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POWER INSTALLATION AT YORKTON, SASK.

DESCRIPTION OF CANADA'S FIRST OIL-ENGINE UNIT FOR MUNICIPAL LIGHT AND POWER DEVELOPMENT — STATION EQUIPMENT AND ARRANGEMENT.

TO the town of Yorkton belongs the distinction of having installed the first Diesel electric unit for lighting and power purposes in Canada. This installation was made during the winter of 1910-11. The plant consists of 150 b.h.p. Diesel fuel oil engine running at 240 r.p.m. and direct connected to a 3-phase alternator with belt-driven exciter. Since starting up in 1911, the plant has operated practically 19 hours per day and has given entire satisfaction.

Towards the latter end of 1912 and the beginning of 1913, it became expedient, owing to the great demand for lighting and power, to augment this small plant by a further installation. Consequently it was decided to build a power house and plant of the most modern type and at the same time make provision for future growth. The project was consigned to Messrs. Munro and Mead, local architects, and the town electrical engineer, Mr. M. M. Inglis, to carry out the work of designing and supervising the complete installation of both power house and plant. This work has now been carried out to a successful issue and the new plant was placed in operation on October 17th of last year.

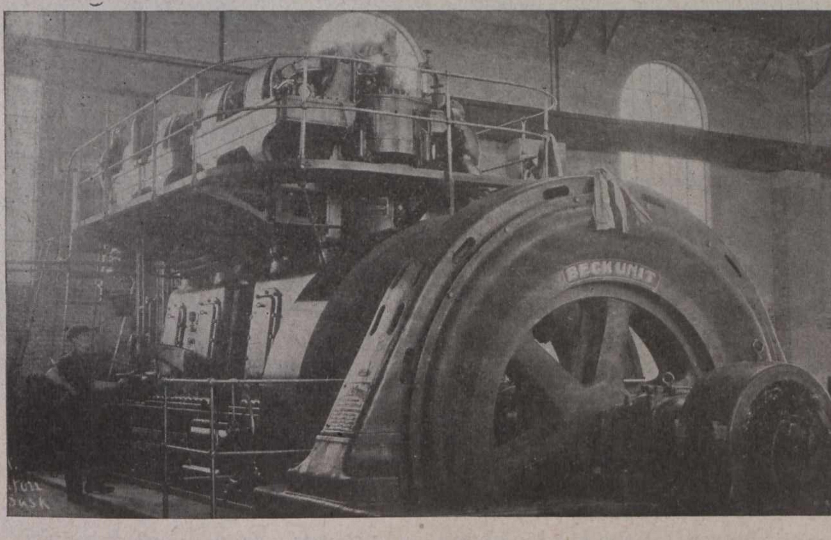


Fig. 1.—Interior View of Power House, Yorkton, Sask.

The power house is 102 ft. long by 58 ft. wide, the offices and stores taking up 20 ft. of this length. It is of fireproof construction throughout with red tapestry brick and Indiana limestone facings outside, with pressed buff brick interior, steel sash, red quarry tile floor and reinforced concrete roof carried on I-beam purlins supported by steel roof trusses. An auxiliary roof of lumber with tar and gravel finish having an air space between it and the concrete roof, thereby preventing condensation of the concrete. The general contractors for the building were Messrs. Ritchie & Watters, of Portage la Prairie. The installation of the heating and plumbing were carried out by Messrs. Parrott & Byers, Yorkton, Sask.

Foundations for two 500 b.h.p. units have already been installed, but there is room for two additional foundations, thus making a total station capacity of 4 units.

The Diesel Engine.—The Diesel engine was built by Messrs. Mirrlees, Bickerton & Day, of Stockport, Eng., and was supplied and erected by their Canadian agents, the Böving Company of Canada, Limited, Toronto. The engine has run 20 hours per day since starting up and exhaustive tests have been carried out to verify the fuel consumption and governor regulation guaranteed at all loads from 25% overload. In no case did the fuel consumption exceed that originally guaranteed by the engine makers. One very important feature is that the engine can be brought from rest up to full speed with full load in about one minute. No boilers are required, therefore no stand-by losses from that source affect the economy of operation.

The engine is of the vertical 4-cylinder totally enclosed, forced lubrication type, and is capable of developing 500 b.h.p. when running continuously at the normal speed of 200 r.p.m. at sea level. It was guaranteed in addition to this to be capable of carrying 25% overload for 2 hours without injurious effects. The cylinders are single-acting and work on the 4-stroke cycle. The cylinder wall is of tubular construction pressed into the casting which forms the water jacket casing and is held in position, as well as the cylinder head, by studs. The valves are opened and closed by cams and springs respectively. Both the air, exhaust and fuel valve levers are in two parts, to facilitate the examination and replacing, when necessary, of the various valves. In addition, the fuel valve spindles are removable for inspection without removing the levers which operate them. The exhaust valve casings are all water-cooled.

The engine is equipped with a forced lubrication system and the oil which is all contained in the crank case is pumped after passing through a filter by a valveless pump which is direct-connected to the engine crank shaft.

The oil is forced through the main bearings then through the drilled crank shaft to the crank end and passes up the hollow connecting rod also to the wrist or gudgeon pin. The piston depends on its lubrication from the oil thrown off the crank webs. The lubricating oil pressure can be regulated very finely either by the shifting valve on the suction side of the pump or by the by-pass valve fitted to the outside of the engine main casting. A relief valve is connected on the delivery side of the lubricating oil pump as a safeguard and is adjusted to approximately 20 pounds pressure, which is quite sufficient for satisfactory working.

The fuel pump is such that there is a separate piston to deliver oil to each cylinder, although they have a common suction, with separate and distinct suction valves. These suction valves are adjustable and one cylinder can be cut out if so desired when the load permits, by opening up a by-pass valve between the two delivery valves of that pump which supplies that particular cylinder.

The governor, which is mounted on a vertical shaft, controls the speed of the engine by timing the closing of the suction valves of the fuel pump so that the actual quantity of fuel delivered to the cylinder is sufficient for the load. It is also fitted with an oil dashpot to ensure good regulation. The fuel oil flows to the engine from two 50-gallon tanks placed above the fuel pump. These tanks in turn are fed by a head tank of 100-gallon capacity, which is mounted on a bracket close to the roof of the engine room and easily accessible by means of a walkway constructed and attached to the truss roof of the engine room.

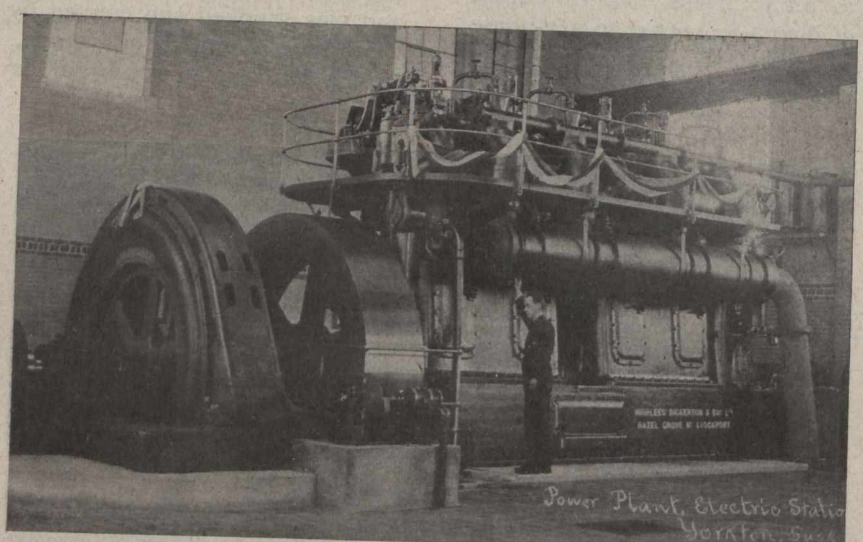


Fig. 2.—View Showing Complete Power Unit, Yorkton.

The fuel oil, which is delivered on a spur adjacent to the main building, is pumped to two large storage tanks situated in the grounds adjacent to the engine room, by a single-acting Paul pump driven through worm gear by a 2-h.p., 3-phase, 550-volt, 60-cycle Westinghouse motor. The fuel oil is pumped from these storage tanks to the head tank in the engine room, when required, by the same pump.

An overflow pipe is connected to the head tank in the engine room and is led back to the storage reservoirs outside the building so that there is no possibility of overflowing the head tanks in the engine room.

Compressed Air Equipment.—The compressed air equipment of the Diesel engine is one of the most important features connected with its operation, as the use of crude oil in this type of engine depends entirely on air at high pressure being available for spraying the crude oil into the cylinders. The air pressure required for satisfactory operation varies from 520 lbs. to 1,000 lbs. per square inch. This is arranged for by the use of storage receivers and blast bottle of solid drawn steel, working in conjunction with a specially designed air compressor.

The compressor is driven by an overhung crank on the end of the main crank shaft. It is of the 2-stage type fitted with silent type renewable disc valves and having intercoolers to cool the air at each stage of the compression.

Air is delivered to the blast bottle and from it, when desired, to the storage receivers as well as to the engine. The receivers, being for starting purposes, are always kept fully charged to approximately 900 lbs. per square inch. The starting receivers are piped to the starting valves of two cylinders and when the engine has gained sufficient speed by means of the compressed air injected, the fuel oil is then injected and the starting air automatically cut off at the same time. The engine then comes into normal operation as the compression temperature in the cylinders is sufficient to ignite the fuel oil.

Water-cooling Apparatus.—The water-cooling apparatus for the cylinder water jackets is located outside the main building. It consists of an open reservoir 50 ft. by 35 ft. by 8 ft. deep, constructed of reinforced concrete and waterproofed throughout with Pudlo concrete. Provision will be made later for a distributer on the outlet pipe from the engine when the additional units are installed. A 4-inch suction pipe connects the cooling tank to a 3-inch rotary pump. This pump is driven off the main shaft by means of a belt. In addition to the cylinder jackets, the exhaust pipes, valves, lubricating oil-coolers and air compressor are all cooled by this system and the water is returned to the open reservoir. By this means the same water can be used with very little waste.

Generator.—The engine is direct-connected to a 400-kv.a., 2,200-volt, 3-phase, 60-cycle generator mounted on a separate bedplate. The generator is excited by an 9.5-kw., 65-volt exciter direct-connected to alternator shaft and mounted on extension of generator bedplate. The generator and exciter were manufactured by Messrs. Siemens Bros'. Dynamo Works, Limited, Stafford, Eng. Tests made after installation proved that the machine was well within the guarantee. The total weight of the engine generator and exciter is approximately 109 long tons.

Switchboard.—The switchboard supplied by the Canadian Westinghouse Company, of Hamilton, Ont., consists of 4 blue Vermont marble panels at present, 2 generator panels and 2 series tungsten lighting panels. Each generator panel is arranged so that it contains its own exciter switching equipment together with the necessary instruments, volt meter plugs, ground detector and synchronizing plugs. In addition to the synchronizing lamps a synchroscope is mounted on top of the switchboard which enables the paralleling of the two machines more accurately than by the older method. Provision has been made for future extensions which are to include a Tirrell regulator and three feeder panels, as well as an additional generator panel similar to those already installed.

To facilitate the erection of the plants and repairs when necessary, a 10-ton travelling crane supplied by the Böving Company of Canada, was installed. The span is 56 ft. 5 in. from centre to centre of long traverse wheels. The bridge consists of two 24-inch Bethlehem steel I-beams fastened to channel iron and carriages on which are mounted the necessary steel spur pinions working in spur wheels which are cast in one piece with the travel wheels. All the gears are machine cut. The hoisting gear consists of a standard 10-ton trolley hoist with 2-speed worm gear and is operated by means of chain and cast sprocket wheel. The cross-travel is overated by means of chain and cast sprocket-wheel operating through machine-cut spur gearing to the trolley. The total weight of the crane is about 14,000 lbs. and is hand-operated throughout.

A Spencer boiler is installed in the basement of the office and store portion of the building for heating the entire building by steam and provision has been made for approximately 30 tons storage space for pea coal. The steam mains are run overhead with branches dropping therefrom to each radiator mounted on the floor. The wet returns from each radiator enter one return pipe which is run under the engine room floor back to the boiler in the basement. The fuel oil delivery pipes, from the motor-driven oil pump to the head tanks in the engine room, are run in the same trench as the wet return steam pipe, in order to take advantage of preheating the fuel oil before being used in the engine.

The total cost of the power house, 500-b.h.p. combined unit, cooling reservoir, fuel oil storage tanks and all accessories, has been approximately $90,800.

STEEL JOINTS BY A NEW METHOD.

A new material called "amalgaline" has been introduced in England for making joints between lead surfaces, and it is said to have been widely adopted by shipbuilders in Scotland and the north of England, as it is useful in flanging and the seaming of lead used in lining refrigerating chambers. The system is not confined to use on small pipes, but is used in an ordinary way on pipes varying in bore from 3 inches to 9 inches. It is an autogenous process, but instead of using an intense local heat the fusion is effected by the action of the amalgaline on the surfaces to be welded, forming an amalgamation between the lead of the flange and the lead pipe. The material is in the form of a metallic ribbon 0.002 inch thick, practically a pure metal, which, when placed between the surfaces of lead and subjected to heat, fuses at a temperature of 160 degrees—lower than the actual fusing point of lead—and in fusing it causes the lead surfaces to run together at a lower melting point than that of the body of the lead. This running together has an autogenous effect, and the minute particles of amalgaline are dissipated into the body of the lead, which, by reason of the absorption, becomes stronger at the junction than elsewhere.

The consulting civil engineering firm of Hazen and Whipple, New York City, announces a change of name to Hazen, Whipple and Fuller.

SEWAGE PURIFICATION AT THE EXPERIMENTAL STATION OF THE ONTARIO BOARD OF PUBLIC HEALTH.

THE recently issued annual report of the Ontario Board of Health has associated with it Bulletin No. 2 of the Board's experimental station. This bulletin gives the results of investigations relating to the disinfection of sewage, the behavior of mechanical filters (with special reference to operation and bacterial removal) and contains a summary of the results relating to the purification of sewage. The bulletin is transmitted by F. A. Dallyn, C.E., provincial sanitary engineer. It contains much interesting and useful information. We wish to refer particularly, however, to the results obtained in connection with the biologic disposal of sewage, examinations to determine which have been carried on since 1911. These results are presented by A. V. DeLaporte, B.A.Sc., who, in 1913, was put in charge of the experimental station. His results show very successful operation of the Imhoff tank which was put into operation at the station in April, 1912. As will be noted in the following, the tank is not a true Imhoff in that it is much shallower than that recommended by Dr. Imhoff. Its operation, however, is identical with that of the tanks which have been erected in Germany. The sludge obtained from it has a similar analysis to that of German sludge, and to that obtained from similar United States experimental units. The sludge dries rapidly in a few days and gives rise to no disagreeable odors. When disposed of in mounds, it does not appreciably take up water more than ordinary loam, and drains rapidly. For these reasons it is suggested that such sludge would make excellent fill, its moisture content after several weeks not being much higher than that of ordinary loam.

The following is extracted from Mr. DeLaporte's report on the purification of sewage:

Septic Action.—The septic tank and biological digestion of organic matter in sewage has received considerable attention in both Europe and America. All of the work done seems to have been with raw sewage, so that the improvement in character of the sewage has been due to sedimentation, as well as to the biological digestion. Both chemical and physical analyses of the effluents from such tanks, unfortunately, have been influenced by the effect of sedimentation and did not give a true measure of the efficiency of biological digestion. It therefore seemed advisable to do some work with septic tanks, precluding any improvement by sedimentation, by the use of a settled sewage. At first the effluent from a settling tank was used; later the work was done with an Imhoff effluent. Consequently, any improvement in character in the sewage was due to the septic digestion of the semi-colloidal and colloidal matter in the sewage—not to an improvement by sedimentation of solids in suspension. In connection with this work two batteries of tanks were operated to find the optimum length of storage for, and the effect of aeration on, septic sewage.

The four tanks used were of concrete, 25 ft. long by 1½ ft. wide and 6 ft. deep, and were so arranged that the effluent from the first two tanks would flow over aerators before entering the second pair of tanks. Baffles were fitted at suitable points to prevent currents and movements of scum or sludge. The sewage was fed through an orifice under constant head. The effluent overflowed from a foot below the surface through a pipe shaped like an inverted U with an air hole to prevent syphoning. The aerators are shown in section and plan in Fig. 3.

In septic tanks particles of sludge attached to gas globules are constantly rising and particles of scum settling. These find their way from time to time into the effluent. Consequently the suspended matter in the effluent varies considerably. This causes large variations in the chemical analysis, necessitating frequent sampling over a long period to find the real efficiency of a unit. To prevent part of the sludge from passing away in the effluent is impossible, but if the sludge be removed from time to time it will help the unit to maintain its maximum efficiency. It is suggested that where tanks are neglected and become full of sludge the length of storage of the sewage is cut down until the effluent has really not been subject to septic action; in passing through the tank it has become charged with particles of digesting sludge, so that it might possibly be as bad, if not worse, than the original sewage. Curves showing normal effect of storage in septic tanks have been drawn from data obtained at the experimental station and are shown in Fig. 4.

Average Analyses Showing the Action of Septic Tanks with Different Periods of Storage.

	Nitrogen as free ammonia.	Nitrogen as albuminoid, NH_3	Oxygen consumed in five minutes.
Influent	19.17	11.5	64.0
8 hours storage ..	24.6	6.37	38.5
16 hours storage..	28.7	5.24	36.75
32 hours storage..	31.5	2.79	25.4

June 2nd-Aug. 16th, 1911.

In order to find the improvement in the character of the dissolved solids, a series of analyses was run on the sewage, the sample being filtered with aluminum cream.

Showing Improvement in Dissolved Matter in Sewage in Passage Through a Septic Tank.

	Nitrogen as free ammonia. Original sample.	Filtered.
Influent	26.6	25.84
32 hours storage	30.8	25.8
32 hours storage (aeration)	28.2	27.6

	Nitrogen as albuminoid ammonia. Original sample.	Filtered.
Influent	7.3	2.7
32 hours storage	6.03	2.6
32 hours storage (aeration)	3.6	2.4

	Oxygen consumed. Original sample.	Filtered.
Influent	32.3	15.1
32 hours storage	23.2	7.5
32 hours storage (aeration)	21.9	7.6

From July 5th-25th, 1912, 11 samples.

The aerators were used between two periods of storage. After one period of storage the sewage was passed over an aerator and then into another storage tank. It was hoped a great improvement would result, due to a constant inoculation of the second storage tank with certain types of organism, thus ensuring a more constant action in the second tank. That this inoculation takes place is easy of proof, but the improvement in the character of the effluent was so small as to be negligible if measured by free ammonia, albuminoid ammonia and oxygen consumed tests. The results were:

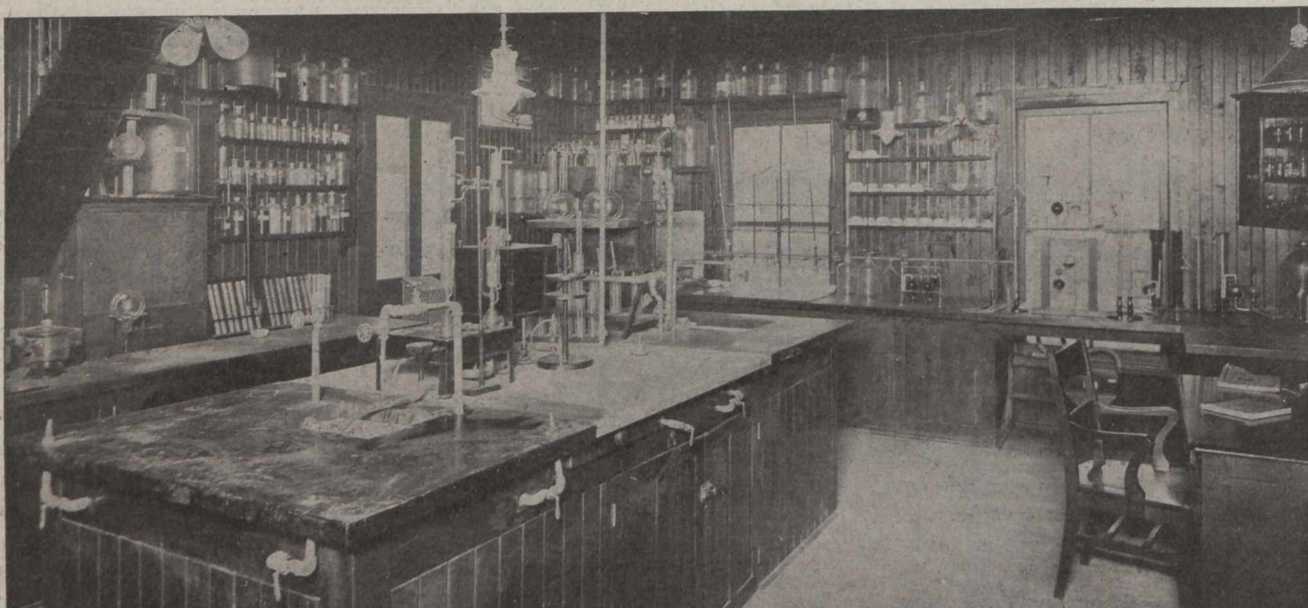


Fig. 1.—A View of the Provincial Board of Health of Ontario Laboratory for Sewage Analysis.

Average Analyses Showing the Effect of Aeration.

	Nitrogen as free ammonia.	Nitrogen as albuminoid, $N.H_3$.	Oxygen consumed.
Influent	19.17	11.5	64.0
8 hours storage before aeration	24.6	6.37	38.5
Immediately after aeration	23.7	5.2	33.2
8 hours storage after aeration = 16 hours	29.4	4.51	27.8
16 hours storage	28.7	5.24	36.75
16 hours storage immediately after aeration	26.6	4.36	29.5
16 hours after = 32 hours	31.5	2.79	25.4

June 2nd-Aug. 16th, 1911.

Another Period Comparing Aerated and Non-Aerated Septic Action.

	Nitrogen as free ammonia.	Nitrogen as albuminoid, $N.H_3$.	Oxygen consumed.
Influent	27.5	12.7	62.0
16 hours before aeration	33.8	3.31	33.25
Immediately after	31.4	3.92	27.2
16 hours after = 32 hours (aerated)	35.5	2.4	25.9
32 hours storage, no aeration (non-aerated)	57.0	2.42	25.6

Sprinkling Filters.—The results of analyses of consecutive samples of effluent from the sprinkling filters showed surprising variation, particularly in the amount of oxygen consumed in 5 minutes. This was found to be due entirely to the suspended matter in the effluent. Some samples seemed to be entirely different when analyzed immediately after shaking, but on analysis after settling showed no practical difference. The amount of flocculent and easily settled matter in the effluent made large differences due to the rapidity with which it takes oxygen from potassium permanganate and also partly to every variation or error being multiplied by 10; thus, a comparatively slight variation in the amount of permanganate used assumed large proportions when multiplied by 10—one drop would become nearly 0.5 cc. These factors must be taken into consideration, and in order to know what work a unit is doing it is necessary to have a true average of a large number of analyses of samples taken at short intervals and extending over a considerable period.

Average Analyses of Sprinkling Filter (Crushed Stone).

	Nitrogen as free ammonia.	Nitrogen as albuminoid ammonia.	Oxygen consumed in five minutes.
Influent	19.17	11.5	64.0
Effluent when working well	10.16	4.6	24.7
Effluent when working badly	24.04	5.6	47.4

NOTE—Both albuminoid ammonia and oxygen consumed are effected by humus in the effluent.

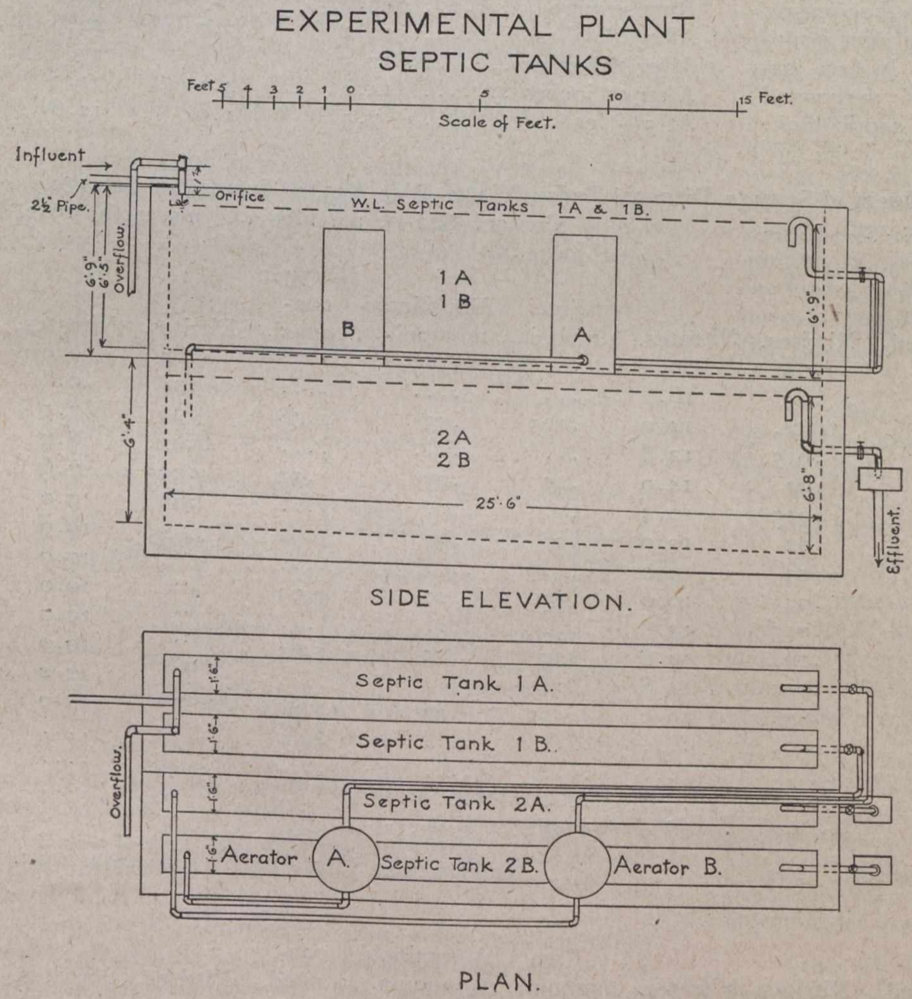


Fig. 2.

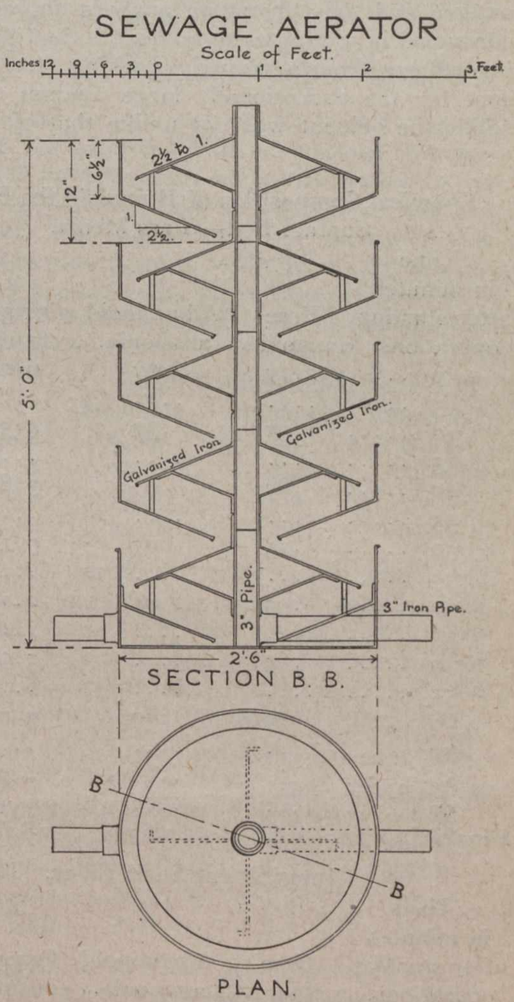


Fig. 3.

An examination of the surface of the sprinkling filter under normal conditions showed each separate piece of stone to have a thin covering of organic growth. Periodically, however, the surface of the filter became practically covered with fungal growths, usually Beggiatoa Alba. Then it became necessary to stop the filter and allow it to rest and dry for a couple of days. This treatment seemed all-sufficient and no trouble would be experienced from this cause for a considerable period. The sewage used on this bed was an effluent from an Imhoff tank. The tank containing fresh sewage quite possibly assisted inoculation with the organism, one cycle growing at the edge of the Imhoff tank which varied 3 inches in level between each throw in of the pump, and this with the ideal condition for the growth existing on the surface of the sprinkling filter, led to a heavy growth. By stopping the filter the humidity of the atmosphere immediately over the surface was changed, stopping further growth and the worms and micro-organisms in the bed destroyed the growth already there. What would happen to a bed if this growth was not destroyed but allowed to continue on the bed was then the problem. We found that the growth over the bed became almost water-tight, the sewage pooling on the surface. The micro-organisms living on the fungus destroyed the old growth but a new growth kept constantly forming on the surface precipitating upon decay a humus which filled the interstices of the stone under the fungus until the original surface of the bed was covered by several inches of organic matter. The conditions in the bed, instead of being aerobic became anaerobic. Analysis of the gas in the bed showed entire absence of oxygen and the effluent on analysis showed the oxygen consumed in 5 minutes to be double that of a corresponding effluent from a properly working filter. In fact, except for the exceptionally large amount of suspended solids the effluent was not unlike that of a septic tank. An investigation of the condition inside the filter at this stage showed that the humus was generally distributed throughout the filter.

What is the effect of depth in the action of a sprinkling filter? To answer this question troughs were placed at different depths—7 in., 13 in. and 18 in.—in the bed and a series of analyses run on the effluent at these depths for comparison with the final effluent which had passed through 5 ft. 6 in. of stone.

Analyses of Sewage During Passage Through a Sprinkling Filter.

(46 Average Analyses—May 16th to September 19, 1912).

	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.
Raw sewage	19.17	11.5	64.0
After 6 inches	22.2	7.7	42.6
After 12 inches	17.5	6.1	37.6
After 18 inches	14.0	4.1	31.3
At 5½ feet	7.5	1.9	12.6

Chemical Composition of Humus in the Effluent of Sewage Disposal Beds—Water Was Applied Instead of Sewage.

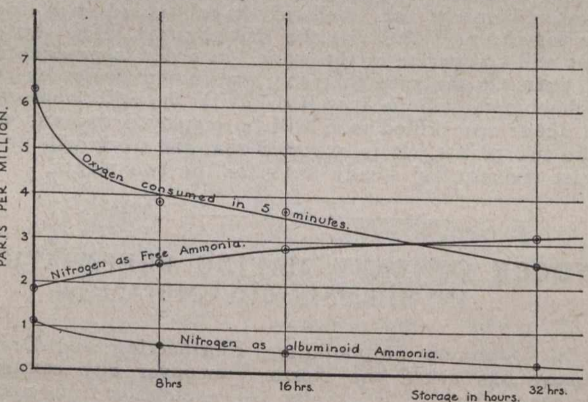
	Contact Bed—Glass Media. June 25th, 1912.					Contact Bed—Coke Media. June 25th, 1912.				
Time in minutes after starting operations.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.	Nitrites.	Nitrates.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.	Nitrites.	Nitrates.
0	2.17	.67	6.05	.08	22.4	.37	.175	3.76	.07	0.6
5	....	....	....	.03	18.8	....	....	....	.01	0.8
10	1.07	.37	4.5	trace.	14.0	.125	.23	3.48	.02	7.5
15	....	....	....	.015	12.8	....	....	....	trace.	8.7
20	.85	0	3.85	.02	14.0	.27	.27	.55	.005	7.6
25	....	....	....	.015	10.4	....	....	....	.01	9.0
30	.75	0	3.16	.02	10.0	.27	.07	1.92	trace.	10.0
35	....	....	....	.03	9.0	....	....	....	"	10.0
40	.95	0	2.11	.03	10.0	.37	.20	4.03	"	10.0
45	....	....	....	.025	13.6	....	....	....	"	10.0
50	.65	....	2.93	.02	14.8	.30	.75	1.92	"	10.0
55	....	....	....	.005	14.8	....	....	....	"	10.0
60	.85	.10	3.0	trace.	16.0	.125	.27	13.8	"	10.0
70	....	....	....	.....	....	....	....	....	....	....
80	....	....	....	.....	....	....	....	....	....	....
90	....	....	....	.....	....	....	....	....	....	....
Final drippings	21.6	2.67	18.6	0.1	28.0	5.07	1.67	9.5	0.1	6.0

	Intermittent Sand Filter. June 20th, 1912.					Intermittent Sand Filter. June 24th, 1912.				
Time in minutes after starting operations.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.	Nitrites.	Nitrates.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.	Nitrites.	Nitrates.
0	2.30	.25	3.86	.06	2.2	.47	.07	2.02	trace.	12.0
5	....	....	....	....	....	....	....	....	....	....
10	....	....	....	0.11	12.2	....	....	....	trace.	16.8
15	....	....	....	....	....	....	....	....	....	....
20	....	....	....	0.10	11.56	....	....	....	.005	25.6
25	....	....	....	....	....	....	....	....	....	....
30	2.55	.55	7.52	.08	11.28	.37	.27	2.5	.012	21.6
35	....	....	....	....	....	....	....	....	....	...
40	....	....	....	.16	11.08	....	....	....	.03	18.0
45	....	....	....	....	....	....	....	....	....	....
50	....	....	....	.14	11.08	....	....	....	.05	16.0
55	....	....	....	....	....	....	....	....	....	....
60	2.7	.50	7.16	0.14	10.8	.77	.37	3.4	.05	12.0
70	....	....	....	.13	10.36	....	....	....	.06	9.2
80	....	....	....	.13	10.36	....	....	....	.09	10.8
90	2.1	.7	9.36	0.10	.....	.77	3.7	2.6	.05	8.6
Final drippings	....	....	....	....	.....	....	....	....	.14	8.4

These results show that the improvement in the sewage is much greater in the first 6 inches than in the second, and greater in the second 6 inches than in the third, and greater in the first foot and a half than in the ensuing four feet. Would there be any advantage in exceeding the 5½ feet depth?

Effluents from sprinkling filters contain suspended matter at all times. The amount of suspended matter in one bed reached a proportion as high as 10 cubic yards per million gallons of sewage for a short period. This was exceptional; the average bed would probably not exceed more than a cubic yard per million gallons. Periodically, however, the beds slough off a large amount of humus-like material filled with worms and low forms of life. A cubic yard of this material is capable of taking all the dissolved oxygen from 50,000 gallons of water saturated with oxygen at 14 degrees C., or the amount of oxygen in over 4,000 cubic feet of air. This matter turned into a body of water would probably produce anaerobic conditions; this means the destruction of the original life in the water and the production of disagreeable odors.

To safeguard against a nuisance produced in this manner, it is necessary to treat the effluent from bacterial beds. Our experience shows that this material is easily sedimented. One hour's storage in an ordinary sedimentation bed removed practically all suspended matter; in twenty minutes the settlement of all the grosser matter had taken place, only very finely divided matter remaining in suspension. This would be readily retained in an Imhoff tank.



CURVES SHOWING EFFECT OF STORAGE IN SEPTIC TANKS.

Fig. 4.

The sludge collected in the sedimentation tanks, used in connection with the sprinkling filter effluent has some very objectionable features. It does not dry readily and has a most unpleasant odor, due probably to the large number of dead worms in it. On storage, under the conditions obtaining in the storage chamber of an Imhoff tank, it would become very similar to an ordinary Imhoff sludge, non-odorous and readily drying. Therefore, the best type of sedimentation tank would be the double chamber type, giving a length of storage of at least twenty minutes in the upper chamber and from one to three months in the lower chamber.

Analyses of Sludge in Effluent of Bacterial Beds.

Fertilizer Constituents.

Total nitrogen	6.8 %
Total phosphoric acid	0.8 %
Potash	0.16%
Grease	6.0 %
Ash	41.7 %

Further results obtained are given in a number of tables forming a part of the report. These tables record in detail all operating data respecting samples taken in the various stages of sewage purification under the different conditions considered. The first table relates to 52 samples examined between June 2nd, 1911, and September 25th of the same year. The free ammonia, albuminoid ammonia and amount of oxygen consumed are recorded in parts per million for the four stages of septic action, viz., (1) untreated raw sewage, (2) sewage after 16 hours septic action, (3) sewage further treated by aeration, (4) sewage 16 hours later, being a total of 32 hours septic action. A summary of the table is as follows:—

Stage.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.
Untreated sewage	22.1	11.9	62.5
16-hour septic	30.6	4.0	35.7
Aeration of same	28.7	4.2	27.5
32-hour septic	32.9	2.6	25.0

Table II. relates to septic action No. 2 and gives in parts per million the corresponding amounts of free ammonia, albuminoid ammonia and oxygen consumed for 33 samples of sewage investigated between June 2nd and August 16, 1911. The stages being: (1) untreated raw sewage, (2) sewage after 8 hours septic action, (3) sewage further treated by aeration, and (4) sewage 8 hours later, having a total of 16 hours septic action. A summary of this table is a follows:—

Stage.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.
Untreated sewage	19.2	11.5	62.8
8-hour septic	24.7	6.4	36.8
Aeration	23.7	5.4	34.7
16-hour septic	29.4	3.6	27.8

Table III. gives the results in parts per million for biologic treatment of 46 samples treated between June 2nd and August 22nd, 1912. The results relating to five stages, viz., raw sewage and state after treatment on two contact beds, sprinkling filter and intermittent sand bed respectively. A summary is as follows:—

Stage.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.
Raw sewage	24.7	14.3	64.3
Contact bed A	18.8	8.5	34.7
Contact bed B	21.8	8.2	37.1
Sprinkler filter	8.7	2.5	20.2
Intermittent sand filter	2.2	1.2	14.5

Table IV. relates to sprinkler filter operating data, giving results for (1) raw sewage, (2) sewage showing effect of first 7 inches of media, (3) same 13 inches of media, (4) same 18 inches of media, (5) same 5½ ft. of media. The tests cover 40 samples taken between January 16th and July 24th, 1912, and 12 samples taken between July 25th, 1914, and September 19th, 1914. A summary of the table is given as follows:—

Stage.	Free amm.	Alb. amm.	Oxygen consumed.	Nitrites.	Nitrates.
Raw sewage	23.0	9.7	50.6	...	...
7 in. of media	21.0	8.5	43.7	0.4	0.8
13 in. of media	17.3	5.4	33.8	1.7	2.6
18 in. of media	13.2	3.8	27.0	3.1	4.5
5½ ft. of media	6.1	2.0	13.2	1.4	7.3

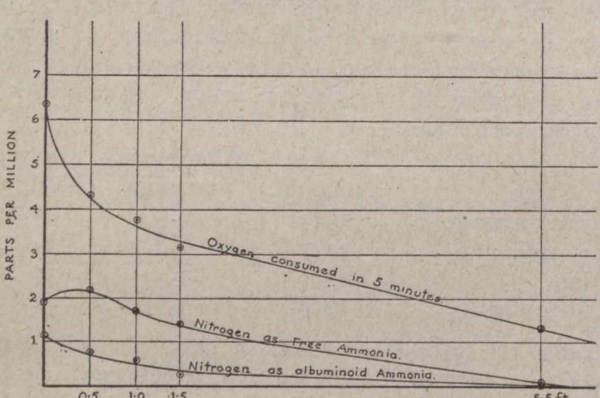
The first part of Table V. relates to chemical change due to filtration only and treats of samples from Imhoff effluent and Imhoff sludge chamber, unfiltered and filtered, respectively. The samples, 32 in number, were taken between May 31st and July 29th, 1911. They are summarized as follows:—

Stage.	Free amm.	Alb. amm.	Oxygen consumed.
Imhoff effluent, unfiltered	27.1	11.8	65.7
Imhoff effluent, filtered ..	25.8	2.7	15.1
Imhoff side, unfiltered ...	28.7	11.7	60.0
Imhoff side, filtered	27.4	2.9	15.2

Part 2 of the table relates also to chemical change due to filtration only, that is, removal of suspended matter for 12 samples taken between June 14th and July 25th, 1912. The results for raw sewage unfiltered and filtered are summarized as follows:—

Samples.	Free ammonia.	Albuminoid ammonia.	Oxygen consumed.
Raw sewage, unfiltered.	19.5	14.85	73.7
Raw sewage, filtered ..	18.9	5.18	24.1

Part 3 of Table V. gives the quantities of chemical constituents in filtered and unfiltered samples of sewage, showing effect after sprinkler washings in 18-inch media



CURVES SHOWING EFFICIENCY AT DIFFERENT DEPTHS OF MEDIA IN A BROKEN STONE PERCOLATING FILTER.

Fig. 5.

and 5½-ft. media, of sprinkler effluent under normal operation, unfiltered and filtered samples being tested in each case. The results of the latter, obtained from 9 samples taken between September 10th and September 19th, 1912, are summarized as follows:—

Samples.	Free amm.	Alb. amm.	Oxygen consumed.	Nitrites.	Nitrates.
Sprinkler effluent, unfiltered	9.13	1.58	10.5	0.71	6.45
Sprinkler effluent, filtered	9.99	1.08	7.2	0.95	5.71

The table on the lower half of page 130 is from the report and shows the chemical composition of humus in the effluent of sewage disposal beds with water applied instead of sewage. The results are given in parts per million.

The production of all kinds of finished rolled iron and steel in 1913 amounted to 967,097 tons, an increase of 105,873 tons, and also was the largest in the Dominion's history. Of last year's output about 95,881 tons were iron and 871,216 steel.

MORE WAR ORDERS GIVEN.

Up to December 25th, and according to an estimate of *The Monetary Times*, approximately $36,481,500 of war materials and equipment, etc., had been ordered by various governments in Canada. Since then, arrangements have been made for the delivery of much more material of various kinds, bringing the total to date to about $47,581,000 divided as follows:—

Orders to December 4th, estimated at	$36,481,500
Orders from December 4th to 25th..........	9,550,000
English order to National Steel Car Company...	500,000
French order to National Steel Car Company...	1,000,000
Pick handles (British order), 300,000............	50,000
	$47,581,500

Orders for about 300,000 pick handles have been placed by Mr. Frederick Stobart, purchasing representative of the British war office. The orders were estimated by Mr. Stobart to be worth about $50,000. Delivery of these will be made at once.

Mr. Stobart estimates that the value of the business placed by him in Canada on behalf of the Imperial authorities has been between $6,000,000 and $7,000,000.

Mr. Basil Magor, president and general manager of the National Steel Car Company, of Hamilton, has returned from France with an order for war material amounting to $1,000,000, and an order from England for material valued at $500,000. These are two of the biggest orders received in Hamilton. They will be delivered as quickly as possible, and the firm will probably work overtime.

The Canada Forge and the Canadian Billings and Spencer Company, of Welland, have shared in a further order for shrapnel shell for the British army. The two companies will co-operate in the work. In order to produce these shell parts at the rate that the government requires them, new machinery will be installed. With the additional equipment about 200 skilled men will be employed day and night by the two plants. It is expected that the work will provide at least six months' steady work for the two plants.

DRYDOCK COMPANY MAKING PREPARATIONS IN BRITISH COLUMBIA.

The Dominion Shipbuilding, Engineering and Drydock Company has asked the North Vancouver city council to grant concessions of free water and exemption from taxation for a period of ten years. This company has commenced operations on the north shore of the inlet, and during the coming year it expects to have its first unit working which will comprise the marine railway, wharves, machine shops, foundries and stores. During the year following, the second unit will be completed, including plate and frame setting sheds, installation of shipbuilding berths, etc. The third year will mark the completion of the entire plant and the drydock, 1,050 feet in length and 100 feet in the gates, and which will be capable of docking the largest vessel on this coast.

In urging the city to grant free water and tax exemption, the company said its main object was to show European capitalists that it has the support of the municipality where its plant was being established. The company guarantees to employ 250 men at the commencement of operations, 300 in the second year and 400 in the third year.

BRITISH COLUMBIA SMELTERS ACTIVE.

In November, more ore was sent out of the Rossland camp than ever before. The Granby smelter at Grand Forks, which was closed for a short time, has four of its furnaces in operation, and it is expected that the other four will be shortly put in commission. This will call for raw material from the company's mines, and will mean a maintenance of fairly good conditions in that part of the province. The smelter at Trail, operated by the Consolidated Mining and Smelting Company, has continued operations without a break. This concern, as well as the Granby, handles custom ores.

WATERPROOFING DESIGN FOR RAILROAD BRIDGE FLOORS.

THE Proceedings of the American Society of Civil Engineers for December, 1914, contains a paper by Mr. S. T. Wagner, presenting a specification for the design, materials and manner of application of the waterproofing of railroad bridges with solid steel floors. There is a widely varying practice in this respect among engineers in bridge construction, and doubtless Mr. Wagner's paper will bring forth much discussion of value in determining on more uniform practice. The specifications presented are the outgrowth of many years' experience with various materials and designs, and the writer states and correlates the more or less fixed prin-

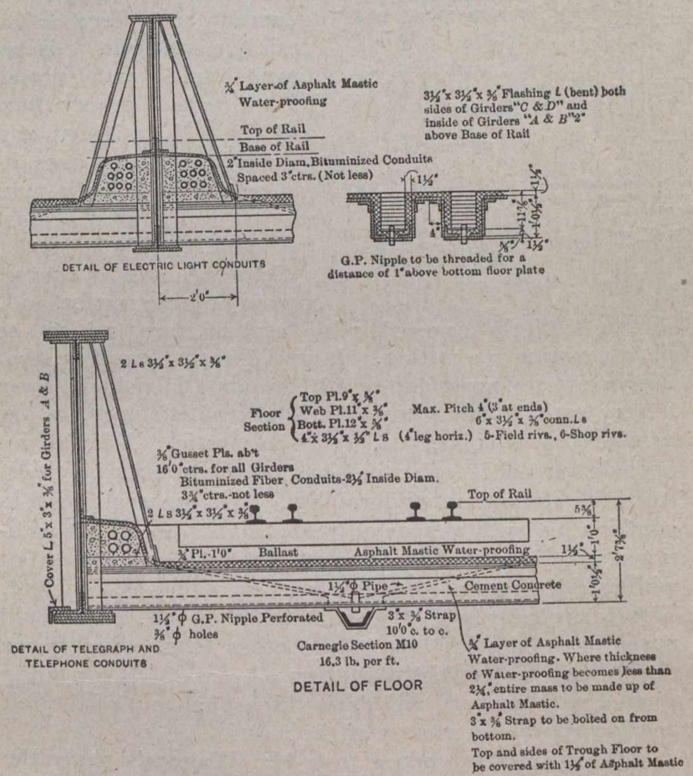


Fig. 1.

ciples which he believes to exist. Waterproofing plays an important part in the details which the designer must bear in mind when engaged on a structure of this type. It is undertaken for two reasons: (1) To protect the metal of the floor from corrosion due to the alternately wet and dry condition of a ballasted floor; and (2) to prevent the water, which is absorbed by the ballast and given off slowly, from dripping on a street beneath.

The primary object is to provide such details as will remove water from the bridge in the quickest possible time and by the shortest route. Another is to design the height of the waterproofing so that it will be above the highest water level, in case of the possibility of water being held on the bridge for any considerable time after a storm. It is also considered inadvisable to throw all the water off the bridge at its ends, over the back walls. It is very difficult to design at this point a satisfactory detail which will prevent water from forcing its way back over the back wall and down the face of the abutment, even though the drainage back of the abutment is specially good. It is much better to collect the water on the deck of the bridge, take it below the floor by inlets and downspouts, and discharge it below the floor on the ground, or into a sewer (if in a city). Such inlets can be made so as to be accessible from below for cleaning, and, with

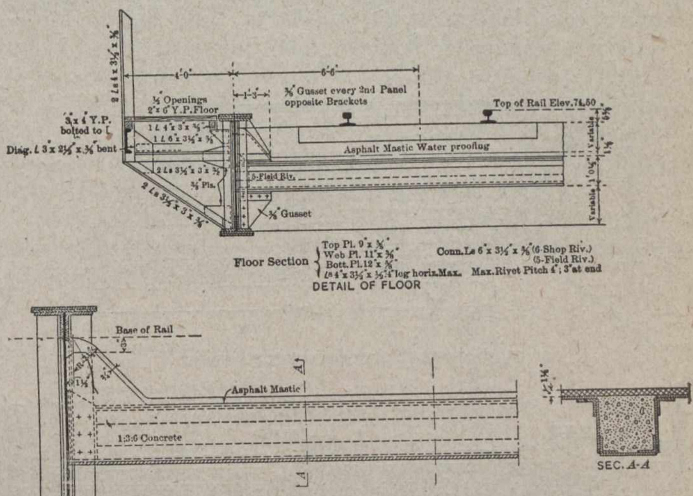


Fig. 2.

ordinary care, can be made satisfactory as far as leakage around them is concerned. To carry the water away quickly, there should be a number of these inlets on any bridge of considerable extent.

In the case of deck structures, the waterproofing details are simple, the principal questions to be settled being the type of waterproofing to be used and the durability of the materials. The application of the waterproofing—whatever kind may be selected—is not difficult.

In a half-through structure the conditions for waterproofing are at their worst. If the top of rail is near the top of girder, it is generally advisable to carry the waterproofing over the girder and encase its entire top in concrete.

The finish of the waterproofing against the web of a half-through girder, the top of which is 3 ft. or more above the top of rail, is one of the most difficult problems to be

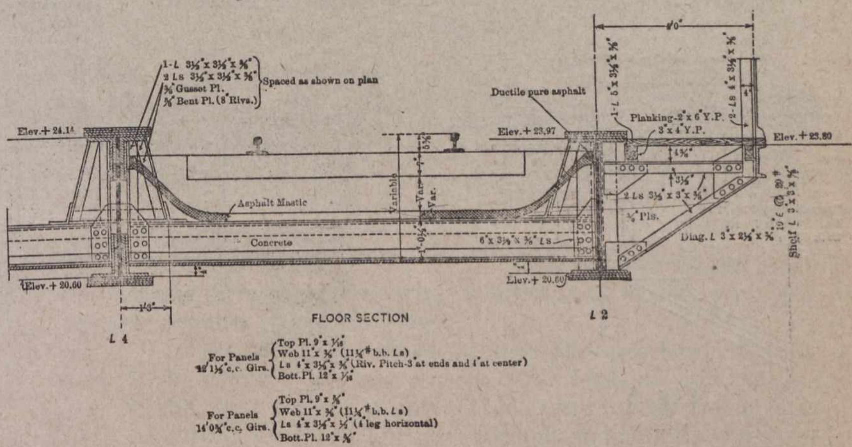
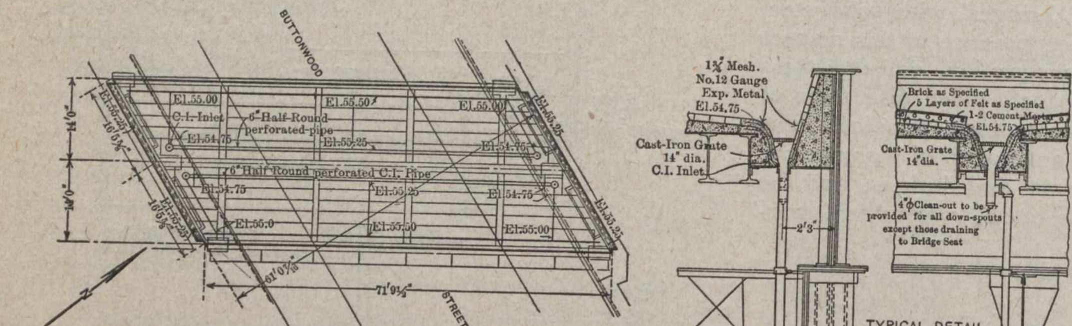


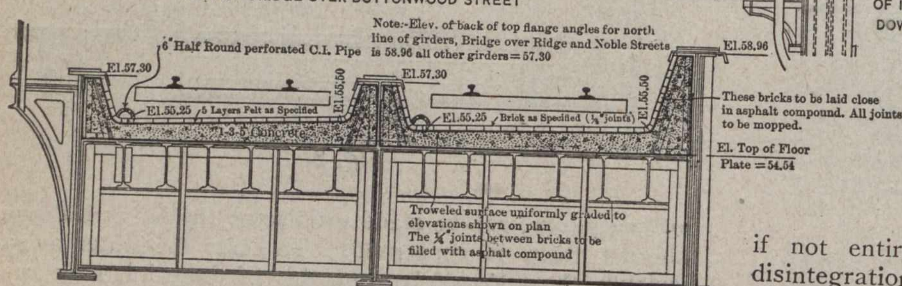
Fig. 3.

solved. In some cases, it is the practice to carry the waterproofing nearly if not all the way up to the top of the girder, and protect it with a considerable thickness of concrete, but, generally, it is finished up against the web not far above the level of the top of rail. This finish, if done satisfactorily, will make a good piece of work of the structure as a whole, provided the detail in respect to water running over the back walls is guarded against. It is believed that riveting a flashing angle to the web does not provide a satisfactory detail, as it is impossible to make it continuous on account of stiffeners and gussets. Placing a pocket of ductile, adhesive mastic (which will not harden in cold weather) as a joint between the waterproofing layer and the web is believed to give the best



PLAN OF BRIDGE OVER BUTTONWOOD STREET

TYPICAL DETAIL OF INLET AND DOWN-SPOUT



TYPICAL CROSS-SECTION SHOWING MAXIMUM THICKNESS OF WATER-PROOFING

Fig. 4.

results, and in case of the deterioration of this asphalt, the detail is in a place where repairs can be made without interfering with traffic. The question of interference with traffic in making waterproofing repairs is one that is giving many railroad bridge engineers serious concern, and is leading slowly, but surely, to much more elaborate, effective, and expensive systems, in order that repairs may be postponed as long as possible. It is possible to make the proper kind of pure asphalt, unmixed with foreign matter, adhere to a clean surface of metal or concrete, and thus secure a tight joint. It has been found advisable to

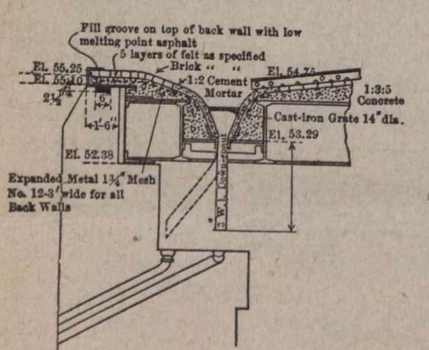


Fig. 5.

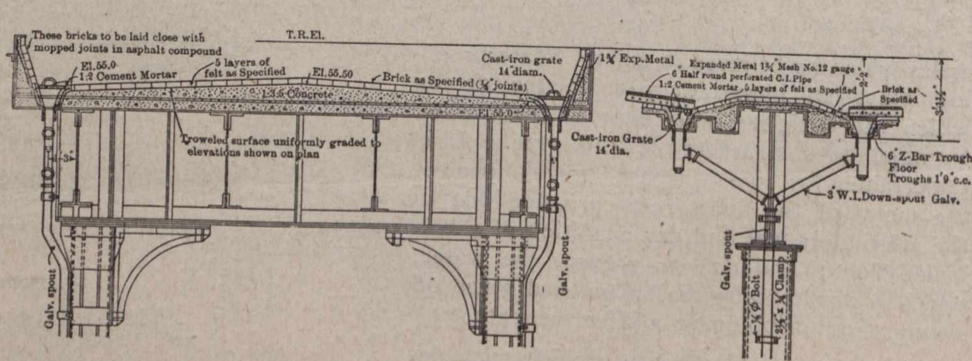


Fig. 6.

protect this pocket of asphalt with a layer of concrete to prevent the ballast, which may be carelessly thrown against the girder, from cutting into it. (See Figs. 8 and 9.)

As to materials to be used for the solid bridge floor, it is believed that, after the question of durability is disposed of—as one of the most important items—the most durable material, which can be shown to possess adhesion and ductility at low temperatures, and at the same time be sufficiently hard to prevent running at maximum exposure temperatures, is the most desirable—say, temperatures generally between 0° and 200° F. Higher melting points are undesirable, for a number of reasons, and should not be used. The most critical time to test a bridge floor is during melting snow, and cracks which may develop at that time are sure to be channels for water.

Whether felt, fabric, or asphalt mastic shall be used, is a debatable question, and will depend somewhat on conditions. If hard pressed for head room in depth of floor construction, the use of asphalt mastic is indicated, and, though it is generally considered an undesirable material, it is believed that, with proper natural rock, proper flux, and careful mixing and placing, first-class results can be obtained, if the pure asphalt seal is used against the metal.

Felts or fabrics, of course, contain organic matter, and, if not entirely covered with asphalt, are subject to disintegration by rotting. It would seem, however, that if properly prepared and laid, these materials should form a very satisfactory membrane—more satisfactory, as far as elasticity is concerned, than the mastic. A felt of inorganic material—asbestos—has all the proper qualities, from the standpoint of durability. It is generally laid in combination with a layer of treated burlap to give it additional strength. Practice sometimes protects asbestos felt with asphalt mastic instead of brick or reinforced concrete. This is probably allowable with asbestos felt, but should never be used with any of the other felts. Experience shows that hot mastic, placed on a layer of felt, or fabric treated with asphalt, will draw the asphalt out of the felt and incorporate it as part of the mastic.

We further reproduce from Mr. Wagner's paper the accompanying illustrations of progress in waterproofing design. This should be considered and studied in the order in which they are numbered as the sequence represents what are considered to be improvements in each case.

Fig. 1 shows half-through plate girder, with trough floor, with flash angles along webs between stiffeners and gussets. Waterproofing of asphalt mastic placed around entire surface of troughs. Each trough provided with nipple in centre, to which floor slopes. Concrete used as filler beneath mastic. Drainage beneath floor by gutters leading to down-spouts and into street gutters beneath bridge. Asphalt beneath flash angle and against web. The nipple is a bad detail. Asphalt will break loose from web of girder and allow water to seep through along web at stiffeners and gussets when flash angle is not continuous.

The cost of such work, including concrete and all drainage, is about $0.25 per sq. ft.

Fig. 2 shows half-through plate girder, with trough floor. Troughs filled with 1 : 3 : 6 concrete and water-

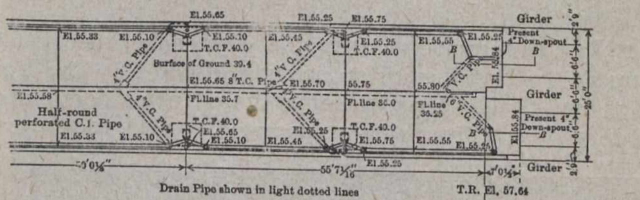


Fig. 7.

proofed with rock asphalt mastic. Drainage to one end of bridge, or, with light or level grades, to both ends, leading to dry stone packing placed against backs of abutments. No special precaution to make asphalt adhere to girder web—will crack and let water through. Difficult to make good detail at back wall, causing water to back up, especially after freezing weather, and run on bridge seat and down abutment.

The cost of such work, including concrete and drainage, is about $0.35 per sq. ft.

Fig. 3 shows half-through plate girder, with trough floor. Very shallow girder shown in drawing, but same principle applicable to girders of greater depth. In case of proportions shown, probably it would have been wiser to have encased and waterproofed entire top flange of girder. Before applying concrete to fill troughs, all openings between girders and ends of floor sections are carefully caulked with burlap dipped in a low-melting-point asphalt. Drainage is over back wall with specially prepared, sealed joint. Waterproofing is 1½ in. of rock asphalt mastic applied in two ¾-in. layers. A V-shaped opening left along the girder web, and around stiffeners and gussets. The sides of this opening cleaned with wire brushes, bellows, and gasoline, and then painted with

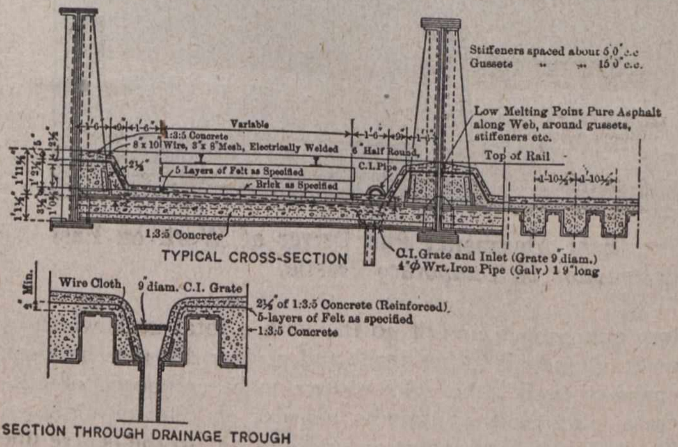


Fig. 8.

asphalt dissolved in gasoline. The V then filled with low-melting-point, ductile, pure asphalt.

This type of floor has been very successful, and costs, complete, about $0.45 per sq. ft.

Fig. 4 shows half-through plate girders with floor-beams and with I-beam and plate floor. Bridge on a level grade. Concrete filling of 1 : 3 : 5 mix, sufficient to produce drainage grades. Waterproofing consists of five layers of surfaced felt and asphalt compound. Waterproofing carried up under top flange of girders, protected by layer of hard brick, laid flat, with joints filled with asphalt compound. Water drains to inlets placed near ends of bridge and graded so as to prevent any water from flowing over the back walls. Drainage through grates and clean-outs into down-spouts to sewer. Half-round, perforated, cast-iron pipe placed on top of brick to assist flow of water if ballast becomes dirty. Another detail of back-wall drainage, shown in Fig. 5, has been very successful.

Costs about $0.75 per sq. ft. High on account of grade of track being level, requiring additional concrete and inlets to provide proper drainage.

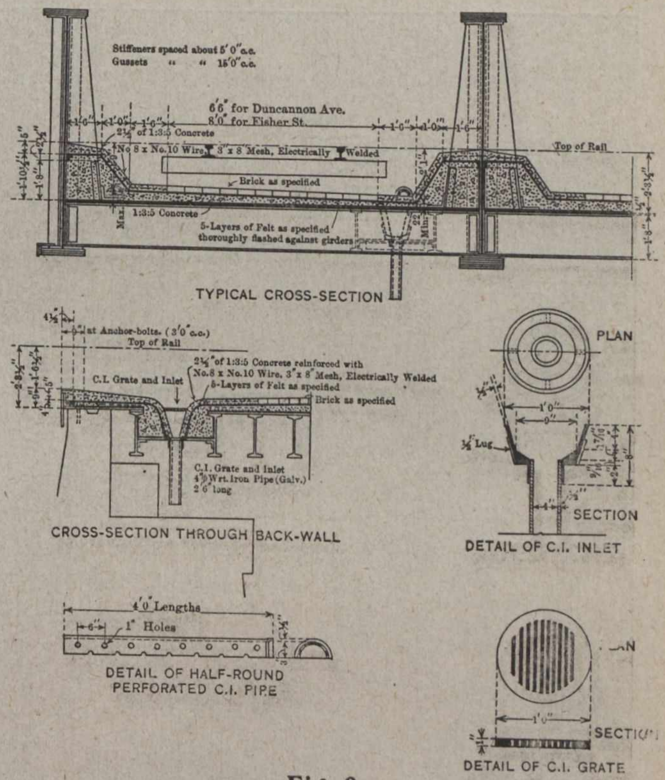


Fig. 9.

Figs. 6 and 7.—Deck viaduct with shallow-trough floor. Tracks level. Troughs filled with 1 : 3 : 5 concrete and waterproofing of same character as in Fig. 4. Drainage shown in Fig. 7. Only improvement suggested is use of cement mortar in place of asphalt for brick protection. Very successful.

Cost, $0.65 per sq. ft. High on account of level grade on viaduct, requiring additional concrete and inlets to provide proper drainage.

Figs. 8 and 9.—Half-through plate girders. Fig. 8 with trough floor and Fig. 9 with I-beams and plates. Filling with 1 : 3 : 5 concrete. Waterproofing, five layers of surfaced asphalt felt with asphalt compound, and protected with hard-burned brick in 1 : 3 cement mortar on flat floor and 1 : 3 : 5 concrete, reinforced with No. 8 and No. 10 wire, 3 by 8-in. mesh, electrically welded in gutters and over haunching. Pocket of low-melting-point, pure asphalt, carefully put in as seal against girders and around stiffeners and gussets before protection is placed. Drainage to inlets. No water going over back walls. Water removed from copings by special inlets built in masonry.

Cost, about $0.62 to $0.80 per sq. ft., including all drainage details.

ST. CLAIR AVENUE BRIDGE, TORONTO.

By E. M. Proctor, B.A.Sc.,
Structural Designer, Bridge Department, City of Toronto.

PRIOR to 1909 there existed on St. Clair Ave., between Bathurst Street and Spadina Road, a small wooden bridge which spanned Black Creek. In 1909 a reinforced concrete culvert (6 ft. x 6 ft.) was built at this location, and an earth embankment 20 ft. in height was constructed across the ravine. In 1911 it was decided to re-grade and widen St. Clair Ave. and to build the now existing St. Clair Ave. civic car line. The width of the street was fixed at 100 ft. and at Black Creek the height of the embankment was raised from 20 to 50 ft., which necessitated the extension of the culvert way in the ravine. Several conditions favored this proposition. Sir Henry M. Pellatt had donated a 100-ft. strip of land in the ravine for this purpose and there was no means of continuing this proposed driveway to the north without constructing a bridge in the embankment at St. Clair Ave. The owners of the flats to the north were claiming heavy land damages on account of the embankment cutting off their ingress and egress. The construction of a bridge and the building of a road in the ravine would combat these damage claims to a great extent.

In the summer of 1912 the city council decided to construct a bridge with an opening of 100 ft. The Railway and Bridge Department prepared plans for a deck plate girder bridge with a concrete span of 100 ft. and

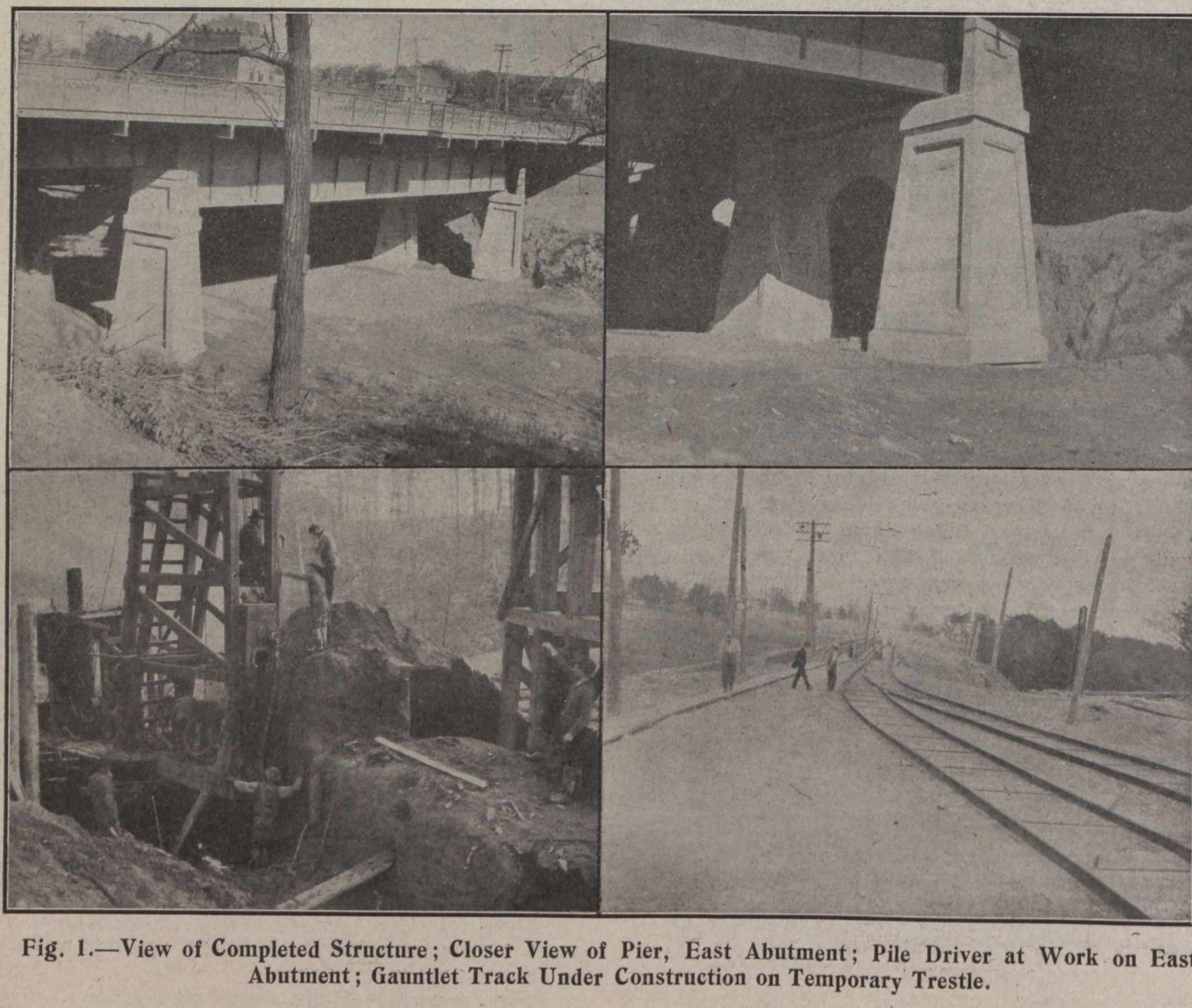


Fig. 1.—View of Completed Structure; Closer View of Pier, East Abutment; Pile Driver at Work on East Abutment; Gauntlet Track Under Construction on Temporary Trestle.

to a total length of 272 ft. This extension was made from the same design as was used for the portion then existing.

In January, 1912, a temporary trestle was built upon the old embankment and a burrow pit opened up, just west of the ravine. Two steam shovels and a work train were used. This filling, being nearly all done during cold weather, was in a more or less frozen condition. On June 26th, 1912, it was discovered that portions of the culvert had failed, the roof having fallen in. The collapsed portions were in the newly constructed culvert, the older part remaining intact.

The failure of the culvert and its necessary repair reopened the question of providing an opening for a drive- two approach spans of 40 ft., with a total deck width of 90 ft. (handrail to handrail) and a clear distance between curbs of 69 ft., the substructure to be composed of concrete piers and abutments bearing on pile foundations. The bridge is skewed at an angle of 23° to the centre line of St. Clair Ave. and is on a .67 per cent. grade.

The plans were approved and contracts let in the early summer of 1913 to the McGregor & McIntyre Co. for the structural steel work, and to Scott & Law for the piling and concrete work.

The first work to be done was to repair the culvert and excavate a site in the embankment for the bridge.

When the excavation was completed a temporary timber trestle was built to accommodate the civic street railway and pedestrian traffic. The railway was not ready to operate till several weeks after the trestle was completed.

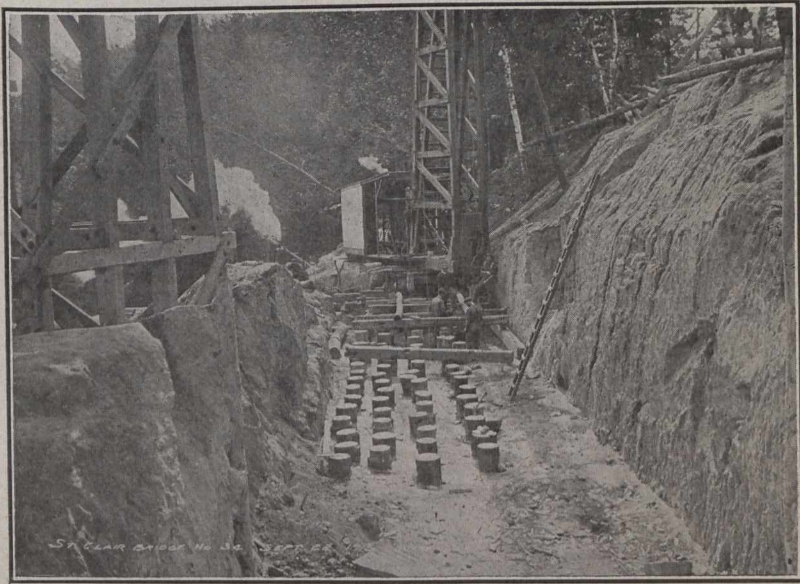


Fig. 2.—Piling in West Abutment, Showing Piles Cut Off.

This trestle was so constructed that the new bridge could be built without interfering with the street railway traffic. This was accomplished by bridging over the spaces occupied by the piers and abutments with steel beams, which could be easily removed when it was necessary for the pile driver to pass through; this was always done at night when few cars were running. The two street railway tracks were merged into a gauntlet track on the trestle (as shown in Fig. 1). This construction did away with the necessity of the cars stopping and turning a switch at the ends of the trestle, and brought the cost of the trestle down to a minimum. The operation of this gauntlet proved very satisfactory, very little inconvenience resulting to the operation of the car line. The city did all this preliminary construction by day labor.

The specifications for the permanent bridge were the City of Toronto's and Ontario Railway and Municipal Board's specifications. The item of most interest in the specifications is the loadings assumed. (See Fig. 4.)

The ground on which the permanent bridge was to be built is all filled-in-material and below that rather soft soil; it was necessary, therefore, to resort to piling for a proper foundation. Piles were supplied according to the following specifications: "Piles shall be of white oak, of straight, live timber, free from cracks, shakes, rotten knots, or other blemishes. They shall be so straight that a straight line taken in any direction and run the length of the pile shall show that its centre is at no point over four inches out of a straight line. They shall show an even, gradual taper from end to end and must not be in diameter less than eight inches at the point and not less than sixteen inches at the butt. The ends shall be cut square, the body barked and all knots trimmed smooth."

The pile driver used was an Arnott 4-ton, double-acting steam hammer, with the following dimensions: Stroke 21 in., diam. of piston 9½ in., steam pressure (working) 60 pds. per sq. in., the energy of each blow figures out to be 10,000 ft.-pds., 110 blows per minute

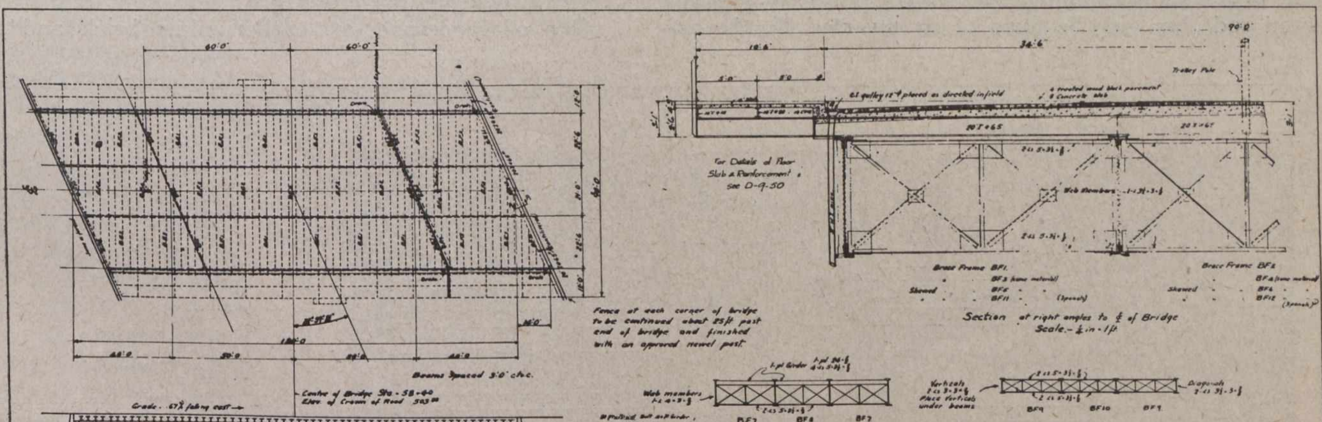


Fig. 3.—General Design of Bridge.

were delivered to the pile. Most of the piles were driven to refusal. An idea of the force of the blow of the hammer can be obtained from the following incident: A ⅜-in. bolt broke, somewhere on the hammer, and the nut and a part of the bolt dropped onto the plate at the head of the pile and before the steam could be shut off, the hammer struck it one blow, flattening the bolt and nut to ⅛ in. thick. Although the tops of the piles are not below water level, yet the perpetual dampness of the clay soil keeps the piles wet and prevents decay. The calculated loading for each pile was fifteen tons.

The abutments and piers are built of mass concrete with local reinforcement. The concrete mix was 1 : 3 : 5 below underside of coping and 1 : 2 : 4 above. The abutments are 26 ft. high and 100 ft. long with 20-ft. wing walls parallel with the street line. The base of the main wall is 13 ft. 3 in. wide. Reinforcing steel (square twisted rods) is supplied in the base over the piles, under the bridge seat, at the rear of the back wall and around the corners. No expansion joints were used.

The piers are about 10 ft. square at the ground line and taper up at a batter of 1 in 12. They are 15 ft. square at the top of the piling. From base of piers to roadway is about 40 ft. The piers are panelled on four sides and are joined transversely by means of a concrete strut which is constructed in the shape of an arch. On top of the piers is a concrete pedestal 6 ft. 2 in. high on which rest the 40-ft. girders. These pedestals are doubly reinforced by 6-1-in. square twisted rods bent in the form of an inverted U, the assumption in the design being that the pedestal has to withstand the expansion and contraction forces of the 40-ft. girders caused by the friction between the bearing plates. Reinforcing steel is also supplied along the top of the piers and struts and diagonally through the arched portions of the struts.

The finishing of the exposed concrete surfaces is best described by quoting an extract from the specifications:

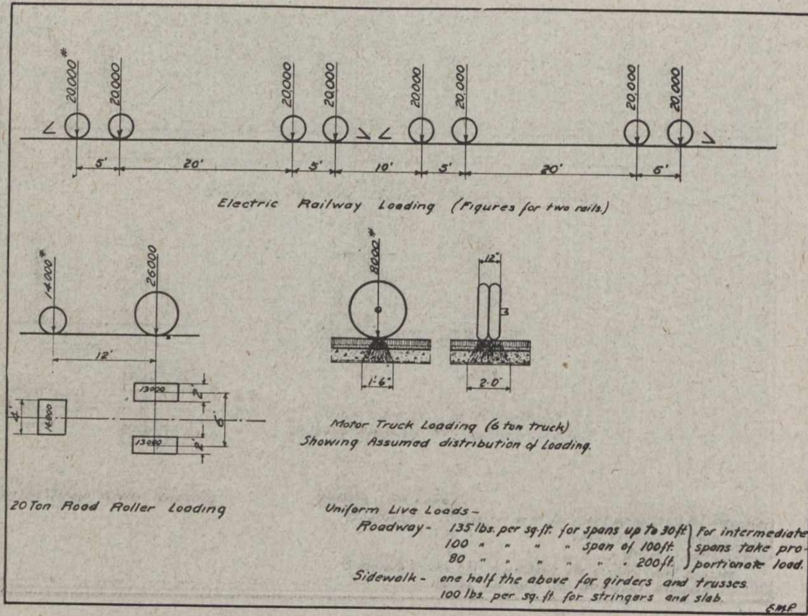


Fig. 4.—Loading Specifications.

"As soon as the forms are removed and all cavities filled, the concrete surfaces shall be thoroughly rubbed with cement grout compound of one part cement to two parts fine sand until all irregularities in the surface are filled, after which the whole surface shall be gone over with a piece of sandstone or carborundum brick and ground down sufficiently to remove all irregularities. The grout surfacing herein specified shall, in no case, be used for the purpose of producing a plaster coating to cover irregularities in the surface, produced by sagging or similar

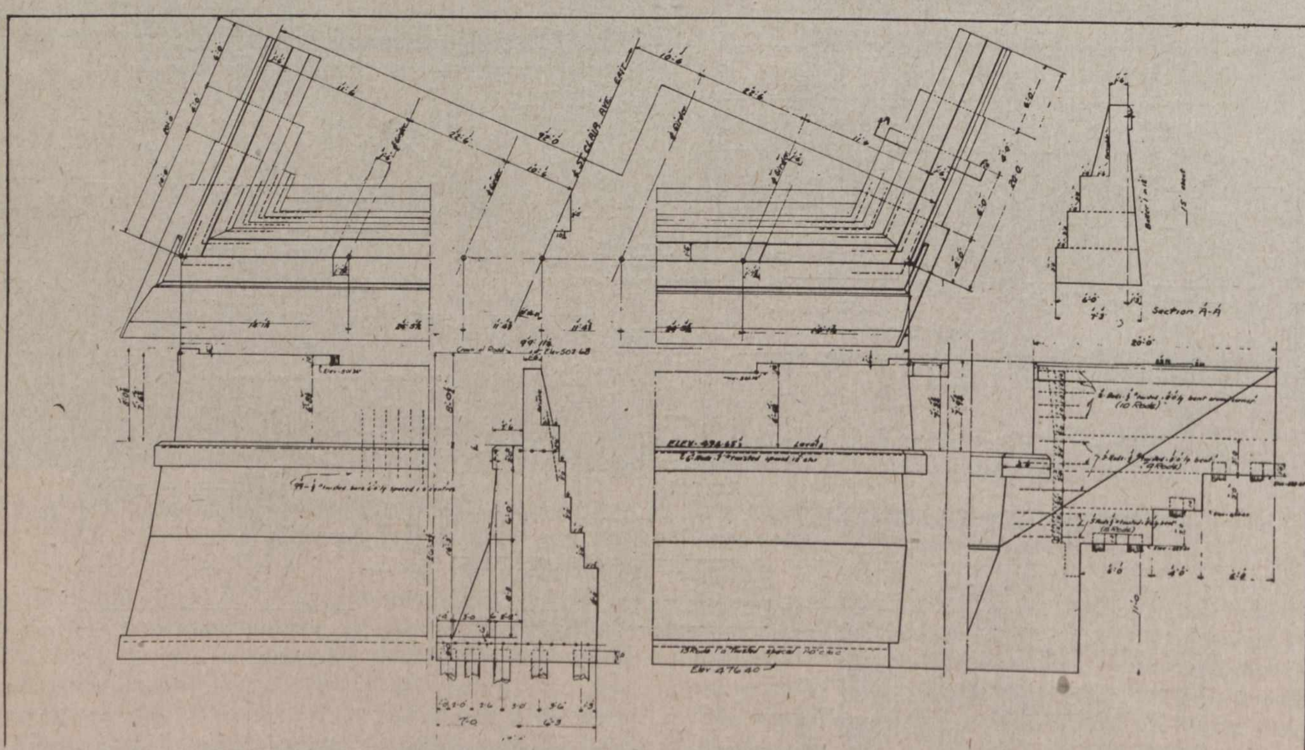


Fig. 5.—Design of East Abutment.

defects in the forms. Care must be taken that the surfaces so treated shall be thoroughly wet before the grout is applied.''

The steel work of the bridge consists of four rows of girders, the centre span 100 ft. and the two outer spans 40 ft.; 20-in. I-beams at 65 lbs. spaced 3 ft. centres rest directly on top of these girders. Every fifth beam cantilevers out to carry the fence and sidewalk stringers. An ornamental iron fence extends from end to end of wing walls on each side of the bridge. The girders are the common plate and angle type; the flange of the inside 100-ft. girder is made up of 2 angles 8 in. x 8 in. x 3/4 in. and 4 cover plates 19 in. x 3/4 in. which with one-eighth of the web gives a net flange area of 76.88 sq. in. This particular girder weighs 40 tons. Cross frames composed of angles are placed about every 18 feet centres between the girders. No horizontal diagonal bracing was used, the great width of the bridge and also the solid type of reinforced concrete floor used making this type of bracing unnecessary. The trolley poles are placed in the centre of the roadway and are carried in an 8-in. diam. iron pipe socket about 3 ft. deep, which is supported on beams between the floor beams. This construction permits the easy removal of the trolley pole when necessary, the pole being merely wedged in the socket and a cast iron wheel guard placed around the base.

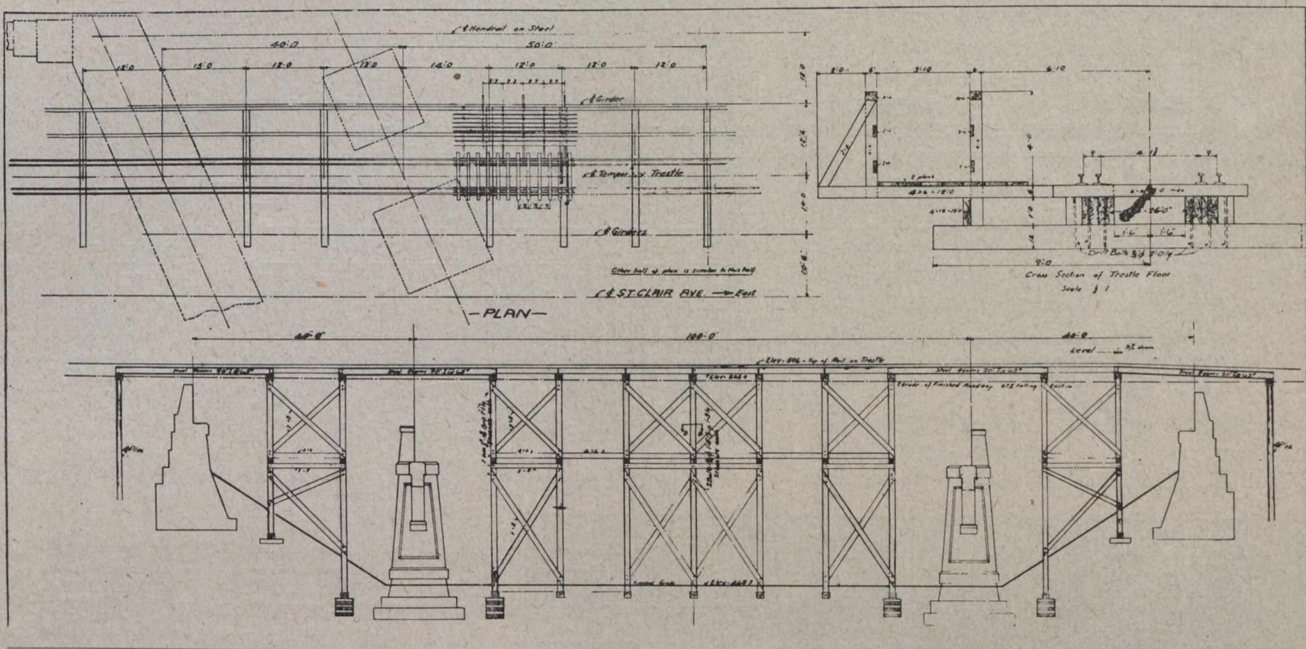


Fig. 6.—Temporary Timber Trestle to Carry Car Line During Construction.

The expansion joints are so arranged as to be invisible from the finished bridge floor, the paving and waterproofing being carried right over the joint. The expansion joint in the bridge floor is constructed of two vertical web plates, cut on top to the curve of the roadway and fastened at the base by means of an angle to the floor beams. To the top of each of these plates is riveted an angle also bent to the curve of the roadway, a cover plate riveted to one of these angles and free to slide over the top of the other completes the expansion joint. On account of the skew of the bridge and the fact that the


Fig. 7.—Sliding a 100-ft. Girder Out Into Position.

street railway rails had to pass through the expansion joint, the detailing of this joint proved a little intricate. The expansion joints at the abutments are the usual apron plate type, with an asphalt joint between the concrete of the bridge floor and the concrete base for the pavement of the approach.

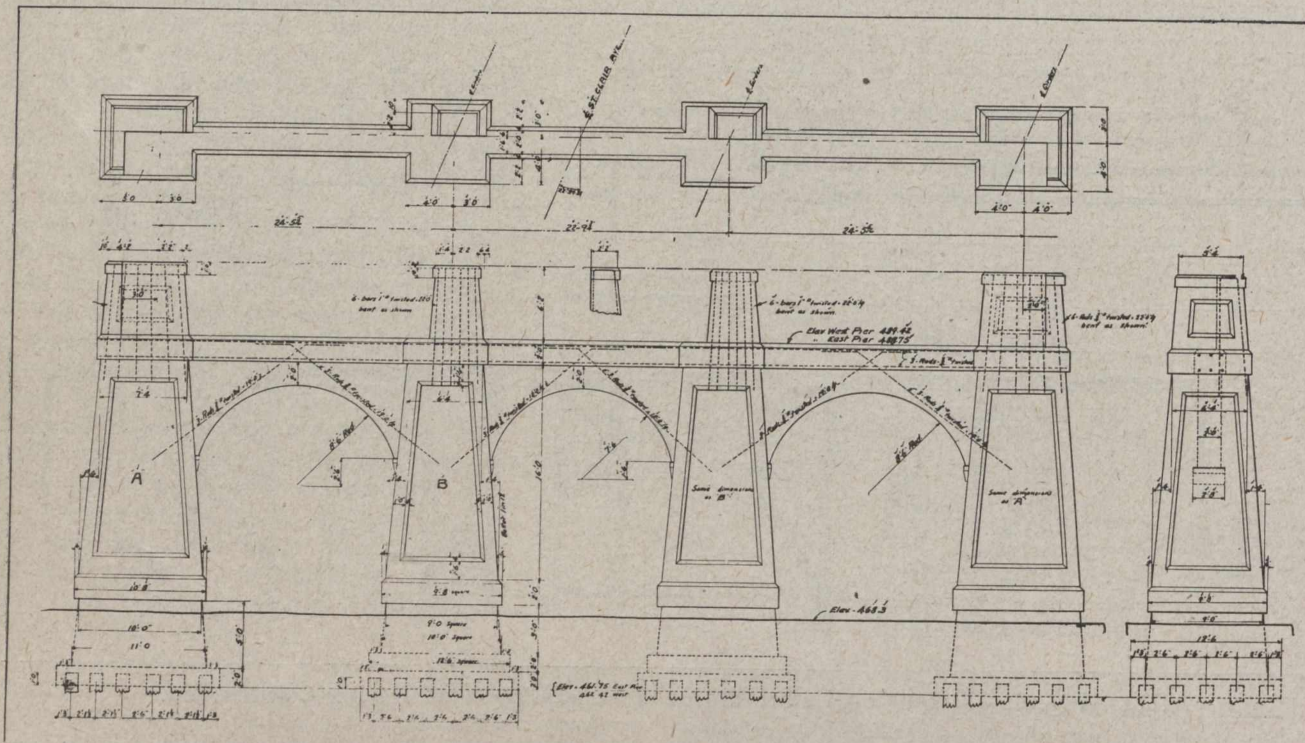


Fig. 8.—Details of Concrete Piers.

Structural steel catch basins are provided at various points in the bridge floor; these are connected to the creek below by 4-in. drain pipes. The sides of these catch basins have a batter of 3 in 12 to destroy the expanding force of ice, if the basin happened to be full of water in cold weather.

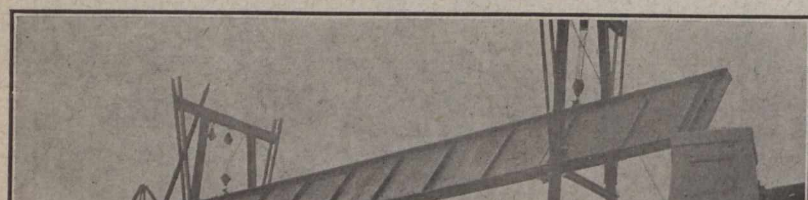


Fig. 9.—Erection of One of the Inner Hundred-foot Plate Girders.

The pier members of the 100-ft. girders at the sliding ends consist of a cast steel bed plate with a phosphor bronze plate inset into the top of it, while another bronze plate inset into the under side of the bearing plate of the girder completes the expansion bearing. At the fixed ends the bronze plates are omitted. The bearings for the 40-ft. girders are the ordinary steel plate type. This type of bronze plate expansion joint has given very good satisfaction so far.

In the design of the fence we were confronted with these two conditions—to make a strong fence and to make it pleasing in appearance. There have been several accidents lately in which the bridge fence was the only thing between a motor car and the ravine below, and the policy of the city now is, to build good stout fences on their bridges. The fence, as built, consists of 18 in. at the top of scroll work made of 1¼ in. x ¼ in. bars and 27 in. of 45° lattice work at the base, made of 1¼ in. x ¼ in. bars, and is 4 ft. high. A Carnegie handrail tee section No. 154 with one 1¼ in. x 1¼ in. x ¼ in. angle underneath to connect the scroll work to, composes the top chord, a 2½ in. x 2 in. x ¼ in. angle separates the scroll from the lattice work and a 2½ in. x 2 in. x ¼ in. angle 3 in. from the sidewalk slab completes the fence. 5 in. x 3 in. tees at 13.6 lbs. at 7 ft. 6 in. centres are used for fence posts. The scroll work and latticing were so designed as to be continuous in appearance at the fence posts.

The steel work was fabricated and erected by the McGregor & McIntyre Co. The transportation of this heavy steel from their plant on Shaw St. to the bridge site over the city streets, a distance of two miles, was admirably solved by the presence of good sleighing. The 100-ft. girders were loaded, flatwise, on two heavy sleighs, the tractive force being supplied by a large six-ton motor truck and a hoisting engine. When the motor truck

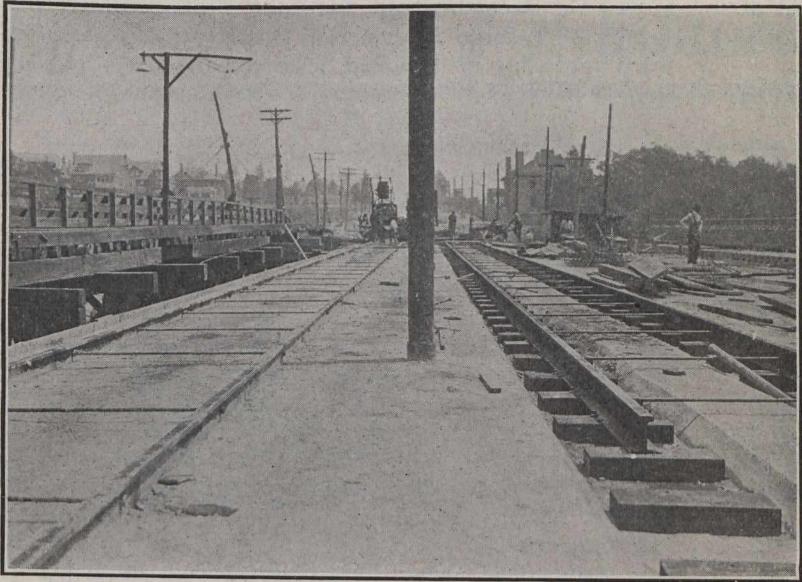


Fig. 10.—Methods of Laying Tracks on Bridge Floor.

could not start the load or when the grade was too steep, the hoisting engine, which was on skids, was snubbed to a telephone pole ahead of the load and a wire cable attached to the load; then with both the truck and hoisting engine no difficulty was experienced in moving the load. In this manner a grade as high as 7½ per cent. was successfully negotiated. On flat grades and generally on light grades the motor truck had no difficulty in "walking right along" with its 40-ton load. It took, on an average, a day to transport one of those big girders to the site, the many corners to turn and the numerous heavy grades to go up and down occupying most of the time. Every time the sleighs stopped for any length of time the runners would freeze tight, necessitating the use of jacks to get started again.

The erection of the small steel was mostly done by means of a hand derrick and gin pole. The 100-ft. irders were erected in the following manner: The girder was laid down flat and hauled, by means of two gallows frames, into position where it was supported, upon its side, on a platform. The girder was then lifted up till it was standing vertical, and then, after taking away the platform, was lowered into place. Two hoisting engines were used in this work, one for each gallows frame.

After the steel was in place and riveted up, the concrete floor, consisting of a 7-in. reinforced concrete slab, was laid. The reinforcing used was, one layer No. 23 triangle mesh and 7/16-in. square twisted rods at 8-in. centres. The sidewalk slab is 4 in. thick with one layer of No. 23 triangle mesh reinforcing. The floor beams with the exception of the cantilevered portions and the sidewalk stringers are encased in concrete. 1:2:4 concrete was used in this work.

The concrete floor slab was waterproofed in the following manner: (1) The surface was thoroughly cleaned by means of a hose and brooms. (2) The surface was well swabbed over with hot asphalt. (3) Three layers of 8-oz. burlap were well swabbed on with hot asphalt, the burlap being laid shingle fashion. (4) One-inch asphalt mastic was spread on top of the burlap. At the expansion joints the burlap was doubled upon itself to allow for expansion. On top of the asphalt mastic was spread one inch of sand and cement mixed dry on which base a four-inch creosoted wood block pavement was laid.

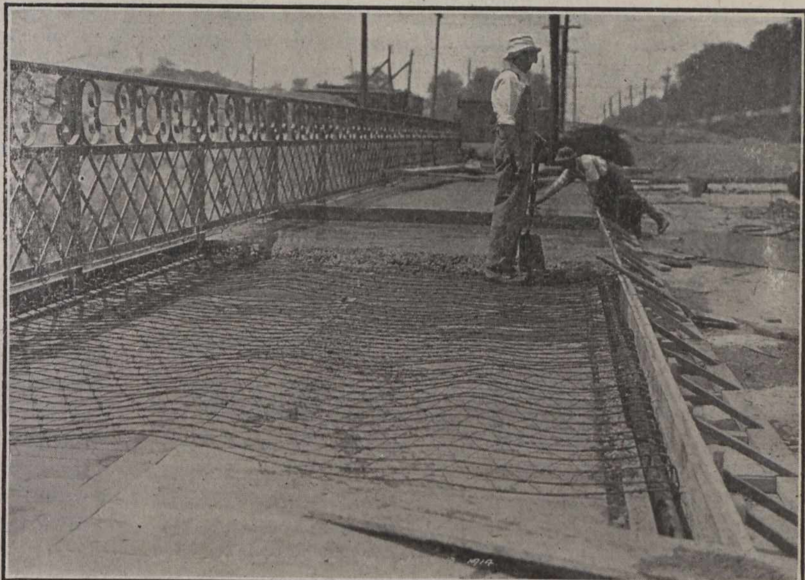


Fig. 11.—Method of Reinforcing Sidewalk Slab.

Fig. 12.—Illustrating the Three Stages of Waterproofing.

The rails were fastened to creosoted wood blocks 12 in. x 12 in. x 4 in. laid 3 ft. centres. The method of fastening was by means of 4-⅞-in. screw spikes, screwed into holes that had been bored into the blocks before creosoting. These blocks rest in a trough provided in the concrete floor which, after the rails had been properly lined up, was filled in with concrete.

The paint used was as follows: 1 shop coat red lead mixed with 22 lbs. red lead (94% pure) to one gallon pure raw linseed oil. 1st, field coat of superior graphite natural color; 2nd, field coat of No. 72 superior grey paint. The steel encased in the concrete was not painted.

The contract for the structural steel work was let to the McGregor & McIntyre Co. at the following prices:

836,346 lbs. steel at 4.3c. per lb.	$35,962.88
455 lin. ft. handrail at $3.25 per ft.	1,478.75
	$37,441.63

The contract for the substructure and floor, exclusive of paving, was let to Scott & Law for $27,000, piling at 40c. per ft. and extra concrete at $9 per yd. and extra excavation at 50c. per cubic yard. The waterproofing, included in the $27,000 contract, was laid by the Canada Floors Company, Limited, Sarco waterproofing being the brand used. The price paid for this work was $2,450, being at the rate of $1.75 per sq. yd.

The concrete quantities were as follows:

2 abutments	1,566 cu. yds.
2 piers	710 cu. yds.
Floor	629 cu. yds.
	2,905 cu. yds.

Reinforcing steel—53,400 lbs.
Piling—596 piles—15,542 lin. ft.

Summary of cost:—

Steelwork	$37,441.63
Concrete	27,000.00
Piling	6,216.80
Engineering, extras, etc.	9,341.57
Total	$80,000.00

The designing, supervision and inspection of all the work was done by the staff of the railway and bridge section of the Works Department of the City of Toronto. R. C. Harris is Works Commissioner.

[The subject matter of this article and most of the accompanying illustrations are from a paper read by the author on December 2nd, before a meeting of the University of Toronto Engineering Society, the paper afterward appearing in "Applied Science," the official publication of the Society.—EDITOR.]

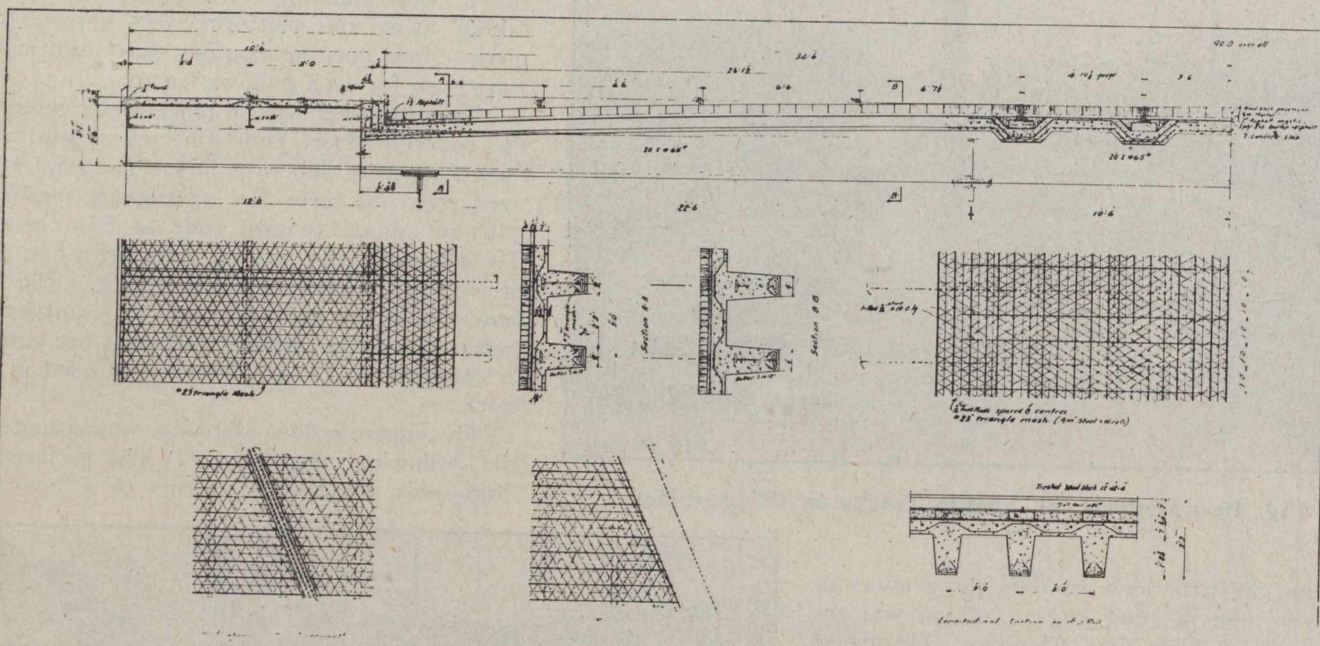


Fig. 13.—Concrete Floor Details.

COPPER PRODUCTION IN JAPAN.

Copper is the most important mineral product of Japan. Its production has been increasing for many years in a steady ratio to the number and growing efficiency of the plants. The year 1913 was not favorable for copper mining, the prices throughout the world fluctuating so that producers were unable to foresee market conditions. Nevertheless, the production of copper in Japan increased by 3,410 metric tons in 1913 over the previous record of 61,471 tons in 1912. The value of the copper production in 1912 was $20,045,526, and in 1913, $20,716,800. The greater part of the ore mined in Japan is smelted at the mines and exports in 1912 and 1913 were less than $1,000.

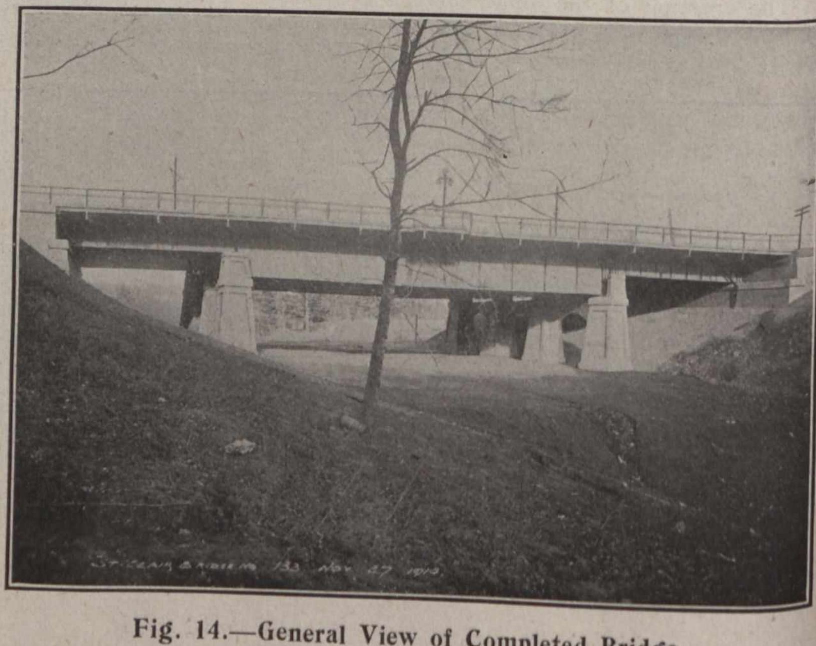


Fig. 14.—General View of Completed Bridge.

Editorial

T. C. KEEFER, C.M.G., C.E., LL.D.

It would seem anomalous to read that the death of a man in his 94th year should have come with astounding suddenness to any one aware that he had attained such a venerable age. But there are great bodies of men, members of national engineering and scientific societies, and men otherwise prominent in public life, many of them young in years and many well advanced, who had never come to realize that a day would arrive when Thomas Coltrin Keefer would be called to his rest. The great engineer has departed—tired in body and brain, bent by the burdens rightly belonging to the past, but giving a pledge of better things for the future of the country, oblivious of the lustre which his many achievements have added to the national civilization he has left behind—tired but filled with contentment and self-respect; while for those who remain to follow the now well-founded bench-marks which he, as a pioneer, established along waterway and contour, his career rises in eminence above the cloud-befogged environments of modern engineering into the glorious sunshine of achievement. His death has brought to a close one of our best examples of how a man may live his life in a way that will be of greatest service to mankind.

Although the level and the pen have been laid aside, the profession may still continue to seek and gain knowledge and inspiration from the nation-builder's books, essays, lectures and reports. In so much so that while it is true his career has terminated with a fullness of years that in themselves bespeak unusual service and devotion, the works that he established and furthered in the interests of the Dominion, the literature that he left for the guidance of the profession, and the example that he set for the many who would deign to follow his footsteps through the intricate windings of such a noble career, are with us still, embodying many features of the predominant character of the man himself.

THE ENGINEER AS A BUSINESS DOCTOR.

The necessary qualifications for a successful business doctor are: the ability to observe and tabulate the right kind of data, the ability to grasp the essential features of the data thus tabulated, the ability to deduce from this data the correct solution to the problem in hand, and the ability to apply the remedy so as to obtain the best results. He must have patience, perseverance and a faith in the inherent honesty of both the work in hand and the men for whom he is working; and above all he must have a knowledge of his fellow man, with the knack of placing himself in their position, and ascertaining their modes of thought. He must be a good all-round man possessing a large amount of what is commonly called "horse-sense," combining the essential features of the scientist, the detective, the lawyer, and the physician. It is not necessary that he be either an orator or a salesman, the force of his arguments being in the shape of figures.

There is a saying that "Figures cannot lie," perfectly correct as pure mathematics, for two and two always make four, and the root of a number can always be found by the Binomial Theorem; but in statistical work reliable information can only be got by careful study of the various factors in the case under consideration. It is not at all uncommon for two factions of a cause to deduce diametrically opposite conclusions from the same figures, each claiming to be right, while in all probability both are wrong.

An engineer who has been fortunate enough to have had a varied experience on many of the phases of the particular branch of his profession, and during that time has taken trouble to develop and systemize the work on which he has been employed; starting in most cases from the ground up, making out his own forms, and adapting to each piece of work that particular system which will produce the best results; then this man is above all others the best fitted to perform the analysis and dissection of a business preparatory to building it up in a substantial manner.

During the coming decade there should be abundant work for this type of engineer. The country has enjoyed a period of abundant prosperity, during which time there has not existed the necessity for the fine supervision of details so essential to a business that would thrive in less abundant years. It remains, therefore, with the engineer on the one hand, to apply himself to the solution of problems that are not of a purely technical character; and for the business man on the other hand to realize that the man best fitted for this purpose by reason of his peculiar training and experience, is the engineer.

INSTRUCTION TO COUNTY ROAD SUPERINTENDENTS.

Mr. W. A. McLean, C.E., Chief Engineer of Highways for the Province of Ontario, informs us that a course of lectures in highway construction has been decided upon by the Minister of Public Works, Hon. F. G. Macdiarmid, for the benefit of county road superintendents constructing roads under the Highway Improvement Act and subsidized by the Provincial Government.

Mr. McLean is arranging the course, and states that the several subjects will be dealt with by the assistant engineers of his department. All county councils will be asked to send their road superintendents or engineers. As the subjects, although applying more directly to county road work, will include a great deal of general interest, all municipalities are invited to send their road or street superintendents. The subjects to be dealt with are enumerated on another page of this issue.

It is anticipated that this course of instruction will be profitable in various ways; that it will give a considerable amount of direct instruction to county road officials; that it will lead to greater uniformity of work throughout the Province; that it will tend to a clearer understanding of the requirements of the Department; that it will lead to an exchange of experience among the various county engineers; that it will bring the county officials into acquaintance with one another, and will lead road superintendents to inspect work completed or in progress outside of their own counties.

THE LATE THOMAS COLTRIN KEEFER, C.E.

The death occurred on Thursday, January 7th, 1915, of Mr. T. C. Keefer, C.M.G., C.E., LL.D., at his late residence, The Manor House, Rockcliffe, Ottawa, Ont., in his 94th year. The remains were interred on Saturday at Beachwood Cemetery, Ottawa.

Thomas Coltrin Keefer was born at Thorold, Ont., in 1821, and spent his boyhood days in that section of the country where he was destined to return in later years and take a prominent part in the construction of one of the then foremost engineering feats, the Welland Canal. His grandfather, George Keefer, of the village of Paulinskill, New Jersey, fell in the War of Independence, while fighting under the command of Sir William Howe. His father, in 1790, at the age of 18, followed on foot an Indian trail from Paulinskill to Lake Erie, reaching a village to be afterwards known as Buffalo, and, crossing the Niagara River, settled in the neighboring peninsula. There, with a number of other United Empire Loyalists, he founded the village of Thorold. The mother was a daughter of Edward McBride, who represented the town of Niagara in the Parliament of Upper Canada. Thomas C. Keefer was a member of a family of ten sons and five daughters.

His early education was received at Upper Canada College, Toronto, and his graduation was followed by an immediate participation in engineering work, at the age of seventeen, on the staff of the Erie Canal. Later, he became associated with the Welland Canal construction, and, in 1845, was made chief engineer of improvements works on the Ottawa River. Many of his early designs are still in evidence among the lumber industries of that river.

In 1848 he married Elizabeth, daughter of the late Hon. Thomas McKay, M.L.C., of Rideau Hall, Ottawa. A year later, while still a comparatively young man, one of his most important publications, entitled "The Philosophy of Railways" appeared, evidencing to all who read his mastery of the pen as of the theodolite, and the profound depth of his zeal and whole-souled devotion to the development of his native country. Naturally, his book greatly influenced the governmental policy regarding the construction of railways in Canada.

In the following year, 1850, he entered the service of the Government to make a survey of the rapids of the St. Lawrence with a view to the improvement of its navigation, by the exploration of easier and safer routes, and with a view also to the construction of a canal or railway between the St. Lawrence and the Upper St. John waters of Lake Temiscouata. In the same year he won Lord Elgin's prize by virtue of his book entitled "The Influence of the Canals of Canada on Her Agriculture."

He assisted in the preparation of reports on the trade of British North America, and his knowledge and grasp of the commercial situation were such as to be very instrumental later in the drafting of the Reciprocity Treaty of 1884.

While the First International Exhibition was in progress in London, 1851, Mr. Keefer officiated as Commissioner for Canada. He visited London in the same capacity in 1862, while in 1878, he was Executive Commissioner at the Paris Exposition, where he served on the international jury of engineering and architecture. At this time he was elected an officer in the Legion of Honor (France) and made a companion of the Order of St. Michael and St. George, by her Majesty, the late Queen Victoria.

After his investigation of the St. Lawrence for the Government, he engaged in preliminary surveys for the Grand Trunk Railway of the line between Montreal and Toronto. He also prepared a report and plans for bridging the St. Lawrence at Point St. Charles, and from his report and designs, the Victoria bridge was built. Subsequently, he was employed on the construction of the waterworks systems for Ottawa, Hamilton, and Montreal. He designed and built Montreal's first aqueduct, and in 1874-75, as chief engineer to the Ottawa Waterworks Commission, he laid out and constructed the Ottawa system. He afterwards served for a number of years as engineer to the Montreal Harbor Commission.

While devoting this period of his life to municipal works, he did not cease to take the keenest interest in railway development, and it was largely owing to his efforts that the change was effected from narrow gauge track to the present standard gauge on Canadian railways.

Space will permit but a brief summary of his many attainments in the more mature years of his life. Among those meriting distinguishable mention are his appointments as chairman of the Royal Commission on Ice Floods; member of the International Deep Waterways Commission; fellow of the Royal Society of Canada, to which he was elected member in 1881, vice-president in 1897 and president in 1898. In 1877 he became a member of the American Society of Civil Engineers, which he served for two periods as vice-president, and as president in 1888. He was president of the Rideau Club of Ottawa in 1881. He was also a member of the Institution of Civil Engineers of Great Britain. So well known has been his association with the Canadian Society of Civil Engineers, that there exists small need of detailed mention here. He was one of its founders and was honored by the presidency in 1887 and a second time in 1897.

The late Mr. Keefer suffered the loss of his first wife in 1870. To them had been born a family of six, of which Mr. C. H. Keefer, consulting civil engineer, Ottawa, is a member. In 1873 the deceased engineer married the widow of the late Mr. John McKinnon, Ottawa.

Mr. Keefer's last public appearance in Ottawa was as an honorary member of the American Society of Civil Engineers, when that Society held its summer convention at the Capital in June, 1913. During the convention he threw open his house and grounds at Rockcliffe to its members and to the invited guests from its sister organization, the Canadian Society of Civil Engineers. The quiet garden party held among the pleasant and recreative surroundings, the congenial welcome tendered to all by the veteran engineer, and the unassuming hospitality which was given to the engineers of the two countries to enjoy in company with each other, are memories which will not soon be forgotten. The event, skillfully planned and executed by himself, afforded opportunity of mutual benefit to the officials of both societies. No more need be said than that those fortunate enough to have been present, carried away with them an esteem for the since departed engineer that time will take long to obliterate.

SELECTION OF MACHINERY FOR HIGHWAY CONSTRUCTION.*

By T. R. Agg,
Professor of Highway Engineering, Iowa State College.

THE wide range of machinery and appliances available for road and pavement construction makes advisable a careful selection for any particular class of work and yet many types of machinery are so much alike in general design that a selection must be based on a careful study of their operating characteristics. Probably there is no one best type for any given set of conditions nor any one best make of a given type as a general rule. It is not within the scope of this paper to discuss the many kinds and varieties of good, bad and indifferent road building machinery, but it is proposed to discuss a few principles applicable to its selection, operation and maintenance.

We find a group of machines available for earth road work, another for macadam construction, and so on through the various classes. These groups overlap to some extent.

Of the machinery offered for earth road work certain types such as the leveller are for a rather limited kind of work while others, such as the blade grader and elevating grader, are for more diverse uses. When a selection is to be made for a special work for which only one class of machine is made, one has only to choose the best bargains from the limited offerings of the class. But when machinery is to be chosen for more diverse uses, operating characteristics and adaptability must be considered. It will usually be found that the selection may be narrowed down to two or three makes and the final choice will depend upon price and personal preference.

The leveller has already been mentioned as an example of a specialized machine, and the mixer for concrete pavement construction is another. Of these, several makes are available and which to select will depend upon the purchaser's opinion as to the value and suitability of individual machines.

On the other hand, the choice for earth road construction will be between the elevating grader and the blade grader and between traction haulage and team haulage and between the steam tractor and the gas tractor. Here the purchaser must decide between the classes first of all, and then between individual makes of the class.

This is typical of the machinery available for many classes of road work and the basis for a proper comparison is not easy to state. It is believed, however, that the following factors must be taken into account: (*a*) Purchase price; (*b*) rate of depreciation; (*c*) maintenance cost; (*d*) cost of operation; (*e*) speed, all of which enter into the cost of doing work with any piece of machinery.

To estimate these factors properly there is at present but incomplete and contradictory cost data available and engineers and contractors can do a great service by giving publicity to any reliable and conclusive cost data that come into their hands.

Purchase Price.—Some kinds of machinery will save their cost in a comparatively short time and such may unhesitatingly be chosen because the user can readily foretell whether he has enough work ahead to make the investment profitable. Other kinds require a large outlay and must be used with reasonable regularity for a term of years before they will prove profitable. Eventually, if they can be kept busy, they will pay out, but before such machinery is purchased, there must be some assurance that the necessary work can be secured. It would often be cheaper in the long run to use a machine which operated at higher unit costs, but which could be purchased at a much lower price.

Depreciation.—Depreciation is probably the most difficult factor to estimate because the carefulness of the operator has such a marked influence on the life of a machine. With most machinery the average life is fairly well established and hence depreciation can easily be estimated. This is a very important cost item and is probably more often placed too low rather than too high.

Maintenance.—The influence of maintenance on unit costs is well understood and needs no especial comment. Probably this item is also more often underestimated than overestimated. It should be borne in mind that maintenance cost really includes not only the charge for making repairs to a machine but also the cost of delay due to the idle time of the machine. When a large gang is working around a machine such as a concrete mixer any delay on account of the machine is expensive.

Cost of Operation.—The cost of operation for a machine should be taken from the average of many runs under normal conditions and not from exceptional runs made under the most favorable conditions. Quite often this average will be double that which is occasionally obtained when all conditions are favorable. This cost will include the pay of all men needed to run the machine and the cost of all supplies regularly used in its operation.

Speed.—The rapidity with which a machine performs its work is a very important consideration not only from the standpoint of cost per unit of work done, but from the impetus it gives to the entire job. This is particularly true in road and pavement construction where favorable weather conditions must be utilized.

Skill Required to Operate.—The skill required to operate a particular machine should be given consideration because expert operators are not always easily obtained and if a machine requires considerable skill in operation to produce the maximum output, its average may be low, due to the difficulty of securing and retaining expert operators. Such machinery should usually be purchased only because of its marked superiority in other respects.

Adaptability.—Adaptability of a machine to various classes of work is an important consideration because it is rarely possible to foretell just where it will be used next and it is better to use a reasonably efficient machine continuously than it is to use a special and highly efficient machine for a certain kind of work and have it idle a large percentage of the time.

Having estimated as accurately as possible the various factors enumerated as above, preference should be given to the one type showing up the best.

The adoption of certain types of machinery for various classes of road work has been largely a survival of the fittest although on account of the new types that are continually being marketed, the process of weeding out is going on constantly. For most classes of highway work the preferred types are fairly well known and to enumerate them here would serve no useful purpose.

In rural communities, labor is usually scarce and the contractor in highway construction will find it to his advantage to utilize every machine that will facilitate his work even though it may not in all cases reduce his unit

*From a paper read before the American Road Congress, held in Chicago, December 14 to 18, 1914.

costs. In the long run, he will profit because of a greatly increased yardage for his season's output.

Methods of Hauling Road Materials.—Those engaged in constructing roads and pavements have long realized what a large item of cost is incurred in hauling materials and some discussion of the methods available is pertinent in this paper. Many factors involved in determining the cost of hauling are variable for work in different localities but for a given piece of work the amount of each of these can usually be selected with reasonable accuracy, and the economy of various methods thus compared.

The cost of hauling varies with the following factors:

1. Length of haul.
2. Rate of travel of the outfit used.
3. Amount of time lost at cars while loading and at road while unloading.
4. Amount of time lost on account of bad roads.
5. Capacity of the outfit per trip.
6. Cost of operation of the outfit.

Length of Haul.—Length of haul for a given piece of work is, of course, the same no matter what method of hauling is used.

Rate of Travel.—The rate of travel varies somewhat between outfits of the same kind and yet there is a value that is reasonably near an average for all outfits of a type. For teams 2½ miles per hour, traction outfits 3 miles per hour, motor trucks 10 miles per hour, and for industrial railway 10 miles per hour may be taken as typical speeds, assuming half the distance is traveled empty and half loaded.

Lost Time.—The amount of time lost at cars depends upon the method of loading the outfit. If hand shoveling is resorted to, the time will be relatively long, but extra units of the outfit may be loaded while the others are on the road. This is advisable for all classes of hauling outfits and is a necessity in traction hauling and with the industrial railway. Bins at the sidings with capacity for a full load for the outfit may be used instead of extra units of equipment and are a necessity when the motor truck is used. For team hauling the loading chute may be employed instead of extra wagons. In any case time lost at the cars is expensive, especially on short hauls, and should be eliminated as far as possible.

Records of loss of time in loading and in unloading are exceedingly diverse, but the following amounts lost per trip are near enough the average to give comparable results: With team hauling, 18 minutes; motor trucks (loaded from bins or hoppers), 6 minutes; traction outfits, 30 minutes; and with the industrial railway, 30 minutes.

Time lost due to the condition of the road cannot be evaluated in a discussion like this because it varies throughout the season, differs with the locality and with the kinds of roads over which the hauling must be done. It is greatest with the traction outfit, is about the same for team and motor truck hauling and is a negligible factor for the industrial railway.

The capacities of these outfits per trip are also exceedingly diverse and perhaps no particular one is typical, but equipment of the following capacities are in common use and will serve as examples: Wagons for team hauling, 2 tons; motor trucks, 5 tons; traction outfits, 15 tons; industrial railway trains, 20 tons.

The cost of operation of each of these outfits will vary with the skill of the superintendent, the character of the operator, the kind of weather encountered, and the nature of the road that is used. Cost of operation should include the following items; interest on investment, depreciation on outfit, maintenance of outfit, fuel, oil and other supplies used and labor cost of operation.

These various items must be evaluated in estimating the cost per hour for operation, and a careful study of the subject has led to the assignment of the following values. If any inequalities exist here it will, of course, change the entire relation, but the method of comparing costs of hauling as outlined is applicable and that is the principal object of this discussion. Cost of operation per hour for teams, $0.50; for motor truck, $2.00; for traction outfit, $3.00; for industrial railway, $4.00.

Knowing the relation that exists between these various factors that enter into cost of hauling, an equation may be written to show the cost per ton which is as follows:

$$C = \frac{rd}{us} + \frac{Tr}{u}$$

where

C = cost per ton for a length of haul = $\frac{d}{2}$.

d = distance in miles traveled per round trip.

u = number of tons hauled per trip.

s = speed of vehicle in miles per hour.

T = time lost loading plus time lost unloading.

r = cost of operation in dollars per hour.

If, in the general expression given above, we insert the values of the various factors for each method of hauling we get the unit cost of hauling by that method for any length of haul $\frac{d}{2}$. These are as follows:

$C = 0.1d + 0.075$, for team hauling.

$C = 0.04d + 0.04$, for motor truck hauling.

$C = 0.066d + 0.10$, for traction hauling.

$C = 0.02d + 0.10$, for industrial railway hauling.

In all of this discussion one factor has of necessity been omitted which is of greater importance than any other, and that is the personality of the superintendent. One man fails to make certain equipment pay out and another succeeds in accomplishing remarkable results with it. Two sets of cost data are obtained, the one showing abnormally high costs, the other showing costs that are exceedingly low. No general discussion can ignore these facts, but they cannot be put into data for use in average cases.

Instruction to Engineers.—States, municipalities and a few construction companies seek to insure that no engineer in their employ will allow the organization of which he is superintendent to fall below the average in efficiency. To that end instructions regarding the use and capacity of various kinds of machinery and as to methods of organization are furnished. Some of these manuals of instruction are excellent treatises on highway construction. Three phases of the use of machinery are usually presented and these cover the normal requirements of such instruction.

The general organization of the work is first outlined. Ordinarily some one machine or operation is the pacemaker for the whole job and when that is true the engineer in charge of construction must build up his whole organization about that machine or operation. The instructions can outline a workable organization but the live engineer will usually be able to improve upon the details.

The instructions next deal with the capacities of machines, rate of construction that can be attained and quality of work that should result. Such matter serves admirably as a yard-stick by which the engineer may measure his efficiency. Here, again, a man's personality will often enable him to do much better than the average set down in the instructions.

And finally, the instructions deal with reports, cost data and records of progress that are required. In this respect the instructions will be specific and lay down exact requirements.

Instructions to engineers are not, nor can they be, a series of exact rules that must be followed because no one can foresee all phases of the multitude of detail that enters into the prosecution of construction work and competent engineers would be hampered by instructions that attempted to prescribe exactly how each machine should be utilized.

Instruction to Operators.—In the widespread use of costly machinery there always lies the danger of loss through incompetent operation. Delays due to breakdowns are costly and often avoidable. Here, again, many states and municipal organizations seek to avoid trouble by furnishing to machine operators complete instructions.

These instructions deal first of all with the operation of the machine and since the work is largely mechanical though skilled, the instructions can say in detail just how the machine is to be handled. Here minute instructions are justifiable and they should include besides suggestions on operations, others on the care of the machine, the making of repairs, methods for adjustments and renewals of working parts.

The matter of personal conduct should also be dealt with in these instructions since the public often obtains its impressions of a department by the conduct of some irresponsible subordinate.

The construction of highways involves the handling of much bulky material and consideration of efficiency and economy requires that the machinery shall be well adapted to the work for which it is used, that the operations be systematized so that each machine will produce to capacity, that the machinery shall be handled in an intelligent manner so as to have normal life, and that the problem of transportation be studied in all its relations before a system is adopted.

MORE RAPID TUNNELLING AT ROGER'S PASS.

A footage of 852 ft. in the 31 days of December is reported by Mr. A. C. Dennis, superintendent for Foley Bros., Welch and Stewart, contractors for the Roger's Pass tunnel of the Canadian Pacific Railway. Readers will recollect the announcement in December 10th issue of this journal to the effect that previous records had been broken during the month of November, where an average of 27.23 ft. per day was made in the west end pioneer heading through slate with small quartzite bands. The record for one week was 220 ft. in a heading the size of which was 10 x 7½ ft.

In December the following record was made:—

East end pioneer heading, 544 ft quartzite with some schist. East end centre heading, 523 ft. schist with some quartzite. West end pioneer heading, 852 ft. slate with small quartzite bands. West end centre heading, 686 ft. slate with small quartzite bands.

This shows an average of 27.5 ft. per day in the west end pioneer heading.

HAMILTON HARBOR DEVELOPMENT.

An excellent summary of the harbor improvements for the city of Hamilton, Ont., is contained in the recently issued annual report of the Harbor Commissioners. The work laid out for last year included the construction of a warehouse on the city dock property at the foot of Catharine St.; the reclamation of about 12 acres of land between Ferguson Ave. and Wellington St.; the dredging of the harbor front and approaches to a depth of 18 ft.; the construction of extensive water shipping facilities. The establishment of an industrial district at Stipes' Inlet. All these works were accomplished or nearly completed during the year, with the exception of the Stipes' Inlet proposition.

The city's concrete dock at the foot of Catharine St. was completed in 1912. The warehouse that has recently been constructed upon it is a fireproof building of structural steel with corrugated iron roof and sheeting, and with concrete floor. It is 300 ft. in length, 34 ft. wide on the dock and 111 ft. wide on the ground fill at the rear. It cost approximately $37,000.

The revetment wall now under construction will, when completed, extend 450 ft. easterly from the old revetment wall, and thence 1,150 ft. into the shore, making a total of 1,600 ft. of wall. Of this length about 870 ft. of steel-faced wall has been completed and about 500 ft. more has been completed under water and partially so above. The pile foundations have been driven for the remainder, and about 300,000 cu. yds. of dredge-fill have been placed behind the completed portion of the wall, so that about 7 acres of the area that is being reclaimed has been filled up to grade level and the remaining 5 acres up to water level. This will provide the city with 12 acres of centrally located water front property, available for commercial purposes and easy of access for rail connection. The total cost of the work is estimated at $200,000.

The expenditure involved by last year's dredging operations has amounted to practically $100,000. To secure a depth of 18 ft. along the harbor front and approaches, 212,383 cu. yds. of material were removed, and the work is to be continued next year. It is of interest to note in this connection that dredging to the extent of about 10,000 cu. yds. will be done in 1915 at Wabassa Park, owned by the city, north shore of the harbor. This work will consist in deepening the approaches to the dock to a depth of 17 ft. and will cost about $2,500.

The reclamation of Stipes' Inlet includes the construction of a channel between Gage Ave. and Ottawa St. to extend from the shore for a distance of 2,500 ft. and to be 300 ft. in width, with a turning basin at the inner end 800 ft. in diameter. A depth of 25 ft. in this channel will be secured, the object being, in the design of the scheme, to accommodate boats up to the 600-ft. class. This development will involve an expenditure of $2,000,000.

In all, the works completed in 1914, those still in progress, and those approved, amount to $2,339,500.

Lathe tools are now made which surpass in hardness those made of the finest special steels, and which outlast them many times in cutting metals. They are composed of an alloy of cobalt, chromium, and tungsten, invented by Elwood Haynes, of Kokomo, Ind., president of the Haynes Automobile Company. These alloys are also used for cutlery, and take an edge equal to good steel and yet are very non-corrosive.

PERSONAL.

J. L. G. STUART, B.A.Sc., has been appointed resident engineer for the Burlington section of the Toronto-Hamilton highway.

A. B. MITCHELL, B.A.Sc., has been appointed engineer in charge of construction for Norman M. McLeod, contractor on the waterworks extensions for the town of Orillia.

Capt. A. O. POWELL, harbor engineer of New Westminster, B.C., was tendered a complimentary dinner on the successful completion of the first section of the city's harbor improvement scheme.

A. K. GRIMMER, city engineer of Medicine Hat, Alta., has tendered his resignation to the city council, to take effect on February 28th. He has been in the employ of the city for over five years.

H. J. GLAUBITZ, general manager of the Hydro-Electric Department for London, Ont., has resigned and will leave shortly for New York City, where he will engage in engineering work in a consulting capacity.

NELSON P. LEWIS, M. Am. Soc. C.E., Chief Engineer, Board of Estimate and Apportionment, New York City, on December 23rd delivered an illustrated lecture on "Planning of Streets and Street Systems" before the graduate students in highway engineering at Columbia University.

GEO. T. CLARK, vice-president of Richardson Bros., Limited, of Saskatoon and Winnipeg, has been appointed by the Department of Public Works, Ottawa, to superintend excavation for the foundation work of the new Saskatoon post-office. Work started on December 30th.

G. H. HOWARD, who has been travelling for the A. R. Williams Machinery Co. for the past seven or eight years, has severed his connection with that company to take a position on the sales staff of the John Bertram & Sons Co., Limited. Mr. Howard will represent the Bertram Company and their associate company, Pratt & Whitney Company of Canada, Limited, in the Niagara District and Western Ontario, with headquarters at Dundas.

GERALD D. CASE, civil engineer, Vancouver, B.C., has been elected a member of the Institution of Civil Engineers of Great Britain, and will hereafter represent the Society in British Columbia. Mr. Case has written several very useful books, such as "Coast Sands and Sand Dunes," "Coast Erosion and Foreshore Protection," and "The Use of Vegetation in Reclaiming Tidal Lands." He is the holder of several of the Institution's prizes, including the Miller and the Clarke prizes.

Sir SANDFORD FLEMING, K.C.M.G., C.E., LL.D., celebrated his 88th birthday on January 7th at his home in Ottawa. Sir Sandford came to Canada in 1845, joining the engineering staff of the Northern Railway, and assuming the duties of chief engineer of that road in 1857. Subsequently he was in partnership with Messrs. Ridout and Schreiber. In 1863 he went to England, urging railway communication between eastern Canada and the central west. He conducted a survey of the C.P.R. route, having been appointed by the Imperial and colonial governments to lay out a railway to extend from the Atlantic to the Pacific within British territory. Sir Sandford's eminence in engineering needs no introduction to our readers.

OBITUARY.

Mr. George Herbert Webster, C.E., whose death was reported in these columns last week, was one of the best-known railway engineers of Western Canada, and had long been connected with the engineering staff of the Canadian Pacific Railway. Mr. Webster was born at Creemore, Ont., in 1858. In 1873 he articled with the engineering department of the Northern Railway. Five years later he was appointed assistant engineer in the service of the Northern and Hamilton and Northwestern Railways, where he remained until 1882, when he moved to Winnipeg to engage in private business with C. W. Moberly. The following year he was appointed engineer of the Manitoba and Northwestern Railway. He remained with this company, rising to the position of chief engineer and land commissioner. When in 1898 the Manitoba and Northwestern Railway was taken over by the C.P.R. he was appointed resident engineer of the C.P.R. at Winnipeg. After several years as resident engineer, Mr. Webster was transferred to Montreal as general terminal engineer, and later was placed in charge of the lease and right-of-way department. In 1904 he was transferred to Vancouver, B.C., where he assumed the duties of divisional engineer. Ill-health proving a handicap, he resigned from the service in 1905, and the remaining years of his life were spent in private practice as a consulting engineer in Vancouver. In 1887 Mr. Webster was elected a member of the Canadian Society of Civil Engineers, and the American Railway Engineering and Maintenance-of-Way Association record him as a charter member.

The death notice has been received of Mr. H. C. Brown, superintendent of the municipal paving plant of Calgary, Alta. He had been in the employ of the city for about three years, and was largely responsible for the establishment of the plant, as well as for its subsequent operation.

INSTRUCTION IN COUNTY ROAD-BUILDING.

As stated on the editorial page of this issue, a course of lectures in highway construction for the benefit of county road superintendents and engineers will be given under the direction of Mr. W. A. McLean, provincial engineer of highways. The lectures will be delivered by various engineers of his staff in a committee-room of the Parliament Buildings, according to the tentative arrangement just announced. They will begin on Tuesday, February 23rd, and continue until February 26th. The subjects to be dealt with will be as follows: Types of Road for the Open Country; Road Location and Grading; Alignment, Straightening, Hills, Sub-base, etc.; Drainage of Roads; Geology of Road Materials; Care of the Roadside; Departmental Regulations; Gravel Roads; Stone Roads; Concrete Roads; Bituminous and Brick Roads; Culverts; Bridges and Abutments; Maintenance and Repair of Roads; Machinery and Operation; Quarrying and Explosives; Cost-keeping, Road Accounts and Reports; Traffic and Modern Road Construction; Dust-laying; Cost Estimates.

Lectures will start at ten o'clock each morning, and will be illustrated by lantern slides. Following each lecture the subject will be open for discussion by the county engineers and superintendents.

It is intended to make the course of lectures thoroughly practical in all particulars, and all municipal road superintendents and engineers should, as far as possible, avail themselves of the privilege offered them. Any further information may be obtained from W. A. McLean, Chief Engineer of Highways, Parliament Buildings, Toronto.