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Index to Volume 31

July-December, 1916

EXPLANATORY NOTE

The following table will be found of assistance when referring to articles. The pages included in each of the twenty-six numbers in this volume are as follows:—

No. 1—July 6....pp. 1- 20	No. 10—Sept. 7....pp. 183-202	No. 19—Nov. 9....pp. 369-390
No. 2—July 13....pp. 21- 40	No. 11—Sept. 14....pp. 203-222	No. 20—Nov. 16....pp. 391-412
No. 3—July 20....pp. 41- 62	No. 12—Sept. 21....pp. 223 242	No. 21—Nov. 23....pp. 413-432
No. 4—July 27....pp. 63- 80	No. 13—Sept. 28....pp. 243-260	No. 22—Nov. 30....pp. 433-454
No. 5—Aug 3....pp. 81-102	No. 14—Oct. 5....pp. 261-282	No. 23—Dec. 7....pp. 455-476
No. 6—Aug. 10....pp. 103-120	No. 15—Oct. 12....pp. 283-302	No. 24—Dec. 14....pp. 477-496
No. 7—Aug. 17....pp. 121-140	No. 16—Oct. 19....pp. 303-326	No. 25—Dec. 21....pp. 497-518
No. 8—Aug. 24....pp. 141-160	No. 17—Oct. 26....pp. 327-344	No. 26—Dec. 28....pp. 519-538
No. 9—Aug. 31....pp. 161-182	No. 18—Nov. 2....pp. 345-368	

Construction News, fillers and short articles of passing or minor interest are not indexed.

Figures in parentheses refer to length of article; e.g., (2) means two columns.

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INDUSTRIES.

LETTERS TO THE EDITOR.

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MISCELLANEOUS.

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The Canadian Engineer

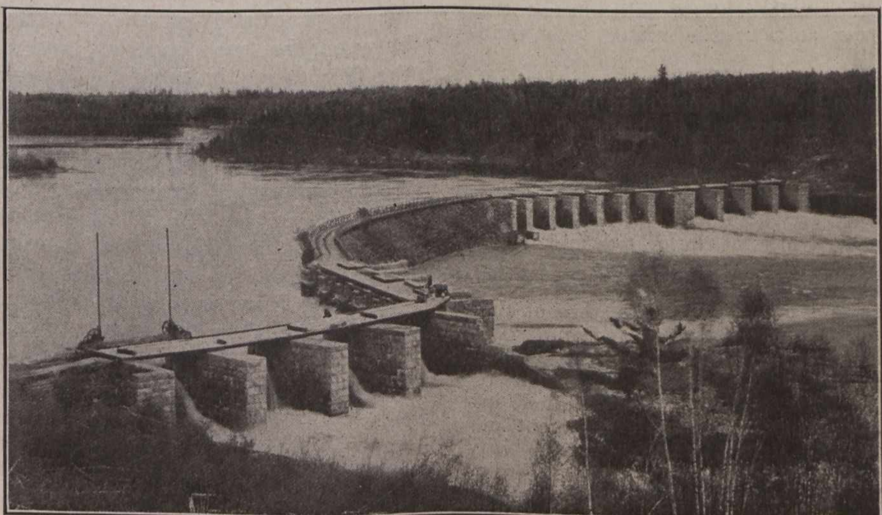
A weekly paper for Canadian civil engineers and contractors

LAKE OF THE WOODS LEVELS AND OUTFLOW

SUMMARY OF INVESTIGATIONS MADE BY TWO MEMBERS OF THE INTERNATIONAL JOINT COMMISSION AND OF REPORT MADE TO THE COMMISSION BY CONSULTING ENGINEERS ARTHUR V. WHITE AND ADOLPH F. MEYER.

SEVERAL facts combine to make the Lake of the Woods levels a prominent subject at the present time. The flood conditions in that district are unprecedented; the International Joint Commission is just about to give out its findings regarding the levels; and the Winnipeg River water power schemes, which depend upon the use of the Lake of the Woods as a storage reservoir, have recently received considerable prominence.

The lake and its tributary waters have a drainage area of 26,750 square miles, almost equally divided between the United States and Canada. Within this area there is a chain of lakes traversed by the international boundary for a distance of fully 300 miles. The largest body of these boundary waters is the Lake of the Woods, which is the western outlet of this great watershed. In area this lake is 1,485 square miles. It is bounded on the south by Minnesota, on the east and north by Ontario, and on the west by Manitoba. From it the international boundary runs eastwardly through Rainy River about 80 miles to Rainy Lake, and thence through the easterly arm of that lake about 45 miles to Kettle River, by which river the waters of Namakan Lake are discharged into Rainy Lake. In area, Rainy Lake is three times larger than Lake Namakan, while the Lake of the Woods is four and one-half times as large as Rainy Lake. It is along the shores of these three lakes and their connecting waters that the principal danger exists from high water conditions.



Norman Dam in Western Outlet of the Lake of the Woods.

The highest known level of the Lake of the Woods previous to this spring, as shown by the rocks around the lake, was 1,062.6, sea-level datum. This is higher than any level reached since 1892, the year when levels were first taken and reported. This spring the level of the lake reached 1,064 for a short period, and with but little assistance from the wind, that is, 1.4 feet higher than a previous extreme high level. The discharge from the Lake of the Woods at Kenora on May 28th was approximately 38,000 second-feet, and during the six days preceding that date the lake had risen at an average of 1 inch daily.

The highest known level for Rainy Lake, as indicated by the water marks on the rocks, was 500, Ontario department of public works datum. This spring it reached 501, practically, and the discharge was more than 32,000 second-feet.

The highest known level of Namakan Lake was approximately 509, Ontario department of public works datum, but this spring it reached 511. It was estimated that the discharge from Namakan was between 15,000 and 20,000 second-feet.

A number of questions centering about the levels of the Lake of the Woods and the use of its waters have been the subject of governmental investigation and international communication at various times. There are many different and conflicting interests. The towns of Warroad, Kenora, Beaudette and Fort Frances object to the levels being held at too high a stage. On the other hand, the town of Warroad and the U.S. War Office object to the water being held at too low a stage, as it interferes with navigation in Warroad harbor. The power companies at the outlets of Rainy Lake and the Lake of the Woods consider that they have vested interests in the flow from these lakes, and they object to any system of regulation which will not recognize the rights that they have enjoyed under existing conditions of control, and which will not allow the use of the lakes as storage reservoirs.

These power interests include the Minnesota and Ontario Power Co., one of the largest manufacturers of news print in the United States; the Lake of the Woods Milling Co., the Maple Leaf Milling Co., the Kenora municipal plant, the Winnipeg Street Railway, the city of Winnipeg municipal plant, etc.

The southerly or Minnesota portion of the lake is bounded by low shores. A considerable number of farmers occupy this territory and object to the periodic flooding of their lands. Numerous saw mills and lumbering interests, elsewhere located, employing thousands of men, are hampered variously in their operations by the water being either too high or too low. The largest interests endangered by present flood conditions is the Canadian Northern Railway, the water being over its main line roadbed in many places.

Then there are the fishing interests to be considered, and local navigation interests, summer tourist traffic, local traffic, docks, towing of logs, water supply for towns on the lakes, sewerage systems discharging into the lakes, and numerous other smaller interests.

It will be seen, therefore, that the question of regulating the levels of these lakes is complicated and that no solution is likely to be arrived at which will not injure some of the interests, and that the problem to be solved is how to distribute the injury most equitably and so as to result in the least aggregate economic damage. The principle of compensation will likely be involved and this also is complicated, including, as it does, three provincial or state governments, two federal governments, and numerous municipal and private vested interests.

On June 27, 1912, the following questions were referred to the International Joint Commission under the British and United States governments:—

"(1) In order to secure the most advantageous use of the waters of the Lake of the Woods and of the waters flowing into and from the lake on each side of the boundary for domestic and sanitary purposes, for navigation and transportation purposes, for fishing purposes and for power and irrigation purposes, and also in order to secure the most advantageous use of the shores and harbors of the lake and of the waters flowing into and from the lake, is it practicable and desirable to maintain the surface of the lake during the different seasons of the year at a certain stated level, and if so at what level?

(2) If a certain stated level is recommended in answer to question No. 1, and if such level is higher than the normal or natural level of the lake, to what extent, if at all, would the lake, when maintained at such level, overflow the low lands upon its southern border, or elsewhere on its border, and what is the value of the lands which would be submerged?

(3) In what way or manner, including the construction and operation of dams or other works at the outlets and inlets of the lake, or in the waters which are directly or indirectly tributary to the lake or otherwise, is it possible and advisable to regulate the volume, use and outflow of the waters of the lake so as to maintain the level recommended in answer to question 1, and by what means or arrangement can the proper construction and operation of regulating works, or a system or method of regulation, be best secured and maintained in order to insure the adequate protection and development of all the interests involved on both sides of the boundary, with the least possible damage to all rights and interests, both public and private, which may be affected by maintaining the proposed level?

The International Joint Commission appointed Arthur V. White, of Toronto, and Adolph F. Meyer, of Duluth, Minn., as consulting engineers, and requested them to report upon the engineering features of the problem. Following receipt of the preliminary report of the consulting engineers, a visit of inspection was made by Chas. A. Magrath and Jas. A. Tawney, members respectively of the Canadian and United States sections of the commission, and constituting a special committee for the Lake of the Woods investigation. In a report made to the commission last month, these two members expressed the hope that in the near future some method of intelligent control of these international waters on the part of both governments will be adopted and enforced, thereby ensuring greater security of their property and of their business—especially in times of extraordinary flood conditions—than they now enjoy under the present inadequate system of control.

The above-mentioned preliminary report of the consulting engineers is extremely thorough and particularly well arranged and readable. The facts are clearly and impartially presented and are free from highly technical discussions. The arrangement is not so disjointed as one might anticipate, considering the many angles from which the problem had to be viewed, and the entire report is liberally illustrated, yet every engraving really illustrates and emphasizes a definite point in the report.

The final report of the consulting engineers will be published in three volumes, including maps, tables, charts and a watershed map. Besides these there is a large atlas presenting the maps of the special surveys. (This atlas will not be available for general distribution.) For temporary use fifty copies of the report have been printed as Advance Sheets, and have all been distributed.

The main divisions of the report are the introduction, description and results of field operations, summary of maps, classification of surveyed areas, meteorological data pertaining to the Lake of the Woods watershed, water gauges and bench marks, observed water levels, outflow from the Lake of the Woods, high-water marks and their significance, run-off from upper Rainy watershed, regulation of outflow from Rainy Lake, regulation of levels and outflow from the Lake of the Woods, outflow capacity required in various methods of regulation, and the desirability and practicability of regulating levels and outflow of the Lake of the Woods.

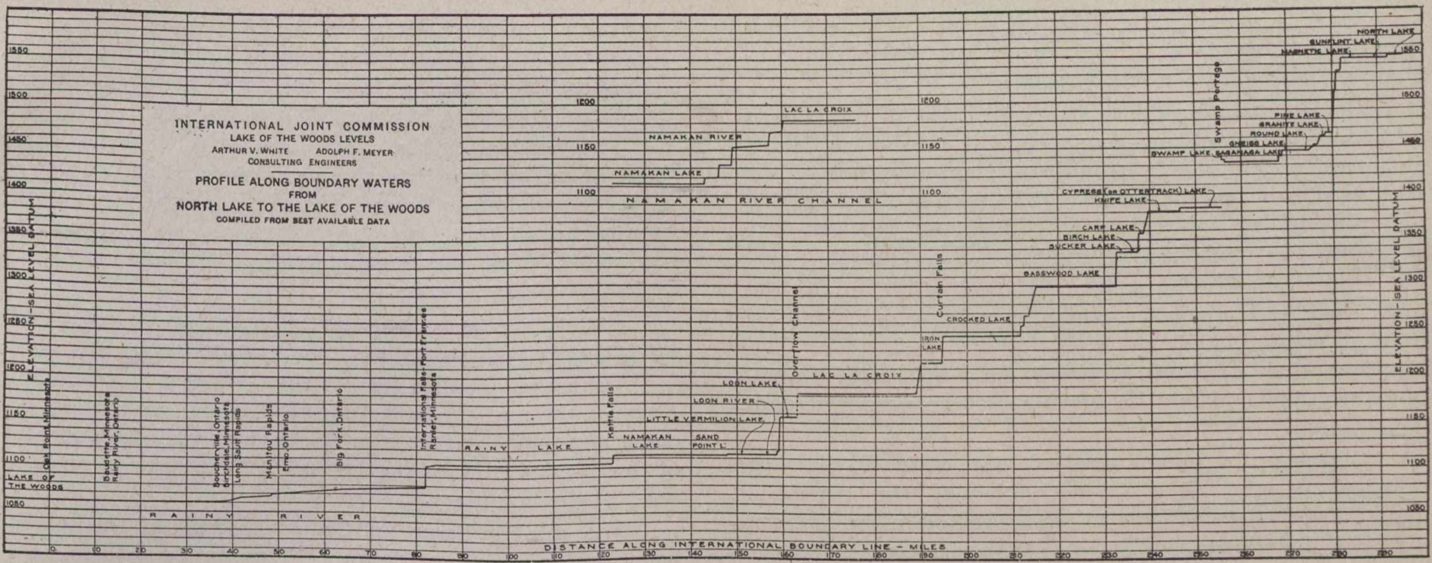
The following is an abstract of the introduction to the report, which summarizes in an interesting manner the events that led to the official reference to the commission:

The principal drainage course of the watershed tributary to the Lake of the Woods is along the boundary between the two countries, and the general direction of the flow is northwesterly. A profile along the boundary waters is shown herewith. The south-eastern extremity of the drainage basin extends to within 15 miles of Lake Superior, where the divide has an elevation of approximately 1,800 feet above sea-level datum. The outlets of the Lake of the Woods are in Canada, near Kenora and Keewatin, Ontario, at the extreme northern end of the Lake. After leaving the Lake the waters drain down the Winnipeg River into Lake Winnipeg, and thence through the Nelson River to Hudson Bay. The average level of the Lake of the Woods during the years 1892-1914, under a state of control, has been 1059.7, sea-level datum.

Under natural conditions there were two main outlets to the Lake of the Woods. The larger of these, known as the western outlet, is that in which the present Norman Dam is located. The present Kenora municipal power plant is constructed in what is termed the eastern outlet.

So far as we have been able to ascertain, the outlets of the Lake of the Woods remained in their natural condition until 1879. In that year a head race was constructed partially in earth and rock excavation, and partially in timber structure, in a depression at the extreme westerly end of Portage Bay, Keewatin. This depression had theretofore acted as a small overflow channel for the Lake at high stages. In about 1885 the intake was further deepened. The power developed at this site was used, during certain seasons of each year, until 1906, for the operation of a saw and planing mill. Since that time the entire plant has been closed.

The extreme northerly portion of the Lake of the Woods, at Portage Bay, is separated from the Winnipeg River, at Darlington Bay, by a natural rock ridge along which now runs the Canadian Pacific Railway. Even at a comparatively early date it appears to have appealed to several persons that the waters of the Lake might, by means of artificially constructed channels, be carried across this natural barrier and used for power development.



In 1881 a small cut was made through the rock ridge at the location of the present Mill "C" head race, and power developed for operating a saw mill. This site changed hands several times during the succeeding years, eventually becoming the property of the Lake of the Woods Milling Company about the year 1906.

Between Portage Bay and the western outlet there is a small inlet which formerly merged into a low area of muskeg extending northward from the Lake of the Woods almost across the rock ridge lying between the lake and the Winnipeg River. The Canadian Pacific Railway has constructed its main line across the head of this bay. The tracks were originally supported by trestle work, which was later replaced by a fill. About 1878, a breakwater, consisting of rock-filled timber cribs, was built on the lakeward side of the trestle, to confine and protect the proposed fill.

Certain parties holding land between the railway and the Winnipeg River apparently entertained the hope that water might seep through the breakwater and the stone foundation of the trestle in sufficient quantity to operate a small mill on the shore of the river below. Consequently, about 1882 or 1883, these parties undertook to make a small excavation across the narrow divide between the lake and river with the object of developing power. Apparently the project was abandoned. Subsequently the railway company completed its solid fill where the trestle formerly stood.

About the year 1889, other parties appear to have acquired the land to the north of the railway, and a small power house (since destroyed), was erected on the shore of the Winnipeg River, even though there was no water to operate such a plant. The interested parties then commenced legal proceedings against the Canadian Pacific, contending that the company had spoiled a natural power site by the fill on its right-of-way. The action was dismissed on the ground that the contentions of the claimants could not be justified. This project was then also abandoned.

In 1887 a canal, several hundred feet west of the first cut, was excavated by the Lake of the Woods Milling Company, for the purpose of developing power for flour milling at what is now Mill "A."

In the winter of 1887 to 1888, a structure known as the Rollerway Dam—and which acted essentially as a submerged weir—was constructed in the western outlet of the Lake of the Woods. The circumstances which resulted in the construction of this dam, according to the best information we have been able to obtain, are as follows:—

In the early eighties there prevailed a period of exceptionally low water on the Lake of the Woods watershed. This low water had adversely affected navigation, milling and other interests on the Lake of the Woods—more particularly in the vicinity of Rat Portage where settlement was then increasing. Certain interests of "Rat Portage, Keewatin, and the Lake of the Woods" which had been suffering by reason of the low water, transmitted to the Minister of Public Works, Canada, a memorial dated October 7th, 1884, drawing attention to the fact that:—

"The water of the Lake of the Woods, during the past few years, has been gradually decreasing, and is now so low that the lumbering and other manufacturing interests are seriously interferred with, and the general business and prosperity of the place is retarded."

Suggestion was made to the effect that the outlets of the Lake of the Woods near Rat Portage might be dammed so as to raise the level of the lake, thereby removing the difficulties due to low stage, and at the same time rendering more valuable the water power possibilities existent at the outlets of the lake.

The low water was evidently a matter of considerable public concern. A. D. McQuarrie, who subsequently was placed in charge of the Norman Dam at the time the Ontario Government assumed control, stated that in the early eighties he was editor of "The Rat Portage Progress," and that, at that time, the low-water period was producing a marked adverse effect on the navigation of the lake and on the milling interests near Rat Portage; and, further, that through his newspaper, representations were made showing the public need for adopting some means of preventing the lake from dropping to such low-water stages. Persons prominently identified with the development of the Lake of the Woods country endeavored to secure government assistance to hold the levels of the lake at more advantageous stages. Among such persons was John Mather, himself a pioneer and largely interested in lumbering and milling operations on the lake.

On the 5th of April, 1887, an order-in-council was passed by the Dominion, in which it is stated that John Mather had offered to undertake the erection of a suitable structure, provided that assistance to the amount of $7,000 be furnished by the government. The order-in-council recites that:—

"The Minister states that the chief engineer of his department reports that the objects for which the construction of the dam is sought are:—

"(*a*) To maintain the water of the Lake of the Woods at a constant level and thus permit the shallow draft steamers, which have been built for the navigation of the lake to ply during the whole of the season of navigation and thus afford uninterrupted connection between the settlements around the lake and the C.P.Ry.; and,

"(*b*) To maintain a constant head of water for the mills, both saw and grist, which have been and hereafter may be erected, and which depend for their power and therefore their constant working upon an ample supply of water, which would be given were the proposed dam constructed."

Subsequently, on the 23rd of June, 1887, Parliament voted $7,000 towards the construction of the proposed dam. The Rollerway Dam was constructed in the western outlet in the winter of 1887 to 1888, and after its completion the sum previously voted was paid to the proper parties.

From such enquiries as we have been able to make, it appears that it was the intention of those erecting the Rollerway Dam, to have the low-water level permanently raised thereby to the extent of about 3 feet. The dam finally was removed by blasting in 1899, but some portions of the old dam are still in evidence.

Field of Barley on August 18th, where Ducks Swam After Storm of June 5th, 1913.

In 1892 a small power plant, later owned by the Citizens Telephone & Electric Light Co., was constructed on the eastern outlet of the Lake of the Woods, but the natural outflow through this outlet of the lake did not really come under control until the construction of the present Kenora municipal power plant in 1906.

Between 1893 and 1895, a dam consisting of two sets of masonry piers and sluices, joined by a rock fill, and known as the Norman Dam, was constructed in the western outlet of the lake about a mile below the old Rollerway Dam. The Norman Dam did not effectively control the passage of water through this outlet until a considerable number of stop-logs were placed in the sluices in 1898, in which year the Ontario Government entered into an agreement with the owners of the dam—The Keewatin Power Co., Limited—to operate the dam "for the purpose of improving the navigation of the said lake."

In consequence of these various changes at the outlets of the lake, and more particularly as the result of the construction of the two dams in the western outlet, the subject of the levels of the Lake of the Woods first came prominently to public attention in the United States in 1895, when A. F. Naff, special agent of the United States General Land Office, was sent to investigate the flooding of lands on the southerly shore of the Lake of the Woods, alleged to have resulted from the construction and maintenance of the dams in the outlets of the lake.

The essence of Mr. Naff's report is, that the stage then prevailing was "an abnormal one and the source of much dissatisfaction"; and further, that the lake at the time of his examination was being held up "some three feet above what the normal level of the lake would be under natural conditions."

Apparently no action was taken by the United States government as the result of this investigation by Mr. Naff.

With the opening up of the country surrounding Rainy Lake and the Lake of the Woods, navigation became a prominent factor in the commercial development of the district adjacent to the Lake of the Woods on both sides of the boundary.

The mining boom in Ontario increased the water-borne traffic very considerably. Navigation on the Lake of the Woods centered largely around Rat Portage, now Kenora.

In 1900 the United States army engineers were authorized by congress to report upon the practicability of the creation of a suitable harbor on the south shore of the lake. At that time, according to the report of the engineer who made the investigation, "Warroad itself consists of a few temporary buildings, occupied by two saloons, a barber shop, a restaurant, a general store, and a hotel. The land has been lately opened for settlement, which, under the homestead law, must be occupied five years before a deed can be obtained."

The district officer, Major Frederick B. Abbot, in his report of June 21st, 1900, to his chief, states:

"On the American side of the lake the country is as yet a wilderness, consisting almost entirely of Indian reservation, portions of which only have been thrown open to settlement. Warroad is one of these localities thus opened."

And further: "The entire Canadian shore is said to be reasonably well settled, and with a number of points at which boats can land in safety. . . . The commerce of the lake is very considerable, being carried in some eight steamers, some of them drawing as much as 7 feet of water, loaded."

C. W. Raynor, the engineer who made the examination on the ground, drew attention to the navigation interests of the district in the following terms:—

"Rat Portage, on the north shore of the Lake of the Woods, has hitherto controlled the bulk of the commerce on the lake and Rainy River, supplying the region from Winnipeg. . . . Warroad River affords the only natural harbor on the American side of the lake, and, if open to a navigation depth, would transfer the bulk of this commerce to Warroad, which is 12 miles nearer Winnipeg and in a direct line with the Rainy Lake region. . . . The people of this region are unanimously desirous of having the necessary work done to make Warroad River accessible to all boats plying on the Lake of the Woods, of which there are over 100 engaged in commerce and pleasure, and of which the maximum draft is 8 feet. Warroad, with a navigable harbor and the railroads, has, by its location, every prospect of becoming a place of several thousand inhabitants and of carrying on much of the trade which at present falls to the Canadians."

In order to obtain a navigable harbor such as it was believed would develop navigation and enable successful competition to be carried on for some of the existent Canadian trade, the district officer recommended that a 7-foot channel, at a lake stage of 1060.8 sea-level datum, be dredged across the bar at the entrance to Warroad River.

The project as recommended and approved by the chief of engineers and the secretary of war, was passed by Congress, and $45,000 appropriated for executing the work.

After the United States Government had created the Warroad harbor, it was found that the level of the Lake of the Woods was falling lower than the assumed 1060.8 stage.

In May, 1905, the United States secretary of war wrote to the United States secretary of state, requesting that an arrangement be entered into with the British government by which a dam across the outlet of the Lake of the Woods, which was under the control of the provincial government of Ontario, and by means of which the level of the lake could, to some extent, be regulated, should be so operated as to prevent the level of the lake from falling below the datum of 1060.8.

In its communication of May 6th, 1905, to the British Embassy at Washington, D.C., the United States department of state writes respecting Warroad Harbor as follows:—

"The improvement depends very largely upon the level of the Lake of the Woods, all the estimates for dredging the harbor and its approaches being based upon the maintenance of this level at or above the datum of 7.2 feet on the Warroad Harbor gauge (1060.8 sea-level datum).

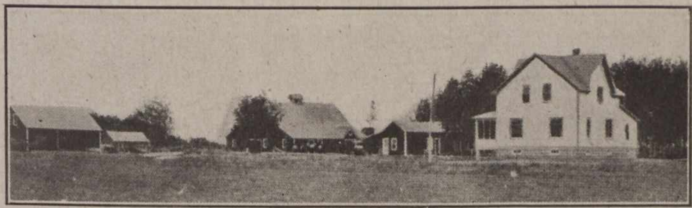
The recommendation of the United States chief of engineers was eventually brought to the attention of the public works department, Ontario, which department had undertaken to operate the Norman Dam in the interests of navigation.

Commenting upon the action taken by the Ontario government at the time the recommendation of the United States chief of engineers was under consideration, the deputy minister of public works, Ontario, who was chief engineer of that department at the time, states:—

"In 1906, there was brought to the attention of this department a recommendation made by the United States chief of engineers that the level of the Lake of the Woods be not permitted to fall below a stage of 7.2 on the Warroad gauge. This 7.2 was taken to be approximately an equivalent of 100.90 on the gauge which the public works department had established in the vicinity of Kenora. In making this request, the chief of engineers pointed out that there were several water power companies at or near the dam which would be benefited by the maintenance of the lake at the highest possible datum.

"After giving this matter consideration, it was decided that the 7.2 asked for as a minimum stage was too high, because it would not make provision for the handling of the flood water without causing stages at certain seasons of the year to be much higher than this 7.2. I reported that a minimum stage of 7.2 would not be in the interest of all parties concerned, and that the interests of navigation, both in Canada and the United States, could no doubt be served by keeping the level of the lake in the near vicinity of from 100 to 101 on the gauge at Kenora. Consequently, in the interests of navigation, as conducted by both the United States and Canada, as nearly as possible what may be called a general stage, instead of a minimum stage, of 7.2 has been maintained."

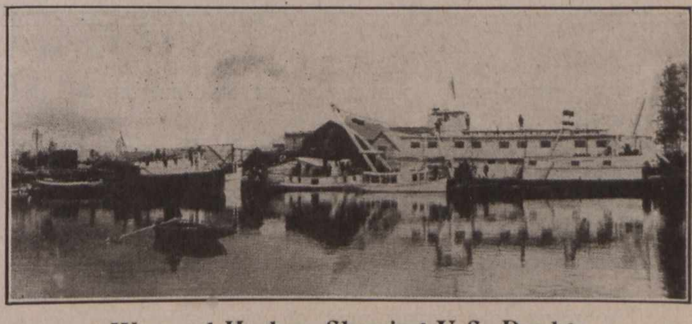
As a result of high water during the summer of 1905 numerous protests were received by the United States department of state from settlers on the southerly shore of the Lake of the Woods, complaining of damage to their land from high water. No immediate action was taken. Further complaints were made to the department, and on February 1st, 1908, the United States secretary of state requested from the secretary of war information respecting the relation between 7.2 feet on the Warroad gauge and "the normal level of the lake under natural



Best Farm Buildings on the South Shore.

conditions." This request was referred to the district officer of the corps of engineers, U.S.A., at St. Paul, Minn. The investigation of the district office was apparently confined largely to an examination of the records of the Warroad gauge, with the conclusion that "the mean level of the lake, during the open seasons of these six years, (1899, 1903, 1904, 1905, 1906, and 1907), has been 7.17 feet"; that there was "nothing unusual" in the stage which prevailed during the preceding year; and that this stage was "due to natural causes." Upon further inquiry being made by the chief of engineers, the district officer reported that no records were available from which the level of the lake, before the construction of the Rat Portage (Norman) Dam, could be determined. Apparently, no further action was taken at that time.

During the exceptionally low water season, early in 1911, the channel at Warroad proved to be of insufficient depth to permit of navigation by a few of the deeper draft boats plying on the Lake of the Woods. In consequence, protests against the low water were sent by citizens of Warroad to the United States war department, urging the deepening of the channel. The matter was



Warroad Harbor, Showing U.S. Dredge.

referred to the district officer of the corps of engineers, U.S.A., at St. Paul, Minn., who, in a letter dated June 9th, 1911, reported against the necessary deepening of the channel, largely for the reason that it could not be done under the existing project for the improvement of Warroad Harbor, as authorized by the Congress of the United States. He further reported the stage then

(Continued on page 18.)

PRETORIA AVENUE BRIDGE, OTTAWA.

By L. McLaren Hunter,
City Engineer's Office, Ottawa.

IN *The Canadian Engineer*, January 20th, 1916, there was published an article describing the Pretoria Avenue bridge at Ottawa. In that article particular attention was devoted to the piers, while the present article goes more particularly into the design of the lift span and also the methods of construction.

The bridge consists of a central 95-ft. lift span and two 52-ft. 6-in. stationary spans. The curved wing walls, the winding roads and paths forming the approaches to the bridge promise to form a very artistic setting for the structure.

The roadway will be 44 ft. wide and will carry a double street car track with a 6-ft. sidewalk on each side.

The side spans will be of plate girder construction but the outer girders will be encased in concrete so that their appearance will be that of concrete or masonry arches and thus harmonize with the piers and retaining walls.

The most interesting part of the structure is the movable span and this particularly since it is of a type which has only been developed recently but which has nevertheless gained consideration from leading Canadian and United States engineers.

This type of bridge is known as the Strauss direct lift bridge. In contrast to the Bascule bridge which lifts by rotating around one end as the lid on a box, the direct lift bridge moves straight up and down like an elevator, but the Strauss direct lift bridge distinguishes itself from the elevator and from other lift bridges which have been built in former years by the complete absence of cables or wire ropes. Such cables or wire ropes have for many years been the only means of bringing about a vertical movement and of connecting such a structure with the necessary counterweights, but experience has shown that these cables do not stand up where they are used out of doors and exposed to the action of the elements. This bridge represents departure in this field, in that it substitutes a system of levers for the cables and sheaves and in this way brings about both exact counterbalancing and the operation of the bridge through any height of lift. In this instance, the vertical movement of the lift span is 20 ft. so that when the bridge is fully open it affords a clear channel about 80 ft. in width and of 30 ft. clearance.

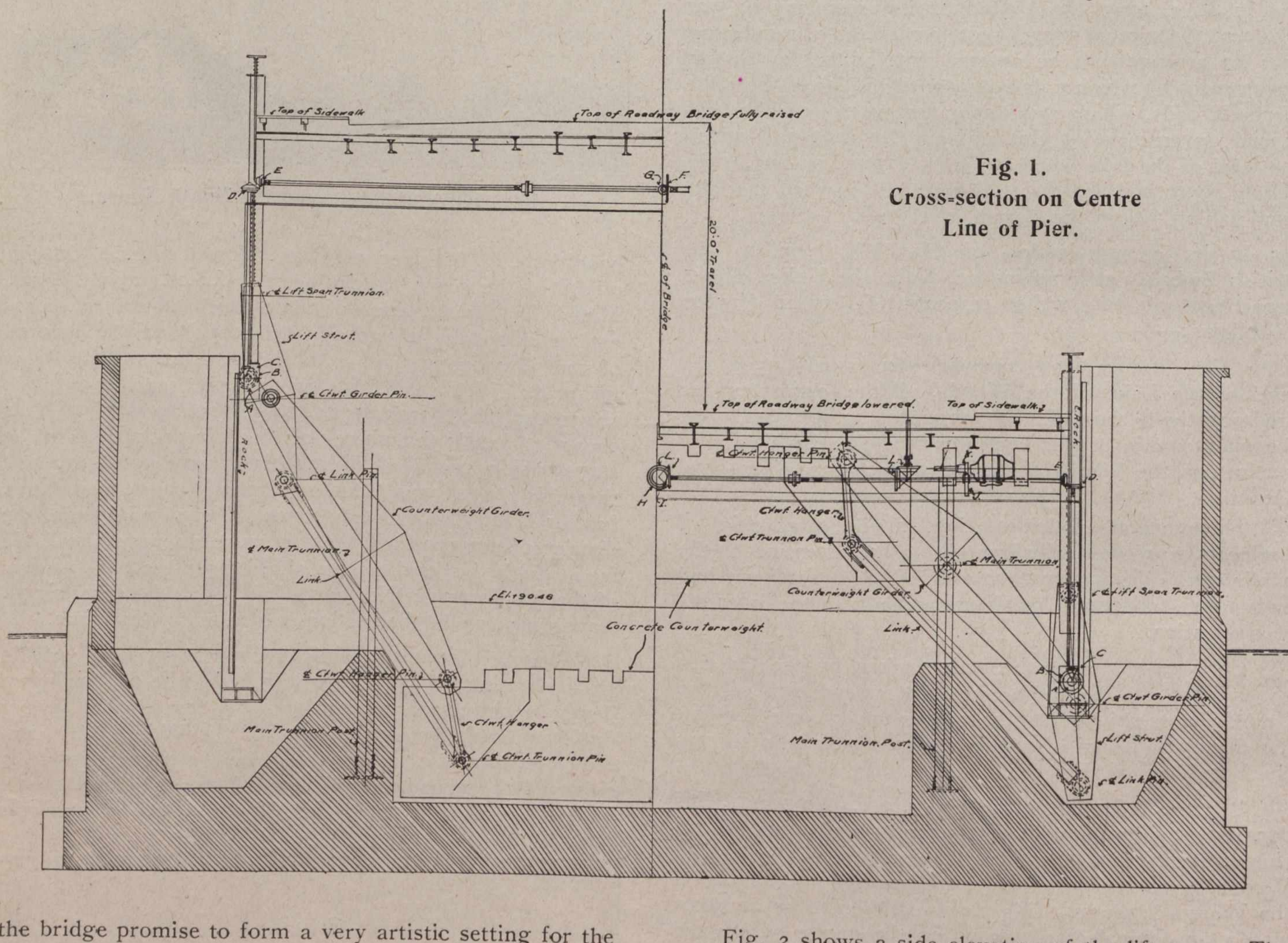


Fig. 1.
Cross-section on Centre Line of Pier.

Fig. 2 shows a side elevation of the lift span. The motor is indicated at the centre, together with shifting pinions and gears, transmitting power to the racks upon which the bridge is guided.

The bridge will be operated by electric motors, and it will be possible to open or close it in less than a minute. The mechanical and electrical installation of the bridge will be fully up-to-date and includes all the latest and most modern control and safety devices.

Among the latter are two so-called automatic chain barriers, one at each end of the bridge which, when the bridge is closed, are concealed under the roadway but which come into action when the bridge is to be raised. These barriers, which are controlled electrically from the operator's house, have some resemblance to a lawn tennis net stretched out over the roadway and the important feature of this particular gate or barrier is that if struck by a street car or by a fast-moving automobile it will "give," *i.e.*, the chains which form the barrier will pay

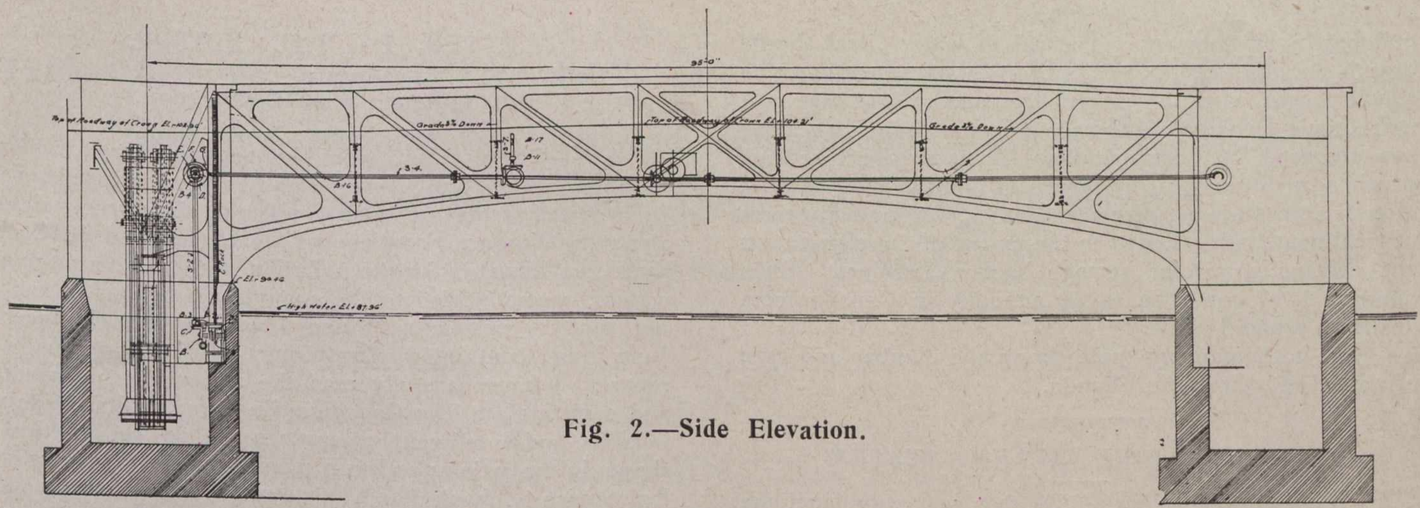


Fig. 2.—Side Elevation.

out under a gradual increasing resistance and the vehicle will therefore be brought to a gradual stop without injury. Early designs of safety gates for draw bridges and railroad crossings were either so light that they formed no barrier at all and did not therefore prevent a fast-moving machine or the like from going into the channel or else they were made so strong and rigid that colliding with the gate would be about as dangerous as going into the river, and not until the chain barrier was invented has the problem been solved of a protection gate which really protects.

Fig. 1 shows a cross-section on centre line of pier. The left half shows the bridge raised to its fully open position (30 feet clear headroom), the right half shows the span in its closed position. It will be noticed that all mechanism, counterweight, etc., are entirely hidden under the roadway. The bridge is perfectly balanced in every position.

The contract for the superstructure was let to the Dominion Bridge Company, of Ottawa.

The whole works are being supervised by F. C. Askwith, acting city engineer, and Robt. Henhan, bridge engineer.

POLLUTION OF CANADIAN STREAMS.

"THE question of stream pollution is becoming very serious in Canada," says a recent report issued by the Commission of Conservation. "As a proof of this the following list of inland waters receiving raw sewage has been compiled, the figures following each stream showing the number of municipalities thus disposing of their sewage:—

"Nova Scotia—Annapolis River, 3; Cornwallis River, 1; La Have River, 1.

"New Brunswick—Miramichi River, 1; Peticodiac River, 1; St. John River, 3.

"Quebec—Bécancourt River and tributaries, 3; Châteauguay River, 2; Chaudière River, 2; L'Assomption River and tributaries, 3; Lièvre River, 1; Nicolet River and tributaries, 4; North River, 2; Ottawa and des Prairies Rivers, 6; Richelieu River and tributaries, 5; River du Loup, 1; Ste. Anne River, 1; St. Francis River and tributaries, 15; St. Lawrence River, 29; St. Maurice River, 3; Saguenay River and tributaries, 4; Yamaska River and tributaries, 9.

"Ontario—Bear Creek, 1; Bighead River, 1; Bonnechère River, 1; Credit River, 1; Grand River, 2; Junction Creek, 1; Lake Erie to head of St. Clair River, 6; Lake Huron to head of St. Mary River, 9; Lake Ontario to head of Niagara River, 10; Lake Simcoe, 1; Lake Superior, 2; Moira River, 1; Muskoka River, 1; Otter Creek, 1; Ottawa River, 3; Rainy River, 2; Rideau River, 1; St. Lawrence River, 6; Saugeen River, 3; Sturgeon River, 1; Sydenham River, 1; Tay River, 1; Lake Timiskaming, 1; Madawaska River, 1; Maitland River, 1; Marshy Lake, 1; Thames River, 1; Thessalon River, 1; Trent tributaries, 2; Twelvemile Creek, 1; Wabi River 1.

"Manitoba, Saskatchewan and Alberta—Assiniboine River, 2; Bow River and tributaries, 3; Boyne River, 1; Oldman River, 1; Red River, 3; Red Deer River, 1; North Saskatchewan River, 2; South Saskatchewan River, 2.

"British Columbia—Columbia River, 1; Kootenay River, 1.

"From most of the above streams, municipalities draw their water supply, the intakes being situated at points below the discharge outlet for sewage.

"The supply of water to communities is the most important use of inland waters and the value of a pure supply, as compared with one polluted by sewage, can scarcely be over-estimated. Even where water systems are provided with filtration plants, there is great danger of overloading the filters if the source of supply is grossly

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Sewerage Systems in Canada.

(In this compilation, the items, which it was impossible to obtain from the municipalities, have been estimated and included.)

Province	Sewers				Sewage Treatment		
	No. of Systems		Total No. of Miles	Total Cost (dollars)	No. of Systems Where:		Cost of Treatment Plants (dollars)
	Combined	Separate			Not Treated	Treated	
Nova Scotia	16	4	153	1,716,590	20	...	...
Prince Edward Island	...	2	28	175.000	2	...	...
New Brunswick	5	5	123	1,101,062	10	...	...
Quebec	60	38	829	20,861,531	86	12	389,000
Ontario	54	41	1,670	24,195,834	60	35	1,774,287
Manitoba	5	4	335	6,084,736	6	3	116,291
Saskatchewan	3	12	237	3,623,962	3	12	694,485
Alberta	7	7	407	7,896 477	8	6	131,300
British Columbia	5	11	441	8,849,226	9	7	113,572
Canada	155	12[illegible]	4,223	74,504,418	204	75	3 218,935

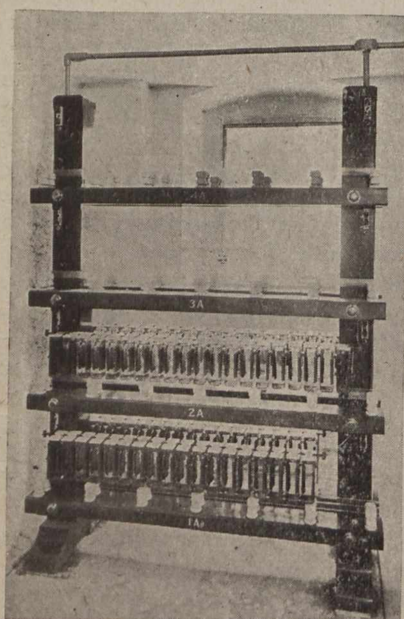
polluted by raw sewage. The use of water filters should be only an additional factor of safety in an operation which should begin with the proper treatment of sewage. A well-known Canadian authority on municipal engineering has advanced the statement that, 'if the domestic sewage which now discharges, by means of underground sewers, directly into streams, rivers and lakes, without any form of treatment, were treated to the extent of the elimination and destruction of the sewage bacteria, at least fifteen hundred lives could be saved annually in Canada from death by typhoid alone.' "

The accompanying table shows the number and type of sewerage systems in Canada.

LACHINE'S FIRE ALARM SYSTEM.

THE city of Lachine, P.Q., has just completed the installation of a new storage battery central office equipment for use in connection with their fire alarm service. The new office, although not as large as some, is one of the best that has ever been installed in Canada.

The office contains the following apparatus: One 2-circuit storage battery switchboard; one motor-generator set; one specially insulated storage battery rack; eighty cells of storage battery, 6 ampere-hour capacity.



The switchboard is a combination board having facilities for both charging and discharging on the same set of panels, and is so designed that should it ever be necessary to add additional circuits to the present fire alarm system, this could be done by simply adding another panel to the present set of two. In other words, the switchboard is built on the unit principle, the main charging panel being designed to take care of as many as four unit panels of two circuits each.

The storage battery rack is designed to give the greatest insulation possible, both between jars and between jars and shelf, the well-known principle of using glass rails and two-piece porcelain insulators being employed. This rack is shown in the above illustration.

The storage battery jars used are of special design, in that they are arranged with special grooved bottoms so that they can be set and held securely on the glass rails and that they have lugs cast on their sides for the purpose of holding the jars apart and preventing any acid, which might possibly creep over, getting between the jars and short-circuiting them.

Mr. Gadbois, the city electrician, has also employed a specially designed porcelain cover which will effectually prevent the acid boiling over the jar when charging.

The equipment was manufactured by the Northern Electric Company, Limited, Montreal.

LETTER TO THE EDITOR.

International Joint Commission.

Sir,—On my return from Buffalo and Detroit, where the International Joint Commission has been engaged since June 21st, hearing representatives from the various cities along the Niagara Frontier and the Detroit and St. Clair rivers, on remedies for the pollution of these international waters, recommended to the commission by our consulting sanitary engineers, I find *The Canadian Engineer*, June issue, containing your review of Professor Phelps' report. I have carefully read the review of this report and congratulate *The Canadian Engineer* on its eminent fairness and intelligent comprehension of the subject, shown in the article; and as a member of the Commission I also wish to thank *The Canadian Engineer* for this and for previous articles published on the work of the International Joint Commission.

In this connection, permit me to say that as a member of the commission, constituted as we are by the Treaty, judges for both countries, our work (like that of the work of the civil courts of the respective countries) is not sensational and therefore receives little or no attention from the press, especially in the United States. The attention, therefore, which *The Canadian Engineer* has paid to the commission and its work has been very helpful in calling to the attention, especially of scientific and technical men, the importance of the fact that these two countries have a tribunal that is dealing with and determining international questions peacefully, successfully and in perfect harmony.

Recently the commission has had to deal with the extraordinary international situation growing out of the unprecedented flood conditions in the Lake of the Woods and Rainy Lake watersheds. The regulating works at the outlet of the lakes and rivers in this watershed, with the exception of the Norman Dam at Kenora, are owned and controlled by private interests. Although the precipitation in the drainage area of these waters (26,750 square miles—about equally divided between Canada and the United States) since the first of November last, to May 1st, was greater than in any year since 1873, it is the opinion of many that had these dams and other controlling works, including the dam at Kenora, been under international control, much of the loss and damage incident to the extraordinary high water might have been avoided.

JAMES A. TAWNEY,
Member, United States Section,
International Joint Commission.

Winona, Minn., June 29, 1916.

The International Paper Co., of New York, has plans made for a 200-ton newsprint mill, to be erected in Canada.

According to statistics compiled jointly by the American Wood-Preservers' Association and the Forest Service at Washington, D.C., there was treated at 102 plants in the year 1915 a total of 141,858,963 cu. ft. of timber. To treat the 141,-858,963 cu. ft. of timber shown for 1915 required 80,859,442 gal. of creosote, 33,269,604 lb. of zinc chloride and 4,899,107 gal. of all other preservatives, which included crude oil, coke-oven tar, refined coal-tar, carbolineum oils, etc. Of the creosote used in 1915, 54 per cent., or 43,358,435 gal. (41,333,890 gal, coal-tar creosote and 2,024,545 gal. water-gas-tar) was domestic, and 46 per cent. or 37,501,007 gal., German and English oil. In 1914 the larger consumption of creosote was met by imports, the falling off in 1915 being explained by the scarcity of foreign supplies due to the European war. The imports of creosote into the United States in 1915 (37,501,007 gal.) were 13,806,729 gal., or nearly 27 per cent. less than the previous year.

Table Giving Velocity in Feet per Second and Discharge in Cubic Feet per Second of Circular Sewers, on a One Per Cent. Grade with Various Depths of Flow; Based on Kutter's Formula "N = .013."

—By the late Andrew Rosewater, M.Am.Soc.C.E.

Ratio of depth to diameter

Size of Sewer	1		93/100		9/10		8/10		7/10		6/10		5/10		4/10		3/10		2/10		1/10		5/100	
	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.	Vel.	Dis.
0 4	1.81	0.16	2.03	0.17	2.06	0.17	2.10	0.15	2.05	0.14	1.95	0.10	1.81	0.08	1.64	0.06	1.35	0.03	1.02	0.01	0.60	0.003	0.33	0.001
6	2.52	0.49	2.83	0.53	2.87	0.53	2.93	0.47	2.86	0.42	2.73	0.32	2.52	0.25	2.28	0.17	1.87	0.09	1.42	0.04	0.84	0.008	0.47	0.002
8	3.17	1.11	3.56	1.21	3.62	1.20	3.68	1.10	3.60	0.94	3.43	0.73	3.17	0.55	2.87	0.38	2.36	0.20	1.79	0.08	1.05	0.019	0.59	0.004
9	3.47	1.53	3.90	1.67	3.96	1.66	4.04	1.52	3.94	1.30	3.76	1.01	3.47	0.76	3.14	0.53	2.58	0.29	1.96	0.12	1.15	0.026	0.64	0.005
10	3.77	2.05	4.24	2.25	4.30	2.22	4.38	2.04	4.28	1.74	4.08	1.36	3.77	1.02	3.41	0.71	2.88	0.38	2.13	0.16	1.25	0.036	0.70	0.007
1 0	4.34	3.40	4.88	3.70	4.95	3.68	5.05	3.38	4.93	2.89	4.70	2.26	4.34	1.70	3.93	1.18	3.23	0.64	2.45	0.27	1.44	0.059	0.81	0.01
3	5.12	6.29	5.75	6.85	5.84	6.81	5.95	6.25	5.82	5.34	5.54	4.18	5.12	3.14	4.63	2.19	3.81	1.18	2.89	0.51	1.70	0.109	0.95	0.02
6	5.87	10.37	6.60	11.30	6.69	11.23	6.83	10.31	6.66	8.81	6.36	6.90	5.87	5.18	5.31	3.61	4.37	1.95	3.32	0.83	1.95	0.180	1.09	0.04
8	6.35	13.85	7.13	15.10	7.24	15.00	7.38	13.77	7.21	11.77	6.88	9.21	6.35	6.92	5.75	4.82	4.73	2.60	3.59	1.11	2.11	0.240	1.18	0.05
9	6.57	15.79	7.39	17.21	7.49	17.10	7.64	15.70	7.46	13.42	7.12	10.51	6.57	7.89	5.95	5.49	4.89	2.96	3.71	1.27	2.18	0.273	1.22	0.06
10	6.80	17.94	7.64	19.56	7.76	19.42	7.91	17.84	7.72	15.25	7.35	11.94	6.80	8.97	6.16	6.24	5.06	3.37	3.84	1.44	2.26	0.311	1.27	0.07
2 0	7.24	22.74	8.14	24.78	8.26	24.63	8.42	22.61	8.22	19.35	7.84	15.14	7.24	11.37	6.56	7.91	5.39	4.27	4.09	1.83	2.41	0.40	1.35	0.08
2	7.67	28.27	8.62	30.82	8.75	30.62	8.92	28.11	8.71	24.03	8.31	18.82	7.67	14.13	6.95	9.83	5.71	5.31	4.33	2.27	2.55	0.50	1.43	0.10
4	8.08	34.53	9.08	37.64	9.22	37.40	9.40	34.33	9.18	29.35	8.75	22.99	8.08	17.26	7.32	12.00	6.01	6.48	4.57	2.78	2.69	0.60	1.51	0.12
6	8.48	41.64	9.53	45.39	9.68	45.10	9.86	41.40	9.63	35.40	9.18	27.73	8.48	20.82	7.68	14.48	6.31	7.82	4.79	3.35	2.82	0.72	1.58	0.15
8	8.88	49.59	9.98	54.06	10.13	53.72	10.32	49.30	10.08	42.15	9.62	33.02	8.88	24.79	8.04	17.24	6.61	9.31	5.02	3.99	2.95	0.85	1.66	0.17
10	9.26	58.36	10.41	63.63	10.56	63.22	10.76	58.02	10.52	49.61	10.03	38.86	9.26	29.18	8.39	20.29	6.89	10.96	5.23	4.70	3.08	1.01	1.73	0.20
3 0	9.63	68.09	10.82	74.22	10.98	73.78	11.20	67.69	10.94	57.88	10.43	45.34	9.63	34.04	8.72	23.68	7.16	12.79	5.44	5.48	3.20	1.18	1.80	0.24
2	10.00	78.78	11.24	85.88	11.41	85.36	11.63	78.32	11.36	66.97	10.83	52.46	10.00	39.39	9.06	27.39	7.44	14.79	5.65	6.34	3.32	1.36	1.87	0.27
4	10.36	90.39	11.64	98.53	11.82	97.92	12.04	89.87	11.77	76.84	11.22	60.20	10.36	45.18	9.39	32.65	7.71	16.97	5.85	7.27	3.44	1.57	1.93	0.32
6	10.71	103.0	12.04	112.3	12.22	111.6	12.45	102.4	12.16	87.56	11.60	68.59	10.71	51.50	9.70	35.82	7.97	19.34	6.05	8.29	3.56	1.78	2.00	0.36
8	11.05	116.8	12.42	127.3	12.60	126.5	12.85	116.1	12.55	99.28	11.97	77.77	11.05	58.40	10.01	40.61	8.22	21.95	6.24	9.40	3.67	2.02	2.06	0.40
10	11.39	131.5	12.80	143.3	12.99	142.4	13.24	130.7	12.94	111.8	12.34	87.57	11.39	65.75	10.32	45.73	8.47	24.69	6.44	10.58	3.79	2.28	2.13	0.46
4 0	11.73	147.4	13.19	160.7	13.38	159.7	13.64	148.5	13.32	125.3	12.70	98.16	11.73	73.70	10.62	51.26	8.73	27.68	6.63	11.86	3.90	2.55	2.19	0.51
2	12.07	164.5	13.57	179.3	13.77	178.2	14.03	165.5	13.71	139.8	13.07	109.5	12.07	82.25	10.93	57.20	8.98	30.89	6.82	13.24	4.01	2.85	2.25	0.57
4	12.39	182.7	13.93	199.1	14.14	197.9	14.40	181.6	14.07	155.3	13.42	121.7	12.39	91.35	11.22	63.33	9.22	34.37	7.00	14.70	4.12	3.17	2.31	0.64
6	12.71	202.2	14.29	220.4	14.50	219.0	14.78	201.0	14.44	171.9	13.76	134.6	12.71	101.0	11.51	70.31	9.46	37.97	7.18	16.27	4.23	3.50	2.37	0.71
8	13.01	222.4	14.63	242.4	14.84	240.9	15.13	221.1	14.78	189.1	14.09	148.1	13.01	111.2	11.78	77.34	9.68	41.76	7.35	17.89	4.33	3.86	2.43	0.78
10	13.31	244.2	14.98	266.2	15.19	264.5	15.47	242.8	15.12	207.6	14.41	162.6	13.31	122.7	12.06	84.92	9.90	45.85	7.52	19.65	4.43	4.23	2.49	0.85
5 0	13.62	267.5	15.31	291.6	15.54	289.8	15.84	266.0	15.47	227.4	14.75	178.1	13.62	133.7	12.34	93.02	10.13	50.23	7.70	21.52	4.53	4.63	2.54	0.93
2	13.94	292.1	15.67	318.4	15.90	316.4	16.21	290.4	15.84	248.3	15.10	194.5	13.94	146.0	12.63	101.5	10.37	54.86	7.88	23.50	4.64	5.06	2.60	1.02
4	14.23	317.8	16.00	346.4	16.24	344.3	16.55	316.0	16.16	270.1	15.41	211.6	14.23	158.9	12.89	110.5	10.59	59.67	8.04	25.57	4.73	5.50	2.66	1.11
6	14.53	345.1	16.34	376.2	16.57	373.8	16.90	343.1	16.51	293.4	15.74	229.8	14.53	172.5	13.16	120.0	10.81	64.80	8.21	27.77	4.83	5.98	2.71	1.20
8	14.78	373.0	16.62	406.6	16.86	404.1	17.19	370.8	16.79	317.1	16.01	248.4	14.78	186.5	13.39	129.7	11.00	70.04	8.36	30.01	4.92	6.46	2.76	1.30
10	15.07	402.8	16.94	439.1	17.19	436.3	17.52	400.5	17.12	342.4	16.32	268.2	15.09	201.4	13.65	140.1	11.21	75.63	8.51	32.41	5.01	6.98	2.82	1.41
6 0	15.36	434.3	17.28	473.4	17.53	470.5	17.86	431.8	17.45	369.2	16.63	289.2	15.36	217.1	13.91	151.0	11.43	81.54	8.68	34.94	5.11	7.52	2.87	1.52
3	15.78	484.2	17.74	527.8	18.00	524.5	18.35	481.4	17.93	411.6	17.09	322.5	15.78	242.1	14.29	168.4	11.74	90.92	8.92	38.95	5.25	8.39	2.95	1.69
6	16.20	537.7	18.21	586.1	18.48	582.5	18.84	534.6	18.40	457.1	17.54	358.1	16.20	268.8	14.68	186.9	12.05	101.0	9.15	43.26	5.38	9.31	3.03	1.88
9	16.57	593.1	18.63	646.5	18.91	642.5	19.27	589.7	18.82	504.2	17.95	395.0	16.57	296.5	15.01	206.2	12.33	111.4	9.36	47.72	5.51	10.27	3.10	2.07
7 0	16.98	653.4	19.09	712.3	19.37	707.8	19.75	649.6	19.29	555.4	18.39	435.1	16.98	326.7	15.38	227.2	12.63	122.7	9.59	52.57	5.65	11.32	3.17	2.28
3	17.37	717.2	19.53	781.8	19.82	776.9	20.20	713.4	19.79	609.6	18.81	477.6	17.37	358.6	15.74	249.4	12.92	134.7	9.81	57.71	5.78	12.42	3.24	2.50
6	17.77	785.1	19.98	855.8	20.27	850.5	20.66	780.6	20.19	667.4	19.24	522.8	17.77	392.5	16.10	273.0	13.22	147.4	10.04	63.17	5.91	13.60	3.32	2.74
9	18.12	854.7	20.37	931.7	20.67	925.9	21.07	849.8	20.58	726.5	19.62	579.2	18.12	427.3	16.42	297.2	13.48	160.5	10.24	68.77	6.02	14.80	3.39	2.98
8 0	18.50	930.0	20.80	1013.8	21.11	1007.4	21.51	924.6	21.01	790.5	20.04	619.4	18.50	465.0	16.76	323.4	13.76	174.6	10.45	74.83	6.15	16.11	3.46	3.24
3	18.87	1008.9	21.22	1099.8	21.52	1092.9	21.94	995.1	21.44	857.6	20.44	671.9	18.87	504.5	17.09	350.8	14.04	189.4	10.66	81.18	6.27	17.47	3.53	3.52
6	19.25	1092.4	21.64	1190.8	21.96	1183.4	22.38	1086.1	21.87	928.6	20.85	727.5	19.25	546.2	17.44	379.8	14.32	205.1	10.88	87.89	6.40	18.92	3.60	3.81
9	19.57	1177.1	22.00	1283.1	22.33	1275.1	22.76	1170.3	22.23	1000.6	21.19	783.9	19.57	588.5	17.73	409.3	14.56	221.0	11.06	94.71	6.51	20.38	3.66	4.11
9 0	19.94	1268.6	22.42	1382.9	22.75	1374.3	23.19	1261.3	22.65	1078.4	21.60	844.9	19.94	634.3	18.06	441.1	14.84	238.2	11.27	102.7	6.63	21.97	3.73	4.43
3	20.29	1363.7	22.81	1486.5	23.15	1477.3	23.60	1355.8	23.05	1159.2	21.97	908.2	20.29	681.8	18.38	474.2	15.10	256.1	11.46	109.7	6.75	23.62	3.79	4.76
6	20.65	1463.7	23.22	1595.6	23.56	1585.6	24.01	1455.2	23.46	1244.2	22.36	974.8	20.65	731.8	18.71	509.0	15.36	274.8	11.67	117.8	6.87	25.35	3.86	5.11
9	20.96	1565.0	23.56	1706.0	23.91	1695.3	24.37	1555.9	23.81	1330.2	22.70	1042.3	20.96	782.5	18.99	544.2	15.59	293.9	11.84	125.9	6.97	27.71	3.92	5.46
10 0	21.31	1673.7	23.96	1824.5	24.31	1813.1	24.78	1664.0	24.21	1422.7	23.08	1114.7	21.31	836.8	19.31	582.0	15.85	314.3	12.04	134.7	7.09	28.98	3.98	5.84
3	21.65	1786.2	24.34	1947.1	24.70	1935.0	25.18	1775.9	24.59	1518.3	23.45	1189.6	21.65	893.2	19.61	621.1	16.11	335.4	12.23	143.7	7.20	30.93	4.05	6.23
6	21.99	1903.9	24.72	2075.4	25.09	2062.5	25.57	1892.9	24.98	1618.4	23.82	1268.0	21.99	951.9	19.92	662.0	16.36	357.5	12.42	153.2	7.31	32.97	4.11	6.64
9	22.28	2022.7	25.05	2204.9	25.42	2191.2	25.91	2005.1	25.31	1719.3	24.13	1347.1	22.28	1011.3	20.19	703.3	16.59	389.8	12.59	162.7	7.41	35.03	4.16	7.06
11 0	22.62	2149.6	25.43	2343.3	25.81	2328.6	26.31	2137.2	25.70	1827.2	24.50	1431.8	22.62	1074.8	20.49	747.5	16.83	403.6	12.78	173.0	7.52	37.23	4.23	7.50
3	22.94	2280.5	25.79	2486.0	26.17	2470.4	26.68	2267.3	26.06	1938.5	24.84	1518.8	22.94	1140.2	20.78	793.0	17.07	428.2	12.96	183.5	7.63	39.20	4.28	7.96
6	23.27	2417.0	26.16	2634.8	26.55	2618.3	27.06	2403.0	26.44	2054.5	25.20	1609.7	23.27	1208.5	21.08	840.5	17.31	453.8	13.15	194.5	7.74	41.86	4.35	8.43
9	23.56	2554.3	26.49	2784.4	26.88	2967.1	27.40	2539.5	26.76	2171.2	25.52	1701.1	23.56	1277.1	21.35	888.2	17.53	478.6	13.31	205.5	7.83	44.14	4.40	8.91
12 0	23.88	2700.5	26.85	2943.8	27.25	2925.4	27.77	2684.9	27.13	2295.6	25.86	1798.5	23.88	1350.2	21.64	934.0	17.77	507.1	13.49	217.3	7.94	46.77	4.46	9.42
3	24.19	2850.8	27.20	3107.6	27.60	3088.3	28.13	2834.3	27.48	2423.3	26.20	1898.0	24.19	1425.4	21.92	991.3	18.00	535.3	13.67	229.4	8.04	49.37	4.52	9.95
6	24.50	3007.0	27.55	3277.9	27.95	3257.5	28.49	2989.6	27.83	2556.1	26.50	2002.6	24.50	1503.5	22.20	1045.6	18.23	564.6	13.84	241.9	8.15	52.02	4.58	10.47
9	24.77	3163.6	27.85	3448.6	28.26	3427.1	28.81	3145.3	28.14	2689.2	26.83	2106.9	24.77	1581.8	22.44	1100.1	18.44	594.1	14.00	254.5	8.24	54.79	4.63	11.04
13 0	25.09	3329.9	28.21	3629.9	28.63	3607.3	29.18	3310.6	28.50	2830.6	27.17	2217.7	25.09	1664.9	22.73	1157.9	18.67	625.3	14.18	267.9	8.35	57.67	4.69	11.62
3	25.39	3500.3	28.55	3815.6	28.97	3791.9	29.53	3480.0	28.84	2975.4	27.50	2331.2	25.39	1750.1	23.00	1217.1	18.89	657.8	14.35	281.6	8.44	60.62	4.75	12.22
6	25.69	3677.3	28.88	4008.6	29.31	3983.6	29.87	3656.0	29.18	3125.9	27.32	2449.1	25.69	1838.6	23.28	1278.7	19.11	690.5	14.51	295.9	8.56	63.69	4.80	12.83
9	25.95	3854.3	29.18	4201.6	29.61	4175.3	30.18	3832.0	29.48	3276.3	28.10	2566.9	25.95	1927.1	23.51	1340.3	19.30	723.7	14.66	310.1	8.65	66.75	4.85	13.45
14 0	26.25	4041.9	29.51	4406.1	29.95	4378.6	30.53	4016.8	29.82	3435.8	28.43	2691.9	26.25	2020.9	23.78	1405.5	19.53	758.9	14.83	325.2	8.73	70.00	4.91	14.11
6	26.84	4432.2	30.18	4831.5	30.63	4801.4	31.22	4406.8	30.49	3767.6	29.07	2951.8	26.84	2216.1	24.32	1541.2	19.97	832.2	15.16	356.6	8.93	76.76	5.02	15.47
15 0	27.39	4839.9	30.80	5276.0	31.25	5243.0	31.85	4811.9	31.12	4114.2	29.66	3223.3	27.39	2419.9	24.82	1683.0	20.38	908.8	15.48	389.4	9.11	83.83	5.12	16.89
6	27.95	5274.5	31.43	5749.7	31.89	5713.8	32.50	5244.0	31.75	4483.6	30.26	3512.8	27.95	2637.2	25.32	1834.1	20.79	990.4	15.79	424.4	9.29	91.35	5.22	18.41
16 0	28.48	5726.8	32.02	6242.8	32.50	6203.8	33.12	5693.6	32.35	4868.2	30.84	3814.0	28.48	2863.4	25.80	1991.4	21.19	1075.3	16.09	460.8	9.47	99.18	5.32	19.99
6	29.03	6208.4	32.64	6767.8	33.12	6725.5	33.76	6172.5	32.98	5277.5	31.44	4134.8	29.03	3104.2	26.30	2158.8	21.60	1166.6	16.40	499.5	9.66	107.5	5.43	21.67
17 0	29.55	6707.1	33.23	7311.4	33.72	7265.8	34.36	6668.3	33.57	5701.4	32.00	4466.9	29.55	3353.5	26.77	2332.3	21.99	1259.4	16.70	539.7	9.83	116.2	5.52	23.41
6	30.08	7236.3	33.82	7888.3	34.32	7839.1	34.98	7194.4	34.17	6151.2	32.58	4819.3	30.08	3618.7	27.25	2516.3	22.38	1358.8	17.00	582.2	10.00	125.8	5.62	25.25
18 0	30.58	7783.1	34.38	8484.3	34.89	8431.4	35.56	7738.0	34.74	6616.0	33.12	5183.5	30.58	3891.5	27.71	2706.4	22.75	1461.4	17.28	626.7	10.17	134.8	5.72	27.16
19 0	31.59	8958.4	35.52	9765.5	36.04	9704.6	36.75	8906.5	35.89	7615.1	34.21	5866.3	31.59	4479.2	28.62	3115.1	23.50	1682.1	17.85	720.8	10.51	155.2	5.91	31.26
20 0	32.58	10236.	36.64	11158.3	37.19	11088.6	37.89	10176.8	37.01	8701.1	35.28	6877.2	32.58	5118.0	29.53	3559.3	24.24	1922.0	18.41	823.6	10.83	177.3	6.09	35.72

Grade per 100 feet	Square root of grade	Grade per 100 feet	Square root of grade
.04	.200	1.02	1.000
.05	.224	1.04	1.019
.06	.245	1.06	1.029
.07	.265	1.08	1.039
.08	.283	1.10	1.049
.09	.300	1.12	1.058
.10	.316	1.14	1.067
.11	.332	1.16	1.077
.12	.346	1.18	1.086
.13	.361	1.20	1.095
.14	.374	1.22	1.105
.15	.387	1.24	1.113
.16	.400	1.26	1.122
.17	.412	1.28	1.131
.18	.424	1.30	1.140
.19	.436	1.32	1.149
.20	.447	1.34	1.157
.21	.458	1.36	1.166
.22	.469	1.38	1.175
.23	.479	1.40	1.183
.24	.489	1.42	1.192
.25	.500	1.44	1.200
.26	.510	1.46	1.208
.27	.520	1.48	1.216
.28	.529	1.50	1.225
.29	.539	1.52	1.233
.30	.548	1.54	1.241
.31	.557	1.56	1.249
.32	.566	1.58	1.257
.33	.574	1.60	1.265
.34	.583	1.62	1.273
.35	.592	1.64	1.281
.36	.600	1.66	1.288
.37	.608	1.68	1.296
.38	.616	1.70	1.304
.39	.624	1.72	1.311
.40	.632	1.74	1.319
.41	.640	1.76	1.327
.42	.648	1.78	1.334
.43	.656	1.80	1.342
.44	.663	1.82	1.349
.45	.671	1.84	1.356
.46	.678	1.86	1.363
.47	.685	1.88	1.371
.48	.693	1.90	1.378
.49	.700	1.92	1.386
.50	.707	1.94	1.393
.51	.714	1.96	1.400
.52	.721	1.98	1.407
.53	.728	2.00	1.414
.54	.735	2.05	1.432
.55	.742	2.10	1.449
.56	.748	2.15	1.466
.57	.755	2.20	1.483
.58	.762	2.25	1.500
.59	.768	2.30	1.516
.60	.774	2.35	1.533
.61	.781	2.40	1.549
.62	.787	2.45	1.565
.63	.794	2.50	1.581
.64	.800	2.55	1.597
.65	.806	2.60	1.612
.66	.812	2.65	1.628
.67	.818	2.70	1.643
.68	.825	2.75	1.658
.69	.831	2.80	1.673
.70	.836	2.85	1.688
.71	.842	2.90	1.703
.72	.849	2.95	1.717
.73	.854	3.00	1.732
.74	.860	3.10	1.761
.75	.866	3.20	1.789
.76	.872	3.30	1.816
.77	.877	3.40	1.844
.78	.883	3.50	1.871
.79	.889	3.60	1.897
.80	.894	3.70	1.924
.81	.900	3.80	1.949
.82	.905	3.90	1.975
.83	.911	4.00	2.000
.84	.916	4.10	2.025
.85	.922	4.20	2.049
.86	.927	4.30	2.074
.87	.933	4.40	2.098
.88	.938	4.50	2.121
.89	.943	4.60	2.145
.90	.949	4.70	2.168
.91	.954	4.80	2.191
.92	.959	4.90	2.214
.93	.964	5.00	2.236
.94	.969	5.20	2.280
.95	.975	5.40	2.324
.96	.980	5.60	2.366
.97	.985	5.80	2.408
.98	.990	6.00	2.449
.99	.995	6.50	2.549
1.00	1.000	7.00	2.646

Method of using the table.

To find the velocity and discharge of a 3'-8" sewer, 7/10 full, on a 2.25 per cent grade. Find the velocity and discharge as given in the table opposite 3'-8" in the 7/10 column, and multiply them by the square root of 2.25. Thus 12.55 × 1.5 = 18.825 the required velocity, 99.28 × 1.5 = 148.92 the required discharge.

When the velocity and discharge is desired for different values of n than (n = .013) very good approximate values can be deduced as follows: for n = .011 multiply tabular quantities by 1.20; n = .012 by 1.09; n = .015 by 0.84; n = .017 by 0.73. Error does not exceed 5% except in extreme cases. The above approximations give excessive values for small diameters and insufficient values for large diameters.

Through the courtesy of Mr. Geo. W. Craig, city engineer of Calgary, we are able to publish the accompanying diagram. It is a portion of the unpublished work of Andrew Rosewater, who was a member of the American Society of Civil Engineers and who died some six years ago. Mr. Craig was associated with Mr. Rosewater for a number of years prior to his death. The table will undoubtedly be found of interest to many of our readers, especially those more directly concerned with sanitary engineering. We shall be pleased to furnish readers with extra copies of this table mounted on cardboard.—[Editor.]

BRIDGEBURG SEWAGE DISINFECTION.*

THE town of Bridgeburg is situated at the Canadian end of international bridge over Niagara River. It is chiefly a freight-handling point for international traffic of the Grand Trunk Railway.

In 1915 Bridgeburg had a population of 2,110, located chiefly at the bridge terminal and along a river frontage of 1¼ miles. Its water supply is derived from the Niagara River and is used without treatment to the average extent of 504,000 U.S. gallons daily, a consumption which is equivalent to 239 gallons per capita. This use of water is additional to that of the railroad, which maintains an independent pumping station and supply.

For its size, Bridgeburg possesses the most costly sewerage of any of the riparian towns, having expended for sewer and treatment-works construction a total of $98,103.58, or upon the basis of its present population at the rate of $46.50 per capita, an amount which is over double that prevailing in large cities.

The sewerage consists of several main drains tributary to the river and intercepted by a marginal sewer which discharges by gravity to treatment works. The interception is effected in a manhole by means of a small opening in a dam placed across the lateral. An overflow weir permits of storm-water discharge to the river outlet. The marginal sewer in its maximum size is a 24-inch vitrified pipe laid on a 0.001 grade carrying 6 cubic feet per second at full capacity. This is equivalent to 1,835 U.S. gallons per head per day from the present tributary population. With arrangements as existing, such diversion is not possible, as the size of the opening and the height of the overflow weir are such as to limit the interception to about 4 or 5 per cent. of the storm capacity of the laterals. Moreover, the smallness of the discharge orifice in the dam permits of occasional stoppage from sticks, leaves, and paper, with consequent dry-weather over-flow to the storm outlets. However, both the collection and diversion devices are capable of intercepting all the dry-weather flow, together with a reasonable percentage of storm water.

The treatment works are situated just beyond the northerly city limits, and consist of three covered tanks, each 66 feet long, 12 feet wide, and 6½ feet deep below water line. These dimensions are such as to give a total capacity of 115,900 U.S. gallons, equivalent in terms of present average water consumption to a 5½-hour retention. At maximum dry-weather rates of sewage run-off the detention is perhaps in the vicinity of four hours, while for night flows the period is considerably longer.

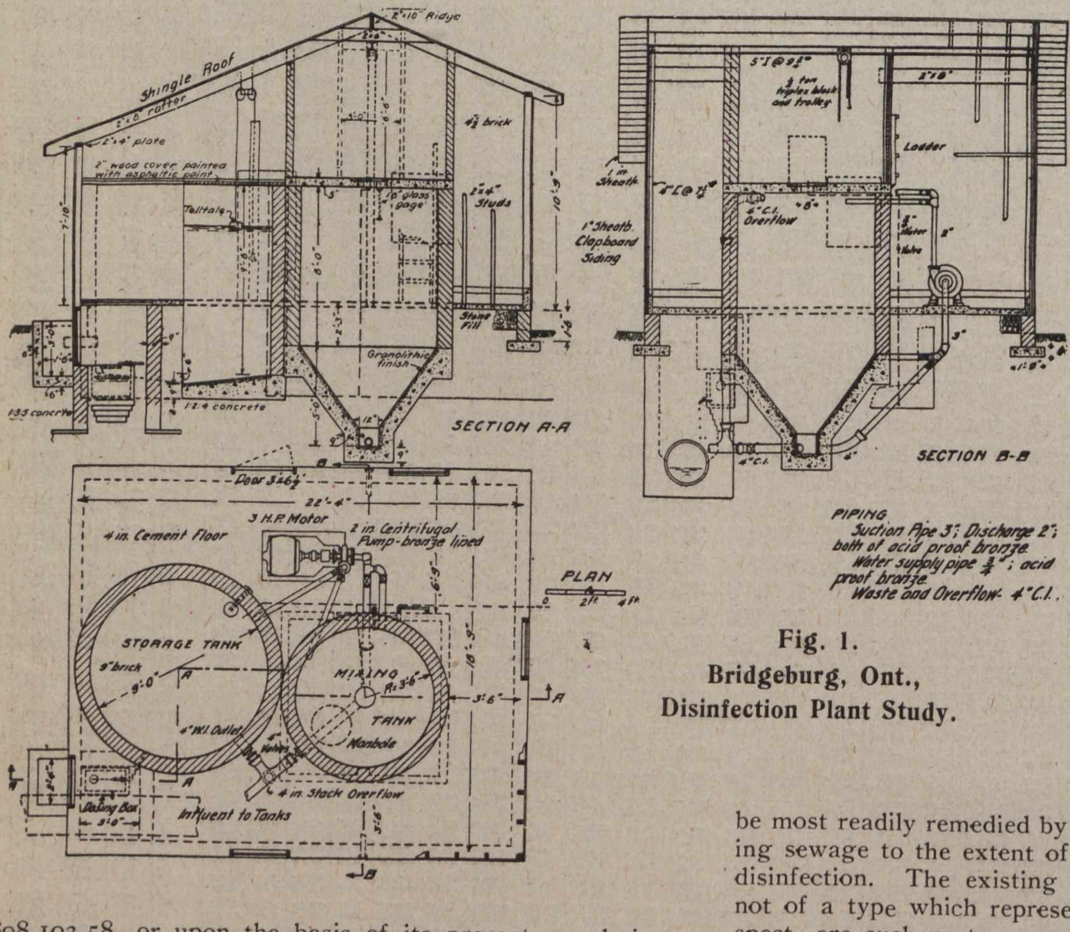


Fig. 1.
Bridgeburg, Ont., Disinfection Plant Study.

At the time of inspection a slight scum was noted in the tanks; the effluent was turbid but did not carry any large suspended solids. The general locality was entirely free from odor.

The tanks have been cleaned once in a period of three years, at which time some 50 or 60 cubic yards (estimated) of sludge were taken out, some of this being grit which had escaped the local detritus tanks of a stone working establishment. At present, attendants are reputed to occasionally open clean-out valves to permit of sludge discharge direct to the river.

The conclusion of the Niagara River report is that existing international pollution of boundary waters can be most readily remedied by the treatment of contaminating sewage to the extent of clarification accompanied by disinfection. The existing works at Bridgeburg, while not of a type which represents modern ideas in this respect, are such as to accord reasonably well with the clarification requirement. To secure complete conformity with the remedy suggested, necessitates but the addition of disinfection.

Fig. 1 represents a typical installation which has been designed in detail to meet Bridgeburg needs. It consists of a small frame house, planned to be placed over the existing distribution manhole on the tank influent line. Contained in the house is a hopper-bottomed circular tank of dimensions sufficient to enable the mixing into solution of the contents of a 750-pound drum of bleaching powder. The drums are handled by chain hoist and trolley and opened in a small chamber located above the mixing tank. The bleach is washed out by means of a water jet, while mixing is accomplished through vortex motion of the liquid as created by a small circulating pump. A proper operating schedule will insure mixing in advance of need of the solution in order that it may settle in the mixing

*Notes abstracted from report of F. C. Tolles, District Engineer, made to Prof. Phelps, Consulting Engineer to the International Joint Commission.

tank before being pumped to the stock tank, which latter feeds to the dosing apparatus.

The dosing apparatus consists essentially of a needle valve which controls the discharge of the stock-tank solution to an orifice box. Constant, or nearly constant, head in the box is maintained by the movement of the valve as actuated by a float. All piping or metal in contact with the chemical is made of phosphor-bronze, or of similar resisting metal.

The operation entailed by disinfection will add but little to the labor now needed for care of overflows and occasional inspection of tanks. A few hours weekly for mixing the solution, and a daily examination of the dosing apparatus when once attuned should suffice. The expense for chemical, water, and electric power should not exceed $500 per annum, if economy of dose be secured.

USE OF PRECIPITATION DATA.

Where data of run-off covering a considerable period of years are available at or near the power site, power estimates can be made with considerable certainty. The opposite extreme occurs in the case where little or no run-off data are available and where resort must be had to the use of precipitation data. The writer has found in numerous studies of this kind that monthly ratios of run-off to precipitation are of little value, as in a given month these ratios will vary very widely, even for the same total precipitation during the month, depending on the distribution of the precipitation during the month and the conditions for some time prior to the month in question. By dividing the "water year" into perhaps three periods, better results can be obtained in cases where storage is contemplated and the natural flow over short periods of time is not essential. A more satisfactory method of treatment in such a case, however, often consists in estimating the water losses and subtracting these from the precipitation to get the probable run-off. The water losses from land area may be considered substantially as (1) soil evaporation; (2) interception losses (that is, rainfall caught by vegetation and evaporating before reaching the ground); and (3) transpiration losses, or practically the requirements of growing vegetation.

To make an intelligent estimate of run-off based upon precipitation, taking into account the above factors, requires, of course, a knowledge of the drainage area and of the characteristics which affect the above factors.

Obviously it is difficult or impossible to measure separately these different losses on a given drainage area, but their determination by experiment upon small areas and the checking up of estimated losses with actual run-off measurements affords an interesting field for research in which there is opportunity for much effort.

While there is usually an increase in precipitation with elevation, at least in the general vicinity of the Atlantic and Pacific coasts, a much safer method of procedure consists in plotting a curve in which the arguments are elevation and, say, mean annual precipitation, to ascertain what precipitation is likely for a given elevation, selecting data from stations adjacent to the locality in question.

*H. K. Barrows in Journal, Boston Society of Civil Engineers. Discussion of L M. Wood's paper on "Power Estimates from Stream Flow and Rainfall Data."

A REMOVABLE BRIDGE ACROSS THE ASSINIBOINE RIVER.

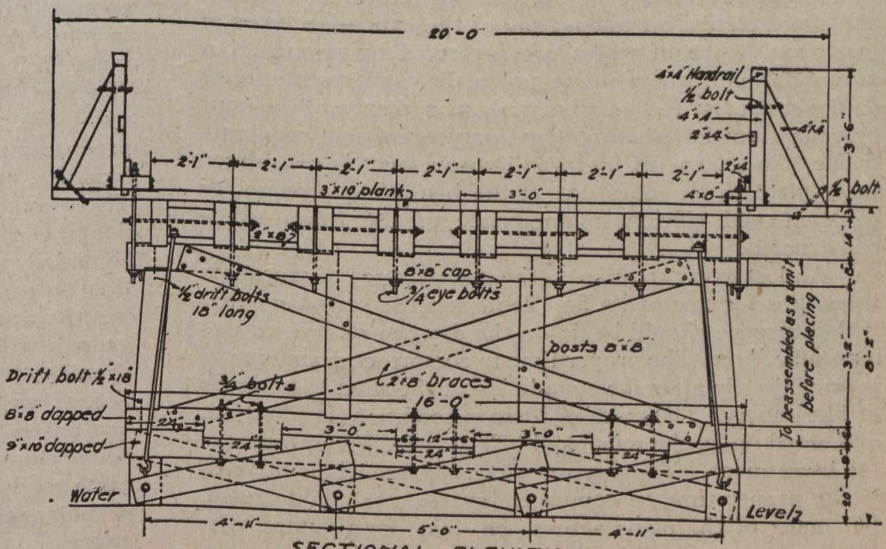
By G. W. Rogers, A.M.I.C.E.,
Engineer, Municipality of Assiniboia.

In the fall of 1915 a bridge was erected across the Assiniboine River at Headingly, about 12 miles west of Winnipeg, the cost and maintenance of which will be borne by the municipalities of Assiniboia and Charleswood.

The bridge is 380 feet long and is designed in such a manner that all above the piles and caps can be easily removed in the spring and replaced after the ice has passed away.

The piles and lumber were obtained from contractors to the Canadian Pacific Railway who were at the time removing a temporary bridge in the city of Winnipeg. The quantities bought and the prices paid were as follows: No. 152 piles, 34 feet to 35 feet, $1.50 each; lumber, 81,587 feet B.M., $10 per 1,000 feet B.M.

The lumber used in the bridge, allowing for waste, was 60,000 feet B.M., and cost $13.13 per 1,000 feet delivered on the site. The piles cost $2.27 each delivered on the site.



SECTIONAL ELEVATION

Scale ½"=1'

The cost of the bridge was as follows, the labor being done by contract.

Lumber, 60,000 ft. B.M. @ $13.13	$ 787.80
Piles, 104 @ $2.27 each	232.08
Driving piles, 1,664 ft. @ 14½c.	241.28
Labor on lumber, 59,270 ft. B.M. @ $6.90	408.96
Supplying iron, 8,798 lbs. @ 4½c.	395.91
Placing iron, 8,798 lbs. @ 1c.	87.98
Fixing mud sill, south approach	4.12
Fixing mud sill, north approach	2.75
Nails, 225 lbs. @ 5½c.	12.37
Total	$2,173.25

[Note: If new lumber had been used the cost would have been $4,059.00.]

In March, 1916, a contract was let for the taking down and replacing of the bridge at $1 per lineal foot. The actual cost of taking down was $80, thus leaving the contractor $300 for replacing. In consequence of the unusual high water this year it has been impossible to re-erect the bridge up to the present.

MACADAM ROAD MAINTENANCE.*

By W. H. Huber, C.E.,
Engineer, Ontario Highways Department.

THE revolution in the character of highway traffic within recent years has resulted in a demand for road surfaces very different from those which have heretofore been considered quite satisfactory. This change in character, and increased intensity, of traffic has also brought about a marked change in the methods of maintenance, and has advanced the question of maintenance from a position of importance second to that of construction to one at least of equality. Whereas formerly, a properly constructed road was looked upon as built almost for all time, the present tendency is to consider no road or pavement permanent, much less that type composed of crushed stone bound with its own dust and known as macadam. Formerly, the road-builder looked at the completion of the road as the end of his work; to-day it is only the beginning; for no builder of highways would claim the ability to construct a road or pavement that will withstand the severe strain imposed on it by present-day traffic. True, one may read and hear extravagant claims for almost any of the expensive types of pavement, some of which are protected by patents, but how many of them will live up to these representations? In the case of water-bound macadam, and even bituminous macadam roads, which are to carry even only moderate traffic, the scheme of highway improvement is considered incomplete if it does not at the beginning provide for constant and efficient maintenance of the roads to be constructed.

Almost every treatise on the maintenance of macadam roads has for one of its first sentences the statement that "Maintenance should begin on the day the road is opened for traffic," or "The proper time to commence maintenance is immediately after the completion of the road," or words of like import. The truth of these exhortations is admitted, and acted on by the municipal official, who would preserve his investment. The day on which the road is completed is the proper time to commence systematic maintenance, but many of the plans should be laid long before this. Realizing that a well-built road will require much less expenditure to keep it in good condition than one built to a lower standard, it will be well, before commencing construction, to consider carefully the relation between original cost and the cost of subsequent maintenance.

The annual cost of maintenance on macadam roads may be quoted roughly as from one to ten cents per square yard, depending on many conditions, such as the nature and intensity of traffic, quality of material and standard of work originally employed, character of the sub-grade, excellence of the drainage facilities, and efficiency of the maintenance organization, with much emphasis on the last named. While we have come to the conclusion that roads carrying heavy concentrated traffic must be something more than ordinary waterbound macadam if they are to be maintained in good condition at reasonable cost, financial considerations in many instances decree that the expenditure on construction must be limited as nearly as possible to the cost of the ordinary type. In such cases it is well to remember that a moderate increase in the cost of construction may materially lower the annual maintenance charge. For example, if an increased outlay of 20 cents per square yard will give a road surface on which the yearly maintenance cost will be reduced 1½ cents per square yard, the saving in maintenance will repay the increment in 20 years, and the expenditure will be justified. And 20 cents per square yard added to the cost of the average waterbound macadam road will make a vastly better road. It will, for instance, permit an increase of from two to three inches in the depth of stone, and a corresponding increase in the strength of the road. Or it will provide an extra inch or two of stone, and in addition a bituminous carpet coat to protect the surface and prevent dust. The latter will result in an improved road, both top and bottom, and it cannot be denied that the annual maintenance cost of such a road surface will be reduced by at least 1½ cents per square yard. Or, in the case of a 12-foot road costing $1 per square yard, the equivalent of 20 cents per square yard on this width, added to the cost, would allow for an increased width of from two to three feet, and would permit of a wider distribution of traffic over the metalled surface.

To first-class construction must be added constant care in maintenance, in order that the cost of the latter may be kept down. The less attention a road receives, the more it will require in the end, and the greater will be the cost of eventually bringing the surface back to its original good condition. Efficient maintenance consists in more than keeping the travelled roadway smooth; it must include careful protection of the metalled surface, and also the earth shoulders and sub-grade from the numerous agencies which tend to destroy them. Such a programme will include careful attention to the drainage facilities, and the improvement of these wherever possible. The growth of grass and weeds on the earth shoulders is one of the most effective enemies of surface drainage, and should always be discouraged. Not only does the vegetation prevent the rapid draining off of all surface water, but the accumulation of the remains of successive years' growth will, before many seasons have passed, raise the shoulder above the metal, and form a basin for the retention of water to soften the stone surface and sub-grade, and hasten wear and rutting. The use of the log-drag is being emphasized in connection with the maintenance of earth roads. It may also be used with profit on the earth shoulders of macadam roads, both in keeping them smooth and maintaining a proper chamber, and in preventing the growth of weeds.

By improving the conditions under which a road performs its work of supporting traffic, and by taking such precautions as are practicable to decrease wear and deterioration, and the consequent necessity for maintenance and repair, much expense may be saved, and the annual charges materially reduced. Some of the destructive agencies to which the road is subjected are almost entirely preventible, and may, with proper construction, be almost eliminated. Of these, the chief is probably the action of water and frost in the sub-grade. With proper drainage there will be no water under the road, and where there is no water, there is no danger of damage from frost. Internal movement and attrition may also be prevented by precautions to secure a solid sub-grade and thorough consolidation and binding of the stone. Other agencies, however, such as the abrasion and pulverization caused by horses' feet and vehicle wheels, the shearing action of fast-moving automobile tires, and the chemical action set up on the weathering of the stone, cannot be entirely prevented, and protection against them consists mainly in minimizing their effects.

While effective maintenance will depend largely on the attention given the road and the labor expended on it, there are influences which may be exerted to reduce the

*Paper read before the 3rd Canadian and International Good Roads Congress, March, 1916.

effects of some of the foregoing destructive agencies. Much of the wear and damage sustained by roads subjected to increasingly heavy traffic are due to the inconsideration of the users of the road. To counteract this negligence educative steps will in some cases be necessary, while in others legislation has been brought into play, and further steps along similar lines would be justified. In the former class may be mentioned the tendency to drive in a single track, thereby hastening the formation of ruts. This is frequently encouraged by building narrow roads with high crowns, and a partial remedy is found in widening the metalled portion and reducing the crown. Prevention of abuses of the latter class, which can usually be achieved only with the assistance of the law, includes limiting the speed of automobiles and the weight and speed of motor trucks. The advantage attending the use of wider tires for heavy horse-drawn traffic has frequently been discussed, but the only hope of securing their adoption appears to be in legislation prohibiting the use of narrow-tired vehicles carrying heavy loads on improved roads. The same remarks apply to the question of having front and rear wagon axles of different lengths.

But when all is said on the causes of road deterioration and methods of preventing it, the fact remains that road maintenance consists largely of labor expended on the road surface itself. The question of how the road may be best maintained in the good condition which, we shall assume, followed construction, is the vital question on thousands of miles of road at the present moment. Not only must the maintenance be effective, but it must be carried on at a cost commensurate with the original cost of the road, the nature and amount of traffic using it, and the financial capabilities of the municipality on whose shoulders rests the burden of meeting the cost.

No matter how good the construction, wear will occur, and it is the chief object of maintenance to take care of this wear before it goes so far as to require heavy repair work. Ruts and depressions will form, especially in a newly built road which has been laid on an earth subgrade. The second season is usually the road's worst time. Ruts, caused by the sinking of the stone into the sub-grade must be filled, the occasional ravelled spots found on almost any road must be re-rolled, and the contour of the surface restored if necessary.

It is frequently desirable to repair ruts which have been formed in the foregoing manner, or which are caused directly by the concentration of traffic in one line. Two courses are open, either of which will be found effective and inexpensive. The first consists of spiking up the ruts with the roller, and filling with new stone. It will be found that the rear roller wheels just cover the ruts, which may be picked without moving the roller from its tracks, and without loosening the remainder of the road. Short spikes should be used in this operation. Two to three round trips over a given section will usually loosen the stone sufficiently to permit a bond with the new material. In the ruts thus loosened, fresh stone from one inch to one and one-half inches in size is carefully placed, in quantity sufficient to restore, after consolidation, the old cross-section. This is then rolled and bound with screenings and water, as in the case of the original road. The second plan eliminates the loosening of the road surface, and depends on the use of tar or asphalt to keep the new stone in place. The ruts or depressions are first thoroughly swept out till the bare stone is exposed over their entire area. The surface of the hollow is then painted with bituminous material, usually a heavy asphaltic oil, or medium grade refined tar. New stone is next placed over the bitumen in the quantity mentioned, and rolled. A small amount of bituminous binder is applied to the surface and the whole finished with stone chips and rolling. This process is an application of the penetration method of bituminous road construction on a small scale, and possesses the advantage of providing a bituminous bound surface on that part of the road which receives the greatest wear.

Experience has shown that the surface of a waterbound macadam road cannot be expected to withstand the effects of rapidly moving motor traffic. While still the mainstay in the body of thousands of miles of the country's main roads, stone screenings as a binder for wearing surfaces subjected to much of this class of traffic has reached the end of its usefulness, and substitutes must be, and are being, provided.

The use of oils on road surfaces is usually considered in connection with the prevention of dust, but systematic treatment with a good asphaltic oil ranks with the most efficient methods of road maintenance. If a good grade of asphalt oil, say, 40 per cent., is applied regularly to a properly prepared surface, the effects are soon seen to be in a measure permanent, the asphaltic base remaining on, and penetrating into, the road after the volatile constituents have evaporated, and forming a permanent binder for the surface. The same penetration may be obtained from the use of a light refined tar, the grade known as Tarvia B, being generally used for this purpose. In either of these cases, sand sprinkled on the road after the application of the bitumen will furnish a wearing surface which will effectively protect the stone during the life of the treatment.

The most lasting and generally the most satisfactory treatment of a macadam surface, particularly when subjected to much motor traffic, is found in what has been termed the "carpet coat." This consists of a thin covering of bitumen, filled with stone chips, pea gravel, or coarse sand. The result is a surface from one-eighth to one-half inch thick composed of stone and a bituminous binder, the former taking the wear of the traffic and the latter binding the stone together and holding it on the road.

While more expensive than treatment with light oils, a bituminous carpet coat is usually cheaper in the end, owing to the greater durability of a single application, and the better condition in which the road is preserved. When properly applied a carpet coat may last, with a small amount of maintenance, for from two to five seasons, and the road thus treated has many advantages equal to those of a bituminous macadam road. In some respects a well-built waterbound road with a bituminous carpet coat is to be preferred to one with several inches of a bituminous bound surface. The cost is less, being equal to that of an ordinary waterbound road plus eight to ten cents per square yard. The body of the road, if built on a firm sub-grade, is perhaps more rigid than the bituminous macadam, owing to the danger in the construction of the latter type of using an excessive quantity of bitumen. This is especially true in the case of country roads, where experience in the use of bituminous binders is not so general as in city street paving. If a suitable system of maintenance is organized, the only work necessary is that required for keeping the carpet coat in good condition, correct practice being to repair any defects in the surface before the body of the stone is injured. This follows the principle of maintenance of city streets, where the concrete base is considered permanent, and the wearing surface, of whatever character, is renewed as occasion requires.

The successful application of a carpet coat depends on a number of details, neglect of which may result in partial or total failure.

(1) All dust must be thoroughly swept off the road in order to secure adhesion between the carpet coat and the body of the road. For economy this should be done by a horse-drawn rotary sweeper, dust being removed from ruts and depressions, if necessary, by hand brooms. The bare stone must be exposed over the entire area.

(2) All bitumen which does not penetrate the road must be taken up with stone chips to take the wear of traffic and to prevent creeping of the carpet coat and the consequent formation of lumps.

(3) Bitumen must not be applied in quantities greater than just sufficient to cover the road. For a heavy carpet coat, an application of from one-third to one-half gallon per square yard is usually made of 80 per cent. or 90 per cent. asphaltic oil, or medium grade refined tar.

(4) Care must be taken that it is heated to the correct temperature, else its viscosity will require the use of more than is necessary or advisable. The temperature mentioned in the specifications covering work with any given material must be rigidly adhered to.

(5) Sufficient stone must be used to take up all the bitumen, and extra chips added wherever "bleeding" occurs.

(6) In order to prevent creeping and to insure the success of the treatment the stone must be consolidated by rolling. During this operation the stone is forced into the bitumen which comes to or near the surface. The principle on which the rolling is considered of such importance is that the voids in the stone chips must be reduced to a minimum, and these voids be filled with bitumen. If they are not reduced to the limit, there is an excess of bitumen which will come to the surface and cause "bleeding" in hot weather, when, assisted by the crown of the road, it will tend to run toward the sides and cause lumps. The roller should make several passages over each portion of the road, and fresh chips be applied wherever the tar or oil comes to the surface.

Results of the treatment described are to a large extent dependent on the degree of penetration, or at least on the adhesion between the bitumen and the stone surface. It should therefore be left undisturbed for some time after being applied. A warm day assists materially, keeping the bitumen in a more liquid state. If applied in cool weather it will become cold and thick before penetration or adhesion has commenced, and peeling will probably occur soon after. Also, the stone chips used in covering will not enter the bitumen as they should, and bleeding and movement on ensuing hot days will result. On no account should any traffic be allowed on the road between the applications of bitumen and stone chips. The bitumen will adhere to wheels and horses' feet, and results may usually be seen in the subsequent peeling of that part of the coat which has been disturbed.

The cost of a heavy carpet coat such as described will usually be from eight to ten cents per square yard, and the life of such a coat with careful, though not necessarily expensive, maintenance is estimated at from two to five years. Including the cost of upkeep, the annual cost of this form of road protection in ordinary cases will be from two to four cents per square yard. The cost will be somewhat increased on main travelled and suburban roads, in which case it may be as high as six or eight cents per square yard per annum.

Since one of the greatest objections to the carpet coat as a form of road preservation lies in its tendency to creep, and as this tendency depends largely on the thickness of the coat, recent practice has changed somewhat to a preference for a thinner coat, composed of a lighter grade of asphaltic oil or tar, filled with smaller stone chips or coarse sand. The durability of such a treatment is not merely equal to that of the heavier coat, but the lower cost at which it can be applied will permit more frequent resurfacing. It possesses the additional advantage that rolling is not absolutely necessary, and the cost of this item may be eliminated. The same care must be taken, however, as regards cleaning the road surface prior to the application of the bitumen and the prevention of disturbance by traffic before the sand has been applied. The cost of this treatment, using approximately one-quarter gallon per square yard and covering with sand, is ordinarily from three to four cents per square yard. With ordinary country road traffic it will last a full season, and in most cases a moderate amount of repair work will make it good for a second, making an average cost of from one and one-half to three cents per square yard per season.

The size of stone chips required will vary, with the grade of bitumen used, from coarse sand to half inch. Whichever size is used it must be free from dust. Since it is to constitute the actual wearing surface of the road it should be carefully selected, and as carefully applied. Trap or granite chips should be used wherever obtainable at a reasonable price. First quality limestone is next in preference, while pea gravel and coarse sand may also be used.

In order that the benefits of a carpet coat as described may be continued, and in order that the body of the road may suffer no deterioration, great care must be taken to keep the surface completely covered. Bare spots must not be allowed to develop or pits will form. Experience has shown that where the stone becomes bare, disintegration will rapidly set in, due to the fact that the bitumen has prevented the penetration of moisture to the road. In the case of an untreated road, the surface will absorb a certain amount of moisture, which is necessary to maintain the bond. Proof of this is seen in the ravelling of many macadam roads during continued hot, dry weather. When oil or tar is applied it replaces the moisture, and the surface bond is maintained, and even improved. When the bitumen has worn or peeled off the surface, the stone beneath, robbed of its bond, will ravel, and a pit is the result. The scheme of maintenance should provide for a frequent and systematic inspection of all treated roads, and the application of a small quantity of bitumen and stone chips, of the same grades as those originally used, to any spots where bare stone is showing.

The mention of constant attention naturally introduces the subject of patrol work in connection with road maintenance. There is now no question of the economy of small repairs continuously made, as opposed to periodic resurfacing amounting practically to reconstruction. The employment of patrolmen on the main roads is now quite general, and it remains to have this system extended to cover the less important roads which must also, in the interests of economy, be kept in a state of first-class repair.

The length of road which a single patrolman can properly cover will depend on the original condition of the road and the intensity of traffic. Briefly put, his duty will be principally to keep the road in as good condition as when it was built. At the first sign of wear or deterioration steps must be taken to repair it in order that the work may be done as cheaply and expeditiously as possible.

Attention to the travelled roadway, while perhaps the most important, is not his only duty, and the care of the entire road allowance from fence to fence will be entrusted to him. The maintaining of the drainage, and its improvement where practicable, are of vital importance. All side ditches and culverts must be kept open and free from rubbish. No water must be allowed to stand in any ditch or culvert, but must be carried to its proper outlet. A patrolman's instructions should include a positive order to traverse his entire section immediately after each rain to see that all ditches and culverts are working properly, and that water is not being held back in any place; also to look through each culvert at least once a week.

Weeds on any part of the road allowance should be cut and burned before going to seed. On the earth shoulders, they may be kept far from the seed stage with a log drag, which will at the same time keep the shoulder smooth. Broken guard rails should be immediately repaired. Approaches to bridges and other embankments should be watched in order that any shifting of earth may be promptly arrested. Damage to bridges or other property on the section, repair of which does not lie within the patrolman's field, should be immediately reported to his superior officer.

For purposes of patrol work, a man with a single horse and wagon, and heating kettle, is generally employed. For social reasons it might be preferable to have two men with a wagon, and to double the length of the section patrolled. This would double the amount of work done per outfit, and reduce the cost to somewhat less than twice that of a single man. In the wagon are carried the necessary tools for the work, a quantity of stone chips for repairing the bituminous surface, and a supply of fuel for the heating kettle. The outfit can start from headquarters in the morning fully equipped with tools and materials for any repair or maintenance work which will be encountered during the day, and lost time, usually spent in going for supplies for a particular job, is eliminated. In efficiency the patrol system has already proved its worth, and the organization of such a sustem, suited in detail to local conditions, will result in better kept roads at less cost.

In conclusion, macadam roads form the greater percentage of the heavily travelled roads in this country; they represent an expenditure of millions of dollars, and it is our duty, as engineers and roadbuilders, to see that this investment is preserved to as great an extent as possible.

RAILWAY EARNINGS.

The following are the weekly railway earnings during the first three weeks of June:—

Canadian Pacific Railway.

	1916.	1915.	
June 7	$2,674,000	$1,585,000	+ $1,089,000
June 14	2,629,000	1,623,000	+ 1,006,000
June 21	2,631,000	1,619,000	+ 1,012,000

Grand Trunk Railway.

June 7	$1,107,091	$ 959,977	+ $ 148,114
June 14	1,113,418	949,313	+ 164,105
June 21	1,152,440	989,072	+ 163,368

Canadian Northern Railway.

June 7	$ 629,700	$ 409,400	+ $ 220,300
June 14	880,400	403,500	+ 476,900
June 21	744,300	413,800	+ 330,500

The Canadian Northern Railway's statement of earnings and expenses for May is as below:—

	1916.	1915.	Increase.
Gross earnings	$3,088,900	$1,721,400	+ $1,367,500
Expenses	2,361,700	1,362,800	+ 998,900
Net earnings	727,200	358,600	+ 368,600
Mileage in operation	9,039	7,271	+ 1,768

LIFE OF CONCRETE STRUCTURES.

By Bertram Blount, F.C.S.

At the International Engineering Congress held towards the end of last year in San Francisco, Mr. Bertram Blount, of Westminster, contributed a paper dealing, from the standpoint of an analytical chemist, with the probable and presumptive life of concrete structures embodying modern cements.

The chief possible causes of destruction of concrete, as stated by the author, are bad cement, bad aggregate, bad proportions, bad mixing, bad workmanship, bad design, external violence and chemical action.

With regard to this category, Mr. Blount is qualified to speak with special authority on the subject of cement, concerning which he remarks: "It may be confidently said that, given careful manufacture, rigid inspection and thorough testing to a searching specification, modern cement can be obtained free from all inherent vice, and that structures of which it forms part will not be brought to a premature end by internal treachery."

Bad aggregate is characterized as a fruitful source of trouble. The one property which is indispensable is that aggregate must be chemically stable under the conditions in which it is to be used. Therefore, in general, rocks containing pyrites should be avoided, but it would be pedantic to reject a granite or a hard limestone on the ground that specks of pyrites are present. Substances containing sulphates or sulphides, capable of oxidation under working conditions, are so dangerous that their use should not be tolerated, and the need of this restriction can be the better realized when it is remembered that 1 per cent. of SO_3, calculated on the aggregate, may mean 5 per cent. or more on the cement. Perhaps, of all the materials used as aggregates, the most dangerous is coke breeze. The danger lies in the fact that some samples contain an abundance of sulphates, and, on account of the porous nature of the breeze, these are readily extracted and do their deadly work on the cement. Aggregate may be mechanically as well as chemically bad; such obvious defects as softness, cracks, and excessive smoothness need no more than mention, but how far a "dirty" aggregate carries it our condemnation is a more difficult matter to decide. While clayey matter round the coarser lumps will prevent a proper bond, the effect of a small amount of clayey matter in the sand is not necessarily harmful. The author does not refer to the special need for scientific grading of aggregate and sand, this being a most important factor which too frequently receives inadequate attention.

Four other conditions prejudicial to the endurance of concrete, *viz.*; bad proportions, bad mixing, bad workmanship, and bad design, are matters for the engineer and the contractor rather than for the analytical chemist and are passed over with little comment by the author. All these defects can be obviated if the designer and the contractor are qualified by technical knowledge and above all, by practical experience for the performance of their respective duties.

After referring to the possible effects of wind, wave and earthquake, Mr. Blount quotes the results of laboratory tests illustrating the resistance of concrete to high temperatures, and discussing chemical action as the result of immersion in sea water, he emphasizes the need for impermeability. In fact, he says, the one indispensable condition for a long life of work exposed to the sea is the denseness and imperviousness of the concrete, and this is difficult to secure unless the cement is used liberally. It is difficult to fix a proportion, as that will depend on the aggregate. Every case must be judged for itself, the voids being determined and enough cement used to fill them. Many attempts have been made to obtain imperviousness by the addition of various materials, such as barium salts, soap and fatty or mineral oils, but at present there is nothing better than concrete made with carefully chosen and graded aggregate and an ample proportion of cement. Concrete made thus can only be attacked on the surface, and its destruction by percolation is well-nigh impossible. To state its probable length of life would be a rash attempt; it should last indefinitely, in fact, until the harbor or other marine work had become obsolete.

Following some remarks on the corrosive effects of acids, actual or potential, Mr. Blount refers briefly to possible attack by electrolysis, saying that the divagations of stray electric currents should be prevented by proper insulation; it should not be necessary to protect concrete from them because those errant currents should be kept in their narrow channel. These words apply, of course, only to American practice, for, as our readers are aware, the safeguards adopted in this country have proved efficacious in preventing stray currents and consequent risk of injury.

Turning now to reinforced concrete, it is said that all the causes of attack which have been discussed under the head of ordinary concrete are equally valid, and in addition there are some other causes peculiar to reinforced concrete. In practice the reinforcement consists of steel and is liable to the same corrosion as steel in other structures, but fortunately cement is an alkaline substance and the metal, iron, in an alkaline medium does not rust. This comforting fact does not warrant the deduction that the steel reinforcement is immune from corrosion. That is true only if it is completely enclosed with concrete which is fully in contact with it, and is free from fissures, a cogent reason for the use of concrete, for reinforced work, of a higher grade than that generally necessary. It is highly desirable that the concrete should not only be without fissures, but should be impervious. The advantages in preventing the percolation of any saline or corrosive substance are so great that the extra trouble and cost are well repaid. With the knowledge of the present date, it seems fairly certain that little fear need be felt of steel reinforcement rusting when well embedded in good nonpervious concrete of adequate thickness, even when the structure is exposed to seawater or other saline solutions. In summing up his discussion of the possible causes of the destruction of concrete structures in general, the author says that by far the most important is corrosion by saline solutions. For such structures impermeability is imperative. The material must be free from interspaces which are not microscopic and disconnected. This axiom has been arrived at painfully and with heavy cost in the hard school of experience before reinforced concrete was thought of.

All other causes tending towards destruction sink into insignificance beside this, which, of course, affects a comparatively small proportion of the total number of concrete structures executed, and which can be counteracted by proper care. The next worst is the injury caused by aggregates of the class of coke breeze containing sulphates or potential sulphates. From the very nature of the material, and from the use to which it is put, namely, to make light floors, ceilings and partition walls, it is clear that it cannot be impervious, and it follows that whatever water reaches one of its surfaces will speedily make its way to the interior. Where water can go, air can follow, and the assumption that sulphides are fairly harmless falls to the ground, because they are in the most favorable condition to become sulphates, and the fate of the structure is then settled.

The general conclusions drawn by the author are these: (1) that there exist potential causes of destruction, which, if uncontrolled, will destroy any structure, even when its design is impeccable; (2) that all such causes, except extreme external violence, can be controlled, and their effect nullified by knowledge, care and skill, and, as a necessary result, security and permanence can be attained.

SUGGESTED FEES FOR ENGINEERING SERVICE.

Through the courtesy of Arthur Surveyer, M.Can.Soc. C.E., Montreal, we are enabled to present a brief summary of the code of ethics and proposed fees as adopted by the Association of the Alumni of the Ecole Polytechnique of Montreal.

According to this code, a consulting engineer is quite within his rights, in some cases at least, in charging a percentage of the actual cost of the work involved. The following schedule of fees is suggested: For the preparation of a piece of work or the examination of any work which has been prepared by other engineers, the charges for the services of an engineer and of his staff shall be equal to 2 per cent. of the cost of the work, provided this cost does not exceed $50,000 or less than $10,000. Where the work will probably cost less than $10,000 the remuneration shall be at least $200. If the work involved an expenditure of $70,000 to $100,000 the charge shall be 1½ per cent. of the cost, while if the work costs more than $150,000 the percentage charge shall be 1 per cent. of the cost.

Where an engineer is merely consulted the charge will, of course, be proportioned to the time spent on the work, the basis of the charge to be a day of six hours, and to be paid for at the rate of $50 to $100 a day, depending upon the experience and reputation of the engineer.

Where a consulting engineer undertakes complete supervision of a piece of work, including office consultations, supervision of the contractor, etc., it is, according to this code, reasonable to charge 5 per cent. where the work involved means an outlay of $1,000,000 or more, 6 per cent. to from $100,000 to $500,000, and 7 per cent. to under $60,000. In no case shall the fee be less than $700.

The code furthermore specifies that six hours shall be considered the working day of an engineer.

Where an engineer prepares a written report covering certain work, the following charges are suggested: For preliminary study of a project with a report, or for an examination of a project prepared by another engineer with a report on the subject, or a study and report on questions of irrigation, or the preparation of depositions before courts, or presence in courts during trials, the charge shall be $50 to $100 per day or more for the first five days devoted to the client's services, and $25 to $50 a day for succeeding days. In addition, the client shall be expected to pay salaries of all assistants and an additional amount equalling 100 per cent. of those salaries in order to cover overhead expenses of the engineer's organization.

STANDARD PAVING BLOCK SPECIFICATIONS.

THE American Society for Testing Materials, of Philadelphia, Pa., which is affiliated with the International Association for Testing Materials, has issued proposed tentative specifications for wooden paving blocks. Criticisms of these specifications are solicited and should be directed, preferably before January 1st, 1917, to Dr. Hermann Von Schrenk, consulting timber engineer, Tower Road and Flad Avenue, St. Louis, Mo. Dr. Von Schrenk is chairman of the Society's committee on timber. The proposed tentative specifications are as follows:—

Timber.—1. The wood, which shall be treated, shall be Southern yellow pine, hemlock, Norway pine, Douglas fir, or tamarack. Only one kind of wood shall be used in one contract.

2. Paving stock lumber of all species shall be 3 or 4 ins. thick, 5 to 10 ins. wide, and 8 ft. or longer, surfaced one side uniform to within 1/16 in., allowing ¼ in. from full nominal thickness for surfacing. The widths shall run full nominal size. The scale shall be on the full nominal sizes.

3. (*a*) Except as modified below under species headings, all paving stock lumber shall be well manufactured, green, square edge, sound-knotted, free from checks impairing the strength of a block cutting, free from wane or bark, unsound, loose or hollow knots, knot holes, ring shake, dote or decay. Defects of any character may be admitted at one point on each 8-ft. section of plank, provided such defects do not affect at one point more than 4 ins. of the length of the piece.

(*b*) Yellow Pine.—Southern yellow pine paving stock may be of longleaf, shortleaf, Cuban or pond pine, and shall show not less than six annual growth rings, with an average of 33⅓ per cent. summer wood in any one inch measuring radically from the pith centre on one end of the timber. All measurements shall be made on a section of wood cut perpendicular to the grain.

Southern yellow pine shall further conform as to grade to the requirements specified in Paragraph (*a*).

(*c*) Hemlock.—Hemlock paving stock shall be selected No. 1 green, and shall further conform as to grade to the requirements specified in Paragraph (*a*).

(*d*) Norway Pine.—Norway pine paving stock shall conform as to grade to the requirements specified in Paragraph (*a*).

(*e*) Douglas Fir.—Douglas fir paving stock shall show not less than six annual growth rings, with an average of 33⅓ per cent. summer wood in any one inch measuring radially from the pith centre on one end of the timber. All measurements shall be made on a section of wood cut perpendicular to the grain.

Douglas fir paving stock shall further conform as to grade to the requirements specified in Paragraph (*a*).

(*f*) Tamarack.—Tamarack paving stock shall be selected No. 1 green, and shall further conform as to grade to the requirements specified in Paragraph (*a*).

Blocks.—4. The width of the blocks shall be either 3 or 4 ins., and all blocks for any one city block or piece of work shall be the same width. The width shall not vary more than ⅛ in. over or under that specified.

5. The length of the blocks shall be not less than 5 ins. nor more than 10 ins., with an average length of 8 ins.

6. The depth of the blocks, parallel with the fiber, shall be from 3½ to 5 ins., depending on the service. For light traffic 3½ ins. may be used; for extremely heavy traffic a depth of 5 ins., and for average traffic a depth of 4 ins. is recommended.

The depth, parallel to the fiber, shall be at least ¼ in. more than the width of the blocks. Where blocks are laid on a sand or mortar cushion, the depth may vary ⅛ in. from that specified, but where the blocks are laid on a smooth foundation, without any cushion, the depth shall not vary more than 1/16 in. from that specified.

Preservative.—7. The preservative shall be wholly derived from coal-gas tar or coke-oven tar, and shall conform to the following requirements:

8. The specific gravity at 38° C. shall not be less than 1.06 nor more than 1.12.

9. Not more than 3 per cent. shall be insoluble by continuous hot extraction with benzol and chloroform.

10. On distillation, the distillate, based on water-free oil, shall be within the following limits:

Up to 210° C	not over	5	per cent.
Up to 235° C	" "	30	"
Up to 315° C	" "	70 nor under 35	"
Up to 355° C	" under	65	"

11. The specific gravity of the distillate between 235 and 315° C. shall not be less than 1.02 at 38° C., compared with water at 15.5° C. The specific gravity of the distillate between 315 and 355° C. shall not be less than 1.08 at 38° C., compared with water at 15.5° C.

12. The specific viscosity at 82° C., when taken in an Engler viscosimeter, shall not exceed 1.3. The term "specific viscosity" shall mean the number of seconds found for the sample tested, divided by the number of seconds for water at 20° C., as given in the official certificate for the viscosimeter used.

13. The oil shall contain not more than 3 per cent. of water. Oil samples taken by the inspector from the treating tank during the progress of the work shall at no time show an accumulation of more than 2 per cent. of foreign matter, such as sawdust and dirt. Due allowance shall be made for all foreign matter, either water or material insoluble in benzol and chloroform, by injecting an additional quantity of oil into the block.

14. All tests and analyses shall be made in accordance with the Tentative Methods for Sampling and Analysis of Creosote Oil of the American Society for Testing Materials.

Treatment.—15. To secure a thorough and uniform penetration of the creosote and eliminate expansion and contraction, the wood shall be properly air-seasoned or conditioned by steaming, before treatment, in the following manner:

(*a*) The lumber from which the blocks are manufactured shall be kiln dried or air-seasoned before being cut into blocks.

(*b*) After the blocks are cut and placed in the cylinder, live steam shall be admitted and gradually raised to 30 lb. gauge pressure during a period of one hour; then maintained for at least two hours, during which time and at 15-minute intervals the condensation shall be blown out from the bottom of the cylinder.

At the completion of this steaming process the steam shall be blown off and a vacuum of not less than 22 ins. applied and held for a period of not less than one hour, or until such time as the cylinder is practically free from condensation. During this vacuum period the temperature in the cylinder shall be maintained by heating coils to at least 140° F.

Creosoting.—16. After the blocks are properly conditioned a vacuum of not less than 22 ins. shall be applied to the cylinder. The cylinder shall then be completely filled with creosote, and the pressure applied so that such additional creosote may be forced into the cylinder from the measuring tank as is required. During this operation the temperature of the creosote shall not be less than 160° F. nor more than 180° F. The creosote shall then be returned from the cylinder to the measuring tank and a vacuum of not less than 22 ins. applied to the cylinder and maintained for at least 30 minutes or until such time as the exterior surface of the block is free from drippage. The remaining creosote in the cylinder shall then be returned to the measuring tank and the net amount of creosote retained by the blocks determined.

17. Blocks for pavements having extremely heavy traffic, where 15 years' life is expected, shall be treated with 15 lb. of creosote per cubic foot. Where a longer life is expected from the blocks, 16 to 18 lb. of creosote per cubic foot is recommended.

18. After the creosote pressure treatment, the spring wood shall show a thorough penetration. In order to accomplish this, the pressure should be gradually applied and then maintained for a reasonable length of time, depending on the condition of the wood.

19. The net amount of creosote retained by the blocks may be either 10 per cent. under or 10 per cent. over that specified.

Inspection and Rejection.—20. The blocks, before treatment, shall be inspected as they are leaving the block machine, and all blocks that do not meet the specifications will be rejected.

POLLUTION OF BOUNDARY WATERS.

The International Joint Commission held public hearings at Buffalo June 21st and at Detroit June 26th for the purpose of receiving evidence concerning Dr. Phelps' report re pollution of boundary waters.

Very little new information was brought out at Buffalo. That city is now engaged in an investigation of Dr. Phelps' report and of the data concerning Buffalo which has been secured by the commission, and will report on their findings to the commission at a later date. The findings of the commissioners will not be given out for several months, pending the completion of Buffalo's investigation.

At Detroit the city officials appeared well pleased with Dr. Phelps' work and are willing to co-operate in every way possible to carry out whatever the International Joint Commission may find to be in the best interest of the people residing on both sides of the border. T. Chalkley Hatton, chief engineer of the sewage commission of Milwaukee, appeared before the commissioners at Detroit and gave an interesting statement regarding the results of activated sludge experiments. There is no doubt but that this method of sewage disposal will be given careful consideration by the commission in preparing their findings.

The Canadian municipalities in the Windsor district are taking the preliminary steps toward an organization which will put into effect the requirements of the commission. The Essex Border Public Utilities Commission has been organized with William Woollatt, mayor of Ojibway, as chairman, and J. E. Doane, of Walkerville, secretary. This utilities commission represents the six Canadian municipalities that are interested. Appointment of a board of engineers was discussed, with the intention of preparing plans for joint sewerage and water systems.

LAKE OF THE WOODS LEVELS AND OUTFLOW.

(Continued from page 5.)

prevailing to be "very unusual," and stated it was probably the result of control of the outflow from the lake. He further stated:—

"It would be perfectly possible by proper works at the outlet to maintain a good depth of water in the Lake of the Woods at all times. In this particular, however, the interests of navigation and those of power development are directly opposed, the one requiring constant level and very variable discharge, and the other a constant discharge with greatly varying fluctuations in lake level. It is my belief that the Canadian government has decided for the latter alternative; intends to develop power at the outlet, and has made its channel (referring to the mouth of Rainy River) sufficiently deep to offset the bad effects of fluctuations of lake level. It is certainly to be recommended that this matter be brought to the attention of the International Joint Commission."

As an outgrowth of this recommendation, the three questions contained in the official reference previously quoted, were submitted to the International Joint Commission, under the provisions of Article IX. of the treaty of January 11th, 1909, between Great Britain and the United States.

Everything in the nature of final conclusions or recommendations has been purposely omitted from the consulting engineers' report, in order to allow the International Joint Commission the fullest latitude in preparing their reply to the questions of the official reference. The purpose of this is evident; also no final recommendations would be warranted until all parties concerned had been heard by the commission. But the parties could not present their cases until they had received the commission's data as assembled and analyzed by the commission's engineers. This was why the Advance Sheets of the report were printed.

[Note.—This review of the consulting engineers' report will be continued in further articles. In next week's issue the subjects of reservoir control in general and regulation of outflow from Rainy Lake will be discussed.—Editor.]

The Bradford, England, tramways committee, has under consideration a scheme which it believes will open up a new era in local transportation. It is proposed to carry merchandise of every description and weight on the street railways. An experimental vehicle has been built at the Bradford tramway works, and its trials have been declared successful. It is run on the trackless trolley principle, but an important additional feature is that it is fitted with accumulators which will take their supply of current from the overhead wires, and will enable the vehicle to leave the tramway route at any point in order to reach its destination and deliver goods. These vehicles are to be run between the ordinary passenger cars.

Japan is about to widen its railway gauge at a cost of $150,000,000. The original gauge was three feet six inches. The railways are operated by the State in great part. The reconstruction will take a period of years, and so many millions will be allotted each year. Japan is going in for a heroic railway policy. There are parts of the country still to be served by railway lines, but the Government is showing great energy in supplying these as fast as possible. Japan builds her own railway systems now and supplies her own equipment—largely at any rate. In this matter of railways Japan has adopted every Western accommodation or improvement, while she has given thought to betterments of her own devising.

Editorial

THE GROWTH OF "THE HYDRO."

The last (eighth) annual report of the Hydro-Electric Power Commission of Ontario shows a power load in October, 1915, of 96,000 h.p., an increase of 28,000 h.p. over October, 1914, or an increase of 54,000 h.p. over October, 1913. The power load in December, 1915, was 122,000 h.p. Not counting the municipalities served by the recently absorbed Electric Power Co. system, over 160 municipalities are now being served, compared with 99 municipalities one year ago. This shows the very rapid growth of "the Hydro."

It also gives some indication of the power that will be required in the future when the hydro-electric radial system is in operation, and when other municipalities join the power union. It is estimated that over 200,000 h.p. will be required for the Niagara district alone within a year.

As its contract with the Ontario Power Co. calls for only 100,000 h.p., it is evident that the commission is in immediate need of additional power. At present more cannot be obtained from this company, as it already carries a large Canadian load and is operating to capacity.

There are only two other companies at Niagara to which the commission can turn; namely, the Electrical Development Co., and the Canadian Niagara Power Co. Affiliated as it is with the Mackenzie interests, the Electrical Development Co. is naturally not the commission's first choice. It has, therefore, notified the Canadian Niagara Power Co. that it will require 50,000 h.p. by December next. As the Canadian Niagara Power Co. exports practically all of its power, this will not deprive Canadian users. The company asks $15 per h.p. year, but the commission considers this price too high, and, according to newspaper reports, threatens to call the Federal Government to its aid, if necessary, to curtail the export of power by the company. A license must be received from the Federal Government for the export of power, and this license is terminable at the end of any year. It is probable, however, that the matter of price will be satisfactorily adjusted, and that the commission will be able to obtain an additional supply from the Canadian Niagara Power Company without any necessity for requesting Federal intervention which, incidentally, might not be granted by the Dominion authorities.

In view of the prospective demand, this additional supply will be more or less of a stop-gap, and it seems imperative that the commission make an immediate start upon the construction of the proposed Queenston plant, as under the best of conditions power cannot be hoped for from this source until at least two, perhaps three, years after the commencement of construction.

The 200,000 h.p. which this plant will primarily supply will do much to relieve what is rapidly developing into a very serious situation. The commission's project is unique in that it will utilize an effective head of 300 feet as against the heads of 136 to 200 feet now being used at Niagara. It is understood, furthermore, that power can ultimately be produced at Queenston at a cost considerably less than the price now being paid to the Ontario Power Co.

PROPOSAL TO DAM NIAGARA RAPIDS.

Dr. T. Kennard Thomson, M.Can.Soc.C.E., a well-known consulting engineer of New York, has laid a proposition before the Ontario government to pay $2.00 per horse-power year as a royalty for the Canadian power rights in the lower Niagara River. Dr. Thomson's idea is to build a dam, a short distance above Queenston, of such height as to drown out the rapids and create an operating head of 90 feet at the site of the dam. By this means it is proposed to develop about 2,000,000 h.p., which is to be divided equally between the two countries.

At first glance it would appear that the outstanding problem in connection with such a development is the construction of the dam. As a matter of fact, the structural difficulties in connection with this portion of the work are of secondary importance compared to the really vital features of the design. Every engineering problem involving purely structural difficulties can be solved by the adequate expenditure of capital, and it may reasonably be assumed that the structural difficulties in connection with Dr. Thomson's dam could be overcome.

But no engineer who has observed and studied the regimen of the Niagara River can fail to appreciate the gravity of the hydraulic problems to be solved in connection with maintaining a 90-foot head at Queenston, and at the same time, in the restricted space of the gorge, providing for the efficient control of flood water, the supply of water to the turbines, and the prevention of destructive ice-jams which even now periodically form in a channel unobstructed by any artificial agency.

Apart altogether from its engineering features, Dr. Thomson's scheme is hardly likely to find favor with that large and influential section of the Canadian and United States public which is interested in preventing private interests from destroying the scenic beauty of Niagara. If Dr. Thomson's scheme materializes, the whole river from the foot of the Falls to Queenston will assume the characteristics of that comparatively sluggish section of the present river between the foot of the Falls and the cantilever bridge. The splendid rush and billowing of the rapids will be no more. The titanic expenditure of energy which is necessary to wrench this plunging mass of water around through an angle of 90 degrees at the whirlpool will no longer be necessary, and in place of the present maelstrom of whirling cross-currents which now characterizes the sinister beauty of the whirlpool, there will be nothing but a gentle eddy.

MONTREAL AQUEDUCT REPORT.

Persistency, thou art a jewel!

Or words to that effect.

Continual hammering has made its impression upon the aldermen of Montreal, who last Thursday evening requested the Board of Control to invite the Montreal engineers to report on the aqueduct enlargement.

It will be remembered that thirty-one of the most prominent engineers in Montreal petitioned the Board of Control to appoint a commission of engineers to report upon the aqueduct enlargement in all its phases. The board refused to grant the petition, despite pressure that was brought to bear by the leading business interests of Montreal. The engineers who presented the petition then offered to appoint a committee from among themselves who would report upon the matter free of all cost to the city, although the work would be worth some eight or ten thousand dollars and would accupy a month of time. The Board of Control refused that offer also, but it now seems that the aldermen have been wiser.

The official request will likely be forwarded to the secretary of the Canadian Society of Civil Engineers by the secretary of the Board of Control.

CANADIAN SECTION OF THE AMERICAN WATER-WORKS ASSOCIATION.

The petition for the formation of a Canadian Section of the American Waterworks Association has been submitted to the executive committee of the association and has been favorably acted upon.

There are at present about 46 members of all grades of the association resident in Canada. This number should be sufficient to form the nucleus of a strong and active section. Such a section can be made of great value to engineers in Canada who are especially concerned with the construction and maintenance of waterworks, filtration plants, sewerage systems and sanitary engineering generally.

It cannot, however, render the greatest possible service to the membership unless that membership in turn is sufficiently concerned in the welfare of the organization to contribute of its time and interest. Members of the association will get no more out of the section than they put into it. It calls for the practical co-operation of all those engineers in Canada who are interested in this particular phase of engineering effort.

PERSONAL.

SMITH & SMITH have been appointed engineers of Victoria County, Ont.

FRANK CHAPPELL, A.M.Can.Soc.C.E., who until recently was town engineer of Oshawa, Ont., is a lieutenant in the 182nd overseas battalion. He has qualified as captain.

STANLEY L. EISENHOFER, assistant engineer in the Hamilton Hydro-Electric system, has received an important appointment with the Hydro-Electric Power Commission of Ontario.

J. J. MOYAN, of the Department of Railways and Canals, Ottawa, now engaged on the new Welland Canal, was in Hamilton recently to discuss the question of a garbage reduction plant.

Prof. J. C. GWILLIM, of the Engineering Department of Queen's School of Mining, Kingston, Ont., has been appointed Captain in the Canadian Engineers, and will leave shortly for Valcartier Camp.

R. C. HARRIS, Commissioner of Works for the city of Toronto, accompanied by several members of his staff, will visit Milwaukee during the next few weeks to inspect the activated sludge experimental plant.

Lieut.-Col. J. W. STEWART, of the railway contracting firm of Foley, Welch & Stewart, has opened a recruiting office for the 239th battalion of railway and bridge builders at No. 703 McArthur Building, Winnipeg. The men will be engaged in building war railways for the Allies.

OBITUARY.

Lieut. H. J. HAFFNER, formerly the senior member of the firm of Messrs. Haffner & Wartell, civil engineers, Victoria, has been killed in action. Lieut. Haffner was in charge of the machine gun section of the 48th Battalion, which left Victoria, B.C., last June, but on account of his expert engineering knowledge, he was transferred to the corps of engineers on reaching England. He was a native of Elora, Ont., but had lived in British Columbia for several years prior to the outbreak of the war, having followed the profession of civil engineer during most of that time, and in that capacity he was engaged in the construction of the famous Windermere Road. He was 35 years of age.

ROBERT MAITLAND ROY, general manager of the Hamilton Bridge Works, Hamilton, Ont., died last week after nearly a year's severe illness. Mr. Roy was a full member of both the American and Canadian societies of civil engineers, and was well-known as a structural designer of considerable ability. As an executive Mr. Roy built up the Hamilton Bridge Works from a comparatively small shop to its present prominent position in the trade. He was an alderman of the city of Hamilton, and chairman of the works committee of council. As a boy, he worked with the G.T.R., and at a later date with the old Peterborough Bridge Co., thus receiving his initial training in the structural steel business. He entered the employ of the Hamilton Bridge Co. twenty years ago as head of their highway bridge department. At the time of death Mr. Roy was forty-six years of age.

CANADIAN SOCIETY OF CIVIL ENGINEERS—ELECTION OF MEMBERS.

The council of the Canadian Society of Civil Engineers met at Montreal June 27th and made a number of elections and transfers as follows:—

Members—Farley G. Clark, of Toronto; James H. Fuertes, of New York City; Wallace R. Harris, of Regina; Alex. McLellan, of Belleville; and John W. Moore, Jr., of Victoria, B.C.

Associate Members—Walter Bowden, of Revelstoke, B.C.; Edwin A. A. Cowen, of Montreal; Andrew W. P. Lowrie, of Calgary; James T. Mitchell, of Ottawa; J. Arthur H. O'Reilly, of Winnipeg; Norman M. Sutherland, of Calgary; and Christopher J. Yorath, of Saskatoon.

Junior—Harry W. Mahon, of Halifax, N.S.

Transferred from Associate Member to Member—Alexander Gray, of Ottawa; and Wilfrid S. Lawson, of Ottawa.

From Junior to Associate Member—Raymond J. Beausoleil, of Montreal; Francis H. Kortright, of Oakville; Ernest M. Salter, of Winnipeg; Thomas M. Schenk, of Halifax, N.S.; Louis G. Trudeau, of Rimouski, Que.; and James M. Wardle, of Ottawa.

From Student to Associate Member—Alphonse Lafleche, of Quebec; and Clyde C. Sutherland, of Edmonton.