shear which come into play with a moving train on the bridge. The track stringers are fitted with plate-splices so as to form a continuous chord, and a similar chord is provided by heavy timbers at the bottom of the pontoon. The trestle bents act as verticals for the truss, while the diagonals are 2-in. rods with upset ends and turnbuckles. There are two diagonals per panel in each direction in each truss. The trestle is further stiffened by horizontal members, and a double bracing of 3-in. by 10-in. timbers on the outer posts on each side. It was found necessary to add braces and hog-bars to stiffen the framing and prevent distortion of the ends of the pontoon below the approach-aprons. The timber is Douglas fir and long-leaf yellow pine treated with carbolineum.

The apron-girders at each end provide automatically for a variation of 6 ft. in the water-level of the canal. They are 64 ft. long, and rest on hinged supports at each end. They consist of spare lock-gate parts. When the bridge is turned, the girders are lifted clear of the concrete piers by an electrically driven mechanism, and are temporarily supported by blocking on the ends of the pontoon. The mechanism for lifting the girders, moving the bridge by means of the anchor-chain already referred to, and operating the rail-latches and the main latch at the west end, is controlled from a central house on the bridge. It takes 10 minutes to turn the bridge, and about 45 minutes for a complete operation, including unlocking, opening, closing, and re-locking.

We are indebted to Engineering (London) for the illustration and for these notes regarding its design.



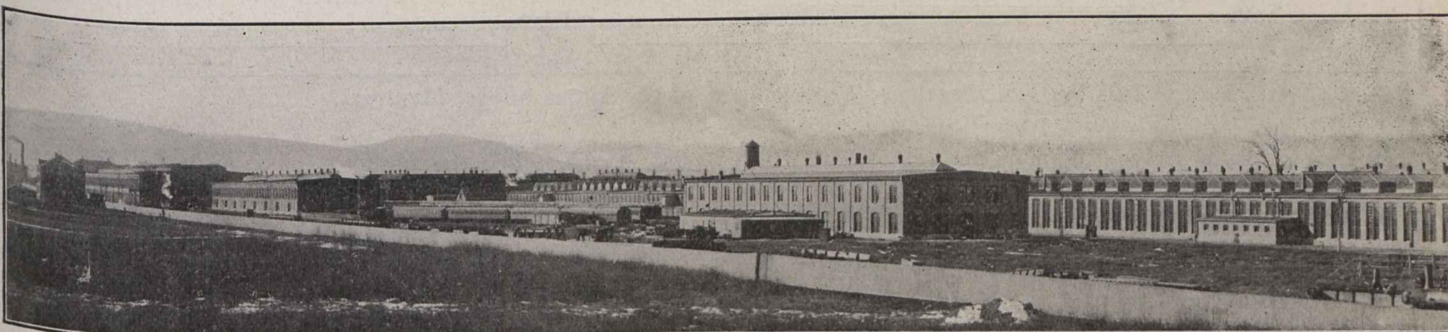

**Plan, Elevation and Section of the New Swinging Pontoon Bridge Across the Panama Canal at Paraiso.**

# LOCOMOTIVE AND CAR SHOPS OF THE CANADIAN PACIFIC RAILWAY

DESCRIPTIONS OF THE ANGUS SHOPS, MONTREAL, AND THE OGDEN SHOPS, NEAR CALGARY, FOR THE UPKEEP OF ROLLING STOCK ON THE EASTERN AND WESTERN LINES RESPECTIVELY.

In a railway system of nearly 15,000 miles, earning annually over $10,000 per mile, the upkeep of rolling stock is an item upon which much depends. Safety, despatch and reliability of service figure largely in the eye of the travelling public, and, while many are apt to stop after a question of roadbed or upholstering, the more experienced traveller fully understands the vital importance of the many mechanical details surrounding the question, not only of construction, but of proper maintenance and repair, is a very important one for the C.P.R.

These requirements are looked after for the most part in two large shops, *viz.*, the Angus shops, near Montreal, for the rolling stock on the eastern lines, and the Ogden shops, near Calgary, Alberta, for similar service on western lines. The former shops have been in use for ten years, but were enlarged in 1913 to include the con-



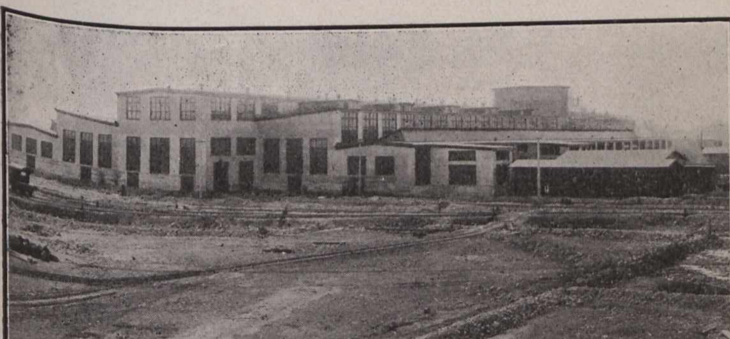
**The C.P.R. Shops at Angus, Quebec.**

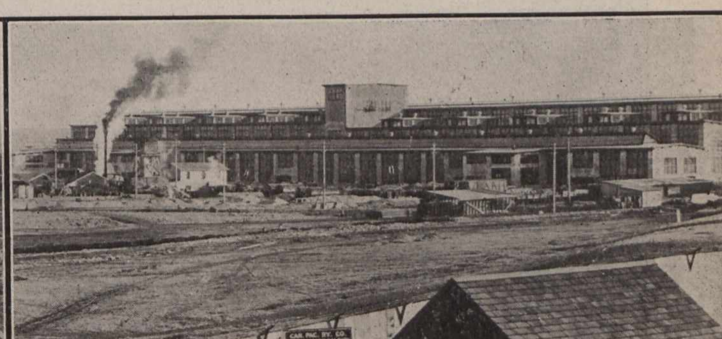
locomotives and cars and their efficient operation. During the recent tremendous strides in track laying throughout Canada—strides that have set the world wondering as to her knowledge of the obligations they entail, strides, in fact, that have forced many a prominent railway authority to believe that track laying in Canada has been immensely over-done of late—one has lost sight of the item of wear and tear to rolling stock on old established lines, particularly under the heavy traffic that the road under consideration has met, and met with a preparedness that warrants some brief explanation.

struction of steel passenger and freight cars. The Ogden shops were put into operation in the spring of 1913.

### The Angus Shops.

The city of Montreal has grown to now practically include within its boundaries the Angus shops in its eastern section. These are on a plateau 175 ft. above the St. Lawrence River, and cover an area of about 200 acres. It is impossible to find on any line of railway a more desirable site, and the same is practically true in the matter of building and plant arrangement. For the pur-

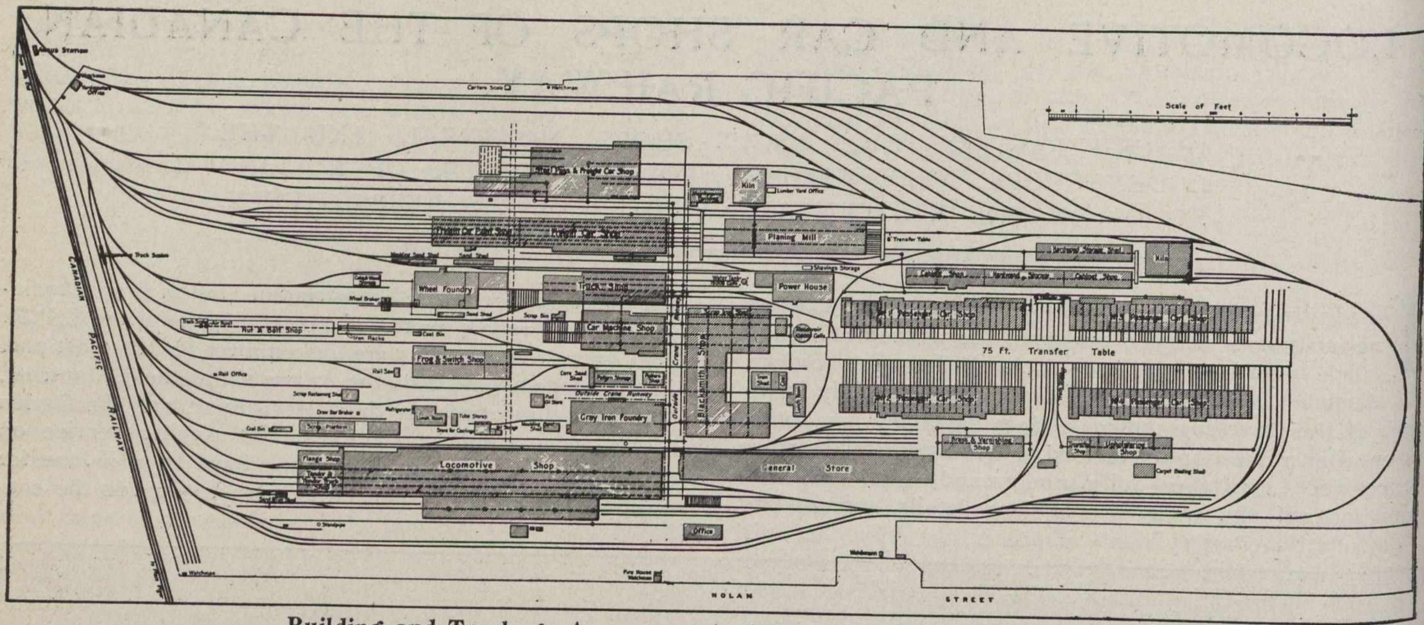




**Locomotive, Erecting and Machine Shop Section of the C.P.R. Shops at Ogden, Alberta.**

It is interesting to know that this term "rolling stock" includes in the case of the C.P.R. some 2,255 locomotives ranging up to the Mallet Compound type, over 2,700 passenger cars and upwards of 87,500 freight cars. The orders of the company in 1912 amounted to 493 locomotives of the superheater type alone, nearly 500 passenger cars and 28,400 freight cars. It is evident that

poses of brief description, the shops may be dealt with in three divisions: shops devoted exclusively to car works, shops for locomotive construction and repairs, and shops common to both of these departments. It is to be borne in mind, as is evident from an inspection of the arrangement, that a primary bearing on the original design was the question of economical and direct handling of ma-



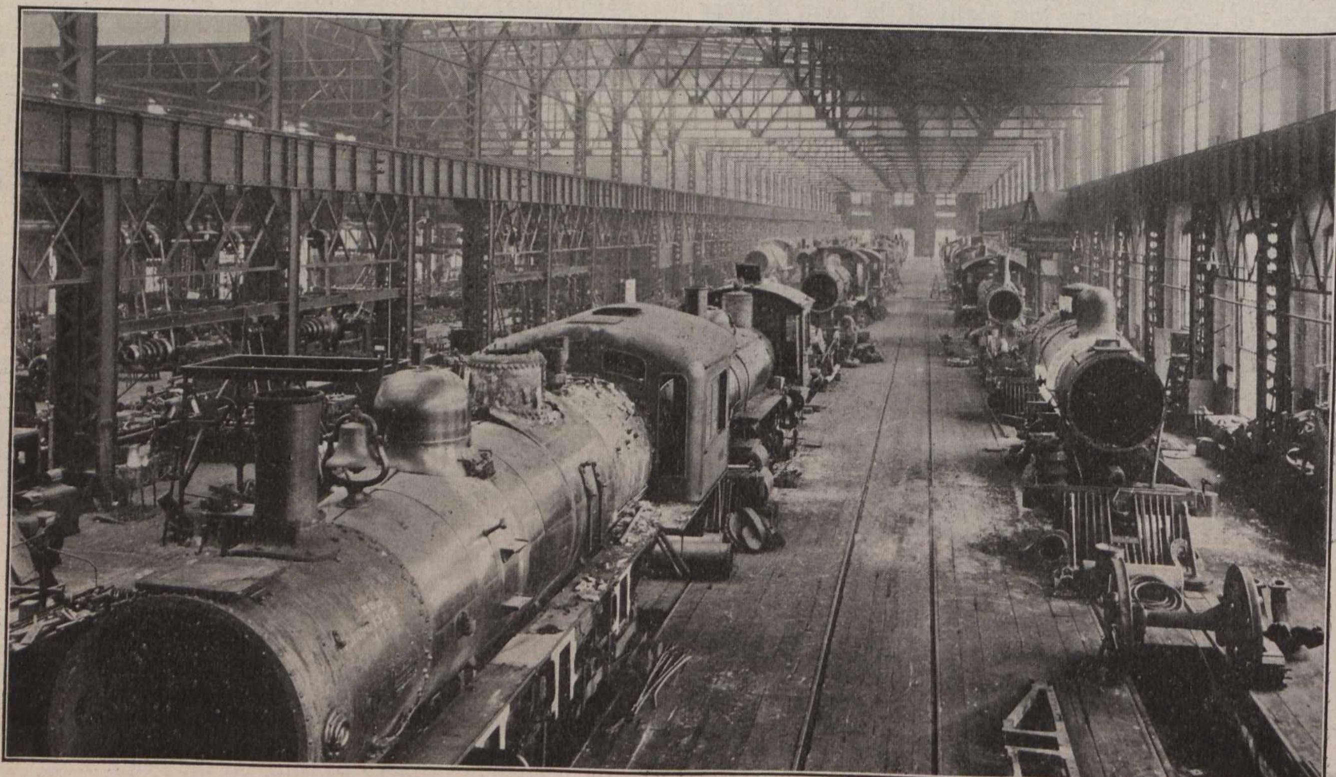

**Building and Trackage Arrangement of the Angus Shops, Montreal.**

terial during the processes of manufacture. The layout is virtually a combination of transverse systems, as indicated in the accompanying plan. When first constructed, each building was arranged to provide for future enlargement and for the incorporation of additional buildings when required. The judgment of various extensive preliminary investigations into details of arrangement have been severely tested and vindicated during the past few years, particularly upon the subsequent erection of the steel-car shops.

The department devoted to car work comprises separate shops for passenger cars, freight cars, and trucks, in addition to planing mill, cabinet shop, machine shop, wheel foundry and dry kilns. The locomotive work is mainly concentrated in the large locomotive and erecting shops, while the foundry, pattern shop, and blacksmith shop serve both these departments.

The buildings are arranged along a transverse avenue 80 ft. wide, over which a 10-ton overhead travelling electric crane operates through a distance of about 1,000 ft.

The locomotive shop is of the longitudinal type, with three bays each 1,165 ft. long, of which 300 ft. is devoted to tank work. The erecting bay is 80 ft. wide, the machine shop bay 50 ft. wide, and the third bay 25 ft. wide. In the erecting bay the locomotives are handled by two 60-ton electric travelling cranes, each with a 10-ton auxiliary. There is a 20-ton crane in the boiler shop, while the machine shop is equipped with one 15-ton and one 10-ton crane over its 50-ft. span.



**A Section of the Locomotive Erecting Shop at Angus, Quebec.**

The old freight-car shop has a capacity of 25 to 30 cars per day. It has four tracks for erection purposes, each 540 ft. long, besides intermediate supply tracks. Six travelling cranes fitted with air hoists are in operation over its width of 107 ft.

The old passenger-car shops are 100 ft. wide and 672 ft. long. There are four of them, each having 28 tracks spaced at 24-ft. centres. They are served by a transfer table over which operates an electric crane with 75-ft. span.

Power for mechanical and lighting purposes is generated in a central plant, equipped with seven 415-h.p. boilers, working under 150 lb. pressure, one 150° super-heat boiler, and one boiler for testing up to 300 lbs. The plant includes three 750-h.p., cross compound, non-condensing engines, connected to 500-k.w. a.c. generators, at 150 r.p.m. These units provide all light and power excepting that necessary for variable speed tools and for cranes. A special d.c. generator, driven by a 300-h.p. simple engine at 180 r.p.m., supplies this. The plant is fully equipped with motors of varying capacities and speeds.

The new shops, added in 1913, and used exclusively for the construction of steel passenger and freight cars, have a capacity for 10 of the former per month and 8 of the latter per day. The freight-car section added over 41,500 sq. ft. and the passenger-car section over 47,000 sq. ft. to the total floor area of the plant. The truck department of the old shop supplies the trucks for both the new additions, apart from which the latter are practically complete in themselves.

The steel shop proper consists of two 100-ft. bays running parallel and one 72-ft. bay, 405 ft. long, at right angles to them. The passenger shop erecting section is composed of four 27½-ft. bays, 202½ ft. long, at right angles to the 100-ft. bays and parallel to the freight section. The crane service includes a 10-ton travelling crane of 96 ft. 3 in. span, on a 309-ft. runway covering the material section of the shop. There is a 10-ton crane of like span in each of the bays. All these cranes provide a headroom of 27 ft.

In the erecting section of the freight shop there is a 10-ton crane of 67½ ft. span and 35½ ft. headroom. In the passenger shops 4 cranes, each of 2-ton capacity, 24 ft. 10 in. span, and 20 ft. headroom are used for handling light material.

The new building is of steel with brick walls, the design specially providing for a large area of light, the window space occupying about 30 per cent. of the total wall space.

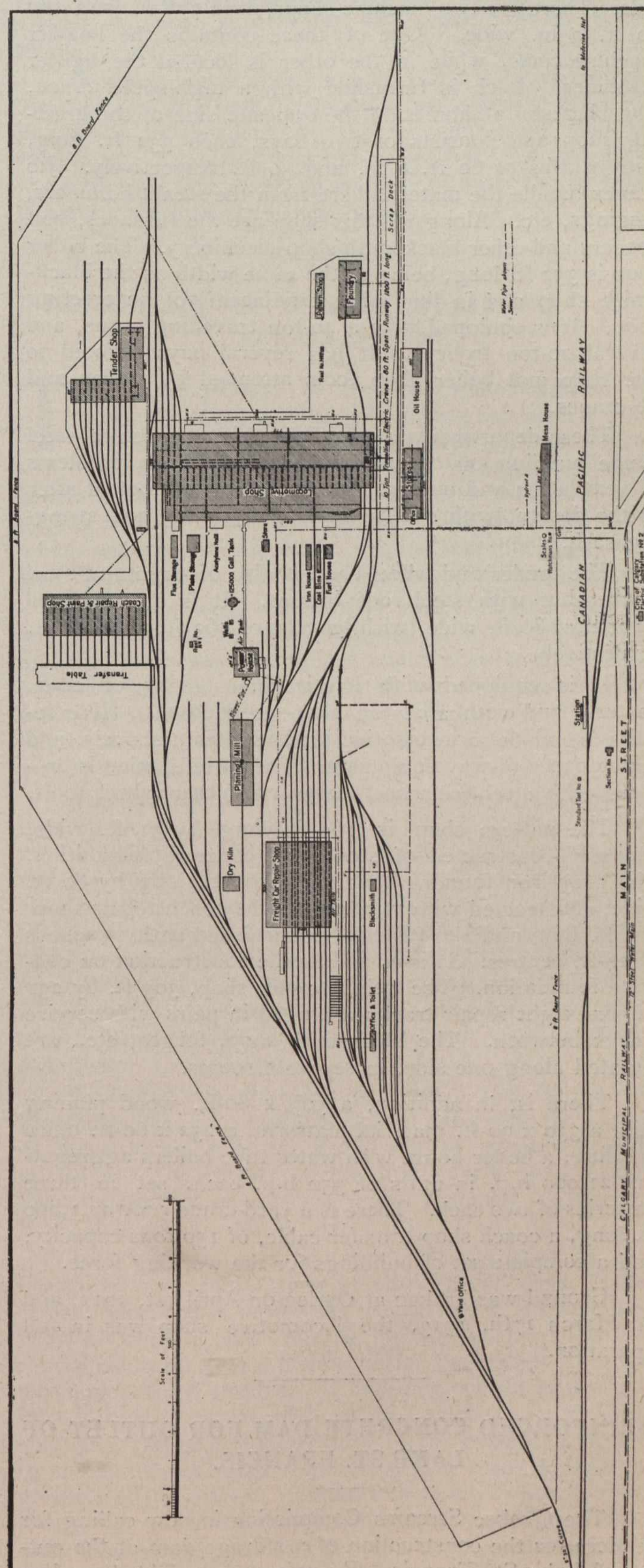
In each shop there is a very systematic routing of material and of operations, from the point where the trucks are brought in until the finished cars are reported for service. There is a decided uniformity in both shops in the arrangement of machinery, and in the method of handling supplies.

There are many items of note to engineers regarding structural features, water supply, sewerage system, fire protection, etc., as well as engine machinery and equipment.

### The Ogden Shops.

This system of shops is situated on a stretch of open prairie about 4½ miles from Calgary, being distant from its eastern complement by some 2,250 miles. The Ogden shops consist of a main locomotive shop, including boiler, machine, blacksmith and erecting shops, repair shops for both passenger and freight cars, and the necessary pattern shops, planing mill, foundry, tender and wheel shops.

The locomotive erecting shop is of the transverse lift-over type, 778 ft. long and 75 ft. wide. It contains 35




**The C.P.R. Shops at Ogden, Alberta.**

bays at 25-ft. centres. Two electric cranes, one of them of 120 tons capacity, and equipped with 50-ton trolleys, operate over the entire shop. Another electric crane operates to and fro between the erecting shop and the blacksmith and machine shops which parallel it on either side. There are two machine shops, each 778 ft. long and 60 ft. 9 in. wide. One of these contains the heavier machine tools, while in the other is located the lighter machines. Each is furnished with a high-speed crane. The blacksmith shop is on the opposite side of the erecting shop and consists of two bays, each 332 ft. long, with widths of 60 ft. 9 in. and 50 ft. respectively. Jib cranes handle the material here from the steam hammers, forgings, etc. Alongside this shop are the furnaces, bolt headers and other blacksmith shop machinery. The boiler shop is 352 ft. long, being of the same width as the blacksmith shop and in line with it adjacent to the erecting shop. It is equipped with a 40-ton travelling crane, and several 20-ton trolleys. It has several bays devoted to flue shop and boiler shop tools attended by trolley and jib cranes.

These departments are all housed in a structural steel frame building on concrete foundations. The problems of ventilation and natural lighting were well looked after in the design, with roof monitors, skylights, and swinging sash.

The tender and wheel shop is also of structural steel frame, but with steel roof trusses. It is an L-shaped structure, 80 ft. wide, with lengths of 263 ft. and 180 ft. respectively.

It is equipped with longitudinal tracks of 20-ft. centres, and with a 20-ton high-speed crane. Here repairs are made to locomotive tenders, steam shovels, and maintenance-of-way equipment. The wheel section is provided with steel-tire wheel lathes and other wheel tools.

The pattern shop is 162 ft. long by 31 ft. wide, similarly constructed of steel with concrete foundation. The grey iron foundry building is 203 ft. long by 80 ft. wide, constructed with two bays. The coach repair shop, 362 ft. long and 146 ft. wide, is furnished with 15 tracks at 24-ft. centres. It is of hollow tile construction on concrete foundation. The freight repair shop, 303 ft. by 231 ft., has eight repair tracks arranged in pairs with service tracks between. The blacksmith shop, forges, etc., are situated along one side, in separate rooms.

There is, in addition, a 303 x 80-ft. wood planing mill, a 350 x 90-ft. material platform, a 252 x 60-ft. office building, a boiler house with water tube boilers aggregating 21,000 h.p. in units of 350 h.p. each, set in three batteries of two each. There is a yard crane runway 1,260 ft. long, a coach shop transfer cable, of 150 tons capacity, and a complete set of buildings for the working force.

Ground was broken at Ogden on April 1st, 1912, and on March 17th, 1913, the locomotive shop was in full operation.

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## REINFORCED CONCRETE DAM FOR OUTLET OF LAKE ST. FRANCIS.

The Quebec Streams Commission is now calling for tenders for the construction of a storage dam at the outlet of Lake St. Francis. By reference to *The Canadian Engineer* for July 8th the reader will note the importance of the proposed St. Francis River regulation in the interest of both water powers and lumber industries along it and its tributaries.

## DIESEL ENGINES FOR PRODUCTION OF ELECTRICAL POWER.

ONE of the papers to be read at the Panama-Pacific Convention of the American Institute of Electrical Engineers, San Francisco, Cal., describes the adoption in Europe of Diesel engines of large capacity. The author, Mr. Chas. Legrand, had, in 1912, investigated the suitability of Diesel engines for driving generators of 500 kw. to 1,000 kw. capacity under conditions generally prevailing in mining camps in the southwest. At that time, no American-made engines of sufficient size were available and the investigation was carried on in Europe, mostly in Belgium.

Four-cycle engines of 175 effective b.h.p. per cylinder had been in use for several years and the results of their operation known. Cylinders of 250 effective b.h.p. were made, but Mr. Legrand states he did not see any.

Two-cycle engines of 250 effective b.h.p per cylinder had been in operation for a short time, but no data as to maintenance or repairs was available. Engines with cylinders of 600 effective b.h.p. were under construction after shop experiments had been carried on with one single cylinder of that size. One cylinder of 1,000 effective b.h.p. was being experimented upon, and builders were ready to take orders for engines using this size cylinder. All of the above cylinder ratings were for sea level conditions. The four-cycle engines inspected had trunk pistons air-cooled. The two-cycle engines had water-cooled pistons with cross-head and slides.

All engines used forced lubrication for cylinders. Both types were used successfully to drive alternators in parallel, the generators being equipped with damping windings. For a given number of cylinders, the four-cycle engine required a heavier flywheel. Heavy oils could be used in both types with proper arrangement for heating the oil and using a light oil at start and finish of a run.

The fuel consumption per b.h.p. of a four-cycle engine is from 7 per cent. to 10 per cent. less than that of the two-cycle engine, depending on the load and, for both types, is practically independent of the size of the engine.

The four-cycle engine is simpler, having no scavenging pump or moving water connections to the piston.

The two-cycle engine has no exhaust valve, the exhaust taking place through ports in the cylinder wall; this is an advantage when using oil containing sulphur, as the exhaust valve is principally affected when sulphuric acid is formed in the cylinder and condenses on the seat of the exhaust valve, requiring frequent grinding of this valve.

The scavenging pump is an advantage on engines to be used at high elevations, as by increasing the size of this pump, the pressure in the cylinders at the beginning of the stroke can be increased above atmospheric pressure and restore sea level conditions, if found advisable, at a comparatively small increase of fuel consumption. This could be done on four-cycle engines by the addition of an air pump, but would complicate this type of engine.

The lubricating oil consumption of four-cycle engines is higher per horse-power than that of the two-cycle engine. The total consumption of lubricating oil of a 525-h.p., three-cylinder, four-cycle engine in actual practise being approximately five gallons per b.h.p.-year of engine rating, while that of a five-cylinder, two-cycle engine of 1,250 b.h.p. is 2.5 gallons per b.h.p.-year, both being on sea level rating of engines and for continuous service.

The proportion of cylinder oil to engine oil used in the two-cycle type seems to be greater than in the four-cycle. In the four-cycle, the cylinder and engine oils used are about the same, according to builders' statements, while in the two-cycle, the cylinder oil is approximately twice the engine oil from actual practise during three months.

The four-cycle engine takes a little more room and is heavier than the two-cycle engine of the same power.

Briefly stated, the advantages of the four-cycle engine were: Well-established type with known maintenance and repair costs, smaller fuel consumption, greater simplicity; those of the two-cycle engine were: Less lubricating cost, steadier running, less liability of trouble from sulphur in fuel oil, greater output per cylinder, less cost per horse-power especially at high altitudes.

After due consideration, the company with which the writer was connected decided to try the two-cycle engine in actual practise, and two five-cylinder engines rated at 1,250 b.h.p. at sea level, direct connected to 815-kv.a., 6,600-volt, three-phase, 180-revolution generators, were installed. One of them has been in operation since December, 1914, and the other since March, 1915. The load at present is so small that only one engine is operated at less than 25 per cent. capacity, and it is too early to give any results of operation; however, from the numerous tests which we have made, parallel operation is quite easy.

The exciters are direct connected to engines and run in parallel on the regulator.

Before paralleling the generators, the exciters were run in parallel for half an hour, one engine having a slightly variable load of 90 kw. and the other no load. The variation of load on the two exciters did not exceed 10 amperes from the average of 90 amperes.

The two generators were then paralleled on a total load of 90 kw. and the variation of load between engines could hardly be seen on indicating wattmeters. After a sufficient length of time to satisfy ourselves that there was no difficulty in parallel running, we cut off the fuel supply on one cylinder of one engine, then on two cylinders. With one engine running on three cylinders and the other on five cylinders the load varied approximately 30 kw. between the two engines, after the governor had been adjusted to divide the load about equally. This test was then repeated after increasing the total load to 200 kw., with the same results. Later on, the two engines were connected in parallel, then the fuel supply was cut off altogether on one engine, running its generator as a motor; the fuel supply was then put on again, but we have been unable to make the generators fall out of step and they behave much better than any compound steam engines with which the writer has had experience. The current readings were too small to get reliable data on interchange of current between generators.

The engines use California crude oil of about 16 deg. B. gravity, heated to 120 deg. F. by means of the circulating water of the engines, except at start and finish of a run, when a lighter oil is used so that it will flow when cold.

Regarding cost of installation as compared to a steam plant, this has to be figured for each particular case. The character of the load has an important bearing on the total capacity of generating machinery to be installed.

With a steady load the total capacity of units is practically the same, as both have the maximum efficiency at rated load.

With a variable load, subject to high peaks, the Diesel engine plant would require a greater capacity than the steam plant, as, like all internal combustion engines, the Diesel engine has little overload capacity.

With conditions prevailing generally, on rated capacity of plant installed for total power between 1,000 and 2,500 kw., the cost of a Diesel engine plant compares favorably with a high-grade steam plant using condensing Corliss engines, superheater and economizer in boiler plant.

In designing a Diesel engine plant it is well to remember that the fuel consumption per effective b.h.p. is practically independent of the size unit used, that an engine can be started and put under full load in a very short time so that a greater number of units can be used if it suits the load conditions better.

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## DURABILITY OF CEMENT DRAIN TILE IN ALKALI SOILS.

THE disintegration of concrete when exposed to strongly alkaline soils and waters has been a subject of discussion by engineers and users of cement for the past 10 or 15 years. There are many concrete structures in certain districts which do not appear to be affected by the salts, but there are some which were apparently made of good materials and were well fabricated which show indications of being attacked.

Many engineers believe that well-fabricated concrete will not disintegrate when exposed to these alkali salts and that many cases of failure which have been reported have not been caused primarily by the alkali but resulted from the use of poor aggregate, improper methods of fabrication, or other causes which resulted in a poor quality of concrete.

A laboratory investigation was started in 1908 by the technologic branch of the United States Geological Survey to determine the effect of alkali waters on cements and concretes. In 1910 this work was transferred, with all structural materials investigations, to the Bureau of Standards. The investigations were continued and the results were published in 1912. Briefly, these investigations showed that practically all cements are attacked by alkali waters upon exposure in the laboratory, and complete disintegration can be obtained under certain conditions.

Following up the line of study, the Bureau of Standards began an investigation to determine the effects of these alkali soils on drain tile of various cement mixtures. The results of the first year's observations form the subject of a recent report prepared by Messrs. R. J. Wig and G. M. Williams.

The report points out that disintegration in the laboratory can apparently be obtained in two ways. If the cement specimen is somewhat porous and it is constantly supplied with a salt solution which is permitted to crystallize in the pores, disintegration may result from the mechanical force exerted. If hydrated cement is brought into intimate contact with certain sulphate or chloride solutions, the uncarbonated lime of the cement is subject to comparatively rapid solution, with a resulting decomposition of the cement. Laboratory tests, however, must always be interpreted with caution, as conditions often differ somewhat from service, and it is on this account that a field investigation was undertaken in which cement mortar and concrete mixtures of various qualities could be brought into intimate contact with alkali salts under natural conditions.

The survey made by the Bureau of Standards relates to concrete structures exposed to alkali waters in several of the Western States. A description of five of the structures which were examined will serve to illustrate the conditions found: 1. A small concrete "turn-out" for irrigation water, built about 1907, showed one portion completely disintegrated, while another portion is sound, the sound portion being a beam on the lower side extending into wing-walls exposed to the earth at each end, and located half above and half below the concentrated alkali waters. 2. The lower end of a small concrete gate culvert was found badly disintegrated, alkali salt being visible on the surface of the soil surrounding the lower end. 3. The concrete wing-wall of a large culvert was cited as a case of disintegration due to alkali salts, but upon investigation it was found that during flood the creek carried heavy boulders against the wall. Alkali salts visible in the pores of the eroded surface indicate that the alkali is present, but probably incidental and contributory rather than the initial cause of disintegration. 4. A large railroad culvert with a portion of an old concrete structure was examined. The latter was completely disintegrated, so that it could be torn apart with the fingers, and alkali salt was found in the pores. The newer culvert, about eight years old, appeared sound and normal with the exception of a few spots near the ground line. 5. A small concrete retaining wall coping was found disintegrated, the surface of the surrounding soil showing the presence of alkali salts.

It is practically impossible, according to the authors, to analyze some of the failures which have occurred and state definitely the part played by the alkali salts. It was therefore deemed desirable to make field tests in which concrete of known composition and fabrication would be exposed in some of the worst known alkali districts in the west.

It was decided that this investigation should be started by exposing various cement mixtures in the form of drain tile, because of its economic importance. It will probably become necessary to drain the greater part of all lands under irrigation, and much of this drainage will require the use of tile. The cost of drainage has been estimated as approximately $25 per acre, from which it is seen that many millions of dollars must be spent for this purpose. At the present time there are few known deposits of clay available for the manufacture of satisfactory clay tile in these districts, while materials for the manufacture of cement tile are usually found close at hand, but many engineers are skeptical of the permanency of cement tile, as a number of failures have occurred which have been reported to have been caused by the alkali salts.

A committee was organized and finally developed a programme which required the manufacture of about 8,800 cement drain tile made up of sixteen different varieties. The proportions of cement and sand varied from 1 : 1½ to 1 : 4. The tile were made under contract at a commercial tile plant. Both hand-made and machine-made specimens were used, and the curing was either by sprinkling or by steam. The tile were installed in operating drains on eight projects in the most concentrated alkali soils available in the west, and, for comparison, on projects where there was practically no alkali.

The first physical tests of the tile were made during 1914, about one year after the tile were placed, by a small portable hydraulic testing machine. The results are generally quite uniform and compare favorably with other tests of drain tile. Occasionally results of tests of similar tile differ by 30 or 40 per cent., but usually they agree within a few per cent.

Notes were made on the length and thickness of the tile at each end, and its condition if in any way abnormal. Some of the tile which had a normal or slightly reduced strength showed evidence of alkali action by sharpened edges or cracked surfaces. Where such action has been noted it is possible another year or two of exposure may cause the failure of the tile, although this need not necessarily result.

In its conclusions the report points out that special care should be observed in the use of cement drain tile to employ only the best materials and good workmanship in its fabrication. If these precautions are not observed, failure will result if the drain is located in some of the more concentrated alkali soils.

Drain tile of cement mixtures not leaner than 1 : 3, manufactured as described, are apparently unaffected structurally when exposed for one year in operating drains in very concentrated alkali soils similar to any of those included in this investigation. Cement mixtures leaner than this should not be used for drain tile in localities where the character of the alkali and concentration are similar to that found at the sites of drains used in the investigation, *viz.*, at Grand Junction, Col., and Garland, Wyo. It is possible that subsequent results will show that no leaner mixture should be used in any district where appreciable alkali is found.

Drain tile of 1 : 4 mixture (the leanest used) is apparently unaffected structurally by exposure of one year in an operating drain in localities where the character of the alkali and the concentration are similar to those found at Fort Shaw, Mont.; Sunnyside, Wash.; Yuma, Ariz., and Roswell, N.M.

It is anticipated that this report will be amended from time to time as later results are available.

## THE C.N.R. TRANSCONTINENTAL NEARLY COMPLETED.

The first Canadian Northern Railway train to travel between Toronto and Vancouver entirely over the company's own line left the former city on August 22nd, a number of the chief officials of the company being on board. The 872-mile portion between Toronto and Port Arthur was made at an average speed of 47 miles per hour, not allowing for stops. The train reached Vancouver on Friday, August 27th.

In British Columbia there is considerable ballasting to be done on the last portion of the line to be constructed. The first regular train schedule was recently established between Pacific tidewater at Port Mann, B.C., and Hope, 78 miles east. The ballasting of the line as far east as Kamloops is practically finished and north of Kamloops to Yellowhead Pass the work will be completed by the end of August. The entire line from the Pacific Coast to Quebec should be in operation late this summer.

The British Columbia section of the line has involved very heavy construction and expense has not been spared in the endeavor to secure a line through the mountains on a low grade. The average cost of the 500 miles in British Columbia has been about $70,000 per mile, and in one instance grading for a mile of track, including a 548-ft. tunnel, cost $326,000 and involved the removal of 250,000 cubic yards of material.

# Editorial

## RESEARCH AND INDUSTRIAL PROGRESS.

The nation that is to advance commercially must do so by the aid of scientific knowledge. Search for new knowledge is the insurance for the future of the industries. Many of them will later be manufacturing things not even conceivable to-day. The past has proved it. Most of the present products will, like the ox-yoke and flail of our grandfathers, be replaced in our factories by utilities more fitting to our new needs and less exhaustive of our energies and assets. This change is practically continuous. Technical complacency means a lingering suicide.

The American Academy of Political and Social Science recently published in its annals an address by Dr. W. R. Whitney, pointing out that while utility is the prime factor in modern research work, it is to be remembered that purely academical research has lead to some of our greatest developments. A knowledge of every fact concerning nature is of great value. A few months ago Lord Rayleigh found a slight difference in the density of nitrogen taken from air and nitrogen derived from other sources. He felt obliged to know about this little difference. In co-operation with Sir William Ramsay, he discovered argon. This was present in the atmospheric nitrogen and had always escaped detection. It formed less than one per cent. of the air. It was discovered to be entirely inert and chemically inactive. This was an apparent promise of great chemical uselessness. At that time it was also exceedingly difficult to separate it from the air, and except for its scientific interest, it seemed destined to be left inactive. Newly discovered methods of liquefying air and of combining nitrogen for fertilizer, as in the cyanamid process, have just made the argon available commercially. Other pure scientific research had shown the value of such a gas in incandescent lamps, and it is just at this time being used to produce the most efficient incandescent lamps of our knowledge. It was the recently discovered differences between this gas and other gases which made this lamp possible. When its existence and properties were known, its application was relatively simple and easy.

## FINANCING GOOD ROADS

The building of good roads in Canada, while stopped to some extent by the lack of funds, continues in many sections of the country. During the fiscal year ending 1914, Quebec province expended $3,303,882 on the good roads movement, ample provision being made out of revenue for meeting sufficient annual interest and sinking fund charges to repay in a term of years the whole amount borrowed for this service. A fairly large amount was spent last year also. This betterment of country roads is adding largely to the value of farm lands, and to the comfort, contentment and prosperity of the farmers, and the popularizing of agricultural pursuits.

Saskatchewan is another province making excellent progress with the building of good roads. Ontario for some years has made a policy of better roads of primary consideration. It is building roads to assist settlers in Northern Ontario and also in the more settled communities. Now being constructed is a concrete highway from Toronto to Hamilton, a distance of about 40 miles. These roads are just as necessary as railways and canals. While we have no lack of the former, the lack of good roads is striking.

The financing of this work seems often to have been a drawback to its progress. Cities, counties, towns, villages and townships do not always agree as to their financial share of construction and maintenance. Sir Edmund Walker, who spoke at the recent convention of the Ontario Good Roads Association, said he firmly believed that every city and every town should bear a proportion of the cost of the roads for a certain distance beyond its precincts. The people of Toronto, for example, should pay for the roads beyond this boundary, because it is the people of Toronto who destroy these roads, and not the country people. We speak of the farmer being unwilling to pay his share. He would not be unwilling if we were fair enough to ascertain his share. In New York State their idea is that his share is about 15 per cent. It seems only fair that the provincial and Dominion governments should each pay so much towards trunk roads, and that the abutting farmers should pay so much. If we were to ascertain what was fair in that respect we should obliterate a large part of the difficulty of building good roads; but as long as the people in the cities complain about the farmers not building good roads suitable for motor traffic, so long we shall keep from having good roads. As Sir Edmund said, we must recognize the fact that those who use the roads are really those who should pay for them. It is absurd to say that the man who abuts on the highway is the person who makes the most use of the highway. If we can only make up our minds what to do with the abutting owner and the township, and the county, and the province, and the various cities, and the Dominion government, as to the great and small highways in this country, we would in ten or twenty years accomplish a great deal. If it took us thirty years to build railroads we should not be discouraged. We will begin to accomplish something in the way of good roads when we have made a square deal as to the cost of building roads and as to the cost of their maintenance.

## PROPOSED WATER POWER DEVELOPMENT ON THE ELBOW RIVER, NEAR CALGARY.

As a culmination of several years' thorough investigation by engineers of the Dominion Water Power Branch and private interests desiring the right to develop water power on the Elbow River, near the city of Calgary, in the Province of Alberta, the Dominion Government has recently issued an agreement under the Dominion Water Power Regulations covering a project, the general plans of which have been worked out by Messrs. Ducane, Dutcher & Co., Consulting Engineers, of Vancouver, in consultation with Messrs. C. H. and P. H. Mitchell, of Toronto, Consulting Engineers to the Dominion Water Power Branch. This scheme of development contemplates the utilization of a 475-ft. working head. A dam, 123 feet maximum height, and 565 feet long on the crest, spans the river, forming a storage reservoir of 21,100 acre-feet capacity. From the reservoir a pressure tunnel carries the water direct to the power station and turbine, some 4¼ miles below, driving generators of a maximum capacity of 15,000 horse-power.

An agreement covering this project has been issued in accordance with the strict conditions of the water power regulations, which provide for the immediate commencement of construction operations in accordance with plans which have just been accepted and approved by the Dominion Water Power Branch. The agreement provides that at least 2,000 horse-power must be developed and made available for use by July 15th, 1919; that the continuous beneficial operation of the plant and the carrying on of the whole business arrangement must be acceptable to the Dominion Government; that control of rates to consumers of power and the rental to be charged for the privileges granted shall be under the control of the Government and subject to periodic revision. The taking over of the plant by the Government is also provided for, should the public interest demand such a course in the future.

## EXPERIMENTS ON THE FLOW OF WATER THROUGH SLUICEWAYS.

By J. J. Traill, B.A.Sc.,
Department of Hydraulics, University of Toronto.

THE experiments described in this article were performed in the Hydraulic Laboratory of the University of Toronto by Mr. N. E. D. Sheppard, B.A.Sc., as a thesis investigation of the flow of water through sluiceways formed by piers of different designs.

**Purpose of the Experiments.**—The flood discharge of the Ottawa River is given as 193,000 cu. ft. per second, the mean flow, 46,000 cu. ft. per second, and the minimum flow 11,000 cu. ft. per second at Ottawa. The design of a dam to render available the power of such a river which, at the same time, will not cause excessive flooding of the lands upstream during a period of high discharge and will permit large quantities of ice to pass without causing jams is a problem that merits considerable study.

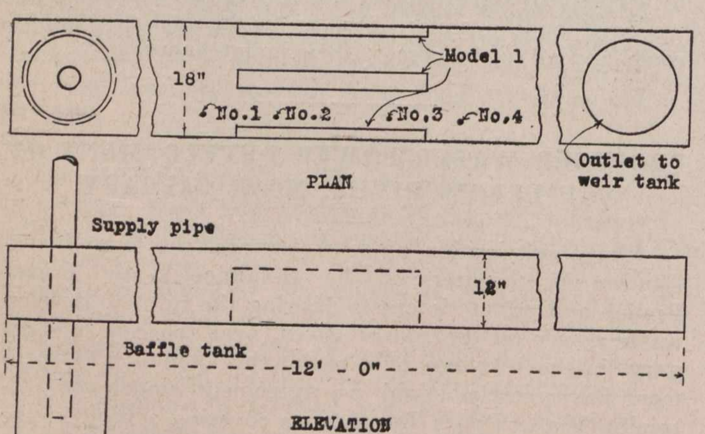


Fig. 1.—Experimental Trough with Model No. 1 in Place.

A dam of the sluice and pier type to suit these conditions might be built with piers of a number of different forms in horizontal cross-section. In the experiments about to be described model piers of three different designs were considered. Model 1 (Fig. 1) was a rectangular pier with side and end faces vertical. Model 2 is shown in Fig. 2. By its form this pier causes a gradual reduction in the clear waterway through the dam and has, therefore, a decided advantage from an hydraulic standpoint over model No. 1. This design was one considered by the Chaudiere Dam Commission and rejected by them on account of certain local conditions. Model No. 3, shown in Fig. 3, is similar in some respects to model No. 2, but has a form that will cause a more sudden change in the velocity of the water as it enters the sluiceway.

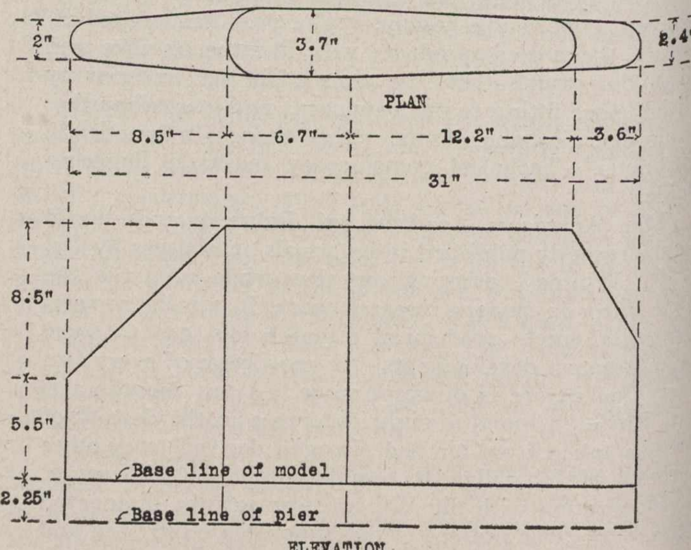


Fig. 2.—Plan and Elevation of Model 2.

The piers of the Chaudiere Dam at Ottawa are similar in design and proportions to this model, all linear dimensions of these piers being fifteen times the same dimensions of the model.

**Equipment for Experiments.**—All the models are of the same thickness and length. Model 1 was of timber, 2 and 3 of plaster of Paris smoothly finished, and all were coated with shellac. For the experiments they were set up in a galvanized iron trough 18 inches wide, 12 inches deep and 12 feet long. Fig. 1 shows the position of model 1 in the trough. It will be noticed that one com-

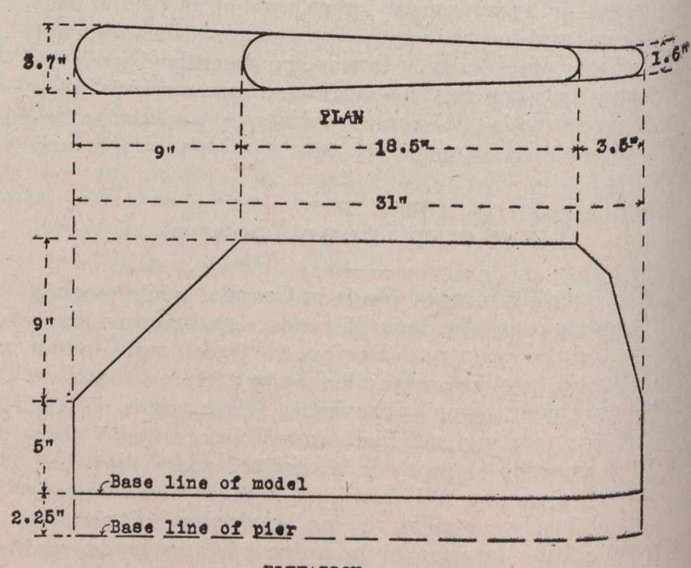


Fig. 3.—Plan and Elevation of Model 3.

plete model and two half models were used, the complete model being in the centre of the trough and the half models against the trough walls so that two complete sluiceways are provided. A 15-inch galvanized iron tank 22 inches deep was soldered to the bottom of the trough and the supply pipe carried into this. This tank acted as a baffle and provided excellent conditions of flow in the trough upstream from the models.

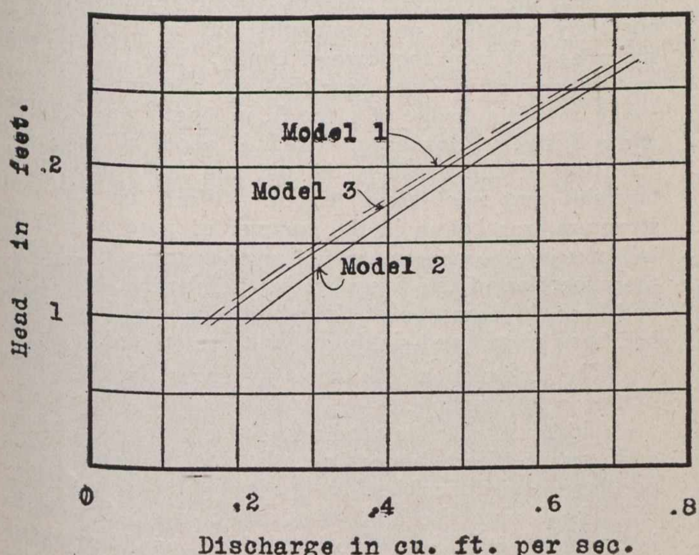


**Fig. 4.—Discharge of Sluiceways Between the Different Models.**

After the experiments on model 1 were completed the model was replaced by 2 and 3 in turn.

The water, after passing the models, was discharged into a large tank provided with a brass weir plate with 12-inch crest. This weir had been carefully calibrated before being used to measure the discharge past the models.

**Experiments.**—Tests were made on the models, first, to determine the comparative discharging capacity of the sluiceways, and second, to examine the profile of the water surface in the sluiceways. A further test was made on model 3 by placing coarse sand in the bottom of the trough. Those portions of the trough from which the sand was scoured would evidently be localities of high velocity.

With a view to obtaining the head at different points in the system and to have a check on the surface curve readings, four holes one-eighth of an inch in diameter, drilled in the bottom of the trough, and from each of these a tube lead to a separate stilling box in which observations of water level were made. The positions of these holes are indicated in Fig. 1 and marked "No. 1," "No. 2," etc. In comparing the discharging capacity of the sluiceways formed by the different models the drop in water surface from "No. 1" to "No. 4" is taken as the head causing flow.

The results of the different experiments follow.

**Discharging Capacity of the Sluiceways Between Models.**—Six experiments were made in which the discharge was measured. Each experiment continued for about fifty minutes so that in so far as the length of the experiment affects the accuracy of the results excellent conditions obtained. The results of these experiments are shown in Table I.

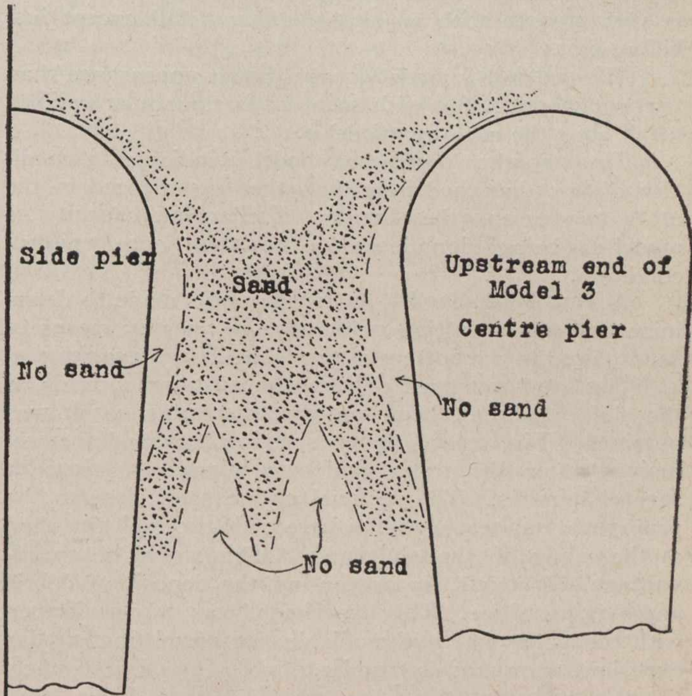


**Fig. 6.—A Test with Sand.**

TABLE I.

| Model No. | Measured heads, in feet. At No. 1. | At No. 4. | Net. | Head on weir, ft. | Discharge, cu. ft. per sec. |
|---|---|---|---|---|---|
| 1 | .333 | .121 | .212 | .291 | .507 |
| 2 | .167 | .058 | .108 | .175 | .241 |
| 2 | .333 | .108 | .225 | .322 | .588 |
| 3 | .166 | .058 | .108 | .153 | .198 |
| 3 | .250 | .088 | .162 | .231 | .362 |
| 3 | .333 | .112 | .221 | .306 | .548 |

Fig. 4 shows these results graphically. Evidently model 2 forms a sluice with considerably greater discharging capacity than model 1 or model 3. For example, the discharge of model 2 is nine per cent. greater than model 1 at a head of two-tenths of a foot. The discharge recorded in the table above is, of course, the total discharge of the two sluiceways formed by the whole model and the two half models.

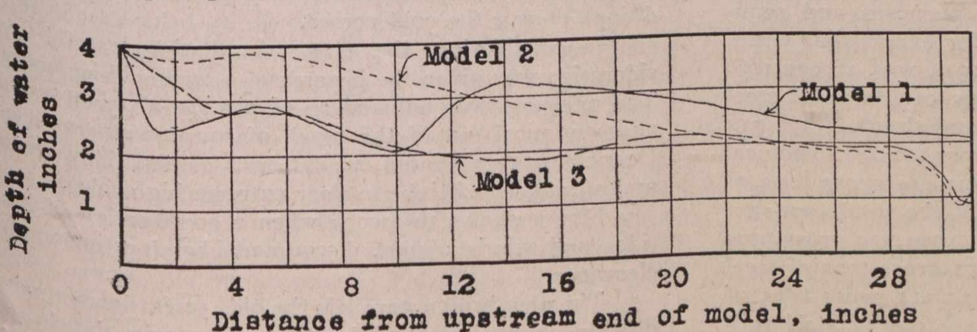


**Fig. 5.—Profile of Water Surface in Sluiceways Between the Models.**

**Profile of the Water Surface in the Sluiceways.**—Nine experiments were made in which the profile of the water surface was measured at intervals of two inches from end to end of the models. The profile for three of these is shown in Fig. 5.

The abrupt fall in the water surface as it enters the sluiceway of model 1 is somewhat striking. Following this profile out a jump will be noticed about twelve inches from the section of entry, beyond which the water surface is quite smooth.

For model 2 only a slight drop in the water surface at entry is noticed, and throughout its length the profile is very smooth with an almost uniform fall except just before exit.

The profile for model 3 has a better appearance than that for model 1, but with scarcely as smooth or uniform a fall as is the case for model 2.

The smoother profile for model 2 indicates a condition of less disturbed flow than that experienced in the other two cases, the greater discharging capacity of model 2 being doubtless due to this more uniform condition.

**A Test With Sand.**—An attempt was made to determine the general action of the stream lines by means of sand placed in the bottom of the trough from gauges 1 to 4. The sand remained only in the upstream portion of the sluiceway, but here a very interesting result was obtained. Fig. 6 is a sketch showing the sand that remained after the water had been allowed to flow for several minutes. The removal of the sand close to the pier would suggest a region here of higher velocity than at the centre of the sluiceway. This would be an advantage, of course, in preventing the deposit of debris and lodging of ice. This experiment was only performed with model 3, the time available not permitting similar experiments on models 1 and 2.

## CANADIAN MUNITION WORKERS IN ENGLAND.

Messrs. William Windham and G. N. Barnes, M.P., who came to Canada last May on behalf of the British Government to secure skilled mechanics for British arsenal and naval works, sailed for England recently, having completed their work. During their stay, 1,710 Canadian skilled iron and steel workers, chiefly riveters and turners, had secured work in England under contract with the War Office.

## UNITED STATES PRODUCTION OF ROLLED IRON AND STEEL IN 1914.

The 1914 figures for finished iron and steel, as published by the American Iron and Steel Institute shows a large decrease when compared with the output of 1913. The total falling off amounts to 6,421,047 tons or 25.9 per cent. of the total production of all kinds of iron and steel rolled into finished form (including blooms, billets and axle blanks rolled for forging purposes and semi-finished products which were rolled for export that year). The total gross tonnage rolled in 1914 was 18,370,196. It consisted of 1,945,095 gross tons of iron and steel rails, 4,757,814 gross tons of plates and sheets, 2,431,714 gross tons of wire rods, 2,031,124 gross tons of structural shapes not including plates and 7,204,444 gross tons of bars, skelp, and all other forms. Of the total tonnage, 1,167,776 gross tons were iron, and 17,202,420 gross tons were steel. The items include 288,471 gross tons of steel bars for reinforced concrete work, 35,314 gross tons of rolled sheet piling and 33,249 gross tons of steel railroad ties.

## THE CONSTRUCTION OF THE FOUNDATIONS OF THE BEAR RIVER BRIDGE, NEAR DIGBY, NOVA SCOTIA.

THE building of the Bear River Bridge channel piers by open dredging caissons involved some construction features which may not be devoid of interest.

The bridge derives its name from Bear River, which rises near the Height of Land of Nova Scotia, and flowing northerly, empties into Annapolis Bay at a point about six miles east from the town of Digby. The D.A.R. Railway crosses Bear River near the bay, and due to a 30-ft. range of tide a bridge of 1,700 ft. in length was required, and a bridge of this length was built about 26 years ago. The new bridge parallels the old and is located on the bay side and is of equal length. Work on the substructure was begun in the summer of 1912 and by the fall of 1913 the abutments and piers were complete, with the exception of the five piers in the channel. No work had been done on two of these and on three the caissons had been placed and sinking operations started.

The completion of these five piers is the subject-matter of this article.

Tidal and climatic conditions were somewhat unusual and severe, and added greatly to the construction problems and difficulties.

The bridge site is at the head of a small wide bay into which Bear River empties. When winds were from a northerly direction they had a sweep of about seven miles across Annapolis Bay, causing rough water at the bridge site. The frequency of high seas, due to these winds, decreased the efficiency of floating equipment. The tide had a range of 30 ft. and the incoming and outgoing current at the bridge site was about four miles an hour. As previously stated, some work had been done on three of the caissons. These had been sunk so that their tops were only a few feet above extreme low tide, and owing to their being considerably out of plumb the straightening of these was necessarily confined to about four hours in the 24, and required a careful arrangement of schedule, covering the various operations, to avoid very considerable loss of time due to moving the forces from one piece of work to another.

From January to April, 1914, weather was recorded that was exceptional in the annals of the weather bureau. Gales were almost of daily occurrence and severe storms frequent. In February, the temperature of minimum 25 degrees F. was reported, making one of the lowest records for 50 years. This extremely low temperature froze ice to a considerable depth on Bear River and in a part of the bay, and the movement of this ice with the tide was a source of some danger to the work and required constant efforts night and day to prevent its jamming and carrying away stages, shoring and other temporary work in the river. Fig. 1 illustrates ice conditions during the cold period.

In considering the plant installation, careful consideration was given the hazards of storms and ice action. The principle was adhered to of placing all plant as far as economical out of the reach of rough water and ice. Derricks were mounted on platforms substantially braced and of sufficient height to clear extreme high tides.

Fig. 1 shows the work when a combination of high tides and winds almost discounted liberal estimates for clearance.

The new bridge parallels the old, 50 ft. down-stream, and the channel piers of the new are opposite the channel piers of the old. The railroad was operated over the old bridge until the new was completed, consequently, it was necessary to take precautions against impairing the strength of the old piers by the operations in connection with building the new. These precautions consisted principally in substantially shoring the old spans with the idea that if the old piers were undermined or damaged the shoring would support the entire load. This shoring was done preliminary to active operations in the new foundations. Each old span was supported by frame bents supported by piles, one bent under each end of the span. Changes in the point of support in the old spans required rebracing of the trusses. Fig. 2 shows one of these bents.

Bear River is navigable, and the old bridge has a swing span which was kept in commission as long as possible and then shored. Navigation was provided for by cutting through one of the old fixed spans—giving a 38-ft. opening. The railway traffic crossed this opening on a temporary lift bridge, hinged at one end and lifted by a derrick at the other end.

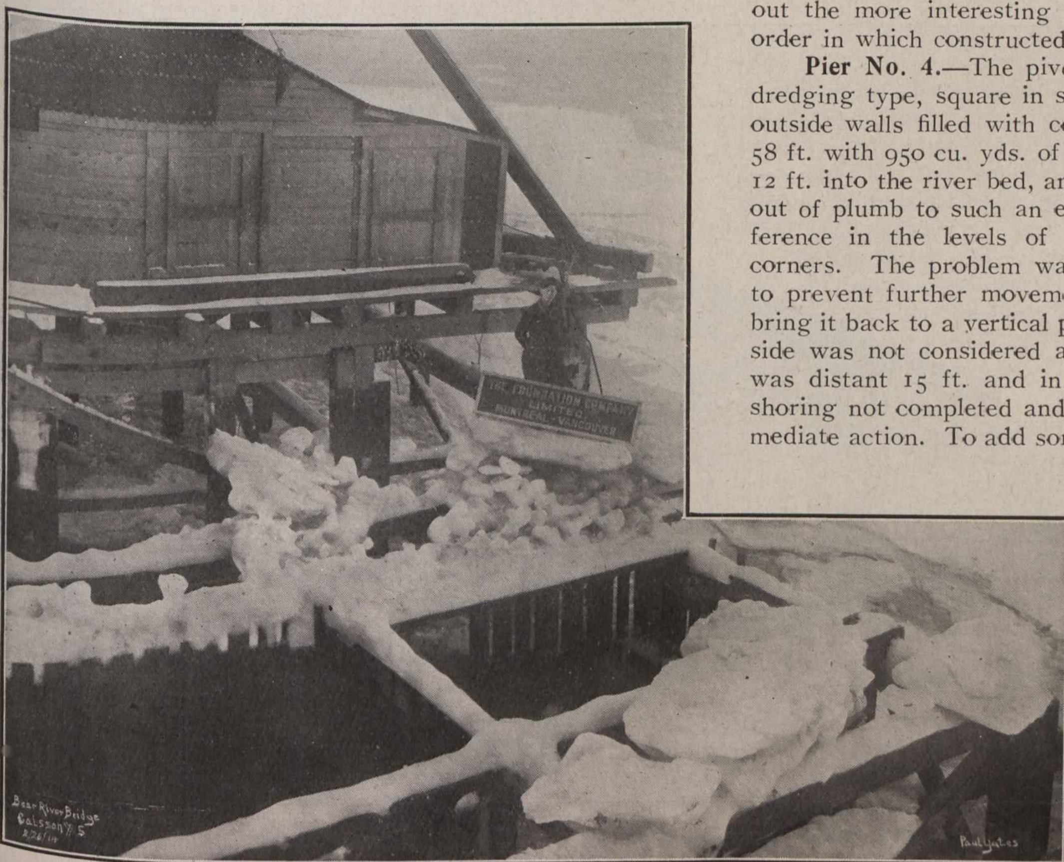

**Fig. 1.—An Illustration of Ice Conditions During the Sinking of Caisson No. 5.**

Shoring consumed 400 65-ft. piles and 200,000 B.M. yellow pine timber. As the shoring was completed the work proceeded on the new piers.

To summarize, in the fall of 1913 the five channel piers were yet to be completed. Pier No. 3 had been built to a height of 63 ft. and sunk until its top was a foot or two above water at extreme low tides. Pier No. 4 had been built up 58 ft. and sunk until its top was 12 ft. out of water at extreme low tide. Pier No. 5 had been built up 62 ft. and sunk until the top was about 8 ft. out of water at extreme low tide. Pier No. 6—the caissons had been started but not launched. Pier No. 7—no work had been done at the site of this pier. The general plan of operation was to first straighten the three caissons already in place, Nos. 3, 4 and 5, and then sink to a suitable bearing. While this work was in progress to build caissons for piers 6 and 7 and so scheduling the various operations as to keep the various gangs efficiently employed.

At piers 3, 4 and 5 depths of water and material to sink through were quite similar. Depth of water at low tide varies from 35 ft. at pier No. 3 to 30 ft. at pier No. 5; the main channel being between these piers. Borings indicated silt from river bottom down 25 ft.; below the silt a compact sand and gravel. It was assumed that if the sand and gravel proved satisfactory the caissons would be founded on it. Borings at piers 6 and 7 indicated mud from river bottom down 50 ft., then sand and gravel. It was decided to sink the caissons 18 to 20 ft. into the stiff mud, then drive piles to a firm bearing.

As the construction problems differ, a brief description of the construction of each pier is necessary to bring out the more interesting features. Piers will take the order in which constructed.

**Pier No. 4.**—The pivot pier caisson was the open dredging type, square in section, 33 ft on a side, double outside walls filled with concrete. It had been built up 58 ft. with 950 cu. yds. of concrete in the walls and sunk 12 ft. into the river bed, and in the sinking process, came out of plumb to such an extent that there was 8 ft. difference in the levels of the southwest and northeast corners. The problem was to at once take precautions to prevent further movement out of plumb and then to bring it back to a vertical position. Dredging on the outside was not considered advisable as the old pivot pier was distant 15 ft. and in none too good condition and shoring not completed and it was imperative to take immediate action. To add some resistance to the settlement, a row of piles were driven 40 ft. from pier No. 4 and a substantial shoring frame built up of 10 x 10 timbers, which, when complete, were floated into position, one end being properly weighted and sunk so as to bear against the row of piles. An even bearing on the piles was made by divers blocking up to the sill of the shoring frame. The unweighted upper end of the bent was placed in position and wedged against the caisson. Provision was made so that jacks could also be placed to assist wedging. A cable sling was placed around the top of pier No. 4 and two 1¼-in. cables run to shore, a distance of 500 ft. These cables were strained by a hoisting engine winding up the cable reeved through a pair of double-sheaved steel shell blocks. Wedges, jacks and the pull on the cable was now tending to hold the caisson from further movement. High-pressure water jets were then operated by divers with the object of removing the material under the high side. This started the caisson, and by carefully conducted dredging operations with a clam-shell bucket, the caisson was gradually brought to a vertical position. All soft ground was removed from the interior of the caisson and concrete deposited through the water by means of a special type of bucket. The concrete was brought up to the elevation of the bottom of the shaft and allowed to set and the shaft form placed in position. This form was built complete, then launched and afterwards placed in position.

A watertight diaphragm was placed near the top of the form, and sides caulked so that it would float in a vertical position after launching and also to facilitate setting. The shaft form was filled with concrete and reinforced coping built above the top of the form. The form was left on as a guard to the concrete.

**Pier No. 5.**—The caisson for this pier was of the open dredging type double walls, with a cutwater at each end, 34 ft. long by 20 ft. wide between cutwaters. It had been built up 62 ft., weighted by 600 cu. yds. of concrete in walls and sunk 25 ft. into the river bed. It was out of plumb with a decided lean towards pier No. 4. The difference in elevation between the high and low sides was 2 to 3 ft. in a distance of 20 ft., throwing the top 6 ft. out of position towards pier No. 4. At low tide the top was 6 ft. out of water. With pier No. 4 firmly founded and piers Nos. 3 and 5 each leaning towards it, a system of struts was erected between piers 4 and 5 and piers 4 and 3. Against 5 and 3 shoring jacks supplemented by wedges 8 ft. long and driven by a hammer operated by a hoisting engine arrested further movement of piers 3 and 5 towards pier No. 4. The jetting so efficient in pier No. 4 was repeated and combined with dredging outside on high side, gradually brought the caisson to within an inch of vertical, which was considered satisfactory. At high tide the depth of water inside the caisson was 80 ft. The operation of cleaning out the concrete and placing the shaft form was similar to pier No. 4, except the forms, being much lighter, were picked up from building stages and set by a travelling crane.

**Pier No. 3.**—The caisson was same type as pier No. 5, like dimensions and cross-sections. It had been built up 63 ft., weighted with 700 cu. yds. of concrete and sunk 23 ft. in the river bottom. The top was about water level at extreme low tide, consequently, the work on this was confined to about two hours a day. The caisson leaned towards pier No. 4. It was 2.7 ft. between high and low sides and 3/10 ft. between high and low ends, throwing the top 7.5 ft. out of position. The concrete in the walls was about 5 ft. from top so that the same system of struts used on pier No. 5, similarly placed, might displace the unfilled wooden walls unless precautions were taken. Vertical 10 x 10 timbers were set against the low side struts set against these and No. 4, provision being made for wedges and jacks to act on the struts. To assist the action of the struts, a sling of 1¼-in. cables was placed around the caisson below the top of the concrete. Tackle consisting of double steel sheave and steel blocks was fastened to the sling and run to pier No. 2 which acted as an anchor. A strain was taken to the full power of a 7 x 10 hoisting engine. By keeping a strain on the sling, following up by jacks and wedges, and following similar methods to those used on pier No. 5, jetting and dredging, the caisson was brought to its correct position, interior cleaned and concreted and shaft built, as in the case of pier No. 5.

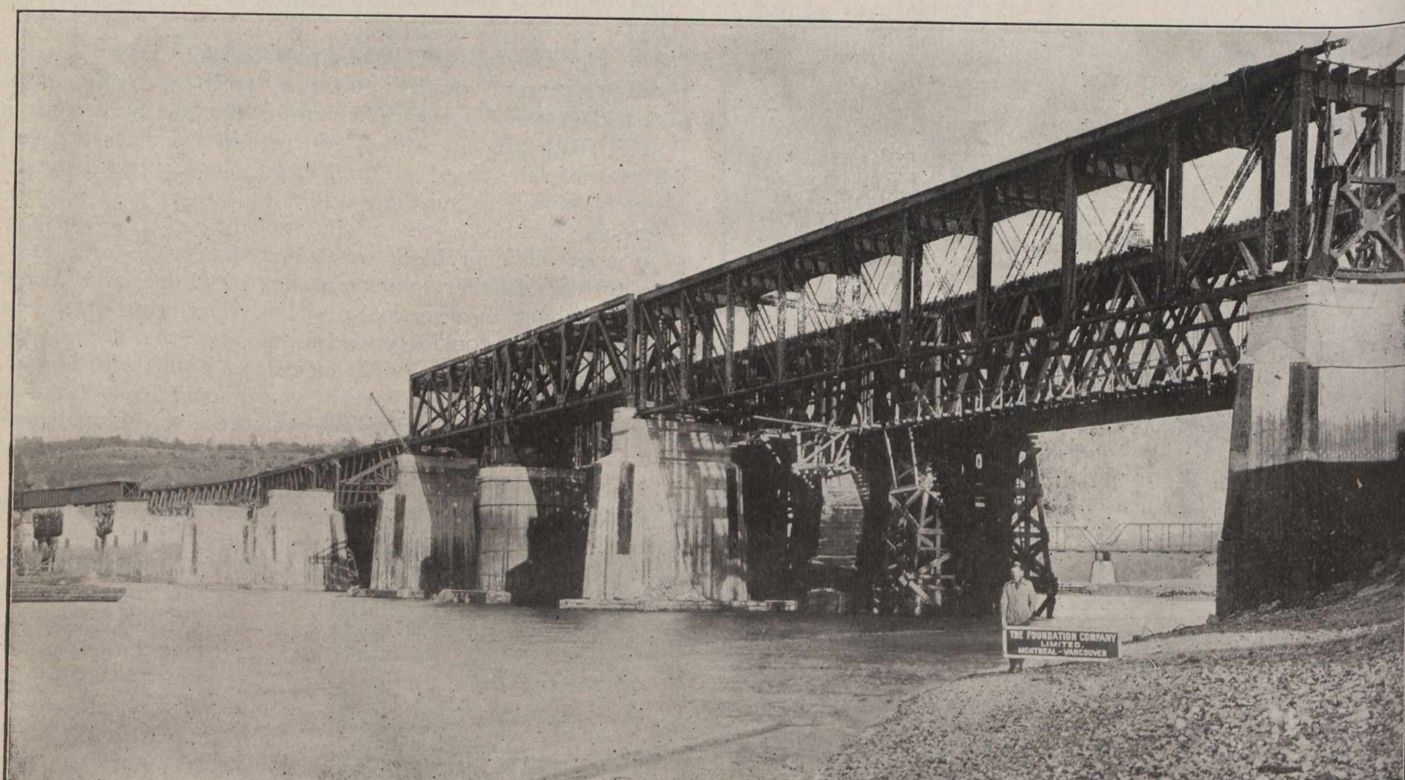


**Fig. 2.—The Bear River Bridge Under Construction.**

**Piers 6 and 7.**—The caisson for No. 6 had been commenced. The structural steel cutting edge had been removed and utilized in a caisson of somewhat different design. The caisson was 31 ft. by 51 ft. at cutting edge (outside dimensions) double walls about 7 ft. apart for a distance of 20 ft. above cutting edge. Single walls of timber from top of double wall to the top of caisson. Inside single walls 17 ft. by 38 ft. The caissons were built on launching ways, as high as depth of the water at ways would permit, then launched and towed to deeper water, there built up as high as possible and still float in vertical position. The sites of the piers partially dredged, the caisson placed in position and weighted by rails and sunk by carefully dredging. Cutting edge was sunk 18 ft.

below the river bed without accident or interruption and left in its correct position. Piles were driven, 152 in all, at all tides; at high tide there was 60 ft. of water over the top of piles. The method of driving was by means of an apparatus designed by the contractors. This apparatus was suspended in position and piles placed in same and driven, and after a few piles were driven to determine the proper length, all piles were then cut to their correct length and driven home, thereby avoiding cutting these piles under water.

The piles averaged about 45 ft., the tops were left at an elevation of about 4 ft. above the cutting edge. After the piles were driven the soft mud was taken out and concrete laid under water to an elevation about 12 ft. above cutting edge, forming a base 51 ft. x 31 ft. over piles. At this elevation the bottom of the interior wall was embedded two feet in the concrete. After the base was set concreting was continued in the interior wall to the elevation of the bottom of the shaft. This section was 17 ft. by 38 ft., completing the base. On the base the shaft was built as in the case of piers 3 and 5.

All concrete was 1 : 2 : 4 mixture; that in the caissons being placed by means of buckets through the water, that in the shafts being laid in the open air as the tides permitted.

A fairly good mixture of sand and gravel was obtained from a nearby beach and this was used without treatment.

The five piers were completed between November 17th, 1913, and June, 1914, with about 50 days out for storms, when it was impossible to work, leaving a net working period of approximately five months.

The contract was under the direction of Mr. P. B. Motley, bridge engineer of the Canadian Pacific Railway, and Mr. Hare, chief engineer of the D.A.R. Railway Company. Contractor for the channel piers above described, The Foundation Company, Limited, Montreal and Vancouver.

The bridge superstructure consists of one 85-ft., seven 103-ft. and one 50-ft. deck plate girder spans, four 157-ft. deck truss spans and a deck truss swing span 141 ft. 10 ins. long centre to centre of bearings. Of these the swing and the 103-ft. girders were newly made, the remainder being taken from existing C.P.R. bridges. Floating was adopted as the means of placing both new and old truss spans—all being erected on falsework in one opening and being skidded down a falsework track until they could be picked up on the scows. The superstructure was erected in 1914 by the Dominion Bridge Company.

## RAILROAD EARNINGS.

The railroad earnings for the first two weeks of August are as follow:—

**Canadian Pacific Railway.**

| | 1914. | 1915. | Decrease. |
|---|---|---|---|
| August 7 | $2,236,000 | $1,787,000 | — $449,000 |
| August 14 | 2,162,000 | 1,815,000 | — 347,000 |

**Grand Trunk Railway.**

| | 1914. | 1915. | Decrease. |
|---|---|---|---|
| August 7 | $1,106,823 | $ 993,773 | — $113,050 |
| August 14 | 1,068,710 | 1,004,412 | — 64,298 |

**Canadian Northern Railway.**

| | 1914. | 1915. | Decrease. |
|---|---|---|---|
| August 7 | $ 354,400 | $ 259,500 | — $ 94,500 |
| August 14 | 319,500 | 249,000 | — 70,500 |

# COAST TO COAST

**North Vancouver, B.C.**—The engineering department of the municipality has just completed the construction of a timber dam across Mosquito Creek to impound a surplus water supply of 600,000 gallons.

**Edmonton, Alta.**—The operating expenses of the Edmonton Radial Railway have been reduced $106,869 in the past six months, due to more economical handling of the department and the saving effected by the motormen of 0.03 kw. per car mile.

**Victoria, B.C.**—Beginning early in August and for the next two months the dredge "King Edward" will be engaged in dredging a channel from deep water to the mouth of the Courtenay River at Comox Harbor. The channel will be 100 ft. wide, with a low-water depth of 8 ft.

**Victoria, B.C.**—About 13,000 square yards of civic paving have been completed to date, and about 10,000 square yards are yet to be finished under the 1915 programme. The grading and foundation work on a large portion of it have been completed, and the civic paving plant is in operation.

**Sarnia, Ont.**—In connection with the trouble which the new waterworks system has been giving, the city council now proposes to sink a well, 25 ft. in diam., at the edge of the river to about 15 ft. below the water level, and to pump water from it to a lagoon alongside the infiltration basins.

**Peterboro', Ont.**—Mr. R. H. Parsons, city engineer, reports that 9,540 lineal feet of sidewalks have been laid to date this year at an average cost of 12¾ cents per sq. ft. The sewers on Monaghan Road, Chemong Road, Aberdeen Avenue, Bethune Street, Westcott and Ware Streets have been completed.

**Saanich, B.C.**—About 1½ miles of grading and paving on the Saanich Road have been completed, and the whole work as far as Royal Oak will likely be finished by September 15th. A new road will be opened up from East Saanich to Cordova Bay, to have a maximum grade of 5 per cent., and to replace the present road, which has grades as high as 17 per cent.

**Chilliwack, B.C.**—The city sewerage system has been completed. It has been under construction for the past sixteen months, the work having been handicapped by water and quicksand. Originally it was being done by contract, but it was later taken over by the city and completed under the direction of Mr. A. Hobson, city engineer.

**Edmonton, Alta.**—Under the direction of the Department of Mines at Ottawa, the laying of a pavement was commenced last week in which is being used asphalt from the deposits in Northern Alberta, chiefly at Fort McMurray. It is expected that similar experiments will be made in Calgary at an early date. The product has been given the name of McMurray Asphalt and indications point to its successful use as a paving material.

**Montreal, Que.**—The Cedars Rapids Manufacturing and Power Co. has closed a contract for another block of 10,000 h.p. delivery to commence in March, 1916. The company is already selling about 83,000 h.p. from its new plant, described in *The Canadian Engineer* for January 1st and July 9th, 1914. The total capacity of the plant, of which the original installation provides for 100,000 h.p., will be 160,000 h.p. Work applicable to extensions was carried out last year with a view to supplying future demand at low cost.

**Edmonton, Alta.**—Mr. G. W. Farrell, of G. W. Farrell & Co., financiers, Montreal, is interested in the development of a hydro-electric power site on the North Saskatchewan River for the city of Edmonton, and looked over the ground a few weeks ago. The Edmonton Hydro-Electric Company, which is the name of the promoting concern, has a site about 60 miles west of Edmonton and 10 miles above Rocky Rapids. Preliminary investigations have been proceeding during the past three years, and a $6,000,000 scheme is now contemplated. The company proposes to negotiate with the city council at once regarding a contract, as it is anxious to begin construction work during the winter while the water is low. Sir John Jackson, Limited, of London, England, and a number of capable hydro-electric engineers are admitted by Mr. Farrell to be connected with the enterprise.

## PERSONAL

NORMAN CORYELL has been appointed master mechanic of the Moncton Tramways, Electricity and Gas Company, Limited, of Moncton, N.B., succeeding Mr. R. A. McCharles.

R. J. CLUFF has resigned his position as general manager of Steel and Radiation, Limited, Toronto, to engage more actively in war munition work.

A. J. MITCHELL, comptroller for Mackenzie, Mann & Company, and assistant to the vice-president of the Canadian Northern Railway, of Toronto, Ont., has been elected vice-president of the Chatham, Wallaceburg & Lake Erie Railway, to succeed Mr. J. D. Morton.

LOUIS C. FRITCH, assistant to the president of the Canadian Northern Railway at Toronto since the spring of 1914, has been appointed general manager of the lines east of Port Arthur in addition to his present duties. Prior to 1914 he was chief engineer of the Chicago Great Western for several years.

CHARLES D. McARTHUR, for the past 15 months chief engineer for Foley Brothers, Welch, Stewart & Faquier, contractors, of Halifax, N.S., on work in connection with the construction of the first unit of the Halifax Ocean Terminal for the Intercolonial Railway, has again assumed the office of chief engineer of the Blaw Steel Construction Company of Pittsburgh.

## OBITUARY.

The death occurred in Hamilton, on August 18th, of Mr. J. W. Eber, who resigned from the general managership of the Toronto, Hamilton & Buffalo Railway a few months ago.

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The following mining engineers have been attached to the following military camps as mining instructors: Mr. James McEvoy, with the rank of captain, Niagara and London, Ont.; Mr. Walter Herd, with the rank of Captain, Valcartier camp; Mr. E. D. Black, with the rank of captain, Sewell camp, Sask., and Mr. F. A. Fortier, with the rank of lieutenant, Barriefield camp.

## PAN-AMERICAN ROAD CONGRESS.

Governor Ernest Lister of the State of Washington has written to Governor Charles W. Gates of Vermont, chairman of the executive committee of the Pan-American Road Congress, inviting the members of the American Road Builders' Association and of the American Highway Association to visit the State of Washington, and especially Spokane, when going to or returning from the Congress.

The invitation is issued in behalf of the State and of the Spokane Good Roads Association. Governor Lister assumes that practically every one from east of the Rocky Mountains who attends the Pan-American Road Congress will travel in one or the other direction through the Pacific Northwest, and that by making a stop at Spokane and other points, much detailed knowledge may be gained by the visitors concerning road building in the Northwest, and suggestions may be made which will be of value to the Washington road builders. The invitation is highly appreciated by the members of the executive committee of the Congress.

Mr. Samuel Hill, who is known throughout the United States and abroad as one of the most enthusiastic and progressive of good roads advocates, is now president of the Pacific Highway Association, which, with the Tri-State Good Roads Association, will aid in the work of the Congress from a Pacific slope standpoint. Mr. Hill is an ex-president of the American Road Builders' Association, which organization, jointly with the American Highway Association, has organized the Pan-American Road Congress.

It is anticipated that among the official delegates from Central and South American countries, there may be some who will furnish technical information regarding those wonderful ancient roads which are found there. Much has been written concerning them, but it has chiefly been from a non-professional standpoint. Technical descriptions will be welcome.

Thursday, September 16, has been designated as Pacific Highway Day at the Pan-American Road Congress.

## COMING MEETINGS.

NEW ENGLAND WATERWORKS ASSOCIATION.—Annual Convention to be held in New York City September 7th to 9th, 1915. Secretary, Williard Kent, 715 Tremont Temple, Boston, Mass.

AMERICAN ROAD BUILDERS' ASSOCIATION and AMERICAN HIGHWAY ASSOCIATION.—Pan American Road Congress to be held in Oakland, Cal., September 13th to 17th, 1915. Secretary, American Road Builders' Association, E. L. Powers, 150 Nassau Street, New York, N.Y. Executive Secretary, American Highway Association, I. S. Pennybacker, Colorado Building, Washington, D.C.

AMERICAN ELECTRO-CHEMICAL SOCIETY.—Twenty-eighth annual general meeting to be held in San Francisco, Cal., September 16th to 18th, 1915. J. M. Muir, 239 West 39th Street, New York City, Chairman of Transportation Committee.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Calvin W. Rice, 29 West 39th Street, New York City.