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Volume 29. Toronto, December 9, 1915. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

SOME DIFFICULT SEWER CONSTRUCTION, TORONTO

A DESCRIPTION OF CONSTRUCTION DIFFICULTIES AND METHODS EMPLOYED ON THE WEST TORONTO STORM-WATER OUTLET.

By W. G. CAMERON,
District Engineer, Sewer Section Department of Works, Toronto.

IN *The Canadian Engineer* for November 18th, 1915, a summary account was published of the extent of the sewer system recently constructed by the sewer section of the Department of Works, City of Toronto, for that portion of the city generally known as West Toronto. In our issue of December 2nd a description appeared of the first section of this system, *viz.*, the outlet at Lake Ontario and for a distance of 450 feet along Keele Street. It was shown to be of the culvert type and heavily reinforced under the Lake Shore Road and under Grand Trunk subway just north of this thoroughfare. The following relates to the section between this outlet section and the stand-by tanks at Bloor Street, a distance of 5,211 feet. Though different parts of it were built of different materials and by different methods of construction, these parts were all circular in shape, of the same size and all let in one contract. The route was north through High Park, parallel to Keele Street and nowhere more than 50 feet from it. Beginning at the lower end, the sewer was not very deep and was built in open cut for 800 feet. From here to the tanks, with the exception of 100 feet where it crosses the head of a ravine, the sewer was to have been built in tunnel of 18-inch brickwork, as shown in cross-section in Fig. 3.

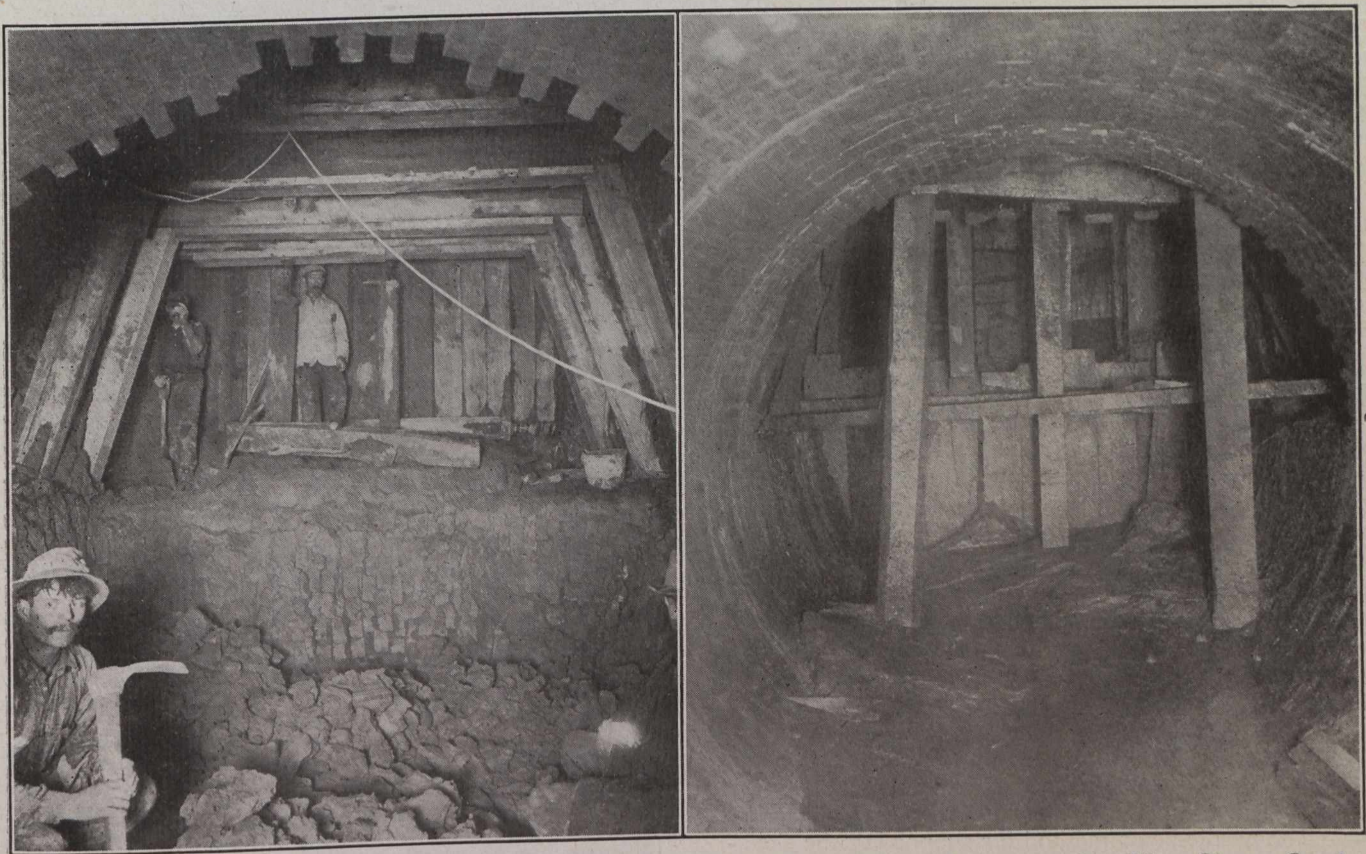

Fig. 1.—Tunnel Headings 80 Feet Apart in the Keele Street Sewer Work, Toronto. One View Shows Good Working Clay and the Other a Heavy Water Seepage Requiring 12 to 18 lbs. of Compressed Air.

In the first 800-foot section, of which Fig. 2 is a cross-section, the ground rises more quickly than in the part described in the last article. Therefore, a better grade (1 in 136) was given and consequently a smaller sized sewer was required. There was plenty of cover too, so a 9-foot circular sewer was built with a square bottom. The excavating was done by hand and the material carried out of the trench in buckets on a cableway. The buckets were then dumped into wagons and the contents carried away to the dump, which was a new roadway in High Park. As the material was of dry sand with small seams of clay loam, the sides of the trench had to be sheeted with 2-inch tight sheeting, while 6-inch x 8-inch timber was used for walings and struts. As this portion of the work was done in open cut, the construction material was all concrete, since the sewer is entirely for storm-water and will be in use only a few times each year. The concrete walls are 18 inches thick, and the concrete was mixed in a Wettlaufer drum mixer. The forms were built up as each section was poured, the length varying from 10 feet to 20 feet or over, as convenient. The ribs of the forms were placed in position and then lagging, levelled on two sides to form chords of the circle, was placed, a piece at a time, as the walls were built up. It is in this section that the 18-inch tile pipe sewer mentioned in the previous article leaves its position under the large sewer.

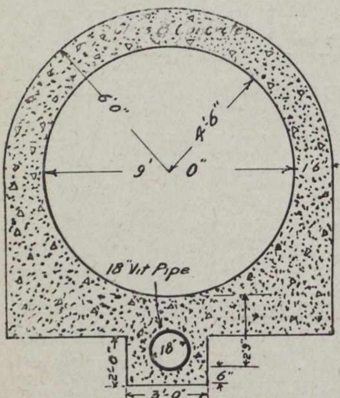

Fig. 2.—Concrete Section in Open Cut.

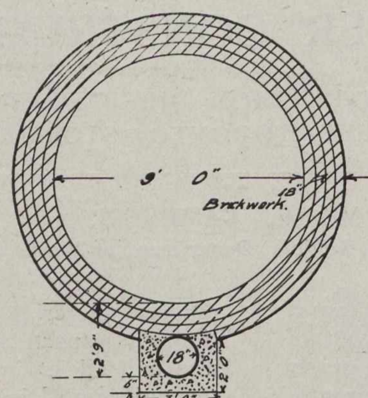

Fig. 3.—Brick Section in Tunnel.

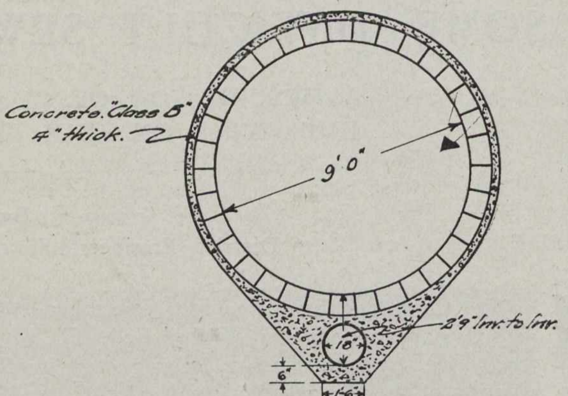

Fig. 4.—Alternative Section, Using Vitrified Segment Sewer Blocks.

In the tunnel portion of the work, the contractors sank three shafts, which we shall call Shafts No. 1, 2, and 3. The intention in constructing these three shafts all at the same time was to complete the work as speedily as possible. They expected to complete the work in eight months, and would have accomplished their object but for some unforeseen difficulties. As it was, the work was completed in nine months—a very creditable record. At the end of the 800 feet of open cut, the ground was dry sand. The contractors accordingly decided they would tunnel as far as possible, thus saving the extra haul of material and surplus which would have been necessary if the tunneling had been done from the shaft farther north. At first the tunneling was attempted by ordinary methods, but work had proceeded only a few feet when the sand became moist. The needle-beam method for supporting the sheeting was then employed.

When this method is used, a small cap and leg drift is driven ahead in the centre of the top half of the future tunnel, the caps being above the future brickwork. The needle-beam, as it is called, is in reality a large stick of timber, perhaps 16 inches by 16 inches by 20 feet, the size depending on the weight the timber has to carry. This needle-beam is taken ahead into the drift, the front end resting on a sill on the solid ground in the bottom of the drift, and the back end on blocks, etc., just inside the finished brickwork. Screw-jacks on posts are then inserted along this needle-beam and are screwed up until they take the weight off the caps. The legs are then removed and the miners begin at the ends of the caps to enlarge the tunnel. As room is made, planks for sheeting are inserted lengthwise of the tunnel and they in turn are supported and kept in place by posts from the needle-beam. Thus the work proceeds, the tunnel being enlarged gradually from the top until completed, as shown in Fig. 5. The sheeting is composed of 2-inch planks in the top half of the excavating and 1-inch lumber in the bottom. The posts are generally 6-inches by 6 inches in section.

This tunneling had proceeded 260 feet when the sand became fine and wet and the work was abandoned from this heading. A brick bulkhead was then built in the finished end. The reason for this bulkhead will be explained presently.

Shaft No. 1.—While this work was proceeding shaft No. 1, 32 feet deep, was being sunk at 16 + 60. As the workmen approached the bottom of this shaft, fine wet sand was encountered. It was, therefore, decided that it would be more economical to tunnel with the aid of compressed air. The shaft was lengthened from each end by open cut so that air-locks could be built. Hence the bulkhead just mentioned, to prevent the air from escaping as the work approached from shaft No. 1. The work on the south of the shaft or towards the bulkhead proceeded smoothly at the rate of from 5 feet to 7 feet a day and was completed with only minor difficulties. About 5 lbs. of

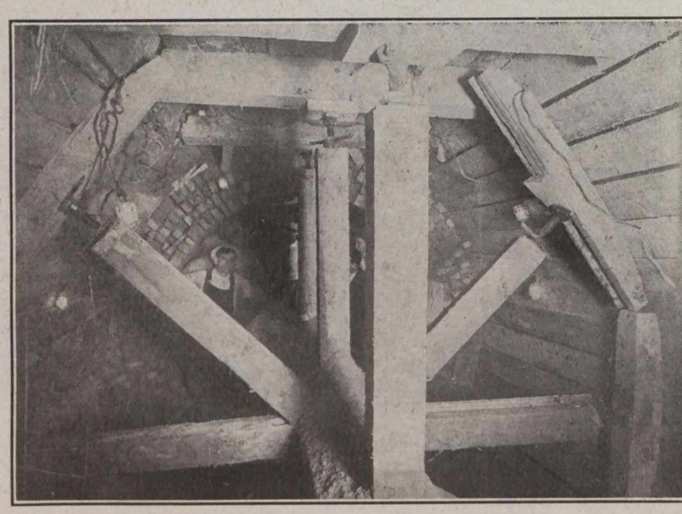

Fig. 5.—Illustrating the Needle-beam Method of Supporting the Sheeting as the Tunnel Progresses.

compressed air were used, and the needle-beam method was employed.

North from this shaft, however, the contractors found difficulties along the path of construction in the form of old logs, stumps, old drains and an old cribwork. It would appear that this was the former head of a ravine. The cribwork had evidently been erected as a retaining wall and then the head of the ravine had been filled in with stumps and old logs, etc. Of course, this had been done in past days when wood was plentiful. It was decided to open cut another portion of the work, since the sewer, being near the bank of the ravine, as shown in Fig. 6. These logs, etc., would allow the air to escape too rapidly. When the bottom was reached, there was found to be from 2 feet to 3 feet of soft, flowing sand above a layer of clay. The soft material was removed and 1:4:9 concrete put in its place as it was considered that it would not be confined. Since the bank was so near, and since logs, etc., were in the fill, it was believed that as soon as weight was put on the new sewer, the soft sand would ooze out through the bank into the ravine, allowing the sewer to settle, spread and finally collapse. There was another reason, also, for its removal. The weight of earth was mostly on one side and the soft material would allow the sewer to slide towards the ravine, in time wrecking the same. The surplus earth taken from the tunnel and open cut was dumped over the side of the bank. By this means the bank was extended and the weight equalized on the sides of the sewer.

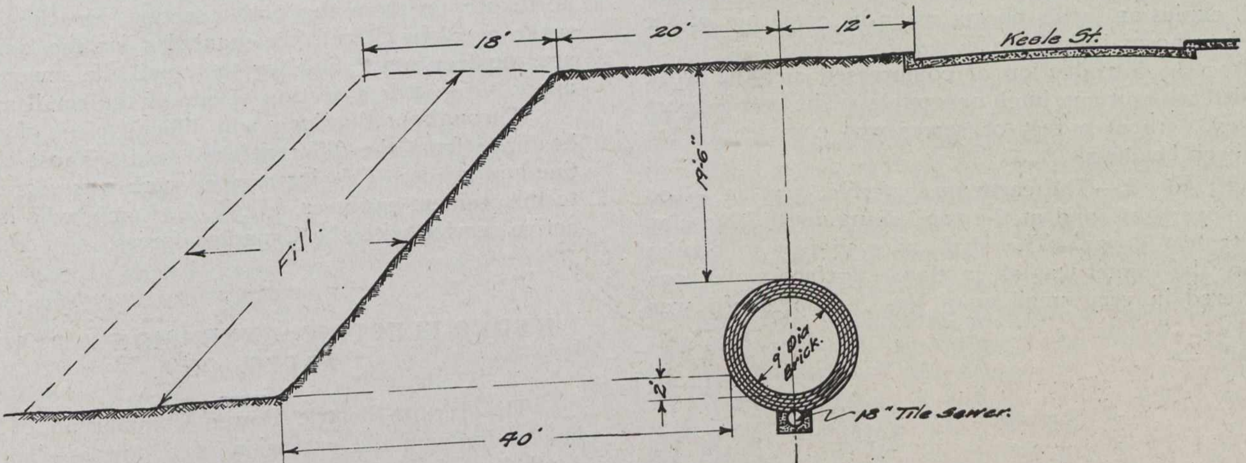

Fig. 6.—Extension of Bank Where a Ravine Closely Approached the Line of Sewer.

An air lock was then built and the work attempted in tunnel with the aid of compressed air. About 50 feet of sewer was finished in tunnel but only 2 feet, 3 feet or 4 feet was finished each day and sometimes, indeed, none at all. The logs were still encountered quite frequently, as many as five or six appearing in an 8-foot length of excavated tunnel. They were vertical, horizontal, or in any position in the ground. The compressed air escaped to the surface so rapidly along these logs that it was impossible to keep up sufficient pressure in the tunnel to hold back the water. The logs had to be chopped out and they also interfered with the sheeting of the work. Everything combined, the work was so difficult that tunneling was again given up and 150 feet done in open cut to a point where the fill was passed and solid ground reached. Tunneling was then attempted again and this time was carried out favorably, with the aid of 5 or 6 lbs. of compressed air and the needle-beam to support the sheeting.

Shaft No. 2.—In sinking shaft No. 2 at 23 + 01 no provision was made for the use of compressed air. The reason was that borings had shown the ground to be composed mostly of clay at the elevation of the sewer. A small amount of water was encountered but the quantity was not great enough to hinder the work. Tunneling was commenced at the north and south ends of the shaft. In the north end difficulties commenced almost at the start. It was found, as so often happens in this district, that the layers of sand and clay fold and form pockets. Water occurred in fair quantity in the sand just above the clay. When 30 feet of tunnel was completed, work was temporarily abandoned. The contractors decided that their finances would have to stand the buying of a complete new air plant since their other plant was in use at shaft No. 1. Accordingly pumps and motors were ordered and in due time arrived on the scene. The work from the south end of the shaft progressed more favorably for a short time. Two illustrations are shown (Fig. 1) one of each end of this shaft. They clearly indicate the change in the ground in 80 feet. About 120 feet of tunnel was built at this end when it too was abandoned for the use of compressed air. Air locks were built here in the finished tunnel. But by getting back over the arch and thence to the surface, the air escaped so rapidly that grout had to be forced in through holes bored in the brickwork to seal the space which remained between the arch and the earth. Various

Fig. 7.—A Portion of the Work Required Very Little Sheeting Owing to the Favorable Nature of the Clay.

pressures of air were used but finally it was found that, to thoroughly dry the ground, 12 to 18 lbs. were necessary.

It was here that one laborer got his first lesson in physics. He was a foreigner who worked as a bricklayer's helper. When he went into the tunnel for his 8-hour shift he took his lunch with him, part of which consisted of a bottle of tea. The bottle had an air-tight screw top. After he had drunk his tea, he screwed the top tight on, quite unconscious that he was imprisoning a pressure of 18 lbs. to the square inch. To his astonishment there was a small explosion in his pocket when he come out of the tunnel into normal pressure.

After the introduction of compressed air, the work proceeded without any hitch or trouble. The needle-beam was used. About 9 feet of sewer was completed each day in each heading.

Shaft No. 3.—The earth in shaft No. 3 at 41 + 00 was composed of sand at the top, changing to blue clay about 15 feet down. The shaft was 33 feet in depth; therefore the tunnel was all in clay. Surface water was encountered in very small quantities. The shaft was

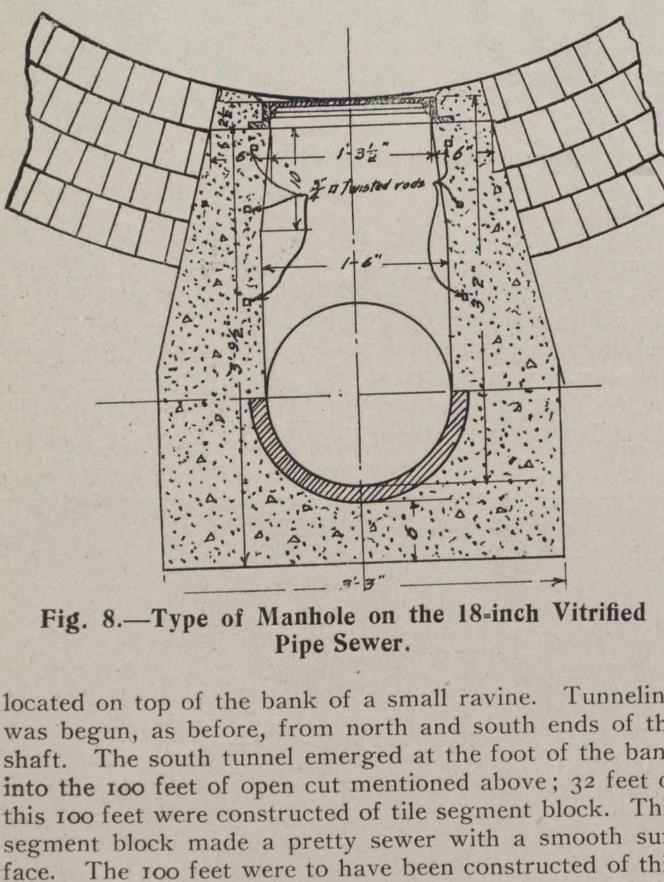

Fig. 8.—Type of Manhole on the 18-inch Vitrified Pipe Sewer.

located on top of the bank of a small ravine. Tunneling was begun, as before, from north and south ends of the shaft. The south tunnel emerged at the foot of the bank into the 100 feet of open cut mentioned above; 32 feet of this 100 feet were constructed of tile segment block. This segment block made a pretty sewer with a smooth surface. The 100 feet were to have been constructed of this material, but after 32 feet, brick was substituted for the reason that, the sewer being at the bottom of a steep bank the blocks had to be carried down to it, and owing to the weight of the blocks this handling was slow and difficult and many of them were broken.

When the open cut was finished, the sewer was continued in tunnel. The surplus was taken up shaft No. 3. In two cases short lengths of sewer had to be open cut because in these places pockets of wet gravel came below the roof of the excavation, and caused the roof to give way before it could be supported. In this end of the tunnel sheeting was used in the roof nearly the whole way.

At the north end of the shaft the ground was composed of clay and tunneling proceeded at a rate of 6 feet to 8 feet a day. Very little sheeting had to be used in the roof. Everything was going smoothly when suddenly the roof caved in so quickly that the workmen had scarcely time to escape from the heading. A pocket of sand was the cause of this. The extent of this pocket was not known and the contractors, not wishing to take any chances, decided to open cut. A shaft 30 feet long and 70 feet deep was necessary to repair the damage. The heading was picked up and the work proceeded to the end of the contract at the stand-by tanks. This shaft was at 44 + 90.

In the whole of the work referred to above, *i.e.*, the north section from the outlet section to the stand-by tanks at Bloor Street, the manholes for the large sewer are 500 feet apart, and for the small tile sewer 300 feet apart. Fig. 8 is a section of one of the small manholes.

Throughout this long and difficult piece of work the headings from the different shafts met almost exactly in line and grade. This instrument work was a great credit to the resident engineer, Mr. T. L. Lamb, who is now on active service with the Canadian forces.

HYDRO-ELECTRIC EXTENSION AT SOUTH FALLS, ONT.

The Hydro-Electric Power Commission of Ontario has under way the extension of a power plant on the south branch of the Muskoka River. This plant, located at South Falls, and formerly operated to supply the town of Gravenhurst, had a single unit with a capacity of 450 k.w. It is being enlarged by the addition of a 750 k.v.a. unit. Excavation work was recently commenced and most of the equipment has been ordered.

Provision was made in the design of the existing plant for such an extension, and the installation of the latter does not alter the previous arrangement.

A wood stave pipe line, 100 ft. long, will connect the existing headworks with about 60 ft. of steel penstock leading to the new unit. The head gate mechanism, steel penstock, turbine, governor and relief valves are all being supplied by the William Hamilton Company, Limited, of Peterborough, Ont., the generator and transformers by the Canadian General Electric Company, Limited, Toronto, and the wood stave pipe line was supplied by the Pacific Coast Wood Stave Pipe Company, Limited, and is being laid by the Commission. Orders for the switchboard equipment have not yet been placed.

The extended plant will supply the towns of Gravenhurst, Bracebridge and Huntsville.

RECENT PRODUCTION OF GOLD AND SILVER IN ONTARIO.

Returns made to the Ontario Bureau of Mines for the nine months ended September 30th, 1915, show an increase in value of gold of $1,884,093 and a decrease in value of silver of $2,051,760. The gold districts of Northern Ontario, the report says, are fulfilling the prediction made several years ago that they would make good the loss caused by the waning of the silver mines of Cobalt. Thus, the combined value of the gold and silver output of the first nine months of the present year was only $167,661 less than for the same portion of 1914, notwithstanding the fact that the yield of silver fell off over 20 per cent. Part of this decrease is due to the low prices which prevailed during the whole nine months, but which, however, made a sharp recovery in November.

CANADIAN WATER POWERS.*

By Frank D. Adams, D.Sc., F.R.S.,
Dean of the Faculty of Applied Science, McGill University, Montreal.

CIVILIZED man differs from uncivilized man in the amount of power which he uses. The Bedouin in the Arabian desert supplies all his own power. The needs of civilized communities, however, incident upon their higher scale of living can exist only when immense stores of power can be made available. Hence the demand for power—modern comfort is based upon it.

The various sources of power are: Atomic power (the immense stores locked up in the Molecule); heat of the earth's interior; the sun's heat; movement in the atmosphere, *i.e.*, wind power; movement in the hydrosphere, *i.e.*, water power; heat development by chemical changes, *e.g.*, oxidation of coal, oil, gas.

All three of the last mentioned—wind, water and the power derived from burning coal, etc.—are really derived from the sun.

Dr. Prichett is responsible for the statement that on a clear day, when well above the horizon, the sun delivers upon each acre of the earth's surface exposed to its rays the equivalent of 7,500 h.p. working continuously.

Water Power.—This is, of course, really a form assumed by the energy given out from the sun in the form of heat. For the water falls from a height to which it has been raised when under the influence of the sun's heat; the water of the ocean is evaporated, raised into the air as clouds which condense as rain in the higher lands.

Rain falling on the earth (according to Dr. McGree in U.S.A.) may be divided as follows: (*a*) Run-off = ⅓, (*b*) fly-off = ½, (*c*) cut-off = 1/6. This sinks into the earth or is taken up into the structure of plants. The tissue of plants of annual growth consists of 75% of water (about).

It is the "run-off" only with which we are concerned The rain water which falls on low plateaus and level land standing about sea level gives rise to streams which are of little value for water powers—it is that which falls on higher land and mountain slopes which gives rise to streams with considerable head to which we look for power. But this is not necessarily of value as a source of energy. A stream to be of value must have a large flow, a flow which is comparatively uniform throughout the year and one which has a very considerable fall. Speaking generally, we may say that the effective flow of a stream is the amount of its discharge at low water, for the supply of power, if it is to be used for the ordinary purposes for which power is required, must be practically uniform throughout the year—the chain, so to speak, is no stronger than its weakest link.

This comparative uniformity of flow is secured by the maintenance of a forest cover about the head waters of the stream or by the creation of a sufficiently large storage basin there, in which the surplus water of one portion of the year may be stored and allowed to increase the normal flow during that part of the year when there is a relatively smaller rainfall. The former is a natural feature which must be maintained; the latter is usually an artificial device which can only be secured by a large expenditure of money.

*From a paper read before the Undergraduate Society of Applied Science, McGill University, November 17th, 1915.

Results of Deforestation.—If the lumberman is allowed merely to remove the larger trees for merchantable timber, no harm is done, for the forest still survives. But if, through his operations, he leaves the tops and branches of the trees in such a way as to make the forest a prey to fire, it almost always is burnt. The ground thus laid bare in some rocky lands has the soil washed off and all possibility of restoring its forest growth vanishes. In other cases the growth which comes even after years is thin and of relatively little value. Fire follows fire and the drainage conditions of the country become completely changed. The water which falls as rain rapidly drains off, causing the rivers to run as violent torrents which rapidly subside and are followed by periods in which the flow of the stream is enormously reduced. This gives rise to disastrous floods at some seasons of the year and lack of water at others. The actual amount of the run-off is also increased at the expense of the cut-off—the amount and level of the ground water is lessened and the vegetation of the country suffers correspondingly.

This has taken place in many of the United States rivers as a result of deforestation and the clearing of land for agriculture. For instance, on the Mississippi the run-off 50 years ago was 19,500,000 million cubic feet, while it is now 22,000,000 million cubic feet. This has resulted in disastrous floods in recent years, as that of Dayton, Ohio. The damage caused by the floods of the Ohio River in 1913—largely concentrated in the two cities of Dayton and Hamilton, Ohio—was somewhat over $180,000,000.

To protect some of our more important streams, the Dominion and Provincial Governments have set aside certain large areas about their head waters as permanent forest reserves or national parks. These areas, in recent years, have been greatly increased on the recommendation of the Commission of Conservation. The total area of the Dominion forest reserves at the present time is 35,804 square miles and the total area of national parks in Canada is 4,114.25 square miles. In the forest reserves no land can be taken up for settlement, and the forest cover will be permanently preserved, while in the national parks the game is also preserved, so that they become sanctuaries for the wild animals of the country. One of the most important of these forest reserves is that on the eastern slopes of the Rocky Mountains in Alberta, which will not only protect the catchment areas of the rivers flowing through the great plains but will also supply timber to the future population of this great district.

This action of the Government is worthy of all commendation. Other reserves should be added to those which have been already set aside, as, for instance, the tract about the head waters of the Winnipeg River recently recommended by the Commission of Conservation, the area being one which is unfit for settlement, but of great importance in connection with the equalization of the flow of this river on which such enormous water powers are now being developed and which have such an important bearing on the welfare and future of the province of Manitoba.

In addition to the maintenance of forests on the catchment area of rivers, the presence of large reservoirs at the head waters of rivers also tends to maintain a uniform flow. These may be natural lakes, as in the case of the St. Lawrence, which owing to the enormous size of the lakes in which it takes its origin, has a more uniform flow than any other river in North America or perhaps in the world. But when lakes are not present, they may be, and are in certain cases, formed by the construction of dams in the upper courses of rivers. This has been done on the Ottawa, St. Maurice and other rivers in Canada.

Care must be taken in such cases to construct the dam of such a height that storage is obtained for the surplus water in rainy seasons, the amount of the storage required depending, of course, on the size of the drainage area and the amount of the rainfall, and, of course, only a certain flow can be obtained. It needs a careful survey to determine the size of the area and a long series of observations of the amount of rainfall to enable the engineer to decide the amount of flow which can be obtained and the size of the dam which it is most economical to construct. In all cases of the draining of streams the question of the damages to flooded areas is one of great importance.

Primary and Secondary Power.—Now, as stated above, the amount of power which can be supplied by a waterfall throughout the year is the power in which we are primarily interested in the case of any water power development. It is, therefore, termed primary power. In many cases when it is not possible to secure a practically uniform flow, the power developed in excess of that which can be supplied regularly throughout the year, and which, of course, is only available at certain times, is applied to certain special uses which do not require a continuous service. This is called secondary power. Similarly as the daily demands of primary power varies from hour to hour excess power is available at certain hours of the day; this is also called secondary power. Thus at Shawinigan Falls the secondary power is used in the manufacture of calcium carbide, while the primary power is used for the supply of light, heat and power to the city of Montreal, as well as to cotton factories, aluminum works, etc.

The Development of Water Power as Compared with Other Uses of Streams.—The International Boundary Waters Treaty between Great Britain and the United States, as ratified in 1909, gives the rules or principles which shall govern the International Joint Commission in determining the order of procedure which shall be observed in the disposition of water privileges as follows:

"The following order of procedure shall be observed among the various uses enumerated hereinafter for these waters and no use shall be permitted which tends materially to conflict with or restrain any other use which is given preference over it in this order of procedure:

(1) Uses for domestic or sanitary purposes.

(2) Uses for navigation, including the service of canals for the purposes of navigation.

(3) Uses for power and for irrigation purposes,"

Thus, under this ruling the very valuable power possibilities on such waters as the St. Mary, the Niagara or St. Lawrence Rivers are regarded as of less or only "incidental" value as compared with the primary intention of navigation.

Uses for Which Water Power May Be Economically Employed.—Water powers were of relatively little value in former years, but have now become of great importance owing to the fact that formerly the power developed from a waterfall had to be employed in the immediate vicinity, if at all. Hence many water powers, great and small, which, as is so often the case, were located in comparatively inaccessible regions were valueless.

It is the possibility of transmitting this power to centres where it is required and where is can be economically employed that has attracted to the water powers of the world the special attention which they have received in recent years.

This transmission has been affected by the discovery that it is possible to transform the power of falling water into electric power and, carrying this on wires to distant points with little loss, and there transform this electrical energy again into light or mechanical power.

Long-distance transmission of power by electricity dates from the year 1882, when Marcel Deprez, at the Munich Electrical Exhibition, transmitted about one horse-power a distance of 35 miles to a place called Wiesbach. So marked, however, are the advances which have been made in the science of electrical engineering since that time that it is now possible to carry the energy developed by our water powers for very great distances. The Pacific Light and Power Co., of Los Angeles, Cal., is now transmitting over 100,000 h.p. for a distance of 240 miles. The Hydro-Electric Power Commission of Ontario is transmitting power a somewhat greater distance—242 miles—from Niagara Falls to Windsor. If electric power is carried for a radius of only 100 miles from any centre, it serves an area of over 31,400 square miles. If it be carried for a radius of 240 miles, it covers an area of rather over 180,000 square miles, or somewhat less than half the area of the province of Ontario. A water power of sufficient magnitude can thus be made available to millions of people.

The distance to which electrical energy can be profitably transmitted is governed by the annual charges on the outlay in constructing the transmission lines, and the cost of coal at the point where the electric power is delivered. Some late developments, notably the use of synchronous reactors at the receiving end of the line, have considerably increased the amount of power which can be conveniently transmitted over any one transmission circuit. This new feature will allow of the design of transmission lines to be operated with the most economical loss in the line. Professor Herdt* lately advised the use of such machines for the power plant and transmission line from Point du Bois to Winnipeg for the city of Winnipeg. The capacity of the transmission lines has been doubled by the installation at the terminal stations of synchronous reactors.

Water power thus electrically transmitted may be used:—

(*a*) For the development of mechanical power for every purpose for which such power is required, *e.g.*, factories, mines, railroads, street cars, elevators, etc.

Not only is electrical energy readily applicable to large installations, but it has the enormous advantage over all others in its capacity for ready subdivision. It may be carried to the small shop, to the barn, to the home. Already in cities where electrical power is cheap, it is running the sewing machine, cleaning the floors and doing other heavy work of the household. Similarly on the farm it may do much of the heavy work, both indoors and outdoors. In certain lines of industries, it may be the means which will keep industry in the small shop instead of concentrating it in the large factory.

(*b*) For the production of light. Electric light so produced is practically the only light used in most large cities.

(*c*) Heat. Electric heating has already been employed on a small scale for domestic purposes in cooking, ironing, etc., and will, as the power becomes cheaper and facilities for delivering it are improved, meet with an ever-increasing demand.

But it has opened up an entirely new economic field in the introduction of the electric furnace, which on account of the very high temperatures which can be obtained

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*Louis A. Herdt, D.Sc., E.E., Professor of Electrical Engineering, McGill University.

by its use, has led to the development of a whole series of new and most valuable industries.

Thus, for instance, the smelting of the metal aluminum, which has risen from a few pounds in 1885 to 69,000 tons in 1913, with a fall in price of from $6.85 per pound in 1886 to about 18.63 cents in 1914.

It is unnecessary to more than refer in passing to the widespread employment of this metal at the present time. The Northern Aluminum Company at Shawinigan Falls has a capacity of 20,000 h.p. The metal zinc and certain kinds of iron are also smelted from its ores by the electric furnace.

Calcium carbide is formed by heating quick-lime and coke together at the temperature of the electric arc. This, when brought in contact with water, gives rise to acetylene gas, now so extensively used for lighting purposes. This industry was started in Ottawa, Ont., in 1895, with Mr. Wilson* as one of the pioneers. In 1913, 340,000 tons were made. It is manufactured in Canada at Ottawa, Thorold, and at Shawinigan Falls. The management of these three plants are now united under the name of The Canadian Carbide Company.

Nitrogen Products.—The principal sources of nitrogen for fertilizing purposes are manure, dried blood, wool wastes, sulphate of ammonia obtained in coking coal, nitrate of soda obtained from mines in South America, nitrate of lime and cyanamide. These two latter are produced by the electric furnace, and their manufacture is an interesting chemical operation.

The air consists of a mixture of nitrogen and oxygen. These, when passed together through any ordinary furnace, do not react on one another in the slightest degree, but when the air is submitted to the extremely high temperature of the high-voltage electric discharge, the nitrogen unites with the oxygen with the eventual production of nitric acid, which may be obtained as such or obtained in combination with lime or soda.

The world's consumption of nitrate of soda annually is about 2½ million tons. Norway last year exported 70,171 tons of nitrates. The United States imports it to the annual value of $21,000,000. Most of this comes from Chili but the Norwegian Nitrogen Co. have now in operation plants for the manufacture of nitrates requiring 180,000 h.p. and are undertaking the construction of others which will require a total of 540,000 h.p.

Calcium cyanamide is an artificial fertilizer containing nitrogen, carbon and calcium. This material, when buried in the ground, liberates ammonia and is hence a valuable fertilizer. It is obtained by passing a current of nitorgen over carbide of calcium when made red hot in the electric furnace. There is a plant for its manufacture at Niagara Falls on the Canadian side which has a capacity of 24,000 tons per annum.

There are other products of which mention might be made if space permitted, *viz.*, caustic soda and bleaching powder, carborundum, alundum, artificial graphite, etc.

The Use of Water Power Will Conserve Our Coal Supplies.—Water power is perhaps unique among the resources of a country in that it is not diminished by use nor conserved by non-use. By using it, however, the drain on the fuel supplies of a country are lessened. It can be shown that it takes five tons of coal to produce energy to the extent of one horse-power per year. So that every horse-power of energy which runs away unused in a waterfall in an inhabited country is equivalent to the depletion of coal resources of this country by five tons annually.

*See *The Canadian Engineer* for July 29, 1915, page 212.

An example of this saving on a small scale is afforded by the Cobalt district. This district in 1909 imported 63,739 tons of coal between June and December. In 1910 during the same period it imported 17,349 tons of coal, this saving of 46,390 tons being effected by the introduction of electric power in that year and its introduction into all the mines.

Furthermore, while it is a good and economical steam plant which will utilize 10% of the energy of the fuel, the hydro-electric plant can make available as much as 70% of the energy of a waterfall. "It is, I believe, within reason to hope," said Prof. Herdt, of McGill University, in his recent address before the Royal Society of Canada, "that the use of coal for the production of power in our large cities will before long be almost entirely abandoned and that hydro-electric power, economically transmitted and distributed, will in time light every home and drive the machinery of every factory in the country."

Amount of Water Power Available in Canada.—As may be easily understood, the accurate determination of the amount of horse-power represented by the hundreds, or rather thousands, of waterfalls to be found in Canada is a task which involves so many facts and such extended observations that many years must elapse before a final result can be secured.

The height of each fall, the volume of water passing down it at every season of the year, the effect of ice in winter, the area of the catchment basin, the average rainfall of the district, and many other facts must be known, and can only be known accurately after observations extending over a long series of years. Such observations and measurements are now being made by the Commission of Conservation of Canada, by the Water Powers Branch of the Department of the Interior, and other bodies.

An address on the subject, given as far back as 1869 by the late T. C. Keefer, C.M.G., as president of the Royal Society of Canada, has attracted a good deal of attention. In it an attempt was made to show in a general way the extent of the water powers in the central portions of Canada. The problem was approached as follows:—

One of the most striking physiographic features of Central Canada is that great area of rocky country lying between St. Lawrence and Great Lakes on the south and the Arctic Sea on the north. This has an area of about two million square miles and an average elevation of about 1,500 feet above sea level. There are other elevated tracts in this portion of the Dominion, as, for instance, the highlands along the Notre Dame Mountains. Now, all the water falling on this area falls 1,500 feet on its way to the sea; consequently all the rivers draining it, in addition to courses of swift water, have along their course many waterfalls, some of them of great height. There are also innumerable lakes.

Mr. Keefer states that if we take the rainfall as 24 inches and assume half of this power as available, every ten square miles would yield on an average nearly one horse-power for every foot of fall. A million square miles would give 100,000 h.p. per foot of fall. Now, if there is a fall of 1,500 feet, there would be power to the amount of some 300,000,000 h.p.

Such estimates, however, are misleading, for they are far in excess of any figures which can be realized. Most of the falls are too small and will ever be too remote to be available. Many others would require the expenditure of too much capital to render the power available. Still others are frozen up for a considerable portion of the year; and so on.

A series of small pamphlets describing the water powers of the several provinces of the Dominion have just been issued by thhe Water Power Branch of the Department of the Interior and these give the latest and most reliable information with reference to the power available in the water powers of Canada. This is set forth in the accompanying table.

	Total capacity of development.	Now developed.
Ontario	4,929,000	702,000 h.p.
Quebec	5,600,000	520,000 h.p.
British Columbia		230,000 h.p.
Prairie Provinces	several millions	100,000 h.p.
Maritime Provinces ..		38,500 h.p.
		1,590,500 h.p.

One published estimation places the total available power from the waterfalls of Canada at 17,000,000 h.p., but Mr. Denis, of the Commission of Conservation, states that "this does not and cannot rest on any basis of reliable information." The statement, however, is made in one of the Government reports just mentioned that "The outstanding feature of the water power situation in Canada is the fact that practically all industrial and commercial centres in the Dominion from coast to coast have sufficient potential water power within easy transmission radius and of sufficient capacity and assured economic feasibility of development to meet all anticipated requirements for the future."

Ottawa now has developed from the Chaudiere Falls 36,000 h.p., which could be raised to 84,000 h.p.

The following is a statement of the water powers which supply power to the city of Montreal:—

	Capacity of development.	Now developed.
Cedars Rapids	500,000	180,000*
St. Timothe	50,000*	20,000
Soulanges Canal		13,000
Lachine	400,000	13,000
Chambly		20,000
Shawinigan Falls, Grand Mere and other falls of the St. Maurice	650,000	258,000
		504,000

*On completion of present installation.

A recent report makes the statement that "having considered the leading sources of power in the Montreal district, it is not difficult to realize that this city enjoys a more bountiful supply of cheap power than any other city in the world."

The Grand Discharge of the Saguenay also is a water power from which it is estimated that 1,000,000 h.p. can be developed, while 240,000 h.p. can, it is estimated, be developed from the Lower Falls of the same river.

(Dr. Adams then describes the work and extent of the Hydro-Electric Power Commission. Lack of space prevents the inclusion here of this portion of the address, the subject having already been fully covered by *The Canadian Engineer.*)

Lest we should feel unduly elated by the consideration of the great amount of power to be found in Canada, we must remember that several very eminent foreign electrical engineers have expressed the opinion that only relatively few of our water powers would be found capable of furnishing large amounts of power at a price which would enable them to compete with the water powers of other countries as a basis for manufacturing industries.

These opinions were based on the undoubted fact that most of our falls have a low head and large discharge. From such falls the development of power is expensive. Then there is the long winter which reduces the flow of water and induces other complications as well. The remoteness of many of the falls and the high cost of labor are other adverse factors.

One eminent authority has gone so far as to say that Niagara Falls and Shawinigan Falls are the only two centres from which very large sources of power supply can be expected.

These opinions, expressed by Messrs. Dalemont and Pitaval and others, are, however, no longer valid, for through the advance of engineering knowledge and the improvement of engineering practice much more power can now be obtained from low-head falls than could formerly be obtained from water powers of this character. The statements of these engineers must, therefore, be very largely revised in the light of recent engineering knowledge and development. Many of the opinions which they expressed are now quite obsolete. It is well, however, for us to remember when we are considering the future development which may be expected from the water powers of the Dominion, that there is a certain element of truth in their observations.

(The author then outlines the development and extent of the Niagara power situation, dealing first with the concentration of ownership and control and then summarizing the outstanding features of each of the developments in operation there.)

Two very important questions are bound up with the subject of our water powers. (*a*) The first is the question of lease and ownership. (*b*) The second is the question of the right of exporting electrical power.

The title of all water powers within a province (with a few exceptions) belongs to the Provincial Government, the title of those in Dominion lands to the Dominion Government.

In the United States there has been, and still is, a very vigorous attempt on the part of big interests to get control of all the important water powers in the Republic. This has given rise to a very vigorous popular opposition in favor of government restriction. This agitation is now being carried on. The ideal aimed at is that the government should sell no power falls, but should lease them under proper conditions and with suitable restrictions. Thus the lease should run for a term of years, say, 20, and be renewable for a further term if conditions had been satisfactorily complied with—the royalty being at that time readjusted, if necessary. Further, the development of the power would have to be made within a certain specified time, and provisions should be made in constructing the dam so as to obtain eventually the maximum power which the waterfall will yield, otherwise the river may be so dammed as to produce a small horse-power and spoil the fall for the subsequent development of more power.

The character and value of the restrictions differ under the various Federal and State Governments, but the tendency of the government representing the interests of the people is to lease the falls under these and similar restrictions, while the tendency of the big interests is to secure the permanent control, and if possible, absolute ownership of all the water powers in sight, even although they cannot make use of them all at the present time.

The other important question for Canadians is that of the export of power derived from waterfalls. Under the Dominion "Electricity and Export Fluid Act" no one may export such power without a government license which is revocable. This, at first sight, seems reasonable. Why not sell our surplus power until such time as we may want it for our own purposes? A very palpable objection to this course is now, however, manifesting itself, for the Public Service Commission of the State of New York, and other interests in the United States, have now taken the ground that if such power is once secured and with it industries are founded and built up, this establishes a vested claim or of a vested interest in the power in question, and Canada cannot legally revoke the permit to export the power even if she should require it later on for her own use. In fact, certain interests in the neighboring Republic have urged that as much electricity as possible, at as early a date as possible, be imported from Canada and employed in the United States, since otherwise manufacturers will go to Canada and establish themselves there to the detriment of the United States industries. This is a difficult question, but it is one which Canadians should have clearly in view.

The need for all the available power which Canada possesses is well set forth by Professor Herdt in his recent address before the Royal Society of Canada, who spoke as follows:—

"The use of coal for the production of power in our large cities will before long be almost entirely abandoned and hydro-electric power, economically transmitted and distributed, will in turn light every home and drive the machinery of every factory in this country. To provide the immense quantity of power required for this purpose, we shall require the surplus waters of our canals, the falls and rapids of the St. Lawrence River and the powers of our great inland waters. These are, and will remain, among Canada's richest assets, and will be the great source of our future development. The importance of effectively and economically utilizing these water powers cannot be overestimated. A definite, comprehensive policy, with respect to the nation's vast water power resources should be formulated. This great asset of the raw material from which the finished product is made by the expenditure of money and brains should not be given away unless the power is developed and placed at the service of the people. Reasonable encouragement, however, should be given to power schemes, bearing in mind that a water power undeveloped is like unmined gold—it takes money to place it at man's service. They should be developed in such a way as to render available, in a profitable manner, the energy which is now going to waste, and at the same time conserving for future generations our other natural resources."

NIAGARA RIVER BOULEVARD MAINTENANCE COSTS.

In our issue of November 4th, 1915, some figures were given on page 535 relating to the cost of road repair and maintenance in Queen Victoria Niagara Falls Park. The following corrections are forwarded us by Mr. John H. Jackson, C.E., superintendent. In the data relating to Tarvia-A treatment the surface treated was 50,400 square yards and not 54,400, as stated. The cost per square yard was 11.08 cents. The cost of Tarvia, including freight and demurrage charges, amounted to 5.72 cents per square yard, bringing the total cost of materials per square yard to 7.60 cents as given. These corrections apply also to the figures presented in the report for 1914 of the Commission.

A COMPARISON BETWEEN BLEACH AND LIQUID CHLORINE DISINFECTION.*

By C. R. Avery, M.A.Sc.

On account of the claims made by the advocates of liquid chlorine on the one hand and by advocates of bleach on the other, the following work was undertaken with the idea of ascertaining what difference, if any, existed between the disinfecting quality of bleaching powder and liquid chlorine when used in water treatment.

From the results of the following experiments it is evident that the disinfecting qualities may be considered in all respects equal on an available chlorine content basis. Taking the results as a whole, the advantage of what difference there is seems to lie with the bleach. This difference is small, however, and the conclusion is that if a

TABLE 1.

Sewage Infected Water treated with 0.2 parts per million Available Chlorine Reduction of Bacterial growth.

Date of Experiment.	Source of Available Chlorine.							
	Bleaching Powder.				Liquid Chlorine.			
	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.
			18°–22°C. count.					
December 31, 1914	3,266	2,400	800	720	....	4,800	520	1,400
	....	1,280	640	450	....	2,700	1,100	1,600
January 4, 1915	11,000	10,400	5,000	7,000	....	11,000	12,000	7,800
	....	7,000	6,500	8,800	....	8,000	8,800	6,500
" 5	5,033	5,600	3,600	3,200	....	6,000	4,800	4,800
	....	5,500	4,000	4,200	average	8,000	4,800	4,000
" 5	6,733	4,800	4,000	5,600	....	6,800	4,800	2.800
	....	2,500	3,000	4,400	8,738	6,400	7,200	1,500
" 6	10,200	4,400	2,800	3,400	....	1,200	440	250
	....	6,000	3,200	1,000	....	480	200	400
" 7	1.600	2,800	1,600	300	....	2.400	1,600	2,100
	....	1,600	2,800	180	....	2,200	720	600
" 8	28,333	16,000	9,600	3.600	....	7,200	5,200	1.000
	....	10.000	11,000	4,400	....	8,800	8,400	2,000
Average	8,738	5,734	4,182	3,375	8,738	5,247	4,327	2,625
Per cent. Reduction	....	35.5	52.0	61.3	....	40.0	50.4	70.0
			37°–40° Count.					
December 31, 1914	....	760	360	160	....	760	240	440
	....	980	340	360	....	1,100	450	220
January 4, 1915	....	2,800	2.800	450	....	3,200	4,800	4,200
	average	2,900	3,600	2,400	average	2,500	3,600	2,900
" 5	....	4,000	1,800	4,400	....	5,000	2,500	1,500
	5,376	4,500	2,000	2,600	5,376	4,000	3,200	1,600
" 5	....	4,800	2,800	2,400	....	5,000	800	1,400
	....	4,500	3,000	2,000	....	3,200	4.400	1,600
" 6	....	1,000	360	800	....	200	160	220
	....	1,400	300	800	....	300	200	280
" 7	....	2,000	4,800	1,000	....	1,000	2,800	1,000
	....	1,900	1,900	1,200	....	1,600	5,600	2,200
" 8	....	8,400	3.000	1,050	....	2,400	1,680	1,000
	....	7.200	2,800	1,600	....	2,000	2,000	640
Average	5,376	3.367	2,133	1,515	5,376	2,304	2,316	1,371
Per cent. Reduction	....	37.3	60.3	71.8	....	57.1	56.9	74.5
			Colon Group. (per 100 c.c.)					
December 31, 1914	550	100	20	0	....	100	20	100
January 4, 1915	1,000	100	100	100	....	20	100	0
" 5	1,000	100	100	100	average	100	100	100
" 5	100	100	20	100	4,664	100	100	100
" 6	10,000	100	20	4	....	100	100	100
" 7	10,000	100	100	100	....	100	100	100
" 8	10,000	100	100	20	....	100	100	0
Average	4,664	100	65	60	4,664	88.6	88.6	71.4
Per cent. Reduction	....	97.8	98.6	98.7	....	98.0	98.0	98.5

normal water supply be treated with the same amount of available chlorine, whether from bleaching powder or liquid chlorine, and provided proper mixing takes place, the disinfection in either case will be the same.

In this report no account has been taken of the problems of mixing and other problems more or less of a mechanical nature met with in municipal chlorination plants. It is quite true that both methods have their advantages and disadvantages; experience has shown that the most fool-proof arrangement is the best with regard to treating a water supply. A municipality should be well advised and should look carefully into the matter of plant arrangement before deciding which of the two to use. The difficulty of obtaining proper diffusion is probably the most

*From the 33rd annual report (for the year 1914) of the Provincial Board of Health of Ontario.

TABLE 2.

Sewage Infected Water treated with 0.4 parts per million Available Chlorine Reduction of Bacterial growth.

Date of Experiment.	Source of Available Chlorine.							
	Bleaching Powder.				Liquid Chlorine.			
	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.
			18°–22°C. count.					
December 31, 1914	....	520	100	200	....	600	200	400
	....	240	200	70	....	1,400	120	400
January 4, 1915	....	7,200	4,000	5,200	....	6,400	1,700	4,800
	average	5,000	5,600	2,600	average	2,200	4,400	6,800
" 5	8,738	3,400	1,200	1,600	8,738	2,400	2,200	1,200
	....	5,600	1,800	480	....	3,600	1,800	720
" 5	....	400	150	80	....	1,600	1,800	180
	....	450	160	200	....	4,000	2 800	140
" 6	....	140	110	50	....	70	50	30
	....	120	70	70	....	70	60	20
" 7	....	200	50	80	....	960	200	10
	....	380	20	40	....	440	160	20
" 8	....	3,600	540	500	....	2,450	1,600	400
	....	4,400	800	120	....	2,000	1,600	450
Average	8,738	2,261	1,057	806	8,738	2,371	1,335	1,112
Per cent. Reduction	....	74.1	87.9	90.7	....	72.8	84.8	87.3

37°–40° Count.

December 31, 1914	800	520	28	22	....	400	440	43
	....	900	80	28	....	860	160	25
January 4, 1915	5,066	3,200	650	650	....	3,600	1,600	1,600
	....	3,600	3,200	850	....	2,800	2,800	2,800
" 5	3,866	2,500	2,000	1,200	....	3,000	1,600	400
	....	4,200	1,600	600	....	2,400	1,000	400
" 5	4,600	2,000	700	100	average	250	70	60
	....	2,200	1,050	120	5,376	170	50	40
" 6	10,866	40	0	60	....	30	40	50
	....	240	0	60	....	30	20	50
" 7	2,966	200	280	150	....	600	2.400	100
	....	200	80	90	....	700	4,000	180
" 8	9,466	2,800	100	240	....	400	400	170
	....	2,400	150	200	....	500	500	130
Averages	5,376	1,785	708	312	5,376	1,124	1,077	430
Per cent. Reduction	....	66.8	86.8	94.3	....	79.0	79.9	91.9

Colon Group. (per 100 c.c.)

December 31, 1914	....	100	20	0	....	20	0	0
January 4, 1915	....	100	100	100	....	20	100	0
" 5	....	100	100	100	....	100	100	100
" 5	4,664	100	20	20	4,664	100	20	20
" 6	....	20	4	0	....	100	100	4
" 7	....	100	20	4	....	100	100	20
" 8	....	100	100	0	....	100	100	0
Averages	4,664	89	52	42	4,664	77	74	21
Per cent. Reduction	....	98.1	98.8	99.3	....	98.3	98.4	99.5

TABLE 3.

Sewage Infected Water treated with 0.6 parts per million Available Cohlorine Reduction of Bacterial growth.

Date of Experiment.	Source of Available Chlorine.							
	Bleaching Powder.				Liquid Chlorine.			
	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.
			18°–22°C. count.					
December 31, 1914	....	26	4	10	....	440	10	40
	....	10	10	3	....	90	4	60
January 4, 1915	average.	800	240	500	....	1,600	2,400	240
	....	200	260	300	....	1,100	1,200	320
" 5	8,738	800	120	70	8,738	200	240	60
	....	200	240	60	....	200	300	30
" 5	....	700	120	30	....	6	12	10
	....	400	80	0	....	6	12	10
" 6	....	16	2	7	....	9	4	2
	....	8	1	2	....	5	5	2
" 7	....	0	4	0	....	5	25	2
	....	2	2	4	....	4	7	0
" 8	....	450	240	54	....	320	120	100
	....	520	180	80	....	400	120	70
Averages	8,738	295	107	80	8,738	313	318	68
Per cent. reduction	....	96.6	98.7	99	....	96.4	96.3	99.2

37°–40° Count.

December 31, 1914	....	140	6	10	....	480	28	10
	....	110	18	7	....	410	48	5
January 4, 1915	average.	200	200	80	....	1,200	240	150
	....	180	80	40	....	1,800	280	110
" 5	5,376	360	200	10	5,376	160	200	40
	....	360	60	50	....	80	180	0
" 5	....	70	30	20	....	300	10	20
	....	50	30	20	....	120	30	0
" 6	....	16	3	2	....	30	20	4
	....	6	2	1	....	....	15	2
" 7	....	8	12	16	....	80	20	5
	....	6	16	15	....	50	22	15
" 8	....	240	100	36	....	320	200	20
	....	200	60	38	....	220	80	16
Averages	5,376	139	58	24	5,376	375	98	28
Per cent. reduction	....	97.4	98.9	99.5	....	93.0	98.1	99.5

Colon Group. (per 100 c.c.)

	average.							
December 31, 1914	....	20	0	0	....	20	0	0
January 4, 1915	....	100	20	20	....	20	4	0
" 5	4,664	100	20	4	4,664	100	4	4
" 5	....	100	20	20	....	20	20	4
" 6	....	20	0	0	....	20	0	0
" 7	....	20	20	4	....	100	20	4
" 8	....	100	20	0	....	100	100	0
Averages	4,664	65	14	7	4,664	54	21	1
Per cent. reduction	....	98.6	99.7	99.8	....	98.8	99.5	99.9

TABLE 4.

Sewage Infected Water treated with 0.8 parts per Million Available Chlorine Reduction of Bacterial growth.

Date of Experiment.	Source of Available Chlorine.							
	Bleaching Powder				Liquid Chlorine.			
	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.	Initial Count.	20 min. Action.	50 min. Action.	90 min. Action.
			18°–22°C. count.					
December 31, 1914	....	120	10	10	....	56	16	20
	average.	10	6	3	....	25	4	18
January 4, 1915	....	360	....	180	....	720	160	10
	....	220	320	....	8,738	320	40	10
" 5	8.738	100	34	3	....	48	4	3
	....	70	30	9	....	25	9	1
" 5	....	14	.4	0	....	14	8	4
	....	15	6	0	....	10	4	1
" 6	....	10	2	4	....	4	1	1
	....	6	2	2	....	7	4	1
" 7	....	1	16	0	....	3	1	0
	....	4	2	0	....	....	0	0
" 8	....	60	40	8	....	400	160	120
	....	45	25	8	....	230	100	100
Averages	8,738	74	38	16	8,738	133	37	21
Per cent. reduction	....	99.1	99.6	99.8	....	98.5	99.6	99.9

37°–40° Count.

December 31, 1914	....	12	7	7	....	4	4	....
	average.	16	5	4	....	12	10	2
January 4, 1915	....	32	22	6	....	22	11	4
	5,376	24	10	7	5,376	18	19	6
" 5	....	68	68	24	....	40	6	4
	....	70	30	14	....	50	13	10
" 5	....	40	30	0	....	20	5	2
	....	30	15	1	....	22	2	2
" 6	....	7	6	0	....	24	6	0
	....	5	2	1	....	....	3	1
" 7	....	19	30	4	....	8	80	30
	....	5	6	8	....	4	20	2
" 8	....	80	24	24	....	80	100	24
	....	12	14	12	....	28	32	22
Averages	5,376	30	19	8	5,376	24	22	8
Per cent. reduction	....	99.4	99.6	99.8	....	99.5	99.6	99.8

Colon Group. (per 100 c.c.)

December 31, 1914	average.	20	0	0	average.	4	0	0
January 4, 1915	4,664	0	0	0	4,664	4	0	0
" 5	....	100	4	0	....	100	20	0
" 5	....	100	4	20	....	20	4	0
" 6	....	4	0	0	....	20	0	0
" 7	....	20	20	4	....	20	4	20
" 8	....	100	4	0	....	4	20	0
Averages	4,664	51.4	4.5	3.4	4,664	24.4	7	3
Per cent. reduction	....	98.8	99.9	99.9	....	99.5	99.9	99.9

TABLE 5.

Sewage Infected Water treated with 1.0 parts per million Available Chlorine Reduction of Bacterial growth.

Date of Experiment.	Source of Available Chlorine.							
	Bleaching Powder.				Liquid Chlorine.			
	Initial count.	20 min. action.	50 min. action.	90 min. action.	Initial count.	20 min. action.	50 min. action.	90 min. action.
	average.		18°–22°C. count.					
December 31, 1914	8,738	3	6	5	8,738	50	2	7
	....	2	7	3	....	12	2	19
January 4, 1915	....	80	40	6	....	50	3	5
	....	48	3	10	....	60	7	6
" 5	....	12	28	1	....	30	15	4
	....	40	6	1	....	12	2	1
" 5	....	4	1	0	....	0	3	2
	....	5	3	0	....	1	3	1
" 6	....	16	9	....	....	10	4	1
	....	8	3	....	....	3	4	2
" 7	....	1	4	0	....	6	0	0
	....	1	3	0	....	0	0	1
" 8	....	6	2	7	....	50	15	8
	....	10	6	11	....	16	7	4
Averages	8,738	17	9	3	8,738	22	5	3
Per cent. reduction	....	99.8	99.9	99.9	....	99.7	99.9	99.9

37°–40° Count.

	average.							
December 31, 1914	5,376	9	2	3	5,376	8	7	5
	....	11	3	7	....	4	3	4
January 4, 1915	....	8	5	8	....	5	14	4
	....	6	4	3	....	7	4	3
" 5	....	30	18	7	....	40	10	7
	....	20	7	10	....	22	20	7
" 5	....	18	12	0	....	5	9	5
	....	8	6	2	....	25	5	1
" 6	....	6	6	1	....	6	2	1
	....	4	0	....	....	5	7	3
" 7	....	14	20	2	....	5	38	5
	....	15	6	4	....	10	10	3
" 8	....	14	12	8	....	20	20	5
	....	16	11	10	....	12	12	14
Averages	5,376	13	8	5	5,376	12	11	5
Per cent. reduction	....	99.7	99.9	99.9	....	99.7	99.7	99.9

Colon Group. (per 100 c.c.)

December 31, 1914		0	0	0	....	20	0	0
January 4, 1915	average.	0	0	0	....	0	0	0
" 5	8,664	100	4	0	4.664	100	20	0
" 5		4	4	20	....	4	4	0
" 6		20	0	0	....	20	0	0
" 7		4	4	0	....	4	4	4
" 8		4	0	0	....	20	20	0
Averages	4,644	16.5	1.7	2.8	4,664	24	7	1
Per cent. Reduction	....	99.7	99.9	99.9	....	99.5	99.9	99.9

serious one facing liquid chlorine. Whereas the bulky nature of the bleaching powder plants will always militate against them.

Method of Conducting the Work.—The liquid chlorine used in this work was supplied to the city of Toronto by the Leavitt-Jackson Company, from one of their drums or carboys. A saturated solution was secured which served for making the standard solutions used in the following work. In order to ensure a fair comparison the solutions used for disinfecting the samples were prepared and titrated by the chemist at the experimental plant immediately before use.

Known quantities of water were infected with different amounts of sewage, varying the pollution to such an extent that the counts ranged from 1,000 to 30,000 bacteria per cubic centimeter. In each of the first pair of sample bottles 150 cc. of this infected water was placed, in one sufficient bleach solution was added to treat the sample at the rate of 0.2 or more parts per million of available chlorine, to the other was added an amount of liquid chlorine solution sufficient to give it an equal amount of available chlorine. These samples were analyzed for the bacterial content in duplicate after standing intervals of 20 minutes, 50 minutes and 1½ hours.

Other samples were treated with 0.4, 0.6, 0.8 and 1.0 p.p.m. of available chlorine and analyses made after the same intervals. In order to obtain as accurate results as possible a large number of analyses were made, it was also necessary to be very precise in all quantitative measurements, dilutions and shakings.

Tables of Results.—Table 1 shows the results obtained on treating samples of infected water with 0.2 parts per million of available chlorine from bleaching powder; the last four columns show the corresponding results obtained on treating the same samples with a similar amount of liquid chlorine. In the first column are shown counts per cubic centimeter in the untreated samples, the second column shows the counts resulting 20 minutes after the addition of the chlorine, the third and fourth columns show the counts 50 minutes and 1½ hours, respectively, after the addition of the chlorine. Below each column is shown the average count for the whole series, and at the bottom of the 3rd, 4th, 5th, 7th, 8th and 9th columns are shown the average reductions occurring after the different intervals. The first part of the table deals with the results of the 18°-22° C. counts, then follows the 37°-40° C. counts and the colon group. On close examination it will be seen that very little difference exists in the disinfection produced by either the bleach or the liquid chlorine. Where small quantities of chlorine are used the time interval after treatment is of much greater importance than when larger quantities of chlorine are used. Summing up the action of 0.2 parts of available chlorine, whether from bleach or liquid chlorine, the reduction in the counts is not high but the reduction in the colon group is remarkable when one considers the high pollution of the water samples and the small quantity of disinfectant used. So close are the reductions by either disinfectant throughout that it would be unfair to say that the advantage lies with either.

The arrangement of the remaining tables illustrates the difference in the actions of 0.4, 0.6, 0.8 and 1.0 parts of available chlorine per million. With regard to the results, little further comment is necessary, the close similarity between the disinfecting action of the bleach and liquid chlorine is self-evident throughout the entire work.

In order to test the advisability of using a colorimetric method of testing for free chlorine, after the plating was completed the bottles were left in a row and treated with equal quantities of Pot. Iodide solution, starch solution and acetic acid (about 2 cc. of each). The samples containing the liquid chlorine were a deeper color than those treated with bleach and the color was not nearly so well graded. In both cases the tint was very slight and uncertain in any sample which had been treated with less than 0.8 p.p.m. of available chlorine. This shows how unreliable it is to depend on the color test as a measurement of the disinfecting action.

Technique used in making the comparative analysis for bleach and liquid chlorine disinfection.

On the back of the table a row of bottles is placed, each containing 150 cc. of water sample used. In front of these are placed one or more rows of dilution bottles each containing 100 cc. of sterile water. At a noted time bottle No. 1 was treated with sufficient standard bleach solution to give it 0.2 p.p.m. of available chlorine, two minutes later bottle No. 2 was treated with sufficient to give it 0.4 p.p.m., and so on. After 10 minutes, bottle No. 6 was treated with liquid chlorine solution to give 0.2 p.p.m.; after 12 minutes No. 7 was treated with sufficient to give 0.4 p.p.m.; after 18 minutes all samples had been treated. After 20 minutes bottle No. 1 was analyzed; after 22 minutes bottle No. 2 was analyzed, etc, so that each sample was analyzed 20 minutes after adding the chlorine. In a similar manner, as will be seen from the schedule, each sample was also analyzed 50 minutes and 1½ hours after the addition of the chlorine. This schedule was rigidly followed throughout so that there was no variation whatever in the storage periods.

A USEFUL ROAD EXPERIMENT.

The U.S. Office of Public Roads has an interesting bit of experimental work known as the Chevy Chase road. It consists of different types of pavement—bituminous macadam laid by the penetration method, surface treatments of waterbound macadam, asphaltic surfaces on concrete foundations, bituminous surfaced concrete, plain and oil cement concrete and vitrified brick, all of which are under daily observation to ascertain which of the types is best suited to the traffic and which is condemned by practical test under the same conditions of climate, soil, rainfall, heat and cold and like traffic requirements. The entire road has been laid with the utmost care and the test is one of materials, construction, durability, cost and maintenance throughout. In the stones used their specific gravity, their weight per cubic foot, their water absorption, their percentage of wear, their hardness and toughness are all determined by careful scientific tests. Patrolmen are constantly employed on this road to keep account of whatever defects in materials and construction may develop and exact data as to the cost of maintenance.

The road was so placed that all of its sections or types have been subjected to precisely the same sort of traffic year in and year out and the section or type that has not stood the strain has been as important an object lesson to roadbuilders as the section or type that has maintained itself under like strain.

According to the report of the Trespass Committee of the United States Association of Railway Claim Agents, reports from roads representing an aggregate mileage of 231,000, contain statistics showing upwards of 11,000 accidents to trespassers on steam railroads during 1914. The records of the Interstate Commerce Commission indicate that during the past 25 years, trespassers have comprised the bulk of deaths on railroads, in fact, to the extent of 52 per cent.

SAND CUSHION vs. GROUT BASE FOR STANDPIPES.

THE following discussion relates to the comparative merits of the grouted base and the sand cushion for standpipes. It is from a paper read by Mr. Chas. W. Sherman before a recent meeting of the New England Waterworks Association.

The writer points out that probably the most common method of transmitting the pressure from the bottom of a standpipe to the masonry or concrete foundation is by means of a sand cushion, or in some cases a cushion of sand mixed with cement. Without such a supporting layer it is obvious that the empty tank would rest upon the rivet heads, and when filled the plates between the rivets would be bent in such a way that a considerable part of the plates would come in direct contact with the foundation.

As far as transmitting the loads from the plates to the foundation is concerned, there is no material criticism of the sand cushion. It is a fact, however, that even with the best of workmanship the bottom of the standpipe is not absolutely flat. Certain plates or parts of plates will bulge either up or down. Those parts which bulge up, or "dome," will not rest upon the sand cushion when the tank is empty, as the sand cannot be caused to flow enough to fill these empty spaces, and the confined air has no opportunity to escape. When the tank is filled with water the plate is bent down into contact with the sand, but when the tank is emptied the plate will spring back to its original position.

It is, of course, impossible to get at the under side of the bottom of the tank for cleaning and painting, and it is, therefore, of importance that the material with which the plate comes in contact should have a preservative action upon the metal. It is well known that hydraulic cement has such a preservative action. Probably for this reason it has been customary in many cases to mix dry cement with the sand cushion on the supposition that in the course of time slight leaks in the bottom plate, or water absorbed from the atmosphere, or by capillarity through foundation, may be sufficient to cause the cement to set. It is obvious, however, that if the cement should set, when the tank is empty the domed places in the bottom plate would again spring back to their original position, leaving voids between the metal and the cushion.

As an alternative method it has been attempted in some cases to grout the space between the bottom plate and the foundation by pouring cement grout through holes left in the bottom plate, these holes being afterward stopped by iron plugs. Although it is somewhat difficult to fill all the voids under the bottom plate by this method without forcing in the grout under so great a pressure as to lift the bottom plate itself, nevertheless it is possible, by careful work, substantially to fill the entire space. When the bottom is well grouted in this way the plate should be in intimate contact with the cement mortar through its entire extent, and accordingly should be subject to the preservative action of the cement. As an example of the use of the latter method the writer describes the recent installation of a standpipe, 55 ft. in diameter and 44 ft. high, resting on a foundation of cement concrete. The holes for grouting were arbitrarily spaced 10 ft. apart in both directions. This spacing was unfortunate, as it left a few plates without any grouting holes whatever in them, and in several cases brought the holes close to the seams between the plates. The holes were 2 in. in diameter and were fitted with 2-in. pipe 2 ft. in length and with threaded plugs.

The grout was made of a 1:1 mixture of cement and screened sand, using sufficient water to make it of the consistency of cream, and was poured from coalhods into tin funnels inserted in the tops of the 2-ft. lengths of 2-in. pipe. A stick about ¾ in. in diameter and somewhat uneven was worked up and down in the grouting pipe while the grout was being poured, thus assisting in keeping the grout well mixed and in causing it to flow freely through the pipe.

The experience in pouring the grout varied considerably. In some cases the grout would flow freely to a long distance from the hole through which it was poured; in others, it could not be made to run more than a short distance. In one case, at least, the grout flowed to a distance of 7 ft. on one side and 8 ft. on the opposite side of a particular hole. In one case where the grouting hole was located close to a seam the grout apparently did not flow past the seam at all.

It was found practicable to determine closely the extent of the filling beneath the plate by pounding upon the bottom with a heavy stick. When the grout at last ceased to flow from any pipe it was apparently due to a stoppage at the bottom of the pipe itself, and there was no evidence that hydrostatic pressure was transmitted to any distance around the pipe in such a manner as to tend to lift the bottom plate.

As previously stated, the spacing of the grouting holes was somewhat unfortunate, and complete filling of the space beneath the bottom plate from the holes originally drilled was not successful. Nearly all of the space was filled, however, and 132 bags of cement were used in the grout poured through the original 27 holes. By pounding the bottom after this work was completed the points where additional grouting was required were determined and were marked. Additional holes were drilled at these points and the grouting continued.

If the points for the grout pipes had been spotted upon the bottom in advance of drilling, instead of being arbitrarily located at a fixed distance apart, there would probably have been no difficulty in completing the job from the first set of holes. The holes should have been so located that there would be at least one in every plate. They should be located approximately axially upon the centre line of the plate, and also in the high spots of the bottom if any exist.

A different method of insuring that the bottom of a standpipe is in perfect contact with the foundation has been employed by Mr. William Wheeler, of Boston, in twelve or fourteen cases and with entire satisfaction. This method consists in constructing the bottom of the tank in the form of an inverted cone. In Mr. Wheeler's practice the altitude of this cone has been uniformly 2 ft., and this method has been used on tanks as large as 40 ft. in diameter.

It is obvious that the conical form possesses the advantage of being able to resist pressure from beneath without deformation, so that it is possible to put in grout under pressure without in any way lifting the bottom, and also that there is no opportunity for air pockets. In setting these tanks it has been Mr. Wheeler's practice to lower them into final position about 2 ins. above the previously constructed masonry foundation and to fill the 2-in. space with a 1:1 mortar mixed rather wet and forced into place by a long, thin rammer, working from the outside.

THE ECONOMICAL TOP WIDTH OF NON-OVERFLOW DAMS.

A PAPER to be presented before the American Society of Civil Engineers on January 5th, 1916, by Mr. Wm. P. Creager, treats of the most economical width of top of the commonly accepted type of section of solid, gravity, non-overflow dams. The writer believes it to be the general opinion of engineers that the section with a zero top width, namely, a triangular section, contains the minimum area consistent with fixed assumptions; and that the adoption of a definite width of top for a roadway or other purpose is made at a sacrifice of economy. Presumably, for this reason, many dams have been built with tops as narrow as 5% of the height. This investigation, however, shows that the most economical width of top for usual designing assumptions is not zero, but lies generally between 10 and 17% of the height, according to the assumptions used in the design. As the difference in the volumes of sections, having quite a wide range of top widths, is very small compared with the uncertainty of many of the designing assumptions, the paper may be considered of academic rather than of economic interest.

It is just this point in particular, however, which the writer brings out, namely, that his investigations, as far as they have been carried, indicate: (1) That there is little or no economy in the adoption of extremely narrow tops; and (2) that exceptionally wide tops may be used, if desired, with comparatively little sacrifice of economy.

The curves shown on Fig. 1 cover seven sections, designed under different assumptions. They indicate for each the most economical width of top, in terms of height, and the relative areas of sections having other top widths. The assumptions used have been designated by letters, and are as follows:

Location of Resultant—

A.—Resultant, reservoir full, to intersect all horizontal joints at the exact extremity of the middle third; except near the top before the down-stream face departs from the perpendicular, where the resultant lies within the middle third.

B.—Same as *A*, except to intersect at a point within the middle third a distance equal to one-fifteenth of the width of the joint.

C.—Resultant, reservoir empty, to intersect all horizontal joints at the exact extremity of the middle third; except near the top, before the up-stream face departs from the perpendicular, where the resultant lies within the middle third.

D.—Resultant, reservoir empty, to have no influence on the design of the section.

Forces Considered—

E.—Weight of concrete; assumed specific gravity, 2.25.

F.—Weight of concrete; assumed specific gravity, 2.33.

G.—Horizontal component of water pressures.

H.—Vertical component of water pressures on the battered up-stream face.

I.—Horizontal silt pressure; silt assumed to be a liquid with a specific gravity of 0.64 in addition to the water pressure. Depth of silt five-tenths of the height of the section.

J.—Uplift on all horizontal joints. Total uplift assumed to be represented by a triangle, the unit uplift equal to five-tenths of the hydrostatic pressure due to the total head of water at the up-stream side diminishing uniformly to zero at the down-stream side.

Joint Pressures—

K.—Limited to 9 tons per sq. ft., at the down-stream face.

L.—Limited to 11 tons per sq. ft., at the up-stream face.

M.—Joint pressures not considered.

Up-stream Face—

N.—Battered to conform to Condition *C* only.

O.—Battered to conform to Condition *L* only.

P.—Vertical throughout.

Curve No. 1.—Assumptions *A*, *D*, *E*, *G*, *M* and *P*: In starting the investigation of this subject, a design was made for a section 200 ft. high, with a top width of 10 ft. The assumptions used in the design are indicated by the

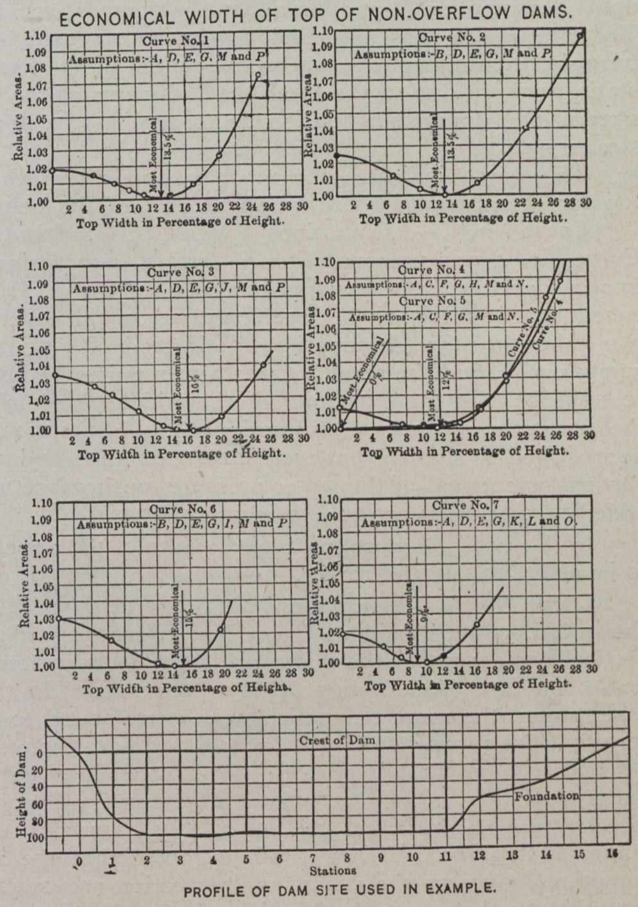


Fig. 1.

letters. This section, or any part thereof, can be changed to suit other heights by simply changing the scale to which it is drawn, as all weights and forces vary as the square of the height, and both the moment of stability and the moment of overturning vary as the cube of the height.

All the dimensions of the top 40 ft. of this section were then multiplied by 2.5, resulting in a section 100 ft. high, with a top width of 25 ft. The area of the resulting section was then computed as being the area of a dam 100 ft. high, with a top width of 25% of the height.

The top 50 ft. of the original section was then multiplied by 2.0, resulting in a section also 100 ft. high, but with a top width of 20% of the height.

In this way a number of sections were produced, each 100 ft. high, but having different widths of top. The relative areas are plotted on Curve No. 1 as ordinates and the top widths in percentages of the height as abscissas.

It will be noted from this curve that the most economical top width of sections designed in accordance with these assumptions, is about 13.5% of the height.

Curve No. 2.—Assumptions *B*, *D*, *E*, *G*, *M* and *P*: Curve No. 2 was prepared in the same manner and under the same assumptions as adopted for Curve No. 1, except that the resultant, reservoir full, instead of intersecting all horizontal joints at the exact extremity of the middle third (Assumption *A*), was required to lie within the middle third a distance of one-fifteenth of the width of the joint (assumption *B*).

This curve, though slightly different in shape from Curve No. 1, also indicates the most economical width of top to be about 13.5% of the height.

Curve No. 3.—Assumptions *A*, *D*, *E*, *G*, *J*, *M* and *P*: Curve No. 3 was derived under the same assumptions as those governing the design of Curve No. 1, except that uplift (Assumption *J*) at all horizontal joints was included. The total uplift was assumed to be represented by a triangle, the unit uplift equal to five-tenths of the hydrostatic pressure due to the total head of water at the up-stream side diminishing uniformly to zero at the down-stream side.

This curve indicates the most economical width of top for these conditions to be about 16% of the height.

Curve No. 4.—Assumptions *A*, *C*, *F*, *G*, *H*, *M* and *N*: Curve No. 4 was prepared from a section, also designed in accordance with the assumptions used for Curve No. 1, except that in this case the specific gravity of the concrete was taken at 2.33 (Assumption *F*), instead of 2.25 (Assumption *E*), and the resultant was also required to intersect the base at the extremity of the middle third when the reservoir is empty (Assumption *C*). Assumption *C* necessitated a slightly battered up-stream face and the vertical component of the water pressure on this face was added to the forces acting (Assumption *H*).

In this case the most economical width of top appears to be about 12% of the height.

Curve No. 5.—Assumptions *A*, *C*, *F*, *G*, *M* and *N*: Curve No. 5 is the same as Curve No. 4, except that the vertical component of the water pressure on the battered up-stream face (Assumption *H*) was neglected. In this case, alone, the most economical width was found to be zero, but the curve is seen to be nearly horizontal between 0% and 14%, at the latter width involving an increase of material of only ½ of 1 per cent. This curve will apply directly to "Theoretical Type No. 2," by Edward Wegmann, M.Am.Soc.C.E., as it will be noted that the assumptions covering the design of the section are exactly the same as those used by Mr. Wegmann. It might be remarked here that the condition of requiring the resultant to lie within the middle third with reservoir empty is often omitted by engineers, a vertical up-stream face being adopted, unless a batter is required for the condition of limiting toe pressures.

Curve No. 6.—Assumptions *B*, *D*, *E*, *G*, *I*, *M* and *P*: Curve No. 6 was based on the assumptions used in preparing Curve No. 2, except that in this case silt pressure (Assumption *I*) was included. The silt pressure was assumed to be a liquid with a specific gravity of 0.64 in addition to the water pressure, and its depth was assumed as five-tenths of the height of the section.

On account of the silt pressure, the expedient of changing the scale, resorted to in computing previous curves, would apply from the top of the dam to the surface of the silt only. The rest of each section had to be computed separately for each point on the curve.

Assumption *I* seems to lead to a slightly larger economical top width appearing on the curve to be about 15% of the height.

Curve No. 7.—Assumptions *A*, *D*, *E*, *G*, *K*, *L* and *O*: Thus far there has not been taken into consideration the condition of limiting joint pressures (Assumptions *K* and *L*). Curve No. 7 is based on these assumptions. In other respects the assumptions used were the same as for Curve No. 1.

On account of Assumptions *K* and *L*, the expedient of changing the scale, resorted to in computing Curves Nos. 1 to 5, would apply only from the top of the dam to the elevation at which the limiting joint pressures began to govern the design. The rest of each section had to be computed separately for each point on the curve.

The vertical component of the water pressure on the battered up-stream face (Assumption *H*) was neglected in order to simplify the calculations. A comparison of sections 200 ft. high was also used in computing Curve No. 7.

For this curve the most economical width was found to be about 9% of the height. In all probability, to include in the calculations the vertical component of the water pressure on the battered up-stream face would increase the most economical width, as it was seen from Curves Nos. 4 and 5 that it resulted in an increase from 0 to 12 per cent.

Method of Application.—It must be remembered that the curves apply only to dams of constant height throughout their length. In order to obtain the greatest economy, the top width, theoretically, should be a fixed percentage of the height at any point. As a varying width of top is objectionable, for many reasons, a constant width should be adopted which will be somewhat less than that corresponding to the most economical for the maximum height, the amount of such reduction depending on the relative quantity of material contained in that portion of the dam less in height than the maximum.

In order to indicate the amount of such reduction the writer has designed a dam for the profile indicated on Fig. 1 in accordance with the assumptions used in computing Curve No. 3, and found the most economical top width for this dam to be 14% as compared with 16% indicated on Curve No. 3 for the maximum section (100 ft.).

This indicates that very little reduction in top width is necessary unless the variation in height of dam at different points along the profile is considerable.

Conclusion.—The assumptions used herein cover in a general way most of the important conditions usually considered, with the exception of ice thrust. However, as the consideration of overturning force in addition to the water pressure seems to increase the most economical top width, as in the case of uplift and silt conditions (Curves Nos. 3 and 6); and as the consideration of ice thrust, in itself, increases greatly the top part of the section, it seems logical to assume that an economical top width for ice thrust condition would be at least as great as that indicated in Curves Nos. 3 and 6.

It is believed, therefore, that, except for Curve No. 7 (which, however, would probably have been similar to the rest if the vertical component of the water pressure had not been neglected), practically no economy results in selecting a top width for dams of practically uniform height less than about 14% of the height; and that, for some designing assumptions, a width of even 17% involves no sacrifice of economy.

It is true that the assumptions on which these conclusions are based do not consider sliding or vertical shear. It is believed, however, that cases where these considerations affect the shape of the section are the exception rather than the rule. Moreover, in the light of these investigations, as far as they have gone, it is hard to say whether these conditions would require a smaller or a larger top width than indicated in the curves.

OVERLAND PIPE SCHEME, OTTAWA.

By L. McLaren Hunter, C.E.,
City Engineer's Department, Ottawa.

OWING to the Insurance Underwriters imposing a heavy surcharge on fire insurance in the city of Ottawa, an Insurer's Committee was formed by the Board of Trade to report upon a safe and abundant supply of water at a reasonable cost, to meet the present exigencies. The committee suggested that any work done now should be with the view that same should be good for at least fifteen years' service, and, if possible, form a part of a comprehensive plan that may be of value to the city as a stand-by, or auxiliary, to any scheme that may be finally adopted.

Messrs. Wm. Kennedy and W. S. Lea, hydraulic and water supply engineers, were called in to consult with the Insurer's Committee, of which Mr. J. B. McRae, consulting engineer, Ottawa, was a member.

The first thing to be settled was the best point at which the intake would be placed. It was decided that the Lemieux Island site was preferable, not only on account of engineering considerations but owing to the fact that it has been tried out and has never failed by reason of ice troubles.

It is proposed to construct a high-lift pump-house on Lemieux Island. This building will be so located as to draw water from the present intake basin. The water will enter the intake channel through a submerged entrance, protected by a heavy rack. The stop-log checks and fine screens will be located inside the pump-house, and operated by means of a travelling crane. Provision will be made for placing a steam-heated rack in front of the screens to combat ice troubles should such be experienced.

The station will initially contain two high-lift pumping units, and provisions for extensions as required. The pumping units will consist of centrifugal pumps, each rated to deliver 20,000,000 Imperial gallons per day of twenty-four hours, against a total head of 280 feet. These pumps will be direct connected to induction motors of 1,600 horse-power each. All the necessary equipment in connection with the same, excepting the electric current transformers, will be conveniently located in the building, all properly housed and protected against accident. The building is to be a fireproof structure.

The transformers and heating plant will be housed in a separate building to meet the requirements of the Canadian Fire Underwriters' Association.

Fig. 1.—A Portion of the Map of Ottawa, Showing the Overland Pipe Scheme.

It is intended to use the existing chlorinating apparatus and apply the hypo-chloride at the pumping stations as done at present.

Two 51-inch water mains will be laid from the pump-house crossing Lemieux Island to the South Channel of the Ottawa River, the river crossing being made on a bridge suitably designed for this purpose and for light traffic as well. The pipes will then proceed to connect with the general distribution system as designed by Mr. W. S. Lea, of Montreal, last year.

In the accompanying illustrations Fig. 1 shows the adopted route for the overland pipe. Fig. 2 illustrates the arrangement of valves at Lemieux Island. These valves are so constructed that water can be immediately supplied to the city when the first of the pipes has been completely laid. When the future permanent scheme is

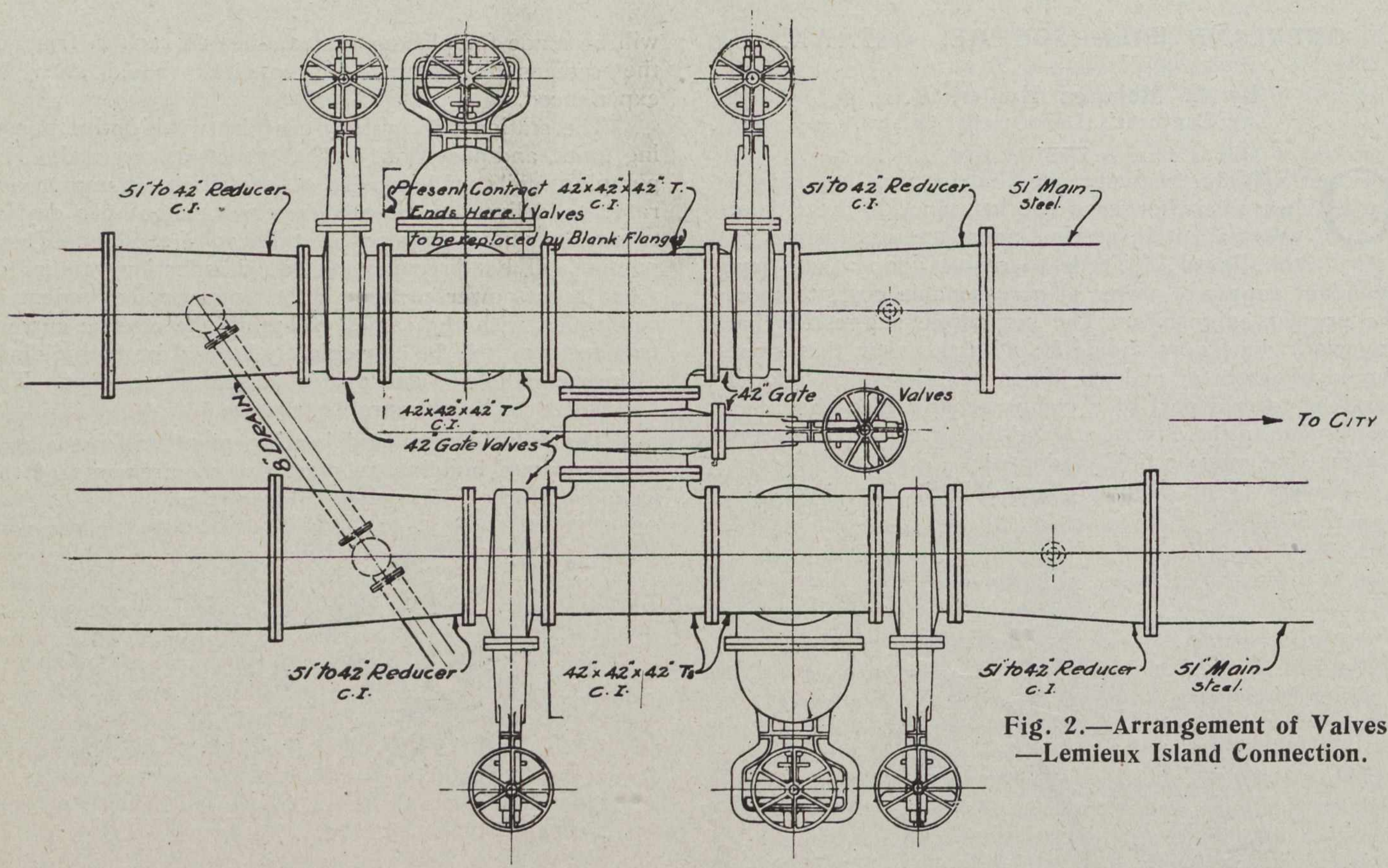
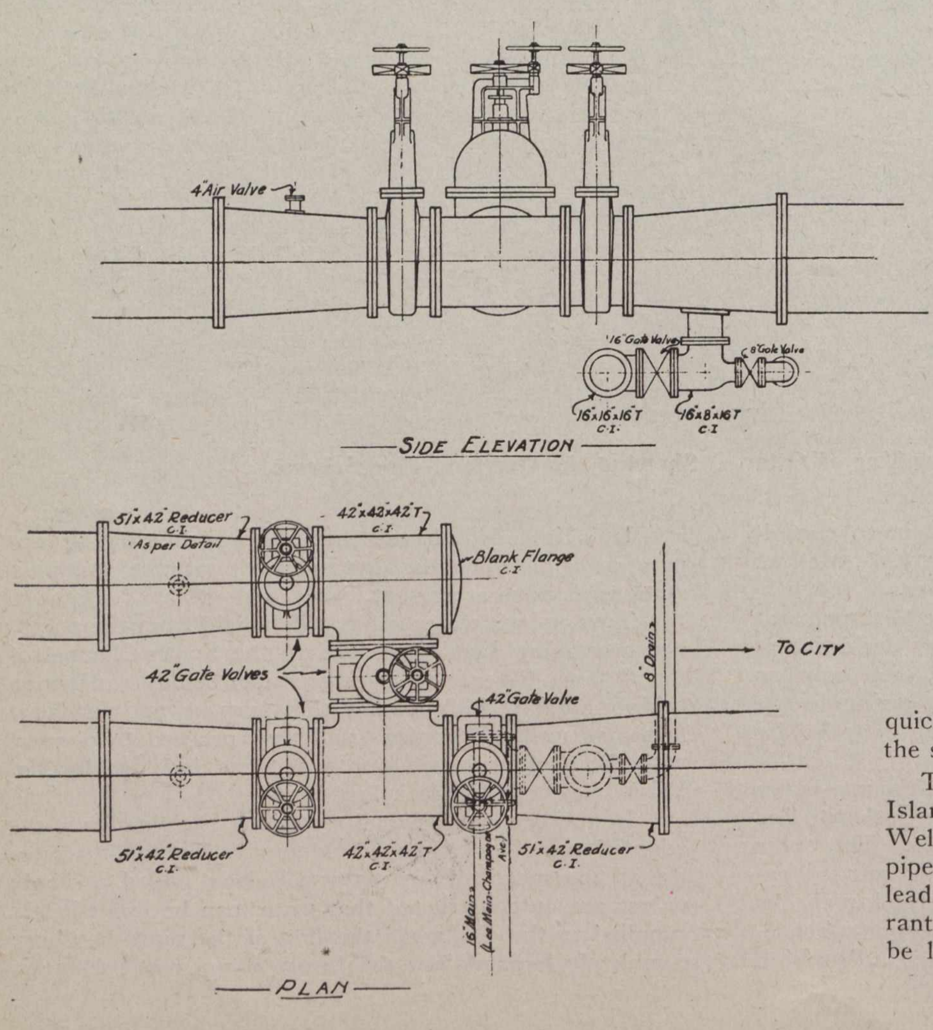


Fig. 2.—Arrangement of Valves —Lemieux Island Connection.

settled, the pipes can then be connected without interferring in any way with the city's supply. It is to be noted that 51-inch x 42-inch reducers were placed at each valve. This procedure effects a considerable reduction in cost and is considered to be quite as satisfactory. By shutting off the alternate set of valves, repairs or tests can be made



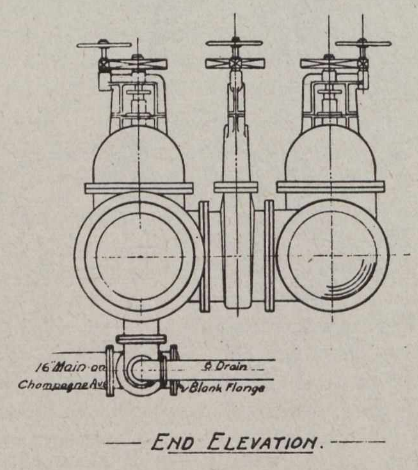


Fig. 3.—Wellington Street Junction of the Two 51-inch Pipes with the Single 51-inch Pipe Line.

quickly and conveniently without hampering the supply.

Twin 51-inch pipes are laid from Lemieux Island to the intersection of Champagne and Wellington Streets. Fig. 3 shows these twin pipes connecting into a single 51-inch pipe leading to the city. When circumstances warrant the extension an extra 51-inch pipe can be laid in this remaining portion of the line.

The contract for the trenching of the pipe was let to Mr. Thos. McLaughlin, of Ottawa, for $63,514 and work is now proceeding very rapidly. Mr. J. B. McRae, consulting engineer, Ottawa, has charge of the work. The tender for the lock-bar type of pipe was awarded to Messrs. Laurin & Leitch, of Montreal, at a cost of $19,400.

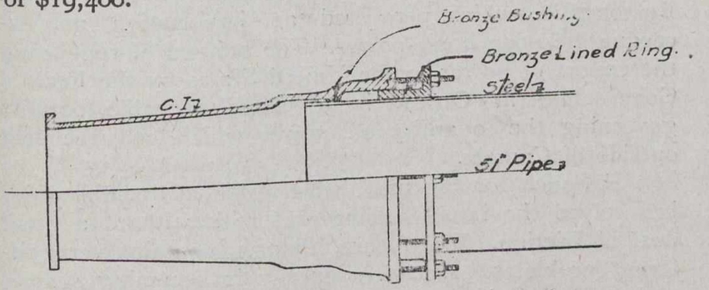


Fig. 4.—Detail of 51-inch x 42-inch Reducer Expansion Joint.

ONTARIO HYDRO RADIAL PROJECTS.

The Hydro-Electric Power Commission of Ontario has prepared an elaborate scheme of hydro radials for what is generally known as the western peninsula of the province. The project, with a total estimated cost of about $13,734,000, will consist of a line from Toronto westward to London, with an approximate length of 127 miles, divided into eight sections as follows:—

Toronto Terminal-Humber River section: From a passenger terminal located near the foot of Yonge Street the line will run westerly to Sunnyside, using Harbor Board property and private right-of-way wherever possible; thence to the Humber River the line will parallel the G.T.R., as at present constructed.

Humber River-Port Credit section: From the west limits of the city of Toronto at the Humber River, the line runs westerly parallel to the G.T.R. main line. It crosses the Credit River at a point between the Lake Shore Road and the G.T.R.

Port Credit-Milton section: Leaving Port Credit, the line crosses the G.T.R. about one mile west, running thence to a point north of Sheridan P.O., and from there directly to Milton.

Milton-Guelph section: Crossing the C.P.R. west of the C.P.R. station at Milton, location runs to township of Esquesing, thence to township of Nassagaweya, thence to township of Puslinch, and thence in the general direction of the Eramosa River to Guelph.

Guelph-Berlin section: From Guelph the line continues to Berlin, leaving Guelph in a westerly direction and entering Berlin from the northeast. The location lies north of the present G.T.R. between Guelph and Berlin.

Berlin-Stratford section: From Berlin the line runs to the G.T.R. main line, which it parallels to a point near Baden, and thence south of the G.T.R. to a point east of Stratford, where it will cross the G.T.R. and enter the city.

Stratford-St. Marys section: In Stratford the line runs westerly over private property and over the city streets to the western limits of the city. Thence it runs parallel to the G.T.R. to St. Marys, through Downie and Blanchard townships. It then runs southerly and westerly through the town over private property and streets, crossing the C.P.R. at grade and thence over the Thames River.

St. Marys-London section: From the western limits of the town of St. Marys the line runs in a southwesterly direction through Blanchard and Biddulph townships parallel to the G.T.R. to Granton. From Granton it runs through Biddulph township southerly to the northern boundary of London township. From thence it runs southeast through London township to a point between the Sarnia Road and the Thames River, a short distance west of the Wharncliffe Road just outside the northwesterly boundary line of the city of London. From this point the line runs southeasterly over private property and city streets and over the Thames River to Bathurst Street, and easterly along Bathurst Street to the London and Port Stanley Railway, which at present terminates on Bathurst Street just east of Richmond Street.

In this system, as outlined a few days ago by Sir Adam Beck, chairman of the Commission, the total amount of debentures to be issued by the respective municipalities for deposit with the Commission is as follows: Township of London, $630,389; Trafalgar, $578,921; Waterloo, $521,903; Blanchard, $402,909; Wilmot, $479,065; Downie, $418,735; South Easthope, $316,262; Toronto, $345,355; Nassagaweya, $343,147; Guelph, $361,025; Etobicoke, $401,335; North Easthope, $248,585; Biddulph, $142,166; Esquesing, $91,922; Puslinch, $70,300; Eramosa, $42,180; Nelson, $31,130; Ellice, $33,100; East Zorra, $39,000.

City of Toronto, $4,240,196; London, $1,109,303; Berlin, $774,040; Guelph, $734,862; Stratford, $651,735.

Town of Waterloo, $193,900; St. Marys, $153,940; Milton, $65,000.

Village of Mimico, $111,200; New Toronto, $82,250; Port Credit, $54,050; New Hamburg, $66,250.

Total amount of bonds to be issued, $13,734,155.

The maintenance charges for the entire road, apart from operating expenses, are estimated at $214,583. The operating revenue is estimated at $1,692,175, and the operating and maintenance at $817,025. The total amount estimated to be needed annually for interest charges is $686,708, and the sinking funds needed for the whole road amount to $137,342.

On Tuesday, December 7th, a conference was held relative to Toronto's share of the scheme, a report of which is too late for publication in this issue. At this meeting Sir Adam Beck, and the city's Rapid Transit Commission, consisting of Messrs. E. L. Cousins, chief engineer of the Toronto Harbor Commission; F. A. Gaby, chief engineer of the Hydro-Electric Power Commission, and R. C. Harris, commissioner of works for the city, met the Board of Control for the purpose of discussing the scheme prior to submitting it to the City Council.

It is probable that the various municipalities concerned will vote upon the project at the January municipal elections.

RAILROAD EARNINGS

	1915.	1914.	Inc.
Canadian Pacific Railway			
November 7	$3,015,000	$1,908,000	+ $1,107,000
November 14	3,035,000	1,878,000	+ 1,157,000
November 21	2,960,000	1,729,000	+ 1,231,000
Grand Trunk Railway			
November 7	$ 986,755	$ 906,941	+ $ 79,824
November 14	971,715	860,676	+ 111,039
November 21	935,884	841,607	+ 94,277
Canadian Northern Railway			
November 7	$ 806,500	$ 525,800	+ $ 280,700
November 14	820,800	533,700	+ 287,100
November 21	768,900	5[illegible]	+ 257,400

DIVERSION OF WATER FOR POWER PURPOSES AT NIAGARA FALLS.

THE power situation at Niagara Falls is dealt with at considerable length in the recently issued report for 1914 of the Queen Victoria Niagara Falls Park Commission. The reference supplements an extensive review of the subject, which appeared in the report of the Commissioners for 1911, and adequately discusses the general trend during the past few years of the power development at Niagara. The following notes are reproduced:—

It will be remembered that for many decades the principal thought of scientists and captains of industry centered around the possibility of producing power for industrial use. Then the concentration of engineering skill not only announced the feasibility of the project, but financial interests became convinced of the practicability of engineers' theories and resolved to risk capital in the venture. A period ensued when all discussions centered about the development and what it had in store, not only for the cities of Niagara Falls in Ontario and the State of New York, but the districts at a distance, if long distance transmission of electrical energy could only be accomplished. With the wearing away of the novelty of huge hydro-electric installations, larger than had been attempted in any part of the world before, public sentiment, always slow to assert itself, was gradually seized with the thought that the aesthetic features of Niagara Falls were very intimately bound up with this ingenious scheme of the designers and builders to turn one of nature's masterpieces to the benefit of the utilitarian requirements of man. And while the general sentiment was doubtless lax in failing to realize the interconnection between commercial and aesthetic features in the first instance, there is no doubt but that it was over-zealous in seeking to protect Niagara as a spectacle when this side of the question was grasped. Then followed the immense popular outcry with its thousands of letters from all parts of the North American continent to the Federal Governments at Washington and Ottawa, making protest and avowing that the near future would see the complete spoliation of Niagara Falls and its disappearance as a tourist centre. Theoretical pictures were published showing bare walls of rock with not so much as a trickling stream of water falling over the crest, and Niagara was portrayed as having but one use left, namely, that of an immense bill board. Time has followed on, however, and very few of the evil results have materialized from the use of water, although in low-water stages there is reason to believe that the effect may be detected by close observation.

Upon the other hand, however, these same effects were quite as evident under abnormal conditions many years before power development was either possible or even thought of. Due to strong east winds Lake Erie has been known to increase its depth at the Detroit River to such an extent that the extremities of the Horseshoe Falls showed only ragged streams, because of the lack of water which ordinarily poured over them. The swing of the pendulum brought the great mass of opinion in this country to the realization of the possibility of destroying scenic beauty, and from this it was but a short step to enlist joint action by Canada and the United States to put into effect a limitation upon the total amount of water to be diverted. Thus we have the ratification of the Boundary Waters Treaty on May 13th, 1910. This treaty allotted 20,000 cubic feet of water per second to the United States and 36,000 cubic feet of water per second for use in Canada, the difference in quantity being accounted for by the fact that power developed within the limits of Ontario was being transmitted to the New York side of the river. There was a further limitation in the United States covered by the Burton Bill, which permitted an importation not exceeding 160,000 horse-power. The method of regulating the export of power to the United States by the Federal Government at Ottawa is to issue revocable permits governing the quantity of power which may be sent outside of Canada.

So much for the past, which with all its difficulties has solved the issues arising before it without a great deal of friction. The future, though, contains very different problems. Electrical energy is becoming scarce, and the time is approaching when the demands will exceed the limitations placed by the International Boundary Waters Treaty. The five-year period mentioned in the Treaty expires this year, and a twelve months' notice by either party will serve to terminate its provisions. The Burton Bill limitation has expired for want of reenactment, although its limitations have not been exceeded materially, if at all.

The principle guiding negotiations in connection with boundary waters in the past has been the equal use by Canada and the United States of any waters diverted for power purposes, and this, as above indicated, was taken cognizance of in the unequal allotment of water at Niagara Falls, and was compensated for by transmission of power from Canada to the United States. Now, however, in the public press, and even in the written opinion of some public bodies, the suggestion is made that it is a duty of New York State to obtain for its people the use of the full amount of power which can be obtained from the Canadian hydro-electric plants, and the reason for this is not stated to be the equalization of the use of the waters of the river for power purposes by the two neighboring countries, but on the contrary because industrial establishments and works once enjoying this privilege will by the vested rights and interests created make it impossible for the return of power to the Canadian side no matter what necessity may arise. The Public Service Commission of the State of New York, Second District, in considering an application for the import of a 46,000 horsepower block of power created in Ontario made some very significant statements, and it is interesting to quote the opinion of the Commission as decided February 12th, 1914:—

Governmental Limitations Upon the Export of Electrical Power from Canada.

The Canadian Government requires the taking out of a yearly license permitting exportation of Niagara electric power. Upon the limitations existing as to the exportation of electric power from Canada into the United States, it appears that for many years, under the so-called Burton Act, and by action of the Canadian Government, a very large amount of Canadian produced Niagara electric power has been and is now being imported into this country at and about the Niagara frontier, and is being distributed for light and industrial power and railroad purposes within the State of New in many places, embracing Syracuse to the east, the south-western part of the State, territory south of Lake Ontario and Buffalo, and Niagara Falls in the west. The companies distributing this imported power have issued stocks and bonds in very large amounts based upon their business of distributing Canadian power. This applicant is now seeking to enter the same field. Without going into details, it seems sufficient to say that the prohibition of exportation from Canada of this present electric power which now comes into this country would paralyze business and industry of many kinds and would deprive numerous localities of electricity for light. American produced Niagara power is so far from supplying the vital needs of the sections of the State above described that the immediate results of such prohibition would plainly amount to a great public calamity.

The Electrical Development Company enjoys rights obtained from the Canadian Park Commissioners, and which were granted under authority of the Ontario Provincial Government, including the right to export electric current not to exceed fifty per cent. of its plant capacity. The form of securing a license yearly from the Dominion Government is required by the Dominion law, but such license has been granted yearly to the other great producing electrical corporations of Canada, and no reason appears for apprehension that any discrimination would be made against the Electrical Development Company or the Toronto Power Company, lessee. We have nothing before us but the suggestion that the Dominion of Canada may at some future time forbid this exportation. This Commission must assume that international relations affecting so important a subject as the means of continuing great industries which have grown up in reliance upon the use of this imported power, and as well the interests of the Canadian producing companies themselves, have become fixed and subject only to such changes as will fully protect the great commercial and industrial interests and rights now served by this power brought from Canada. The time has long since passed when governments proceed ruthlessly from pure national rashness or anger to destroy the settled accepted commercial relations and formally vested rights of persons and corporations.

It will be seen from this that the revocable permits of the Ottawa Government are looked upon as more or less formal and not designed to be withdrawn should occasion demand it. In other words, they are not protective, but simply for information.

Evidence is not wanting to show that the opinion is held by representatives of the people and men in authority that it would be a good business stroke to secure and use large amounts of power from the Canadian side under the plausible argument that its return would be impossible because of the jeopardy to established conditions which this return would entail. Legislation has been introduced at Washington having for its object the permission to import larger quantities of power than heretofore allowed, and other legislation has been put forward making the importation without limitation of any kind upon the ground that it is a natural commodity and its use very beneficial to industry. Fortunately, the situation now unfolding is revealed before the power generated upon the Canadian side is exhausted and turned to the benefit of manufacturies and developments which bring no advantage to the people of Ontario.

The question of procuring tonnage is said by Mr. E. Hamber, Vancouver, to be the great question now before the British Columbia lumber industry. Markets are in existence in Australia, South Africa and the Orient and still larger markets are looming up in the United Kingdom and Europe, but the ships are lacking for the conveyance of the cargoes.

GENERAL NOTES ON FOUNDATIONS.

In a paper presented at the annual meeting of the American Society of Mechanical Engineers held in New York, December 7 to 10, Mr. Chas. T. Main discussed the subject of foundations. The following notes abstracted from his paper, present a general consideration of the subject that will be found of value:—

After the location of a plant has been decided upon, and the site selected, a sufficient number of borings should be made or test pits sunk to determine the character of the soil and its bearing capacity. Such exploration will reveal whether the site is suitable or whether the cost of foundations would be excessive. If the site is found suitable, the knowledge of the underlying soil or rock is necessary for the proper and economical design of the foundations.

The borings are made for the purpose of determining at what level firm soil is to be reached, if at all; the the thickness of any stratum of firm soil; the character of the underlying material; the level of the ground water; whether piles will be required and the probable length of same.

It is of great importance to support all structures on a stratum of soil below silt or peat. If the structure is to be a heavy or an important one and it is found necessary to use piles, some of the borings should be carried to bed rock, if possible, and dry samples of the soil should be taken every few feet in depth. The samples should be examined as soon as taken, as the moisture in them evaporates and their character changes rapidly. If uniform conditions are found a few widely scattered borings will be sufficient, but where the conditions vary a greater number should be made.

If it is found necessary to drive piles, test piles should be driven and careful records kept. Piles should be tested by loading until marked settlement takes place and careful readings should be made before and after each increment of load. If possible, loads should be allowed to rest at least 24 hours after each increment, except the final load which should remain on at least 48 hours unless a failure of pile or testing platform prevents. All test piles should be pulled, whether load-tested or not, to determine their condition and suitability for the work.

From the accumulated data obtained from borings, test pits, test piles and from pile loading tests, it will be possible to select working loads for the piles suited to the building to be supported. In general, the working pile values should have a factor of safety of not less than 2½ based on a load producing ⅜ in. total settlement by test. However, it may be desirable to select a working load based on allowable settlements such as 1/16 in. to ⅛ in. The values of the factor of safety and working or ultimate settlement are all to be fixed to suit the class of structure to be supported.

Buildings which are to contain moving machinery or delicate instruments would naturally require piles with fairly large factors of safety, while in cheap one-story structures for storage purposes the safety factors could be much lower. Where piles are not load-tested, the values given by the Engineering News formulæ can safely be used. These formulæ are:

For a pile driven with a drop hammer, $P = \dfrac{2WH}{S+1}$.

For a pile driven with a steam hammer $P = \dfrac{2WH}{S+0.1}$, in which P = safe load in lbs., W = weight of hammer in lbs., H = fall of hammer in ft., S = penetration or sinking in inches under the last blow.

Test pits should be sunk for determining the level of the ground water and for making a study of the soil for a reasonable depth more accurately than can be done with borings. Both the maximum and minimum levels of the ground water should be determined, the maximum for obtaining the hydrostatic head on waterproof basements and the minimum for finding the safe level for cutting off wood piles or to determine if it will be better or cheaper to use concrete piles.

When the structures are of any considerable magnitude and piling is unnecessary, tests should be made to determine the bearing capacity of the soil to insure the maximum economy in design. Having ascertained the condition of the soil and decided that piles are not necessary, and having also decided upon the maximum pressure to which the soil is to be subjected, the widths of foundations can be determined from the estimated loads.

Solid ledge forms the most secure support for foundations, providing it goes all round the building. Part earth and part ledge are apt to cause unequal settlements. The ledge, if uneven, should be levelled off and, if on a slope, cut to form steps to give an approximately horizontal surface. In going from rock to earth, the footing courses of the foundation should be spread out to a greater width on the soil next to the ledge, gradually narrowing into the regular width for earth foundations. If there should be any unequal settlement, it will be spread over a greater length of the superstructure and probably save cracks in the walls which might otherwise occur at the junction of earth and rock.

Hard gravel or hard pan is quite as desirable as ledge. Gravel and sand are also good when kept dry. A stratum of 6 to 8 ft. of hard-compacted and well-cemented material, even if underlaid by softer material, is usually safe. With dry sand, this stratum should be double the thickness.

Clayey soils are somewhat treacherous. Upon exposure to the air they dry and crack, and exposed to rain they become semi-fluid or expand. With this soil it is best to open only a small portion of the trench at a time and quickly fill in behind.

With buildings used for industrial purposes, there is usually more or less vibration caused by machinery in motion, and the loads carried by the foundations should be less per square foot of bearing material, or less per pile, than in buildings which are not subject to such vibration. On soft clay or running sand confined, the pressure should not exceed ½ to 1 ton per sq. ft.; medium blue clay, whether or not mixed with fine sand, 1 to 2 tons; hard clay, 2 tons; compact sand and gravel, 2 to 3 tons; hard pan, 5 to 6 tons per sq. ft. Under favorable conditions of soil and use of building, these loads may be exceeded.

In any building with a uniform firmness of earth under it, the area of foundations for walls, towers, piers, and other portions of the building should be in proportion to the pressure. The loads on the outside walls may be a little lighter than those on the piers. In case the soil should vary considerably in one portion from another, the areas supporting equal weights should be changed to correspond with the soil. In this way unequal settlements are avoided and the most economical structures of approximate uniform strength obtained.

Where there is unreliable soil, piling must be resorted to. If firm earth cannot be reached by the bottom of the piles, the supporting force is friction alone. If there should be an underlying firm stratum, even at such a depth that excavation would be too expensive and sometimes impossible, but still within the reach of piles, then piling can be used with good success.

Where wood piles are properly driven, that is, not broomed or broken, the bearing capacity of the piles, when driven into sand, usually shows under the test loads a slight increase over that indicated by the above formula; but those which have brought up hard and have been crippled will show a much less capacity under the test load than was indicated by the formula.

From tests recently made on wood piles embedded in in medium and stiff clay on the site of the new buildings for the Massachusetts Institute of Technology, it was found that for about each 5 ft. of embedment of the pile in clay, 1 ton value could be added to that given by the above formula for drop hammers.

Spruce or similar soft wood piles without iron points, driven with drop hammer, should be used cautiously where there is a hard crust of gravel or sand overlying clay. Oak piles without iron points will usually penetrate the hard ground and come practically to a standstill without material injury. Any wood pile which is to depend largely upon point bearing for its value should be of oak or southern pine.

When piles are driven through a hard fill and an intervening layer of peat, silt or mud, to the hard sub-soil it will be necessary to reduce the value given by the formula as it contains the values of the hard fill above the intervening peat. This value can be approximately corrected by subtracting the value shown when driving in the fill or a conservative value assumed after comparing with other piles passing through no complication of strata.

Unless batter piles are used, it is necessary to drive far enough into the solid material to give stiffness to the structure against vibration, especially where the fill above is soft.

Concrete piles should be used where the distance to good bearing material is great, where wood is scarce or the ground water low. Considerable expense may be saved in the foundations under the latter condition.

The three kinds of material commonly used in foundations are dry rubble masonry, rubble masonry laid in mortar and concrete. Dry work is unsuitable for industrial buildings. Stone laid in cement mortar with bedded joints is very satisfactory and should be used where there is an ample supply of stone at a low price. Concrete is most commonly used and is usually the most convenient material to handle, and under ordinary conditions it can be used at the lowest cost.

A foundation for a chimney and other isolated structure having a small base and heavy pressure should be carried to the lowest depth to which it would be necessary to go with any other work reasonably near it, since if it is on sand there is a liability of undermining it.

Among Canada's imports to Great Britain during the last two fiscal years, the following items are of particular note to the engineer:—

	Value in £ 1913-14.	Value in £ 1914-15.	Increase or decrease.
Asbestos	73,961	92,147	+ £18,186
Mica	8,957	7,611	— 1,346
Machinery	114,977	109,396	— 5,581
Copper	57,110	116,648	+ 59,538
Iron and steel	24,425	110,668	+ 86,243
Crude zinc	18,514	25,526	+ 7,012

Editorial

THE IMPERIAL MUNITIONS BOARD.

The organization of the Imperial Munitions Board involves no reflection upon the Canadian Shell Committee. It means simply that there has been a change in the character of the work to be done, and that financiers must handle it, rather than technical men.

The problem in Canada to-day is, "How can we get paid for the shells we deliver?" The problem of yesterday was, "Can we make shells in Canada? and how can we mobilize our industrial resources to the best advantage?"

The Canadian Shell Committee, made up of technically skilled men, was necessary to solve yesterday's difficulties. That it did its work most satisfactorily is best proven by the fact that Mr. Hichens is now able to handle the situation with a Board in which there sit but two engineers, General Bertram and Colonel Carnegie. The other five members are all financiers. That proves that the worry now is "money," not "production," and shows that Mr. Hichens is correct when he states that "the Shell Committee have for the past fourteen months been carrying on a work of the most exacting and strenuous nature, and have fulfilled their task well; the changes which are now being made are the logical development of their work."

Though the financial strain on Germany has been greater, that on England has not been light, and in order to enlarge the "silver bullet," it is deemed desirable by the British Government that Canada should finance the making of Canadian shells, and give credit to the Allies. To do this, the Canadian Shell Committee would have had to borrow from the banks and, by many other means, put through a financial deal of far greater magnitude than any ever before handled by a single group of Canadians.

Obviously, a reconstruction of the committee and an infusion of financial knowledge was necessary. The result was the appointment of E. R. Wood, president of the Dominion Securities Corporation; J. A. Vaillancourt, president of Banque d'Hochelaga; C. B. Gordon, director of the Bank of Montreal; G. H. Dawson, Surveyor-General, Victoria, B.C., and J. W. Flavelle, director of the Canadian Bank of Commerce. These men are all experienced financiers, each of them connected with numerous concerns, and have the entree into most financial circles in Canada.

The experience and knowledge gained by the retiring members of the Shell Committee will not be lost to the country, however, as Thomas Cantley, George Watts and E. Carnegie have been appointed as members of a new commission which will report on the conservation of raw materials required for war munitions.

DIVERSION FOR POWER PURPOSES OF NIAGARA RIVER WATER.

In view of the reference appearing on another page to the diversion of water from the Niagara River and in view, also, of the schemes that are being advanced to meet the demand for more power, it is of interest to refer to the purport of an order-in-council, approved by His Honor the Lieutenant Governor of Ontario in June, 1914. This order-in-council advises that in view of the restrictions expressed in cubic feet per second, which have been placed upon the diversion of Niagara River waters for power purposes under Article V. of the Boundary Waters Treaty of 1910 between Great Britain and the United States, there should be fixed in cubic feet per second, in the case of each of the powers companies now operating within the limits of the Queen Victoria Niagara Falls Park under agreements with the park commissioners, a specific portion of the total volume of water which is available for diversion in Ontario under the terms of the said treaty.

Notifications to this effect were given to the respective companies by the Queen Victoria Niagara Falls Park Commission on November 5th, 1913, and representatives of each of the companies were heard, and the committee of council advised that the specific portions of the total volume of diversion which the companies may use be fixed as follows:

In the case of the Canadian Niagara Power Company a volume of diversion from the Niagara River above the Falls of Niagara not to exceed eight thousand two hundred and twenty-five (8,225) cubic feet of water per second.

In the case of the Electrical Development Company a volume of diversion from the Niagara River above the Falls of Niagara not to exceed nine thousand nine hundred and eighty-five (9,985) cubic feet of water per second.

In the case of the Ontario Power Company, a volume of diversion from the Niagara River above the Falls of Niagara not to exceed eleven thousand one hundred and eighty (11,180) cubic feet of water per second.

The committee further advised that each of the companies be required, upon reasonable notice being given, to provide facilities for the making, by the Hydro-Electric Power Commission of Ontario, of any hydraulic and electrical measurements and tests which may be necessary in order to determine from time to time: (*a*) Quantity of water used; (*b*) operating head; (*c*) hydraulic and electrical efficiency of individual units or of the plant as a whole; (*d*) amount of hydraulic and electrical power being developed.

The order-in-council also advised that the Hydro-Electric Power Commission be authorized to inspect the plans, specifications, and method of installation of all mechanical, hydraulic and electrical plant now installed, or to be installed, by the said power companies; and that properly accredited officers of the Commission be given authority to make such inspections, measurements and tests, and to enter upon the premises of the companies for such purposes.

CIVIC IMPROVEMENT LEAGUE.

We refer in our issue of December 2nd to the formation of a Civic Improvement League for Canada, and also report Mr. Thomas Adams' address to the conference. It is, therefore, unnecessary to explain the objects and purposes of this new organization further than to state that they comprise almost everything that concerns the general welfare of the people. We hope that the Civic Improvement League will succeed in forming branches in every city, town and municipality and in creating a real live interest on the part of the people. The task set before the National Council is by no means a small one, and the work devolving on the Council will not be light, if the function of that body is fully organized and put into operation. The field for activity is great and fertile. Canadian municipal government is passing through the early stages of development and growth, when mistakes are common and experience is gained at considerable cost. The demand for various public improvements was great in the past and will continue so in the future. Experience in the administration of municipal affairs was limited but it is now great, and it remains to be seen how much we have profited by past errors. It is in this regard we hope the new League to assist the people to develop new lines of thought and new ideals of government, because the tendency for the people to become apathetic, owing to inadequate or inefficient administration, is strong and is liable to become increasingly so unless there is some organization to reawaken public interest in municipal affairs.

The objects of the League, as set out in the report, cover sufficient ground for thought and action, so that lethargic branches should be rare exceptions. If the objects are discussed from coast to coast and periodical conferences are held, we anticipate lively debates, when the best minds will act in unison for the development of great things in Canadian municipal politics.

REPORT OF WELL-DRILLING FOR OIL AND GAS IN ONTARIO.

THE Ontario Bureau of Mines has recently issued a very useful report, consisting of records of wells drilled for oil and gas in the province. The report was compiled by Cyril W. Knight, and should be of considerable value to the practical driller. Mr. Knight points out in his introductory paragraphs that of the 407,262 square miles comprising the Province some 30 per cent. are underlain by rocks of Paleozoic age, the remaining 70 per cent. by pre-Cambrian. Over half of the surface area of the Paleozoic lies in the northern part of the Province adjacent to the flat-lying coasts of Hudson and James Bays, and the remainder occupies the region in the vicinity of Lakes Huron, Erie and Ontario. There is also a comparatively small Paleozoic area near the junction of the Ottawa and St. Lawrence Rivers. The northern Paleozoic region is virgin ground in so far as prospecting for oil and gas is concerned. Oil and gas do not occur in economic quantities in the granites, gneisses, quartzites and other rocks of the pre-Cambrian. Hence, when the driller passes through the Paleozoic sediments and encounters the pre-Cambrian he invariably, if he is well advised, ceases drilling.

The important oil and natural gas wells of the Province are confined to the Paleozoic rocks of the Erie-Huron peninsula, which is defined as that part of the country west and south-west of a line between Georgian Bay and Toronto. It may be pointed out that wells which have been drilled show that these almost flat-lying undisturbed sediments have a thickness of nearly 3,800 feet in Lambton county, and that their thickness decreases as the pre-Cambrian rocks to the north are approached. No reliable estimate can be made regarding the thickness of the Paleozoic adjacent to Hudson and James Bays.

The two main conditions necessary for the accumulation of oil and gas in economic quantities, states Mr. Knight, are (1) a porous sandstone, limestone or other rock, and (2) impervious strata of shale, or other material, capping the porous reservoir to prevent the escape of the oil or gas.

The porosity or vacant space of an ordinary sandstone is from 8 to 10 per cent., but there may be a rapid change in the same strata from dense rocks, almost impervious to oil and gas, to loose, porous sand. Some sandstones are uniform over large areas. In others the size of the individual grains varies, as does also the amount of the cementing material, both these conditions causing variations in porosity. Sandstones may pass into conglomerates, which, if loosely cemented, may be more porous than sandstones.

The pores or vacant spaces are filled with varying amounts of water. In the Appalachian field, for instance, the lowest strata seem almost dry, but, as higher members are approached, they become more and more saturated.

If oil and gas are present in a dry, porous rock, the oil may descend and collect at the bottom, or near the bottom, of synclines. In a porous rock saturated with water, however, the oil and gas are forced to rise on account of the differences in specific gravity. When saturated strata are gently folded into anticlines, the gas may be found at the top of the anticlines, the oil on the flanks, and the water in the basins or sides. The occurrence of oil or gas in anticlines is known as the anticlinal theory. In rocks partly saturated with water, the oil may collect at any point on an anticline or syncline.

Regarding the accumulation of gas, it may be said that under all conditions it will most probably be found in the anticlines.

The report goes into considerable detail respecting the geology and physical features of the western peninsula. The production of crude oil in Ontario up to the end of 1914 is given in tabular form, from which the various totals for the past nine years are extracted:—

	Barrels.
1906	588,959
1907	779,974
1908	528,956
1909	420,660
1910	314,408
1911	288,632
1912	240,935
1913	226,166
1914	212,496

The production of natural gas from the six gas fields in the province shows, on the other hand, a very large increase during recent years, having an approximate value of $250,000 in the year 1904, and of $2,350,000 in 1914.

The well records which the publication presents are quite extensive, occupying as they do some 70 pages of tables.

Canada's war loan of $50,000,000 will enable the Dominion to finance its share of the war expenditures for almost four months.

COAST TO COAST

Calgary, Alta.—The Public Works Department of the city has recently completed the improvement and gravelling of four miles of main roads in the suburbs.

Petrolia, Ont.—Acting on the recommendation of the Hydro-Electric Power Commission, the town has purchased the existing electric light plant, the price being $11,285.

Berlin, Ont.—A public meeting was held last week to decide upon the route which the proposed hydro-radial railway from Toronto to London should take in passing through Berlin.

Port Moody, B.C.—Plans and specifications have been prepared and tenders will shortly be called for the erection of the Port Moody Steel Works. Mr. Mynohan, of Pittsburgh, is general manager of the company.

Port Moody, B.C.—A new water supply system is to be installed at a cost of about $37,000. The contractors are Messrs. Robertson, Godson & Co., Vancouver, and are expected to complete the plant before May next.

Truro, N.S.—The Canadian Government Railways staff has had several survey parties out this summer locating between Truro and Painsec Junction, with a view to possible changes in the line of the Intercolonial Railway.

Sarnia, Ont.—The Reid Wrecking Co. will make an examination of the old waterworks intake pipe which extends several hundred feet into the river, to ascertain to what extent it needs cleaning, and if there are any broken joints.

Port Arthur, Ont.—Speaking with regard to the prospect of colonization road work continuing during the remainder of the war, Mr. J. F. Whitson, commissioner of colonization roads, expressed it as his opinion that the work should go on.

Bassano, Alta.—At the recent convention of the Western Canada Irrigation Association a resolution was passed urging the Dominion Government to extend irrigation facilities as rapidly as possible to an area of about 350,000 acres in the Lethbridge District.

Hamilton, Ont.—The Steel Company of Canada is planning extensive additions to its plant. Three new open-hearth furnaces are to be built, the blooming mill extended, and two forge shops erected. The improvements will cost several thousand dollars.

Calgary, Alta.—A deficit of $769.82 was experienced by the Municipal Street Railway for the month of October, when all things are considered, including a depreciation reserve without which the month's operation would have shown a profit of approximately $2,000.

Transcona, Man.—It is reported in Ottawa that the government has leased the Transcona shops for the manufacture of shells and war munitions. These shops, which are the equipment of the National Transcontinental Railway, are very suitably adapted for this purpose.

Fort Vermilion, Alta.—On the Smoky River and on other water courses in this section of the province the Department of the Interior, Canada, is engaged in measuring the stream flow. P. H. Daniels is in charge of the work at Fort Vermilion and J. R. Strome at Peace River Crossing.

Peace River Crossing, Alta.—Test pits are being sunk and other preliminary investigations made for the new bridge to carry the Edmonton, Dunvegan and British Columbia Railway over the North Heart River. There is a span of about 600 ft. and its height above the river will be approximately 40 ft.

Moose Jaw, Sask.—Mr. George D. Mackie, city engineer, announced last week that repairs to the break in the infiltration gallery at Caron had been completed, and that a satisfactory supply was not being received through the 20-mile pipe line. The work of repair was carried out by the McManus Construction Co.

Toronto, Ont.—The report of the Rapid Transit Commission consisting of Messrs. E. L. Cousins, harbor engineer; F. A. Gaby, chief engineer, Hydro-Electric Power Commission, and R. C. Harris, commissioner of works for the city, has been practically completed, and parts of it are in the hands of the printers.

Victoria, B.C.—Mr. C. H. Rust, city engineer and water commissioner, estimates that at small expense a 1,000-h.p. electrical development could be made on the east fork of the Sooke River. The city's arrangement with the British Columbia Electric Railway Co., however, prevents the establishment of a competitive system.

Quebec, Que.—Good progress has been made on the new Union Station, a description of which appeared in one of the summer issues of this journal. The C.P.R. terminal arrangements, described in *The Canadian Engineer* for September 23rd, 1915, will provide for the company abundant room to assemble large numbers of coaches and freight cars in anticipation of demand.

Vancouver, B.C.—That the completion of the Pacific Great Eastern Railway through Prince George into the Peace River country in the near future is of vital importance to Vancouver and the coast district, is the statement of Mr. W. G. Gillett, mayor of Prince George. The Pacific Great Eastern Railway is already graded into Prince George, and steel has been laid as far north from Vancouver as Clinton.

Montreal, Que.—By the end of the year the city will have 200 miles of paved streets, of which 40 miles have been laid this year. This constitutes the largest mileage of any single year yet recorded in the history of the city. Last year some 36 miles of new paving was laid. In 1910 Montreal had only 70 miles of paved streets. One feature of this season's work is the large proportion of asphalt paving that has been laid.

PERSONAL.

N. LEBLANC has been reinstated as town engineer of Aylmer, Ont.

C. H. R. FULLER, B.A.Sc., secretary of the Toronto Branch of the Canadian Society of Civil Engineers, has received a commission in the Ninth Mississauga Horse.

E. L. WARNER has been appointed general sales manager, with headquarters in Toronto, of the Dominion Paint Works, Limited, Walkerville. JOHN GRIEVE has been appointed eastern representative and is in charge of the Montreal office of the firm.

J. A. BANCROFT, professor of geology at McGill University, Montreal, recently delivered an interesting address in that city on the subject of zinc deposits in the province of Quebec.

W. G. WORDEN, a graduate in engineering of the University of Toronto, and formerly an employee of the Department of Works, Toronto, has been appointed town engineer of Oshawa, Ont., succeeding Mr. F. A. Chappell, resigned.

W. H. FRASER, electrical superintendent of the British Columbia Electric Railway, recently addressed the Vancouver section of the American Institute of Electrical Engineers, his subject being "The Electric Vehicle and the Central Station."

Lieut. ED. A. BAKER, a graduate of Queen's University in electrical engineering, has been recommended for the military cross. Lieut. Baker is now in a hospital in England, having lost the sight of both his eyes through the bursting of a shell.

E. R. SHIRLEY, formerly electrical superintendent for the Canadian Exploration Co., Limited, Naughton, Ont., has been appointed power house superintendent of the new plant at Seven Falls on the St. Ann River, Quebec, of the Laurentian Power Co.

Major FRANK A. CREIGHTON who, at the outbreak of hostilities, had held a commission in the Corps of Guides, and had become attached to the First Ontario Battalion, has been second in command of that battalion since September. Major Creighton has been a member of the Canadian Society of Civil Engineers for some ten years. In Ontario and Maritime provinces he has had a wide experience in railroad location and construction. From 1907 to 1913 he was successively city engineer and engineering commissioner of Prince Albert, Sask. When the La Colle Falls hydro-electric project was undertaken by the city he was appointed general manager. He resigned in the fall of 1913 and established an office as consulting engineer in Winnipeg.

OBITUARY.

The death occurred in Ottawa on November 28th of Mr. George Goodwin, formerly a prominent contractor and builder. The deceased was 72 years of age. He was at one time actively associated with the construction of railways, canals, locks and public buildings in different parts of Canada.

A recent casualty list contains the name of Lieut. G. K. Wilgress, a young civil engineer who went to France with the 21st Battalion. The deceased was a graduate of the Royal Military College, Kingston, and prior to enlistment was engaged in survey work in Western Canada.

WESTERN CANADA IRRIGATION ASSOCIATION.

At its Bassano convention the Western Canada Irrigation Association elected the following officers for the coming year: Hon. president, Hon. Dr. W. J. Roche, Minister of the Interior; president, Hon. W. R. Ross, Minister of Lands, B.C.; hon. vice-president, J. S. Dennis; first vice-president, Hon. Duncan Marshall, Minister of Agriculture, Alberta; second viec-president, Senator Bostock, Kamloops, B.C.; executive committee, west of Rockies, J. L. Brown, president, Kamloops Agricultural Society; James Johnston, alderman, Nelson; F. Maurice Smith, Penticton, and W. E. Scott, Deputy Minister of Agriculture, Victoria; east of Rockies, F. H. Peters, commissioner of irrigation, Calgary; G. R. Marnoch, president, Lethbridge Board of Trade; R. A. Travis, secretary Bassano Board of Trade, and Joseph Dixon, Maple Creek, Sask. Norman S. Rankin was unanimously elected permanent secretary of the association. Next year's convention will be held at Kamloops, B.C.

OTTAWA BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Ottawa Branch held its first luncheon for the season on November 2nd. Brigadier-General Bertram, M.Can.Soc.C.E., formerly chairman of the Canadian Shell Committee, addressed the meeting on the subject of munitions.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

Regular Meeting, December 2nd, 1915.

One of the most interesting electrical papers ever presented to the Canadian Society of Civil Engineers was read by Mr. R. M. Wilson, M.Can.Soc.C.E., at the regular meeting at Headquarters on the evening of the 2nd instant. The hall was filled, and amongst those present were the majority of the leading electrical engineers of Montreal and the district. Mr. Wilson's paper was the third, or rather the fourth, of a series describing the hydro-electric development of the Cedars Rapids Power Manufacturing Company, being a description of the electrical part of the work. After comprehensively describing the electrical equipment and the tests in the text of his paper, Mr. Wilson exhibited about fifty slides giving the more important views and details, as well as reproductions of efficiency curves and test charts. To add further to the interest the author gave a most interesting resumé of the unit costs throughout the work. In a future issue we shall have pleasure in referring to the article in detail.

At the conclusion of the paper a very animated discussion was joined in by Dr. L. A. Herdt, Mr. K. B. Thornton, Mr. Julian C. Smith, Mr. R. A. Ross, Mr. C. S. Saunders and Mr. R. M. Wilson.

A hearty vote of thanks was moved by Mr. J. de Montrouge Duchastel and tendered to the author amidst applause. The chair was occupied by Mr. Walter J. Francis, who expressed the hope that the members would join freely in a written discussion as soon as the complete series of papers will have been printed and issued. Mr. Francis then announced that at the next meeting, which will be held on the 16th instant, Dr. Howard T. Barnes will deliver an illustrated paper on submarines.

COMING MEETINGS.

INTERNATIONAL ROAD CONGRESS.—To be held at Worcester, Mass., December 14, 15, 16 and 17, 1915. General Secretary, Herbert N. Davison, Chamber of Commerce, Worcester, Mass.

AMERICAN FORESTRY ASSOCIATION.—Annual meeting to be held at Boston, Mass., January 17th and 18th, 1916. Secretary, P. S. Ridsdale, Washington, D.C.

CANADIAN NATIONAL CLAY PRODUCTS ASSOCIATION.—Fourteenth annual convention to be held at Toronto January 18th to 20th, 1916. Secretary, G. C. Keith, 32 Colborne Street, Toronto.

James, Loudon and Hertzberg, consulting engineers, Toronto, have moved their offices from the St. James Chambers to the Excelsior Life Building, Toronto Street.