VOL. X. 1896. PART I.

TRANSACTIONS

OF THE

Canadian Society of Civil Engineers

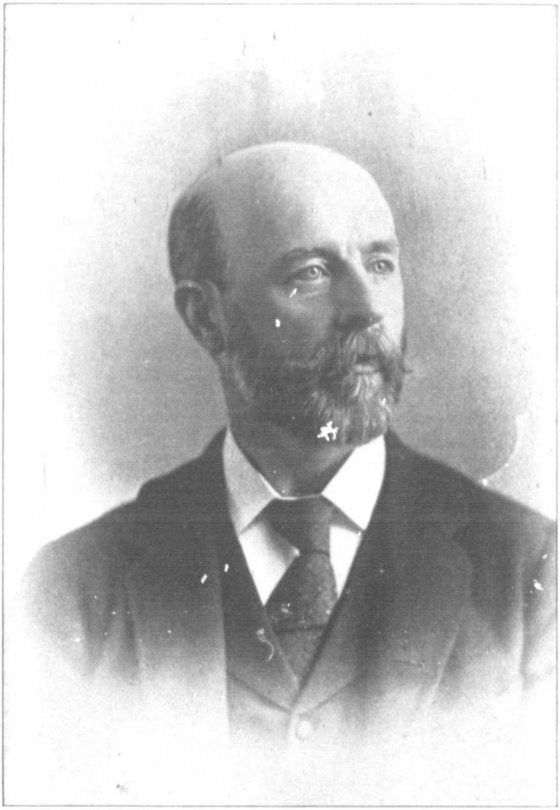
JANUARY TO JUNE, 1896.

CONTENTS

Montreal

Printed for the Society by JOHN LOVELL & SON

1896



Yours truly,

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Yours truly,
Rev. C. Wallis

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The Society will not hold itself responsible for any statements or opinions which may be advanced in the following pages.

"The papers shall be the property of the Society, and no publication of any papers or discussion shall be made except by the Society or under its express permission."
—*By-Law No.* 47.

CONTENTS.

ILLUSTRATIONS.

PROCEEDINGS.

INSTRUCTIONS FOR PREPARING PAPERS, ETC.

In writing papers, or discussions on papers, the use of the first person should be avoided. They should be legibly written on foolscap paper, on one side only, leaving a margin on the left side.

Illustrations, when necessary, should be drawn on tracing paper to as small a scale as is consistent with distinctness. They should not be more than 10 inches in height, but *in no case* should any one figure exceed this height. Black ink only should be used, and all lines, lettering, etc., must be clear and distinct.

When necessary to illustrate a paper for reading, diagrams must be furnished. These must be bold, distinct, and clearly visible in detail for a distance of thirty feet.

Papers which have been read before other Societies, or have been published, cannot be read at meetings of the Society.

All communications must be forwarded to the Secretary of the Society, from whom any further information may be obtained.

The attention of Members is called to By-laws 46 and 47.

1894.	1895.	1896.
P. Alex. Peterson.	Thomas Monro.	Herbert Wallis.
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L. A. Vallee.	L. A. Vallee.	W. J. Sproule.
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		Thos. Monro.
C. H. McLeod.	C. H. McLeod.	C. H. McLeod.
K. W. Blackwell.	K. W. Blackwell.	K. W. Blackwell.
Wm. McNab.	Wm. McNab.	Wm. McNab.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

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Thursday, 30th January.

HERBERT WALLIS, President, in the Chair.

The scrutineers for the ballot on the Code of Engineering Ethics reported that all the By-Laws had been passed. In accordance with the instructions of the Annual Meeting, it was ordered that the articles of this Code should now be incorporated in and form part of the by-laws of the Society.

The discussion on Mr. Smith's paper on "Cement Tests" occupied the Evening.

Thursday, the 13th February.

HERBERT WALLIS, President, in the Chair.

The discussion on Mr. Dawson's paper on "A New Method for the Design of Retaining Walls" occupied the evening.

Thursday, 27th February.

HERBERT WALLIS, President, in the Chair.

Paper No. 110.

PENN YAN (N.Y.) WATERWORKS.

BY ANGUS SMITH, STUD.CAN.SOC.C.E.

Penn Yan has a population of about 5,000. It is situated at the outlet of Lake Keuka in the western part of New York State, about 50 miles southeast from Rochester.

Lake Keuka is about 20 miles long by ½ a mile wide, and it is very deep. It is from this lake that Penn Yan takes its water for fire and domestic purposes. At a distance of one mile up the lake from the town, the banks rise quite rapidly, so that it was easy to get a suitable place for a reservoir at a short distance from the lake, and at an elevation that would give good pressure for fire purposes.

The plan adopted was to build a pump house on the shore, and extend an intake pipe out into the lake 550 feet; also to build a reservoir back 1800 feet from the shore and at an elevation of 320 feet above the surface of the lake.

Surveys, plans, specifications and estimates were made by the town engineer, estimating the entire cost for pumps, pump-house, reservoir, trenching, pipes, hydrants, etc., the whole system complete, at $60,000.

The elevation of the reservoir was such that ample pressure (90 lbs.) could be obtained in the higher parts of the town. The town was built on an incline, as is shown by the contour lines in the plan. (Plate No. I.)

The capacity of the reservoir was 1,000,000 gallons, which it was computed (in case of accident to the pumps) could be delivered to the centre of the town through the 12 inch pipe in 5 hours; this computation was made from the formulæ

$$q = av = 0 \cdot 7854\ d^2 \sqrt{\frac{2\,gh}{1 \cdot 5 + f\frac{l}{d}}}$$

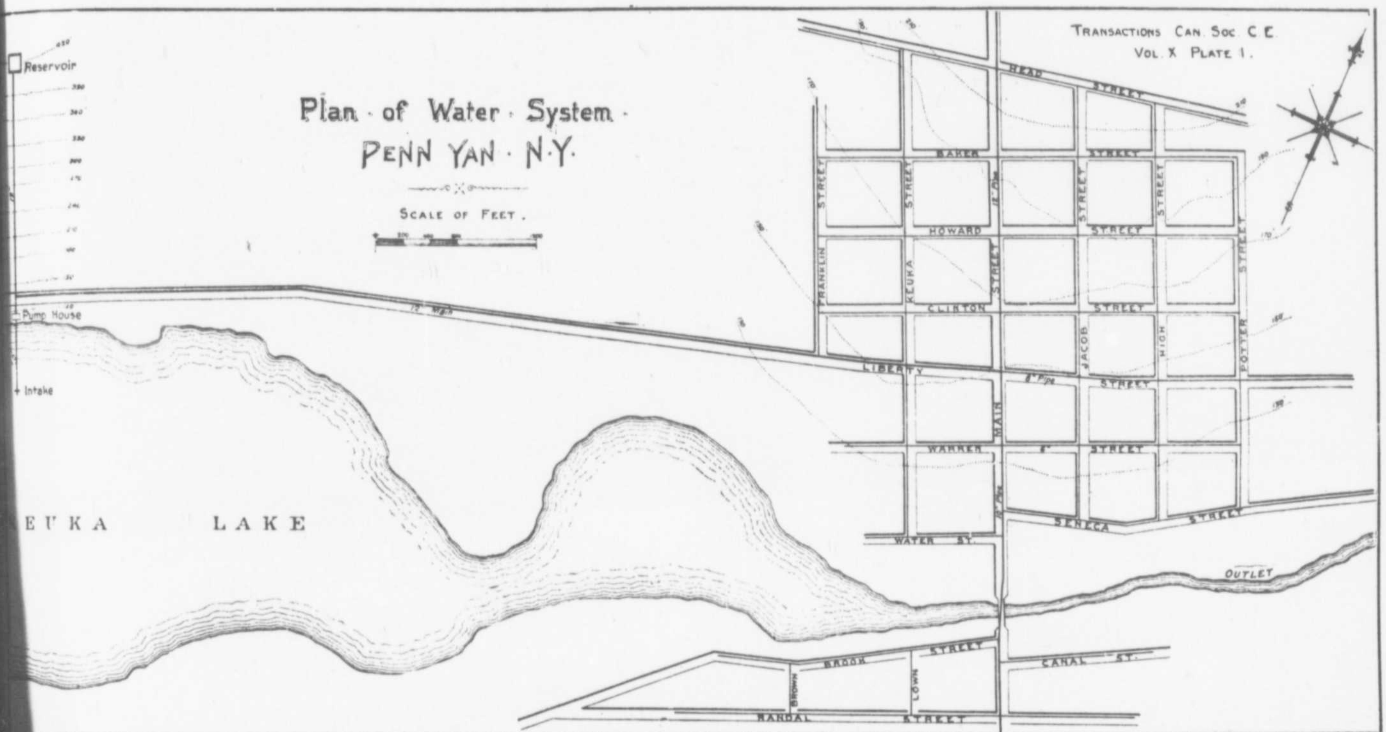
A 6 inch overflow pipe was put in the reservoir 2 feet from the top of wall, and conveyed the water 75 feet from the reservoir. This pipe was computed to carry off 850,000 gals. daily before the water would overflow the walls.

The following were some of the specifications :—The trenches were 5 feet deep, and, where possible, made in straight lines. They were kept dry and made wide enough that the laying and caulking could be properly done. Care was taken not to injure gas, water, or sewer pipes already laid. The boxes for stop gates were placed vertically over and around the top of the gate, and then surrounded for a thickness of about one foot with small loose stones or coarse gravel, which was carried up to within 20 inches of the grade of the street. Upon this mass of loose stone or gravel a sufficient amount of fine gravel was deposited to form a bed for the gate-box stone into which the jacket inclosing the upper portion of the box was suspended.

Each pipe, special casting, stop gate and hydrant was firmly supported and adjusted to the required alignment and grade by a wooden block and two wooden wedges, which were in general placed near the hubs of the pipe and fixtures. The blocks were of sound hemlock or oak, not less than 16 inches long, 3 inches thick, and 9 inches wide; the wedges were 10 inches long, 4 inches wide, and 3 inches thick. These blocks were evenly sawed, and remained under the pipe after refilling the trench.

The spigots were inserted into the hubs, so that the shoulder of the hub was in close contact with the face of the spigot, and were then adjusted by the wedges so as to give an even and uniform space all around


Pump



Plan · of Water · System ·
PENN YAN · N·Y·
SCALE OF FEET.
TRANSACTIONS CAN. SOC. C.E.
VOL. X PLATE 1.
Reservoir
Pump House
Intake
EUKA LAKE
HEAD STREET
BAKER STREET
HOWARD STREET
CLINTON STREET
LIBERTY STREET
WARREN STREET
SENECA STREET
WATER ST.
FRANKLIN STREET
KEUKA STREET
MAIN STREET
JACOB STREET
HIGH STREET
POTTER STREET
OUTLET
BROOK STREET
CANAL ST.
BROWN
LOWN
RANDAL STREET

coming up to

Surveys, plans, specifications and estimates were made by the town for the lead joints. Hemp yarn was securely driven into the joints, so as to leave $2\frac{1}{8}$ inches in depth and at least $\frac{5}{16}$ of an inch in thickness all around for the lead. The yarning and caulking was performed by faithful and competent mechanics. The cutting of the pipe was done by sharp cold chisels, the cut being first distinctly marked all around and then carefully followed by the chisels. The hydrants were set upon large wooden blocks bedded securely in the bottom of the trench, at such a depth that the top of the jacket surrounding the hydrant was about $1\frac{1}{2}$ inches above the sidewalk; the stop gates were also set firmly upon wooden blocks. Iron plugs and caps were leaded and caulked into the dead ends of the lateral pipes, and behind these plugs, rubble masonry was laid in cement, reaching from the plug to the end of the trench. The pipes were each 12 feet long. They were free from scoria, sand holes and air bubbles, and were clean in all respects. They had to pass a careful hammer inspection under the direction of the Engineer or his assistants, and thereafter were subjected to a proof test by water pressure of 300 lbs. to the sq. inch.

The pumping engines consisted of two duplex, compound, non-condensing engines, each capable of delivering 750,000 gals. daily at a piston speed of 100 feet per minute with 80 lbs. of steam. The floor of the engine room was 17 feet above the surface of the water in the lake.

The force main was 10 inches in diameter for a length of 200 feet, and 12 inches for the remaining 1600 feet to the reservoir. The surface of the reservoir was 300 feet above the engine room.

The boiler was of homogeneous steel in 3 courses, each course in one sheet $\frac{3}{8}$ of an inch thick and with a tensile strength of 60,000 lbs. per sqr. inch. The boiler was 14 feet long and 5 feet in diameter.

The intake pipe commenced 2 feet outside of the wall of the pump house, and for 150 feet consisted of 10 inch cast iron pipe weighing 50 pounds per lineal foot. Connecting with the lake end of this pipe were about 400 feet of standard wrought iron, lap-welded water pipe of 10 inch internal diameter and 0.366 of an inch in thickness of shell, with an average weight of 40 pounds per foot. This pipe was coated inside and outside with a coating similar to that used on the cast iron pipe. The pieces were screwed together into lengths of about 100 feet, and these lengths again connected by ball and socket joints, so as to admit of being deflected in any direction from the line of pipe, by at least 25°. The outer end of this pipe was connected to an appliance consisting of a pipe with laterals and three vertical bells coming up to within 8 feet of the surface of the water. Each of these bells had a diameter of 16 inches, and were protected by strainers. Over the pipe, near the intake, piles were driven and planks fastened to them, to make a platform, so that the intake could be lifted out of the water by means of the ball and socket joint, and the strainers examined at any time from the platform.

The reservoir was constructed 320 feet above the surface of the water in the lake. Its dimensions were 112 feet by 120 feet inside and 12 feet deep. It was impossible to get a plot of ground large enough, that was nearly level, so that the excavation was excessive. It amounted to about 11,500 cubic yards, and the last two feet were so hard as to almost resist the pick.

The walls were 12 feet deep, 6 feet wide at the bottom and 3 feet at the top; they were constructed of rubble masonry, laid in hydraulic cement. The masonry was composed of sound, well shaped and durable stone, found in the vicinity of Penn Yan. No stone was less than 5 inches nor more than 12 inches in thickness. They were laid in full beds of hydraulic cement mortar, composed of one part by measure of freshly burned Rosendale cement, mixed dry with two parts of clean sharp sand; afterwards, enough water was added to make the mortar work freely under the trowel, and into all interstices between the stones. The faces of the walls were made true and even by flushing and pointing the joints with mortar.

A bed of hydraulic cement concrete, one foot in thickness, was laid on the bottom of the reservoir, and extended one foot outside the walls all around. Under the gate chamber it had a depth of two feet. The concrete was made of one measure of hydraulic cement and two of clean, sharp sand, mixed dry, and afterwards enough water added to make a mortar. Broken stones, free from dust and dirt, and small enough to pass through a ring two inches in diameter, were incorporated with the mortar so as to give a surplus of mortar when rammed. The proportion not to exceed 1 of mortar to 2½ of broken stone, the concrete was laid in layers of 6 inches, and was expeditiously rammed and compacted.

The interior surfaces of the walls were plastered to a thickness of one inch from bottom to top with Portland cement mortar, composed of one part by measure of the best imported Portland cement and one part of clean, sharp sand.

The soil of Penn Yan is a sandy loam, so that no rock or hard pan was encountered.

There were 27,500 lineal feet of 4 inch pipe, 17,300 lineal feet of 6 inch pipe, 5,400 lineal feet of 8 inch pipe, 3,000 lineal feet of 10 inch pipe, and 7,500 lineal feet of 12 inch pipe, making a total length of 11.5 miles.

The weights per running foot of the cast-iron pipe, including hubs and spiggots, were as follows :—

150	net	tons	4	in.	c. i.	pipe,	20	lbs.	per ft.
170	"	"	4	"	"	"	22	"	" "
140	"	"	6	"	"	"	30	"	" "
100	"	"	6	"	"	"	33	"	" "
90	"	"	8	"	"	"	43	"	" "
120	"	"	10	"	"	"	65	"	" "
185	"	"	12	"	"	"	75	"	" "

There were also 15 net tons special castings, 85 double nozzle, 4 in. fire hydrants; 5 double nozzle fire hydrants, 6 in. connection; 10 three way fire hydrants with secondary gate, 6 in. connection.

41— 4	in.	gate	valves.
38— 6	"	"	"
15— 8	"	"	"
9—10	"	"	"
8—12	"	"	"

111 gate boxes and stones.

The two engines were built by Worthington, and had a capacity of 750,000 gallons per day. Non-condensing engines were used because, from all the figures attainable, there did not seem to be sufficient saving of fuel to warrant the additional cost of condensing engines. In larger sized engines there is of course no question about the advantage and economy of using condensers. There were two boilers made by Aimes.

The assessed value of property in Penn Yan was $1,800,000. The commissioners purposely avoided having a sinking fund, as they did not wish to have the care and responsibility of it. This they could not have avoided had they issued bonds to be sold in the open market. They borrowed from the Comptroller of the State, and are to make annual payments on the same.

Penn Yan has not as yet a sewerage system, although surveys were made for, one at the time of putting in the waterworks.

The entire system of waterworks proved very satisfactory when completed. The accompanying plan shows the relative position of the town, lake and reservoir.

DISCUSSION.

Mr. W. J. Sproule. Mr. Sproule said he would like to know if anyone present could give any information about the relative advantages of gas engines and steam engines for such conditions as existed at Penn Yan. Certain published statements showed that gas engines were more economical than steam engines at the present time, but the average engineer did not seem to be aware of that fact. He could get no satisfactory information on the subject.

Mr. H. Irwin. Mr. Irwin thought the question was one as to the cost of gas. The Dowson gas, which was used in a good many places where the gas was only for engines, reduced the cost of running the Otto gas engines about $1\frac{1}{2}$ cents per horse power per hour. He thought the engines described in the paper were intended to work continuously, while gas engines generally proved more economical in comparison with steam engines when used intermittently.

Prof. C. B Smith. Mr. Smith said there were one or two little points he would like to draw attention to. In one part of the paper the author has stated that a 6 inch overflow pipe was put in to carry 850,000 gallons daily, and in another that "the engines will both only pump 1,400,000 gallons per day." The overflow pipe was therefore much larger than was required. He thought that an objectionable feature of the work was the use of wood, especially in the case of the hydrant seats. Concrete would be about as cheap, and would last forever. He also observed that the author had not said anything about tamping around the pipes. He should have thought that when they were putting in $11\frac{1}{2}$ miles of pipe, they would have done it in such a manner that it would not have to be replaced very soon.

Mr. J.G. Kerry. Mr. Kerry did not think that Mr. Smith's objection as to the use of wood was well taken. All those small towns were rapidly growing, and they managed their municipal affairs in the least expensive way. The probability was that, before the wood, carefully covered as it was, had had time to rot, the pipe would have to be taken up and replaced by a larger one. In most of these small towns wood was used for these purposes.

Mr. H. Irwin. Mr. Irwin had noticed one method of work which did not seem to be good practice, that is, ramming the end of the spigot hard up against the inner end of the hubs, especially if the pipes were laid at a lower temperature than they were afterwards liable to reach on account of the relatively high temperature. He would like to know from the author when the work was done, and whether there had been any trouble from frost or heat, causing the masonry walls to crack from contraction and expansion. He would also like to know whether they built up earth at the back of the reservoir walls, and what section the walls had. He suggested that the author be asked to send sections of the wall, showing whether it was built on the side hill or exposed to the weather on the outside.

Mr. Smith said he would like to get some information about the relative duration of the wrought iron and cast iron pipe submerged in water, and whether the wrought iron was protected from rusting in the same way as the cast iron pipes were by a coat of tar asphalt. Prof. C. B. Smith.

Mr. Wallis observed that he would never think of using wrought iron pipe if he could get cast iron. The President.

Mr. Sproule noticed that they used a good deal of 4 inch pipes. He thought it was a great mistake to put in 4 inch pipes instead of 6 inch. Mr. W. J. Sproule.

Mr. Wallis was of opinion that the actual difference between the cost of 4 inch pipes and 6 inch was very trifling when compared with the advantage that was gained. The President.

Mr. Irwin remarked that 4 inch pipes could not be depended upon to give a good stream from hose in case of a large fire, and that he noticed that about 45 per cent. of the pipes were only 4 inch, the length being about $5\frac{1}{4}$ miles. A small amount of incrustation inside these small pipes would increase the annual cost of pumping considerably if proper pressure were maintained. Mr. H. Irwin.

CORRESPONDENCE.

Mr. H. J. Bowman.

Mr. Herbert J. Bowman stated that he considered it preferable not to have wooden blocks and wedges under water pipe in ordinary ground, and that tarred jute packing for the joints was better than hemp yarn, which rotted very quickly and might affect the water. The height of the floor of the engine room above the water of the lake, viz., 17 feet seemed excessive unless there were local circumstances requiring the pumps to be placed so high. The extent of the system of waterworks described seemed to indicate that at a cost of $60,000 good value had been received for the money. The price of pipe and some estimate on the cost of trenching would be interesting. The fact that the money was borrowed from the Comptroller of the State seemed to point out that there was some State legislation aiding the construction of waterworks, or that under the State laws ordinary bonds might have interest and sinking fund kept separate. Under Ontario law, bonds or debentures might be sold so as to be repaid in equal annual instalments of interest and principal, thus avoiding the care of a sinking fund, and towns in good financial standing could sell waterworks debentures at par when bearing 4 per cent. interest and running not longer than thirty years. It would be interesting to have further particulars of the Penn Yan bonds, as engineers should be able to state what the annual tax on a community would be to build waterworks, sewers, etc.

Mr. Angus Smith.

Mr. Smith in replying stated it was considered that coal would be cheaper delivered in Penn Yan at $2.30 per ton than gas, which would cost at least $1.75 per 1,000 cub. ft. It has never been necessary to run one of the pumps longer than 10 hours in any 24 hours, although there were 420 taps in use, and about 300 of them had lawn hydrants, and there was no restriction regarding their use for lawn and street sprinkling. If it were not for the lawn sprinkling it would never be required to run one of the pumps for more than 4 hours in any 24 hours. In the original plan there was a pipe running directly from the pump to the reservoir, and a pipe running from the reservoir down to near the pump house and thence on to supply the village. Mr. W. N. Wise, secretary of the Board of Water Commissioners, insisted that the second pipe was unnecessary, and after the plan had been submitted to a consulting engineer in Rochester, one of these pipes was erased from the plan, and the delivery pipe from the pump to the reservoir was fed into the main running to the town. He regretted that he did not mention this in the paper, as he would have liked to have had this feature of the plan discussed by the Society.

Regarding the overflow, it would be used in case the engineer neglected to shut down his pump in time, notwithstanding that the pressure gauge in the engine room showed where the water stood in the reservoir. Regarding the sinking fund, the commissioners (six of them) gave a note signed by themselves to the party from whom they borrowed the money, just as one individual would do with another. The note required that they should pay a certain sum on every 1st of January after four years; these sums were so arranged that the entire debt could be wiped out in thirty years.

The fact that they borrowed from the Comptroller had nothing to do with any special law in that State. It happened that the Comptroller had a certain amount from the school fund of the State of New York which he was permitted to use at his discretion, and he loaned it to this town, exactly as one individual might lend it to another. The corporation of Penn Yan borrowed about $60,000.00, agreeing to pay 3½ per cent. per annum.

At the time of laying the pipe it was thought that the proportion of 4 inch pipe used was less than that employed in older works. Owing to the great pressure, they anticipated no difficulty in getting sufficient water for fire purposes.

The reason the wrought iron pipe was used was because one of the commissioners insisted on it. He believed it would last at least twenty-five years, and that the contract for placing it in the lake could be let at a very much lower sum than a cast iron pipe, because twenty foot lengths could be screwed together on the shore and shoved out into the lake. The wrought iron pipe was coated in the same way as the cast iron pipe.

The walls were only exposed to the weather for perhaps 2 feet in some places. The hole for the reservoir was made in the side of the incline rising from the lake. On the upper side the top of the wall was almost flush with the surface of the ground, and the dirt thrown out formed a bank against the other sides of the reservoir.

The pipes were laid in July, August and September of 1894, and the works were finished in the fall of 1894. Neither heat nor frost has affected the masonry of the reservoir during or since its construction.

The cast iron pipe for this contract was sold at $18.85 per ton (2,000 lbs), delivered there on the cars.

The prices of the trenching were :

4″ at 13c, 6″ at 16c, 8″ at 19c, 10″ at 25c, 12″ at 28c.

The height of the engine room above the lake was decided upon, partly on account of the lay of the land and because the lake lowers and rises 8 feet from the highest to the lowest water.

The special act of the Legislature under which these works were built provides that any deficiency shall be raised by tax. At the end of the first year the deficiency was $1,200.00, and it was thought that it would not be necessary again to assess any taxes to meet either principal or interest.

There have been some breaks in the mains, which were supposed to have been due to air pockets forming at the high points in the pipes.

Thursday, 12th March.

Herbert Wallis, President, in the Chair.

The following candidates having been balloted for were declared duly elected as :

Associate Members.

Walter Joseph Francis, John Walter Harris.

Students.

William I. Bishop, Hamilton Lindsay.

The following were transferred from the class of Student to the class of Associate Member:

John Edward Schwitzer, Alexander W. Spence, Alfred James Stevens.

Paper No. 111.

EFFECTS OF ENGINEERING WORKS ON WATER CURRENTS.

By Cyrus Carroll, C.E., M.Can.Soc.C.E.

It is believed that in designing piers, abutments, breakwaters, wharves, and the like, too little attention is generally given to the effects such works are likely to produce by reason of their inducing currents or interfering with those already existing. We see fairly navigable rivers ruined for purposes of navigation by currents interfered with by costly works that have not fully answered the purpose intended. These failures very frequently result from ignoring certain fundamental laws that should guide us into working in harmony with the natural tendency of the elements we have to deal with. If at present a beach is forming, let us, if possible, in using it so manage as not to prevent it from continuing its formation. If a river enters a lake in a peculiar manner, beware of diverting it—rather assist it in keeping its normal course. In whatever way the bar across its mouth has been made, heightened and strengthened in one part so as to form a basin at the mouth of the river, by penning back its waters by the dam so made,—and in another part washed away to form a deeper channel for the river, the natural tendency of *the elements* is to continue such action and formation.

Does a current follow along the lake shore or meet a river-current in any prevailing manner: do not obstruct it very much if you would avoid shoaling water. Do not divert it without weighing well the effect such diversion may have on works already constructed or hereafter to be made in such locality.

In the case of rivers having one constant direction of current, resulting from gravity, it has been found that the planting of abutments on either side and piers in the stream will cause a washing away of the banks above such works—that is to say, on the up stream side. This is especially true of rivers of 50 to 100 yards in width, and having a rapid current. Such effects will be minimized by planting the abutments well back into the banks, and making piers as narrow as possible. Where timber is easily got, the writer has found it most economical to drive a single line of piles for each pier for common road bridges, then to frame a heavy cap on top, making it a bent in fact. The sides are planked up to above high water line, not only to keep out floating timber, but to serve as diagonal bracing as well.

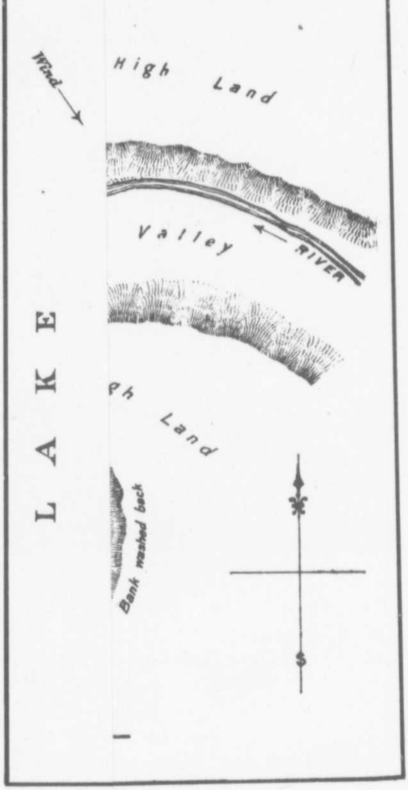
Where banks begin to wash away, it has been found that fine brush is generally the best and cheapest remedy. It should be secured by stakes or stone, or both, as the case may warrant.

In Lakes Huron and Erie the shore currents point down the lakes, in the direction of the natural flow of the water. This, it is thought, is a mere coincidence, as there is not enough of flow of water to make any appreciable current. The prevailing winds are no doubt the cause of the more constant currents along the shores.

In Fig. 1, Plate II, we have a very fair illustration of the mouths of the Rivers Saugeen, North Sables, Penetangore, Pine River, Maitland, Bayfield, South Sables and other rivers. By turning the same diagram as indicated by the dotted north point, it fairly represents Kettle Creek, Big Otter Creek, Little Otter Creek, Catfish Creek, and other rivers and streams flowing into Lake Erie. Long Point too bears down the lake.

It will be noticed that sand bars are formed across the ends of the river valleys, as the results of the opposing currents of rivers and lakes meeting, sometimes fairly and squarely, but generally at an angle, when they coalesce and form one current, the direction of which is determined by their relative forces after the manner of the polygon of forces.

RANSACTIONS CAN. SOC. C.E.
VOL. X. PLATE 2.



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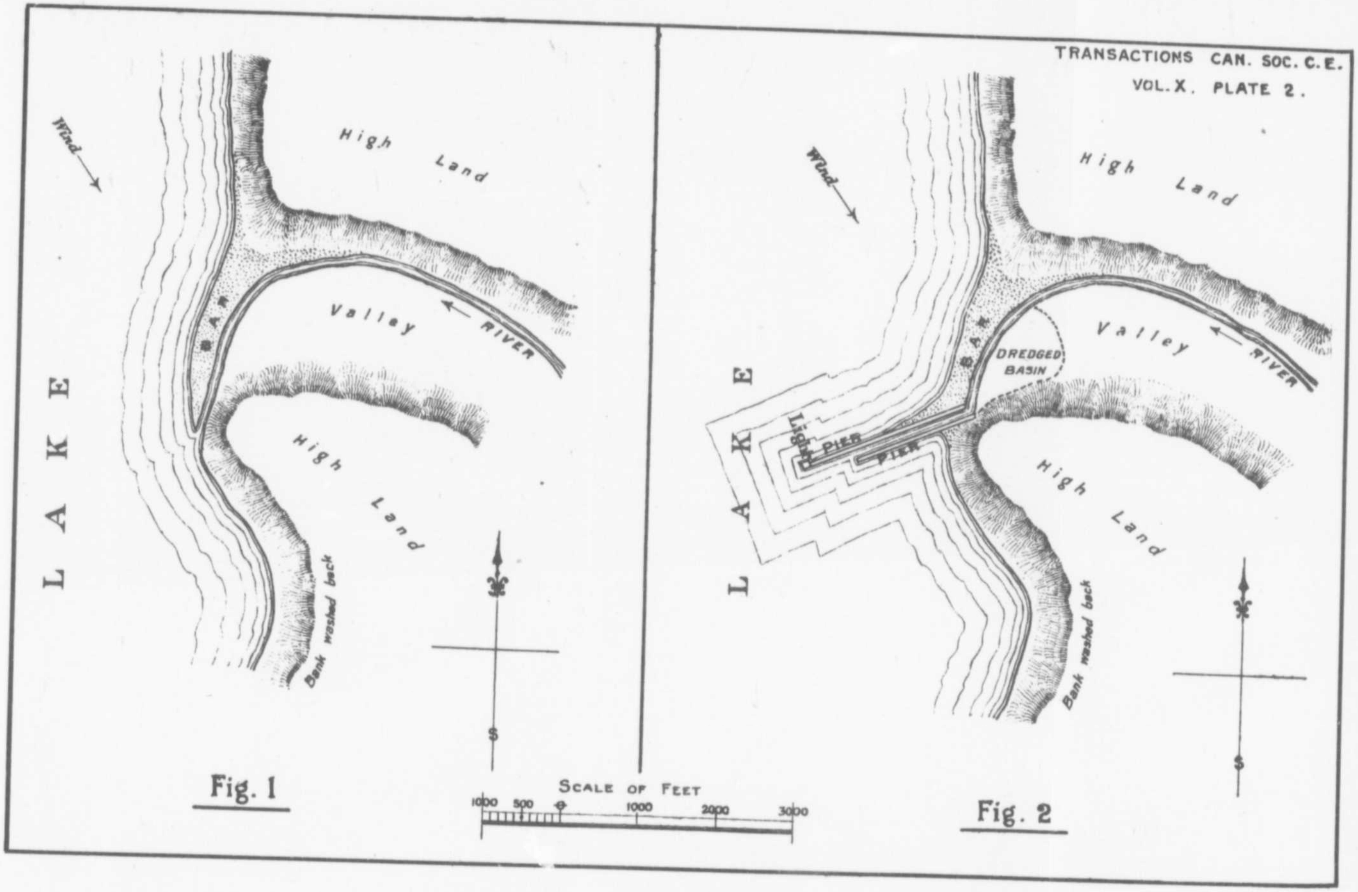
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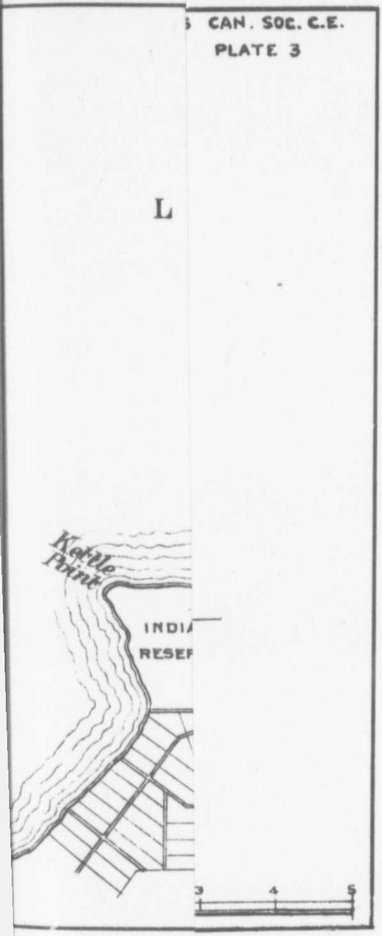

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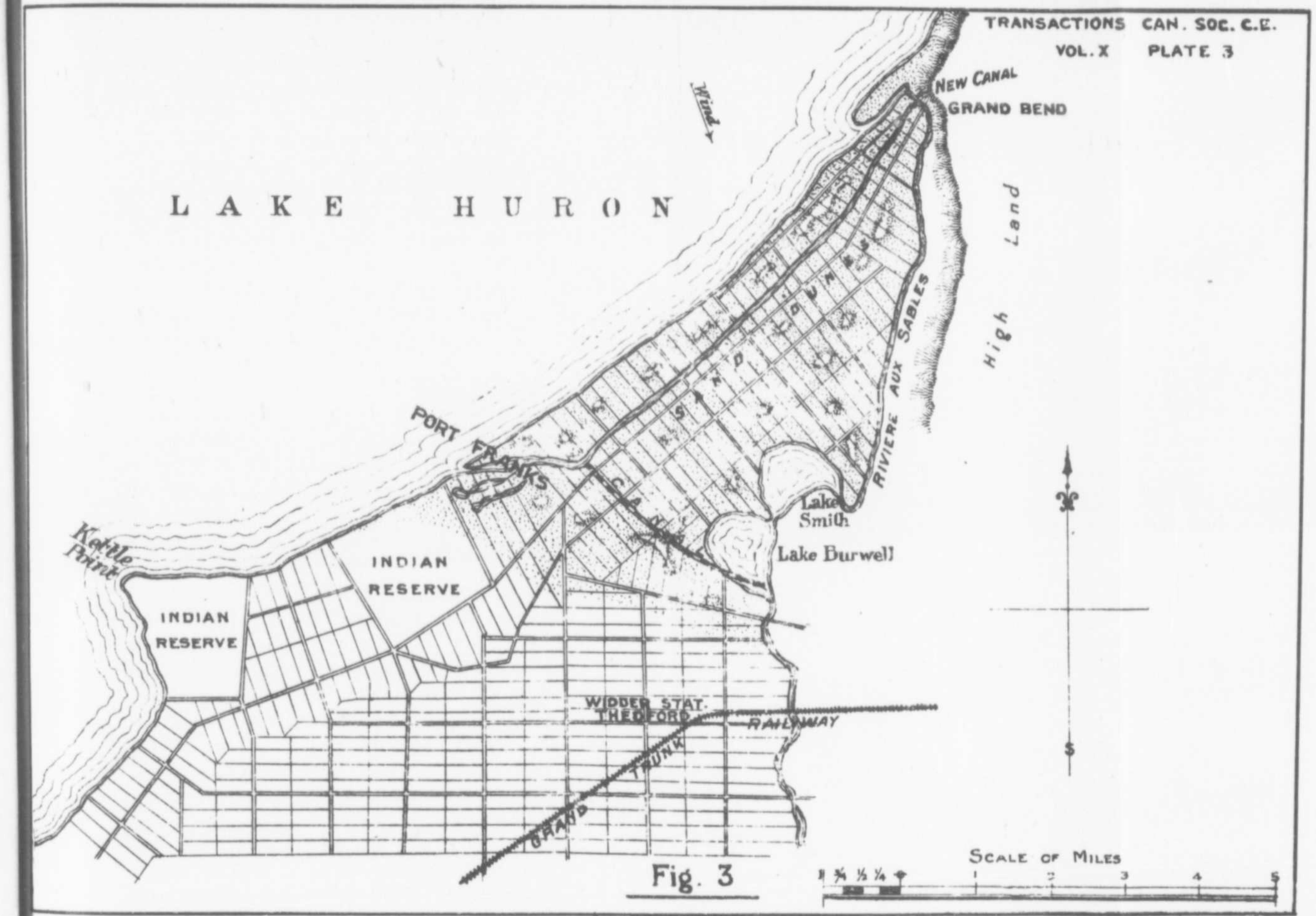

Fig. 3

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These sand bars begin at the windward side of the valley, and extend quite across, being crowded out into the lake water at the end, by the river current prevailing over the lake current at that point. The river too is crowded against its leeward bank, which is often very steep from being washed away at the base. As a result of such crowding of bar and river, the channel is often narrow and deep where it passes the bar. The bar or bank on the windward side is strengthened and re-enforced by the wash of lake silt up against it. On the river side of the basin the bar is strengthened by the silt of the river constantly being deposited. The river bank, or rather the lake bank, on the leeward side is generally washed away. This is particularly noticeable at Port Burwell and Port Stanley, where large areas of high table land have been washed away within the last fifty years.

In Fig. 2, Plate II, we see how some of these basins have been made to answer as harbours, after a fashion, as they could not always be entered during storms, though, as a general rule, any vessel making the lee side of the longer pier could in the stiller water move along into the harbour, or tie up to the pier. In case of very rough weather on Lakes Huron and Erie, vessels make for the large rivers at either end of such lakes, or seek the shelter of an island if near to one. Failing these, they anchor and endeavour to ride out the gale.

It is here submitted that the plan (Fig. 2, Plate II) is the best that can be adopted in utilizing at a moderate cost the mouths of rivers entering lakes. Where such works have not proved sufficient, it would be much the best and cheapest way to continue such works out into deeper water.

In no case is it advisable to close up the old channel and form a new one by cutting through the bar or beach. In Fig. 3, Plate III, we have an illustration of the effects of changing the channel of a river.

Lake Burwell, with its neighbour, Lake Smith, formerly portions of Lake Huron, have in comparatively recent times been cut off from that body of water and not yet filled up by sand dunes, have for their outlet the South Sables river. The sand dunes extend from the old shore of Lake Huron to its present shore, the distance between such old and new shores being at Port Franks about 4 miles. The river reached the lake by a very circuitous route. Lakes Burwell and Smith being first cut off by the dunes, the river flowed out northerly. The dunes about the lakes becoming higher and extending northerly by the action of Lake Huron, crowded the river up against the edge of the higher land. Thus was the line of the dunes extended northerly, and with it the channel of the river, till the nature of the shore at the Great Bend turned the river nearly due west. There the current of the lake opposed it from the north-west, and then a bar or beach began to form between the river and lake, crowding the river close up to and along the base of the dunes already formed. The beach extended several miles, as shown in the sketch. Had the river not been interfered with, the beach would in time doubtless have reached Kettle Point, where, from the nature of the bottom, the formation of the beach and of the dunes must have ceased.

In the sketch (Fig. 3, Plate III) it will be noticed there are a few sections of old channel not yet filled up. The river must have been obstructed here at different times from natural causes—new mouths made and old ones closed.

From Grand Bend to Port Franks the course of the river shows that it followed along the base of the dunes that had been previously formed. In 1872 a contract was let for the excavation of the Lake Burwell canal. The canal was intended to act as a drain, to reclaim 16,000 acres of land, which at $5 per acre would amount to $80,000.

The cost of the canal was about $80,000, but the result was very disappointing. Land was benefited to some extent, but not reclaimed. Only 1000 acres of the benefited lands have been sold. The canal began at 1½ miles east of Lake Burwell, bottom width 30 feet, side slopes 1½ to 1, average depth about 6 feet in clay and vegetable matter. About one mile of the canal through Lake Burwell in water and soft mud. Then west of Lake Burwell, through two ridges of 65 and 75 feet elevation, and generally about 30 feet of elevation for the distance of 1¼ miles to the Sables River, where the canal ended. The author has been unable to learn how the excavation was done, but thinks it was probably by tram-cars and dredge. Lake Burwell was about 4 feet above Lake Huron. As soon as a trench was made, the water rushed out with such force as in a short time to excavate a channel an eighth of a mile wide. The immense amount of sand carried out into the river stopped up the mouth, and a new mouth was formed farther to the north. Mouths were successively formed and closed in a retrograde manner,—that is to say, each new one to the north of that which had preceded it. The river channel from the canal forwards was continually choking, shifting and shoaling. A tug at the end of the canal could only get out to Lake Huron and back again by going backwards, so that the screw would scoop out the sand so as to leave a channel for it to float in.

There was a considerable amount of lumber produced at Port

Franks; also salt,—there being large salt works there. Since the canal was dug, the river has been useless for navigation, and these products have been carted four miles over the soft dunes to the Grand Trunk Railway.

The *regimen** of the river has been completely destroyed. No works of a permanent nature can be made at the lake shore or along the river. The damage resulting is not easy to compute in dollars and cents. Every year, and up to the present time, every freshet brings down a lot of sand for the river to work through and out of as it may. The narrowest part of the canal is 60 feet, its widest ¼ of a mile, and this through and amongst the highest of the dunes. Lake Burwell is nearly dry every summer. Lake Smith covers two-thirds of its former area.

From the Grand Bend, the old channel, deprived of its current and of carrying the water out of Lakes Burwell and Smith, filled up for a very considerable part of the distance between Grand Bend and Port Franks. On this portion so filled, the sands have been heaped up so that no trace of the former channel is visible. The lands near Grand Bend have become more flooded with water than ever.

In 1892 a new canal was cut through the beach at Grand Bend, at a cost of $21,500. It was to have a bottom width of 30 feet, slopes 1½ to 1. The general depth of the beach was 30 feet; length of canal ¼ of a mile. It was excavated as follows: top part by scrapers; then by spade, tram car, etc., till a small stream trickled through the trench. This soon washed out a channel nearly as required. The work was completed by a dredge worked in from Lake Huron through the beach, and thence where required, for several miles up the old channel of the river, in which it was at least once disabled by coming in contact with timber buried in the mud and sand. The flow of water has now made a channel out to the lake 100 to 200 yards in width. As might have been expected, a beach or bar at once began to form across the mouth of the canal from its north side. This is now rapidly extending southerly, and carrying the channel along the base of the old dunes, on the line that was the margin of Lake Huron previous to the building of this canal, with the beach between the channel and the lake almost parallel to the old channel of the river.

The lake bottom at Grand Bend being harder than it was farther south, the dunes were less there than they were farther to the south,

* The term "regimen" has for several years been used by the U. S. A. Engineers to express the natural and equable condition of a river such as it has acquired from natural causes and in a long period of time.

—where the soft nature of the lake bottom favoured their formation. Hence the waters penned back flowed out at Grand Bend, and scoured out a channel from that point to Lake Smith, through the soft material along that part of the river. But at Grand Bend a hard bank of clay with boulders was encountered, which turned the stream west or south of west. Here the beach began to form which crowded the old river up against the base of the dunes, and extended itself, carrying the river with it to and below Port Franks.

One of our learned Chief Justices has remarked, that the man who diverted a large river assumed an immense amount of responsibility. As the writer in 1885 stood on the bank of the canal 100 feet above the water, with the washed-out channel $\frac{1}{8}$ of a mile wide in front of him, he thought he could appreciate the force of the Judge's remark.

CORRESPONDENCE.

Prof. Butler said Mr. Carroll's paper suggested many interesting considerations. In some parts of Canada there were probably opportunities of obtaining very beneficial results by the judicious training of rivers and the direction and concentration of erosive power, which now was either dissipated and wasted, or which by its action led in some cases to very serious consequences. Prof. W. R. Butler.

This was particularly noticeable in many of the Bay of Fundy rivers, where expense was continually incurred in the digging out of berths for vessels, etc., the necessity of which might probably be avoided once for all by simple works having for their object the training of the current of the ebb tide. Cases were also of frequent occurrence, in which valuable tracts of reclaimed marsh land were endangered or destroyed for want of similar operations.

The diagrams accompanying Mr. Carroll's paper suggested that the bars at the mouths of the rivers referred to were principally due to wave action, the erosive action of the river current being overpowered and the current naturally diverted by the beach thrown up into a direction in which it received the greatest assistance possible from the littoral current; the deeper water thus produced in these cases upon what is termed the *leeward* lake bank leads to more destructive wave action.

If it was desired to maintain a basin in such a position as that marked "dredged basin" in diagram Plate No. 2 (the lines of the pier being as nearly normal to the shore line as could be admitted), might it not be worth considering whether it would be advantageous to train the portion of the river channel above this, by means of groynes or by training walls, into a direction more nearly in line with the piers, and thus to utilise the current as far as possible to assist in keeping open the dredged basin; the position of which, with respect to the course of the river channel, as indicated in the diagram, makes it the natural place of deposit of alluvial matter.

The hydraulic gradient would in such case become increased; and in addition to this a possibly dangerous scour at the shore ends of the piers would be avoided.

It might perhaps be expected that the diversion of the natural discharge into a course more nearly normal to the shore line would lead to a deposit of alluvium near the outer ends of the piers which would be beyond the power of the littoral current to disperse, and dredging might be necessary to prevent, as the ultimate total effect, a transfer to the pier head of conditions somewhat similar to those previously existing at its base.

In the case of the Lake Burwell Canal, it may be suggested that the silting up of the channel might possibly be much reduced, by confining it between training walls or by placing groynes at intervals nearly at right angles to the banks, and by thus confining the stream increasing the hydraulic mean depth, and consequently increasing its velocity and its erosive and transporting power.

Diagram No. 1 seemed to show in an interesting manner how in the cases of these rivers the current was only able to contend with the invasion of material due to the action of wind and water in virtue of this latter principle, as the stream seemed to retain its narrow width up to the point of its joining the littoral current.

In the case of Fort Franks, works might possibly have been designed having for their object the more rapid restoration of this "condition of equilibrium"; the upper reaches of the river or canal being trained as just now suggested, and the direction of final discharge being brought nearly into line with the littoral current.

Mr. Carroll in reply stated that he was very much pleased with Prof. Butler's remarks.

Where the direction of the river was nearly in line with the piers, it might be beneficial to confine it in a narrow channel so as to increase the current.

If a curve existed at the basin it would probably be difficult to so train the river as to make it flow in a straight line through the Harbor, and in the same straight line out between the piers.

The writer has not had experience with groynes in rivers, but thought that such would be of great benefit in the case of broad and shallow streams.

Groynes in lake waters have, so far as the writer knows, proved of no use in preventing the washing of banks by the littoral currents. It was true that the scouring action ceased for a time, but when the silt had filled in to the outer ends of the groynes, which it soon did, then the current carried the scour and deposited it much as it had done before. The suggestion as to the Lake Burwell Canal is a very good one.

In the case of Port Franks the suggestion is equally good. But since the opening of the channel into the lake at Grand Bend, so much water flowed out that way that there was not water enough left in the old canal to keep an open channel from it into the lake, no matter how trained.

The writer has felt himself hampered as to the freedom with which he desired to refer to works which have proved failures, but the ethics of the profession, written and unwritten, have prevented him from doing so.

Thursday, 12th March.

HERBERT WALLIS, President, in the Chair.

The discussion on the topical subject: "That engineering works shall be constructed by day's work, under the immediate supervision of a civil engineer, instead of being done through a contractor," occupied the evening.

Thursday, 9th April.

HERBERT WALLIS, President, in the Chair.

Paper No. 112.

THE DRY DOCK AT KINGSTON, ONTARIO.

By HENRY F. PERLEY, M.CAN.SOC.C.E.

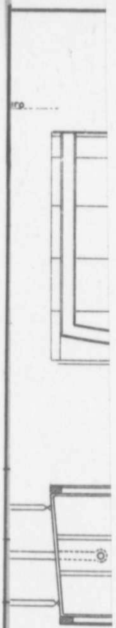
To provide for the repairing of craft on the Great Lakes, the Government of Canada in 1889 commenced the construction of a dry dock at Kingston, Ont., which was brought to completion in 1892, the plans and specifications for which, excepting the details of the pumping plant and engine house, were prepared by the writer.

After an examination of several sites had been made, that known as "Power's Ship Yard" fronting on the harbour was selected, and purchased on reasonable terms. In addition to the property thus acquired, the lower portion of Union street, which had been closed some years previously under an arrangement for the construction of a dry dock, was ceded by the City to the Crown, which thus became the possessor of a frontage of 400 ft. on the harbour, a frontage having deep water at but a little distance from the shore.

The site is situated between Gore and Union streets, having the shops of the Kingston Locomotive Works on one side, and those of the Kingston Foundry Company on the other.

When taken possession of, the site was encumbered with several buildings, the remains of an abandoned marine railway, an old wharf, and the work that had been executed on a proposed dry dock and abandoned, all of which had to be removed.

In determining the dimensions of the dock, it was judged that they should exceed by a small amount those of the locks on the Welland canal, so that any vessel which could pass through them could be admitted to the dock, and a length of 280 ft. on the floor and 48 ft. width of entrance were adopted. During construction, representations were made, that the width of the entrance was not sufficient to admit some paddle-wheel steamers plying on Lake Ontario, and it was increased to 55 ft., such change involving the widening of the body of the dock, increasing the size of the caisson and the dimensions of the caisson chamber.



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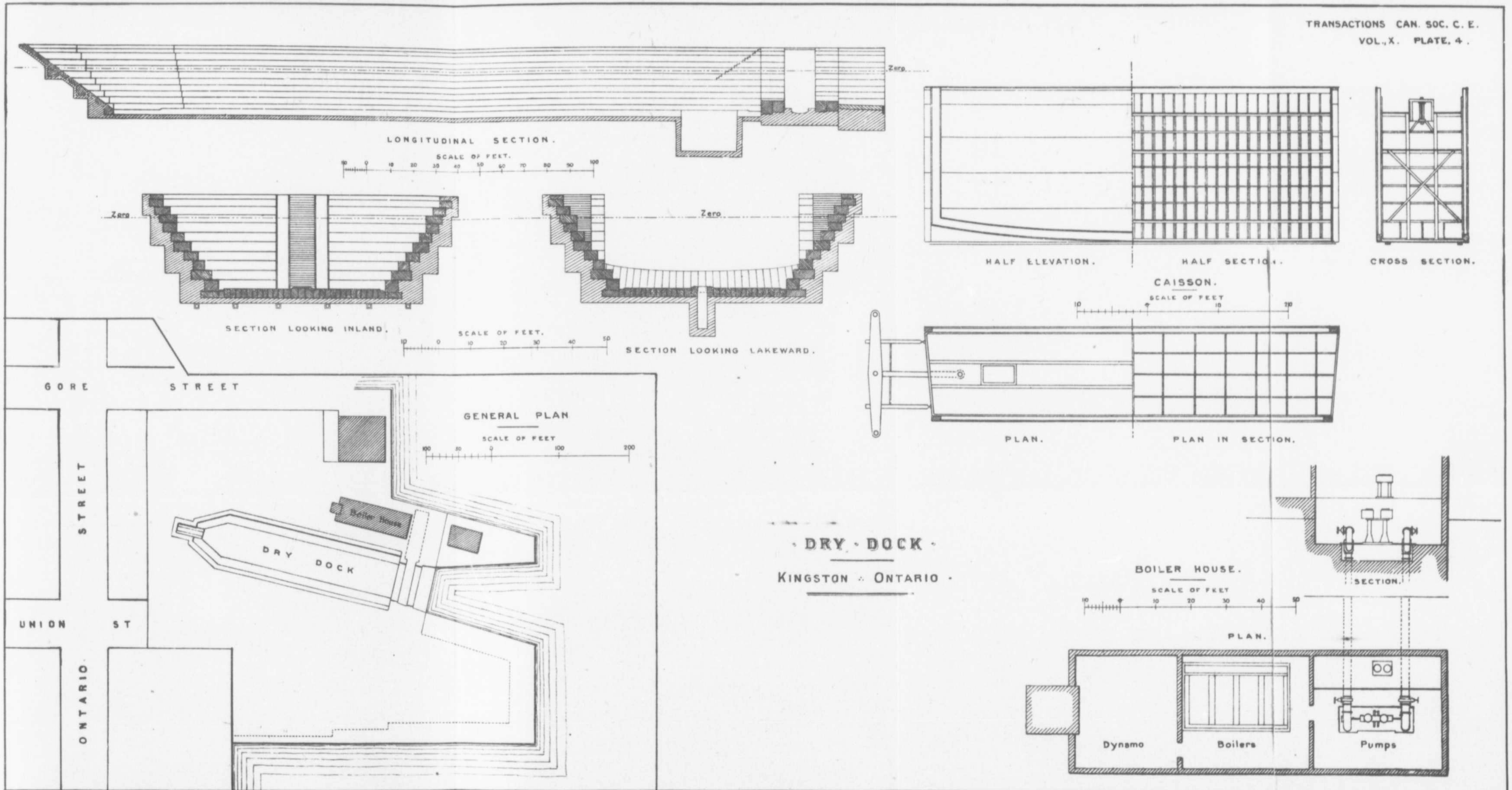


- DRY - DOCK -

KINGSTON - ONTARIO -

After cleaning the bottom in front of the site, an earthen coffer-dam was placed, the material (clay) composing it being obtained from the channel of the Cataraqui through the marsh above the highway bridge. This dam failed when the work was about one-third completed, but the break was easily filled and the work resumed.

The dock is built of limestone obtained from quarries at Belleville, and fully up to the requirements of the specification, which demanded that the ashlar in the altars, except in two instances, should be built of stones 2 ft. 8 ins. in height. As stretchers could not be less than 4 ft. in length with a bed not less in width than 1½ times the rise, the smallest stone that could be used weighed over three tons. The coursing of the sidewalls was carried through the body of the work, the whole with ¼ in. joints, and dressed with the fine end of a Bouchard hammer. The backing consisted of large and well-shaped stones of such thickness, that *two* courses were equal to *one* course of face-work. The floor was of stone, the central 6 ft. carrying the keel-blocks being raised 6 ins. above the dock bottom. The foundation of the engine house, chimney and machinery were carried up from the rock, and the floors paved with stone.

A quantity of concrete was used, composed of 6 parts of broken stone, 1 part clean, sharp sand, and 1 part of Portland cement.

The whole of the masonry was laid in a compound of *one* of Portland cement to *two* of sand, mixed and used as required, each course being grouted up and filled full with the compound. All joints were lipped for 4 ins. from the face with a compound of 1 of cement to 1 of sand, and neatly pointed and finished off when green.

Only Portland cement was used in the work, and a constant testing was carried on during construction. Samples were taken from every *tenth* barrel as delivered, and tested for fineness by the whole sample passing through a 2,500 sieve. Briquettes of neat cement, after remaining for twelve hours in the air and seven clear days in water, gave an average tensile strength of 445 lbs. per square inch.

The quoins of the outer face of the inner invert and side walls were of grey granite, all remaining stones in the invert being of limestone. The granite and limestone quoins facing on the caisson berth, and of the walls on either side, were worked with a projection of ¾ in., and a full width of 12 ins., and set absolutely perpendicular and in a true plane, the faces being finely axed and rubbed down, for on these meeting faces depended the tightness with which the caisson fitted, thus preventing leakage when the dock was empty.

An extension of the caisson-berth forms a chamber into which the caisson is drawn to admit a vessel. Along each side of the bottom are heavy cast iron rollers placed at intervals, on which the caisson rests and travels when being moved.

The width of the inner invert is 55 ft., and of the outer invert 57 ft., this difference being necessary to permit the caisson being floated into its berth. They are built to a radius of 193 ft., and the stones forming them are cut with radial joints. The lowest point in the inverts is 15 ft. 6 ins. below zero, or the assumed average low water level of the lake, 22 ft. below coping level, and 4 ft. 6 ins. above the floor of the dock.

Outside the outer invert is an apron of stone 20 ft. in width, and 2 ft. lower than the centre of the invert, in which are placed granite blocks on which the caisson can rest if at any time it is found expedient or necessary to effect repairs in the caisson berth or chamber, or to dock a vessel longer than the floor of the dock, or, in other words, a vessel of 310 ft. in length.

Under the foundation of the dock bottom are arterial drains, by means of which the leakage from the lake is carried to and discharged by the auxiliary pump, when the dock is empty.

Access is had to the dock floor by steps on either side at the entrance end, and on either side of the timber slide at the head.

In the floor at the lake end is a rudder well, 24 ft. long, 3 ft. wide, and 12 ft. deep, which has proved of much service, as it permits an easy removal and replacing of a rudder.

Sixteen cast-iron mooring parts, set in and filled with concrete, are placed around the dock, together with six heavy, double purchase capstans. On the dock floor are cast-iron keel-blocks capped with hard wood, placed at intervals of 5 ft., and 32 bilge-blocks at 10 ft. centres, which are operated from the dock coping.

The dock is filled through a culvert 4 ft. in diameter, the mouth of which is outside the entrance works, and the discharge over the inner invert, the whole being submerged 6 ft. below zero, and controlled by a 4 ft. cast-iron valve. Provision has been made whereby, in an emergency, filling can take place through the emptying culvert, which is also 4 ft. in diameter and controlled by a valve. The caisson chamber and berth is connected by a 12 in. pipe with the auxiliary pump, so that either can be emptied in the event of the stop-logs being put in place.

The engine-house, which comprises an engine-room, boiler-room and dynamo room, is of stone. The chimney—also of stone, and 90 ft. in height—is placed partly within and partly without the building. Over the engine and the dynamo rooms the roof trusses are of wood, and over the boilers of iron, the party walls being carried up to the roof as a safeguard in the case of fire.

The major portion of the floor of the engine room is 6½ ft. below zero, or 13 ft. below coping level, and on it is placed the pumping plant, which consists of two vertical 18 ins. centrifugal pumps, one right-handed, the other left-handed, having discs 4 ft. 8 ins. in diameter, each operated by a vertical, high pressure engine, having cylinders 18 ins. in diameter, and a stroke of 18 ins. The pumps are connected directly with the engines and are in line; and by means of clutches they can be geared together so that *one* engine can drive both pumps, or an engine can drive the opposite pump.

The suction pipes, which are 22 ins. in diameter, are furnished with foot-valves, and are led through the engine room floor to the pumps, all joints being absolutely water-tight. The pumps discharge through 22 in. pipes, the centres of which are 9 ft. below coping level, or 2 ft. 6 ins. below zero, and when the lake is at that level, the pumps operate against a head of that height. To prevent inflow when the pumps are not in use and the dock is empty, each discharge pipe is provided with a 22 in. valve.

The auxiliary pump and engines are placed on the upper or higher portion of the engine room floor. This pump, which is an 8 in. horizontal centrifugal, has a maximum lift of 31 ft. 6 ins., and discharges 3 ft. above zero. It is operated by a pair of vertical, high pressure engines, having 12 in. cylinders and 12 in. stroke, which are also used to move, by means of intermediate gearing, the caisson into and out of place. On the lower floor of the engine room is a "Knowles" fire pump, the steam cylinder being 15 ins. and the water cylinder 10 ins. in diameter, both having a stroke of 21 ins. This pump can be used in the event of the auxiliary pump being disabled. A delivery pipe is carried to the outside of the building, having a proper cap for attaching four lines of 2½ in. fire hose.

A "Knowles" patent duplex boiler feed pump, with steam cylinder 6 ins., and water cylinder 4 ins., and stroke 7 ins., is placed in the boiler room.

The boilers—four in number—are of the cylindrical, multi-tubular type, set in brick work, with all the fittings and appliances for their successful working. They are 14 ft. long and 5½ ft. in diameter, each containing 84 No. 9 W. G. lap welded charcoal iron tubes, $3\frac{1}{2}$ ins. external diameter, and furnished with domes 3 ft. high and $2\frac{1}{2}$ ft. diameter. The shells and ends are of $\frac{3}{8}$ steel, the longitudinal seams being lapped and double rivetted, the circumferential seams lapped and single rivetted. Before acceptance they were subjected to a cold water test of 180 lbs. per square inch, the working pressure being set at 100 lbs. Two of these boilers supply steam enough for the main engines. The smoke flue runs along the front end of the boilers, where connection is made with the uptakes, and is carried to and through the party wall of the dynamo room, when it is led downwards and under the floor to the chimney.

A boiler of the drop flue type, 9 ft. high and 4 ft. in diameter, with 250, $1\frac{1}{4}$ ins. by 18 ins. flues, with circulating tubes, is placed in a corner of the boiler room, and supplies steam to the auxiliary engines which can also take steam from the main boilers.

A travelling crane to lift 3 tons has been placed in the engine room, and with it any part of the engines or pumps can be handled for repairs.

The dock is closed by a caisson, built of steel, which may be described as an irregular rectangular box with parallel sides and inclined ends, measuring 57 ft. in length on the inner face and 59 ft. on the outer; 11 ft. 10 ins. in width and 21 ft. 6 ins. in height. Two keels, 4 inches by 8 inches, run the whole length of the bottom, on the outer edges of which are inserted at regular intervals 4 by $4\frac{1}{2}$ ins. shear steel bars, properly bent, their places in the keels being truly planed to the required curvature. The keels rest on the rollers in the caisson berth and chamber, and the curved bars, which project somewhat beyond the sides of the keels, are for the purpose of preserving the parallelism of the caisson while being moved. The lower 3 ft. is of cellular construction for strength and stiffness, and composed of $\frac{1}{2}$ in. plates and $3 \times 3 \times \frac{3}{8}$ ins. angles. All angles for the sides and ends are $3 \times 3 \times \frac{1}{2}$ in., and for the reverse bars $3 \times 3 \times \frac{3}{8}$ in. The cross-beams up to the lower dock are $4 \times 4 \times \frac{1}{2}$ in. angles, and above $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{1}{2}$ in. Under the lower and upper floors, Z beams $5 \times 3\frac{1}{16} \times 2\frac{3}{4} \times \frac{1}{2}$ in. were used. The upright posts are $6 \times 3 \times \frac{3}{8}$ in. channels, and the diagonal braces, $4 \times 3 \times \frac{1}{2}$ in. angles. The plates in the bottom and first row on the sides and ends are $\frac{1}{2}$ in. in thickness, and those above diminish to $\frac{1}{4}$ in. in the top plate, which is finished with a $9 \times \frac{3}{8}$ in. bulb. The floor plates are $\frac{1}{2}$ in. in thickness. All outside plates were planed on their edges, and lapped $2\frac{1}{2}$ ins. in the work, and were single rivetted. Where required, filling pieces were placed between the plates and the frames, to make up for the difference in the thickness of the plates, and voids between the plates and the frames.

For the movement of the caisson a hauling bar 13 ft. 4 ins. in length is connected by means of a 4 in. pin, the outer end projecting 7 ft. 9 ins., and carrying a yoke 17 ft. 8 ins. in length attached by a 4 in. pin, the outer ends being supported by two hinged brackets coupled with parallel motion bars.

For ballasting purposes, two 6 in. sluice valves are placed in the outer face above the line of the upper floor, to which are attached 6 in. cast iron pipes leading to within 4½ ft. of the bottom. At the bottom of the inside face a 4 in. valve is placed to drain the caisson when the dock is empty; and the caisson can also be emptied by a No. 5 pulsometer.

The cellular bottom is filled with concrete, and the further permanent ballast is supplied by the requisite amount of stone.

On the outer faces are rivetted 6 × 6 × ½ in. angles, which carry the white oak meeting faces, which are secured in place by ¾ in. bolts.

The caisson weighs 255,000 lbs., and when the lake is at zero its displacement is 358 net tons. It is moved into and out of place by wire ropes, which pass over traversing grooved wheels secured to the masonry at the dock end of the chamber, and over spirally grooved drums keyed on a horizontal shaft at the head, which is actuated by the auxiliary engines.

The dock at zero contains 2,100,000 gallons of water when unoccupied by a vessel, and can then be emptied in 75 minutes, the pumps and engines making 175 revolutions per minute, each pump thus throwing 14,000 gallons per minute. Through the filling culvert the dock can be filled in 55 minutes.

A large portion of the dock property as it stands to-day is made ground, the area being enclosed by crib-wharfing of the usual type, and filled with the materials excavated in grading the site, and from the dock pit.

The cost of the dock may be placed as follows:—

Land	$ 20,000.00
Dock proper	365,000.00
Pumps, engines, etc.	26,000.00
Engine house	26,000.00
Caisson	18,000.00
Engineering and contingencies	42,000.00
Total	$497,000.00

DISCUSSION.

Mr. H. F. Perley. Mr. Perley, in reply to questions which had been asked, stated that the dock was founded entirely on rock, and no piles were used in its construction.

Only a comparatively small quantity of concrete was used—principally under the floor of the dock, where the thickness averaged 18 inches, and in places where it was desirable to equalize the roughness of the bottom and make an even foundation for the masonry.

The projection downwards in the longitudinal section, and the section looking lakeward, represents the position, etc., of the rudder wall.

A plan of the coffer dam cannot be furnished, as there was not any in existence. According to the specification the dam was to have been either a crib-work or a pile structure. After the commencement of the work it was proposed to substitute a dam of clay enclosing the area required, as piles could not be driven, and there might be a difficulty in maintaining a tight joint under a crib work structure. Clay was therefore dumped into the lake and carried up 4 or 5 ft. above zero.

The failure alluded to was caused by the washing away, during a storm, of the dam at a weak point at water level where settlement had taken place, thus making a gap through which the lake water flowed. A few sheet-piles, and a small quantity of clay stopped the breach, and the dam, thus repaired, remained intact until the work was completed.

Thursday, 23rd April.

HERBERT WALLIS, President, in the Chair.

The discussion on Mr. Perley's paper on the "Dry Dock at Kingston, Ont.," and on Mr. Carroll's paper on "The Effects of Engineering Works on Water Currents," occupied the evening.

Thursday, 7th May.

HERBERT WALLIS, President, in the Chair.

Paper No. 113.

THE SEWERAGE OF VICTORIA, B. C.

By E. MOHUN, M.CAN.SOC.C.E.

For over a quarter of a century after the capital of the Province of British Columbia had been laid out as a city, its inhabitants either failed to see the need of, or to provide for, a system of sewerage.

Without the commonest precautions having been taken to guard the public health, the death rate was not excessive, and it was thought that the comparative immunity from epidemic disease was to a great extent attributable to the favoured situation, and the purifying influence of the sea breeze, which almost invariably prevails for several hours each day. This fortunate state of things could not naturally last for an indefinite period; and as the soil became contaminated, and the waters of the harbour polluted by a constantly increasing deposit of filth, a demand arose for the construction of sewers, and for the maintenance of the waters of the harbour in a reasonably pure condition. From 1885 to 1889 this demand occupied the attention of successive City Councils.

On two occasions by-laws were submitted to the ratepayers for the purpose of providing funds to build a combined system, but failed to receive the assent of the property owners. The author, with others, was opposed to the introduction of the combined system; firstly, because the site of the city, nearly surrounded by salt water, and sloping easily towards it, offered ample facilities for the discharge of surface water by its natural channels; secondly, because during the summer months the rainfall is so light that the sewers would not receive sufficient water to render them self-cleansing; and thirdly, because the expense of construction would be enormous if not prohibitive.

With reference to the rainfall the following figures for the summer months, during a period of sixteen years, have been obtained from the observations taken at Esquimalt from 1874 to 1879 and at Victoria from 1879 to 1889.

Month.	Highest.	Lowest.	Mean Annual.	No. of Years.
April	2.70	0.14	1.164	16
May	2.42	0.19	0.916	16
June	2.23	0.14	0.802	16
July	1.24	0.00	0.380	15
August	1.84	0.00	0.606	14
September	4.00	0.52	1.450	15

There appear to be no records for the months of July, August, and September, 1879, and August, 1878.

Considering that violent rainstorms are rare in Victoria during these months, and that the summer rainfall is generally made up of moderate showers at infrequent intervals, it is obvious that no useful supply from this source can be reckoned upon during the dry season.

The great cost involved in the construction of large brick sewers, as originally contemplated, in a country where very inferior brick for such a purpose had alone been produced, and where it was well known that a large proportion of the necessary excavation would require to be made in a very hard trap rock, proved a powerful argument in the hands of the opponents of the combined system.

In 1890 the Corporation called for competitive plans on the separate system, covering the area bounded by Cook street on the east, Bay street on the north, the waters of the harbour on the west, and the Straits of Fuca on the south. (See Plate 7.) In response nine sets of plans were received, two from England, two from New York, three from Ontario, and two from British Columbia. Mr. Rudolph Hering, M. Can. Soc. C. E., was selected by the Corporation to examine and report upon them, and it was the good fortune of the author to be awarded the premium, and the appointment of Chief Engineer, with Mr E. A. Wilmot, M. Can. Soc. C. E., as Resident Engineer.

In referring to this matter the author must admit that from his intimate personal knowledge of the locality and general conditions, he had a considerable advantage over his competitors; nevertheless, it was a great source of gratification to him to be permitted to inaugurate a system on the principles he had been advocating for several years.

The better to elucidate the succeeding remarks, it will not be out of place here to make a few statements as to the general design and its construction.

The egg-shaped sewers (Figs. 1, 2 and 3) were of concrete, the

FIG. 1

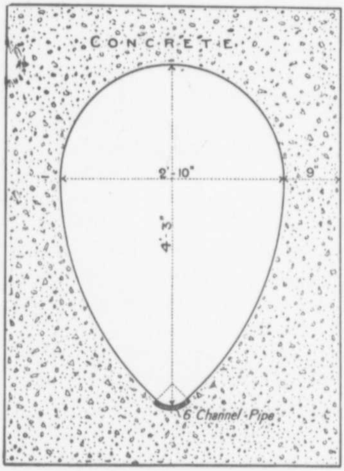


FIG. 2

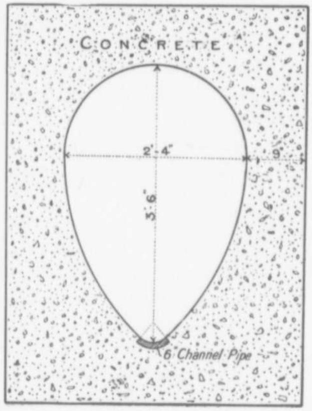
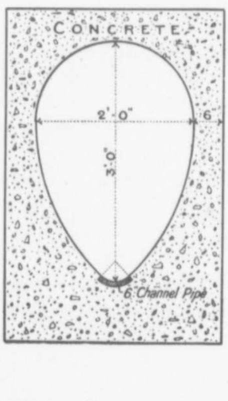


FIG. 3



smaller radius being in all cases three inches. A segment of a six inch pipe was laid in each to form the invert; this was found a very useful arrangement, saving the green concrete from erosion and affording a firm support for the centering of the arch. The pipes were the best quality of vitrified pipe, capable of standing all the usual tests. The joint was the well-known Stanford joint, and was cast on the pipes at the Corporation shed by the City workmen. The sewers were laid at sufficient depth to provide for the sewerage of basements.

The author proposed that, as the work proceeded, the house sewers should be laid as far as the curb, to avoid disturbing the street surface more than once; but although the matter was repeatedly brought to the notice of the City Council and invariably met with its approval, that august body as invariably failed to take the necessary steps to enable the recommendation to be carried out, and the suggestion was for all practical purposes ignored.

For the purpose of lowering the water table it was strongly recommended that drain tiles should be laid in the sewer trenches, and be provided with outlets at convenient points, of which there were many. This proposition the Council refused to entertain.

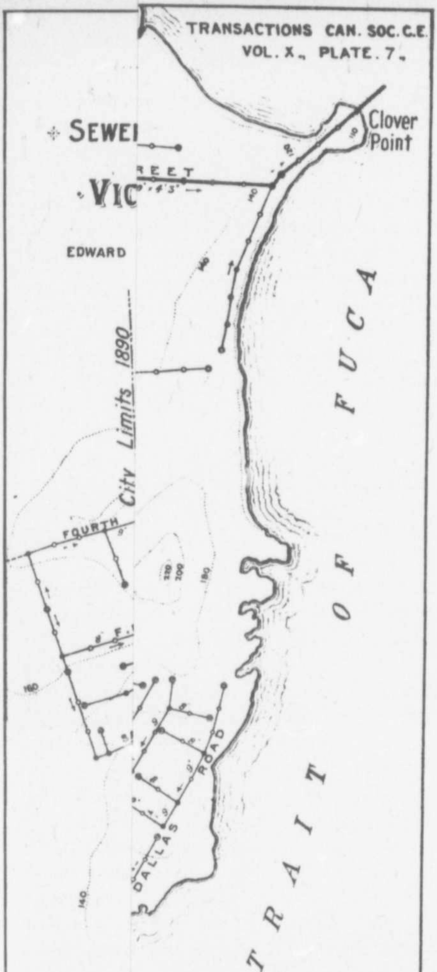
An important condition of the competition was that no sewage should be discharged into the harbour; and the author believes that his was the only design which entirely fulfilled that condition.

As a considerable portion of the suburb, locally known as "James Bay", lying to the westward of Beacon Hill Park, was not of an elevation to permit its drainage by gravitation except into the harbour, the sewage from that area was to be raised by Shone ejectors and discharged through steel rising mains into the system of sewers discharging by gravity. At the north end of Government street, and also near Point Ellice, are two low-lying areas, the sewage of which is to be similarly dealt with. With a view to the economical working of this part of the system, it was suggested that the compressors should be run in connection with the electric light plant owned by the Corporation. It is to be regretted that this suggestion has not been considered, although new electric light works have recently been erected by the City Council.

The flow of sewage to be provided for was estimated upon the following assumptions:

(*a*) That each individual represented a flow of five gallons an hour.

(*b*) That each house represented five individuals, or twenty-five gallons an hour.


TRANSACTIONS CAN. SOC. C.E.
VOL. X., PLATE. 7.
SEWEI
VIC
EDWARD
Clover
Point
City Limits 1890
FOURTH
DALLAS
ROAD
STRAIT OF FUCA
Manholes a
Ventilators
Flush Tanks
Ejectors
Rising Mai
SCALE OF FEET
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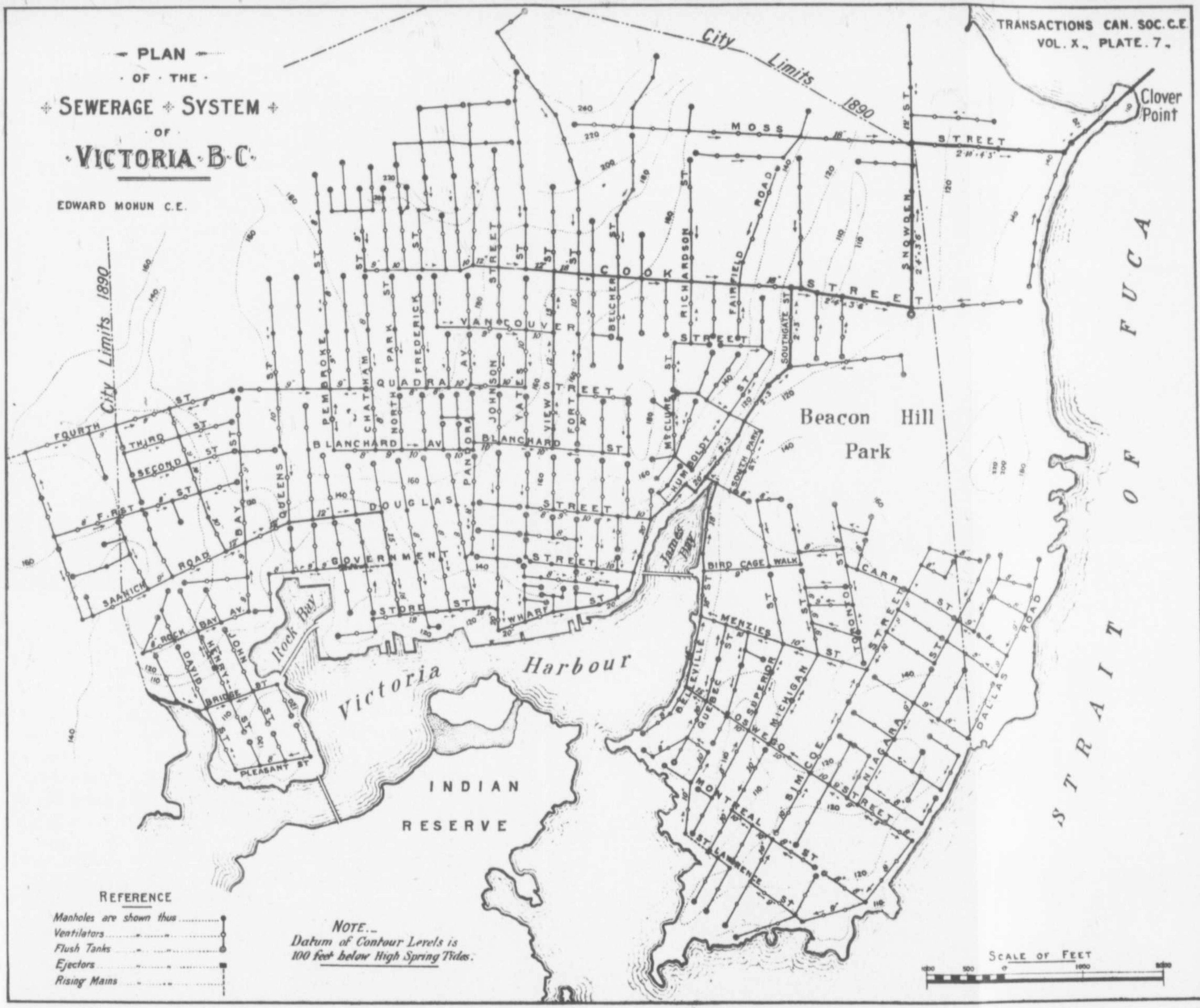

PLAN OF THE SEWERAGE SYSTEM OF VICTORIA B.C.
EDWARD MOHUN C.E.
TRANSACTIONS CAN. SOC. C.E.
VOL. X. PLATE. 7.
City Limits 1890
Clover Point
MOSS STREET
COOK STREET
VANCOUVER ST
QUADRA ST
BLANCHARD AV
DOUGLAS STREET
GOVERNMENT STREET
STORE ST
WHARF ST
FOURTH ST
THIRD ST
SECOND ST
FIRST ST
SAANICH ROAD
ROCK BAY AV
BAY ST
QUEENS
PEMBROKE ST
CHATHAM ST
NORTH PARK ST
FREDERICK ST
JOHNSON ST
YATES ST
VIEW ST
FORT ST
PANDORA
BELCHER ST
RICHARDSON ST
FAIRFIELD ROAD
SOUTHGATE ST
SNOWDEN ST
MCCLURE ST
HUMBOLDT ST
SOUTH PARK ST
DAVID ST
HENRY ST
JOHN ST
BRIDGE ST
PLEASANT ST
Rock Bay
James Bay
Victoria Harbour
INDIAN RESERVE
Beacon Hill Park
STRAIT OF FUCA
BIRD CAGE WALK
MENZIES ST
CARR ST
TORONTO ST
BELLEVILLE ST
QUEBEC ST
SUPERIOR ST
OSWEGO ST
MICHIGAN ST
SIMCOE ST
NIAGARA STREET
MONTREAL ST
ST LAWRENCE ST
DALLAS ROAD
REFERENCE
Manholes are shown thus
Ventilators
Flush Tanks
Ejectors
Rising Mains
NOTE.
Datum of Contour Levels is 100 feet below High Spring Tides.
SCALE OF FEET

(*c*) That each twenty-five feet of frontage in the closely built area, and each sixty feet of frontage in the residential, or suburban localities, represented a dwelling, or twenty-five gallons an hour.

A proportion of roof water was to be admitted to the sewers, particularly at their upper ends. It was proposed to provide automatic flush tanks at the head of each sewer; and the Doulton Syphon, which the author has used with success, was adopted. Man-holes and ventilators, which were also used as lamp-holes, provided for access, ventilation and inspection. The outlet works and the following lengths of sewers, viz:

2′ 10″ × 4′ 3″	concrete	sewer	3,290	lineal feet
2′ 4″ × 3′ 6″	"	"	3,414	" "
2′ 0″ × 3′ 0″	"	"	2,640	" "
20″	pipe	"	3,610	" "
18″	"	"	4,750	" "
15″	"	"	1,590	" "
12″	"	"	2,000	" "
10″	"	"	3,300	" "
9″	"	"	7,730	" "
8″	"	"	57,630	" "

together with 113 man-holes, 218 ventilators, and 66 flush tanks, were comprised in the first contract, which was let at schedule rates to Mr. Alexander McBean on the 20th December, 1890. Work was commenced by the contractor in the following March.

Prior to this, a by-law to raise the sum of $300,000 for sewerage purposes had been approved by the ratepayers after an opportunity had been afforded them of inspecting the general plan at the City Hall.

This by-law provided that three Commissioners, the Honourable J. H. Turner, now Premier of the Province, Messrs. Thos. Earle, M.P., and J. Teague, should have the sole control of the funds and the work. This proved to be a wise arrangement, as it prevented interference on the part of the Aldermen with the contractor. It is, however, a wonderful provision of nature that no sooner does the ordinary individual fill the office of Alderman than he becomes, in his own opinion at least, a thoroughly competent consulting engineer. With a few bright exceptions this was the case in Victoria. To the hearty co-operation and assistance which the author received from the Commissioners, is to be attributed the complete success attained.

The accompanying contour plan of the city (Plate 7) shows the sewers, manholes, ventilators, flush-tanks, ejectors, etc., and will probably afford a fair idea of the general scheme. The datum is 100 feet below high spring tides; the contours given are ten feet apart, the intermediate ones being omitted for the sake of greater clearness. It will be observed that the area has been divided into zones, each with its own main, but all converging to one outlet at Clover Point.

OUTLET WORKS.

At Clover Point the outlet sewer, 2′ 10″ × 4′ 3″ terminates in a concrete house (Plate 6), in which the sewage, after falling through a grating, is conveyed in a 22″ steel pipe and discharged at a point below L. W. M., distant 240 feet from the shore. There is also a 16″ steel overflow pipe, 120 feet long. Both these pipes are laid in and covered with concrete, the channel for them having been excavated in rock, as shown on the drawing.

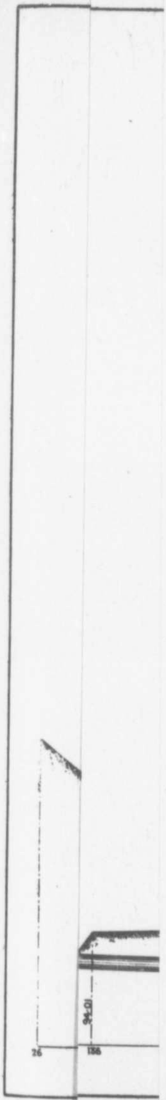
It was the intention to protect the outlet ends of these pipes with gratings, but when in 1892 the Municipal Council terminated the contract, subject to a six months' term of maintenance by the contractor, two lengths of the 22″ pipe still remained to be laid, and since then nothing has been done to complete this portion.

CONCRETE SEWERS.

Leaving the outlet and following the 2′ 10″ × 4′ 3″ sewer (Fig. 1) upwards for 696 feet, the south end of the Moss street tunnel is reached. This tunnel had eight shafts, now converted into man-holes and ventilators, and was 2,038 feet long with two curves. Of this distance 921 feet were in earth, 319 feet in hardpan, and 798 feet in rock. Its depth below the surface is from 20 to 50 feet. From the north end of the tunnel the same sized sewer is continued to the intersection of Moss and Snowden streets, where it is joined by an 18″ pipe from the east, and a 12″ from the north. The length of this sewer was 3,245 feet. At this point the sewer decreases to 2′ 4″ × 3′ 6″ (Fig. 2) and runs west to Cook street, where there is a large flush tank, thence it runs north to the intersection of Cook and Southgate streets; its length is 3,394 feet. Here it again decreases to a 2′ × 3′ (Fig. 3) and is continued westerly, partly along a right of way purchased by the City to McClure street, a distance of 2,605 feet. The fall in these sewers is 1 in 1200.

PIPE SEWERS.

At McClure street, the James Bay 18″ pipe and the Humboldt street 20″ pipe connect with the 2′ × 3′ sewers. The latter from east of Gordon street to the intersection of Fort and Wharf streets is laid in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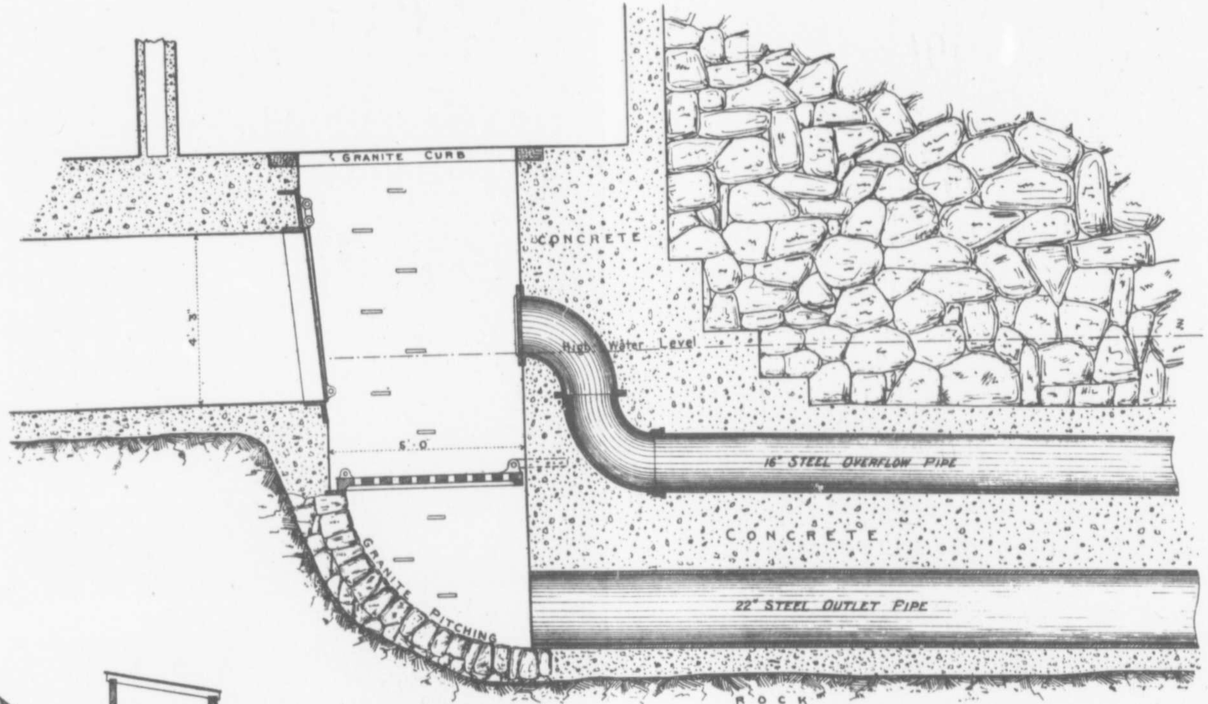
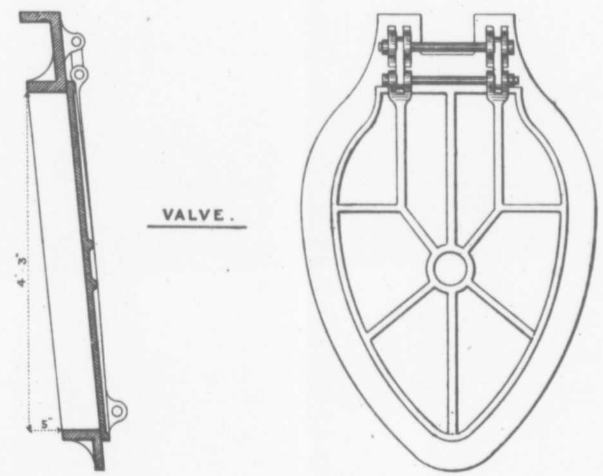
TRANSACTIONS CAN. SOC. C.E.
VOL. X. PLATE 6.

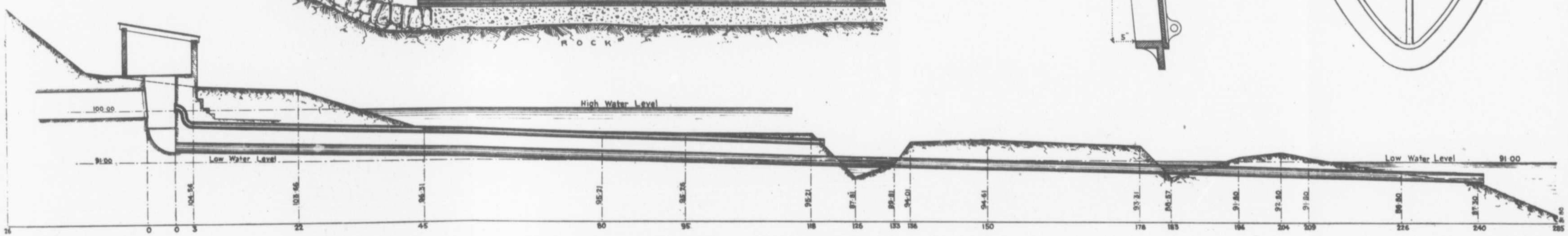
THE SEWERAGE OF VICTORIA B.C.

EDWARD MOHUN C.E.

OUTLET WORKS.







a continuous rock tunnel. This main is 3,837 feet long to the corner of Store and Johnson streets, where the Store and Johnson street mains connect with it. The 18″ Store street main is continued to the intersection of Chatham and Government streets, where the sewage from the low-lying area, before referred to, enters it. Beyond this again, the sewer is laid east and north, at various points receiving subsidiary mains, as shown on the plan. Returning to the intersection of Cook and Southgate streets an 18″ pipe has been laid on the former street to its intersection with View street; beyond this street it will be seen that several smaller mains and their branches are tributary to it. The residential district of James Bay south of the harbour is treated in a similar manner.

Considerable difficulty was experienced in the alignment of the pipe sewers; large fire tanks were found sometimes in the middle of the street, sometimes at the sides; water and gas pipes erratically wandered from side to side; old box drains, some running, some choked with filth, were continually encountered; blasting was frequently necessary within a few feet of these obstructions, and it speaks well for the care and vigilance exercised by the contractor that in no instance was any damage done to water or gas mains.

From the foregoing it is believed that a clear general idea of the work may be obtained, and it is thought that a few details as to construction and cost will prove of interest.

CONCRETE.

The principal quantity of concrete used was, of course, in the construction of the egg-shaped sewers and man-holes. This was in the proportion of $2\frac{1}{2}$ shingle, $2\frac{1}{2}$ sand, and 1 best English Portland cement. The shingle and sand were both from the sea beach, and were perfectly free from impurities. Very great care was exercised in mixing. On a roomy platform a rectangular frame, without top or bottom, was placed; in this was deposited $2\frac{1}{2}$ barrels of shingle, which was spread to an even depth; on this $2\frac{1}{2}$ barrels of sand were similarly spread, the two layers aggregating 6 inches in thickness; on top of the sand 1 barrel of cement was evenly spread, and the frame removed; the whole was then turned over with shovels two or three times while dry till thoroughly mixed, after which the turning was continued, while water was gradually added through a rose nozzle until a sufficient consistency was attained, when it was immediately wheeled into place, deposited on thin layers and immediately rammed. All surfaces unfinished at the close of the day were left rough and porous, and well grouted on the resumption of the work.

During the construction of the concrete sewers malicious reports were constantly being circulated to the effect that the sewers were leaky, that the grades ran in the wrong direction, etc.; yet, upon the completion of the work, when men were sent through for the special purpose of detecting any flaws, it was found that the sewer from invert to springing line was a monolith 9,244 feet long without crack or flaw. At the junction with the arch a few small leaks were discovered which were easily stopped with a little cement. As the ground water was higher than the crown of the sewer, it is thought impossible that a leak in the invert or sides should have remained undiscovered.

The method adopted in building the concrete sewers was as follows:—

In earth the trench was excavated four inches wider than the outer measurement of the sewer, and nine inches below the level of the invert, and the sides planked with two inch lumber. In fine sand a plank bottom nine inches below the invert was also placed. In rock or hard-pan the planking was altogether omitted, and the concrete was in this instance to be not less than 6 inches thick.

In the bottom of the trench the concrete was well rammed to a sufficient height to allow the channel pipe to be laid with absolute accuracy both as to grade and alignment. Lightly resting on the channel pipe, and secured to the planking on each side, moulds shaped to the lower section of the sewer were placed, and the concrete well rammed between them and the plank wall with a T headed iron having a slightly curved handle. These moulds were allowed to remain thirty-six hours; that is to say, the moulds placed on Monday would be removed on Wednesday, another set being used for Tuesday's work. Upon the removal of the moulds the surface was rendered perfectly smooth with two to one cement mortar, after which centres for the arch, resting on the channel pipe, were placed, and the top of the walls having been well grouted the work was carried on in a similar manner.

In order to give some employment to the Victoria brick-yards it was originally proposed to build the arch of radial brick, but the difficulty of obtaining thoroughly good material caused this plan to be abandoned, after between 1700 and 1800 feet of brick arch had been built, and concrete was substituted. As the work proceeded, water was pumped into the sewer to prevent the concrete drying too rapidly. The concretefor the man-holes was handled in a similar manner.

It may be stated that the man-holes and flush tanks were made rectangular to save the heavy carpenter's bill which would have been incurred in making oval or circular moulds, as many different ones would have been required, the man-holes varying much in size and shape, particularly on the main sewers. By using the rectangular form the frames of rough plank could be set by common labour, and, if not used again for the same purpose, could be utilized in timbering trenches, etc.

PIPE SEWERS.

In rock trenching the excavation was carried down 6 inches below the invert, and the bed brought to its true grade with 14 to 1 concrete. When unsound ground was found in the bottom of a trench, it was, with the exceptions hereafter noted, removed and replaced with 14 to 1 concrete.

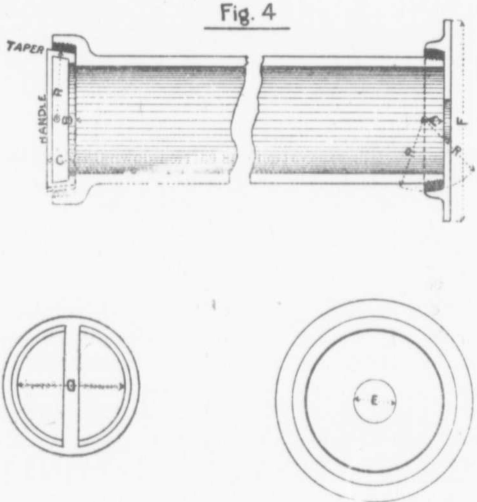
In 1890 a company was engaged in the vicinity of Victoria in the manufacture of drain pipes, etc., but at that date had not placed any sewer pipe on the market. This Company, however, contracted to supply the pipe required partly from its own works and partly from San Francisco. The pipes were delivered by the Company at the Corporation yard, when they were culled, tested, provided with the Stanford joint and delivered to the contractor's teams. To show the small probability of a defective pipe reaching the sewer, let us trace one through the ordinary course. Having been delivered at the yard it was accepted or rejected : if the former, it was stacked ; if the latter, it was carted away or broken up. Its next appearance was in the pipe shed, where the joint was cast on it, and if thought a little inferior it was placed on one side to be used in the ventilators, after which it would be ready for delivery to the contractor. On its arrival, at the trench it would be again examined by the inspector on duty before it was laid, and no pipe was laid except in the presence of an Inspector. It is confidently believed that there are no damaged pipes in the sewers, with the exception of a few slightly cracked large ones which, having retained their shape, the contractor was permitted to surround with concrete. (Trans. Can. Soc. C. E., Vol. VIII., Part I.)

THE STANFORD JOINT.

The Stanford joint (see Fig. 4) was first introduced by the author on the Pacific Coast eight years ago, in the Vancouver Sewerage System.

It consists of what is practically a ball and socket joint formed by castings, hereafter described, in the socket and upon the spigot.
figure 4 shows a pipe and moulds in position, the "compo" being represented in black.

Fig. 4



The moulds were made of cast iron, and the working surfaces were truly turned in the lathe. The socket joint was a taper, and the spigot joint spherical. The author furnished templates for these. The dimensions of the moulds were as follows, the letters at the heads of the columns referring to those in the figure :—

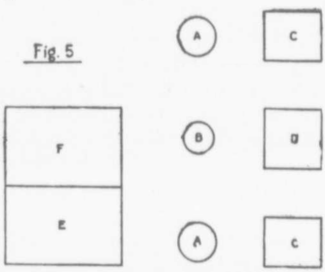
Diam. "	A "	B "	C "	D "	E "	F "	R "	Taper.
6	$1\frac{5}{16}$	$1\frac{1}{2}$	2	6	4	13	$3\frac{15}{16}$	1 in 10
8	$1\frac{3}{8}$	$1\frac{9}{16}$	$2\frac{1}{4}$	8	6	15	$5\frac{1}{8}$	1 in 10
9	$1\frac{3}{8}$	$1\frac{9}{16}$	$2\frac{1}{4}$	9	7	16	$5\frac{3}{8}$	1 in 10
10	$1\frac{1}{2}$	$1\frac{3}{4}$	$2\frac{1}{2}$	10	8	17	$6\frac{1}{4}$	1 in 10
12	$1\frac{1}{2}$	$1\frac{3}{4}$	$2\frac{5}{8}$	12	10	19	$7\frac{1}{4}$	1 in 12
15	$1\frac{5}{8}$	2	$2\frac{3}{4}$	$15\frac{5}{8}$	13	23	$9\frac{1}{8}$	1 in 12
18	$1\frac{3}{4}$	$2\frac{1}{8}$	3	$18\frac{1}{4}$	16	26	$10\frac{13}{16}$	1 in 14
20	2	$2\frac{1}{2}$	$3\frac{1}{4}$	$20\frac{3}{4}$	18	28	12	1 in 14

It must be remembered that these measurements were largely dependent upon the outer diameters of the spigots and the inner diameters of the sockets, the diameters of the latter exceeding those of the former, at the very least, by one inch. It was essential that both the spigots and the sockets should be rough, to enable the compo to firmly adhere to the pipes, which generally required chipping with a cold chisel to obtain this result.

The accuracy of the moulds was ascertained by casting a joint from them, and testing it under pressure.

Figure 5 shows the arrangements in the pipe shed. A_1 A_1 representing compo kettles; B a tar kettle; C_1 C_1 cast iron hot tables; and D a sheet iron tray for drying sand. Beneath each of these there was a gas jet; the gas under the hot tables and sand tray having been mainly used in cold and damp weather. E represents the surplus bin, and F the sand bin. This plant was equal to the requirements of two working gangs.

Fig. 5



The kettles for boiling the tar to evaporate the ammonia, and for melting the "compo" ready for casting, were heated by gas at a cost for each of about 13½ cents a day. The "compo" was made of crude rock sulphur, clean sharp sand (not sea), and coal tar. The proportions of the materials varied with the size of the pipe, a greater proportion of sand being used for the larger sizes than for the smaller. An average mixture would probably be about four of sulphur, six of sand, and one of tar by measure.

The men soon acquired the knack of mixing the compo. The sulphur was first melted, then the tar, and the sand was afterwards added. Care was necessary in regulating the heat and judging the amount of sand needed; if too much sand was used the compo became brittle, if too little it became too soft. After mixing, constant stirring was required.

At the commencement of the day's work the jets were lighted and the sulphur measured into the kettles. The moulds were placed on the hot tables to warm. One man watched and stirred the sulphur, while the others were engaged in sifting sand, chipping pipes, etc., until the compo was ready. The moulds were then wiped with an oily rag, a pipe adjusted as in the figure 4, and the joint cast. While the men were scraping off the surplus, which was returned to the kettle, the compo hardened and the pipe was ready for use. A little dry sand was kept inside the moulds to be used for stopping any leakage of the compo into the pipe.

In laying the pipe the joint was lightly covered with a mixture of tallow and resin, the spigot was inserted in the socket and driven home with a slight tap. It was necessary that both spigot and socket should be perfectly free from dirt and grit when the joint was made.

This form of joint permitted a deflection to a small extent, and no trouble was experienced in laying the pipes true to grade and alignment. The joint itself ensured that the pipes were concentric.

The cost, owing to various circumstances, proved larger than was anticipated, but the results have proved so satisfactory that the author would not hesitate to employ the same joint again. It must be remembered that the cost of laying is less than when a cement joint is used, that a defective pipe can be removed and replaced, or a junction substituted for a straight, or an absolutely water-tight joint made in a wet trench, or under water, with reasonable care, and with great rapidity.

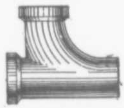
No separate account was kept of the time occupied in jointing and that spent in receiving, culling, testing, and delivering; but the author is under the impression that one-third of the cost of the yard may reasonably be deducted for the latter. Upon this basis the following would approximate the cost of jointing per lineal foot of pipe, viz. 8″, 6½ cents; 9″, 7½ cents; 10″, 8¼ cents; 12″, 10 cents; 15″, 12¼ cents; 18″, 15 cents; and 20″, 16½ cents. The contract prices for laying were 6 cents for 8″, 9″, 10″, 12″ and 15″, and 10 cents for 18″ and 20″ per lineal foot; these prices included loading, hauling, and unloading.

MAN-HOLES.

Man-holes have been placed at all junctions of sewers, and at all changes of direction, whether horizontal or vertical. In leading the subsidiary into the larger stream the former follows a curve, the radius of which is five times the diameter of the sewer, and the tangents of which are the directions of the two sewers. The invert of the smaller sewer is in all cases raised above that of the larger, and the fall is slightly increased on the curve to compensate for the increased friction. At the outlet of each man-hole flushing groove provides for the accumulation and instantaneous discharge of a considerable volume of water or sewage, should a flush be required. The inlets in man-holes are provided with vulcanite flap valves. All man-holes act as ventilators, being provided with perforated cast-iron covers, beneath which are suspended dirt trays. Through these covers access is obtained to the sewers, step irons of the usual description being built into the walls.

VENTILATORS.

FIG. 6.



The form of ventilators employed is shown in Fig. 6. These also act as lamp-holes, and are provided at not less distances than 300′. They consist simply of a vertical pipe, proportioned to the size of the sewer, but in no case less than eight inches in diameter. The pipe is surrounded by seven to one concrete, three feet square, the surface of which is one foot below the level of the street; on this stands a cast-iron curb, fitted with a perforated cover. The top of the pipe rises six inches above the concrete, and is protected by the unperforated part of the cover. Dirt falling through the cover drops upon the concrete, whence it is easily removed, while water drains off under the curb.

FLUSH TANKS.

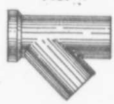
It will be remembered that provision was made for an automatic flush tank at the head of each sewer. Were the author in charge of the works at the present day it is probable that many of these tanks would be dispensed with as not vitally necessary to the efficiency of the sewers; at all events at points where the upper ends of the sewers could be connected with the hydrants. On this subject the reader is referred to a paper by Mr. Odell, published in Trans. Am. Soc. C. E., Volume 34, No. 3. The tanks, however, are economical in construction and in consumption of water, while from their position they benefit those portions of the sewer receiving but small and intermittent supplies of sewage.

One large flush tank has been constructed for flushing the egg-shaped sewers when necessary. It is furnished with an ordinary tilting flush gate having an area of 6½ square feet and discharging 2,800 gallons. If thought advisable this tank could be easily rendered automatic.

RAMP BREAKS.

When, as is frequently the case, the main sewers are considerably below the depth required for a branch, the latter has been laid at its proper depth and connected with the former by a ramp (Fig. 7).

FIG. 7.



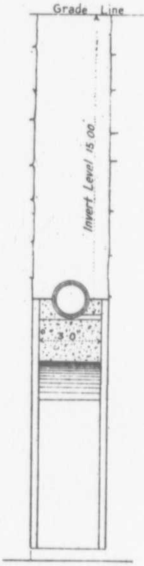
SPECIAL DIFFICULTIES.

In crossing the Johnson street ravine (Plate 5) on Store street, it was found that a hollow about 50 feet wide and 25 feet deep had been filled with earth and rubbish. It was considered advisable to carry the 18″ main across it on a concrete rib. Near the southern side of the ravine the filling was penetrated by an old brick culvert 3′ 4″ × 5′ 0″. The filling round this was removed and replaced by concrete forming the southern abutment 13′ long and 3′ wide; the northern abutment was 3′ 5″ long and of the same width. A central pier 6′ 6″ × 3′ divided the concrete rib (5 to 1) into two spans of 19′ 6″ each in the clear, having rises of 1-10th the spans. At the crown the thickness was 2′; on this the 18″ pipe was laid in 14 to 1 concrete, up to the haunch.

The centreing was made of 1″ plank sprung to the curve and securely spiked to cross scantlings affixed to the side planking of the trench.

The View street bog is a quaking peat morass about 700 feet long and 20 to 25 feet deep. This was crossed on piles driven in pairs supporting a plank floor on which the pipe was laid in concrete. At the end of the first three months a slight settlement, about 3½ inches, if the author's memory is correct, was found to have taken place; but as in the following six months no further change could be detected, and the lights in the lamp-holes could be seen from the man-holes, it was not thought necessary to take steps to bring it to its true grade.

The Snowden street sewer 2′ 4″ × 3′ 6″ passed through a water-charged running sand which necessitated lining the trench with plank floor and sides, and keeping a powerful centrifugal pump constantly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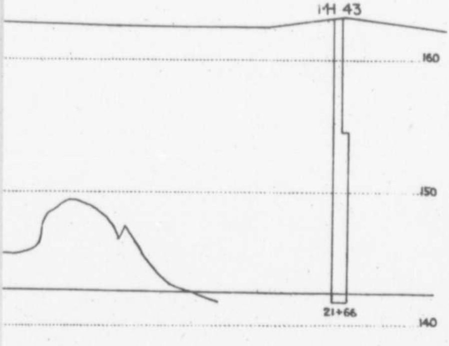
3.0

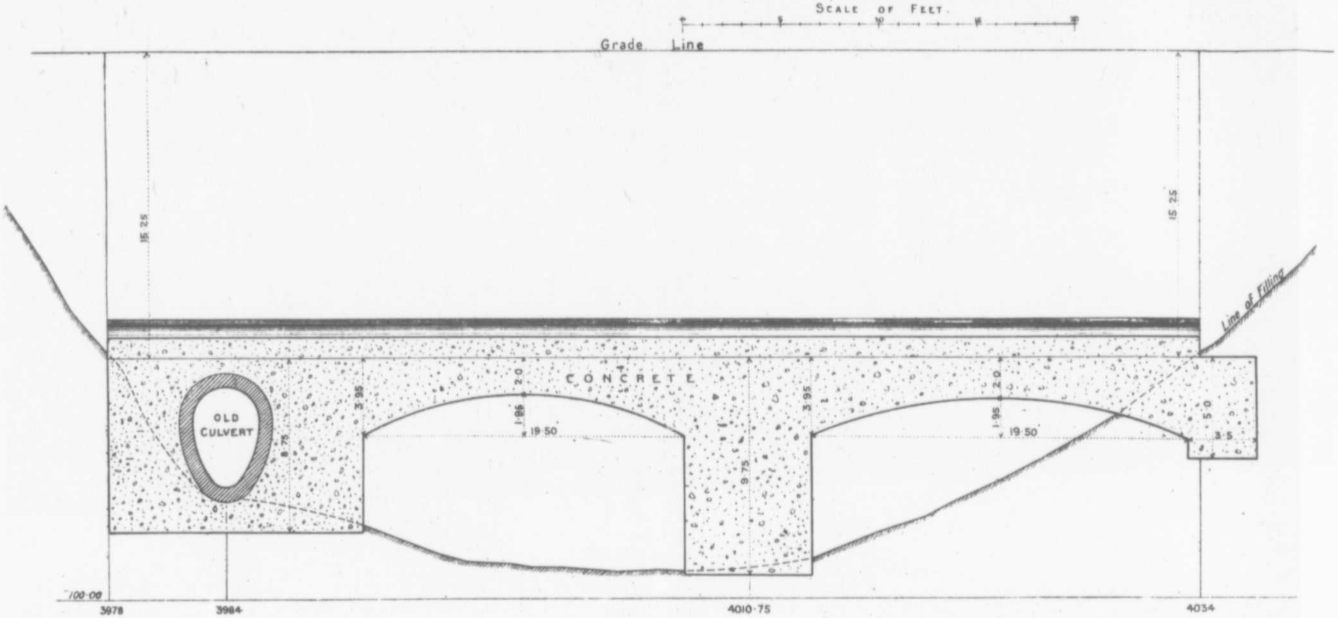

MH 43
160
150
21+66
140

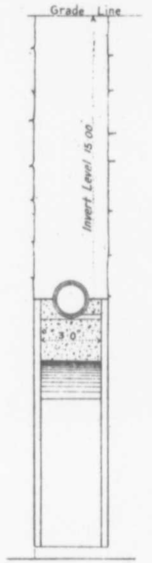
TRANSACTIONS CAN. SOC C.E.
VOL. X PLATE 6.

THE SEWERAGE OF VICTORIA B.C.

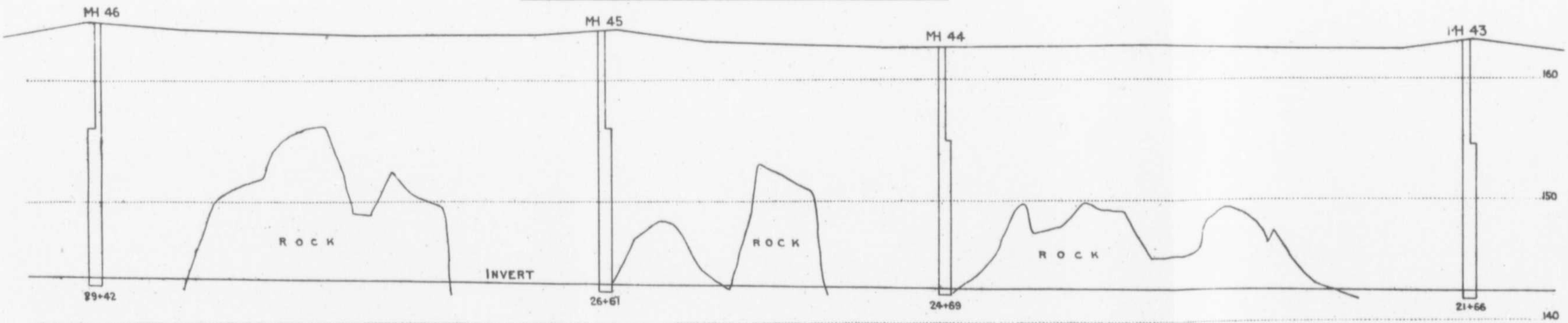
EDWARD MOHUN C.E.

JOHNSON ST. RAVINE CROSSING.





PROFILE OF PART OF THE COOKE STREET SEWER.



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running. Below the level of the sewer a small box drain was run to a sumph at the pumping engine. After this no difficulty was experienced in construction.

The Humboldt street sewer was laid, as stated before, for a considerable distance, some 1200 feet, in a rock tunnel; the bottom was excavated 6″ below the level of the invert of the pipe, which was laid in 14 to 1 concrete. Access to the tunnel and its drainage was provided for at the man-holes. At all points where junctions for house sewers were, or were likely to be, required, a side trench was blasted out for about 5 feet before the main was laid.

In making the connections the main is protected by sacks of earth from the effect of shots until the trench or tunnel is ready for the reception of the house pipe. No difficulty has been experienced hitherto in making these connections, nor has any injury resulted to the main.

HOUSE CONNECTIONS.

Curved junctions (Fig. 8) for pipe and slants (Fig. 9) for concrete

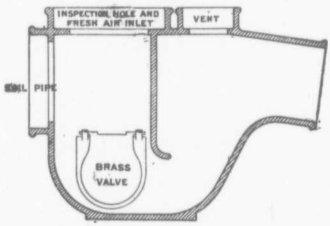
FIG. 8.

FIG 9.

sewers were placed at all points where house connections were, or were likely to be, required. The upper ends of these junctions were at such a level as to preclude an overflow of sewage through them unless the sewer itself became choked. As many of them were not required for immediate use they were provided with earthenware stoppers, through which the ground water was allowed to percolate into the sewers; this was considered advisable, since the system was designed for a considerable addition to the existing population, and it was thought that the small amount of sewage available could hardly be depended upon to render them self-cleansing. At each junction a piece of 2″ × 2″ scantling was brought up to the surface.

In order to have a trustworthy record of the positions of the junctions, plans on a scale of 50 feet to one inch were prepared showing all man-holes, ventilators, flush tanks, and junctions, with the measurements of the last from fixed points. On these plans are also shown all buildings with the position of the house pipes, and the points at which they enter the buildings to connect with closets, baths, sinks, etc. They also show the nature of the subsoil, whether earth, hardpan or rock. The drainage of basements, and the admission to the sewers of subsoil water, and the exclusion of sewage from the basement drains was a matter which received serious consideration. To attain the foregoing results a special trap was designed, which so far has been found to answer the purpose (Fig. 10). This trap is sometimes placed under the

FIG. 10.



sidewalk, sometimes in the basement in a sumph hole below the level of the floor, in which the subsoil water is collected. Its body is of cast-iron; it is provided with ventilator and fresh air inlet. The subsoil water enters through a brass flap valve with ground faces. The valve can only open to admit the subsoil water when the head exceeds that of the sewage pressing against its inner side. To prevent foreign substances entering the trap through the valve a fine grating is provided; indeed the author has suggested that in addition to the grating the water should pass through a filter of small shingle. Several of these traps have been in use for the past two or three years, and it is believed have given general satisfaction. The method of hanging the valve has proved simple and efficacious. The flap is suspended from two hooks which allow it a slight horizontal play, so that when pressure is applied from the inside, the ground faces are immediately brought into close contact.

HOUSE PLUMBING, ETC.

It was felt that however well the public sewers might have been designed and constructed, their utility would be diminished or destroyed if buildings were connected with them in a haphazard manner, and therefore that all connections should be made under the direct supervision of a competent officer. This being conceded, it followed that it was also necessary to provide that all work directly or indirectly connected with the sewerage system, and whether on public or private property, should only be performed by duly licensed pipelayers or plumbers, working under the personal supervision of a competent inspector, and in accordance with stringent regulations as to material and workmanship. For the proper control of the work, the Council passed a special by-law and set of regulations.

Up to the 30th June, 1893, when the author's connection with sewerage construction ceased, the following works had been executed under his direction, viz :

(*a*)	Outlet works at Clover Point.		
(*b*)	3,245	lineal feet of 2′ 10″ × 4′ 3″	sewer
(*c*)	3,394	" " " 2′ 4″ × 3′ 6″	"
(*d*)	2,605	" " " 2′ 0″ × 3′ 0″	"
(*e*)	3,837	" " " 20″	"
(*f*)	5,027	" " " 18″	"
(*g*)	1,342	" " " 15″	"
(*h*)	1,977	" " " 12″	"
(*i*)	4,428	" " " 10″	"
(*k*)	926	" " " 9″	"
(*l*)	7,944	" " " 8″	"

with 81 man-holes, 70 ventilators, one large and one small flush tank.

The following is an abstract from the final estimates showing the cost of the work:

ABSTRACT OF COST.

Excavation other than trenching	$ 3,225.14
Filling	891.06
Trenching, tunnelling, and back filling	106,371.85
Concrete	62,207.40
Bricks, radial in cement	3,659.12
Pipe laying and haulage	2,524.51
Timbering left in trenches, tunnels, etc	9,637.75
Cast iron	6,307.52
Wrought iron	1,237.85
Steel pipes	1,377.00
Vitrified pipes	28,325.09
Sundries	126.35
Purchase of right of way	3,044.37
2 man-holes, 3 vents, 1 flush tank, additional	1,023.00
	$229,958.01

PIPE SHED.

The cost of the pipe shed, 80′ × 40′, and plant, and fencing the yard, 180′ × 160′, was $1711.53. The ground was rented by the Corporation at $240.00 per annum.

STAFF.

The whole charge of the works was in the hands of the three Commissioners, with their Secretary and Treasurer, the City Clerk and City Treasurer respectively. The constructive department was under the charge of the author, acting as Chief Engineer under the instructions of the Commissioners, assisted by a Resident Engineer, Draughtsman, Inspector, and a varying number of sub-inspectors.

ENGINEERING, INSPECTION, ETC.

Contracts aggregating over $400,000 were let by the Council of 1890. The cost of preparatory surveys, plans, specifications, etc., amounted to a trifle less than one per cent. On construction 9 per cent. on the value of the work covered all other charges.

The glorious uncertainty as to the nature of the subsoil to be encountered is fairly illustrated by the profile of part of the Cook street sewer (Plate 5). Here it will be seen that four man-holes were sunk 9″ below the invert of the sewer at distances of 303, 192, and 281 feet apart respectively without encountering rock, yet it was met with in each intervening piece of trench ; nor was there any indication on the surface from which such a result might have been reasonably anticipated.

Occurrences of this sort became matters of frequent and serious inconvenience, as under such circumstances the earth trenching gang had to be unexpectedly and immediately removed to some other locality, only perhaps to have the operation repeated in a few days or hours.

With a view to forming some reasonable estimate of the amount of rock likely to be met with, the Council spent in the summer of 1890 $500 in boring on the lines of the proposed sewers, with the result that it was estimated that 85 per cent. of the excavation would be in earth, 5 per cent. in hardpan and 10 per cent. in rock.

The following table shows the percentages under the different classifications, together with the total and average cost per lineal foot of trenching, tunnelling, and back filling. The average is in earth 77.4, hardpan 1.7, rock 20.9 per cent:

Sewer.	Length in Feet.	Percentage.			Average cost per Foot.	Cost.
		Earth.	Hard-pan.	Rock.		
2′ 10″ × 4′ 3″	3,245	47	16	37	$8.69	$28,202 40
2′ 4″ × 3′ 6″	3,394	100			0.74	2,517 96
2′ 0″ × 3′ 0″	2,605	100			0.65	1,686 90
20″	3,837	35		65	10.20	39,131 42
18″	5,027	82	1	17	3.01	15,146 00
15″	1,342	88		12	1.28	1,711 90
12″	1,977	100			0.73	1,447 13
10″	4,428	84		16	1.45	6,429 73
9″	926	47		53	3.35	3,105 79
8″	7,944	91		9	0.88	6,992 62

Of the excavation for man-holes, etc., the rock amounted to 18 per cent.

The contract prices for excavation other than trenching were: for earth thirty cents, for hardpan fifty cents, and for rock five dollars per cubic yard.

The trenching was let by the lineal foot, at schedule rates varying with the depth, width and classification. It was paid for in a manne which can be best described by giving an example. Assume a trench to have been 15 feet deep, of which the upper ten feet was in earth and the lower five in rock; then referring to the contractor's rates, it was found that the cost of a trench in earth 10 feet deep was, say, $1 per lineal foot,—that a trench in rock 10 feet deep cost $5, and 5 feet deep $10 per lineal foot. Then the rate for such a trench would be $1.00 + $10 — $5.00 = $6.00.

TRAFFIC.

Care was exercised throughout the work that traffic should be impeded as little as possible. Speaking from memory, the author does not think that any street was closed to traffic, at all events for more than a few hours at a time, and that very rarely. Wherever the sewer crossed an intersecting street, there was either a tunnel or a bridge.

Since the 30th June, 1893, the system has been extended under Mr. Wilmot, City Engineer.

The additions consist of

13,026	lineal	feet	of	8″	sewer
4,650	"	"	"	9″	"
3,938	"	"	"	10″	"
1,678	"	"	"	12″	"
1,723	"	"	"	18″	"

In connection with these additions, 79 man-holes, 73 ventilators, and 29 flush tanks have also been constructed. The total expenditure since the 30th June, 1893, to the 31st December, 1895, has been $104,674.

These additions have also been constructed in accordance with the author's plans, except, it is believed, in one matter of detail, brick having been substituted for concrete above the level of sewage flow.

In 1892 the first connections with the sewers were made, and to the 31st December, 1895, the number is as follows, viz: 1,061 buildings, 1,364 W. C's., 330 baths, 1,018 sinks, 154 urinals and slop-hoppers, 399 wash basins and tubs, 1 swimming bath.

The City Engineer's Report for 1895 says: "The working of the sewers has in every respect been highly satisfactory, as there has not been a stoppage or obstruction in any part of the system since its first going into operation."

The same report states that the working expenses of the system, say 12 miles, are $38.00 per month.

In conclusion the author desires gratefully to acknowledge the hearty co-operation and assistance for which he was so heavily indebted to the Commissioners, the Resident Engineer, and others of the staff; while the employment of a thoroughly honest and capable contractor rendered the progress of the work satisfactory, and without those disputes which frequently arise between the contracting parties in similar works.

DISCUSSION.

Mr. J. H. Turner, Premier of British Columbia, said: It seems to be only justice to Mr. Mohun, that he should testify to the great ability that the author has shown in designing and carrying out his plans etc. He did this under great difficulty, the City Council constantly thwarting him. It seems inherent in Councils, that as soon as a new one is elected, every member of it considers himself a competent engineer, and will use every effort to make changes in the plans of any competent engineer that may at the time be carrying on city works; but in Mr. Mohun's case, though every difficulty was thrown in his way, he went straight on, and completed the first contract, the most important part of the scheme, and this has proved perfectly successful,— in fact, is, the writer thinks, about the most effective system that he knows of; it has worked without a hitch and without expense since its completion. Unfortunately the city has not carried out the second part of the system strictly under the original plan, having, in one of the annual changes to which we are unfortunately subject under municipal system, put another engineer in charge; but still, with this drawback, the excellence of the general plan has carried the whole over the difficulties that were found in it. The writer speaks with full knowledge of the matter, as he was one of the sewerage commissioners for the first part of the system. He resigned at its completion, as there was really so little power in our hands. Mr. Mohun has worked without an error, and had so perfectly calculated matters that the total expenses, including commissions, advertising, etc., was only 8 per cent. on the contract.

Mr. D. Oppenheimer, of Vancouver, said:—He had read with interest Mr. Mohun's paper on the "Sewerage of Victoria, B.C.," and though not an engineer, was pleased to have an opportunity of recording his appreciation of the sewerage works designed and constructed by him.

During the writer's connection with the city of Vancouver both as mayor and alderman, the sewers were constructed by Mr. Mohun, and as the writer was mainly instrumental in obtaining Mr. Mohun's, services for the city, it gives him much gratification to be able to state that the system designed by him has worked here perfectly, as he is informed is the case in Victoria.

Thursday, 21st May.

HERBERT WALLIS, President, in the Chair.

A discussion on the general affairs of the Society occupied the evening.

PROCEEDINGS OF THE TORONTO SUMMER MEETING.

June 17th, 18th and 19th, 1896.

The Executive Committee of local arrangement consisted of

W. T. Jennings, Chairman.
C. H. Chapman,
Willis Chipman,
J. Galbraith,
E. H. Keating,
H. D. Lumsden,
Alan Macdougall,
E. Wragge.

C. H. Rust, Secretary.

The meetings were held in the School of Practical Science, Queen's Park.

The opening session took place at 11 o'clock a.m. on Wednesday, June 17th.

On motion by Mr. J. D. Barnett, seconded by Mr. H. A. F. MacLeod, Col. Sir C. S. Gzowski, K.C.M.G., took the chair.

Sir C. S. Gzowski. Sir Casimir Gzowski said he was very grateful for the honour done him, but regretted that he had lost strength to an extent that prevented him from doing any physical work. His love for the Society was as strong as ever it was. Anything that he could do for its welfare he would be only too glad to do, as he tried to do from the very beginning. As one of the oldest engineers in Canada, his whole heart was for the success of the Society.

Mr. W. T. Jennings. Mr. Jennings, on behalf of the Local Committee, announced the programme of entertainment that had been provided for the members and ladies accompanying them.

Prof. J. Galbraith. Prof. Galbraith outlined the experiments proposed for the evening meeting in the laboratory of the School of Practical Science.

Mr. W. T. Jennings. Mr. Jennings stated that he had received from the President and Secretary of the Canadian Electrical Association, now in session in this city, an invitation to the members to attend their gathering and also their banquet.

The Chairman. The Chairman, Sir Casimir Gzowski, at this point begged to be excused from presiding, and thanked the members for their kindness in naming him Chairman.

Mr. Barnett, member of Council, then took the chair, and called upon Mr. Alan Macdougall to open the discussion on the proposed Acts of Incorporation of the Society.

Mr. Alan Macdougall.

Mr. Macdougall said the members were aware that prior to the last annual meeting, drafts of the proposed Acts of Incorporation were prepared and submitted to the members for their consideration. These were accepted at the last annual meeting. The first Act referred to the Dominion Parliament. Under that Act, so far as the Dominion of Canada was concerned, he thought the Society would receive all that it wanted,—that it is to say, it would become a thoroughly close corporation. The second Act was intended to be presented to every provincial Parliament in the Dominion, in order that each province should pass it, f not exactly in the words given, then as nearly so as possible. There might be some legal conditions which required some little amendment, but it was hoped and anticipated that this Act, as it had been prepared, would be the Act for the whole of the seven provinces of the Dominion, and that it would be equally possible and as practicable to apply it to the Province of Quebec as it would be to apply it to Nova Scotia or New Brunswick, to the Northwest Territories or to the Province of British Columbia. This Act having been accepted by the Society, the members resident in Manitoba lost no time in applying to the Local Legislature for Incorporation. The Manitoba Civil Engineers' Act was assented to on the 19th of March of this year, and was almost word for word the Act which was accepted at the annual meeting in Montreal. He thought there were only one or two words altered, and did not think the alteration was of any vital importance.

The time has been too short to enable the Committee in Toronto, representing the Province of Ontario, to meet with the Government there, the session having been too far advanced and the proper legal notices not having been given. The speaker, however, had personally had an interview with the Government. After the adoption of the proposed Act at Montreal, and subsequent to the passing of the Manitoba Act, the Council of the Society had suggested one or two modifications and alterations in the Provincial Act. Copies of the memorandum of the Council had been placed in the hands of members.

The Secretary.

The Secretary then read from the minutes the alterations suggested by the Council of the Society, and pointed out wherein the Provincial Act, as adopted in Manitoba, conflicted with the existing by-laws of the Society.

Mr. Alan Macdougall.

Mr. Macdougall said the amendments recommended by the Council had materially affected the bill as it was originally presented. Clause 16 had been very much improved in the different processes it had gone through; and when that clause 16 has been passed in any province, we shall have got all that we require, and looked forward to, as a close corporation. One position which the civil engineer has occupied all over the Dominion of Canada was an anomalous one: he has not been able to perform any act of subdivision of land; no plan of his has been of any use unless he was an ordained land surveyor. Some amendments have, however, been obtained to the Railway Act within the last few years, which have permitted the engineer of a railway company to sign his own plan. Considerable difficulty has arisen also between land surveyors and civil engineers in the Province of Ontario. Nearly all the engineers who have been practising as municipal engineers in water-works, sewerage works, pavements and road constructions in the numerous rural municipalities were land surveyors as well as civil engineers, and ninety per cent. of them were members of this Society. They have obtained licences as land surveyors, in order simply that it might enable them to lay out and subdivide land in the routine of their practice as civil engineers. The Committee of this Society represented by the speaker met and had a long discussion with the Council of the Provincial Land Surveyors Association, concerning the matter of incorporation, and was very well received. The question had not been discussed in the Surveyors Association, but the Council had discussed it fully. The deputation from this Society consisted of Sir Casimir Gzowski, Mr. Butler and the speaker, the members of the Ontario Provincial Committee. A copy of the proposed Act, with the amendments of Council, was sent to the Committee of the Association, asking them to bring the matter under the consideration of their Council and also of their special Engineering Committee, and to let us have another meeting with them. The speaker did not think there would be any difficulty with the land surveyors in Ontario, with whom some satisfactory arrangement could be made. In the Province of Manitoba the difficulty has been overcome by the Act which has been passed. The engineers in that province have laboured under very great disadvantages, improperly qualified persons having undertaken very large and important public works, and brought discredit on the calling of civil engineering. We find the same difficulties have arisen in the other provinces. He held in his hands a letter from Mr. J. Simeon Armstrong, addressed to the Secretary, calling attention to the proposed incorporation of the Provincial Land Surveyors of New Brunswick. The Secretary had also placed in his hands the following official letter from the Provincial Committee of the Province of Quebec to the Council, which had been transmitted by the Council to this meeting:—

QUEBEC, April 15th, 1896.

Prof. C. H. McLEOD, Secretary Can. Soc. C. E.
112 Mansfield St., Montreal.

SIR,

Your favor of the 10th inst., transmitting amendments to the proposed Provincial Act of Incorporation, has been submitted to us by Mr. Boswell. We anticipate that there will be considerable difficulty in getting a bill passed, with paragraph No. 17 as amended, unless some change is made in the present method of election to membership in the Society; for, as matters now stand, ten per cent. of negative votes can exclude a candidate from membership. This, when the result is to debar an individual from practicing his profession, and deprive him of his means of livelihood, will be a manifest injustice, as a cabal can readily be formed, either owing to professional jealousy or personal dislike, by which ten per cent. of negative votes can be secured against a candidate. If membership in the Society is to be a condition precedent to practicing as a Civil Engineer, then we are of the opinion that membership should be determined by personal qualifications and not by election.

We have the honor to be, Sir,
Your obedient servants,
LOUIS A. VALLÉE,
ST. GEORGE BOSWELL,
ERNEST MARCEAU.

Mr. Keating asked how the Act would affect a case like that of Mr. Mansergh, who was recently called in to consult about the Toronto water works. Would the city be prohibited from calling in an expert from abroad if this Act were passed? He thought it would, and pointed out that the Manitoba Act would allow such a case, but clause 16 of the Amended Act would not. Mr. E. H. Keating.

The Secretary said, as the matter stood under the amendment proposed by Council such a case as Mr. Mansergh's would not be allowed. However, that matter was very carefully discussed at the meeting of Council at which these recommendations were made, and it was considered that the question would very easily be met in the case of an eminent engineer who could at once be made an honorary member of the Society. There should be no difficulty at all. The Council The Secretary.

wanted to make it pretty water-tight in so far as any but eminent members of the profession from abroad were concerned, and according to the paragraph as amended, none but members of the Canadian Society of Civil Engineers could act in the capacity of consulting engineers, without some special action of the Society.

Prof. J. Galbraith. Prof. Galbraith said the same difficulty existed in the professions of Law and Medicine. No one who was not authorized by our Medical Council here could practise in Ontario, and the same rule has held in the Law Courts. In the Hyams trial an American counsel was prevented from appearing, except by courtesy.

Mr. Alan Macdougall. Mr. Macdougall said clause 16 in the Council's draft would necessitate anyone desiring to practise engineering joining the Society. The Bill as amended by the Council was much more close than the Manitoba Act.

Prof. J. Galbraith. Prof. Galbraith said according to the Manitoba Act it was not necessary that a man, even a native of the province, practising engineering, should belong to the Canadian Society of Civil Engineers.

Mr. E. H. Keating. Mr. Keating.—No. We should not have so many different classes of engineers in Canada. There should only be one class, namely, those belonging to this Society. While that need not prevent Universities like McGill and Toronto conferring degrees in engineering, yet before the graduates practise they ought to belong to the Society and practise by virtue of its authority.

The Secretary. The Secretary explained that the Manitoba Act was passed in a very great hurry, and it was passed substantially in the form recommended by the Committee, *i.e.*, Mr. Creelman's Act. The portion under discussion had not been changed at all. The Council had not considered the wording of the Act with any care until it had been passed in the Province of Manitoba. It was then found that the last clause did not really amount to very much. The Council felt very strongly that the Manitoba Act should be amended, and our members resident in Manitoba did not, it is understood, anticipate much difficulty in getting it amended.

The Chairman. The Chairman said it was freely expressed at the Council meeting that the Manitoba Act should be rigidly amended to agree with the by-laws of the Society and the Provincial Act as amended.

Mr. C. E. Goad. Mr. Goad asked if the Society had taken any steps in reference to that letter from the Quebec Committee objecting to the by-law of our Society whereby ten per cent. can exclude on a ballot?

The Chairman. The Chairman said that no action had yet been taken. It was in the power of this meeting to make recommendations. Mr. Marceau, a member of the Quebec Committee, was present.

Mr. Marceau said our committee has done practically nothing beyond writing that letter to the Secretary. It was the intention of the Committee to have interviewed the Attorney-General of Quebec in May last, when a change in the government took place, and since then there has been no opportunity of meeting. When the Attorney-General has been seen, which we expect will be at an early date, a report will be made. The instructions were, not to do anything in connection with the passing of the Act, and we have only wished to feel the ground in order to see what can be done towards the passage of the Act. **Mr. E. Marceau**

Sir Casimir Gzowski, being obliged to leave, wished to say that in his opinion Mr. Macdougall deserved the thanks of this Society for the very laborious work which he had been guilty of, if he might so say; because we have all desired to maintain our position where it ought to be as really worthy civil engineers. By the time that we have trained the seven provinces all to do the same thing, the speaker would not be here to partake of the joy, and he was afraid a great many of the members would be gray headed. He moved that the thanks of the Society be tendered to Mr. Macdougall for his labours in endeavouring to secure us what has been called a close corporation. England had tried it and had not succeeded. In the United States you could not attempt it, it is too long and too broad; and if we, from the Pacific to the Atlantic, succeed, a great deal will be due to Mr. Macdougall. He did not expect to be here when the work was completed, but the members were quite right in trying to carry out the project. He had been very glad to have been able to pay his respects to the Society, and trusted the meeting would be a pleasant and profitable one, and that the members would enjoy their visit to the various places of interest. **Sir C.S. Gzowski**

Mr. MacLeod seconded the motion of thanks, which was carried unanimously, and Mr. Macdougall expressed his cordial thanks for this expression of appreciation. **Mr. H. A. F. MacLeod.**

The members rose to their feet when Sir Casimir retired.

The Secretary stated that it was most important that some action should be taken by the Society in regard to the matter brought forward in the letter from the Quebec Committee. It proposed to radically alter the present method of election. **The Secretary.**

Mr. Macdougall thought we must for the present be satisfied with the existing means of election. The elections were so safeguarded **Mr. Alan Macdougall** under the rules and regulations, and under the way in which the elections were looked into by the Council, that it would be almost impossible for a cabal to run out any man, unless they did so on the vote. Of course it might be quite possible to run a man out by giving him the necessary ten per cent. of negative votes. In that case it would be the misfortune of the man; but taking the broad lines under which the Society has been constituted, there would seem to be sufficient safeguard.

Mr. E. Marceau Mr. Marceau remarked that if ten per cent. of the members were sufficient to annul and prevent a person desiring to become a member from being elected, very awkward circumstances might be brought on. Suppose, as in the case submitted by Mr. Keating, that this city wanted to bring in an engineer, an outsider, a man who was well up in the profession, and ten members, through some little spite or through some other cause, did not wish to have him admitted. Ten members could simply boycott him. We have seldom had more than one hundred votes on a ballot.

Prof. J. Galbraith. Prof. Galbraith asked how had the present regulation worked? Had people been taking advantage of that provision to boycott men?

The Secretary. The Secretary replied that there had been very few cases where candidates were black-balled, but one or two had occurred. The number of votes usually returned is correctly stated by Mr. Marceau as amounting to about one hundred, so that practically about ten votes would exclude. Of course in the case of a close corporation, where belonging to the corporation was a matter of "bread and butter," it might alter one's actions considerably as to forming a cabal against any candidate for admission into the Society; and that was what the Quebec Committee felt—not so much on account of fear of this happening, as on account of objections that might be raised to proposed legislation under the present conditions.

Mr. E. Marceau Mr. Marceau said that was the idea.

Mr. C. E. Goad. Mr. Goad remarked that some years ago the American Society of Civil Engineers made an amendment to its constitution, by which, if a candidate were put up and not elected, there might afterwards on request be an open vote taken, in which each member voting would be asked to sign his name. It is quite right that we should exclude a man if we wished to, for certain reasons, public reasons it might be, suppose fifty per cent. of the Society thought he should be excluded.

Prof. C. B. Smith. Mr. Smith asked what proportion of the members do not vote at all? When we do not know a candidate we cannot conscientiously vote for him, and yet do not wish to vote against him, and so do not vote at all

The Secretary replied that about one-half the ballots sent out have been returned. On that number there would probably be about half the number of votes cast that were called for in the ballot papers. That is, supposing there were ten candidates on the ballot sheets, on an average there probably might not be more than five voted for. Some sheets would contain a full vote, others would possibly contain votes for one or two candidates only. The Secretary

Prof. Galbraith said that in the first days of the Society he never voted for any except those he knew; but after considering the matter, he thought that was a wrong theory. The Council had laid down regulations, and they had printed on the list the whole history of each candidate for the purpose of enabling every member of the Society to vote. That was the real intention of publishing the candidate's career, so that every one should vote on every candidate; otherwise there was no object in publishing his career. He did not understand why members did not vote on all candidates. Prof. J. Galbraith.

Mr. Keeley asked whether it would be possible to suggest to the members generally that they were in duty bound to vote for every man who was proposed unless they knew something that should cause them not to do so? Mr. D. H. Keeley.

The Secretary said that at the head of every ballot there has been printed in red letters a special request to vote on account of this ten per cent. by-law. The Secretary.

Mr. Keeley questioned whether that could not be made a little stronger. If time pressed members when the ballot was received, they were inclined to cast it aside. He suggested that they should be reminded that they were in duty bound to vote. Mr. D. H. Keeley.

Mr. Smith thought this a good idea. Prof. C. B. Smith.

Mr. Goad suggested that it would be better to adopt the American system. There the ballots were sent out with simply the word "Aye" printed. Not to mark the ballot means Aye. To cross the Aye means Nay. A member would not feel like putting his pen through it. One who is a member of both societies would just fold up our ballot and put it in the envelope and address it, thinking that he had voted for all the candidates, whereas he had not because he had not scratched out the Nays. Would it be possible to leave out that word Nay? The method would be simpler, and we would have a larger vote. Mr. C. E. Goad

The Chairman remarked that it was quite within the province of this meeting to instruct the Council to have such changes made. The Chairman.

Mr. E. Marceau

Mr. Marceau did not think there had been any difficulty about the ten per cent., but if the Society were a close corporation it would be a very different thing.

The Secretary.

The Secretary remarked that the idea of the Quebec Committee was that an examination should be one of the avenues for admission into the Society, so that in the case of a man having enemies in the Society, that method might be open for admission. The ballot should still be retained for ordinary elections.

Mr. Alan Macdougall.

Mr. Macdougall pointed out that in five or ten years, when every engineer would of necessity be a member of the Society, we should be forced to adopt the principle of examinations both for entrance and advancement from grade to grade, as is the case in other professions.

Mr. C. E. Goad.

Mr. Goad understood that all applications were considered first by the Council before being put on the ballot paper.

The Chairman.

The Chairman assured him that they were very fully considered.

Mr. C. E. Goad.

Mr. Goad said it has been the practice of the American Society to issue a blue ballot a month or two months before the regular one, asking the members to give confidentially any information in their possession about the candidates, and then if for any reason the Council wished to exclude that member from the ballot, they could do so without saying a word about it.

The Chairman.

The Chairman said the last suggestion made by Mr. Goad, in reference to the issuing of the blue ballot, has been under the consideration of the Council.

Mr. E. Marceau

Mr. Marceau moved, seconded by Mr. W. Kennedy :—

Mr. W. Kennedy.

"That in the Provincial Act a clause be added making it possible for a candidate for membership to obtain admission into the Society on passing such a qualifying examination as may be demanded by regulation of the Society, without reference to the present mode of election by ballot, provided that the applicant is approved by the Council of the Society."

Mr. C. E. Goad.

Mr. Goad said that would change the whole constitution of the Society at once, because no one would come in by ballot if he could enter by an examination.

Mr. H. D. Keeley.

Mr. Keeley said this motion does not exclude balloting. There are two avenues of entrance.

Prof. J. Galbraith.

Prof. Galbraith thought examination was just about as indefinite a means of admitting a man to a professional society as could well be devised. He would trust far more to the present method of studying a man's qualifications and having them submitted to a Council than by any system of examination that could be contrived. He objected to the principle of making examinations the test for professional advancement, and defended his thesis at length.

Mr. Kennedy remarked that it was a little interesting to see a professor in an institution of this kind opposing examinations. This motion, however, has not referred to such examinations as Prof. Galbraith has alluded to. The applicant must first have been accepted by the Council, then after that he would be examined by a committee appointed for that purpose, not necessarily on the theoretical subjects which are taught in such an institution as this, but as to his fitness for conducting engineering work. He could not see any objection to a person having been first accepted by the Council and afterwards passing such an examination as in the wisdom of the examiners might be decided upon. **Mr. W. Kennedy.**

Prof. Galbraith said he had been speaking more for the purpose of calling attention to the difference between the kinds of examinations and for clearing ideas as to what was meant by examination. **Prof. J. Galbraith.**

Mr. Kennedy supposed that the examination would meet the individual case. He did not think that was the way members would ordinarily enter; the ballot would be the ordinary way. **Mr. W. Kennedy.**

The Chairman asked if the meeting understood this motion as a recommendation to the general committee on Close Corporation and not an amendment to our by-laws? **The Chairman.**

Mr. Marceau said it was not intended as an amendment to the by-laws, but simply a recommendation to the committee on Close Corporation. **Mr. E. Marceau**

On this understanding the motion was then put and carried.

The Chairman appointed Messrs. Matheson, Ker and Macdougall to act as scrutineers of the ballot.

The session closed at 1.30 p.m.

On Wednesday afternoon the members of the Society and their friends took part in an excursion on the Toronto Bay and inspection of the Harbour works on the invitation of the Mayor and Aldermen of the city of Toronto. The afternoon proved a most enjoyable one, giving as it did an opportunity of meeting many of the city officials, and especially of making the acquaintance of his worship the Mayor.

EVENING SESSION.

The meeting re-assembled at 8.30 p.m., Mr. Barnett, Member of the Council, in the chair.

The Chairman. The Chairman said it had been decided to spend the evening examining the various departments of the School of Practical Science under the leadership of Prof. Galbraith, and watching the experiments which had been prepared for the occasion.

Prof. J. Galbraith Prof. Galbraith gave an outline of the evening's programme. The first experiment would be the determination of the strength in compression of a short brick pier in the large testing machine. After that the delegates would be shown the process of determining the co-efficient of tortial elasticity of a two-inch shaft. The process would be explained during the operation. If time allowed, another shaft would be put in the tortion machine, and broken. A post about ten feet long would also be broken in compression by the large machine. By means of another machine the amount of friction generated on a railway car journal would be shown. The journal would be 3¾ ins. diameter and 7 ins. long. It would be loaded with the average weight of an ordinary freight car, and would be run at three speeds, 12, 25 and 50 miles an hour. The oil used would be heavy mineral oil. The operation would show the friction produced under these conditions, and also the temperature to which the axle rose. All the different departments of the laboratory would be lighted up and open to visitors. One place of interest would be the clock room, where experiments have been made as to the value of gravity in Toronto; another would be the stamp mill; another, the electric galvanometer; another, the hydraulic laboratory. The stamping machine would be running and the pump in motion under a fairly good head of water. The mineral collections, the blow-pipe laboratory and the chemical laboratories would also be visited.

Mr. C. H. Rust. Mr. Rust, Secretary of the Local Committee, announced that Mayor Fleming had offered to send carriages for any of the visiting members who wished to take a drive around the city.

The meeting was then adjourned to 10 a.m. on Thursday, and the evening passed in the laboratories in accordance with the programme outlined above.

SECOND DAY—MORNING SESSION.

Thursday, June 18th, 1896.

MR. ALAN MACDOUGALL, Member of Council, in the Chair.

The meeting was called to order at 10 o'clock.

The Secretary read the report of the Scrutineers, giving the result of the ballot closing June 17th, as follows :—

MEMBERS.

SANDFORD FLEMING. J. A. MACDONNELL. J. W. TYRRELL.

ASSOCIATE MEMBERS.

R. LAIRD. J. W. ORROCK.

ASSOCIATE.

T. A. MORRISON.

STUDENTS.

W. A. MACDONALD. F. A. WILKIN. H. P. RENWICK.

Transferred from the class of Associate Member to the class of Member :—

A. W. CAMPBELL. C. T. SYMMES.

The Secretary read a letter from Mr. Thomas Monro, ex-president of the Society, regretting his inability to be present at the meeting.

Mr. Barnett then read his paper on Pneumatic Power Applied to Workshops.

Paper No. 114.

PNEUMATIC POWER APPLIED TO WORKSHOPS.

By JOHN DAVIS BARNETT, M.Can.Soc. C.E.

In the early days of ironworking the tools were usually brought to the work, and they were manual. Later, as tools increased in size and stiffness, the work was brought to the machine and moved with it under or against the tool. To-day, in many operations, the bulk of metal to be handled is getting so unwieldy that it is again proving common practice to carry the machine tool to the work. Electrical and air motors are certainly factors in this evolution, even if not largely responsible for it.

This paper proposes putting on record the present position of air power, as part of a craft, illustrated more especially by railway shop-work.

A natural hope, then, would be that the author should give figures, comparative between air-driven, water-driven, electrically driven and shaft driven machines.* Such figures the author cannot give from his own experiment, and after wide search is of the opinion that at the present day they have not been obtained ; therefore, this paper must be qualitative rather than quantitative.

EFFICIENCY.

The author does not intend to say that air, for continuons work in plate flanging, or for high pressures in stamping and forging, is a more economical transmitter of power than water, or that pipes, air engines and motors are better or cheaper than wires and electric motors, or independent air driven tools than steam applied through shafting and belts to a compact group of machine tools, but he is of the opinion that if many widely scattered, different and intermittent operations are to be performed ; if a cold climate has to be fought ; if the technical skill and knowledge of the workman employed is limited ; and if the special and portable tools are more or less of home design and manufacture to suit the particular and limiting conditions of their use, then air has

* For such an economical comparison between small motors see Proceedings I. C. E., vol. 105, p. 308.

efficiency, economy, and a wide field of usefulness. For the many and varied services it now is used in and about a railway, see the appendix.

The common opinion that the compressing of air was costly and power transmission by it wasteful, has been the main obstacle to its more extended use. Prof. J. T. Nicolson, M.Can.Soc.C.E., has (in Transactions, Vol. VII) clearly proved that there is no difficulty or great first cost in securing a mechanical efficiency of 86 per cent., a thermodynamic of 92, and a main (pipe) efficiency of 96·2, and re-warming the air near to the motor; that he recommends, the author finds in practice to be easy, cheap, and so effective as to tempt him to emphasize Prof. Unwin's remark (Proceedings I. C. E., v. 105, p. 202), "heat applied in re-warming compressed air is used nearly five times as efficiently as an equal amount of heat employed in generating steam."

COMPRESSORS.

The data and recorded experience in compressors and compressing is enormous, and does not require our attention, except to note that, for delivering small volumes of air, a staple article of machinery supply on the market to-day is belted-compressors, worked from the shop shafting, having single acting pistons, compound pump chambers, and intermediate air cooler, doing the compressing in two or more stages. They are automatic in action, that is, when the receiving reservoir is above normal pressure the driving belt is moved across from the fast to the loose pulley (both on the crank shaft) by means of a small air cylinder, whose piston rod is coupled direct to the belt shifter. The admission of the compressed air to this small shifting cylinder being controlled by the movement of a diaphragm, whose under side is open to the receiver pressure, and whose lift is controlled by an ordinary safety valve lever, carrying a sliding balance weight, adjustable at will. If the demand be very irregular as to amount, several such belted compressors have been used coupled up in automatic series. Also, pressure from the receiver has been used to throw a friction-clutch in and out of gear and thus secure the intermittent action of a belted compressor.

For compressors generally it may be said that it is advisable, where possible, to use large units, run at fairly moderate speeds; to take the air in as free from dust as possible—the author takes it from under the external eavetrough—also to take in the coldest air possible, as for each 5° lower temperature of the entering air there is said to be a one per cent. increased efficiency in the compressor.

PIPES AND STORAGE.

The shop piping or main for ordinary pressures (80 to 100 lbs.) should not be less shan $1\frac{1}{2}$ in. diameter, the larger the better. The author having 4 in. pipe, to spare, on hand, used it with great satisfaction, as it gave ample power storage and little friction. Very slight provision is required for drainage. The main is best carried on the top of roof tie beam, and from the first should be liberally supplied with short branches and outlet valves, at least one to every 18 or 20 feet, with screwed ends to fit the union nuts of the flexible hose ; the hose for hand tools and hoists varying from $\frac{3}{8}''$ to $\frac{1}{2}''$ diameter. Cords from the outlet valve lever run down to within 7ft. of the floor controlling the position of the valve.

Reservoir storage has to be proportionately the larger the more intermittent the work done,—that is, the greater the extreme call for air compared with the maximum delivery of the compressor. The pipes and reservoir together should be capable of holding the total delivery of the compressor (working at normal speeed) for half an hour, which is far cheaper than providing an excessively large size compressor, and cheaper not only in first cost but in daily working. This refers to steam power compressors, which are run at a disadvantage at speeds so slow as to make it uncertain if the fly-wheel is going to carry the crank well over its dead centre. The condensation on the cylinder walls, etc., is also then excessive.

COMPARATIVE COST.

In ordinary compact factories, with fairly efficient steam plant, the gross cost of the motive power, that is, of fuel, oil and water, is but one per cent. of the total paid out in workmen's wages.

In ironworking, pneumatic power often increases a man's output of work by 200 per cent. (threefold). For argument sake allow that it is only doubled. Then, if supplying one man with his proportion of the motive power were by the use of air to increase his proportion of the motive power cost by 50 per cent., it is evident we should then have a similar 50 per cent. margin for profit. As the actual cost is nearer 5 per cent., there is evidently a wide margin for extra outlay in machines or in their repair, which expenditure, per day or per man, is increased in the attempt to use pneumatic power, but in the cost of such tools as drills, rhymers, taps, boring cutters, etc., is not increased per ft. run of actual work done, when compared with manual labour.

Thus it is clear that if the additional machinery a factory makes or purchases in trying to use air as a distributer of power is confined to such tools as will be often or fairly continuously used, this outlay is justified, and the cost of compressing relatively to total wages is so small that tools evidently wasteful in the use of air are economical, or rather show a net balance to the good, if the men find them portable, easily adjustable and handy to use, and their simplicity of make and freedom from repairs and break downs results in but few delays to the steady out-put of work.

ROTARY MOTORS.

It is evident that the use of compressed air has stimulated the use of rotary-motors; not because it was believed that they were economical converters, but because their light weight and small bulk permitted them to be used by hand. However, the making of a more perfect air engine than the steam rotaries, for which so many designs were made and patents taken out between 1830-50, has been attempted, but it is questionable if any advance has been made. The author has no information as to any attempt to use a reaction or impact turbine as a portable air motor. What has probably discouraged this is that the necessity to gear down the high speed would make the engine weighty and the friction excessive, although, as air at the same pressure is twice as heavy as steam, it looks as if air would do well in such a form of reaction engine.

The most simple form of rotary motor is an excentric or cam, forming part of the central shaft, whose length is that of the cylinder in which it rotates, and whose outer surface (belly) touches in the course of one revolution the whole internal circumference of the cylinder. A reciprocating plate moved in centrally from the cylinder wall receives the backward thrust of the air. The admission port is in front of this plate, and the exhaust port at its rear. So made, the small sizes to be held by hand, when at work, give an irregular, wobbling motion, as the shaft—or plug as it is called—is unbalanced. This long ago provoked the use of two parallel shafts or cams geared together, but the author must confess to a failure in an attempt to reverse a form of the Root blower, using it as a small motor.

The later attempts make the cylinder in cross-section oval or elliptic, with several inlets and ports in its walls. The shaft, which is as large as the minor diameter of the ellipse, carries two or four movable blades or pistons in its body, whose outer edges are kept in contact with the varying walls of the cylinder, not by steel springs, but by the admission of compressed air to the bottom of the slots of the shaft in which each radial piston blade plays in and out.

Without dispute, the leakage is large, judged by the standard of a reciprocating steam piston, and is in part due to the several reciprocating blades being subject to wear on their three outer edges as well as looseness in their shaft slots, and in part also to the fact that with air and steam under exactly similar conditions of surface, of metal, and of pressure, air will pass through packing more readily than steam. A suggested explanation for this is that the film of water that condensation leaves on the steam walls retards the passage of steam between smooth metal surfaces.

The dynamic efficiency of such motors is low, so low as to apparently discourage any attempt at metering, indicating or brake-testing them, yet many wideawake shop managers use them in direct application to drills and taps, because, communicating a cutting speed from five to twenty times higher than can be given to the same tool by hand, they therefore prove cheap, although lavish in the use of air.

RECIPROCATING ENGINES.

At the sacrifice of perfect portability much is gained by using small reciprocating engines, weighing from 100 to 200 lbs., with two to four cylinders receiving air pressure on one side only of the pistons.

Their light weight permits one man to readily move them over the shop floor ; having no dead centre, gives prompt starting and regularity of turning movement ; low centre of gravity gives steadiness ; the strain being always in thrust, the engine is practically noiseless, and the elasticity of the air can be utilized in expansive working. The author uses double acting verticle engines (steam hammer type) of home manufacture, with single cylinder 3½ in. diameter by 6 in. stroke, averaging, with 80 lbs. pressure, 225 revolutions per minute.

To re-warm the air just before it enters the valve-chest, it is passed through a 30 in. length of thin copper pipe, ⅝ in. outside diameter, bent into a four turn truncated coil, barely 3½ in. diameter at base and 2¼ in. diameter at top, contained in a tin lamp 12 in. long by 3½ in. diameter at bottom and 1½ in. diameter at top. The lamp cistern carries a double " B" burner, using two ⅞ in. flat wicks, and burns an imperial pint of common coal oil each 30 hours. No glass chimney is required, and the flames come close to the inside of the coil. This lamp is bolted on close to and parallel with the cylinder, and is cheap, neat and inconspicuous, working satisfactorily even when the engine is set at an angle of 15° or 20° out of vertical.

TRANSMITTING SHAFTS.

In transmitting motion from an independent engine on shop floor to the drill or tap, an endless cord $\frac{3}{4}''$ or $\frac{7}{8}''$ diameter has been used, with light weight grooved pullies, the whole kept in tension by counterweights. This gear proved to be a nuisance because of the amount of tackle and the number of pulleys required to change the direction of motion. The "Stowe flexible shaft" has also been used. Even this requires a universal coupling joint at one end to meet many conditions of shop service; lengthening it from 8 ft. to $8\frac{1}{2}$ ft., the total weight for a No. 8 size being 65 lbs. Its life is short, the repairs excessive, the power it will transmit is small, and to do it the speed of revolution must be high; thus the head for a drill or tap must be geared down and therefore made larger and heavier than is required when the shaft and tool are revolving at the same speed.

A shaft more certain in action, quite as portable, and having longer life, is made by using a steel rod 1 in. diameter, sliding freely inside an iron pipe $1\frac{5}{16}$ in. outside diameter, with a universal coupling at each end. A shallow groove the whole length of the shaft and narrow feathers on the inside of the pipe insure that both revolve together; the weight of the whole is 35 lbs., and it is usually sustained by a central cord counterweighted. The ordinary length is $7\frac{1}{2}$ ft., extensible to 12 ft., but by using standard gas pipe thread for all connections, duplicate ports can at any time, if required, be added, increasing the length. It effectively transmits from 200 to 300 revolutions per minute with either or both short ends set at an angle of 35° with the central length.

For the convenience of the workman the portable tapping head is a light frame, with two and even three handles, carrying a pair of bevel-toothed wheels changing the plane of rotation, and permitting the man to guide or to put personal pressure on directly behind the tap, while its spindle is receiving motion from the side. The speed is such that a tap of 11 threads per inch with rhymering end to it, in all about 18 in. long, is screwed through both steel plates forming the water space inclosing a locomotive firebox, in from 50 to 60 seconds.

The drill press is of course somewhat stouter, having to carry the feed pressure screw.

HAMMERS.

The standard shape of pneumatic hand hammer (of any American patent) suggests an overgrown pistol, weighing from 8 to 9 lbs. In the smaller sizes the contained piston has a stroke of 2 in. or $2\frac{1}{4}$ in., and strikes directly on the end of the cutting chisel or other independent tool, which moves freely in a socket at the centre of the outer end of the pistol. This loose tool, of $\frac{3}{4}$ octagon bar steel 6″ or 7″ long, is at the outer end shaped to suit its special work, as riveting, nailing, chipping, caulking, beading, engraving, chasing, stonecutting or planishing. Quite recently an improvement has been made in this all-round useful instrument by increasing its piston stroke to 4″, and putting the pistol in a tubular case of cast iron weighing 80 lbs. or more. Its mass absorbs most of the reaction blow which the workman found so distressing to nerve and muscle, but as it requires to be suspended and counterweighed, it is necessarily not as portable, and cannot be used under conditions as confined and awkward as the hammer of shorter stroke and lighter weight. The hose is $\frac{3}{8}$″ diameter and the pressure used from 20 to 100 lbs. At the latter the hammer delivers 2,000 or more blows per minute, using of free air per minute 15 cubic ft. at 60 lbs., 18 cub. ft. at 75 lbs. and 21 cub. ft. at 90 lbs. It readily does the work of three men; four is claimed, and is possible under some awkward conditions. Men on piece work provided with such a hammer accept one-third the old piece-work price. Their cost, duty and freight paid, is from $150 to $160, and much of their product is decidedly superior to hand work. This is especially seen in beading over the ends of boiler tubes. Air is used in ordinary vertical smithy hammers, having cylinders 10 in. by 28 in., with what economy is not known, but as no choking exhaust pipe is needed, the exhaust is very free.

RIVETING.

Riveting tools require little special mention, as any power riveting tool, acting by a single steady squeeze from water or steam, may be worked by air. At most the change is but one of valve or cock, so that all power movements are controlled by one handle, and if desired, the exhaust air may be directed on to the cooling rivet, as in some cases it is on to the point of a drill to keep it cool.

The pneumatic hand-hammer (with its rapid delivery of blows) is well suited for light tank work, that is, for rivets up to $\frac{1}{2}$ in. diameter. The use of this tool—as in hand riveting—requires a holder up. The number of rivets put home per hour, dependent on size, is increased from 50 to 100 per cent. over hand labour. The unpleasant noise it makes is in some quarters an obstacle to its increased use, and as its quickly repeated blow helps to keep up the heat of the rivet, it is probable that this rapid impact hammer will not prove to be as satisfactory on steam joints as it is on tank work, because, in hydraulic riveting, where the dead pressure can be held on the rivet while it is cooling, the amount of caulking required to finish and make a tight dry job is three or four times more than that usually required to make equally good a hand riveted boiler.

HOISTS.

Common shop practice in the home manufacture of air lifts, is to use for the cylindrical barrels seamless tubes of iron or brass, smoothed internally by forcing a slug through them ; for the piston rod cold rolled steel screwed at its lower end into the lifting hook shackle, and for piston head two cast iron disks with one thickness of leather packing between. To secure the satisfactory action of this leather packing a sprung ring of round steel or brass wire cut shorter than the barrel circumference, and bent larger than its diameter, is put inside the turned over edge of the leather packing, and the lower and smaller of the iron disks has cast in it in its outer upper edge a recess to clear and allow for the free play of this sprung wire ring.

The two cast heads or covers, and the barrel which is slightly recessed into them, are held together by through bolts, outside the barrel. So made, of medium length, a 4 in. costs $18 and a 6 in. $28.

Under such conditions of cheap make, the friction of working varies from 3 per cent. in the large sizes to 20 per cent. in the very small, that is 4 in. and under. This compares favourably with epicycloidal and differential hoisting tackle, but lacks, of course, its certainty of sustaining power.

If two cast iron sprung rings are used as packing in a solid piston head the barrel needs boring out from end to end, and if not in fairly continuous use is liable to have the friction increased by rust. In a spring testing machine made by the author, with two cast iron spring rings, $\frac{1}{2}$ in. wide by $\frac{3}{8}$ in. thick, working in a 20″ cylinder, new and well lubricated, it took 100 lbs. to start the piston, as indicated by a Salter Balance, and 90 lbs. to keep it moving. In so simple a type of hoist it is a matter of indifference which way the cylinder is set. Given sufficient head room, it is suspended vertically from a two-wheeled tandem trolly moving on a single bar runway, so that load, hoist and trolly have horizontal freedom. If head room is wanting it is set horizontally, and the outer end of the piston rod coupled to a chain passing over one or more pulleys, thus changing the direction of the pull, and so used the piston rod on the upper surface has been notched so as to form a rack into which a pall falls, thus locking the suspended weight at any height; and when the hoist cylinder is put on to an old hand crane it is often set at an angle, being for convenience of attachment secured to the diagonal strut. A flexible hose of small diameter gives it elastic connection with the shop air-main.

The widest variation in practice is in the controlling valve used, a three-way plugcock being the cheapest to make and the most troublesome to keep tight. Mitre valves or flat valves with recessed elastic seating are more certain. They require a separate spindle (and cotton-packed gland) for each valve, but each pair is movable by one double-ended lever.

Where air enters the barrel of a hoist a very small hole or self-closing check valve is desirable, so as to prevent the load running down dangerously fast in case of injury either to the air-main or to the supply hose; it is also desirable to have a check or stop on the piston rod so coupled to the valve that in case of an over-stroke the valve is reversed and air is admitted to the opposite side of the piston cushioning it. The same end may be attained by the piston itself striking and opening a supplementary valve, or if the non-working end of the barrel is open to the atmosphere by a small hole in the side of the barrel, so locating this hole that the piston will block it and the confined air act, first as a cushion and then as a stop. Such a hole sucks in the shop dust and grit, increasing the friction and leakage, so that a valve admitting compressed air or exhaust air only, is the better practice.

It is perhaps over the wide surface of a foundry floor, and in the midst of its sand, grit and dust, that pneumatic hoists best show their good qualities. Russel & Co., of Massillon, O., who early appreciated their value, were two years ago using 26 cranes of 5 ton capacity, a cupola stock elevator, and many simpler hoists of from 400 to 1,000 lbs. capacity. Under such shop conditions every foot of air exhausted adds to the health and comfort and therefore working capacity of the moulders.

HOSE FOR HOISTS.

In trying to use a portable suspended hoist, and move it under a long length of shop roof, in most cases—even of modern equipment—the flexible air-hose has to be detached, and after the hoisting cylinder has been moved to a new location the air-hose recoupled to the air-main branch. To avoid this delay and inconvenience the C. & N. W. Ry. Co. use a long length of air-hose, equal to half the total length of the runway that carries the hoist, coupling the hose to the air-main at the centre of the length of the runway. Then, at points some 20 feet or more apart, the hose is suspended from a two-inch grooved pulley running freely on a horizontally tight-stretched wire. Each such suspending pulley requires an independent wire, and the wires are arranged so as not to be in the same vertical plane. The result of this ingenious arrangement is that as the hoist moves towards the centre of its runway it crowds or loops the hose, and then when closely massed each suspending pulley runs past its neighbour as the hoist passes the centre; then, extending and straightening the looped up hose, the hoist is free to travel as far to the left hand of the centre (or point of connection to the shop main) as it was originally to the right hand of that point.

Mr. R. Quayle is so far satisfied with this plan that he has now under weigh some such arrangement to permit a jib crane, travelling on a single floor rail, to propel itself, or to hoist at any point in the length of a 500 feet shop.

FORGING.

The most obvious advantage of air over water as a transmitter of power is its freedom from frost troubles. It is, however, possible under some conditions to effectively combine the two, not only without frost risk, but with added economy and a much wider range of application, without the machine being so large as to interfere with the workman's freedom of movement and his ease in handling the material to and from the tool.

This is done by using a pair of tandem differential cylinders, the outer or upper side of the piston of the larger cylinder receiving the full air pressure and delivering the power through the piston rod at a higher pressure per square inch to the water contained in the smaller cylinder. A third and independent piston at the opposite end of the small cylinder is coupled direct through its piston rod to the forging die.

As developed in detail by Mr. J. W. Harkom, M. Can. Soc. C. E., at Toronto, the differential cylinders are vertical, the large (air) cylinder being high up—that is, well above the working level of the man—and the smaller cylinder is made longer than its piston travel, and just above ground level opens direct into a third cylinder, set horizontally.

The second and third cylinders are actually one and the same, but in the middle of its length is bent to a right angle, and has a piston at each end not coupled together, so that the distance between these pistons is variable, and the space between them filled with water admitted by valve from the city mains.

The piston rod of the third or horizontal cylinder at its outer end carries the forging die, and the piston has water pressure on one side and air pressure on its relief side, so as to carry the die back after the forging squeeze has been given.

All the fluid used is that contained between the two small pistons, and is a quantity variable at will, and this is the key to the economy in the volume of the air used. The dies being variable in depth, and the forgings in thickness, the position of the third piston should be variable in position, both before and after the forging movement. When the movement for any particular set of forgings is to be small, the maximum quantity of water is forced in by opening a valve coupled to the city water-main, which lifts the large air piston up closer to the top cover of the large cylinder, and thus effectually shortens its possible length of stroke.

If the amount of water (and therefore the distance between the two small pistons) was not definitely adjustable, there would be a large loss of air when a small die were in use—or a shallow forging being made—due to the necessary filling and emptying of the cubic contents of the large cylinder at each stroke. The return (after making a stroke) of all pistons is assisted by compensating balance weights, coupled by chains to the piston rods or tail-rods, and air pressure being always on the relief side of the forging (third) piston, the die is withdrawn from the forging as soon as the air is permitted to escape from the top of the large air cylinder. This is controlled by a three-way cock overhead, with two light cords coupled to its double-ended lever, the handles on the lower ends of the cord just clearing the workmen's head. Opening a single drain-cock at the lowest level gets rid of all the water when the men leave the shop at night.

COMBINED BORING AND PLANING.

It is an advantage in trying to secure perfect alignment in the boring and planing of large cylinders, pump barrels, etc., that both these operations be done on the one machine table without resetting the work, and this has of late been done by the M. C. Bullock Co. of Chicago,* the one operation following the other, but with a suitable air motor and flexible hose it should not be difficult to do both operations at once, although the author is not familiar with any portable air motor on the market powerful enough to do the boring in as short a time as the planing usually occupies. It is also possible to do the milling out of the

* *American Machinist*, Jan. 2, 1896.

steamports by a second air motor while the boring is being finished, the whole needing but one attendant, as when on piece work one man regularly attends to three milling machines.

CONCLUSION.

To summarize, air is in practice proving to be a fairly cheap and most convenient transmitter of power, allowing fine sub-division and transportation to remote points with the crowning and unique quality of suffering no appreciable loss when held in storage. For intermittent service it is of great value, allowing widely varying speed of tools, dispensing with long lines of shafting and belts, giving free head room, and increasing the shoplight as well as lessening the first cost of roof frames when they have not to carry shafting. The pipes require no coating; they radiate no heat, and therefore can be put in close corners without increasing the fire risk; their direction is readily changed in any plane without risk of pocketing or water-hammer, and leaky joints (we all get them) are not a nuisance or risk. In no case are exhaust pipes required, and in most if not all cases the exhaust adds to the men's comfort.

APPENDIX.

LIST OF PNEUMATIC TOOLS AND MACHINES AT THE TOPEKA WORKSHOPS OF THE A. T. & S. F. Ry. (see *Ry. Review*, 25-4-96).

1 Riveting machine, of 10 ft. reach, with pneumatic crane.
1 Riveting machine of 6 ft. reach with frame.
1 Combination flange punch and riveter.
2 Truck riveters.
1 Bridge riveter.
1 Frame "
1 Tank "
1 Mudring "
1 Staybolt breaker.
1 Staybolt cutter (nipper).
20 Rotary motors.
4 Brotherhood engines.
1 Grinder.
1 Saw.
6 Hammers (hand).
1 Punch.

1 Angle-ron shears.
1 Bolt machine.
3 Hammers in smithy.
1 Large punch and shears.
1 Bulldozer.
1 Rail saw.
1 Rail drill.
2 Rail benders.
1 Stamping machine for tin shop.
1 Bolt shearer.
1 Port miller.
3 Letter presses.
6 Pulling down jacks.
12 Car jacks.
2 Drawbar jacks.
3 Painting machines.
1 Washer maker.
3 Rivet holders.
2 Tube rollers.
8 Pumps.
1 Transfer table.
1 Driving wheel revolver used in setting slide valves.
30 Hoists in shop.
3 Hoists 10 feet lift outside.
1 Device for handling oil.
1 Hose coupling fitter.
1 Tool for tearing down old car roofs.
1 Drop pit.
1 Device for delivering sand.
1 Device for extracting oil from waste, etc.
1 Shunting locomotive (traction engine).
1 Device for securing sheets at flange fire.
1 Device for cleaning coach cushions.
3 Paint burners.
1 Whitewashing machine.
1 Device for handling work in brass foundry.
1 Turntable revolver.

Air is also used for testing brakes in the shop and yard, cleaning boiler flues, cleaning the shops and engines, and in self-moving dead locomotives from erecting to paint shop.

Although this makes a good showing for one set of shops, it is far from marking the limit of compressed air as applied in railway service to-day. It is used for moving crossing gates; track interlocked derailers; single semaphores and semaphores interlocked with switches and gates, and this, too, at points 18 miles away from the compressing plant; in timber preserving by injection; in moving capstans and winches for hauling and shunting purposes; in coaling locomotive tenders; in lifting their ashes out; in sifting, lifting and delivering sand to locomotives; in delivering sand to rail; actuating whistle signal; moving the rocking firegrate; opening the firehole door; ringing the bell, and perhaps the best known of all in actuating the continuous automatic brake. Also on other rolling stock for controlling snow-plow wings and aprons; ice flangers and scrapers; doors of dump and drop-bottom cars, and for tilting ballast cars; and inside shops for bending pipes; cleaning pipes from internal scale; testing pipes and their jointing; with gas jets for heating tires and other rings of metal; as a blowpipe for straightening bent wrought iron frames; for spraying fuel into oil furnaces; for belt shifting on countershafts; for machine brakes to stop tools at a definite point; for supplementing the wheel and axle hydraulic press; for axle box and journal press; with sand as sandblast for cutting and scouring; and for scrap shears and scrap tumblers at far end of yard where the noise is least annoying, and where there is ample space for scrap sorting.

DISCUSSION.

The Chairman. The Chairman said: You have before you this morning a paper of immense practical value from one who has for several years had practical experience in the use of air machines. The subject has been dealt with in very plain and simple language, which has placed before us the great advantages of air in the application of power to manufacturing purposes.

Mr. J. D. Barnett. Mr. Barnett said one of the items named in the appendix was that air was used for white-washing. Now, that may seem a very small business to bring before a body of learned men. Nevertheless, the whitewashing of a large shop 120 feet wide and 300 or 400 feet long, the point of its roof being 90 feet above the floor level, was an awkward and expensive job when done by hand under the old arrangement. The operation with compressed air on the other hand was very simple. The whitewash was made and run through a very fine sieve, three or four pounds of tallow being put with each barrel of whitewash, making a sort of emulsion. This was put into an iron barrel and the air pressure let in on the top. A pipe from below communicated with the hose, to which was attached a branch about 10 feet long, made of $\frac{3}{4}$ in. pipe, so as to give the operator great freedom of swing. The nozzle was rectangular; $2\frac{1}{4}$ or $2\frac{1}{2}$ inches wide, and barely 1-16 of an inch in depth. The natural result of allowing the whitewash to be delivered from such a nozzle of course would be to deliver it as fluid; but as it was necessary to deliver the whitewash in the shape of a spray, a small pipe was put in at the base of the hose to permit the air to enter, forming the central jet in the middle of what might be called the column of fluid whitewash, acting as an injector. That turned the whitewash into very fine spray. There would be no success if the whitewash was not turned into spray. Whitewash applied as described adhered with such tenacity to the windows, which by neglect were left uncovered, that it had cost 60 cents to clean each window in the shop. The whitewash held on to brick work with a very firm grasp indeed. The mixture consisted of lime and water with three or four pounds of tallow added when the lime was being slacked and mixed up. The presence of the tallow could scarcely be recognised in the whitewash itself, but it increased the tenacity greatly. In subsequent work the windows were protected from the spray by covering them with paper felt.

In using the pneumatic hand-hammer, the piston, as the speaker had called it for brevity, delivering about 2,000 blows per minute, the noise was somewhat unpleasant, especially when beading over the end of boiler tubes or when caulking boilers or riveting up a thin tank. Some inventions have been recently put on the market, claiming a speed of hammer going up to ten thousand strokes per minute. The author failed to see any advantage in the higher speed, and feared the noise would be increased, for blows delivered at that high speed on a tank or boiler or any structure of that kind would set the metal in vibration, giving a high, piercing note. The shrillness of the note made it very oppressive to the human ear; if therefore we could succeed in lowering the speed and doing as effective work, it would be in the direction of improvement.

Prof. Galbraith asked if any difficulty had been found in respect of the burning of the pipes. He imagined that that would be perhaps the hardest thing to overcome in connection with the economical use of compressed air. **Prof. J. Galbraith.**

Mr. Barnett was not familiar with experience elsewhere in reheating the air. His own only covered five months. So far he had had no trouble. The flame did not touch the copper pipe. The copper was just as thin as he could get it, so that it would turn into a 2 inch coil. He could not tell the thickness of the pipe, but it had not burned out, and it had suffered nothing from internal corrosion, but the BB burner did not give a great deal of heat. He only raised the temperature of the air about 40 degrees, which was nothing like what it was raised in Paris and other places where they have had long experience. The speaker's heating appliance looked like a common tin lamp. It was not taller than a water pitcher. There was scarcely any expense except making the coil out of the copper tube. The air was sensibly cold to the hand on entering the heating coil. You could just feel it nicely warm after leaving it. Its great advantage was that when the temperature was 20 below zero outside, the exhaust pipes and valves were not choked with ice. A great nuisance in trying to use these small motors extensively in a low temperature was the formation of ice; therefore, if for no other reason he would say: put a lamp on one of these small motors to get rid of that trouble, even if there were no thermodynamic advantage in its use. **Mr. J. D. Barnett.**

Prof. Galbraith said he thought it was to a great extent the same question as arose in connection with the use of superheated steam, that seemed to be coming in now. The avoidance of cylinder condensation **Prof. J. Galbraith.**

was a great object to be served by the use of superheated steam, and he thought the main objection to its use on any large scale had been this difficulty of the heaters having been burned out. He had seen compressed air used on a fairly large scale in mines, and there they had trouble with the choking of the exhaust with ice; the water carried in the air formed a coating of ice and snow at the mouth of the exhaust. The practice was to burn it off with oil waste, which was wrapped around the pipe occasionally, and fired. One could easily see that even if there was not much thermo-dynamic advantage, the convenience of a free exhaust would be very great. In mining, however, it was a great advantage to have a cold exhaust. He had been at points in mines where the air pipes had not yet been extended, and where the men were working almost naked. The atmosphere there was simply stifling, but when the compressed air drills had commenced to work, the air became just as clear and cool and agreeable as above ground. That was owing not only to the purity of the air, but also to its low temperature as it came from the drills. In mining that was an advantage, while above ground if we could only put back a part of the heat of compression that was lost in carrying the air to a long distance, not only would we have the convenience of a free exhaust, but also we would gain a great deal in efficiency. Mr. Barnett had very well pointed out the advantages arising from the use of compressed air. For many things it was one of the most convenient and useful ways of applying power, especially where any tools have to be used, having percussive rather than continuous action; where hammering of any kind has to be done and dies pressed, air seemed particularly suitable.

Mr. J. D. Barnett.

Mr. Barnett said one thought was suggested by what Prof. Galbraith has said,—the trouble realised in using higher temperatures in steam. It was really apart from the paper; but in locomotive practice, until quite recently, the maximum pressure was 140 lbs. to the square inch. Just about the time of the World's Fair there was a strong attempt made to increase the power and speed of locomotives, and being hampered at many points they thought the way to do it was by raising the boiler pressure; but the early attempts to raise the pressure to 170 or 180 pounds per square inch caused trouble, especially at the piston rods. That trouble seemed, with our present practice, to largely result from the fibre known as piston gland packing, and with the use of soft metal as metallic gland packing. There was practically no difficulty to-day in using steam pressures up to 200 pounds on the square inch. Beyond that, the metal suffers; but in locomotive practice, between the pressures of 140 and 200 it was the fibrous packing that was the practical difficulty.

Mr. Matheson said one remark made by Mr. Barnett was not in accordance with the speaker's practice. He says: "In hydraulic riveting, where the dead pressure can be held on the rivet while it is cooling, the amount of caulking required to finish and make a tight dry job is three or four times more than that usually required to make equally good an hand-riveted boiler." The speaker's experience had been precisely the reverse. He had known where a boiler, made by a pressure of 160 driven by hydraulic power, was almost absolutely tight without any caulking at all. The only care to be taken was to see that there was sufficient pressure on the machine when the rivet was being closed; for instance, when a $\frac{7}{8}''$ rivet was closed with a pressure of 45 or 50 pounds there would be a weak joint; but if the same rivet were closed with a pressure of 90 to 100 pounds, the result would be a tight joint and a tight rivet. He had found a great deal of trouble when the pressure put on the rivet was 45 or 50 pounds, but no trouble whatever when the pressure was increased to 90 pounds. Mr. W. G. Matheson.

Mr. Barnett said that he had had experience with locomotive boilers which he had made throughout by hand-riveting, and he had not tested them until they were mounted, placed in the frame, and the locomotive practically completed. He had never seen that done with a hydraulic-riveted boiler without giving endless trouble in caulking. It was just possible that the pressures were not heavy enough, or that the plates were not all drilled in position. He had known instances where having finished the boiler with hydraulic riveting, heating it up and caulking all defective points, the boiler after cooling would, on re-warming and again getting up pressure, be found to leak at other points that had not shown themselves on the first test. He could never thoroughly understand why that was, but he had known hydraulic-riveted boilers to have to be lighted up for the third time, and caulked and tried before a single mounting was put on it. Mr. J. D. Barnett.

Mr. Matheson said that the practice he referred to had been entirely with marine work and not on locomotives. Mr. W. G. Matheson.

Mr. Keeley thought a great deal of credit was due to Mr. Barnett for the way he had put his paper together, which made the whole matter very comprehensive. As to the noise of the hammers, if it were not for the cumbersomeness of the apparatus it might be possible to get such a high rate of vibration that the noise could not be heard at all. It was found, in connection with experiments to see how far transmission was possible across the Atlantic cables, by apparatus devised by Sir William Thomson, that after a certain number of vibrations noises were not producible at all. If Mr. Barnett could devise an apparatus Mr. D. H. Keeley.

for riveting boiler plates that would vibrate as rapidly as that, we would not have any noise at all. However, of course that would be impracticable. The use of pneumatic tubes in telegraph and newspaper offices was perhaps one of the prettiest applications of air pressure. In the C.P.R. Telegraph office in the Board of Trade building in Toronto, a very elaborate arrangement was being put in, which would not only force the dice-boxes up through the tube, but would also force them down again; a complete circuit of the whole building being made.

Prof. J. Galbraith. Prof. Galbraith exhibited one of the charts made in the School of Practical Science, showing the relation between the power expended in compressing air and the power given out again. The air was supposed to be compressed up to 100 pounds, taken at the average atmospheric, pressure, without re-warming, and just as it was used in the mine. The efficiency shown under these conditions was 55 per cent.

The meeting then adjourned until 8 p.m.

On Thursday afternoon, the Members, accompanied by some friends took the opportunity kindly afforded them by the Bell Telephone Company to examine the new building and telephone exchange. The thanks of the Society are due to Mr. K. T. Dunstan, Superintendent, and to Mr. J. A. Baylis, who conducted the party through the building and explained the various arrangements thereof. The Lozier Bicycle Company's works at North Toronto were afterwards visited under the direction of Mr. Thomas, Manager of the Works, the party having been conveyed to and from the works on special cars provided by the Toronto Railway Company over the tracks of that Company and also of the Metropolitan Railway Company.

EVENING SESSION.

Thursday, June 18th, 1896.

The meeting re-assembled at 8 o'clock, Mr. Macdougall in the chair.

The Chairman said the Society had received a large amount of courtesy and attention from members of societies and organizations in Toronto and its neighbourhood, and in the District of Niagara Falls, and he thought it nothing but right and proper that votes of thanks should be accorded to them.

The following resolutions of thanks were then passed:

Moved by Mr. W. J. Sproule, seconded by Mr. A. H. Smith, and resolved :—

"That the thanks of the Society are due and are hereby tendered to the Toronto Athletic Club, for so kindly extending the hospitality of the Club to the visiting members of the Society."

Moved by Mr. E. H. Keating, seconded by Mr. E. Marceau, and resolved :—

"That the thanks of the Society be tendered to the Niagara Navigation Company, for their courtesy to the Society in granting free transportation to the members from Toronto to Queenstown and return."

Moved by Mr. C. H. Mitchell, seconded by Mr. J. A. Duff, and resolved :—

"That the thanks of this Society be tendered to the Mayor and Council of the City of Toronto for their kind attention in placing at its disposal carriages and a steam yacht for tours about the city and harbour."

Moved by Mr. W. Kennedy, jun., seconded by Prof. C. B. Smith, and resolved :—

"That the thanks of this Society be tendered to the Superintendent of the Suspension Bridge Company, for his kindness in allowing members of the Society to pass over the bridge free of charge."

Moved by Mr. A. Rhodes, seconded by Mr. R. W. King, and resolved :—

"That the Canadian Society of Civil Engineers appreciates very highly the courtesy extended to it by the Niagara Falls and River Railway Company, in placing at its disposal a special train to convey its members from Queenstown to Chippewa, and it tenders to the Niagara Falls and River Railway Company its best thanks for the very effective arrangements made by the Company, which have added greatly to the pleasure of the visit."

Moved by Mr. R. Steckel, seconded by Mr. J. D. Evans, and resolved :—

"That the thanks of the Canadian Society of Civil Engineers be tendered to the Niagara Falls Hydraulic Power and Manufacturing Company, in appreciation of the kind invitation extended to the members to visit their extensive works, which have been carried out so successfully on the east side of the Niagara River, with a view of utilising a portion of the immense power afforded by nature at Niagara Falls for the benefit of mankind."

Moved by Mr. Wm. Kennedy, jun., seconded by Mr. E. Marceau, and resolved :—

"That the thanks of the Society be tendered to the Cataract Power Company, for their kindness in extending an invitation to members of the Society to visit their very extensive and interesting works."

Moved by Mr. Henry Smith, seconded by Mr. E. H. Keating, and resolved :—

"That the thanks of this Society be tendered to Prof. Galbraith, for his courtesy, thoughtful attention and invaluable assistance to its members during their meetings and deliberations on the occasion of this their first special general meeting in Toronto."

Moved by Mr. J. A. Duff, seconded by Mr. J. Hutcheon, and resolved:—

"That the thanks of this Society be tendered to the Canadian General Electrical Company, for their courtesy in extending an invitation to the members to visit their works at Peterboro."

Moved by Mr. R. W. King, seconded by Mr. C. B. Smith, and resolved:—

"That a vote of thanks be tendered to the Central Bridge Company of Peterboro, for the kind invitation to visit their manufactory."

Moved by Mr. E. Marceau, seconded by Mr. J. E. Belcher, and resolved:—

"That the thanks of this Society be tendered to the Owen Sound Cement Works, for the kind invitation to visit their works."

Moved by Mr. A. Rhodes, seconded by Prof. C. B. Smith, and resolved:—

"That the thanks of the Society be tendered to the Toronto Junction and Weston Street Railway Company, for their kindness in extending to the members the privilege of riding over their system while visiting the Lozier Bicycle Works."

Moved by Mr. C. B. Smith, seconded by Mr. C. H. Mitchell, and resolved:—

"That a hearty vote of thanks be tendered to the Lozier Bicycle Manufacturing Company of West Toronto, and particularly to its Manager, Mr. Thomas, for the courtesy extended to members of this Society in throwing open their works for inspection. The respect of the members for the wheel has been increased, and their admiration for this late addition to the triumphs of mechanical skill has been excited by this visit."

Moved by Mr. J. D. Evans, seconded by Mr. James Hutcheon, and resolved:—

"That the sincere thanks of this Society are due and are hereby tendered to the Toronto Railway Company, for the very pleasant outing afforded the members in the shape of a street car ride to the works of the Lozier Bicycle Manufacturing Company and return trip through the streets of the city."

Prof. C. H. McLeod then read the following paper on the Discharge of the St. Lawrence River:—

Paper No. 115.

THE DISCHARGE OF THE ST. LAWRENCE RIVER.

By PROF. C. H. McLEOD, MA.E., M.CAN.SOC.C.E.

The extreme low water of the St. Lawrence in the autumn of the past year called especial attention to the variations in the discharge of the river, and it seemed to the writer to be a matter of no small importance to obtain a measurement of it at the exceptionally low stage existing in the early part of November.

From inquiry made at the time, it was learned that it was not the business of anyone in Canada to gauge the St. Lawrence, and that the only measurement ever made below Montreal was that by Mr. W. J. Sproule, M.Can.Soc.C.E., under the direction of the Montreal Flood Commission, in 1886. Having in view the interest of a measurement at this special time, and as the work happened to fall into line with one of the courses of Surveying lectures then in progress in McGill College, the writer induced some of the students of the University to undertake the work under his direction, assisted by Prof. C. B. Smith, M.Can.Soc.C.E., and Mr. J. G. Kerry, A.M.Can.Soc. C.E. The Hon. G. A. Drummond very kindly placed his private yacht at the disposal of the college for the purpose, and Mr. Frank Redpath gave up two days of his valuable time to take charge of the yacht during the work.

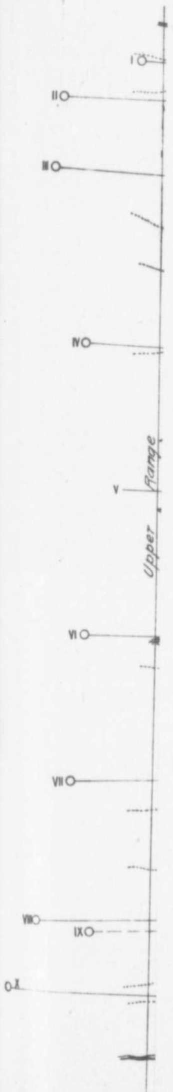
The position chosen for the gauging is situated about forty miles below Montreal, its upper limit being approximately 6,200 feet below the wharf on the north shore of the river, at Lanoraie. This choice was made not only because it is the position best suited for the work within easy reach of Montreal, but also chiefly for the purpose of comparison with Mr. Sproule's work, the position being that in which his measurements were made.

It was intended that the gauging should be made during the first week in November, but owing to unavoidable circumstances it had to be postponed, and was not made until the 13th and 14th of the month. Reference to diagram No. 11 will show that the lowest water levels in 1895 occurred on Oct. 28th, Nov. 2nd and 7th. On the first day of the measurement, Nov. 13th, the water level was seven inches above its lowest point, and it rose three inches while the work was in progress.

For a mile or more both above and below the gauging area, the river runs a straight course and has a very uniform cross section. Over this distance also, the levels which were taken under the direction of the Flood Commission in 1886 showed a constant surface slope.

In order that the measurements might be entirely comparable with those of Mr. Sproule, similar methods to those employed by him were adopted. The velocity observations were made on rod floats immersed to the greatest possible depths. In the reduction of the work, the observed velocities were corrected by reference to a vertical velocity curve obtained from measurements with an electrical current meter, by Amsler. see page 132. The rods were of uniform section, and were loaded with lead weights within tin cylinders, having the same section as the rods. The immersed depths of the rods, as will be seen on the accompanying plate No. 10, ranged from 6 feet to 42½ feet. The average velocities were obtained from the times of crossing of the two ranges, and were checked by the velocities between the stations along the lines, the positions of which were fixed by box sextant angles to points on the shore. All data as to soundings were, through the kindness of Mr. John Kennedy, taken from the plans of the Montreal Flood commission.

The plate No. 8 shows the contour lines of the river bottom and shore lines for the length of 3000 feet, over which the float observations were made. It shows also the courses of the several floats, with their observed velocities and the immersed depth of each float. The plate No. 9 gives similar information for Mr. Sproule's measurements. The plate No. 10 shows the average cross sections for the entire length of 3000 feet. The upper section refers to the work in 1886 and the lower one to that in 1895. The mean position and lateral range of each float is also represented on the diagrams. The dotted lines below represent the most probable velocity curves resulting from the observations. In both cases the plotted velocity curve is that which results from the float observations, after applying the small correction due to depth of immersion, as compared with the average depth of the water along its path. This method of reduction gives, of course, slightly smaller values than those arising from the observed velocities, and the discharge as here computed for 1886 is somewhat less than the official figures of the Flood Commission. The area of the cross section in 1886 was 115,298 square feet, and the discharge 311,101 cubic feet per second. The area of the 1895 cross-section—when the water was one foot nine inches below official low water—was 105,432 square feet, and the discharge amounted to 216,621 cubic feet per second. At the period of lowest low water in 1895, in which the water level was, as


I
II
III
IV
V
Upper Range
VI
VII
VIII
IX
X

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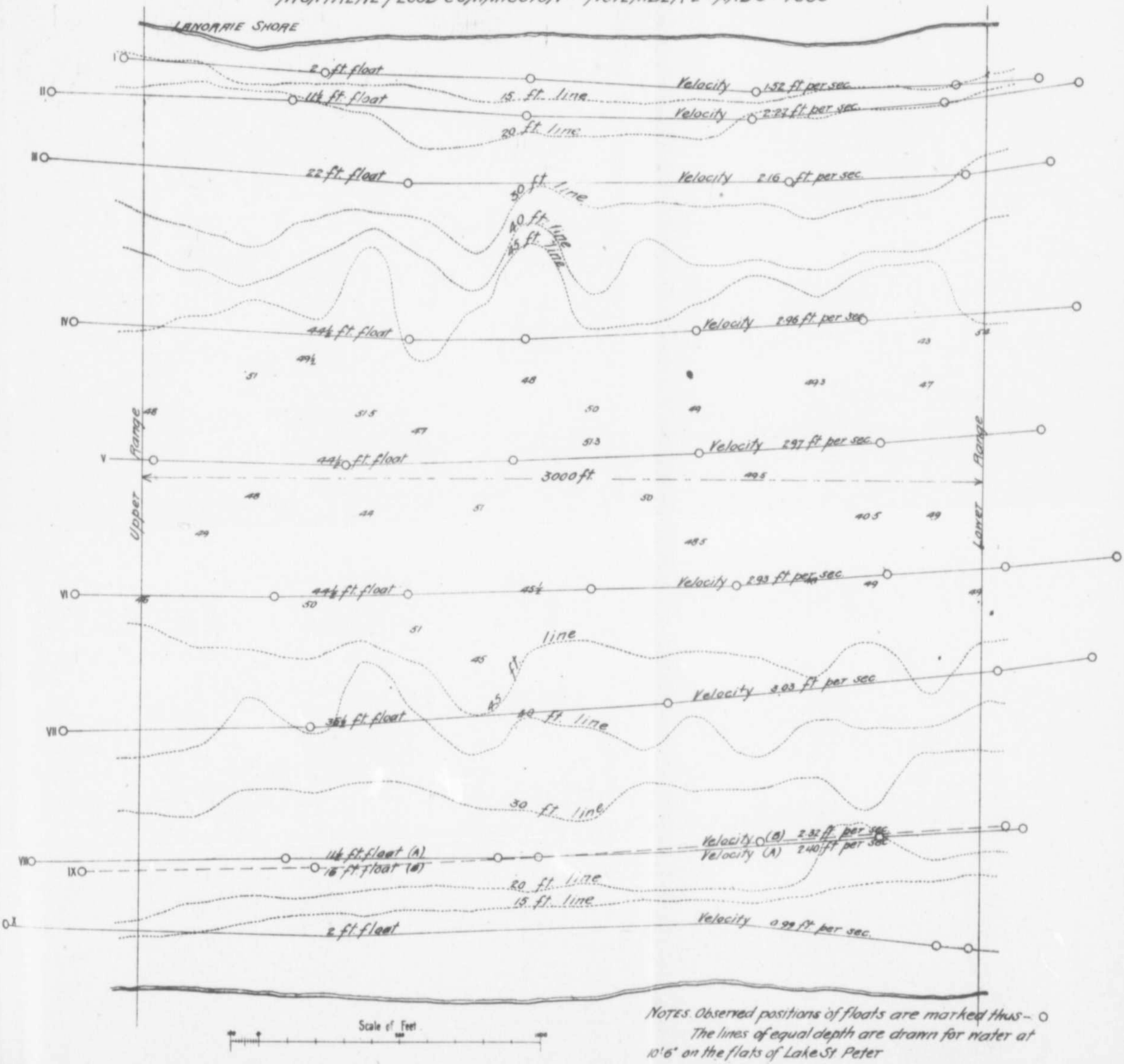
THE DISCHARGE OF THE S^T LAWRENCE RIVER

PLAN SHOWING FLOAT LINES AND LINES OF EQUAL DEPTH

MONTREAL FLOOD COMMISSION – NOVEMBER 2^ND AND 3^RD 1886

C. H. M^c LEOD



NOTES. Observed positions of floats are marked thus – ○
The lines of equal depth are drawn for water at 10' 6" on the flats of Lake St Peter

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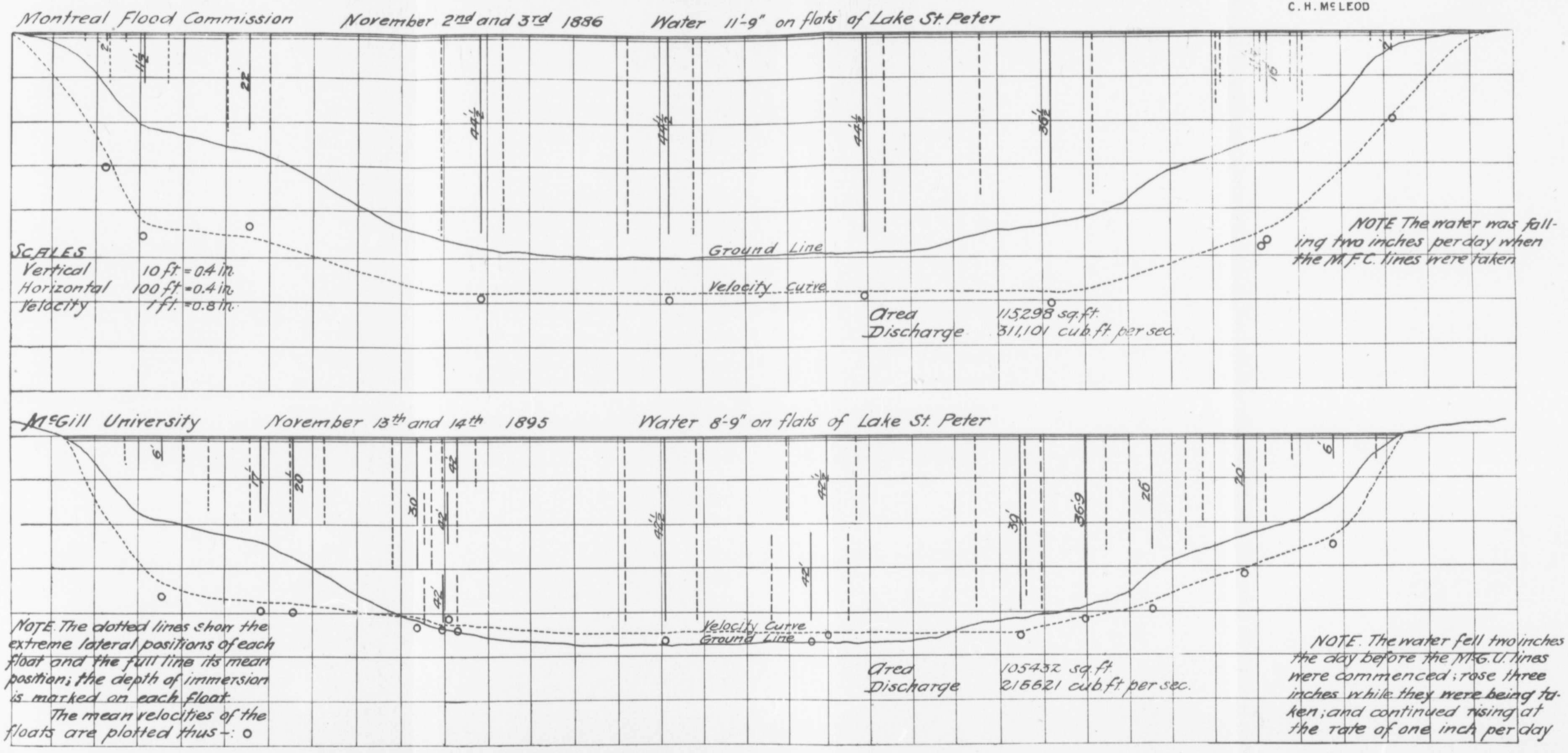
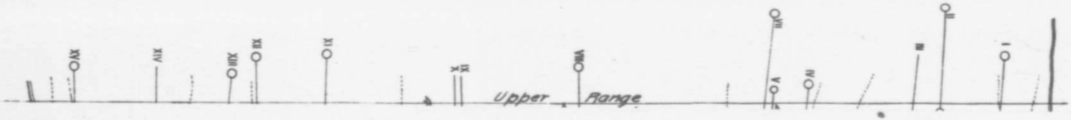
THE DISCHARGE OF THE ST LAWRENCE RIVER

AVERAGE CROSS SECTION SHOWING LATERAL MOVEMENT OF FLOATS AND ESTIMATED CURVE OF MEAN VELOCITIES

C. H. McLEOD





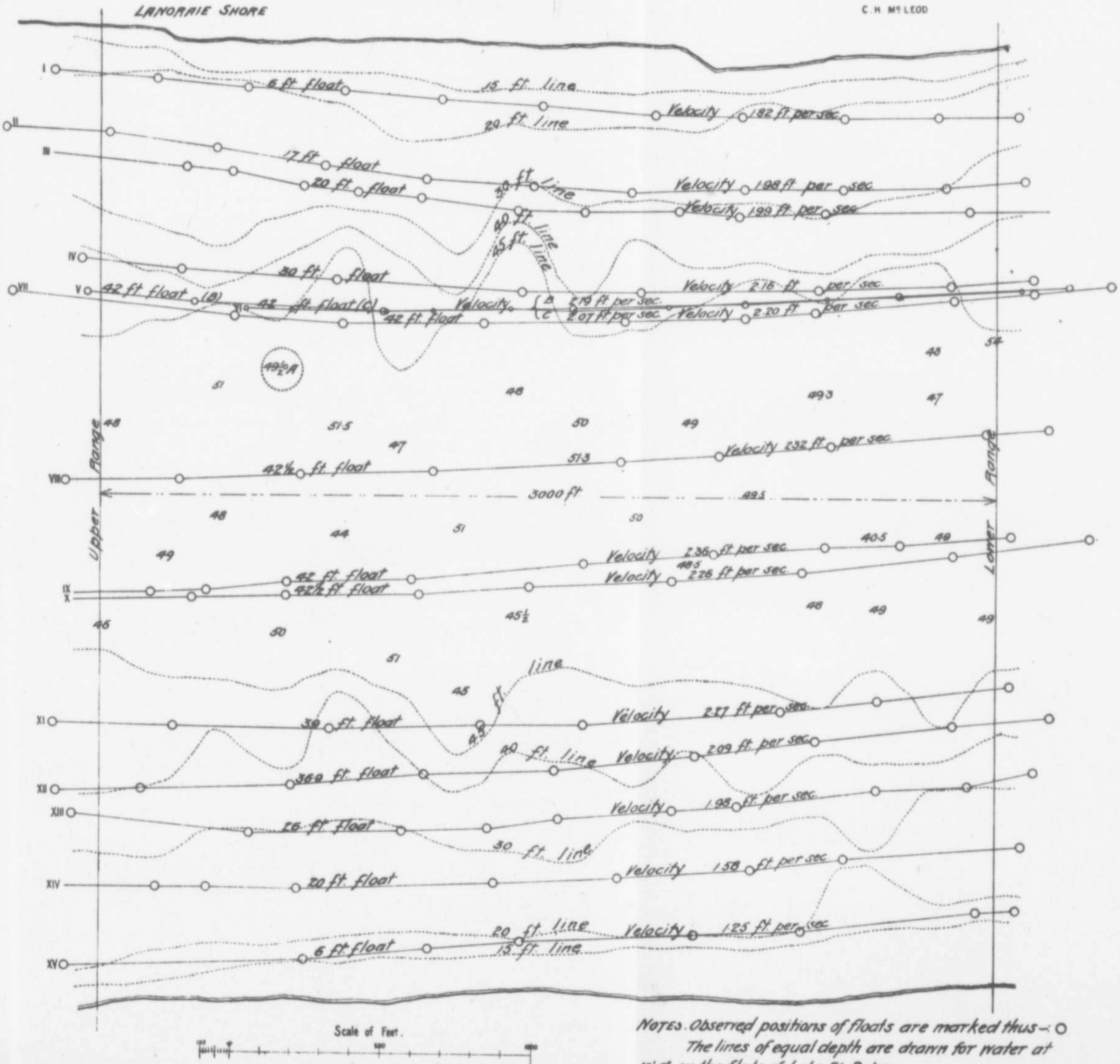
Upper Flange

TRANSACTIONS CAN. SOC. C. E.
VOL X., PLATE 8.

THE DISCHARGE OF THE S^T LAWRENCE RIVER

PLAN SHOWING FLOAT LINES AND LINES OF EQUAL DEPTH

McGILL UNIVERSITY – NOVEMBER 13TH AND 14TH 1895



NOTES. Observed positions of floats are marked thus –: ○
The lines of equal depth are drawn for water at 10'6" on the flats of Lake St. Peter

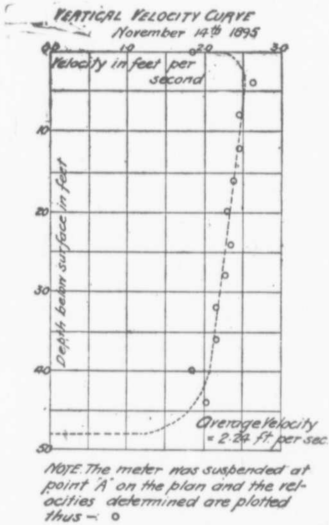
nearly as can be ascertained, two feet seven inches below official low water, or corresponded to a depth of seven feet eleven inches on the flats of Lake St. Peter, and 24·9 feet minimum depth in the navigable channel of the river, the cross section was reduced about two per cent. below that of Nov. 13 and 14, 1895. Assuming that the discharge of the river varies proportionally to the area of the cross section, and taking as data the results of the measurements above given, the discharge at the lowest water stage of 1895 amounted to about 196,000 cubic feet per second.

Referring now to the degree of accuracy which should be expected in work of this kind, the positions of the lines I, III, VII, VIII, X, XI, XIV and XV, Plate No. 8, will be found to accord somewhat closely with those upon which the 1886 discharge depends. The additional lines in groups near to some of these afford an excellent means of estimating the limits of precision of such measurements. The lines V, VI and VII were practically in the same position and the rods were all immersed to the depth of 42 feet, yet there was a difference in the average velocities of two of the rods of 13–100ths of a foot per second, amounting to over six per cent. of the whole velocity. The two lines which show the extreme velocities 2.07 feet per second and 2.19 feet per second were run within a few minutes of each other and under precisely similar conditions, on the morning of the second day of the work, with a strong wind blowing at right angles to their directions, whereas No. VII was run on the previous day during very calm weather. It is perhaps worth noting that although about 10 per cent. of the length of the poles projected above the water surface, there was no appreciable drift in the lines.

A similar, but not quite so great discrepancy occurred in the velocities of the rods IX and X. There the difference amounted to about 5 per cent. of the whole.

The writer cannot but confess to some surprise that under conditions so very favourable to uniform motion in the vertical filaments of water, such great discrepancies as these should be found.

In the diagram on next page, the vertical velocity curve resulting from the measurements by meter at the position marked (A) on the plate 8 is exhibited. The velocities at the several depths are the averages of two independent measurements extending over about three minutes each. The velocities at the surface and at the 4 feet depth are discordant, owing to their proximity to the yacht. Similarly, the variations in the wo lower positions arise probably from deflected currents due to irre-



gularities in the bottom. The average velocity given by the curve agrees very closely with that which would be obtained from a float passing through this position. Owing to lack of time it was impossible to obtain more than one set of measurments, and this curve has been taken as a typical one in the reduction of the work.

Great difficulty has been experienced in this work in ascertaining definitely the elevation of the water, owing to some uncertainty as to the setting of the Sorel gauge and also as to the reading on it which corresponds to low water. The gauges should of course be referred to permanent bench marks, which have themselves been established from an accurate line of levels referred to one datum plane. The bench marks in connection with the Montreal Flood Commission were not intended as permanent points of reference, and some of them, notably that at Sorel itself, is unfortunately unreliable. Lines of levels have been run on both banks of the St. Lawrence by Mr. Steckel of the Department of Public Works, but the author is not aware that the gauges have been established in connection with these.

Plate No. 11 gives the relative water levels in 1886 and 1895 as nearly as the writer has been able to obtain them. There is, however, an uncertainty amounting to about 10 inches.

TRANSACTIONS CAN. SOC. C. E.
VOL. X., PLATE II.

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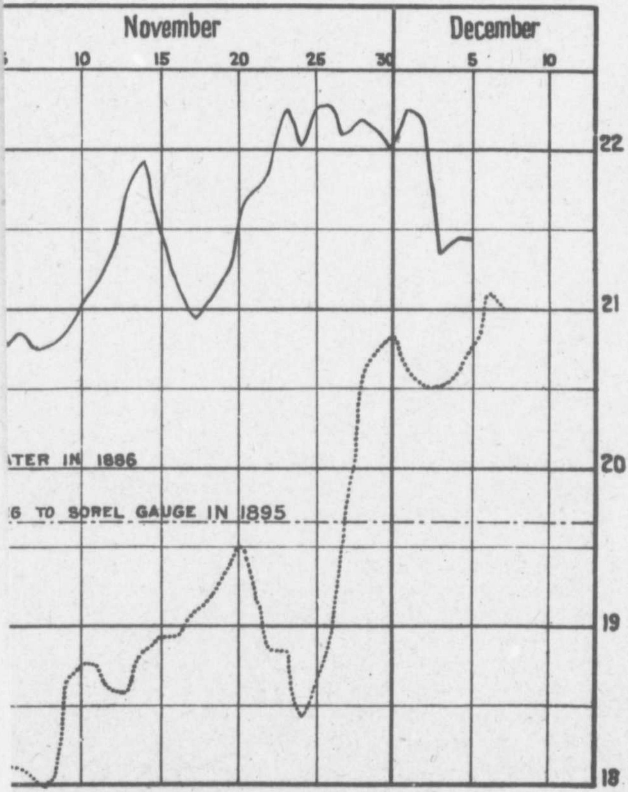
C. H. McLEOD

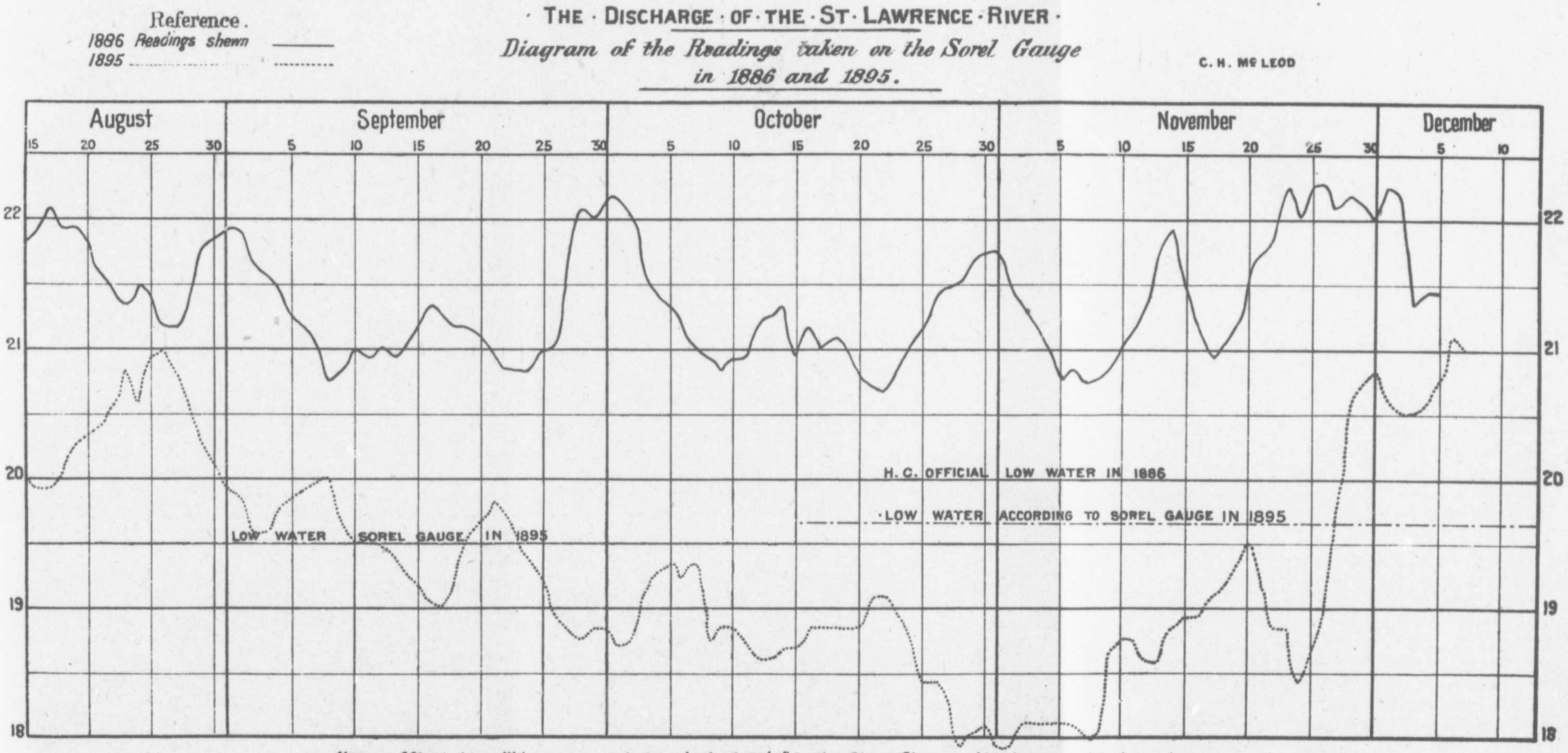


sed to be equivalent

THE · DISCHARGE · OF · THE · ST · LAWRENCE · RIVER ·

Diagram of the Readings taken on the Sorel Gauge in 1886 and 1895.

C. H. McLEOD



NOTE. – Official Low Water corresponds to a depth of 27'·6" in the Ships Channel which is supposed to be equivalent to 10'·6" on the flats of Lake St Peter.

The great question of the causes which lead to so phenomenal a low water period is one which the author has at present not had time to discuss. He is, however, glad to state here that it has recently been the subject of a paper by Mr. Stupart, director of the Meteorological Service, an extract of which referring to the low water period under consideration may perhaps be quoted :—.......................................

....." We can now see why Lake Huron is so decidedly low, it is due to Lake Superior having been low for some years until 1894, combined with the effect of an abnormal deficiency of rainfall from 1887 to 1895, excepting the years 1892 and 1893. At the beginning of this same period in 1887, Lake Ontario was high, but two years of exceedingly small rainfall rapidly lowered the level. In 1889 and 1890, the rainfall was above average, and temporarily checked the fall which would have resulted from the low water in the Upper Lakes ; but in 1891, a marked deficiency of precipitation brought a very low winter stage. Two years, 1892 and 1893, of above average rainfall now improved the level a little, but the deficiency of rainfall in 1894 and 1895, and particularly in the latter year, in conjunction with the effect of a small intake of water by the Niagara River, doubtless produced the almost phenomenally low stage of the past year. I believe that these facts are amply sufficient to explain the present state of affairs....................

..................In view of these facts it is quite unreasonable to suppose that Lake Ontario will, this year or even next year, attain a high stage, the increase is likely to be gradual. Lake Superior is, as we have seen already, high ; this will help to raise the level of Huron, which lake will rise if the rainfall be even up to the average, and then with an improving head of water in that lake, and consequently in Erie, the flow by the Niagara will improve and assist in raising the level of Ontario ; but with so many factors to be considered, it is impossible to predict with any certainty how long it will be before a really high stage is again reached."

DISCUSSION.

Mr. R. Steckel. Mr. Steckel asked if the discharge of the St. Lawrence at one time was only 196,000 cubic feet?

Prof. C. H. McLeod. Prof. McLeod replied that, based upon the two measurements made, that was computed to be the discharge at the time of the most extreme low water last autumn.

Mr. R. Steckel. Mr. Steckel could not see how the proper discharge of the St. Lawrence could have been arrived at in the vicinity where it was taken, because the tide affected the water from the river very much farther up than that point. He had measured the St. Lawrence in the vicinity of Coteau Landing, above the head of the canal, and had calculated that at the lowest water the discharge would be about 277,000 cubic feet.

Prof. C. H. McLeod. Prof. McLeod asked what date was that?

Mr. R. Steckel. Mr. Steckel said of course it had never come to light in any report. He thought it was somewhere about 1877. He did not mean to say that the St. Lawrence could not fall any lower than what was supposed to be low water at that time; it has fallen considerably lower; still, he did not believe that the exact discharge of fresh water could be obtained at the point where it was measured because of the tide. Sometimes the water was set back, the current diminished, and the water raised perhaps a foot or a foot and a half; at other times, when the tides were losing tides, the water went down a foot and a half perhaps, or more; so that that was not the place to obtain the discharge of the river proper.

Mr. W. Kennedy. Mr. Kennedy asked: do we understand that the river was affected a foot by the tides at that point?

Mr. R. Steckel. Mr. Steckel replied yes, and more than that. He knew that by his own measurement. Not at once, but in a fortnight, a foot or a foot and a half. When the tides were gaining, the river rose, and when they were falling, it went down sometimes two or three inches at a time, sometimes less, so that it was impossible there to find the exact discharge of what might be called purely river water. The other water was just simply tide water that was backed up, and then part of it went down. There was always more or less tide water stirred up in that vicinity, even as far as Montreal, but of course very little as far as Montreal was concerned. As to the Sorel gauge, he did not see how that could be disturbed. The author was quite right in recommending that all the gauges should be referred to permanent bench-marks, and that has not been done heretofore. We should have one datum for the whole of Canada,—that is, the mean level of the sea, and we should not be dependent on the United States for the level of the sea, which is different from that of the St. Lawrence.

Mr. Kennedy asked if Mr. Steckel could give any idea as to the difference in the surface level at the point where he measured the discharge at the time of his measurement and at about the time that Prof. McLeod made his measurements? Mr. W. Kennedy.

Mr. Steckel said he could not from memory. He thought it corresponded to 16½ feet at the mitre sill in Montreal. He meant the reduced discharge as calculated for that level was about 277,000 cubic feet. The water was not at that level when he measured it, but he reduced it to that level, which was considered to be the ordinary low water of the time. Mr. R. Steckel.

Mr. Kennedy asked what was the actual quantity observed? Mr. W. Kennedy.

Mr. Steckel said he had not kept the figures in his mind. Mr. R. Steckel.

Mr. Sproule said the water fell last year to 13 feet 3 inches on the sill, which was three feet below what has been called low water. The lowest that occurred for fifty years was 14 feet 11 inches on the sill. That occurred only once and 15 feet 5 inches twice,—1879, 1881. Before that the record was about 16 feet, and the low water taken for the finishing of the ship channel in 1888 was 16 feet 4 inches on the sill. 17 feet had been taken until late years as the ordinary low water of the St. Lawrence; but last year was extraordinary. The three heights referred to were quite exceptional. Last year's record caused a new water level to be taken for the St. Lawrence in the work of the present year. The conditions at that stage of the river seem to be different from what they are at ordinary low water: for instance, at the stage of 16 or 17 feet on the sill the water appears to fall in nearly parallel lines up to Montreal. That is, the mean water, because, as Mr. Steckel had said, the tides exert a certain influence on the river. The water, however, does not rise as a tide; the rise is not perceptible as a tide above Point du Lac, about thirty miles below Sorel. There the tide amounts to about three inches, but at high tides only, and it is lost in Lake St. Peter, which is about twenty miles long. At the head of Lake St. Peter he did not know whether it would be perceptible or not. It might if carefully observed, but for ordinary observation it disappears in Lake St. Peter; but as spring tide approaches, the water is to a Mr. W. J. Sproule.

certain degree kept back, and the general level of the river remains up at Sorel a little higher than it does at the low water stage. Still, he did not see how that could affect the observations of the discharge so materially as Mr. Steckel seemed to think. As he had already remarked, it was observed in digging the ship channel that the water appeared to fall along parallel lines at the 17 feet stage. But when the river reached the very low stage of last year, the fall in Montreal harbour at the foot of Lachine canal was found to be greater than the fall in the river at Pointe aux Trembles, twelve miles below. Much of this difference is likely due to local change of gradient in St. Mary's current, caused by dredging in that vicinity, but possibly the general slope of the river between Montreal and tide water is appreciably less at extreme low water than at ordinary low water. As to the levels on the St. Lawrence, Mr. Steckel's are the only systematic levels that have ever been taken. The Flood Commission levels were carefully and fairly well taken, but on the ship channel work, on which the speaker was engaged during a great part of the work, it was not important whether the river fell a foot in the mile or three feet in the mile ; what was wanted was to get the level for the vessels at every stage. There was no profile of the river taken ; it was not wanted. At the same time, the speaker thought if the same liberality had been extended to the profession of engineering that there has been to other professions, there would have been a good profile of the river taken. The information is at hand which will establish the 16 feet 4 inch stage on the sill, and can be referred to. He had established the gauges himself from Montreal down to Lake St. Peter; all except at Sorel. It was done in a thorough enough manner for all practical purposes, not for philosophic purposes. The gauges were set at a great number of places ; they were four or five or six miles apart, and were observed for a long time. These gauges were set opposite permanent bench-marks and the observations were taken, the profiles were platted and the gaugings were compared, and the low water level at that part of the river established ; that is, that the water surface, we will say at Pointe aux Trembles, would be a certain elevation on that bench-mark when it was 16.4 on the sill at Montreal and when it was 20 feet at Sorel. These bench-marks are in existence yet and can be compared. They had, however, no reference to one another, and he thought it desirable that they should be connected, for a discrepancy came up last year, which produced a great deal of misunderstanding and some inconvenience. He thought Mr. Steckel was not right in saying that the discharge of the St. Lawrence could not be so small. The conditions have so entirely changed from any ordinary conditions that the discharge may have been a great deal lower than any previous record. It does look remarkable of course that a fall of something like three feet in the river should reduce the discharge by nearly one-third. The speaker had a great deal of faith in the method of floats. He would believe more in the discharge of the St. Lawrence as measured by a good system of float observations than he would in anything short of the most elaborate system of metre observations. It must be remembered that the St. Lawrence is an immense river, and there are in it surges as it were; and if the track of one float over that 3,000 feet were taken now, and taken accurately, he believed it might change materially inside of fifteen minutes, because of oscillations or pulsations in the flow. One could observe different conditions of the river at different times,—in fact, the practical ship-pilot and tug men pretend to observe these themselves. Whether these are so large as to make such observation possible or not, the speaker thought they were large enough to account for the apparent discrepancy in the time of the two lines of floats drawing 43 or 44 feet of water and extending above the water a foot or two, with perhaps only a foot or a foot and a half of water under them. You take the time accurately when they pass the two limits, and you get a pretty fair estimate of the average velocity; but of course the precision of the work depends on the elaborateness of the observations. The more floats you use, the more accurate the results. Currents vary a great deal from shore to middle of river, and it becomes somewhat difficult to get the mean velocity, but in that part of the river the circumstances are well adapted to observation by floats; perhaps there are few rivers where there could be found such suitable conditions. The river is deep in proportion to its width, 40 to 44 feet deep, and about 3,300 feet wide, and almost perfectly straight, and the cross-section much the same above and below. The variations before referred to occur gradually and with great uniformity.

Mr. Steckel would observe the discharge by both methods, so that the one would check the other. He did not remember how far apart his observations were made, but as to depth they were every five feet. It was nearly twenty years ago. Of course a difference of three or four feet would make a considerable difference in the flow; but he did not see how it could make that difference. Three or four feet on an average depth of 40 or 42 feet would not make that much. **Mr. R. Steckel.**

Mr. Sproule said it seemed to diminish the velocity very much. **Mr. W. J. Sproule.**

Mr. R. Steckel. Mr. Steckel said it diminished the velocity, but not at that place very much, because, as far as he could see, the mean level of the sea at the gulf affected the level back about as far as the foot of the Lachine Canal at Montreal, so that there would always be some water there that was in a quiescent state; not exactly that, but there was always some back water anyway.

Prof. C. H. McLeod. Prof McLeod said he understood that Mr. Steckel had only made one measurement.

Mr. R. Steckel. Mr. Steckel replied, only one measurement of the St. Lawrence.

Prof. C. H. McLeod. Prof. McLeod asked: And upon that measurement, which was at a higher or lower level than the official low water, 17 feet on the mitre-sill, a computation was made referring from one height to the other, was that it?

Mr. R. Steckel. Mr. Steckel said, exactly.

Prof. C. H. McLeod. Prof. McLeod.—What was the difference in height, did Mr. Steckel remember?

Mr. R. Steckel. Mr. Steckel said he could not say that at present.

Mr. W. J. Sproule. Mr. Sproule said he would like to draw attention to the extremely small fall in the St. Lawrence below Longueuil, below the St. Mary's current. The average fall below Sorel and Longueuil is 1⅓ inches to a mile. The speaker believed the tides did affect it right up to Montreal where the rapids came in; but it would not be perceptible with anything else than gauge readings. On that account he did not think there could be anything like piling the water together that Mr. Steckel referred to, because it was known from observations in the spring when the jam occurred that the water would rise four feet in fifteen minutes, so that if there is anything like a stoppage of the current owing to the backing of the tide it would make an appreciable difference in the time of a float going through 3,000 feet, it would jump right up; but it did not appear that the discharge could vary so rapidly.

Mr. E. H. Keating. Mr Keating said this was an exceedingly interesting subject, and especially to Members of the Society residing in Toronto, because whatever the elements were which affected the level of the St. Lawrence, it might be taken for granted that the same elements affected the level of Lake Ontario. Last year the levels here were lower than they had ever been known before, so far at least as recorded in the Engineer's office. He was sorry that Prof. McLeod had not extended his observations further, and given us the result of further enquiry, and he hoped the matter would be further looked into by all engineers. He noticed that the American Government had some engineers looking into the question, and also that the Department of Public Works were contemplating some further investigations. Of course there were practical questions hinging on the levels of the lakes in reference to the St. Lawrence that it was necessary that engineers should study, and study a little carefully. It seemed to him that there was one element the author omitted in dealing with the height of the water. He was not sufficiently acquainted with the St. Lawrence and what has been done by the Government during past years; but he understood for a year or two years past the channel of the St. Lawrence, the outlet from Lake Ontario, had been deepened from year to year and widened very considerably, so as to improve the depth of water between Montreal and Kingston. Now, if that has been going on for a number of years, it may be one very important element in this question of the lowness of the lake, not only the lake but the river itself, taken in conjunction with the low rainfall, which may not in itself be altogether sufficient to account for the low state of the lake and river.

Mr Steckel said the current was very rapid where the improvements have been made, and he did not think what has been taken out there would make any very great difference. Mr. R. Steckel.

Prof. Smith said there were one or two little points of interest which might be mentioned. One was that the change in the height of water affected the velocity so rapidly, as shown by the velocity curve on plate 10, as to make the change of discharge vary as about the fourth power of the change of area. That would probably answer Mr. Steckel's question as to the great change of discharge produced by the slightly lower water. The other point was that Prof. McLeod spoke of the close correspondence of metre measurements with float observations which occurred here; and the curve on the small plate would show the close correspondence, that is, the velocity near the surface was maintained almost uniformly down to the bottom; but on observations that Prof. McLeod and the speaker had made last year in the Richelieu River, which is a much smaller river, the current velocities taken by floats did not correspond nearly so closely to those taken with the current metre. The thought struck him that perhaps some would be led to think that float observations were quite accurate in all classes of rivers, whereas it was probable that though they would be quite accurate in a river of steady flow like the St. Lawrence, float observations in rivers of only 8 or 10 feet in depth, where the poles could not safely be put down within a couple of feet of the bottom, that the inaccuracy of taking measurement by floats in small rivers would be much greater. Prof. C. B. Smith.

Prof. C. H. McLeod. Prof. McLeod, replying to the discussion, said in reference to the question asked by Mr. Keating, the investigations made by the U. S. Government Engineers in connection with the effect on the upper waters of the deepening of the Galops Rapids would answer that very fully. There was no appreciable effect in consequence of the increased depth of the channel. With regard to Mr. Steckel's criticism, he pointed out that it would be quite impossible to say what the discharge of a given river would be from a measurement at one stage of the river as referred to another stage, unless there had been a complete study of the river in question. No theoretical consideration could apply unless one knew something of the river itself. The estimate which has been given of what the discharge would be at the extreme low level reached last year was intended to be very approximate, and was based entirely on the observations at the two stages. The possible influence of the bi-monthly tidal effect upon the discharge one could scarcely conceive to be of very great extent, not at least as compared with the possible errors of observation, because if such existed, within the limits of observation, the hydraulic gradient would necessarily be altered. He did not believe that any tidal effect would alter the hydraulic gradient appreciably over the distance in question. The matter which Prof. Smith had referred to was a very interesting one, and possibly more pains should have been taken to point out that in the case of the St. Lawrence, where there was such a very large river and such a uniform flow, that float observations might be expected to conform very closely with properly conducted metre observations; but in the case of the currents in the Richelieu, where a series of cross-sections were taken across the river, the curves varied very greatly in character, and showed quite clearly that an accurate measurement of the discharge could not be made by float observations. As the floats could not safely be made more than one-half or at the most two-thirds the depth of the water, on account of the rocky character of the bottom, the vertical curves showed that the results obtained by floats would be much too large.

The Chairman. The Chairman said he was sorry to close the discussion, because the question was exceedingly important; but in view of the late hour, and the members having to get up early to-morrow morning to leave on the Niagara excursion, he would now call on Prof. Duff to read Mr. Fortier's paper on " The Storage of Water in Earthen Reservoirs."

Prof. J. A. Duff. Prof. Duff suggested that as the paper comprised seventeen printed pages, it would be well for the meeting to consider it taken as read, if that course was in accordance with the rules of the Society.

The Chairman said it would be for the meeting to consider whether at this late hour they would be able to give the paper that consideration in discussion which it undoubtedly deserved, and whether it would not be better to defer the reading till the next meeting. He would not take the paper as read. The next regular meeting would be in October. The Chairman.

Mr. Keating moved that the reading of the paper be postponed till the next meeting of the Society. Prof. Smith seconded the motion, which was carried. Mr. E. H. Keating.

The meeting was then closed.

Special Meeting, Friday, June 19th, 1896.

A special meeting of the Society was held on board the steamer "Chippewa" at 7.30 p.m. (between Queenstown and Toronto), on Friday, June 19th, 1896, Mr. W. G. Matheson, Member of Council, in the Chair.

The meeting having been called to order, the following resolution was proposed by Mr. W. J. Sproule of Montreal, seconded by Mr. H. A. F. MacLeod of Ottawa :—

"That a vote of thanks is due and is hereby tendered to members of the Society resident in Toronto and vicinity, and especially to the Toronto Executive Committee of the Summer Meeting of 1896, for their hearty welcome to visiting Members, for the excellent arrangements made for their comfort and enjoyment, and for the untiring energy exhibited in carrying these arrangements to a most successful accomplishment."

The motion was supported by several of the Montreal and Ottawa members, and was carried unanimously with much applause.

Messrs. Macdougall, Rust and others, representing the Local Committee, spoke, acknowledging the vote.

Mr. Fleming, Mayor of Toronto, who was a guest of the local committee on board the steamer, then asked leave to address the meeting, and expressed his pleasure at meeting the Society and extended a cordial welcome to the Society to again visit Toronto at the earliest possible date.

On motion by Prof. McLeod, seconded by Mr. Sproule, a special vote of thanks was given to the Mayor, for his personal efforts in promoting the pleasure and interests of the Society during its visit in Toronto.

The mover explained that a general motion of thanks had been passed at the meeting of the Society held last evening, but that the

Mayor himself had contributed so much to the pleasure of the meeting that he could not let this opportunity pass of emphasizing the special obligations under which the Society stood to his Worship.

The motion having been put and carried unanimously, Mr. Fleming replied in a brief speech.

On motion by Mr. Wm. Kennedy, jun., of Montreal, seconded by Mr. D. H. Keeley of Ottawa, a special vote of thanks was accorded to Mr. W. T. Jennings, as Chairman of the Local Committee.

On motion by Mr. A. Rhodes of Quebec, seconded by Mr. E. Marceau of Montreal, the thanks of the Society were also specially tendered to Mr. Rust as Secretary of the Local Committee.

Mr. D. H. Keeley of Ottawa, seconded by Prof. McLeod of Montreal, moved that the Society takes this opportunity of reiterating the special obligations under which it stands to the Niagara Navigation Company, and its appreciation of the very great courtesy and kindness extended to the members of the Society by Captain Foy. Captain Foy having acknowledged the resolution, the meeting was adjourned.

The following members were in attendance at the meeting:—

J. D. Barnett, Stratford, Ont.
A. B. Barry, Toronto.
J. E. Belcher, Peterboro, Ont.
H. J. Bowman, Berlin, Ont.
A. Brittain, Montreal.
A. W. Campbell, Toronto.
C. H. Chapman, Toronto.
W. A. Clement, Toronto.
Wm. Mahon Davis, Woodstock, Ont.
J. A. Duff, Toronto.
J. D. Evans, Trenton, Ont.
J. Galbraith, Toronto.
C. E. Goad, Toronto.
Henry A. Gray, Toronto.
Col. Sir C. S. Gzowski, Toronto.
O. Higman, Ottawa.
J. Hutcheon, Guelph, Ont.
W. T. Jennings, Toronto.
E. H. Keating, Toronto.
D. H. Keeley, Ottawa.
Jas. H. Kennedy, St. Thomas, Ont.

W. Kennedy, jun., Montreal.
N. J. Ker, Toronto.
R. W. King, Toronto.
Alan Macdougall, Toronto.
H. A. F. MacLeod, Ottawa.
C. H. McLeod, Montreal.
E. Marceau, Montreal.
W. G. Matheson, New Glasgow, N. S.
C. H. Mitchell, Niagara Falls, Ont.
J. A. Paterson, Hamilton, Ont.
W. R. Pilsworth, Toronto.
Carl Reinhardt, Montreal.
A. Rhodes, Quebec.
Geo. E. Robertson, Cardinal.
C. H. Rust, Toronto.
C. B. Smith, Montreal.
Henry Smith, Toronto.
W. J. Sproule, Montreal.
R. Steckel, Ottawa.
F. Thomson, Montreal.
W. F. Van Buskirk, Stratford, Ont.
A. P. Walker, Toronto.