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The Canadian Engineer

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THE WINNIPEG-SHOAL LAKE AQUEDUCT

THE 95-MILE WATER SUPPLY LINE FOR THE GREATER WINNIPEG WATER DISTRICT—ENGINEERING FEATURES OF THE PROPOSED ROUTE AND THE DESIGN THROUGHOUT

THE Administration Board of the Greater Winnipeg Water District has not been tardy in getting down to action in the matter of the proposed supply of water from Shoal Lake for Winnipeg. *The Canadian Engineer*, in September 11th issue, published the salient points of the report of Messrs. Hering, Stearns and Fuertes, the board of consulting engineers instructed on May 20th, 1913, to submit a report on the best means of supplying water from this source, together with an estimate of the cost and general plan of the development.

This project has been the acme of interest for some little time as the most desirable source of supply for the city, although distance 95 miles, and great enthusiasm was evinced when the report, mentioned above, pronounced the proposal quite within the latitude of prudence, and, in fact, a very advantageous one for the city. On October 1st the rate-payers strongly endorsed a by-law authorizing, for the supply from this source of 85,000,000 gallons per twenty-four hours, the expenditure of $13,045,600, as estimated in the report. In the issue of October 16th, this journal announced the appointment of Mr. Jas. H. Fuertes as consulting engineer, and Mr. W. G. Chace, as chief engineer, also the formation of a board of commissioners with Mr. R. H. Reynolds as the first appointed commissioner, with others to follow at an early date. The same issue published a special announcement to contractors relative to tenders for the proposed work, and at the present time the ground is being examined along the proposed route, the contractors taking advantage of the season's remaining permissible weather. A study of Fig. 1 will familiarize the reader with the magnitude of the scheme.

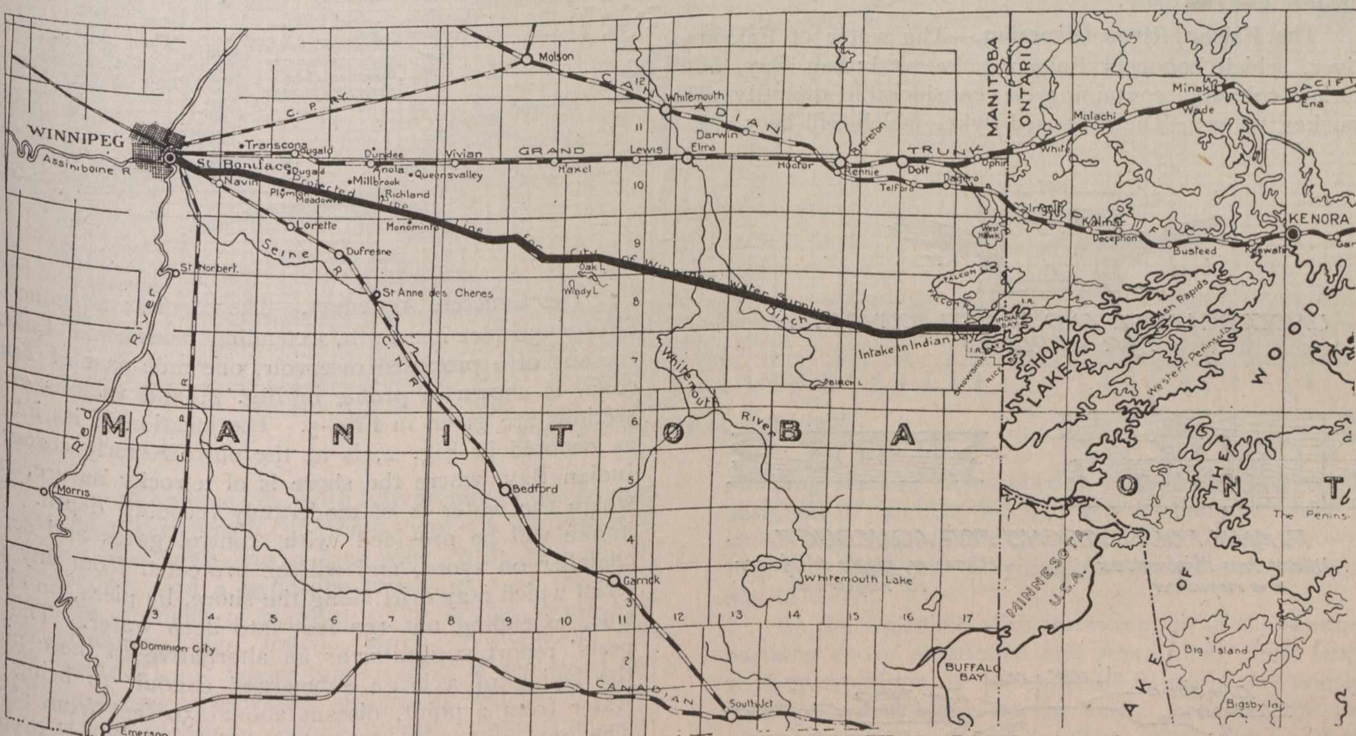


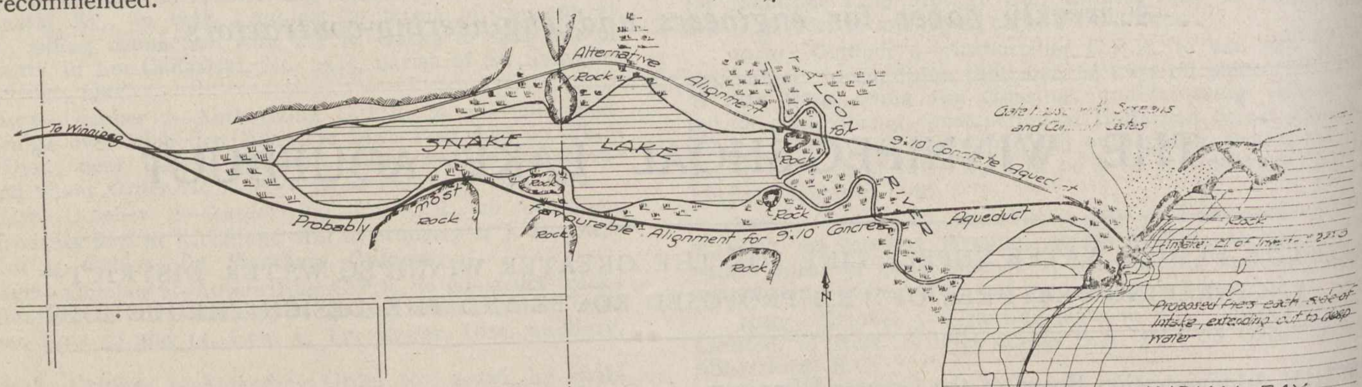
Fig. 1.—The Proposed Route of the Greater Winnipeg Water District Aqueduct.

The main engineering features of the work for immediate construction constitute:—

1. A dyke and channel for the diversion of the Falcon River into Snowshoe Bay.

2. A concrete masonry aqueduct, having a continuous down grade for 84.73 miles from an intake at Indian Bay to a point about one mile east of Transcona, the aqueduct to have a capacity of 85,000,000 gallons of water daily.

3. A pipe 5 feet in diameter, extending from the end of the masonry of the concrete aqueduct, most of the way through streets to Victoria Park on the west side of the Red River in Winnipeg, this pipe to be of steel except under the Red River, where cast-iron pipe laid in a tunnel is recommended.



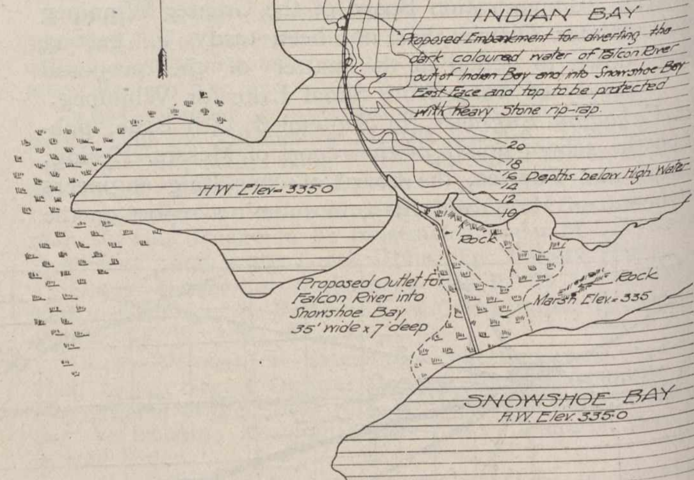


Fig. 2.—Location of Intake and Falcon River Diversion.

4. A 48-inch cast-iron pipe through the streets of Winnipeg from Victoria Park to the McPhillips Street reservoirs. This pipe line will have a capacity of 25,000,000 gallons daily.

The Falcon River Diversion.—The water of Falcon River, which connects Falcon Lake to Indian Bay, is darkly colored, containing a considerable quantity of muskeg water. The proposed dyke, which will be 5,070 feet in length, is to divert this water southward to a proposed channel, 3,300 feet long, 35 feet wide and 7 feet deep, which will form an outlet through a shoulder of marshy land only a few feet above the water level, into Snowshoe Bay, where there will be no liability of this discolored water becoming associated with the water surrounding the intake in Indian Bay. Fig. 2 illustrates this diversion, and Fig. 3 gives a typical cross-section of the proposed embankment. The report estimates the Falcon River diversion to cost in the neighborhood of $120,700.

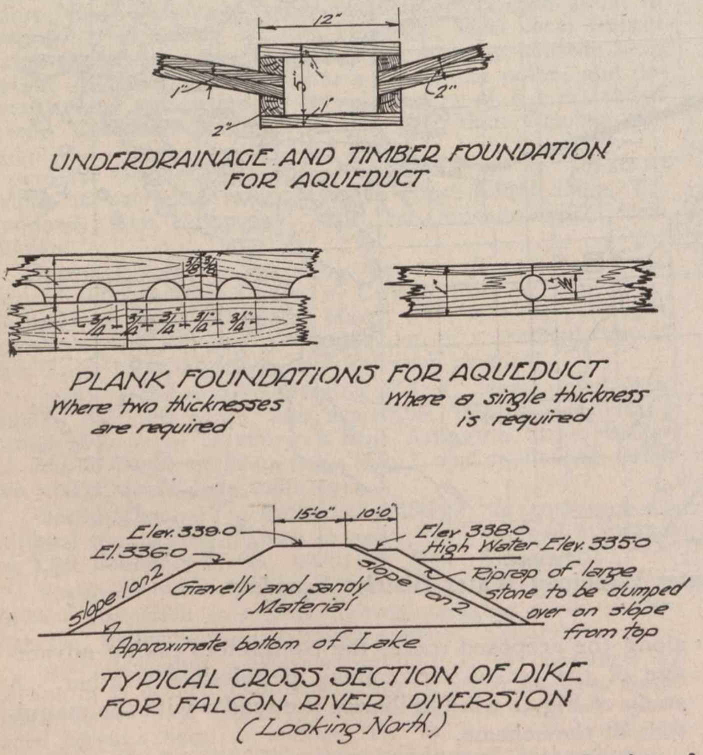


Fig. 3.—Details of Aqueduct Foundation, and Section of Falcon River Embankment.

The Concrete Aqueduct.—The concrete aqueduct, to be 447,330 feet in length, extending from Shoal Lake to the site of a proposed reservoir, one mile east of Transcona, is shown in profile in Fig. 4, and various cross-sections are given in Fig. 5. The location of its intake, as denoted in Fig. 2, is at the northwesterly corner of Indian Bay, where the shore is of a rocky nature, and where the water is of moderately receding depth. The intake will be provided with control gates and screen chamber on shore, and will be protected from any material which may drift along the shore, by piers, on either side, extending out 150 feet into deep water. The experts' report suggests, as an alternative to these piers, the laying of a large submerged conduit to bring the water from a point, distant about 150 feet from shore. The gate and screen chamber will be of liberal area to necessitate as little fall as practicable of the water from the bay to the aqueduct. Details of the design are not in hand, except that the report recommends the use of at least two sluice gates, not less than 5 feet wide and 6 feet high, and screens with a total length of not less than 50 feet, and a height extending from the top of the aqueduct to the surface of the water.

With respect to the advisability of using concrete masonry in the construction of the aqueduct, apprehending the disintegrating effect of the presence of sulphates and sulphuretted hydrogen in certain soils, they being adverse to durability, unless the concrete is smooth, impervious, and able to resist these deteriorating agents, the experts had chemical analyses made of the muskeg waters, and of the materials forming the muskegs and underlying soils. These investigations covered both the Laurentian formation which underlies the greater part of the length of the aqueduct, and the limestone which occurs towards its westerly end. The results show that the sulphates and sulphuretted hydrogen were not present in the former and in minute quantities only in the latter. The method adopted of constructing the aqueduct in a shallow trench, permitting of the drainage of the muskegs nearly as low as the bottom of the aqueduct, will allow very little ground water to come in contact with the concrete. The report doubly emphasizes the use of good materials as a further safeguard against any injurious effects.

For the first 9 miles of the route the land through which the aqueduct will pass is higher than Indian Bay, and necessitates a deep summit cut, for gravity flow. This is shown to advantage in Fig. 4. From this point the gradient is quite variable, although down-grade all the way to Transcona; hence the varying sizes and cross-sections of the aqueduct, as shown in Fig. 5, ranging from one 10 feet wide and 9 feet in height with a sec-

aqueduct reinforced with steel has also been adopted, so that this portion will withstand the pressure resulting from building it 10 feet or more below the regular grade line. The diameter of this particular section is 7.2 feet. At Birch River there is the alternative of carrying the aqueduct over, instead of below, the surface of the water.

At the waste weirs, provision will be made to dispose of any excess of water over the capacity of the pipe line, leading from Transcona into Winnipeg, which might accidentally be permitted to enter the aqueduct at Indian Bay. This may be accomplished by placing stop-planks across the aqueduct to stop or throttle the flow through it. Blow-offs, other than at the locations mentioned above, will be placed where opportunity offers, being convenient for use during the construction of the aqueduct, and while it is being repaired, and to be used in emergencies when the aqueduct is in service.

For the last 26,000 feet of the concrete reservoir leading toward Transcona, the section of aqueduct to be used is designed to withstand the internal pressure that will develop when it is necessary, at some time in the future, to build a large reservoir there, and to provide a

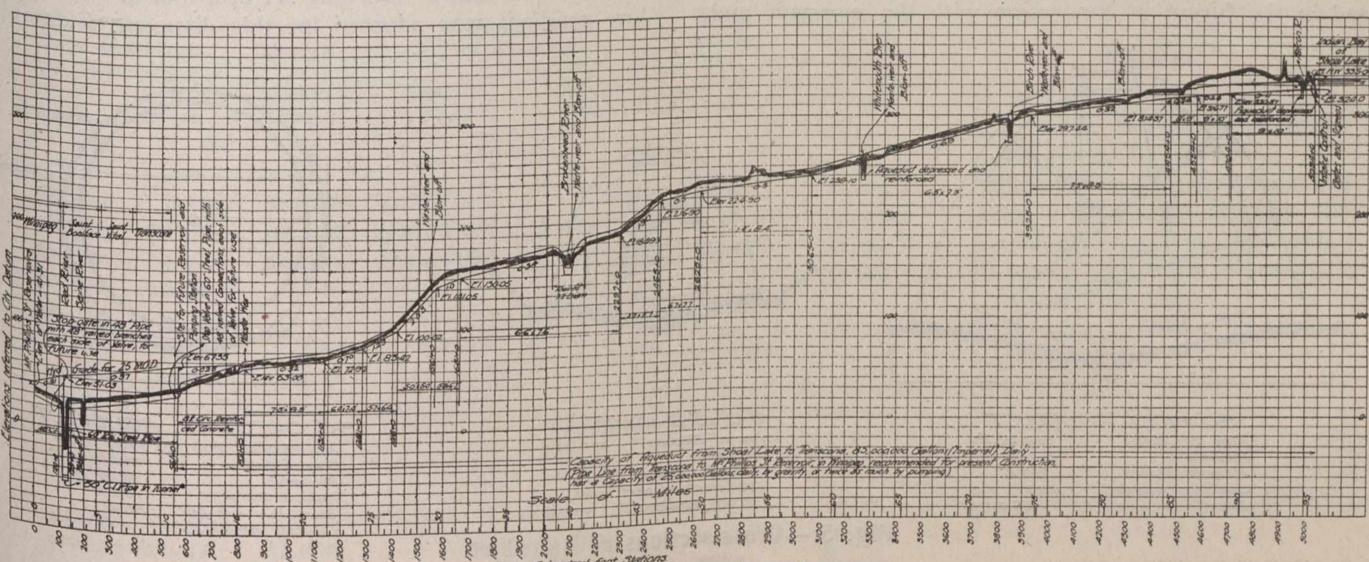


Fig. 4.—Profile of Aqueduct.

tional area of 73.6 sq. ft., with a hydraulic radius of 2.33 feet (used at the summit cut where there is a low gradient) to one 5 feet high and 5 feet wide, with 20.9 sq. ft. cross-section, and a hydraulic radius of 1.24 feet used where the gradient is highest. The profile shows four river crossings, viz., Falcon, Birch, Whitemouth and Brokenhead Rivers, where the aqueduct is depressed and reinforced, and is provided with waste weirs and blow-offs. These crossings require special construction. At the Falcon River depression a pile foundation will be required for about 600 feet, and the depression itself will be 150 feet in length. The top of the aqueduct will be sufficiently low in the water to permit of the passage of boats of light draft. The depressed portion is to be reinforced with steel, and the concrete walls thereat will be considerably thicker than under ordinary circumstances.

The depressions and strengthened sections at Whitemouth and Brokenhead Rivers are similar, although for a part of the distance at the latter crossing, where the muskeg is too steep to permit of the construction of the aqueduct upon a solid natural bottom, a pile and timber foundation will be required. At this crossing also, and through the low-land on either side of it for a distance of 13,000 feet, the circular form of

pumping station. This portion of the aqueduct has been designed of circular form, 8 feet in diameter, and provided with steel reinforcement. The section shown in Fig. 6 is designed to withstand the pressure due to 20 feet of water.

As the aqueduct, with the exception of the reinforced portions above mentioned and some other short lengths at river crossings, is not expected to stand any considerable upward pressure on the arch, measures are to be taken to prevent the opening of the sluice gates at Indian Bay to a height which will permit a quantity of water to enter the aqueduct much, if any, in excess of the rate of 25,000,000 gallons daily, which is the limit of the capacity of the pipe line leading from Transcona to the city reservoirs. The waste-weirs already mentioned will act as a further safeguard in permitting the discharge into the crossed streams of excess of water.

The concrete mix recommended for the construction of the aqueduct, for strength, permanency, and water-tightness, is one of Portland cement, two of sand, and four parts of screened gravel. To prevent transverse cracks in the structure, the precaution is to be taken of building in sections not more than 20 feet in length, and where one section joins another, a steel bar about 3 inches by 1¼ inches will be inserted to act as a water-stop, and prevent leakage at these joints.

It will be noted in the cross-sections of the aqueduct that in each case there is a central wooden box drain and a platform consisting of two thicknesses of 1-inch boards, the upper one being fluted on the under side to furnish channels in which the water may flow from the side to the drain. This arrangement is shown in Fig. 3. The platform furnishes a dry bottom upon which the concrete bottom of the aqueduct will be built and kept dry until it has had time to set. Although the drawing shows a double platform, a single board with grooves in each edge may be used where there is but little water to be taken care of. The boards are to be bedded in sand.

The Steel Pipe Line.—From the end of the concrete aqueduct, near Transcona, a 5-foot pipe line 43,200 feet in length, will convey the supply as far as Red River. This pipe will be of rivetted steel, ⅜ of an inch in thickness. At its upper end a valve it to be provided for shutting off the supply, while above and below this valve there will be branches, each provided with a valve to be used in the future in connection with the reservoir and pumping station to be installed when the 25,000,000-gallon supply to the city becomes inadequate.

Where the pipe crosses the Seine River, a new street has been projected, the design of which provides for the erection of a 30-foot arched culvert, filling over it with earth, and it is intended to lay the steel pipe in this earth.

The Cast-iron Pipe Section.—Reaching the Red River, a tunnel extending about 900 feet horizontally across the river from a shaft in Victoria Park to a corresponding shaft in the opposite side, each 75 feet in depth, will carry the supply in a 60-inch cast-iron pipe, 1.9 inches thick, and provided with a special bell about 15 inches long, so designed as to permit the joints between the pipe lengths to be caulked from the inside with lead wool. The tunnel is to be of only sufficient diameter to permit the placing of the pipe. This provides a minimum of 6 ft. 3 in., although the average diameter, owing to the irregularities in blasting, will be considerably more.

All spaces between the pipe and the sides of the tunnel are to be filled with concrete, as far as it is practicable to place concrete, and the remaining space is to be filled by pumping in cement grout, the aim in using such thick pipe and in filling all spaces with concrete or cement grout being to make absolutely secure this portion of the pipe line which will be inaccessible unless the water is shut off, and the pipe is emptied by pumping.

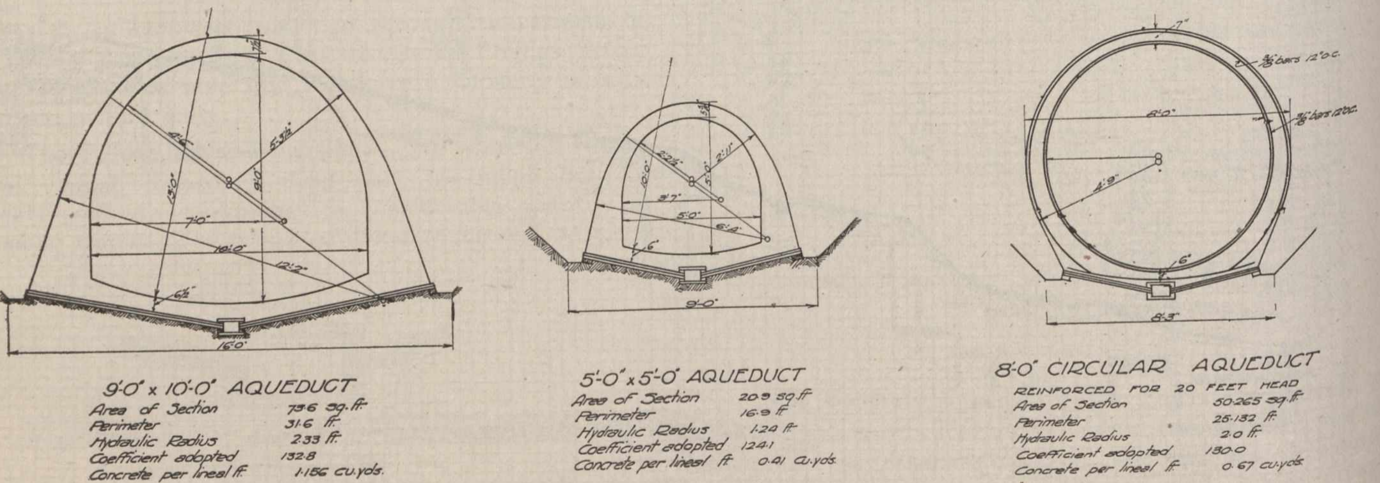


Fig. 5.—Cross-sections of Aqueduct.

The remaining 12,000 feet of pipe to McPhillips Street reservoir is to be laid for almost the entire length in the city streets, and a 48-in. cast-iron pipe has been adopted. This for the reason that steel is less desirable in city streets than cast-iron pipe, and that a pipe larger than 4 feet in diameter interferes too seriously with other structures. The pipes which are to be laid in the streets will be laid to such a depth as to permit a 4-foot covering of earth.

East of Transcona, where the aqueduct will not follow the streets, but will be laid through the open country, a cheaper and more expeditious plan will be adopted of building it in a shallow trench from 3 to 4 feet deep, where practicable, and covering it to a depth of 4 feet with an earthen banking, the top width of which will be at least 8 feet, and nowhere less than the inside width of the aqueduct, so as to make the slopes of the embankment 2 horizontal to 1 vertical.

Gradients.—For a distance of 33,000 feet (6.26 miles) from Indian Bay, the gradient of the aqueduct has been made so low that is falls only .11 of a foot in 1,000. This low gradient was adopted for this distance to diminish the depth of the summit cut and is the most economical gradient, all things considered. As stated, the aqueduct through this section is 9 feet high and 10 feet wide.

For the next 25,000 feet (4.74 miles), the fall per 1,000 is .25 of a foot. The large sized aqueduct, 9 feet high and 10 feet wide, is continued for 15,000 feet of this distance and a smaller aqueduct, 8 feet high and 9 feet wide, for the remainder of the distance. This design is the result of hydraulic computations, which show that with these sections of the aqueduct as planned 85,000,000 gallons daily will flow through the aqueduct when the water in the bay is 3.75 feet below high-water level, provided the water has such a free entrance through the intake and gate and screen chamber that it does not fall more than .25 of a foot in passing through them.

Beyond the three portions of aqueduct above described, the gradient of the aqueduct has been made to follow approximately parallel with the surface of the ground all the way to its end near Transcona, and a size has been adopted for each gradient, with a few exceptions which would give the aqueduct the standard capacity of 85,000,000 gallons per day.

The quantity of water which will flow through the reinforced section of aqueduct, used for the last 26,000 feet, will not depend upon the gradient of the aqueduct itself, but upon the hydraulic gradient available when a reservoir is built east of Transcona, and its size has been computed accordingly. Somewhat similarly, the next two portions of the aqueduct east of the reinforced portion, covering a total length of 46,000 feet, have been made a little larger than the size due to the gradient of these portions, on account of the possible back water effect from the proposed reservoir.

The flow through the pipe line is, of course, dependent upon the hydraulic gradient and not upon the gradient of the pipes. For a flow of 25,000,000 gallons daily, this amounts to .37 of a foot per 1,000 in the 5-foot pipe and .81 of a foot per 1,000 in the 4-foot pipe, making a total fall through these pipes of the McPhillips Street reservoirs of 26 feet.

Table I. gives various statistics relating to the various portions of the aqueduct, including lengths, gradients, elevations and dimensions of the different sections.

To. T. R. Deacon, mayor, is to be accredited a great deal of the developments which the City of Winnipeg has experienced this year in the interests of a better and a safer supply of water. The city engineer, H. N. Ruttan, has been one of the strongest advocates of the Shoal Lake scheme, and it was largely through his persistent emphasis last year that the thorough and accurate investigation of the project was made, as the prospective cost had vied so strenuously with the very desirable qualities of Shoal Lake as a source of supply as to render the proposition an apparently prohibitive one.

In a succeeding issue *The Canadian Engineer* will describe the extensions which were recommended by the Board of Consulting Engineers, to be provided when the increased consumption of water renders the capacity of the pipe lines inadequate.

Table I.—Lengths, Slopes, Elevations and Dimensions of the Various Sections of the Aqueduct from the McPhillips Street Reservoirs in Winnipeg to Shoal Lake.

Total Distance from McPhillips St. Reservoirs		Length of section.	Dimensions of Aqueduct		Slope in feet per 1,000 feet	Elevation of hydraulic gradient at end of section.	Remarks
Feet	Miles	Feet	Height Feet	Width Feet		Feet	
0	0					41.31	High water in McPhillips Street Reservoirs.
12,000	2.27	12,000	4 in. diam.	C. I. Pipe	0.81	51.03	These slopes and elevations are for a discharge through the pipes of 25,000,000 gals. daily.
56,100	10.62	44,100	5 in. diam.	Steel Pipe	0.37	67.35	
82,100	15.55	26,000	8 in. diam.	Rein. Conc.	0.025	68.00	
56,100	10.62					61.00	Proposed high water in reservoir east of Transcona.
82,100	15.55		8.0	8.0	0.29	68.54	This slope based on 85,000,000 gallons daily.
						Elevation of inside of aqueduct bottom at end of section	
82,100	15.55					83.0	Beginning of grade conduit.
113,100	21.42	31,000	7.5	8.5	0.32	72.92	
128,100	24.26	15,000	6.4	7.4	0.70	83.42	
141,600	26.82	13,500	5.7	6.4	1.23	100.02	
156,100	29.57	14,500	5.1	5.1	2.83	141.05	
165,100	31.28	9,000	5.8	6.7	1.00	150.05	
229,700	43.54	64,600*	6.6	7.6	0.54	184.93	
246,500	46.69	16,800	5.3	5.7	1.90	216.90	
262,500	49.71	16,000	6.7	7.7	0.50	224.90	
306,500	58.65	44,000	7.4	8.4	0.30	238.10	
392,500	74.34	86,000	6.3	7.3	0.69	297.44	
445,400	84.35	52,900	7.3	8.3	0.32	314.37	
455,400	86.25	10,000	8.0	9.0	0.24	316.77	
470,400	98.09	15,000	9.0	10.0	0.24	320.37	
503,359	95.34	32,959	9.0	10.0	0.11	324.00	
503,400	95.35	41			0.00	324.00	Gate and screen chamber.

*13,000 ft. of this length at Brokenhead River Crossing is 7.2 ft. in diameter and reinforced.

TUNNEL THROUGH JURA MOUNTAINS.

The Mont d'Or Tunnel, between France and Switzerland, on which boring operations were begun nearly three years ago, was pierced recently. The two boring gangs, advancing from the Swiss and French side respectively, met and shook hands. It was found that the engineers had calculated the cutting with the greatest accuracy. The tunnel, which is three and three-quarter miles long, penetrates through the Jura Mountains, from Gresne to Vallerbe, thus obviating a seven-mile detour by Pontarlio. It should have been completed two months ago, according to contract, the work, however, being delayed by the tapping of a number of springs, which had to be pumped dry. The flow of water at one time reached 2,200 gallons a second. It is hoped that the new line will be opened early next year.

SPECIFICATIONS FOR CONCRETE MASONRY IN HIGHWAY BRIDGES.

IN September 11th issue of *The Canadian Engineer* there appeared under the heading "Typical Specification for Steel Highway Bridges," a portion of a set of typical specifications issued by the Department of Agriculture of the United States. The bulletin contains, in addition, a few specifications governing the use of concrete in masonry. Generally, it requires the concrete to be prepared and mixed in very strict accordance with specifications and plans, the cement to be of satisfactory standard conforming with Government specifications, not to contain lumps or any indications of exposure.

Aggregate.—The sand is required to consist of dry, clean, quartz grains and not to contain more than 5 per cent. of clay, loam, or other foreign materials. The grains shall be well graded and of such size that all will pass a ¼-inch mesh screen and not more than 20 per cent. will pass a No. 50 sieve.

The coarse aggregate may consist of either broken stone or gravel. Stone shall be sound, hard, and tough, broken to the sizes hereinafter specified, and when used shall be free from foreign material. No weathered or disintegrated material shall be used. Gravel shall be composed of hard, sound, durable particles of stone, thoroughly clean and well graded in size between the limits specified below.

Unless otherwise especially provided, there shall be three classes of concrete, known as class A, class B, and class C.

Class A concrete shall consist (by volume) of 1 part of cement, 2 parts of sand, 4 parts of coarse aggregate, and water. All of the coarse aggregate shall be retained on a ¼-inch mesh screen and shall pass a 1-inch mesh screen. Not more than 75 per cent. shall be retained on a ½-inch mesh screen, and not more than 75 per cent. shall pass such a screen.

Class B concrete shall consist (by volume) of 1 part of cement, 2½ parts of sand, 5 parts of coarse aggregate, and water. All of the coarse aggregate shall be retained on a ¼-inch mesh screen and shall pass a 1½-inch mesh screen. Not more than 75 per cent. shall be retained on a ¾-inch mesh screen, and not more than 75 per cent. shall pass such a screen.

Class C concrete shall consist (by volume) of 1 part of cement, 3 parts of sand, 6 parts of coarse aggregate, and water. All of the coarse aggregate shall be retained on a ¼-inch mesh screen and shall pass a 2½-inch mesh screen. Not more than 75 per cent. shall be retained on a 1¼-inch mesh screen, and not more than 75 per cent. shall pass such a screen.

Mixing.—The cement and sand shall first be thoroughly mixed dry, in the proportions specified, on a proper mixing platform. Sufficient clean water shall then be admixed to produce a pasty mortar. To the mortar thus prepared shall be added the proper proportion of coarse aggregate, previously drenched with water, and the whole shall be mixed until every particle of the coarse aggregate is thoroughly coated with the mortar. Instead of the above method a mechanical mixer satisfactory to the engineer may be employed.

Concrete shall be mixed in batches of such size that the entire batch may be placed in the forms by the force employed within 45 minutes from the time that the first water is applied. No concrete is to be prepared from mortar which has taken an initial set and would require retempering.

Placing.—All concrete shall be carefully deposited in place and never allowed to fall from a height greater than 5 feet. Concrete shall never be deposited in running water, nor in still water, except under the direction of an engineer skilled and experienced in that special work.

As fast as concrete is put into place it shall be thoroughly tamped in layers not more than 6 inches thick, and the portion next to the forms shall be troweled by using a spade, or by other means, to bring the mortar into thorough contact with the forms.

Concrete shall not be deposited when the temperature of any of the materials composing it is below 35° F.; and if during the progress of the work freezing temperature threatens proper precautions shall be taken to protect from freezing all concrete laid within the four preceding days.

Forms shall be so constructed as to continue rigidly in place during and after depositing and tamping the concrete. If during the placing of the concrete the forms show signs of bulging or sagging at any point, that portion of the concrete causing the distortion shall be immediately removed and the forms properly supported before continuing the work. The amount of concrete to be removed shall be determined by the engineer, and the contractor shall receive no extra compensation on account of the extra work thus occasioned. Forms for exposed surfaces shall be constructed of dressed lumber.

All forms shall be left in place not less than 36 hours and all supporting forms not less than 10 days after the concrete has been deposited. These periods may be increased at the discretion of the engineer in charge.

It is understood that all prices for concrete masonry shall include furnishing all materials and properly constructing all necessary forms.

When the work of laying concrete is to be interrupted for a period greater than one hour and there are no reinforcing rods projecting, provision for a joint shall be made in the following manner: Square timbers 8 by 8 inches, or some other suitable size approved by the engineer, shall be bedded in the concrete throughout the length of the course for one-half their thickness and allowed to remain until the concrete has taken its initial set. When the work of laying concrete is resumed, the timbers shall be removed and the surface thoroughly wet. No joints will be permitted in reinforced-concrete beams, and in floor slabs the joints shall be vertical and parallel to the main reinforcing bars.

Forms covering surfaces of the concrete masonry which are to be exposed shall be removed immediately after the expiration of the period of time necessary for such forms to remain in place, as fixed by the engineer, and all crevices which may appear shall be filled with 1:2 cement mortar. These surfaces shall then be finished with 1:2 cement mortar and a wooden float, so as to present a smooth, neat appearance.

Reinforced Concrete.—All reinforced arches, beams floors, parapets, guard rails, and all concrete masonry measuring less than 9 inches in thickness shall be made of class A concrete, unless otherwise specified on the drawings or directed by the engineer in writing.

Unless otherwise specified on the drawings or in writing by the engineer, class B concrete shall be used for all abutments and wing walls the thickness of which is not less than 9 inches.

Class C concrete shall be used for all footings and cut-off walls, unless otherwise specified on the plans or directed in writing by the engineer.

Unless otherwise specified on the drawings, all reinforcing steel shall consist of bars which have been deformed in some approved manner. No plain bars will be permitted except as shown on the drawings or directed in writing by the engineer.

The steel bars shall have the net sectional area and shall be placed in the exact positions indicated on the drawings.

Unless otherwise specified on the drawings or in writing by the engineer, all reinforcing bars shall be of medium steel having an elastic limit of not less than 35,000 pounds per square inch, and shall be sufficiently malleable to withstand bending cold with a radius equal to twice the diameter or thickness of the bar through 180° without fracture.

When placed in the concrete, the reinforcing steel shall be free from grease, dirt, and rust, and it shall be the duty of the contractor to provide means for properly cleaning the steel.

Thorough contact of the concrete with every portion of the surface of the steel shall be obtained.

Unless otherwise specified on the drawings or in writing by the engineer, necessary splices in reinforcing bars shall be effected by overlapping the ends of the bars a distance equal to 40 times their thickness or diameter.

Inspection and Testing.—All materials used in connection with the work being done under these specifications shall be purchased especially for that work. The contractor shall furnish the engineer with complete copies of all orders for materials, and shall make all orders subject to the engineer's approval of the materials.

The engineer or his representative shall stamp each accepted piece or parcel with a private mark, and any material not so stamped may be rejected at any stage of the work. The engineer's acceptance, however, does not relieve the contractor from responsibility for faulty material or workmanship and wherever such faulty material or workmanship is discovered is shall be repaired or removed and replaced, as the engineer may direct, by the contractor at his own expense.

The contractor shall furnish the engineer or his representative all facilities for testing materials and workmanship at the shop where material is fabricated, and shall notify the engineer well in advance of beginning the shop work.

The contractor shall furnish all facilities for testing the weight and quality of all material at the mill where it is manufactured. He shall provide, free of cost, a suitable testing machine for making the tests and such test specimens as the engineer or his representative may require.

Erection.—Unless otherwise specified in writing by the contracting parties, the contractor shall furnish all labor, tools, machinery, and materials for erecting the bridge complete in place and ready for traffic, in accordance with these specifications and the plans furnished or approved by the engineer.

The contractor shall do all necessary hauling, set all stone or anchor bolts, remove existing structures when necessary, and perform all other incidental work for which express provision has not been made.

The contractor shall so conduct all his operations as not to interfere with the work of other contractors or close any thoroughfare by land or water except by written consent of the engineer.

The contractor shall assume all risks of damage or accident to persons or property prior to the final acceptance of the finished structure.

The contractor shall remove all false work, piling, and other obstructions produced by his operations, and shall perform any additional work necessary to produce a sightly appearance in the immediate vicinity of the structure.

ANALYSIS OF COALS.

An increasing proportion of the coal consumed in the power stations and the larger manufacturing plants is now being purchased under specifications based on chemical analyses and calorimetric determinations of heat units. In the purchase of fuels many matters that have been left to chance are now carefully investigated. It is the aim of mechanical engineers to construct furnaces and to arrange the heat absorbing surface in a furnace with reference to the peculiar character of the fuel which is to be burned. Noting the composition of the fuel and constructing the furnace with reference to it, he can assure efficient and smokeless combustion. Moreover, in any particular market, the choice of coal generally is limited by its quality and by freight rates to one or two fields in which the character of the coal bed is comparatively uniform. Having on hand a representative analysis of the coal from a given bed in any particular district, the engineer can determine whether the coal he receives comes from the bed and the district stated, and whether it is being prepared for market as carefully as it should be. Wide variations in the composition and heating value of the coals from different districts and from different beds make analyses that are comparable, because of the care taken in sampling and analyzing the coal, almost indispensable to engineers having to install boiler or gas-producer plants in different cities, and also to railroads and steamboat companies.

In Bulletin 22, entitled "Analyses of Coals in the United States," the Bureau of Mines has issued information that designing and operating engineers and industrial superintendents will find of great value. Some five thousand samples of coal taken from fifteen hundred coal mines were considered in the report, and much reliable data are presented regarding the chemical composition and heating value of the coals.

The report is in two parts, one giving the methods used in collecting and analyzing the samples, and the results of the analyses, and the other giving the exact location from which each sample of coal was taken, together with a description of the characteristic features of the coal bed at the point of sampling, the nominal capacity of the mine, and such notes on the preparation of the coal as might be useful to consumers. The data contained in these two volumes is not equalled in scope and detail and in value for comparative purposes by the figures that have been published by any other coal-producing country in the world. The Governments of some of these countries have published analyses of coals from different mines and from different districts but, with few exceptions, the samples of coal were not collected and analyzed under a uniform system that would make the results comparable in all respects, and no country has attempted to publish such a large number of analyses that would be comparable, because of the care taken in collecting and analyzing the samples.

ELECTRIC DRIVE IN MACHINE SHOPS.

At the Philadelphia meeting of the American Institute of Electrical Engineers, Oct. 13, 1913, Mr. Charles Fair read a paper dealing with the possibilities of the electric drive for machine tools. He points out the two important questions before the manufacturer as being to increase products and to decrease cost. Since labor is the greatest cost of production, then, where machine tools are a considerable factor in the production, maximum output from the tool is a necessity. Tools that are limited in production because of a lack of power at the tool are a source of expense to the manufacturer. Power cost is low while labor cost is high. The well designed motor-driven machine of to-day shows the motor as one of the main elements of the tool, it having done away with much of the old mechanical drive, and is no longer a mere adjunct to the tool. Mr. Fair's paper is as follows:—

The importance of the motor drive for the machine shop is every day becoming more evident. Due to the great improvement in motors, accessories and methods of application and to the large number and variety of motor-driven tools in service to-day, the relationship of motors and control to machine tools is much better understood by the machine builder and the user than heretofore and, consequently, comparatively little trouble is experienced with either motors or control for the ordinary type of machine tool. Misapplications of both motor and control occur occasionally due largely to insufficient or unreliable information regarding the characteristics of the machine, but the number of these misapplications is relatively small. The tendency to both over- and under-motor machines is constantly growing less, owing to the large number of tests made and to accurate information available. There is still, however, a tendency on the part of some machine builders to over-motor their machines either with the mistaken idea of the strength of their machine or with the idea that possibly prospective customers will be impressed with the enormous power that their "heavy type" machines take. Conversely, other manufacturers want to show how little power it takes to operate their "very efficient" machines and consequently get into trouble. These extremes are gradually disappearing and a more normal condition is taking its place. In a comparatively short time the greatly over-motored and under-motored machine will be a thing of the past, at least so far as the general type of machine is concerned. A number of manufacturers have already recognized three ratings of motor drive on certain of their machines; namely, heavy, medium and light. Much of the existing trouble in motor applications to special machines or to machines rigged for special operations could easily be avoided if only preliminary tests were made with a temporary motor before making the permanent installation. A not uncommon source of trouble, and one that could easily be avoided, is that of attempting to increase considerably the productiveness of a tool by speeding up the machine, increasing the cuts and attaching automatic feeding devices, etc.; all of which increases production but, in doing so, the motor is often overlooked and, if the tool were originally under-motored and the power is not increased, trouble is apt to result. Increased production often calls for an increase in power although there are cases where this is not true.

To increase production and to decrease cost are two important questions continually before the manufacturer to-day. In the majority of cases labor is the greatest cost of production, thus where machine tools are a considerable factor in the production, the importance of obtaining maximum output from the tool is evident. Although the advantages of the motor drive have been dwelt upon at length numerous times, a brief statement of the advantages derived from electrical installations will perhaps be worth repeating:—

Maximum output of tool due to greater power and overload capacity.—Too much stress cannot be laid on maximum output of tools.

Closer speed regulation.—Allows maximum speed for varying materials and size of work.

Power distribution not only for the tools, stationary or portable, but for cranes, lights, etc.—This means that power and light can be had in any part of the building, buildings or yard, permanent or temporary without regard to structural conditions. Numerous belts obstruct light, whether natural or artificial.

Elasticity in the arrangement of tools.—Tools can be arranged to the greatest advantage for sequence of operation in routing work and for light as well as for compactness when necessary.

Ease of adding new tools and of moving and rearranging tools.—Ease of adding new tools means a great deal in growing plants. Rearranging becomes necessary after reasonable growth or to improvements in methods of manufacture which call for a better routing of work.

Head room for cranes, hoists, etc.—For example, note the expensive manner in which work is often handled because of belt or shafting interference with the installation of cranes or hoists.

Facility for running only such tools as are required, for overtime work.

To a large extent the elimination of belts and belt troubles.

Unobstructed light and sanitation.

Under modern structural conditions, avoidance of the well-understood difficulties of line shaft installations in concrete buildings.

The general use of high-speed steel has made it not only possible, but necessary, for economical production that the cutting speed be increased in order to meet competition. Increasing the cutting speed means more power and while much has been said from time to time regarding the increased production and saving in power due to applying power direct to the tool, yet the writer has very serious doubts if anything like the real importance of this direct application of power is realized in many cases even by those who are advocating it. For instance, the saving of power is looked upon generally as a matter of how much can be saved of the transmission friction load, and though this saving may amount to 50 per cent., it is in many cases only a part of the real saving, as proved by numerous tests made by the writer.

The slipping, due to a belt not being able to pull its cut, means waste power and loss of production. If the cut be heavy enough the maximum slip will be reached when the machine is stalled, the power input remaining approximately the same, the loss being entirely one of friction due to slip in the belt. A familiar illustration of the above is that of an operator decreasing the depth of his cut on account of slow down, because the belt will not carry the load. A natural answer to this would be to increase the size of the belts. This will suffice in some cases, but there are numerous instances where either there is not room to increase the width of the belt or if step cones be used the number of steps will have to be decreased and means (such as multiple counters or additional gearing) taken to complete the speed range. Further, it is difficult to shift large belts, and this method generally results in much loss of productive time. Tools that are limited in their production because of the lack of power at the tool are a source of great expense to the manufacturer, not only on account of the unproductiveness of the tool, but on account of the excessive labor expense due to the additional time required. The power cost of the production is comparatively small, roughly, varying from one to three per cent., while the labor cost is usually a very heavy item of the production cost, say, fifty per cent. or upward. If, therefore, by increasing the power on a given tool its output can be increased, the conclusion is obvious.

Up to a few years ago in the majority of shops where motors were used they were usually belted to the lineshaft or countershaft of the tool. Adjustable speed motors were not so commonly used then as now nor were they made in the great variety of sizes and speeds now obtainable. To-day, especially in the case of new tools with their requirements of high power and close speed regulation, it becomes not only more convenient, but in many cases almost a necessity to apply the motor directly to the tool.

In driving tools with individual motors it will be noted that the motor not only supplies the power and speeds best adapted to the tool, but that in the case of the variable speed tools the speed range of the adjustable speed motor, alone, will in many cases cover the entire speed range of the tool. The motor and its controlling apparatus should, whenever possible, be connected direct to the tool, thus making a compact unit which has also the additional advantage of allowing the tool to be moved by simply disconnecting the leads and connecting them in the new position. In the case of portable tools this, of course, is an absolute necessity.

Many tests have been and are being made to determine the kind and horse-power of motors that should be used for different types and sizes of tools, but up to the present time the motor is generally thought of only as a means of driving the tool and not as to its possibility of becoming one of the main elements of the tool construction. Recent motor improvements will produce many new designs in tools with corresponding higher efficiencies.

While there are numerous motor applications to machine tools which are a decided credit to the machine designers and for which due credit should be given, there are still many motor applications where it is only too plainly seen that the motor is an ofter-thought and thus much of the advantage of the application is lost. In order to derive the greatest advantages from the motor drive, the motor should, as far as possible, be direct-connected to the machine. For example, a recent up-to-date motor application to a machine in common use and one that had been motor-driven for several years, abolished belts, three sets of bevel gears, two splined shafts and considerable other gearing; the motor being applied directly to the machine spindle. There are to-day many cases where motors are driving machines through unnecessary auxiliary apparatus such as belts, gearing, etc. This additional apparatus not only takes up valuable floor space and wastes power, but fails to give the maximum output available when the motor could be connected directly to better advantage and in some cases at actually less cost. From the foregoing it will be seen that the advantages derived from an up-to-date direct method of applying the motor not only increases the productiveness of the tool, but decreases the actual power required to the extent of the friction load short circuited, and also decreases the first cost of the motor on account of the less capacity required. The writer knows of cases where improved drives have cut the power required to half and even less. A cheap first cost is often an expensive investment.

The advantages of the individual motor drive for large tools and for certain of the smaller tools have been conceded for years, but there are many tools where either the cost of the motor or the cost of applying the motor to the tool on account of the construction of the machine is prohibitive. The motor should be a part of the tool rather than a mere addition to it.

Better drives are possible now than formerly, due to the greater motor speed ranges obtainable and to the decrease in dimensions per horse-power of the motors, to more perfect balance of the rotating parts and, to a certain degree, to improvements in gears which allow higher speeds without excessive vibration and noise.

The improvements in control appliances have kept pace with the motor development. Much more exacting requirements of both motor and control are now demanded. Motors driving machines reversing ten times per minute, twenty-four hours per day are now not uncommon. Duty cycles that were impossible to meet only a short time ago are now not only practicable but common. With the great variety of motors and controllers now on the market and the large quantity sold, sometimes without the manufacturer even knowing for what service they will be used, it would be surprising if trouble did not occasionally occur.

Much of the success of a motor-driven machine depends on its control. Magnetic control, which is coming into more general use than formerly, somewhat complicates the control situation. While the possibilities of magnetic control are infinitely greater than the older types of control, likewise the chances for misapplication are greater. However, as the characteristics of the different types of control become better known these complications will disappear.

In the report of Mr. J. McLeish, issued by the Department of Mines, Ottawa, on Economic Minerals and Mining Industries of Canada, the production in 1912 of the three following minerals was as follows:—Lead, 35,763,476 lbs., at the value of $1,597,554; Corundum, 1,960 tons, at the value of $239,091; graphite, 2,060 tons, at the value of $117,112.

In the report of Mr. J. McLeish on Economic Minerals and Mining Industries of Canada the following statistics are given for 1911 and 1912 for the total value of the outlay of clay products in the following provinces, thus:—In British Columbia, for 1911, $675,505, for 1912, $996,568, showing an increase of $321,063; in Alberta, for 1911 $1,052,751, for 1912, $1,356,184, showing an increase of $303,433; in Ontario, in 1911, $3,916,575, in 1912, $4,864,700, with an increase of $948,125; in Quebec, in 1911, $1,341,467, in 1912, $1,680,300, with an increase of $338,833; in Nova Scotia, in 1911, $274,-249, in 1912, $272,053, showing a decrease of $2,196.

SWEDISH WATER POWERS AND THEIR UTILIZATION.

In respect of total water power Sweden ranks third among European countries, coming next after Norway and Austria-Hungary. Dr. Helmer Key, a recent writer on the trade and resources of Sweden, states that the water power is equal to 4,000,000 h.p. or 5,000,000 h.p.; while that of Norway is five or six millions, and that of Austria-Hungary four to six millions of horse-power. The Swedish waterfalls are more difficult to exploit than those of Norway, which are usually higher and more compact; but have often the advantage of flowing from the great lakes, which form natural storage basins. The horse-power already harnessed amounts to 600,000 or 700,000 h.p., of which about half is converted into electricity, to be transmitted to a distance, and the rest is directly employed upon water wheels for use on the spot or at a short distance. Almost all the towns are lighted by electricity, or will be so lighted shortly. A great part of Central and Southern Sweden is now intersected by electric conduits belonging to the State or to private enterprises. Electric energy is frequently used for small industries and for agriculture, though for the latter purpose it is far from general. The Government power stations are much more important than the private concerns. In 1893 the State was whole or part proprietor of 800,000 h.p. of waterfalls, and since that date many more falls have been acquired. A plan has been elaborated for electrifying the railways, but can only be completed in the distant future. A power station has been erected at Trollhättan, to tap one of the largest falls in Europe, yielding about 200,000 h.p. The State has alreads invested nearly a million sterling in the enterprise. It has been intended to transmit part of the current at high tension to Copenhagen, but home consumption seems likely to render this unnecessary, and it is expected that the power provided by this fall will act as a potent stimulus to industry in South and Central Sweden.

Probably the industries which will benefit most from the utilization of water power are those connected with iron and steel. Other metal industries, too, as well as the industries which use timber for their raw material, will doubtless receive great encouragement. For centuries Sweden has been one of the most important mining countries. Time was, indeed, when it was the chief producer both of iron and of copper. The production of copper is now small, for the well-known Falun miners are becoming exhausted. But the output of iron ore has never been so great as it is to-day. The Swedish smelting industry suffered severely from the discovery that iron ore could be smelted with coke instead of with charcoal; but in recent years the output of pig-iron and steel in Sweden has increased rapidly, partly because the native ores are exceptionally pure, and the demand for high-grade steel enables charcoal smelting to be conducted profitably. The mean production of pig-iron grew from 177,000 tons per annum in the years 1856-60, to 471,147 tons in 1891-5, to 528,255 tons in 1901-5, and to 615,778 tons in 1907. The extent to which the crude ore is worked up in Sweden is, however, still very limited. A large amount of ore is exported in the raw state, mainly to Germany. Of the pig-iron produced in Sweden a large amount (134,000 tons in 1910) is also exported, though it is true, on the other hand, that a considerable quantity of foreign pig-iron for foundry purposes is imported. About 60 per cent. of the pig-iron produced in Sweden is said to be manufactured into steel—the best steel in the world. The iron smelting plants consist of a curious mixture of large and small furnaces, the new existing side by side with the old, but the old furnaces are rapidly being driven out of the trade. The use of electricity in the smelting of iron and other ores is one of the most momentous questions of the day in Sweden, for the solution of the difficulties connected with this matter would signify that a further step had been taken towards counteracting the absence of coal. Already water power, converted into electric energy, performs many of the same industrial functions as coal, but the progress of invention can, of course, never make the two completely interchangeable. Some success has already been achieved in the smelting of iron in electric furnaces during the last few years. As a general rule, however, the electric process is suitable only for making iron of good quality, and the process can only compete with blast furnace smelting if water power is cheap. Phosphorus is not eliminated by the electric process, but as the consumption of charcoal, which contains phosphorus, is barely one-third of what is used in ordinary blast furnaces a smaller quantity of phosphorus is found in the pig-iron. Sulphur is not eliminated either in electric smelting, and to produce the best quality of iron it is necessary to use ore with little or no sulphur. Electric pig-iron is suitable for conversion into steel in open-hearth furnaces.

The most important iron mines in Sweden are situated in the province of Norrbotten, within the Arctic circle, in a district which, until the opening of the iron mines, was inhabited only by Nomad Laplanders. The deposits are amongst the largest in the world, and are believed to contain several thousand millions of tons of workable ore. They have been known for centuries, but their exploitation dates only from 25 to 30 years ago, when a railway was built to carry the iron to the coast. The most important mines are those of Gällivara, Luossavaara, and Kürunavaara, the two later forming part of the same deposit. At many points the ore crops up on the surface. The Tuolluvaara mine is another important mine, and is exploited on behalf of some blast furnaces in Central Sweden. There are several mines belonging to the State. The Norrbotten ores all contain a very high percentage of metal, amounting in every case to at least 60 per cent., and sometimes 68 per cent. or 69 per cent. or more. The amount of phosphorus is also usually high, but there is some ore with a proportion of only .05 per cent. of phosphorus. The proportion of sulphur rarely exceeds .05 per cent. to .08 per cent. The iron district of Norrbotten is owned by the Trafikaktiebolaget Grangesberg Oxelösund, a company which forms a sort of iron ore trust. It does not, indeed, control the Swedish market, but is said to exercise a close control over the export of Swedish ore, or at least of the ore rich in phosphorus. In 1907 an agreement was reached between the State and the company regulating the export of ore. The company was to have the right to increase its export each year until the end of 1921, in such a manner that the total export in 1921 and during each of the following 10 years would be 5,100,000 tons. At present only a very small part of the Lapland ore is smelted in Sweden. The rest is exported, principally via the port of Narvik, which is open all the year round, to England, Germany, Belgium, and France. In 1909 the United States began to buy Swedish ores, and it may be expected that the new American tariff will encourage this trade.

PRODUCTION OF POLES AND CROSS-TIES, 1912, IN CANADA.

THERE were 608,556 wooden poles reported in Bulletin No. 39, Forestry Branch, Department of the Interior, as having been purchased in Canada in 1912. This number is an actual increase of 22,853 poles, or 3.9 per cent. increase over the figures for 1911. While this increase is slight, it follows a decided decrease from 1910 to 1911. The average pole has a life of at least ten years, and the demand for poles is, therefore, more or less intermittent, depending on the building of new pole-lines.

Altogether nine kinds of wood were reported for poles in 1912, with Eastern cedar heading the list as in past years. Cedar has been, and probably will be for some time, the most popular wood for telegraph, telephone, and other pole-lines, although the purchases in 1912 show a decrease. Wood for this purpose need not be especially strong or hard, as there is little or no mechanical strain to be endured. Durability in contact with the soil, lightness and a slender tapering form are most essential, and cedar seems to fit those requirements better than any other native wood used in an untreated state.

The use of the British Columbia species of cedar has increased in the last few years with the decrease in the supply of poles of the Eastern species in the greater length-classes. While these poles are not so strong or so durable as those of Eastern cedar, they can be obtained in greater lengths, and the source of supply is more easily accessible. The two species of cedar together formed over 85 per cent. of the total.

Balsam fir was reported for the first time in 1912. This wood is being used more and more each year for all purposes, especially in the Maritime Provinces where the supply of pine is beginning to fall below the demand. As far as form and lightness are concerned, this species should make excellent pole material if its lack of durability were made up for by some preservative treatment. Increases are noted in the use of Western cedar, tamarack, spruce, and chestnut, with balsam fir added to the list; and decreases in the use of Eastern cedar, jack pine, Douglas fir and hemlock. No poles were reported in 1912 of red, white or yellow pine.

The average value of poles in 1912 was $1.83, an increase of only 3 cents over 1911. A slight increase was recorded in the case of Eastern cedar, and other increases were in the value of poles of spruce and jack pine. All other kinds of wood decreased in value and the balsam fir reported in 1912 was valued at an average price below the general average for 1911.

Steam railways, and telephone and telegraph companies reported the purchase of 549,560 poles in 1912. This number is an increase of 5.4 per cent. over the total for 1911, and is noticeable in the cases of Western cedar, tamarack, and the newly added material, balsam fir. All other woods show a decrease in number, although Douglas fir and chestnut were added to the list of woods purchased by steam railways. The average value of $1.51 per pole is an increase over that of 1911. The average values of poles purchased by this class of pole-line companies is always less than with the electric railway, power, and light concerns, as the steam railway and telephone companies are usually closer to the source of supply and purchase their poles in greater quantities. They also use more poles of the shorter length-classes. These companies used all the poles purchased of balsam fir, tamarack, jack pine, Douglas fir, and chestnut. They purchased 90.3 per cent. of all the poles used.

The electric railway, power, and light companies purchased a total of 58,996 poles, 9.7 per cent. of all the poles purchased in 1912. This number is a decrease of 5,135 or of over eight per cent. from the total in 1911. These companies used only four kinds of wood, namely, cedar (Eastern and Western), spruce, and hemlock. Hemlock was not reported in 1911 by these companies, and poles of Douglas fir, chestnut, yellow pine, and tamarack reported in that year were dropped from the list in 1912. The electric companies, as a rule, purchase the best class of poles of the greatest length and seldom obtain their supply locally. These facts are probably responsible for the high values, the average value per pole of $4.79 representing an increase of 24 cents over 1911.

Of the total 608,556 poles, 66.1 per cent. were from 20 to 25 feet in length and were valued at $1.15. Over twenty per cent. were in the 26-to-30-foot class, and were valued at an average of $2.42. In the 31-to-35-foot class, 7.8 per cent. of the poles were placed, and these were valued at $4.01. The 36-to-40-foot poles formed 3.4 per cent. of the total, at $5.38, and the poles of 40 feet and over, at a value of $6.68, made up the remaining 1.5 per cent.

Cedar poles formed the greater part of each length-class and made up practically all the poles in the greater length-classes (36 feet and over). Tamarack and spruce poles were also used in the greater length-classes and formed a large per cent. of the poles between 26 and 35 feet. The jack pine poles were all in the 26-to-30-foot class and practically all the poles of Douglas fir, chestnut, and hemlock were less than 25 feet in length.

The spruce and chestnut poles in the greatest length-class (40 feet and over) were purchased for special purposes, and their low prices do not indicate their relative value.

Many of the pole-line companies use preservative treatments of different kinds to prevent decay and insect injury. These include impregnation of the butts of the poles with creosote, zinc chloride and other chemicals. In some cases the bark is left on that part of the pole which comes into contact with the soil, and this tends to increase the life with some kinds of wood. Painting the butts of the poles with hot tar or creosote will increase their life by several years. Many companies have found that the increased life which is secured by preservative treatment brings about a considerable saving in the annual cost of the upkeep of a pole-line. By thorough treatment with preservatives many non-durable woods, such as balsam fir, are being used satisfactorily where their use in an untreated state would not have been possible.

Cross-Ties.—There was purchased in Canada in 1912 a total of 21,308,571 cross-ties. This was an increase in actual numbers of 6,919,347, or a 48.1 per cent. increase over 1911. This increase took place on almost all the railways in Canada and was especially noticeable on transcontinental lines.

Nineteen different kinds of wood were used, with jack pine still leading. The use of each material increased from 1911 with the exception of Eastern spruce and red pine. Balsam fir and Western spruce were added to the list of woods in 1911, and poplar and black ash were dropped.

The use of the cedar tie has varied greatly from year to year. In 1908, 1909, and 1910, cedar ties headed the list, although the numbers purchased showed decreases each year. In 1911 cedar ties formed only 10 per cent. of the total and fell back to fourth place on the list. In 1912 the use of this material increased by some 1,898,710 ties, and this wood moved up to second place on the list, forming 15.6 per cent. of the total.

Douglas fir has steadily increased in use since 1909, when data concerning its use were first obtained. Oak and the other five hardwoods—chestnut, beech, maple, birch, and elm—have also increased remarkably. There seems to be a tendency on the part of the management of older-established steam railways to reduce the use of soft, light material for cross-ties, especially where fast trains and heavy rolling stock are used. Some of the eastern roads have ceased to purchase cedar, pine, hemlock, and tamarack ties and use only the hardwoods. The use of imported hard pine has increased with the hardwoods, and that wood was used in making 3.1 per cent. of the ties purchased in 1912. Western larch formed 5.6 per cent. of the total number, over a million ties of this wood having been purchased.

The average value of ties, at the point of purchase, increased from 39 to 44 cents in 1912. Increases are noted in the case of jack pine, cedar, hemlock, tamarack, Eastern spruce, chestnut, beech, maple, white pine, birch, red pine, and elm. The increases in the values of beech, maple and birch were probably due to the fact that ties of these three materials were treated chemically in considerable numbers to prevent decay, and their cost materially increased on this account. The decreases were in the values of Douglas fir, oak, hard pine, and Western cedar. Western larch ties were purchased at the same price as in 1911.

The values in all cases, being based on the cost at the point of purchase, can never be considered to represent exactly the relative values of the different kinds of wood for cross-ties. So many variable factors enter into this cost that only in those cases where ties of a certain kind of wood are used in large numbers can the values be said to indicate the intrinsic value of the material.

Steam railways in 1912 reported the purchase of 20,825,209 ties, this number forming 97.7 per cent. of the total for all Canada. The total is an increase of 7,025,227 ties, or an increase of 50.9 per cent. over 1911.

Steam railways paid an average price of 44 cents for their ties as compared to 50 cents paid by the electric lines. The steam railways paid less for every kind of wood used by both classes, with the exception of Eastern spruce. These companies are usually closer to the source of supply, buy in greater quantities, and have better facilities for transporting their tie material than have the electric roads. The steam railways used all the ties purchased in Canada in 1912 of the following kinds of wood: Western larch, chestnut, beech, maple, birch, red pine, and balsam fir.

It is interesting to note the increased use of hardwoods by steam railway companies. In 1911, woods such as oak, chestnut, beech, maple, birch, elm, and black ash together formed only 1.8 per cent. of the ties purchased. In 1912 this percentage increased to 6.7 per cent. through increased purchases of 1,148,578 hardwood ties.

Electric railways in Canada reported having purchased 483,362 cross-ties in 1912. This is a decrease of 18 per cent. from 1911, and, where the purchases of these railways in 1911 amounted to over four per cent. of the total, they formed less than three per cent. in 1912. As stated previously, the values of ties of every kind of wood used by both classes of roads were greater in the case of steam railways, with the single exception of Eastern spruce.

The greater part of the material used by these companies was of the softer, lighter woods. Coniferous woods formed together 99.4 per cent. of the total. The only hardwoods used were oak and elm and these together formed only 0.6 per cent. of the total. Imported hard pine, however, is used to a slight extent, and this material is, in reality, much harder than many of the native so-called hardwoods.

Decreases in the number of ties purchased by electric railways are noticeable in the case of cedar, Douglas fir, oak, and white pine; and these woods together form the bulk of the material used. Increases are seen in the use of hemlock, tamarack, jack pine, and Eastern spruce.

Ties of Western cedar, Western spruce, hard pine, and elm were reported for the first time in 1912. The use of red pine, and chestnut was not reported by electric roads in 1911. These companies used all the Western spruce ties reported in 1912.

Preservative Treatment.—Many Canadian railway companies are now beginning to realize the value of preserving at least a part of their tie material from decay and insect injury. The practice of chemical treatment of railway ties has been carried on by railways in the United States for some years with apparently satisfactory results.

The practice in Canada is just beginning, but is increasing rapidly with the increasing cost of tie material and the constantly decreasing supply. In 1910 practically no treated ties were used by Canadian railways. In 1911 some 206,209 ties received chemical treatment before being placed in the roadbed. This number, while forming only 1.4 per cent. of the total number of ties used, was, nevertheless, an indication of the increase in this particular form of conservation. In 1912 a total of 1,818,189 ties were chemically treated. This number forms 8.5 per cent. of the total number of ties purchased. Steam railways used 1,798,189 of these treated ties and electric roads used 20,000.

The treated ties were mostly hardwoods, as it has been found more economical to treat the heavier, stronger woods than those which are liable to fail from mechanical wear before they have time to decay. The greatest actual saving by preservative treatment is found in the use of the so-called "inferior woods," provided that these are properly protected from mechanical wear. Until the price of the durable woods becomes excessive, the railway companies will not resort to expensive treatment of inferior woods on account of this cost of protecting them from mechanical wear.

SERIOUS RIVER POLLUTION IN SCOTLAND.

During the recent drought the necessity of purifying some of the rivers in the Border district of Scotland was very obvious. In one short stretch of the River Ettrick, extending for about a quarter of a mile opposite the burgh of Selkirk, five spinning mills, four dyeworks and seven tweed-weaving factories were discharging waste liquids into the river or into a mill lade which in turn discharged into the river; while the burgh gas works stand on the edge of the mill lade. The river being very low these polluting materials were not carried away as is usually the case, and the result was an accumulation of the waste matters from all the works and the poisoning of large numbers of fish.

SAND TRAVEL IN HARBORS.

AT the Birmingham meeting of the British Association a paper by Ernest R. Matthews, entitled "Harbor Projections and Their Effect Upon the Travel of Sand and Silt" was read to the Engineering Section. The author pointed out that any seaweed projection on a coast has the effect of arresting or more or less checking the travel of the sand, whether the projection is a groyne extending to low-water line, a breakwater, a harbor pier or arm of 1,000 ft. in length, or a natural promontory extending some miles from the coast line. In the case of harbor arms extending at right angles to the coast, this obstruction (especially on a sandy shore) impounds the travelling material on one side and often causes serious erosion on the other side. The sea-front at Yarmouth, Shoreham, Lowestoft and other places has extended seaward during the past half-century, the first mentioned, at an average of 300 ft., due almost entirely to the construction of the harbor.

At Madras (India) 650,000,000 cu. ft. of sand have accreted on the south side of the harbor within a distance of three miles of the harbor, and 450,000,000 cu. ft. of land has been eroded in the north side within a similar distance. The Madras authorities are now contemplating an extension of the harbor seaward at an estimated cost of about $15,000,000 in order to reduce the extent of the silting of the harbor.

The only method of escaping from the impounded material seems to have been to periodically extend the arm of the harbor further seaward, as proposed for Madras. This means a tremendous cost, and the results are often not satisfactory, for as the pier is advanced the shore also advances. It has been suggested that openings should be left through the shore ends of the harbor arms, for the sand to pass through. This is not practicable, for immediately the travelling material passes through the opening the wave behind it does not possess sufficient force to move the material through, especially where the width of the harbor is considerable.

The author suggested that in order to modify this trapping of the sand the piers should not run out at right angles to the coast, or approximately so, but on the side facing the direction of the travelling material should project from the coast at an angle of 45 degrees. The additional area thereby enclosed by the harbor piers could be utilized, among other purposes, for that of wharfage. The travelling material would, he stated, pass around the harbor projection if the plan of the harbor was on these lines, and would supply the coast on the lee side of the harbor with a natural protection of sand and shingle.

In another paper, entitled "The Transport and Settlement of Sand in Water and a Method of Exploring Sand-Bars," and illustrated by experiments, Dr. John S. Owens dealt with certain phenomena accompanying the movement of sand in water.

Sand ripples were shown travelling under the influence of a current; the grains being swept by the current from the back of the ripple and deposited on its face, the ripple-form moved forward with the current by a process of erosion of its back and accretion of its face. This was demonstrated by means of a trough with semi-circular ends and a longitudinal partition in the middle, thus forming two channels. The water was made to circulate up one channel and down the other, and the movements of the ripples were seen on the sand forming the bottom. The formation of quicksands was illustrated by means of a tank containing ordinary sea-sand, and it was shown that when water was caused to flow upwards through the sand the latter acquired all the properties of a quicksand and swallowed heavy bodies placed thereon. The effect of obstacles lying on a sandy bed in the path of a current was demonstrated by means of a model. Stones, models of piles, and improperly made groynes were placed on sand in the path of a current in a small glass tank, and localized erosion around the obstacles resulted in each case owing to the deflection and increased local velocity of the current. The curious effect of suspended matter on the specific gravity of water was illustrated by means of a glass cylinder containing water in which sand was shaken up; it was shown that while the sand was suspended the specific gravity, measured by a floating hydrometer, was raised above that of water. The influence of such a rise in specific gravity in increasing the intensity of impact of the water, and consequently its erosive power, was indicated.

A tall glass tube filled with water was exhibited, and in this bodies of different shape were allowed to sink; in every case, whether discs, rectangular plates or rods, the bodies settled in the position offering the greatest resistance to movement. It was shown that this property might result in more rapid settlement in running than in still water, and also in a cleavage in sedimentary rocks.

A model of an instrument for exploring sand-bars and river-beds, which was also shown, consisted of two tubes arranged concentrically, connected at the top, but separate at the bottom. A cock-and-hose attachment was fixed on the upper end of the inner tube, and a second cock, with a spout, communicated with the top of an annular space between the two tubes. At the bottom the inner tube ended a short distance above the end of the outer tube. Water, if forced down the inner tube, must pass out at the bottom when the cock to the annular space was closed; in this case the instrument sank if placed on a sandy bottom. When at any desired depth the cock to the annular space was opened the water returned up the outer tube, carrying a sample of the sand with it, and delivering the sample from the spout. By means of this instrument the depth and nature of bars and shoals might be easily ascertained.

HAMMERED PISTON RINGS.

If the rings on a piston are not accurately turned and ground, so as to make a steam or gas-tight joint between it and the cylinder walls, the efficiency of the engine will be impaired, power will be lost, and consequently fuel will be wasted. If the tension of the ring is not approximately the same at every part it will exert greater pressure in one direction than in another; the cylinder will be worn out of shape and soon require re-grinding or re-boring. Further, an unevenly-tensioned ring produces friction, and so causes loss of power.

A special form of piston ring which is claimed to possess many advantages is being made by a patented process, by which the rings are of the same thickness throughout their periphery; and as they are machined concentric, they are seated uniformly in the grooves provided in the piston. Special plant is, of course, necessary for the manufacture of the rings, and a patented system of hammering is used whereby, it is stated, the spring action of the concentric rings can be reduced to a minimum without affecting their efficiency. The result of the hammering is to ensure a perfectly even and constant pressure on the walls of the cylinder. The rings, which are of cast iron, are accurately ground after hammering and are supplied ready for use.

LOCK WORK ON THE PANAMA CANAL.

The placing of concrete in the locks of the Panama Canal has covered a period of approximately four years. It began on August 24, 1909, at Gatun; on September 1, 1909, at Pedro Miguel; and, with the exception of 102 cubic yards laid in 1909, at Miraflores in July, 1910. The end of the fourth year sees the concrete work at all locks practically completed.

Mass masonry at Gatun and Miraflores Locks was completed in the latter part of May, 1913, and at Pedro Miguel Lock, several months earlier.

The work at Gatun since September 1, 1912, as summarized in The Canal Record, has comprised building the lower wing and approach walls, and completing the upper approach wall, which was within three per cent. of completion a year ago.

At Pedro Miguel, during the same period the approach and wing walls at the upper end and the east wing wall at the lower end, were built, and the lower approach wall was extended about 300 feet.

At Miraflores, the lower lock, which was about half done on September 1, 1912, was brought to completion, and the wing and approach walls at both entrances were begun and completed.

Recent and future concrete work at the locks embraces a multitude of relatively small finishing operations around machinery and tracks, etc. Portable mixers are being used in the remaining construction. All of the large mixing and placing plants have been closed and are being dismantled.

Lock Gates.—Over half of the material in the lock gates was erected during the past 12 months. On September 1, 1912, the total quantity erected at all locks was 24,787 tons, or 42 per cent. of the required 58,000 tons; to-day, the lack of completeness of erection is designated by fractions of one per cent. Since September 20, the gates of the west flight at Gatun, and the east flight at Pedro Miguel, have been ready for the passage of vessels, and the west flight at Miraflores Locks was practically completed by the end of the month. All gates at Gatun and Pedro Miguel are to be mechanically completed by January 1, and at Miraflores by March 1, 1914.

Gate works at the locks began on March 21, 1911, in preparing the bearings for the upper guard gates at Gatun. The erection of these leaves began on May 17, 1911, and they were the first to be swung closed. This occurred on August 4, 1912, and the footwalk over them was completed in September, 1912. A year ago, all the leaves in the upper and intermediate levels at Gatun had been erected to full height, and work had just begun on the safety gates in the lower level and the lower guard gates. The first girders for these eight leaves were placed on August 29, 30 and 31, 1912; the lower guard gates were closed, and sea water admitted against them, on June 14, 1913. On September 1, 1913, erection, reaming, and riveting for the gates of Gatun Locks were all within less than one-half of one per cent. of completion.

At Pedro Miguel, gate work began at the upper guard gates, on August 7, 1911. On September 1, 1912, these gates had just been closed, the skeletons of all leaves were at full height, and those in the upper level had been sheathed. To-day, erection and reaming for all gates are within one per cent. of completion, and the finishing work is over 80 per cent. completed.

At Miraflores Locks, work on the gates began first on the upper guard gates and the safety gates of the upper level, in August, 1912. The upper guard gates were closed about the middle of June, 1913, and the lower guard gates on August 20, 1913. At present, all 28 leaves have been erected to full height, reaming is 98.5 per cent. completed, riveting, 90 per cent., and finishing, about 65 per cent. completed.

Emergency Dams.—The emergency dams are to be held in reserve for exigencies if the lock gates should get beyond control and allow a rush of water through the flight. The floating caisson dams are for use only when the water is under control, and are not attached to the lock structures; the first of these is now under fabrication at the Union Iron Works at San Francisco, and will be towed to the Isthmus when completed.

The placing of steel in the emergency dams began in August, 1912, with the laying of the circular track and pivotal base for the east dam at Gatun. Erection of superstructure proceeded directly thereafter and the dam was completed, except for final painting, in May, 1913. The contractor, the United States Steel Products Company, began the final operating tests on May 20, under supervision of testing engineers of the Canal Commission. Erection of the west dam at Gatun began about the middle of November, 1912, and tests were completed on August 15, 1913. This dam was swung across the chamber, and its wickets and gates dropped into place, in 35 minutes. Trained operators will be able to do this in 30 minutes, or less.

At Pedro Miguel, erection of the west dam was undertaken first, beginning on February 1, 1913. This structure was first swung across the approach chamber on September 2, and is now under test. Erection of the east dam, which began on April 1, is about 98 per cent. completed, and the structure will be ready for testing by the time the tests on the west dam are completed.

The Miraflores east dam erection began on June 1, and that for the west dam on July 1. All material for all of the dams, weighing a total of 13,400 tons, had arrived on the Isthmus by August 1, and erection was 80 per cent. completed on September 1, being practically confined to the two dams at Miraflores. These are slightly lighter than those at Gatun and Pedro Miguel, because of the lower head of water against which they will be used; each of them weighs approximately, 1,987 tons, as compared with 2,305 tons at Pedro Miguel and Gatun Locks. The east dam at Miraflores will be finished the latter part of October, and the west dam in November.

Operating Machinery.—In addition to the masonry, gates, and emergency dams there is a great amount of auxiliary machinery contained within the machinery rooms and operating galleries of the walls or in the culverts. This apparatus embraces the rising stem gate valves, which control the flow of water in the 18-foot culverts at the bottoms of the side and centre walls; the cylindrical valves, controlling the 6-foot culverts which run laterally from the wall culverts and pass water to the lock chambers, through the floors; the auxiliary culvert valve machines, which control the flow through a short auxiliary culvert designed to maintain the water at the same elevation on both sides of the upper guard gates; the guard valves and machines, controlling the intake of water into the side wall culverts at the upper end of the locks; the miter gate moving machines, to swing the leaves of the gates; the miter forcing machines, to draw the leaves tightly together when closed, and prevent leakage; the mechanisms which cause the handrails on top of the leaves to fold down when the leaves are swung back into their recesses in the walls; the pumps for unwatering sumps in the miter gate leaves, and in the pits of the fender chain machinery rooms; the machinery for actuating the fender chains, at all upper and lower guard gates, and at the intermediate and safety gates in Pedro Miguel Lock and upper chambers of Gatun and Miraflores Locks; the tracks and conductors for the towing locomotives; and the posts for the illumination of the locks.

Ancillary to the foregoing is an elaborate system of electrical generation and transmission to the transformer rooms in the lock walls, from which power is distributed to the various motors, and the interior and exterior lights. The opening motors number 334 at Gatun Locks, 206 at Pedro Miguel, and 252 at Miraflores; and at each set of locks their operation will be managed from a central control house.

All of this work, as well as the installation of operating machinery in the spillways for Gatun and Miraflores Lakes, controlling 22 "Stoney" gates, each 47 feet long by 19 feet high, has been carried on by the erection subdivision of the First Division of the Office of the Chief Engineer.

SANITARY SURVEY OF RIVERS.

By R. O. Wynne-Roberts,
Consulting Engineer, Regina.

A BULLETIN of the Illinois State Laboratory of Natural History, published last June, comprises an article by Mr. Stephen A. Forbes, Ph.D. LL.D., and Mr. R. E. Richardson, A.M., which is a compilation of scientific information on the biological and chemical analyses of the Illinois River. It is well known that Chicago constructed a huge drainage canal at a cost of $50,000,000, including power-plant, to dispose of its sewage by dilution. This sewage discharges into the river near Lockport.

The article is comprehensive, covering over one hundred pages, and the reader who desires details that are not contained in the following review is advised to obtain a copy of the bulletin. As much attention is now being paid to the purification of rivers, the writer has deemed it of interest, and perhaps of service, to review the work done by the authors of the article, which is largely referred to, in the following paragraphs, by extracts and references:—

"The Illinois River is peculiarly characteristic of the State of Illinois, and, next to the prairies, is its leading natural feature. The level richness of the central plateau of the State is reflected in the turbid waters and the broad, sluggish current of the stream; and its wide bottom-lands, originally covered with huge trees, completely flooded when the river is highest, and holding many marshes and shallow lakes at its lowest stages, are a relic of the time, not so very far remote, when the limpid waters of the Great Lakes rolled down its valley in a mighty flood on their course to the southern gulf. It was not an accident that this river was the first great artery of transportation into and through the State, or that the first colonial settlement and the first fortified post in Illinois were established on its banks. After the railroads had deprived it of its commerce it was discredited and neglected for many years, and the second city in the country and the second city in the State have long used it as a mere convenience for the discharge of their organic wastes.

"These are temporary conditions, however, and the time seems now at hand when the people of Illinois will learn to appreciate and develop this great gift of nature in the various directions in which it may be made to serve their interests and their pleasures. Its frequently beautiful and occasionally picturesque scenery is attracting more attention every year; and when, as is sure to happen in due time, a superior highway follows its course between Chicago and St. Louis; when the attractive building sites on its banks are relieved, as they now might generally be, from the midsummer plague of mosquitoes; when its most interesting situations are converted into parks, and its fisheries are protected and enriched by means of State reservations for the breeding and feeding of fishes; and when, as must eventually come to pass, it becomes once more an indispensable central link in a principal line of traffic between the Great Lakes and the Gulf, it will take for all time, for the State at large, the place which Lake Michigan now holds for our greatest city.

"The senior author of this work began work as a biologist, on Illinois River problems, some thirty-six years ago; and the junior author has virtually lived on the river for purposes of investigation during the last four years. The Natural History Survey of the States has published in the meantime more than 2,500 pages of contributions to its biology; and it is now rounding this work to a close, and bringing its results to bear, in practical ways, upon the economic problems most pressing and important at the present time.

"**Objects of the Investigation.**—The Illinois River work of the Natural History Survey, pursued at irregular intervals since 1877, became virtually continuous at Havana for five years, from April, 1894, to March, 1899, after which it seemed expedient first to diminish, and in 1903 to suspend, field operations in order that more important scientific results might be organized, reported, and published.

"The opening of the Chicago Drainage Canal in 1900 was a revolutionary event in the biological history of the river; and, as the most important period of our earlier work was that immediately preceding this event, an examination of its consequences to the general system of aquatic plant and animal life was an important part of our object in recommencing systematic study. As the Illinois is a rather peculiar member of the great Mississippi River system, it was also much to be desired that comparative studies should be made on the life of the more closely related companion streams; and, as the Illinois is economically one of the most productive rivers in the United States, it was evidently time to study the subject of the conservation and possible increase of its values in the light of the knowledge we had gained, and intended to gain, of its physical, chemical and biological conditions and requirements.

"The reports of the work of the earlier period were largely on the minute plant and animal life of the stream —its so-called plankton—which forms a considerable part of the food of many kinds of fishes, and nearly all the food of the young of almost every kind; and the plankton product of the waters of the Illinois under the new conditions, as compared with those prevailing before the opening of the sanitary canal, was one of the first topics to commend itself to us for careful study. Involved in this subject of food production for fishes, river mussels, and other useful aquatic animals, was the economic effect of a great increase in the flow of the stream, the rise in its levels, and the consequent expansion and longer continuance of its overflows, which, there was reason to suppose, might so increase the food supply and enlarge the breeding and feeding grounds of fishes as to increase the fisheries products of the stream. It was also a matter of interest and importance to learn the effects, both direct and indirect, of the increased inflow of sewage by way of the sanitary canal and the Des Plaines, upon the fishes and mollusks of the waters of the stream and systematic collections from it at various points on its course, under various conditions and at different times of the year."

The investigations of special interest to municipal engineers are those commenced in 1911, when chemical determinations and biological collections for an analysis of seasonal conditions on the upper Illinois and in related waters, were begun July 18th, and repeated at frequent intervals until Dec. 13th. Similar trips were made in Feb. and Mar., 1912, for a study of winter conditions; and in July, 1912, an elaborate series of oxygen determinations was made for the entire length of the river. Aug. 21st to Oct. 12th two such series were obtained for the upper Illinois; and in Nov. two more, for the whole system, with comparative tests for the Mississippi, below and above the mouth of the Illinois. The situations thus brought more or less closely into comparison were the sanitary canal at Lockport, the Des Plaines River at the same place and at its mouth (Dresden Heights), the Kankakee, just above its mouth, and the Illinois River at Dresden Heights, Morris, Marseilles (both above and below the dam which crosses the river there), Ottawa, Starved Rock, Peru, Hennipin, and Chillicothe. The distances of these points from the mouth of the Chicago River are approximately as follows, in miles: Lockport, 35; Dresden Heights, 53; Morris, 62; Marseilles, 80; Ottawa, 86; Starved Rock, 95; Peru, 102; Hennepin, 116; and Chillicothe, 145, ninety-two miles of this last-mentioned distance being on the Illinois River itself.

"Finally, in Mar., 1913, samples of the bottom sediments were collected from all the five Illinois River dams, and from some other points in the main channel, for physical and chemical examination, with a view to ascertaining the condition of the river bottom when the river water has been for some months at or near the freezing point."

Messrs. Forbes and Richardson, for reasons stated, take the years 1897-8 and 1909-10 as the basis of comparison of the plankton production and quality of the waters. The above years are before and after the opening of the Drainage Canal, and, as in the former year the plankton was 3 c.c. per cubic metre of water and in the latter 5.07, "we have sufficient reason for concluding that the plankton production of the stream has been largely increased per unit of volume as a consequence of the opening of the drainage canal, and that, so far as the evidence goes, the ratio of the present yield to the former is at least as 5 to 3. Remembering, further, that the most important plankton product is that of the spring months, when the young fishes are hatching from the egg and are dependent upon the plankton organisms for their earlier growth as fry, we find a special significance in the fact that the plankton yield of the river for the months of March, April, May and June was 2.85 times as great in 1910 as it was in 1898.

"If to these facts concerning the increase, in recent years, in the percentage of plankton contained in the waters of the Illinois, we add those concerning an increase in the average volume and area of the waters themselves, we shall see that their total plankton must have been many times multiplied, and that the fisheries of the stream should feel the effects of this greater abundance of this important element of fish food.

"The importance of an abundance of organic matter in the water as a means of producing a rich plankton is, in fact, so well known that growers of pond fishes in Europe deliberately manure their ponds to increase the supply of food for their fish; and there is considerable evidence, also, that the plankton of the Elbe is largely increased by the sewage of Hamburg and Altona poured directly into that stream."

The Des Plaines River near Lockport in Sept., 1911, was heavily loaded with sewage wastes, and septic organisms were at the maximum. "The most conspicuous of these was the well-known fungo-bacterium, *Sphœrotilus natans*, a filamentous form, which grows in long, loose, hanging tufts and branches in septic and polluted waters. The stony bottom of the Des Plaines, between Lockport and Dresden Heights, was carpeted with this plant, and with it were associated a considerable variety of *Protozoa*, all characteristic foul-water species."

Sir Rupert Boyees, F.R.S., the eminent English biologist and analyst, when giving evidence at the High Courts of Justice of England in an important Welsh river pollution case, stated that there are two kinds of sewage fungus—*Sphœrotilus* and *Leptomitus*. The first was probably known by the obsolete name of Beggóatoa Alba. It is like flock or cotton fluff, and flows in the water near the surface. It usually sticks to twigs in preference to stones and gravel, and the information given by Messrs. Forbes and Richardson is interesting in this respect.

The authors next describe the condition of the Illinois from Dresden Heights to Marseilles. "In July, 1911, it was in an especially saprobic or septic condition, culminating at Morris, if we may judge by the number of septic organisms in the plankton." "The most abundant of these were Sphœrotilus natans, detached filaments of which made about 90 per cent. of the number of the plankton organisms in this and the following section." "Flagellate, colorless Protozoa, which feed upon bacteria, were also extremely abundant in this section. The largest number of *Oikomonas termo*—a bacterium-eating protozoa—were found at Marseilles above the dam."

"In the Starved-Rock-Chillicothe section of the river the outstanding feature of the plankton was the marked increase in diatoms and other chlorophyll-bearing unicellular organisms, plant and animal, which became sufficiently abundant by the time Hennepin was reached to give the water a characteristic greenish tinge. This greening up of the water below La Salle was noticed, in fact, on a down-stream trip in June, 1910, and was conspicuous to the naked eye in both 1911 and 1912, most noticeably so at lowest water levels."

The dissolving oxygen of the water in the sanitary canal at Lockport ranged from 0.4 of one part per million on Nov. 1st, 1912, to 9.3 parts per million on Feb. 17th, 1912. As temperature has an influence on oxygen-dissolving capacity of waters, the above figures require to be reduced to the percentage of saturation at the temperature observed at the time when the test was made. Consequently, the first was equal to 3.5 per cent. of oxygen saturation and the latter equal to 64.9 per cent.; the average of six observations made was 4 parts per million, or 31.9 per cent. of saturation. Fish were found, but these were either dying or dead, overpowered by the toxic contents of the stream. There were no signs of animal life, and the only insects seen in or on the water were a back-swimmer (*notonecta*) and several water-boatmen (*corixa*), both of which, as they breathe air, can afford to be indifferent to the deficiency of oxygen.

(To be continued.)

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INTERNATIONAL HIGHWAYS.

It is to be hoped that Deputy Minister Campbell will be successful in his efforts to persuade Premier Borden to appoint a commission to co-operate with the Joint Congressional Committee on Road Legislation of the United States. Such an international body could do a vast amount of good work in reaching a sound understanding that would make many great international highways possible in the future. It would be highly advantageous to have equitable, uniform road legislation in all the Provinces of Canada and the States along the Canadian border. Road construction could be correlated so that the important roads of each Province would connect with the important roads of the other Provinces and of the adjoining States. This would greatly promote the trade and friendly relations between the two countries. The commission might also consider allowing United States autoists to tour Canada with the minimum of trouble and expense at the border. It is for the benefit of the Dominion to make the roads as inviting and pleasant as possible to United States autoists. The tourists are frequently capitalists, and a better knowledge of Canada would cause many of them to invest more money here.

MATHEMATICS AS AN ENGINEERING STUDY.

The value of a thorough study of mathematics in engineering training is a much-discussed topic. An engineer does not advance far into his profession before he contracts the thought and dwells reflectively upon it.

No science is so intimately connected with engineering as mathematics. Arithmetic, geometry, algebra and trigonometry are regularly employed, while an amalgamation of the science with physics has produced the derivation of stresses, moments, radii of gyration, energy, etc., that form the daily food for engineering thought and accomplishment. Yet, of the science of mathematics the average engineer has forgotten, five years after he graduates, fully two-thirds of the amount he had, at one time, carefully mastered; and when one reviews its scope he is surprised to find the infrequent applications of its higher attainments. It will be noted that the calculus is used comparatively seldom, and a text on analytical geometry finds little entertainment in the routine practice of an engineer. This is apparently as it should be, though, and memory need not be brought to task to have the old and intricate pathways repaved.

Yet the student struggle in the mathematical gymnasium goes on apace, and the study forms the chief channel for his intellectual development. It is, therefore, timely to acquaint those of our readers who are preparing for entrance into the profession, with the necessity of such devoted attention to a study, much of which will later be forgotten.

This is best answered by suggesting to the student of engineering that, when he becomes a graduate, he will take time to reflect upon the mental training derived from it, which is the sum of the necessity for a considerable part of the study. Again, like many commodities that might be mentioned, he will find that when he needs its application he needs it badly. Herein lies a vital point. Though an engineer, eminently successful, may have forgotten everything but the bare principles, a clear knowledge of how to apply them to his work spells its importance to him.

The young engineer must remember that engineering is not merely the getting and holding of jobs, or the handling of a big contract. There is the *science* as well as the *practice* of engineering, and experience shows that the men who have played a prominent part in the development of both have seldom been those who have had an aversion to mathematics.

While there is an excuse for the scarcity of purely mathematical treatises in an engineer's library, in that mathematics is a member of the family of "pure" sciences, it is not to be inferred by the young engineering student that the owner has not still a working acquaintance with the principles, at least, of the science.

CONCRETE CONSTRUCTION.

In every line of construction in which Portland cement has been used, the first objection raised by the layman has been that such skilled construction methods are necessary that frequent failures are likely. Because concrete looks so unstable when first poured, and takes years to reach its height of perfection, it is likely to be condemned even by city commissioners. So, it is not surprising to find many officials vigorously opposing concrete roads because "it requires such a lot of care and watching to get them laid right."

But are faulty construction methods or dishonest contracting any more fatal to concrete roads than to roads of any other type? We hold no brief for concrete roads. As a matter of fact, we believe they will have their limitations of usefulness, just as have macadam and brick. But some of the concrete roads that have been built are so excellent that concrete—properly constructed—must be given place as a paving material worthy of consideration along with other materials. It must not be tabooed merely on account of poor contracting being likely to ruin the road.

Dishonest, careless or incompetent construction can as readily spoil sheet asphalt, brick, bituminous macadam or other pavements, as it can concrete.

EDITORIAL COMMENT.

Dr. J. A. Amyot and Mr. F. A. Dallyn, C.E., water bacteriologist and chief engineer, respectively, of the Provincial Board of Health, have reported as follows concerning the Thirty-One Mile and Pemichangaw Lakes scheme of water supply for the city of Ottawa. (See *The Canadian Engineer*, Oct. 16th, p. 595):

"Investigation of the waters and catchment basin of the proposed water supply for Ottawa at Thirty-one Mile and Pemichangaw Lakes, together with the perusal of the report of Sir Alexander Binnie, convinces us of the feasibility and value of the scheme. We have no hesitation in recommending its approval by the provincial board in preference to any other source and supply heretofore proposed."

* * * *

A couple of weeks ago our esteemed contemporary, "Canadian Machinery," published a proposed design for a new Machinery Hall at the Canadian National Exhibition. The idea is excellent. There certainly should be a new machinery building. The reproduction of the suggested design in our columns is unnecessary, as it is entirely unofficial, but we desire to support heartily the general scheme.

The plan offered by Mr. Hare in "Canadian Machinery" may possibly meet the needs of the machinery firms, but the Exhibition's architects will likely further improve upon it. We would suggest to the Exhibition Board that, when the design of the building is under contemplation, they consult a score or more of the leading machinery manufacturers and obtain their views of their own requirements.

LETTER TO THE EDITOR.

Electrification of the Canadian Northern Tunnel.

Sir,—In your issue of October 9th, you say, on page 571: "Of all the great railway systems of the world using electricity for the operation of their terminals, there is not one which has not adopted this system only after previously using steam. The Canadian Northern terminal in Montreal, therefore, will be the first to be operated entirely by electricity from the commencement. No steam locomotive-drawn trains will enter the tunnel. Specially constructed electric locomotives will be exchanged for the steam engines at the Back River yards."

A few days ago some local newspapers, commenting on the contract awarded to the Canadian General Electric Company for the electrification of the Canadian Northern terminal in Montreal, also stated that this would establish a record, being the first time any railway terminal would be operated by electricity from the beginning. This, of course, is quite wrong, as it is exactly what was done on the Pennsylvania Railroad when, in 1901, it decided to bring its trains to New York, exchanging steam engines for electric locomotives at Newark, some 12 miles away. Aside from the construction and electrification of a new line and of subaqueous and land tunnels it included the construction of a new terminal which, of course, was operated entirely by electricity, as it should be, from the commencement in January, 1910.

Long before this, however, the same had been done in Paris. The Orleans Railway Company decided in 1897 to extend its lines 2.5 miles from the Austerlitz station to a better and more central location in the city of Paris, to its present terminal called the Quai d'Orsay station. This involved the construction of 2.5 miles of tunnels and of a new terminal which were operated by electricity from the beginning of operations in 1899.

Far from changing from steam to electricity, these improvements were designed for electric operation and nothing else.

Mr. A. J. Cassatt, President of the Pennsylvania Railroad, when in Paris in 1900 was so well impressed with the electrical operation of the Quai d'Orsay station and of the practicability of exchanging locomotives on the outskirts of the city to bring the trains in a new terminal that he began at once to orient the policies of the Pennsylvania in that direction.

Many books and technical papers have described these undertakings which it is needless to enumerate in detail. I might, however, mention among them Revue Générale des Chemins de fer et des Tramways, Nos. of February and November, 1898, and of May and July, 1901; and Transactions American Society of Civil Engineers, Volume XLI., LXVIII. and LXIX.

Yours very truly,

PAUL SEUROT.

Montreal, October 13th, 1913.

A DEPARTURE FROM COMMON PRACTICE IN SEWAGE DISPOSAL.*

By Alexander Potter, C.E.,
Consulting Engineer, New York City.

THE city of Springfield, Mo., is located two hundred and forty miles southwest of St. Louis, among the foothills of the Ozark mountains, 1,400 feet above sea level. During the last decade the growth of the city has been very rapid. The population in 1900 was 23,000 and in 1910 it was 34,000. The present estimate is placed at 46,000. The area of the city is fourteen square miles.

The built-up part of the town is sewered and recently sewer extensions have been built into the fast growing outlying districts of the city. Up to the present time over 105 miles of public sewers have been completed.

A ridge running east and west divides the city into two distinct drainage areas, known as the northern and the southern areas. The northern area, which is the smaller of the two, takes in about two square miles and is drained by a number of small streams which discharge into the Sac River. The southern area takes in all of the thickly populated districts, including the new addition south of the city, and drains southwesterly into Jordan and Wilson creeks, tributaries of the James River.

Necessity of Sewage Disposal.—During the greater portion of the year the natural flow of all the streams is so small that they are unable to assimilate the large quantities of sewage that are constantly discharged into them. In the spring of 1911 the nuisance from raw sewage discharged into these streams became so serious that the city authorities realized that unless immediate steps were taken to abate this nuisance the city would make itself liable for damages.

Before calling in an engineer to design the much-needed improvements to the sewerage system, the city appropriated $100,000 to construct sewage treatment plants at two sewer outlets. After appropriating this money the city proceeded to call for bids upon contractors' plans and specifications. This plan was abandoned, however, before the contract was let, and the city retained the writer to design and supervise the necessary sewage disposal plants.

Outline of Improvements.—The ridge extending east and west through the city made it necessary to construct two sewage disposal plants. The most logical location for the sewage disposal plant for the northern district was near Doling Park, directly north of the city limits at the mouth of the existing sewer. In the southern district the ordinance called for the construction of a sewage disposal plant at the mouth of the main outlet sewer. To construct a sewage disposal plant at this point was not recommended. The site is low, subject to inundation, and pumping would have been necessary.

On account of the small quantity of water flowing in Wilson and Jordan creeks during the greater portion of the year, the treatment of the sewage in settling tanks alone would not give a sufficiently pure effluent to abate the nuisance. Some additional treatment, such as contact beds or intermittent filters, was therefore absolutely necessary. To obtain a head at the southern outlet sufficient to operate a filter would back up the sewage in the main outfall sewer for a distance of at least 3,500 feet. This sewer, which is an egg-shaped brick sewer, 28 inches x 42 inches, was not strong enough to withstand any internal hydrostatic pressure without rebuilding. Above its mouth the outlet sewer for a distance of 3,200 feet has a fall of only 4.6 feet; at this point there is a two-foot drop and the grade increases to 4.1 feet per thousand. It was recommended that the treatment plant be built at the point where this change in grade occurs. To obtain at this point the necessary head to operate the plant only 2,000 feet of sewer would be surcharged. For a distance of 1,436 feet, that portion of the length where the hydraulic gradient falls above the natural surface of the ground, the existing egg-shaped brick sewer was replaced with 36-inch reinforced concrete pipe of the Meriwether type, designed to resist this pressure. This reinforced concrete pipe has been found very satisfactory

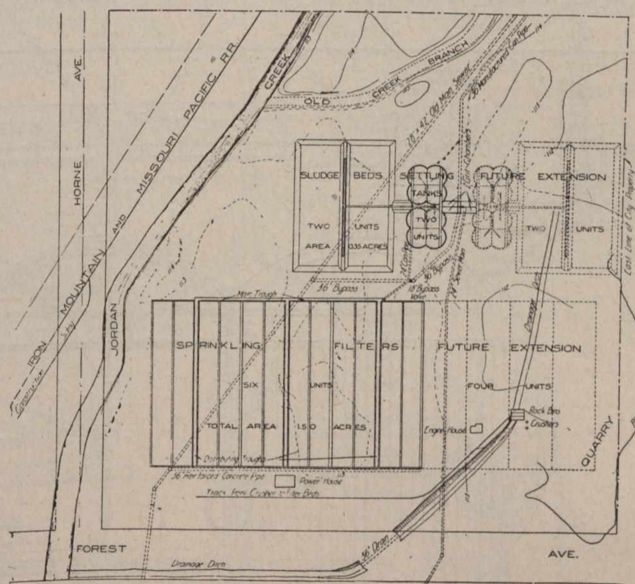

Fig. 1.—Location Plan of Southern Sewage Disposal Plant.

under the head to which it was subjected, viz., from 3 feet to 10 feet, and the line appears to be practically watertight. The existing sewer below the sewage disposal plant was not rebuilt and is used to convey the effluent from the plant to the outlet.

Type of Plant Recommended.—On account of the limited area available it was deemed advisable to use intermittent filters instead of contact beds. The ordinary type of sprinkling filter could not be used, as such a filter requires a head of at least five feet to operate the nozzles. Such a head could be obtained only by pumping. Mechanical distribution was therefore recommended. The distributor selected is operated with a head of only 12 inches.

Fig. 1 shows the general arrangement of the plant as built. It consists of a grit chamber built in duplicate, two settling tanks of the two-story type, a sprinkling filter divided into six units, each 53 feet 9 inches wide and 200 feet long, a sludge bed 0.35 acre in extent, and a final settling basin of 150,000 gallons capacity, located at the outlet, 3,600 feet from the remainder of the sewage disposal plant.

Grit Chamber.—The grit chamber is constructed in duplicate. The flow in the grit chamber is retarded sufficiently so as to retain only the suspended mineral solids

*To American Society of Municipal Improvements, 20th Annual Convention, Wilmington, Del., Oct. 7th to 10th, 1913.

which would interfere with the operation of the settling tanks. Provision is made so that during times of flood the back pressure on the outfall sewer can be readily and quickly relieved, thus scouring out whatever deposits may have formed in the 36-inch reinforced concrete pipe.

Settling Tanks.—Concrete, either plain or reinforced, is practically the only structural material available for constructing sewage settling tanks of the dimensions required for a large municipality. So far as the writer knows, the circular tank has been used in this country only in constructing the smaller units; for the larger sizes it has been customary to use rectangular construction. The rectangular form under all conditions, and especially when a large portion of the tank is above the surface of the ground, is a more expensive form to build. The Springfield sewage tanks are neither square nor truly circular. Each unit is four-leaf-clover shaped, consisting as it does of four semi-cylindrical segments 26 feet in diameter. This type of construction is peculiarly well fitted not only to resist the water pressure from within, but also the earth pressure from without when the tank is below the ground and empty. The construction features of the tank are clearly shown in Figs. 2 and 3. The shell of the semi-circular segments is 12 inches thick, reinforced vertically with ¾-inch bars spaced 3 feet centres and circumferentially with ¾-inch square bars spaced so that the unit stress does not exceed 14,000 lbs. per square inch. The unbalanced tension at the point where the semi-circular segments intersect is taken up by 1¼-inch circular rods embedded in concrete struts, as show in detail H of Fig. 2.

The steel reinforcement in these ties is designed to to resist the tensile forces at the same unit stress as the circumferential reinforcement in the shell. If this is not done, and different stresses are used for the tie rods than are used for the shell, the shell, instead of being subjected to simple tension, will be subjected to bending. The tie rods are fastened to a steel plate 8 inches wide, ⅞-inch thick, bent to a 5-inch radius. By means of double nuts the reinforcement is kept in accurate alignment, which insures equal distribution of the tension among the larger number of tie rods.

The cylindrical segment must be free to expand in all directions. If the expansion is in any way prevented by interior construction, such as the troughs, false bottoms, beams, etc., the shell, instead of being under tension only as contemplated by the designer, will be subjected to heavy bending, often sufficient to cause the fracture of the structure. To permit of the free expansion of the shell when under internal pressure, all interior construction, except at the intersection of the ties and struts with the shell, is separated from the shell by expansion joints.

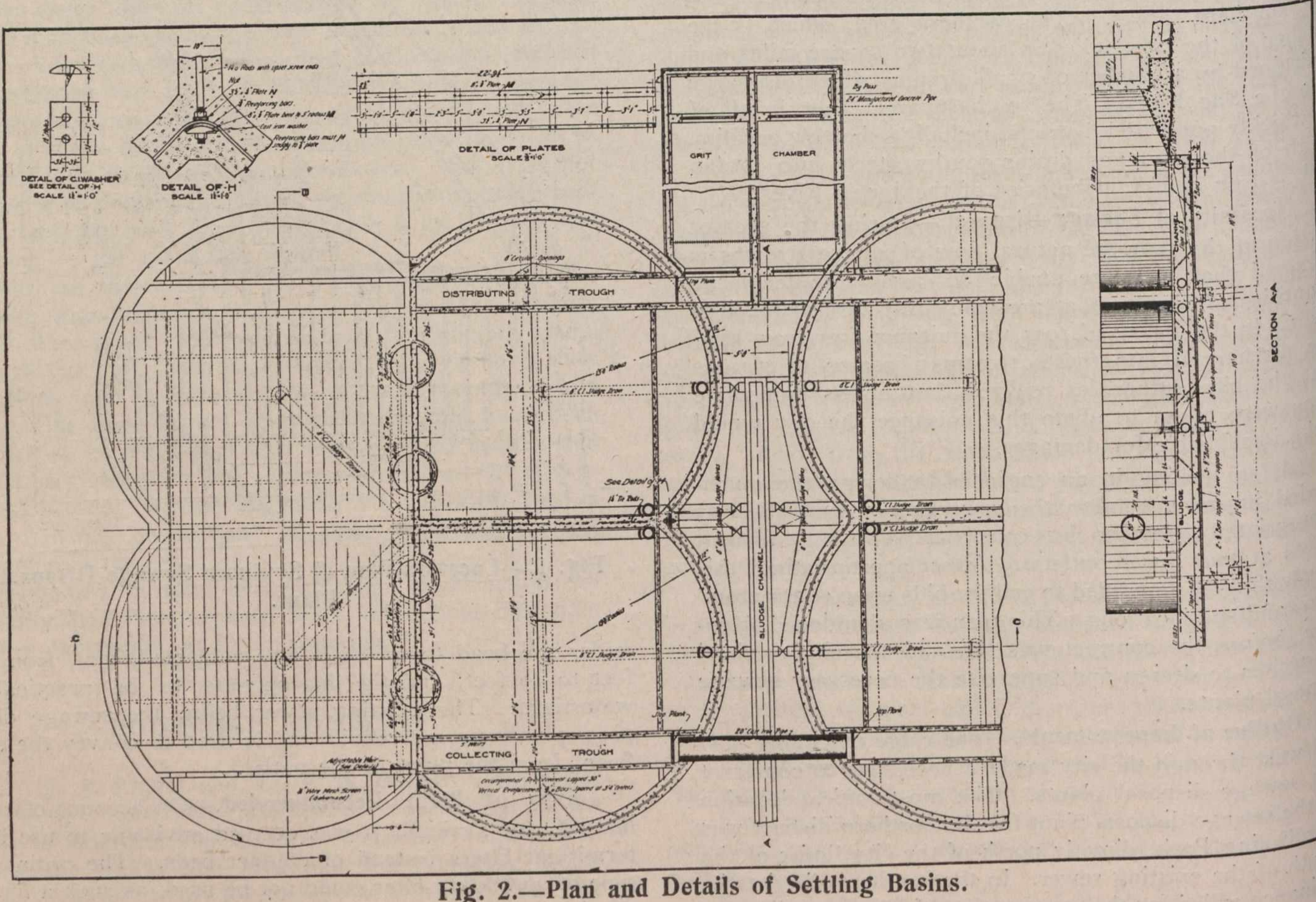

Fig. 2.—Plan and Details of Settling Basins.

After passing through the grit chamber, the sewage enters the distributing trough, which is 2 feet wide, and holds, under normal conditions, about 2 feet of liquid. (See Fig. 3.) Eight 8-inch circular openings, placed in the sides of the trough near the bottom and on the side next the outer wall, admit the sewage to the settling compartment. At the end of the trough is an additional opening, placed so as to be but half submerged, so that whatever scum may tend to collect in the distributing troughs is carried over into the settling compartments. Each settling compartment has a capacity of 111,000 gallons, which gives an average period of retention of 1.4 hours when the plant is operated at 4,000,000 gallons, its capacity. The flow in the settling compartment is parallel to the direction of the slot. To prevent eddies and other disturbances from being set up in the settling compartments which might interfere with the settling efficiency, the liquid is admitted to the settling compartment in a direction opposite to that which it must take in passing through the compartment. The clarified sewage leaves the settling compartment over eight 15-inch weirs discharging into the collecting trough.

The presence of the concrete struts in the settling compartment does not in any was interfere with the efficiency of the tank. Where necessary, they can be capped with wedge-shaped pieces of concrete having slopes of at least 45 degrees.

In that circular segmental area between the distributing trough and the shell of the tank, all of the floating matter is collected and forms a very heavy scum, requiring slight attention from the operator.

To increase the settling efficiency of tanks of the type described, the writer uses vertical circulation. The amount of sewage thus circulated is very small and does not exceed two per cent. of the total amount of the sewage treated. To accomplish the vertical circulation mentioned, a 6-inch cast iron main with four 4-inch circular openings is laid in the digesting chamber of each tank, about 6 feet above the slot. (See Figs. 2 and 3). This circulating main terminates in a small chamber located in the segment between the collecting trough and the shell, which chamber has an adjustable weir to control the flow from the digesting chamber into the collecting trough. In the Springfield plant the liquid thus drawn off is mixed with the effluent from the settling compartment and the resultant mixture is treated on the sprinkling filters. In other plants that the writer has built, the liquid drawn off from the digesting chambers is returned to the distributing troughs. Circulation such as that used in Springfield is especially of value when the sewage to be treated reaches the plant in a more or less septic condition. The plant has not been in operation long enough to determine the exact value of the circulation system.

Sludge Digesting Chamber.—The suspended organic and mineral matter which settles out of the sewage in the settling compartment, slides down the inclined plane through the 8-inch slots located in the bottom of the wedge-shaped settling compartments into the sludge digesting chamber. The sludge digesting chamber has a capacity of 150,000 gallons below the opening. The bottom of this compartment is formed by four cone-shaped depressions in which the decomposed sludge ultimately collects. To draw off the sludge, 8-inch cast iron sludge pipes extend down into these cone-shaped depressions, the sides of which slope at an angle of 30 degrees. The lower ends of these pipes terminate in bell-mouths supported on spiders. The sludge pipes are carried up inside of the tank to the top, giving ready access for cleaning. The sludge outlets, of which there are four for each unit, discharge under a 5-foot head into a reinforced concrete trough which conveys the sludge to the drying beds. The open channel used for conveying the sludge is preferable to the closed pipes generally used. In an open channel the sludge drawn off is at all times visible to the operator, and therefore the character of the sludge drawn off can be controlled far better than when a closed sludge conveyer is used. There is positively no odor during the operation of the sludge valves, either in the trough or upon the sludge beds.

The Springfield tanks have been found to be very economical in construction. Concrete and steel are used under ideal conditions to resist the pressures to which the tank is subjected. From the contractor's standpoint also

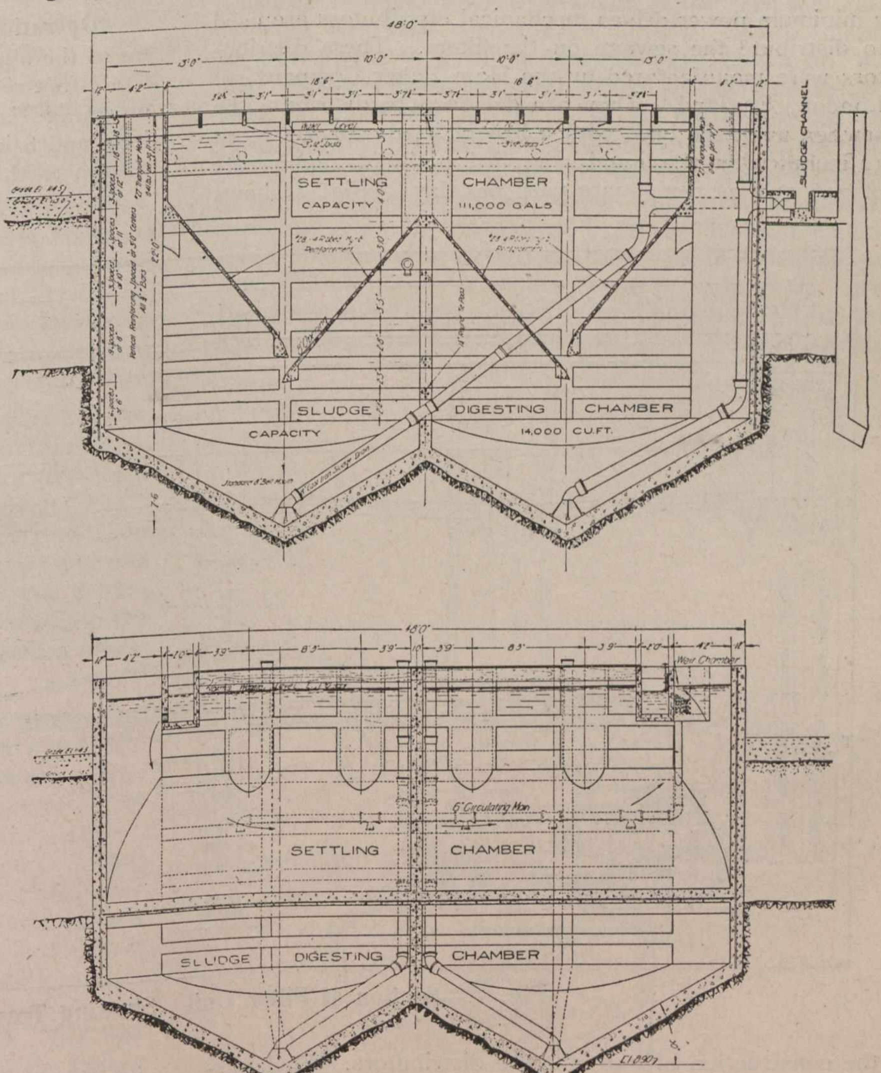

Fig. 3.—Detail Sections of Main Settling Tank.—Upper Section on CC., Lower Section on BB.

the cost of constructing the tank is not excessive. To construct the conical bottoms of the digesting chamber a vertical pipe 2 inches in diameter was placed in the centre of each cone and firmly braced. From this pipe was suspended a wooden triangle adjusted at such an elevation that the hypotenuse described the interior surface of the cone when rotated about the pipe. The concrete was mixed rather dry and placed in 4-inch layers and tamped as much as it would stand, the last layer being carefully brought to a true line by the swinging template. A ½-inch coating of 1 to 2 mortar was applied to the interior of the cones to give them a smooth surface.

To construct the outside shell of the settling tank the contractor used wooden forms made in 5-foot sections 2 feet high. A complete set of inside and outside forms was built extending entirely around one tank, and a complete ring 2 feet high was poured at one time. The following day the sectional forms were raised 2 feet and wired in place at the new point. No trouble was found in shifting the forms and holding the walls plumb and true to line. The false bottoms of the settling compartments were built of No. 28—4-rib hyrib plastered with mortar to a thickness of 2½ inches. The circular ventilators also were built of hyrib and plastered with cement mortar, no other forms than templates being used.

Intermittent Filters.—To reduce the loss of head to a minimum power-driven mechanical distributors are used to distribute the sewage on the filters. There distributors were manufactured by the Ham Baker Company, of London, England. They are designed to distribute the sewage upon the beds with a loss of head, not to exceed 12 inches when the liquid is applied at the maximum rate of 720 gallons per square yard per day. Fig. 4 shows the construction of one of these distributors. Each distributor is supported on three rails, spaced 25 feet on centres. The length of the travel is 200 feet.

The effluent from the settling tanks is conveyed by a 24-inch reinforced concrete pipe to a main distributing trough located at the north end of the filters. The lateral distributing troughs which supply the traveling distributors are fed by 3-foot weirs from the main distributor. The object of these weirs is to insure a uniform distribution of liquid to the distributors. Fig. 4 also shows the construction of the sprinkling filters. The depth of the filtering material ranges from 6 feet 6 inches in the centre to 6 feet at the sides. The underdrains were not built as shown on the drawing. Instead of using 6-inch channel tile, the contractor was given permission to construct 6-inch semi-circular channels in the concrete floor and cover them with vitrified tile slabs. The main collectors are semi-circular in shape, 18 inches in diameter and of variable depth, the distance between them being about 25 feet. The rails on which the distributors travel are supported by concrete girders carried by piers spaced 12 feet, 5¼-inch centres. The area covered by each distributor is enclosed by an 8-inch concrete wall. The winter temperature of Springfield is sometimes so low that it may be questionable as to whether the traveling distributors can be successfully operated in extreme weather. Should the traveling distributors go out of commission or any of them break down, it is possible to utilize the filters or any unit thereof as a contact bed to be operated by hand, suitable gates being provided for this purpose.

Operation of Distributors.—Extending down the centre of the filters between two of the traveling distributors is a 3-foot rectangular conduit in which the normal depth of sewage is 16 inches. A cast iron siphon, 24 inches long and 8 inches in width, conveys the liquid from this trough to the distributor. This siphon is provided with a gunmetal air cock and brass air exhaust pump for starting the flow. The siphon discharges into the feed tubes, of which there are two. These feed tubes are made of wrought iron 3/16-inch thick and have an external diameter of 7⅜ inches. The feed tubes are supported at each end and at the centre by a cast iron carriage braced together by rolled steel beams so as to form a rigid structure. In each feed tube just above the centre are located ⅝ x 4-inch orifices, spaced about 15 inches lengthwise. The even distribution on to the beds is accomplished by a distributing tube 2½ inches in diameter, located between the feed tubes. This distributing tube is built in sections and can be raised or lowered as required to control the flow of sewage upon the beds. The feed tubes are protected with galvanized sheet iron covers provided with hinged access doors. The protection extends to within one inch of the surface of the bed in order to conserve the heat in the sewage as much as possible, especially during the cold weather. It also acts as a preventative of flies. A space is provided between the two channels supporting the feed tubes, which during the cold

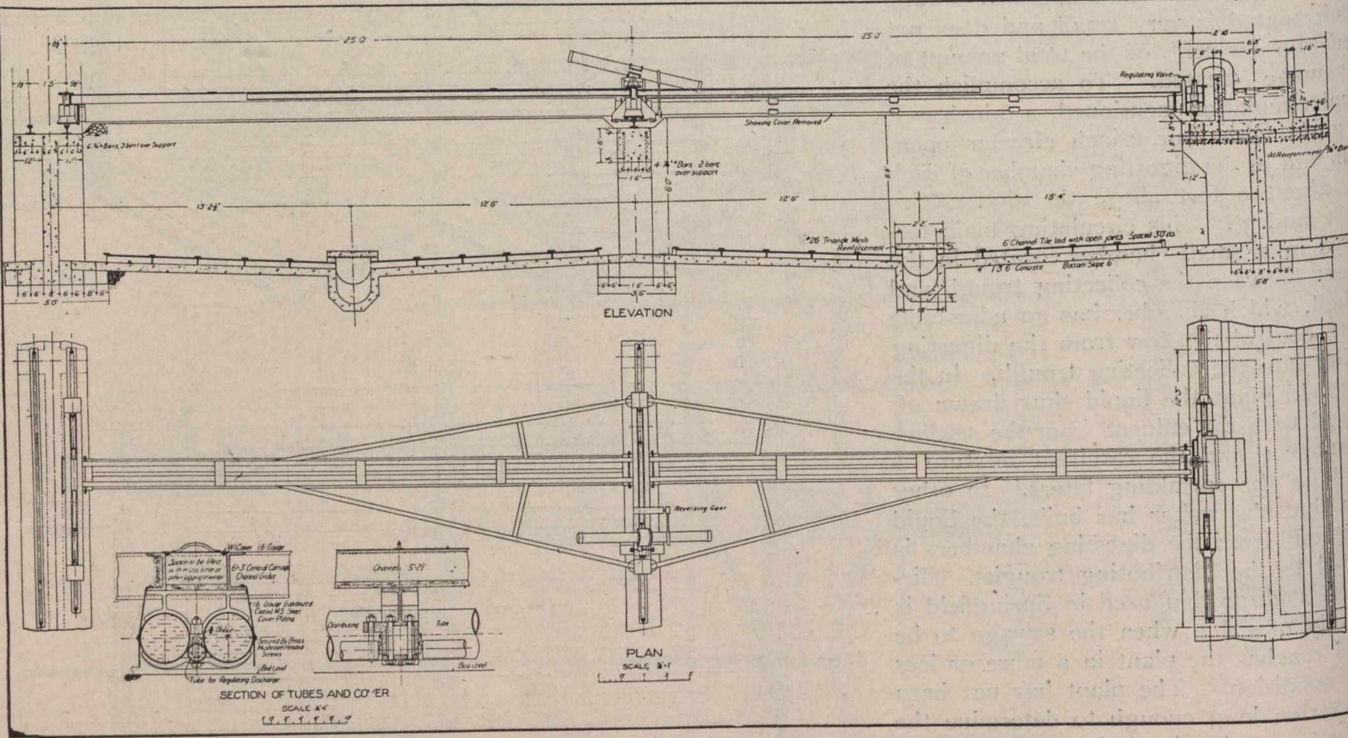

Fig. 4.—Section of Filter Unit Showing Traveling Distributor.

weather is to be filled with moss, leaves or other insulating material.

Each pair of distributors is operated by an endless wire cable. All three sets of cables are driven by one 6-horse-power Otto gasoline engine, which gives the distributors a speed of 38 feet per minute. The change in direction of the distributors is accomplished by means of the reversing lever shown in Fig. 4.

The distributors have realized every expectation. Less than two horse-power is required to drive all six distributors. The writer believes that the distribution of the liquid over the bed is more uniform than can be obtained by the methods now in use in this country. The more uniformly the liquid is distributed upon a filter, the greater the quantity of sewage that can be applied to the filter to obtain the same degree of purification; or, with a given quantity of sewage, the more uniform the distribution, the greater the purification.

To the knowledge of the writer this is the first time that power-driven traveling distributors have been used in this country. The range of temperature at Springfield makes this installation an important one as indicating possible limitations of service in extreme winter weather without covering the filters.

Final Treatment of Filter Effluent.—The existing sewer conveys the filter effluent to the final settling basin located near the mouth of the existing sewer. This final settling basin is 150 feet long and 50 feet wide and has a capacity of 150,000 gallons. A reinforced concrete channel admits the sewage to the basin at the upper end and at the lower end a similar channel conveys the settled liquid through a short length of the existing sewer to the outlet into Wilson creek. It has not been deemed necessary to sterilize the effluent.

Sludge Disposal.—The sludge which is drawn off from the main settling tanks is conveyed by a concrete trough laid to a grade of 5/10 of 1 per cent. to the sludge beds. The sludge bed, which takes in an area of .35 of an acre, is divided by wooden partitions into twelve units, each unit being 25 feet wide and 50 feet long. Each sludge bed is underdrained with graded gravel 18 inches deep at the centre and 12 inches deep at the sides. Down the centre of each unit extends a 6-inch vitrified underdrain laid with open joints. The surface of the gravel is covered with a thin course of mortar sand to prevent the sludge from working its way into the gravel. The bed is given a slope of 1 inch in 10 feet away from the sludge inlet to assist in the distribution of the sludge over the entire bed.

The sewage disposal plant for the northern district, located near Doling Park, has a capacity of 500,000 gallons in 24 hours and, with the exception of the distribution of the sewage over the filter, is in all respects similar to the plant just described. Instead of mechanical distribution, nozzles are used to distribute the sewage over the beds.

The general movement towards the thorough and adequate equipment of Canada's great trade portals, Halifax, St. John, Quebec, Montreal, Vancouver and Victoria, as well as the development of harbors along the great lakes—such as, Toronto, Hamilton, Port Arthur and Fort William—is one which will, when completed, place our country in a position to compete effectively and successfully for its legitimate share of the world's trade.

A CANADIAN ELECTRIC STEEL FURNACE.

By T. R. Loudon, B.A.Sc.,
James, Loudon and Hertzberg.

In 1906 the Dominion Government issued the results of extensive investigations on the electric furnace iron and steel industry of Europe. Since the publishing of this report, which has been and still is a reference of great value, there has been very little evidence in Canada of commercial interest in electric smelting and refining, as far as the actual iron and steel industry has been concerned. Several electro metallurgical plants of great importance have grown up, but none of these has made any attempt to manufacture pig iron, or place steel products on the market on an extended scale. In 1911, the published results of the successful electro smelting of iron ores in Sweden added greatly to the hopes of those interested in electric metallurgy, as it was proven by these Swedish experiments that practical electro smelting was an accomplished fact, provided power and ore were sufficiently low. Canada was naturally looked to as a possible field for the new Swedish processes, as it is well known that Canadian

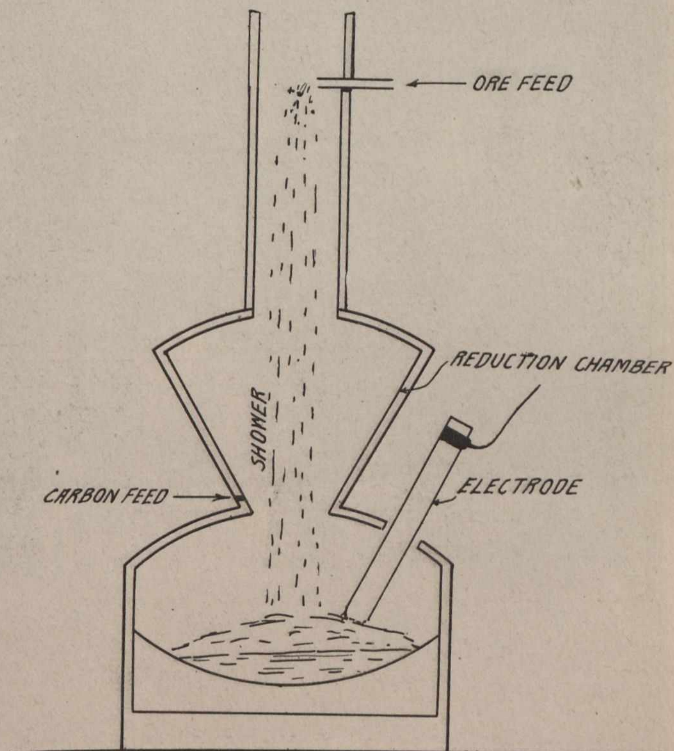

Fig. 1.

iron ores are not suitable for smelting in the ordinary blast furnace without concentrating and briquetting, but can be handled by electro-thermic method. In fact, the Dominion Government electric furnace experiments at Sault Ste. Marie were carried on with a view to making use of these ores. Interesting as the Swedish experiments were, nothing resulted commercially in Canada.

There are, of course, many economic reasons why the electric furnace has not been used in Canada in the steel industry; but, over and above these economic reasons, there exists one that is very largely responsible for the lack of advancement after the beginning made in 1906. This reason may be concisely stated by the well-known phrase, "lack of experience." These new processes required operators familiar with the actual running of electric iron and steel furnaces, and these men are few and far between. Lacking this experience, which, by the way, was confined to a few European countries, Canadian investigators have been working along their own lines, taking what could be gleaned at intervals from the little that is heard of other similar investigations in foreign parts.

In view of all this, it is particularly gratifying from every standpoint to note that an actual commercial electric steel plant has at last made its appearance in Canada. Quite recently an announcement was made of the incorporation of the Moffat-Irving Steel Works, Limited, having for its object the electro thermic reduction of iron ores and refining to steel.

The experiments of which this plant is the outcome have covered a period of some years, and have been of an extremely thorough nature. As intimated above, the difficulties met with in such work are of such a nature that those who persevere and overcome them deserve great credit.

The form of furnace finally adopted differs very slightly from the original design, the main differences being in details rather than principle. Fig. 1 is a diagramatic elevation of the furnace. The crucible is built on a substantial base of concrete. Above this hard-burnt red brick were used for a few courses, and finally, the silica brick forming the main body of the crucible were built up as represented in the cut (Fig. 2). The hearth is of rammed magnesite, giving a good basic bottom.

As indicated in Fig. 1, the ore particles are fed into the upper stack by a mechanical screw feed. The requisite limestone is also fed in at the same level. The carbon, in the form of finely ground coke, is fed into the crucible at the level indicated. The electrodes, three in number, for this furnace which operates on three-phase current, project into the crucible at an angle of about 60°. One of these electrodes is shown in Fig. 1. The remaining two are spaced at equal intervals around the furnace. In falling, the ore particles come in contact with a strongly reducing hot atmosphere of carbon monoxide gas and partial reduction takes place. The final reduction takes place in the crucible.

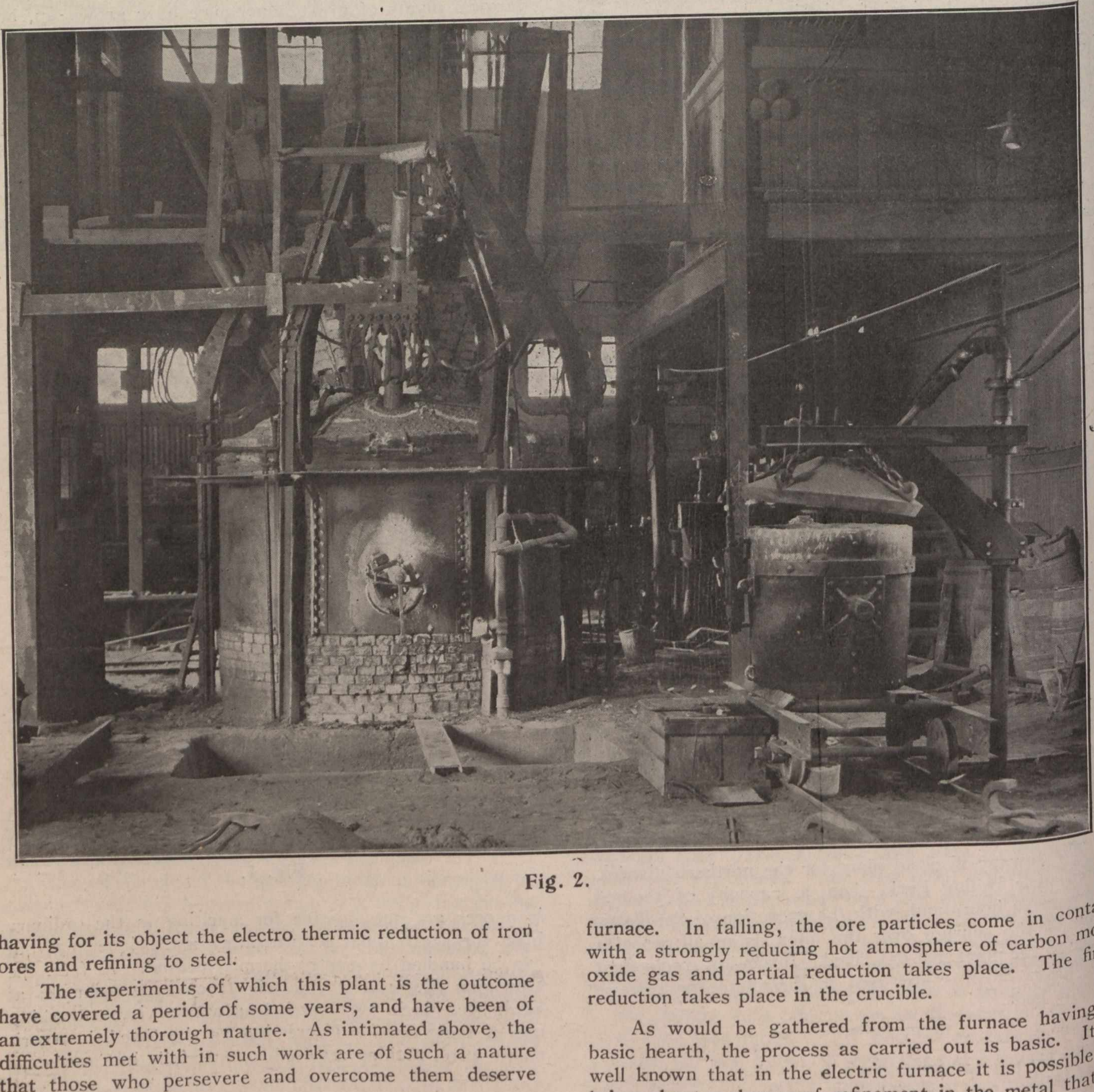

Fig. 2.

As would be gathered from the furnace having a basic hearth, the process as carried out is basic. It is well known that in the electric furnace it is possible to bring about a degree of refinement in the metal that is unattainable in the usual industrial processes. In fact, it is practically impossible, under ordinary conditions, to get the sulphur content of steel below a certain limit. Not that this limit leaves a bad steel, but, to get as far below as is possible in the electric furnace means a very high-grade metal. Another very distinct advantage claimed for steel made under electro thermic conditions, is that it is possible to deoxidize the molten metal to a high degree of perfection. This has been entirely borne out in the work on this furnace. In fact, it was soon apparent in the early stages of the work that the solid condition of the steel, due to this absence of oxides, made the metal very desirable for steel castings. The steel resulting from the process had very much the qualities of the best crucible steel, and physical tests show a tensile strength well above the average; but, this alone does not explain the wearing qualities of castings made from this steel. Indeed, it is only on the basis of the purity of the metal that any explanation of the quality can be made. So far no actual analyses for the presence of oxides and other injurious elements have been made, but the heat analyses for the ordinary elements looked for, show a high-grade metal. The following are some samples:—

C	Si	Mn.	P	S
.20	.30	.71	.03	.010
.30	.25	.78	.03	.010
.32	.25	.75	.035	.010

It is particularly noticeable that there is no difficulty in getting good metal heat after heat, due, of course, to the excellent control of temperature and slag conditions obtainable in the electric furnace.

The furnace, which was built to take 300 kw., is very seldom operated to full capacity, except at the end of a heat, so as to obtain a high temperature in the metal before tapping. A very complete system of oil burners has been installed for ladle heating which has proven to be an important item in the production of good castings. These ladles are of two-ton capacity, but are seldom called on to take off a heat of more than a ton at a time.

A great deal of care has also been spent in experimenting with various mixes of moulding sands, etc. The extremely high temperature attainable in the furnace gives a very fluid metal, suitable for the most intricate steel casting, but which requires facings and sands refractory enough to withstand being completely fused. Steel flasks made by bending channel iron are used entirely. The transformer is of the core type, three-phase and water-cooled. Provision has been made to allow of a voltage regulation of from 56 to 84 volts, giving a range suitable for any condition met in such a furnace. Electrode regulation is carried out entirely by hand, no difficulty being experienced in maintaining even conditions.

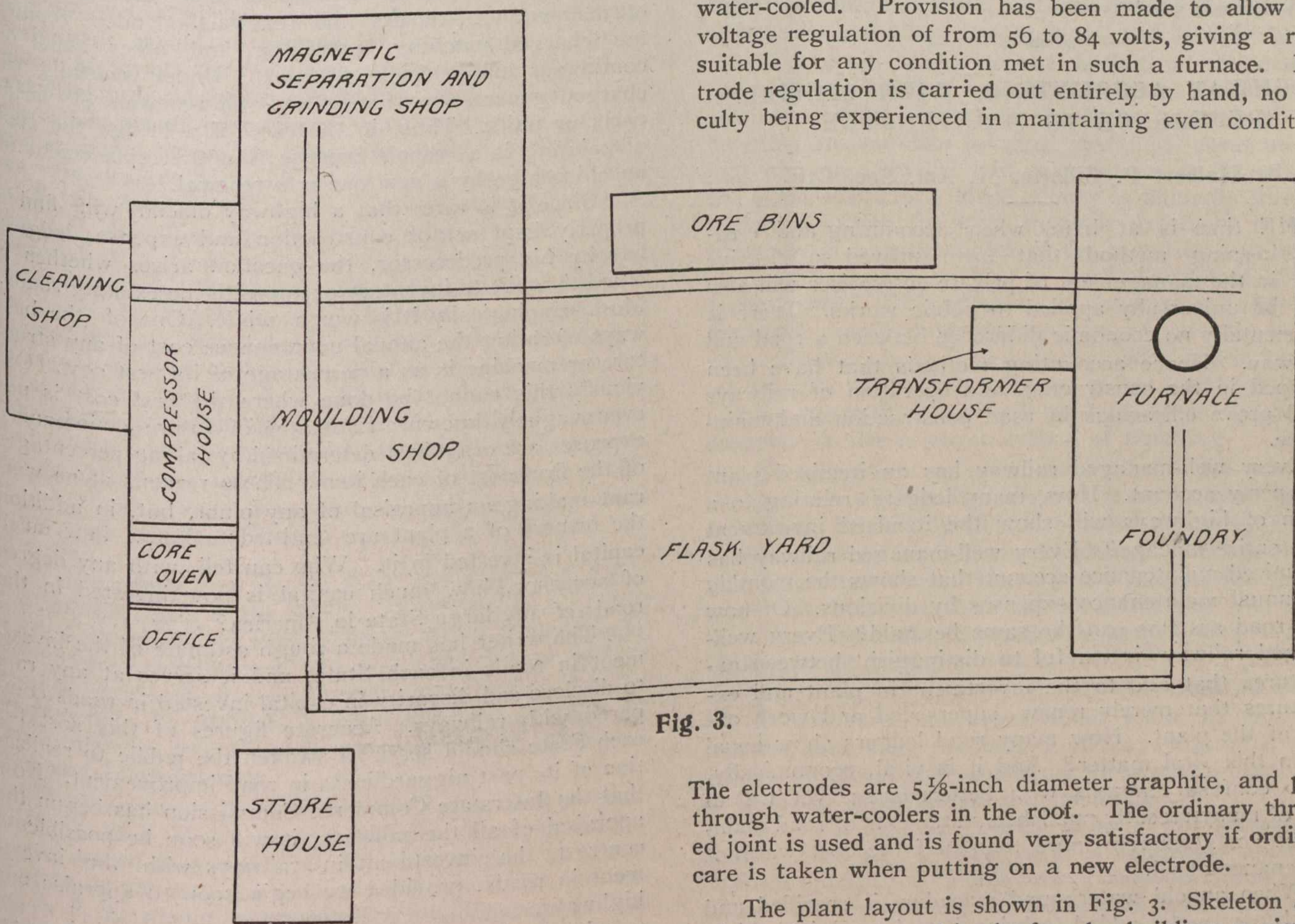

Fig. 3.

The electrodes are 5⅛-inch diameter graphite, and pass through water-coolers in the roof. The ordinary threaded joint is used and is found very satisfactory if ordinary care is taken when putting on a new electrode.

The plant layout is shown in Fig. 3. Skeleton steel construction was used in the foundry building, a view of

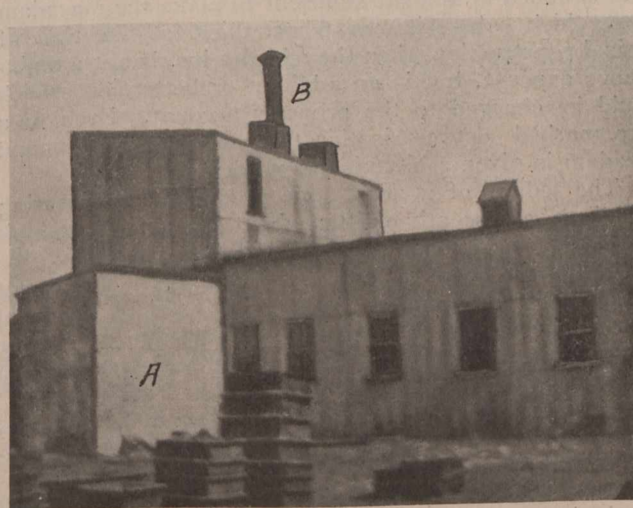

Fig. 4.

which is shown in Fig. 4. The stack B (Fig. 4) is for leading off the waste gases from the reduction chamber. The transformer house A (Fig. 4) is a separate unit containing all the instruments and the electrode control apparatus. The moulding and cleaning shops are equipped with compressed air.

It is hoped to be able to give some more detailed results of the process in the near future. There is no doubt that the problem of handling Canadian ores has been solved in this process. The steel made in the furnace, as intimated above, supports all the predictions and published results up to the present as to the superiority of electro-thermic steel.

HIGHWAY ACCOUNTING, WITH SPECIAL REFERENCE TO MAINTENANCE.*

By Halbert P. Gillette, M. Am. Soc. C.E.

THE time is at hand when accounting and cost-keeping methods that have proved so effective in the management of private enterprises will also be universally applied to public works. There is fundamentally no economic difference between a road and a railway. Hence accounting methods that have been developed in the construction and operation of railways should prove efficacious in road construction and maintenance.

Every well-managed railway has an itemized plant or property account. How many ledgers relating to a system of highways will show the itemized investment in the entire mileage? Every well-managed railway has an itemized maintenance account that shows the monthly and annual maintenance expenses by divisions. Of how many road systems can the same be said? Every well-managed railway is careful to distinguish between expenditures that add to the investment in plant and expenditures that merely renew superseded and worn out parts of the plant. How many road ledgers show equal care in this vital matter? And it is vital, economically, not to confuse renewals with betterments; yet we all know of many recently published statements of road maintenance costs wherein more than half the cost was not maintenance at all.

When an old waterbound macadam is scarified and enough new metal added to bring it to its *original* thickness, the cost thereof is a maintenance expense. But if metal is added in amount sufficient to make the macadam 8 ins. thick where it was 6 ins. thick at the time of original construction, then the added 2 ins. is not a maintenance expense, but is an addition or betterment which should be charged to the property account. Even to a more marked degree is this true when a waterbound macadam is given a bituminous surfacing.

The editor of at least one prominent engineering periodical has recently written about the almost prohibitive cost of road maintenance, and has cautioned the public against bonding for road construction because of the short life of modern roads. This serious editorial error is the result of inadequate knowledge of proper accounting methods, for published road maintenance data are apt to deceive those who think that "maintenance" means what it should mean. As a matter of fact "maintenance, as commonly used to-day in reference to roads, means true maintenance and betterments combined, and is, therefore, a deceptive term.

Maintenance expense should never include anything else than repairs and renewals. Any expenditure that adds to the inventory cost of a road is an addition or betterment and should be charged to the property account.

* Read at American Road Congress, held at Detroit, Mich., Sept. 29th to Oct. 4th, 1913.

By this criterion it follows that if a worn 6 in. macadam is scarified and increased in thickness to 8 ins., the first cost of a 6 in. macadam is deducted from the first cost of an 8 in. macadam, and this difference is charged to the property account. The balance of the expense involved in scarifying, metalling, rolling, etc., should be charged to the maintenance account under the head of renewals.

The writer prefers to keep distinct the two kinds of maintenance—repairs and renewals. Under repairs are charged patching, patrolling, and other small or continuous maintenance expenses. Under renewals are charged general resurfacing and all renewals of large parts or units. Thus, in the case of a bridge the cost of painting is a repair expense; but the replacement of an old bridge by a new one is a renewal.

Since it is rare that a highway official will find a properly kept set of construction and expense ledgers left by his predecessor, the question arises whether it is worth while to inventory or appraise the existing roads. Most emphatically it is worth while. One of the best ways of rating the annual maintenance cost of any structure or machine is as a percentage of its first cost. Obviously this cannot be done where the first cost is not even vaguely known. Estimates of future maintenance expenses are often best determined by taking percentages of the first cost of each item. These reasons alone warrant making an appraisal of any plant, but, in addition the owners of a plant are entitled to know how much capital is invested in it. Who can tell, with any degree of accuracy, how much capital is now invested in the roads of any large State in America?

The writer has made a rough estimate of the investment in roads in each State, and it serves at any rate to disclose sad disparity in capital invested in roads compared with railways. Accurate figures of this sort for each State should serve to awaken the public to realization of its past niggardliness in road improvement. Now that the Interstate Commerce Commission has begun the appraisal of all the railways, it will soon be possible to contrast the investment in railways with the investment in roads, provided we begin soon to appraise our highways.

In opening a property account for a system of roads, it will be well to study the printed instructions to railway accountants issued by the Interstate Commerce Commission; also the printed instructions issued by various State public service commissions.

The writer would suggest a property account for roads as follows:—

Road Property Account.

1. Engineering, Superintendence and Inspection.
2. Administration and Legal.
3. Real Estate and Right-of-Way.
4. Clearing and Grubbing.
5. Grading.
6. Retaining and Slope Walls.
7. Bridges, Culverts and Drains.
8. Fences and Signs.
9. Trees, Sod and Foliage.
10. Paving.
11. Buildings and Fixtures.
12. Furniture and Instruments.
13. Stores and Supplies.
14. Tools and Machinery.
15. Miscellaneous.
16. Bond Discount.
17. Interest During Construction.

All existing roads should be appraised at the cost of reproduction *new*. The depreciated condition may be ascertained, but it is the cost new that should always appear in a plant account. It is now considered bad accounting to "write off" any part of plant value because of depreciation. Preferably a separate account called Depreciation Reserve is provided.

Having opened the construction ledger of a system of highways, using the appraised cost of reproduction new to start with, the cost of every new road and every betterment should be entered in that account, item by item. Many of the 17 items above given should be classified into sub-items. Of course, each new road improvement should have its own separate itemized account, and it would be well to adopt the method used by railways in designating each improvement by a numbered A. F. E. An A. F. E. is an "Authorization for Expenditure." It is made by filling in a printed blank with an itemized estimate of quantities and cost of the proposed improvement and the reasons why the improvement should be made. It is given a serial number, and signed by various officials. Care should be taken to keep the record of actual cost in such a way that it can be entered in detail on the original A. F. E. in a column parallel to the column of estimated cost. If the totals of the two do not check within 10 per cent., reasons should be given for the difference. Instead of extending a given A. F. E. to cover more work than was originally contemplated, the writer prefers to issue a separate A. F. E. for the extension.

Corresponding to the A. F. E. for large additions and improvements is the W. O., or "Work Order," for minor betterments and maintenance. Work orders should be numbered serially, and, where possible, should contain detailed estimates of cost as well as the actual cost in equal detail. In addition, a work order should show in detail how the actual cost is prorated between Maintenance and Improvements.

The location of the work should be described on each A. F. E. and W. O., but, in addition, there should be a map record of every A. F. E. Care should be taken to enter on the map the number of the A. F. E., and on the A. F. E. should be recorded the map number. If this is not done, it often becomes difficult in subsequent years to correlate the maps and A. F. E's.

In addition to a system of accounts that find final summary in two sets of ledgers, namely, Construction Ledgers and Maintenance Ledgers, there should be a separate system of unit cost-keeping records. Ledger accounts must be precise. Cost-keeping records, however, need only be approximate; for the main object of cost-keeping is to ascertain unit costs with sufficient accuracy to determine whether work is being economically done. Of course, unit costs also serve for estimating the cost of projected work, but this is a matter of small importance contrasted with the use of unit costs as a criterion of efficiency. Accounting is a function of book-keepers and accountants, but cost-keeping is a function of engineers. By this I do not mean to imply that engineers should not understand accounting, nor do I mean that there should be entire divorce of accounting from unit cost-keeping. To attempt to record in ledgers the data needed in calculating all unit costs results in greatly complicating the accounting system. Moreover, a good accounting system lacks the flexibility so essential in a good system for recording unit costs. As a rule, the engineer in charge of work finds it desirable to change the method of recording unit costs to fit the local conditions, the character and magnitude of the work, and the sort of men available for keeping the records. An accounting system, on the other hand, should remain the same for all jobs and from year to year.

Of course, unit cost records should show labor and material costs separately. It is desirable that the same separation should also be followed in the accounting system. When this is done it is possible to check roughly the total payroll charged in the ledgers against the total labor cost recorded by the engineers on their cost blanks. Similarly with the total cost of materials. Errors are thus frequently disclosed, and occasionally the "padding" of payrolls and other dishonest acts are brought to light.

Too much stress cannot be laid on the economic necessity of detailed unit cost-keeping. Even for the smallest of jobs, unit costs should be ascertained, if for no other reason than to show that unit costs on small jobs are often several fold as great as on large jobs of the same character. Much money is annually wasted in puttering. Once the total waste is expressed in dollars it usually is seen that most of the puttering can be done away with entirely. This is particularly true of road maintenance. The writer is of those who believe that too much road maintenance consists of patching in small units. There is not a little economic falsehood in applying too literally the "stitch in time" policy. Unit costs, and nothing but unit costs, will show to what extent it is economic to use a parole system of repairing.

To unit costs we must also look for the answer to the question whether day labor or contract labor is more economic. Practically all the recorded unit costs relating to road construction indicate that contract work is cheaper than day labor work The *a priori* reasons for this are numerous; but since there are not a few men who believe they can "save the contractor's profit" simple justice demands that they prove it by recording and publishing the unit costs that occur when they attempt to do so.

In conclusion, the writer would repeat the suggestion that the accounting methods of railways and other public utilities be thoroughly studied by those who are in charge of highway construction and maintenance.

It is not sufficient merely to know the principles of double entry book-keeping as it is commonly applied in business enterprises. Public utility accounting is a special science that involves many departures from the ancient art of book-keeping from which it has evolved.

THE SERVICE RAILWAY OF THE ST. LAWRENCE PULP AND LUMBER CORPORATION, PABOS MILLS, GASPE, P.Q.

By E. S. M. Lovelace, B.A.Sc.,
Civil and Consulting Engineer, Montreal.

THE St. Lawrence Pulp and Lumber Corporation, after purchasing the valuable timber limits and other holdings of the old Pabos Lumber Company, have set about to develop its property along the most modern lines. A sulphite plant with a capacity of over 100 tons of pulp per day is being erected, and saw and rossing mills are also under construction. A townsite is being laid out in the vicinity and, in addition, a standard gauge railway to the interior is now well under way. The writer has been engaged throughout the summer on the location of this railway, and there are a number of points connected with it that will be of general interest.

The peninsula of Gaspé is about one hundred and fifty miles long by seventy-five miles wide, and forms a veritable hog's back between the St. Lawrence River to the north and the Baie de Chaleur to the south. As the height of land in the interior rises considerably above sea-level, the streams on either side of the divide necessarily have heavy falls. The water is thrown off very rapidly and even in time of freshets these streams, for the most part, carry no great body of water. As a consequence of this lack of stream flow, driving operations have not proven very successful, and have hitherto been confined almost exclusively to a few of the larger streams, leaving whole areas of spruce, balsam, birch and cedar quite untouched by the axe. Any method, therefore, by which this vast quantity of timber might be placed on the market, either in the form of pulp or otherwise, should, and in due course must, receive the serious attention and consideration of those engaged in the lumbering industry in the province.

In the development of the plant under consideration, it is proposed to largely follow methods which have proven successful in the State of Virginia, where the president of the corporation, Mr. Robert Whitmer, of Philadelphia, has other large interests. The main line of railway running back from the mill site at Pabos Mills to the timber limits in the interior, will have maximum grades of about 3 per cent., with curves up to 20 degrees being employed. The main-line locomotives being rod engines of special design, are guaranteed to take curves of even 50 degrees, if necessary. So far as the line was located it has been found possible to have, with the loaded trains, either down or level grades, so that only the trains going back light to the woods have any up grades to encounter. This will naturally reduce the cost of operation.

The rails used are sixty lbs. with standard angle-bar connections. The main-line has been substantially built, but lacking, of course, the same degree of excellence required in a line intended for passenger traffic. From the main-line, branches will be constructed, as required, down the various gullies to the lumber camps. On these branch lines engines of a different type from those in use on the main-line will be employed. They are known as the Shea engines, and are specially constructed for climbing heavy grades, the drivers and tender wheels on one side being geared to a longitudinal shafting. There is thus no dead centre, and such engines will lift a load up grades that for ordinary rod engines would be quite out of the question. Grades of even 6 and 8 per cent. can be easily operated upon with such engines. Their speed, however, is slow, about ten miles per hour under favorable circumstances being the limit. It is for this reason that on the main-line there will be an advantage in using the ordinary type of rod engine.

The construction work on the railway this season was done entirely by day labor, but next spring some further sections may be let out to contractors. The main-line has now been constructed a distance of 4 miles into the interior, where it connects with a branch to the first lumber camp. Cutting will therefore proceed through the entire winter at this camp, the wood being brought to the mill by train.

There is a deep water wharf at Pabos Mills, with connecting siding from the mill, so that in summer, when required, shipments can be made by water. Sidings from the mill also connect with the line of the Atlantic, Quebec and Western Railway, and shipments over this railway make connections at Metapedia with the Intercolonial.

The corporation was organized early in 1913. Mr. H. W. Racey, who for some years was connected with the lumbering interests of Price Bros., Limited, Quebec, and of Mackenzie-Mann & Company interests in the far West, is general manager. The corporation is composed of a group of capitalists, most of whom are, or have been, heavily interested in lumbering operations throughout the United States.

COAST TO COAST.

Esquimalt, B.C.—A new system of 128 lamps has been installed and put into operation by the British Columbia Electric Railway Company at Esquimalt, and has marked a new departure in the history and progress of the municipality.

Saskatoon, Sask.—The initial thirteen and a half miles of municipal street railway was set in operation on January 1st, 1913, and almost from the first showed a margin over operating expenses. This margin has increased from a negligible quantity to a gratifying profit.

Toronto, Ont.—An endeavour is being made to bring about reciprocity in boiler inspection by the public works departments of British Columbia, Ontario, Saskatchewan and Alberta. The standards of the provinces are almost identical, and no obstacle should stand in the way of the desired reciprocity.

Port Arthur, Ont.—The C.P.R. has under way an extensive piece of work at Current River. The river has been turned off to one side, and steam drills are being employed at excavation work prior to the construction of the subway under the bridge. Before the subway can be completed, a large quantity of rock must be removed, which is now part of the bed of the river.

Le Pas, Man.—A new wireless station has been built by the Marconi Wireless Company at Le Pas, in connection with the construction of the Hudson Bay Railway, and as soon as all the apparatus in connection with the station is complete, the company will be prepared to receive commercial business along this and connecting wireless chains. This new station will eventually be a link in a chain that will be perfected when the Hudson Bay and Strait have been opened to navigation.

Regina, Sask.—There now seems every likelihood that the City of Regina will enter into an agreement with Mr. A. S. Porter, which will result in a material reduction in the cost of electrical energy. Mr. Porter owns large deposits of lignite coal in the southern part of the province, and he has advanced several propositions to the city, one of which is that a company in which he will be interested will generate power from the lignite coal, and sell the power at a low rate to the city, the city to retail and distribute it. Mr. Porter is now in the city for the purpose of going further into detail with regard to the proposition. Readers will remember mention of this proposal some time ago in *The Canadian Engineer*.

St. John, N.B.—Some interesting data has been furnished concerning dredging operations, which have been in progress from April 1st up to the present, at the St. John harbor, exclusive of Courtenay Bay. The work accomplished has been the dredging at the mouth of the channel required to straighten its entrance, the removal of foul ground, the dredging of the Beacon Bar and the making of the berths at the West Side, where the new wharves are being constructed, the clearing up of the present berths, the deepening of Wellington and Nelson slips, the dredging of the Navy Island Bar in the course of the ferry boat, and the deepening of the West berth at the I.C.R. wharf. In all, these operations represent the dredging of one and a quarter million cubic yards of material.

Brantford, Ont.—Another favorable report on railway construction has been given in connection with the L. E. and N. Railway. The track-laying is in progress, and the rails have been laid southward from Galt to a point 1,200 yards below the power-house at Blue Lake. From the Grand Trunk Crossing at Blue Lake to Paris, and from the crossing of the same railway to the city of Brantford the road bed is ready to have the rails laid. Just as soon as the subway under the Grand Trunk tracks at Blue Lake and Paris are completed, the rails will be laid into Brantford and the ballasting will be done. Contractors are pushing the subway work as fast as possible and Mr. Kellett still has hopes that the Northern branch will be running before the close of 1913.

Fort William, Ont.—The work of drilling and blasting the solid rock under Lake Superior for the new tunnel which will supply Port Arthur with a new water service, has been started and considerable progress made. About 10 feet is being accomplished every 24 hours. Owing to the fact that air pressure in the tunnel will be kept at twenty pounds to the square inch, the work cannot be very rapid; since the very strongest men can not stand being in twenty pound air pressure, or even less for more than a very few hours. The work in the water intake tunnel will be done in shifts of a specified number of hours each. Mr. J. Gass, superintendent of the work, states that in all probability the work will not be finished until next April.

Rogers Pass, B.C.—The C.P.R. will take four years to complete the tunnel now under construction at Rogers Pass in the Selkirk range. This huge tunnel which will require an expenditure of 15,000,000 dollars for its completion is being built for the purpose of lowering the grade through the mountains. Five and three-fifths miles of its total length of 20 miles must be driven through solid rock, and on either side there will be an approach of 7 miles. To carry out the construction, shafts a mile deep will have to be driven through the mountains. The company has undertaken one of the greatest pieces of railway construction work in this age, and one which will dwarf into insignificance all other tunnels in the world.

Regina, Sask.—The Grand Trunk Pacific Railway has opened recently a 105-mile piece of road on its new Calgary-Biggar branch. This stretch of 105 miles lies between Biggar and Loverna, which lies on the boundary line between Saskatchewan and Alberta. Permission has been granted by the Board of Railway Commissioners also for the operation of 50 miles of the Regina-Moose Jaw and Northwesterly branch of the G.T.P., which have been completed to a short distance beyond Mawer, Sask. Ballasting on the Tofield-Calgary branch of the G.T.P. has been finished to Calgary, and first-class passenger service will be established as soon as the terminals at Calgary are completed. This line is a solid construction, and as a consequence will give a splendid service between Calgary, Tofield and Edmonton.

Vancouver, B.C.—In the opinion of Mr. H. H. Stevens, M.P., the people of the Vancouver district should proceed in a business-like way with the construction of the Second Narrows bridge, making no further requests for aid from either the Provincial or Dominion Government. Mr. Stevens emphasized the need of a strong expression of public opinion on the subject to enable the city and municipal authorities to advance plans for procuring the money necessary for the bridge construction. The subsidies subscribed by the governments, and the amounts authorized by the councils of the various districts have brought the total subscription up to $750,000 of the necessary $2,500,000. The councils interested should exercise now their borrowing powers and proceed at once with the erection as a good business proposition.

Halifax, N.S.—That work has been commenced by terminal builders at Halifax may be verified by a picturesque quotation from a local daily paper. "A blackened swath of desolation, gashed through over a mile of what once was the finest of all the natural beauty of Halifax, now marks the preliminary work on the fantastic south end terminal scheme, and fire and axe are daily advancing the work of devastation. Some of the finest public grounds and seven of the beautiful private estates in the city have already been irreparably ruined. From the harbor front a pathway over one hundred yards wide has been gouged along the line of the proposed ditch railway which is to increase the length of the passenger and freight haul to this city from every point to which Halifax has railway connection."

St. John, N.B.—Though the engineers of the J. S. Metcalf Company, contractors to the Federal Government for the building of the new grain conveyers, have made their surveys, the building of the conveyers has not been started. The galleries for the conveyers are to be constructed on hard pine timbers, 54 feet long and 12 inches square, and these timbers have to be secured in the United States. This may be the cause of delay in the work; but if the conveyers are to be available for the shipment of grain at the commencement of the season, very rapid operations will be necessary to complete their construction before the opening of the winter port season. The new conveyers will be more than 2,000 feet long, and will have about 8,000 feet of rubber belting 36 inches wide, costing about $1.00 per foot. These belts will be driven by four 75 horse-power electric motors installed in towers on the galleries. The work of building the conveyers progresses very rapidly when once begun, as while the foundations are being made the gallery tressel is prepared. At Sand Point now it appears that to supply the new berths with conveyers necessitates construction work as extensive as that represented by the conveyers already built. At the present time conveyers are built on berths Nos. 1, 2, 3 and 4. It is probable that the new conveyers will continue from the end of No. 1 berth, and cross the head of the slip along Union Street and then pass down the face of the berths Nos. 5, 6 and 7.

Port Nelson, B.C.—Mr. H. E. Penrose, writing from Port Nelson to the Winnipeg Free Press, says:—"Amongst Canada's great engineering achievements—and these are not a few—the completion of the harbor at Port Nelson will probably rank with the foremost. Whilst the site and climatic conditions of the harbor are by no means perfect, the difficulties are being gradually surmounted; step by step accurate survey and charting have been accomplished, and with the mass of information obtained, plans have been drawn up and the work of construction begun." To carry out the undertaking so that it will be of permanent good, and free from danger of destruction, two breakwaters will have to be built at a point 15 miles up the river to protect the wharfs and harbor works from ice coming down stream as well as to break the force of the current, which has been quoted as one of the arguments against the ultimate success of the project. Below these breakwaters, it is proposed to build an elevator capable of dealing with large quantites of grain at a rapid rate, and to dredge a channel so that ships of moderate tonnage may come alongside. A further suggestion has been the use of floating elevators either in conjunction with or separate from the larger one on shore. Close to the construction camp is the site of the wireless station which will communicate with Le Pas. This high power station acting in conjunction with the proposed chain of stations along the bay to the entrance of the strait, and a possible government scout operating along the track, could communicate full information to ship captains regarding the condition of the route many hours before entering the straits.

PERSONAL.

J. L. LANG, B.A.Sc., has accepted a position in Galt as assistant to the City Engineer, C. D. Campbell.

C. R. HOLMES, B.A.Sc., has joined the Chicago staff of the Hoskin Manufacturing Company, of Detroit, as salesman for electric furnaces, pyrometers, etc.

T. G. HASTIE, Division Engineer in British Columbia for the Great Northern Railway, is conducting the inspection of development work on the Victoria and Sidney Railway, B.C.

WYNN MEREDITH, Consulting Engineer for Victoria on the Sooke Lake water supply project, is recovering from a severe illness in a Los Angeles hospital, and is expected in British Columbia soon again.

M. T. CANTELL, Lic. R.I.B.A., A.S.I., Professor of Architecture and Civil Engineering, Municipal Technical College, Brighton, Eng., and author of "Reinforced Concrete Construction," has become associated with the Success College of Science and Trade, Winnipeg, as Principal.

RUSSELL G. SWAN, B.A.Sc., an honor graduate in Civil Engineering, University of Toronto, has been promoted to the position of Chief Engineer of the British Columbia Hydrographic Survey of the Department of the Interior. As Mr. Swan has had considerable experience in hydrographic survey work, especially in connection with water powers in various parts of the West, he is well qualified for his work. Mr. Swan's headquarters will be in the Dominion Government offices at Vancouver.

A. M. BEALE, B.Sc., Engineer of the Water Power Branch of the Department of the Interior, is now in the West making an investigation of the question of the development of small water powers of less capacity than 200 horse-power which would be of advantage to small communities. It is understood that there are at present a number of applications before the Department for the right to develop such small schemes in various parts of the Provinces of Manitoba, Saskatchewan and Alberta. While these are of small capacity, they are in many cases of great importance to the particular district affected. Mr. Beale's investigations will be watched with considerable interest, as the question of the utilization of power for farm and small mill purposes has been already demonstrated to be a success in various States of the Union, and also in our own Province of Ontario, where the Ontario Hydro-Electric Commission has been able to demonstrate that the milkmaid and the old hand-pump are no longer an absolute necessity.

N.T.R. CONSTRUCTION.

At the October meeting of the Canadian Railway Club, held at the Windsor Hotel, Montreal, Mr. R. F. Uniacke, Bridge Engineer of the National Transcontinental Railway, gave a most interesting illustrated lecture covering some of the difficulties encountered in the construction of the road, showing in some detail the undertakings, their problems and the solutions.

Some of the greatest difficulties he mentioned were due to clay subsoil not capable of bearing the weight of a heavy fill. In one instance the approach to a bridge was shown where the concrete pier at once end and the first span had been entirely carried away. Another was of a deep fill which began to move down along the river, which it approached, as soon as completed, and refused to be stayed. These and similar difficulties were constantly being met.

The speaker stated that the rails were now joined from Moncton to Winnipeg, with the exception of the crossing of the St. Lawrence at Quebec, which awaited the completion of the bridge. Meanwhile a ferry was being built which would be in operation next May. There had been difficulties to overcome in ferrying trains across the St. Lawrence, both winter and summer, in the flow of ice, the rise and fall of the tide, and, as a consequence of this latter, the freezing of the water on the sides of the docks, which sometimes reached a thickness of eight and nine feet. The ferry boat finally decided upon was to be constructed with a tidal deck, with a rise and fall of eighteen feet, and with an "apron" at each end, which joined the rails of the boat with those of the docks.

ONTARIO ASSOCIATION OF ARCHITECTS.

At the twenty-fourth annual convention of the Ontario Association of Architects the following officers and Council were elected for the year: President, C. H. Acton Bond, Toronto; first vice-president, Herbert E. Moore, Toronto; second vice-president, L. Fennings Taylor, Ottawa; treasurer, J. P. Hynes, Toronto; registrar, Franklin E. Belfry, Toronto; and Colborne P. Meredith, Ottawa; J. W. Powers, Kingston; W. R. Gregg, Toronto; W. W. Stewart, Hamilton; Charles E. Langley, Toronto, Council.

AMERICAN SOCIETY FOR MUNICIPAL IMPROVEMENTS.

At the annual meeting, held in Wilmington, Del., recently, the following officers were elected for the ensuing year: President, Edward H. Christ, of Grand Rapids; first vice-president, W. A. Howell, of Newark, N.J.; second vice-president, A. F. Macallum, of Hamilton, Ont.; third vice-president, N. S. Sprague, of Pittsburg; secretary, C. C. Brown, of Indianapolis; treasurer, W. B. Howe.

Boston was selected for the 1914 convention.

COMING MEETINGS.

NATIONAL SOCIETY FOR PROMOTION OF INDUSTRIAL EDUCATION.—Annual convention to be held at Grand Rapids, Mich., October 19th to 25th. Secretary, C. A. Prosser, 105 E. 22nd Street, New York City.

AMERICAN MINING CONGRESS.—Annual convention will be held at Philadelphia, Pa., October 20th to 25th. Secretary, J. Callbreath, Majestic Building, Denver, Colo.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.—Annual convention will be held at Montreal, Que., October 21st to 23rd. Secretary, C. A. Lichty, 319 N. Waller Avenue, Chicago, Ill.

UNITED STATES GOOD ROADS ASSOCIATION.—Convention will be held at St. Louis, Mo., November 10th to 15th. Secretary, J. A. Rountree, L021 Brown-Marx Building, Birmingham, Ala.

NATIONAL MUNICIPAL LEAGUE.—Annual meeting will be held in Toronto, November 12-15. Secretary, C. R. Woodruff, 705 North American Building, Philadelphia, Pa.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Tenth Annual Convention to be held in First Regiment Armory Building, Philadelphia, Pa., December 9th to 12th. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting will be held in New York, December 2nd to 5th, 1913.