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NOVEL THEORY APPLIED TO DIFFICULT FOUNDATION

PAPER PREPARED FOR THE CANADIAN SOCIETY OF CIVIL ENGINEERS, DESCRIBING THE METHOD EMPLOYED IN DESIGNING FOUNDATIONS FOR THE FEDERAL LEGISLATIVE PALACE IN MEXICO CITY.

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IN designing the foundations of the Federal Legislative Palace now being built by the Mexican Government in the city of Mexico, the novel assumption was made that the bearing capacity of the subsoil gradually decreases from the perimeter towards the centre of gravity of the structure.

The building is 420 feet long, 370 feet wide, and in a general way it is composed of three stories and a basement; the highest part of the steelwork in the dome is 221 feet above the foundation.

Work was begun in 1905, after many preliminary experiments rendered necessary owing to the unreliable bearing capacity of a heterogeneous subsoil. The consolidation of the ground, to which we will refer later, was finished in 1910 and the erection of the steel structure was started in April of the same year. Due to the political troubles since 1910, work on the structure has been entirely stopped since the summer of 1913. If the work is carried out according to the original design it will cost over $12,000,000.

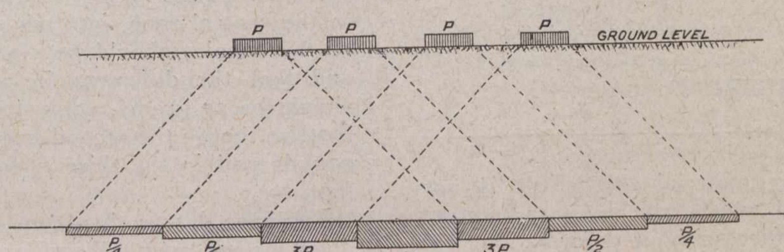

Fig. 1.—Illustrating the Variation of Resistance of a Plastic Body from the Edges to the Centre of a Foundation.

The design of the superstructure, which is of the well-known type of steel skeleton, though very complicated, did not present any unusual problem, but the foundations were designed according to a new theory. The usual way of designing foundations is to assume that the subsoil has a uniform resistance and, therefore, it is loaded at a uniform pressure per unit of surface; the contrary idea prevailed in designing the foundations of the Palace, for the capacity of the subsoil to resist pressure was assumed to gradually decrease from the perimeter towards the centre of gravity of the building.

The greater part of the city of Mexico is built on the site of an old lake called Texcoco, whose elevation is 7,400 feet above sea level. Mountains surround the Valley of Mexico, one of which, the Ajusco, rises 13,000 feet above sea level. The site of Mexico City is the lowest part of the valley and for ages volcanic ejections, alluvial matter, etc., have been washed down into the valley from the mountain sides. At the Palace site the soil is composed of a layer of filling matter, debris, dust, etc., about seven feet thick; underneath comes a very peculiar and unique substance. It has the appearance of clay and lies in alternate beds of various thicknesses of brownish and reddish color. That substance is as soft as butter and some of it emits a peculiar smell as of decomposed vegetable matter. It is mixed in various proportions with volcanic ejection or sand.

From time to time one comes across a thin layer of sand and occasionally we meet a pocket which no doubt was originally filled with water. This substance weighs sometimes as little as 70 pounds per cubic foot; that is to say, some 10 to 15 per cent. more than pure water. When this substance is taken out of the ground, the water cannot be squeezed out by pressure, but if left exposed to the atmosphere and to the sun, it loses from 41 to sometimes 82 per cent. of its volume, becoming a gritty lump. This subsoil has an unknown depth, artesian wells 800 feet deep having been bored without finding bed-rock, though occasionally the drill meets boulders of various sizes.

This clayey material cannot support even a light load without deformation. When the steel for the structure arrived at the site it had to be spread evenly on the ground, otherwise uneven settlement was immediately observed. In all constructions of any importance the walls have to be carried up level in order to avoid uneven sinking. It can be judged from this that foundations in Mexico City are a very delicate problem. Almost all the buildings in the city are out of level and out of plumb.

The most peculiar thing, however, in connection with foundations in Mexico is that the centre of the buildings almost invariably sinks more rapidly than the perimeter; not only that, but the elevations, if of any length, say, 75 feet long or longer, invariably sink more in the centre than on the ends, taking a concave form.

The engineer in charge of the foundations for the Federal Legislative Palace was Senor Gilberto Montiel, who was also at that time Deputy Minister of the Department of Public Works. Senor Montiel was fully aware of the bad quality of the subsoil of Mexico and particularly of the fact stated above, that all foundations sink more in the centre than on the edges. He looked about for an explanation of this evil and it occurred to him that the subsoil of Mexico, under a load, was acting more like a semi-solid or plastic body than like a solid material. After long researches, he found that Rankine had studied this problem in his Manual of Civil Engineering and Applied Mechanics. He also found the entire theory of the resistance of a semi-solid body to pressure in a book called "Théories des Potentiels," by Boussinesq, a French author.

The theory proves that the resistance of a semi-solid body to pressure varies from the perimeter towards the centre as the co-ordinates of an ellipse. The variation of resistance of a plastic body from the edges to the centre of a foundation can also be illustrated graphically. (See Fig. 1.)

We have assumed that the pressure due to a load follows an angle of friction of 45 degrees, but any other angle will give similar results. On the sketch we have taken into consideration four equal loads placed at equal intervals. It is seen that the pressure on the soil decreases from the centre towards the ends because, as we go down the loads merge one into the other, the pressure per unit of surface in the centre in this case and at a given depth being four times the pressure near the ends. When we

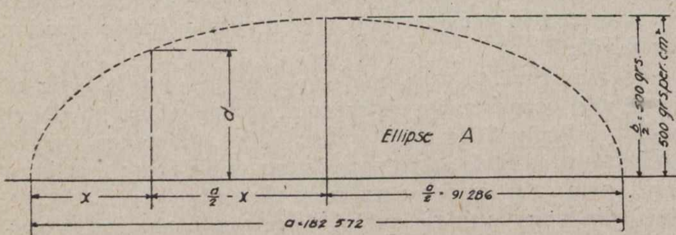

Fig. 2.—Ellipse A.

$a = 182.572 \qquad a^2 = 33{,}332.34$

$b = 1{,}000 \qquad b^2 = 1{,}000{,}000$

$$\frac{a^2}{b^2} = \frac{x\,(a - x)}{d^2}$$

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deal with good foundation material this effect is not noticed because a material which can resist a certain pressure per unit of surface without deformation will equally resist one-quarter of the same pressure; but, when we deal with semi-solid material or such subsoil as we find in Mexico, we recognize immediately that a pressure of one-quarter of a given load will produce less effect than the entire load will. It has occurred to us that if the concave effect is not oftener noticed in construction on weak subsoil it is because walls well built may act as a beam or perhaps as an arch in certain instances.

In preparing the foundation for the Palace, Senor Montiel first excavated a hole four feet below the street level, thereby removing part of the filling. After that, a cofferdam was built surrounding the entire site, said cofferdam being of reinforced concrete five feet thick and extending 24 feet below the floor of the excavation.

Then Senor Montiel proceeded to consolidate the ground; that is to say, to increase its bearing capacity. To accomplish this he drove sand piles in the bottom of the excavation; or, to express it more correctly, he drove holes eight inches in diameter from 10 to 14 feet deep and 20 inches centre to center and proceeded to fill these holes with sand which again was pressed into the ground, pressed down by the pile; the hole was then again filled with sand which again was pressed down into the ground, the operation being repeated two, three and sometimes four times. One hundred and fifty thousand of these sand piles were driven in or injected into the ground, and to give an idea of the quality of this ground, we will say that the holes were made with a wooden pile driven in by a small pile-driver and the pile went in four to five feet at a single blow. Besides, enough sand was injected into the ground to raise the level of the pit five feet, whereas it was found that it only had been raised about one foot. Underneath heavy walls and heavy column loads, long wooden piles were driven in between the sand piles.

After this, work was finished, a bed of loose broken stone about one foot thick was provided, covering the entire surface within the cofferdam. The loads brought on the foundations by the columns and walls were spread out by means of steel grillages. Under each grillage was placed a bed of concrete 20 inches thick, but these beds were isolated and not continuous though, naturally, sometimes these beds serve more than one column, depending on the necessities of the design.

The consolidation of the subsoil required two years of hard work, and no doubt the bearing capacity of the ground has been increased. Nevertheless, Senor Montiel thought that some sinking would still occur and consequently the structure was started four feet higher than required, to allow for expected settlement.

The assumption that the subsoil would still act as a semi-solid or plastic material was adhered to notwithstanding the consolidation, and consequently the ground was loaded unevenly, the unit pressure decreasing as the co-ordinates of an ellipse from the perimeter towards the centre of gravity of the building.

First it was assumed that the average uniform pressure that the ground could safely carry was 1,000 grams per square centimeter, equivalent to 2,048 pounds per square foot. Then it was decided that the pressure in the central zone, into which fell the entire foundation of the cupola, should be 1,947 pounds per square foot, and that the difference in pressure in adjoining zones should be 25 grams, equivalent to 51 pounds per square foot, so that in the second zone the pressure became 1,997 pounds and in the third zone, 2,048 pounds per square foot, etc.

Ellipse A was then constructed. For its semi-minor diameter we adopted 500 grams per square centimeter (1,024 pounds per square foot), or one-half of the average unit pressure, and for its semi-major diameter we adopted the distance from the centre of gravity of the building to the farthest corner of the cofferdam, or 299.51 feet. See Fig. 2.

It was then found that the dividing point between the first and second zones was at a distance of 93.51 feet from the centre of gravity of the building measured on the line running from the said centre of gravity to the corner of the cofferdam. Likewise the dividing point between the second and third zones is 130.55 feet from the same centre of gravity, etc. For a clearer conception of ellipse A it should be regarded as lying in a vertical plane passing through the centre of gravity of the building and the farthest corner of the cofferdam; the centre C of the ellipse coinciding with the centre of gravity and point D with the corner of the cofferdam. See Fig. 3.

Here the reader may well ask if ellipse A has been constructed in strict accordance with the theory developed and analyzed by Rankine and Boussinesq. The answer is that it has not. The researches of these authors cover cases of uniformly distributed loads, whereas at the Palace we have heavy concentrated loads very unevenly distributed. The selection of the major and minor diameters of ellipse A was arbitrary but served the object in view, *viz.*, to have the unit pressure in the various zones decrease as the co-ordinates of an ellipse.

In the central zone the pressure is 1,947 pounds per square foot and in the zone in which the four corner columns of the structure stand, the pressure is 2,560 pounds. The extreme difference in unit pressures is therefore 613 pounds or, say, 32 per cent.

At this stage of our calculation we therefore had various points: 93.51, 130.55, etc., where the pressures were changing and had the building been as wide as it is long, we would have drawn circles passing through these points thus defining the pressure zones. But, the structure being longer than broad, we determined on ellipses for defining the zones. These ellipses, which we call B (see Fig. 4), have all the same centre which is the centre of gravity of the building, have their major diameter coinciding with the longitudinal axis of the building and their minor diameter running along a transverse axis passing through the centre of gravity of the building. This centre of gravity lies 17.39 feet west of the centre of the dome.

Ellipses B lie in horizontal planes, pass of necessity through the dividing points 93.51, 130.55, etc., as determined by ellipse A, and finally their minor and major diameters have the same relation as the width of the building has to its length, *viz.*:

$$\frac{370}{420} = 0.88$$

There remains now only to develop the formulas shown below Fig. 4.

By calculating the area of each zone and multiplying it by its corresponding pressure, we found that the average pressure within the cofferdam was 2,136 pounds per square foot instead of 2,048 pounds, which we had assumed. The error of 4 per cent. being small we disregarded it, though had we been able to reduce all the unit pressures by 102 pounds we would have done it, but it was impossible to do so because the foundation of the dome proper would have encroached on the adjoining beds, thereby upsetting the entire system. Besides, had we reduced the unit pressure, the space within the cofferdam would have been too small to carry the building. Nor did the architect think advisable to reduce the weight of the structure. It should be said here that the cofferdam was built before the total weight of the building was figured and before the system of uneven unit loading was adopted.

Unfortunately, we cannot at present judge whether or not the theory of uneven unit pressure will fulfil our expectation, because the walls have not yet been started. All that can be said is that with the very small loads now on, the foundations have settled, and parts of them unevenly, but this does not prove against the theory because the present loads have no relation to the calculated ones.

The problem of a proper foundation in that part of Mexico City formerly covered by the Lake Texcoco is yet unsolved. A great many buildings, old and modern, have the concave appearance referred to above, but sometimes a corner will sink more than the rest of the structure, showing that the subsoil is not homogeneous. The southwest corner of the Cathedral, built 300 years ago, is four feet lower than the southeast corner. The northwest corner of the National Theatre, now in course of construction, has sunk four feet and four inches in four and a half years; in the same period the northeast corner has sunk only two feet and ten inches. No provisions were made in this building for settlement, with the result that it already looks low and leans on one side. The School of Mines Building, which is one of the oldest and finest in the city, is badly cracked and in some parts in danger of collapse. At the Federal Legislative Palace the subsoil at the southwest corner shows signs of being weaker than any other place within the cofferdam. Indeed, at that place there exists an area of soft subsoil extending one or two blocks westward; other areas of soft subsoil exist within the city where the streets, originally level, are now depressed sometimes as much as three feet.

For the better conception of the problem of foundations in Mexico City, it should be noted that, as stated above, part of the site of the present city was originally under water. Gradually the water receded, but until twenty years ago the lowest parts of the city were subject to periodical floods during the rainy season, and the water level at normal times was almost up to the level of the streets. Twenty years ago a sewerage system and a drainage canal were built by a British firm with the result of eliminating the floods and of lowering the water level throughout the city; we now find water at from three to ten feet, according to location.

In drying up, the ground has shrunk. This shrinking of the ground certainly contributed to a certain extent

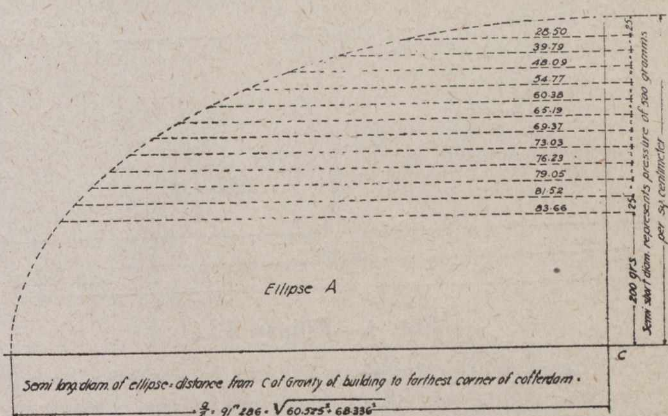


Fig. 3.—Ellipse A.
(Measurements are expressed in meters.)

to the sinking of the houses, but in our estimation the principal element causing the buildings to settle and become out of plumb is the unsatisfactory and unreliable clayey subsoil described above as evidenced by the fact that new buildings, whose foundations are carried below water level, are also sinking more or less rapidly, and as a rule more rapidly than the old existing structures.

It is well proved by a large number of observations that the sinking is more pronounced during the dry season, lasting from November to June than while the rains last, that is from June to November.

Levels run to the rocky mountainside have shown that the City of Mexico as a whole is sinking at the rate of three-eighths of an inch a year.

Some Mexican engineers advocate the driving of piles for reinforcing the subsoil, while others claim that this method is not effective and may even become prejudicial. Examples are known of piles, driven during the day, shooting up during the night and damaging the ground. The writer has seen advocated lately the idea of temporarily loading the subsoil before permanent work is commenced, thus causing an advanced compression and sinking of the ground. This idea, however, can only be carried out in special cases. Besides, we know of buildings 25 years old and more that are still sinking.

One engineer, Senor Angel Peimbert, lately advocated placing the foundations on the crust or present surface of the ground, because the crust, made of debris, dust, etc., is of a different substance than the clayey matter underneath, and besides, it is already compressed to a certain extent. This method would not permit of building cellars, but otherwise it is practicable, there being no frost in Mexico; it might well be adapted to light and moderately heavy structures, because the crust and tepetate bed under have better resisting power than the clayey subsoil. It is evident, however, that notwithstanding any method employed to reduce or stop the sinking, efforts should be used to reduce the unit pressure to a minimum and, when dealing with important buildings covering large areas, tests should be made before permanent foundations are commenced.

Now, can the sinking be arrested, or at least retarded? We believe it can, and the best method we know is by injection, under pressure, of cement or cement and lime mixed, under or close to the foundation. With this method the sinking of a large store building in Mexico was entirely stopped. The method has also been used in connection with the National Theatre with great success. By injecting cement at the proper places, the uneven settle-

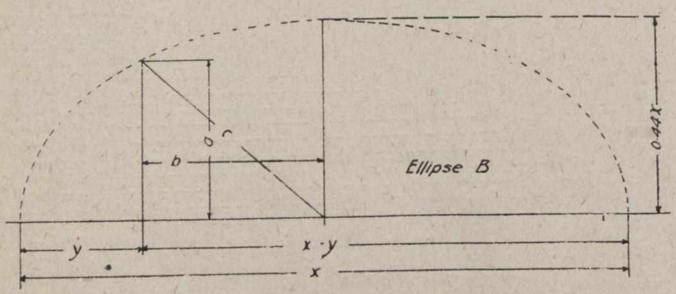


Fig. 4.—Ellipse B.

The length of the building is 127.37 meters, breadth 112.04. Long and short diameters of the ellipses B are in relation to the length and breadth of the building, or $\frac{112.04}{127.37} = 0.88$.

$$y = \frac{x}{2} = b.$$

$b = 1.129\ a.$ $\qquad b^2 = 1.2746\ a^2.$

$$c = 1.5082\ a.$$

$$\frac{a^2}{0.88^2} = 1.2913\ a^2.$$

$$\frac{x^2}{0.88\ x^2} = y\ \frac{(x - y)}{a^2}$$

$$\frac{x}{2} = 1.062\ c.$$

ment has been stopped and the sinking of the entire structure greatly reduced; it was the intention of the Mexican government to continue the injections until the sinking had been entirely stopped.

The mode of operation is simply to make a hole in the ground with a pile driven by an ordinary pile-driver; to fill the hole, or at least place dry cement in the hole, and push the cement into the surrounding ground with the same pile. The cement coming in contact with water contained in the ground will set, thereby increasing the bearing capacity of the soil. Another system used was to push down the cement by hydrostatic pressure.

The metallic structure for the dome of the Federal Legislative Palace is completed and riveted. The present weight on this particular foundation is about 30 per cent. of the calculated load, and with this light load, notwithstanding the consolidation of the ground, the sinking in two years amounted to sixteen inches. Levels were taken monthly and they showed that the sinking was very even and, furthermore, strictly in accordance with Senor Montiel's prevision—so, to that date, the theory was upheld.

The steelwork for the Palace, as well as the foundations, was designed by engineers sent to Mexico by Milliken Bros., of New York, and placed under the writer's charge. All data, however, including the idea of uneven pressure on the foundation, was furnished by Senor Montiel, who alone could take such responsibility on behalf of his government. The foundations are necessarily heavy, due to the enormous weight of the building and to the low bearing capacity of the soil.

The dome is situated near the centre of the structure, and it is the principal feature of it architecturally as well as structurally. It rests on a continuous concrete foundation 150 feet long by 140 feet wide. The grillage weighs over 4,000 tons, consisting mostly of plate girders, of which there are 108, running the entire length and breadth of the concrete bed. Some weigh 50 tons, were fabricated in New York, and were shipped to Mexico City in three sections.

The superstructure of the dome weighs over 3,000 tons. There are plate girders 55 feet long, weighing 27 tons, at the base of the circular drum, which stands 120 feet above the foundation. These were brought from New York in one piece and raised to their final resting place by means of the erecting tower. Supporting these girders are four latticed trusses, one on each side, each weighing over eighty tons, but they came in pieces and were erected by means of falsework. The dome complete, including grillage, has been set by means of an erecting tower 50 feet square and about 200 feet high with one steel boom 70 feet long and of 30 tons capacity at each corner. This tower was set before any steel arrived, and also served to unload and handle the material. It was never moved, but twice we cut the corner posts at the bottom to allow the grillage girders to be erected.

RAILWAY EARNINGS.

The following are the railway earnings for the first week of June:—

Canadian Pacific Railway.

	1916.	1915.	
June 7	$2,674,000	$1,585,000	+ $1,089,000

Grand Trunk Railway.

June 7	$1,107,091	$ 959,977	+ $ 148,114

Canadian Northern Railway.

June 7	$ 629,700	$ 409,400	+ $ 220,300

The Traylor Engineering and Manufacturing Co., Allentown, Pa., has purchased control of the Cement-Gun Co., of New York. The head office has been moved to Allentown, and new officers elected as follows: S. W. Traylor, president; W. J. Roberts, vice-president; F. R. Crispen, secretary; H. Battersby, treasurer; and B. C. Collier, general manager.

The American-Russian chamber of commerce has received information that the Russian cabinet has decided after a conference in Petrograd, to make preparations for the construction of 25,000 miles of railroads in Russia within five years. The Russian ministers of agriculture, industry, commerce, finance and war participated in the conference, according to this information.

WINNIPEG RIVER POWER AND STORAGE INVESTIGATIONS

A BRIEF REVIEW OF WATER RESOURCES PAPER No. 3, AN OFFICIAL PUBLICATION OF THE DOMINION WATER POWER BRANCH, COVERING THE DEPARTMENTAL INVESTIGATIONS INTO THE POWER RESOURCES OF THE WINNIPEG RIVER WATERSHED.

PART II.

THE reach of the river considered in the power studies, covered in Water Resources Paper No. 3, of the Dominion Water Power Branch, extends from Lake Winnipeg to the headwaters of the city of Winnipeg municipal plant at Point du Bois, and comprises practically the entire drop of the river in Manitoba. the hydraulic gradient between the various falls and rapids is usually negligible, a combination of circumstances which renders possible the utilization for power purposes of practically the entire fall of the river.

Ice Conditions.—The northerly latitude in which the Winnipeg River is located necessitates a most careful

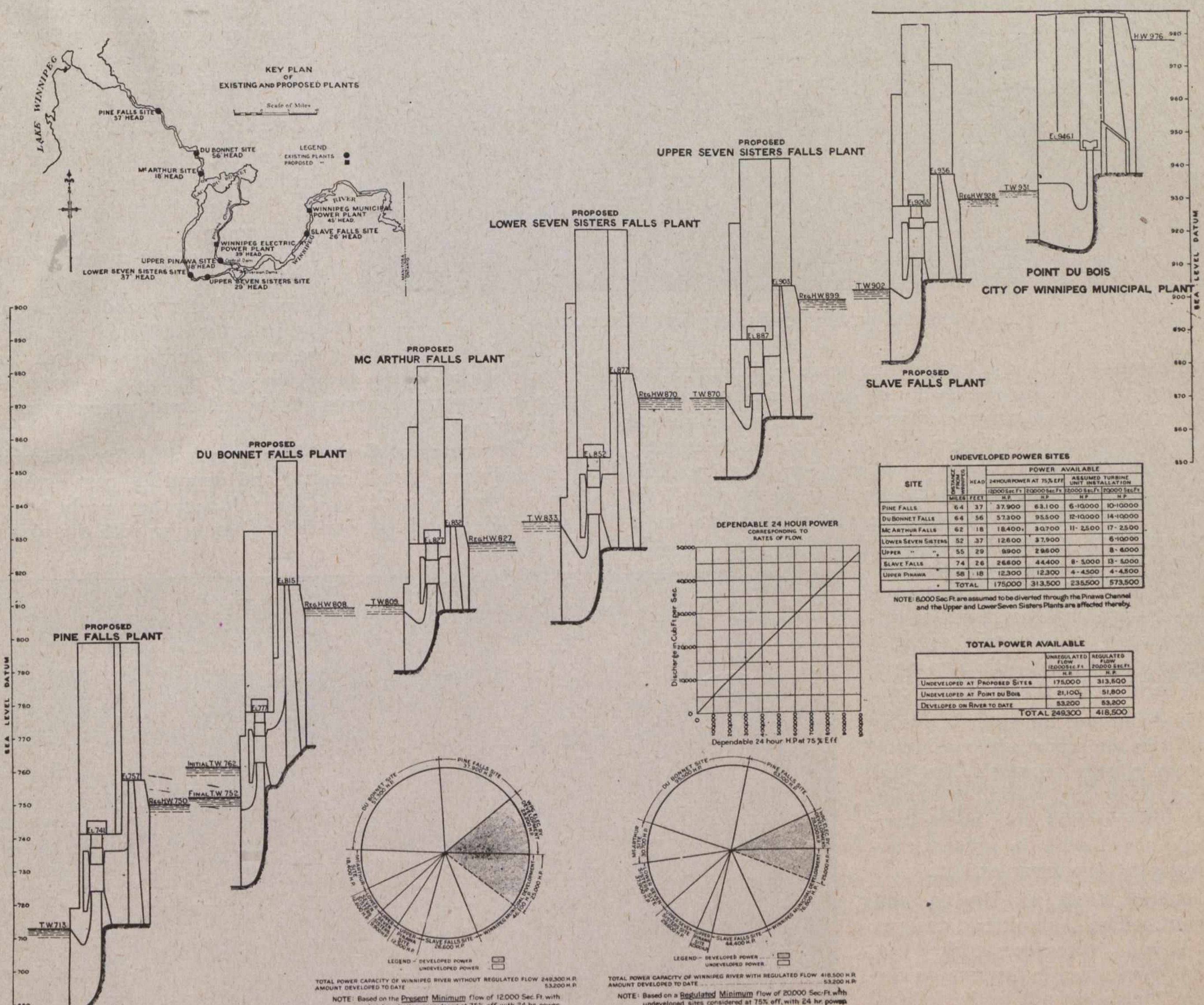


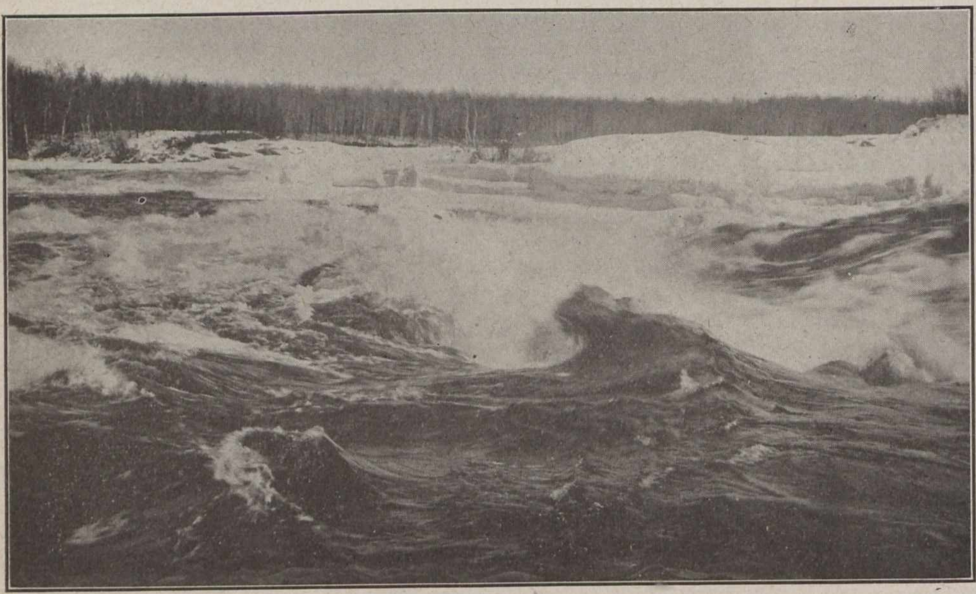
Fig. 1.—Key Plan.

The river is, to a large extent, composed of deep, broad basins with but little current, broken by abrupt changes in level at the various falls and rapids. These pitches take place at, and are occasioned by, granite outcrops, which are invariably in evidence on both river banks and in the stream bed. At such points the bedrock as a rule forms a distinct ridge at a higher elevation than the bed of the river in the pond above, and is, in fact, the controlling features governing the level of the lake-like expanses. As a result, the drops are generally well concentrated, and consideration of possible ice troubles in the design of the hydro-electric plants along the river.

In the layouts which have been designed for the development of the present unutilized head in the river, special attention has been given to the question of protection from ice troubles, and in none of the layouts proposed are they anticipated.

Foundation Conditions.—Unexcelled foundation conditions are assured at all the proposed plants. The natural granite formation which underlies the entire country is exposed on the surface at all locations selected for hydro-electric development. At several of the sites the rock out-crops throughout the entire layout.

Head and Tailwater Elevations.—It is not intended in Water Resources Paper No. 3 to unchangeably fix the exact head and tailwater elevations of all the proposed



Grand du Bonnet Falls, Ice Conditions.

concentrations. These final elevations are dependent on full and complete surface level records under all conditions of discharge. Owing to the comparatively unsettled nature of a large portion of the river banks, it has been very difficult to secure satisfactory and regular gauge readers. As a result, on some reaches of the river, the surface level records under different stages are not as complete as is desired. This information is being secured as rapidly as possible, and will be available in sufficient time to deal with any questions of administration which may arise in connection with the development of the reach along the lines set out.

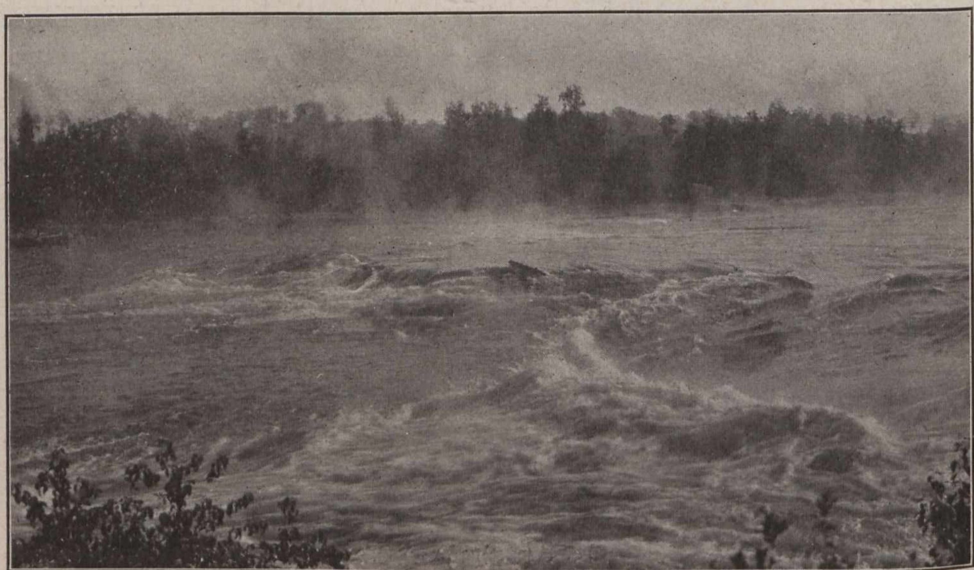
The head and tailwater levels as set out in the report are considered to very closely represent the final levels, and any variation which later information may necessitate should not change the present conclusions to any great extent.

General Basis of Design and Layout.—The submitted designs and layouts have been worked out in the head office in Ottawa on the general basis set out in the following, and have on this basis been approved by Mr. J. B. McRae, consulting engineer to the Dominion Water Power Branch. The designs of the power houses, dams and contingent structures, and the proposed hydraulic and electrical equipment, have been developed only in sufficient detail to permit making accurate estimates of the quantities and costs involved. It is not intended that the designs and layout proposed, and the equipment suggested, should be adhered to in all respects by any parties developing the power at these sites. It is intended, however, that the basic elements of the design be maintained as proposed, in the interests of the complete river development scheme. These basic elements are: Head and tailwater elevations, discharging capacity and stability of dams, and stability and sufficiency of power houses and contingent structures.

The layouts are designed for an initial and for a final installation. At points where the whole flow of the river is available for development, the preliminary installation is designed to utilize 12,000 second-feet (the present minimum flow of the river), with provision for the subsequent addition of sufficient units to properly care for a regulated flow of 20,000 second-feet. The latter is spoken of throughout the rport as the final installation.

The details of the designs, such as sections and plans of the power houses, dams, ice sluices, and embankments, etc., have been standardized throughout all the plants, varying according to the head and to the equipment at each site. In all cases, single-runner vertical turbines have been adopted. The purpose of this standardization of design is the desirability of having the cost of development at each site reduced to the same basis or measure in order that the comparative merits of the different projects can be ascertained.

Estimates of Cost.—The question of the advisability of publishing detail capital and operating cost estimates was at first debated, as it was felt that they might be open to criticism and that conditions changing with the passage



Pine Falls, Main Drop.

of time would possibly very materially alter the published figures. It was thought, however, that the advisability of supplying prospective users of power with some conservative and authoritative measure whereby the economic as well as the engineering merits of the various sites could be readily compared, and with which competing sources of power could be analyzed, more than outweighed other considerations. To neutralize possible future criticism of the published estimates, care has been taken to supply in the report such plans and data covering each site as will enable independent estimates being made by any parties interested in its development.

The general costs quoted are based on a twenty-four-hour output, at 75% over-all efficiency, as this forms a uniform and, considering the more than 90% efficiencies claimed for modern turbine runners, conservative measure for comparison. The figures on this basis, scarcely do the developments justice, since in them no account is taken of peak loads and of the re-sale of power such as is always possible in plants projected for the supply of power for general industrial and lighting consumption. In all designs ample machine capacity has been allowed to care for all peak loads which can be reasonably expected, and to supply spare units for emergencies. This over-development has added largely to the estimated cost of the plants and hence to the unit cost when the latter is based on twenty-four-hour power. On the other hand, costs per horse-power, based on the installation, frequently convey erroneous ideas as to economic efficiencies, since local conditions or an auxiliary steam plant frequently permit the excessive over-development of a particular power site in proportion to the dependable power available from the river. However, in the designs and estimates considered, the machinery installed bears, in all cases, a definite ratio to the power in the river, and this ratio cannot be considered too high in plants handling normal industrial and lighting loads. The unit costs based on installation can, therefore, be profitably studied in conjunction with the unit costs on a twenty-four-hour basis.

In all cases provision has been made for access to the site by rail, or in the case of the Pine Falls plant, by water. In each case 10% has been allowed for contingencies, 5% on this total for engineering and inspection, and 5½% on the whole for one year for interest during construction.

The actual cost of the construction of the two existing plants on the river has been carefully studied and compared with the estimated costs of the various proposed developments. Independent estimates by private engineering firms have also been found to check closely with the capital costs submitted. The estimates may therefore be taken as setting out conservatively and closely the capital construction cost of the proposed sites.

As in the case of the capital costs, the annual operation costs have been estimated to a uniform standard, and hence form a measure whereby the commercial prospects of the different projects can be readily compared.

The operation costs include capital charges and are published in terms of cost per horse-power-year twenty-four-hour power; cost per horse-power-year machinery installed; cost per kilowatt hour at 100 per cent. load factor, and cost per kilowatt hour at 50 per cent. load factor. These costs represent the operating charges at the power station, and do not include transforming and transmission.

Table 1.—Undeveloped Power Sites on the Winnipeg River in Manitoba.

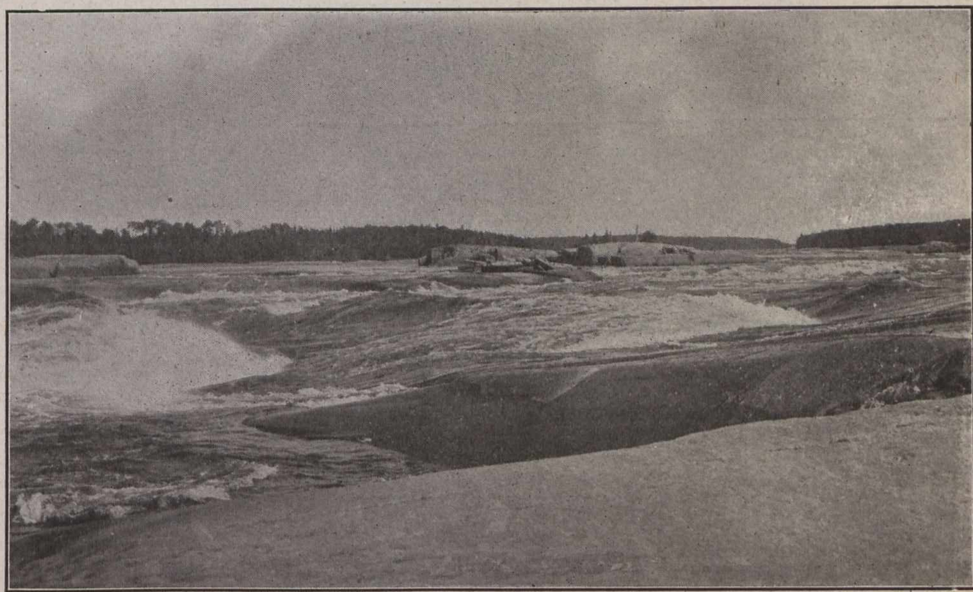
Site	Distance from Winnipeg in Miles	Head	Power Available: 24 Hour Power at 75% efficiency 12.000 Sec. ft.	20,000 Sec. ft.	Turbine Installation (units considered) 12,000 Sec. ft.	20,0000 Sec. ft.
1	2	3	4	5	6	7
Pine Falls	64	37	37,900	63.100	6—10,000	10—10,000
Du Bonnet Falls ..	64	56	*57,300	95,500	*9—10,000	14—10,000
McArthur Falls	62	18	18,400	30,700	11— 2,500	17— 2,500
†Lower Seven Sisters	52	37	12,600	37,900	....	6—10,000
†Upper Seven Sisters	55	29	9,900	29,600	....	8— 6,000
‡Upper Pinawa	58	18	12,300	12,300	4— 4,500	4— 4,500
Slave Falls	74	26	26,600	44,400	8— 5,000	13— 5,000
		Total	175,000	313,500	235,500	473,500

NOTE.—* This tabulation assumes an initial development at the Du Bonnet site utilizing 12,000 second feet at 56 foot head.

† The Upper and Lower Seven Sisters sites are located in the main channel of the Winnipeg River paralleling the Pinawa through which 8,000 sec. ft. is assumed to be diverted for the operation of The Winnipeg Electric Railway Plant.

‡ The Upper Pinawa site is located on the Pinawa Channel.

Summary of Dependable Power.—A summary of the undeveloped power, as outlined in the above power studies,



Seven Sisters Falls, Third Fall.

together with the total dependable power on the river in Manitoba, including that developed to date, is appended in Tables 1 and 2.

Table 2.—Total Power Developed and Undeveloped on the Winnipeg River in Manitoba.

	Unregulated Flow 12,000 sec. ft.	Regulated Flow 20,000 sec ft.
Undeveloped at proposed sites	175,000	313,500
Undeveloped at Point Du Bois	21,100	51,800
Developed on River to date ..	53,200	53,200
Total	249,300	418,500

NOTE.—Power in terms of 24 Hour Horse Power at 75% efficiency.

The above tables indicate that there is 53,200 horse-power developed to date, 196,100 horse-power undeveloped and available in times of present low water on the river, and 365,300 horse-power undeveloped and available when the river is regulated to a minimum flow of 20,000 second-feet. It must be borne in mind that these totals are given in terms of twenty-four-hour power, and hence give a rather limited estimate of the river's resources. A translation of these totals into shorter range power will therefore prove of interest.

Table 3.—Dependable Power on Winnipeg River in Manitoba.

	Unregulated Flow 12 000 sec. ft.	Regulated Flow 20,000 sec. ft.
Twenty-four Hour Power	249,000	418,000
Twenty Hour Power	299,000	502,000
Sixteen Hour Power	373,000	627,000
Twelve Hour Power	498,000	836,000

The above tabulation shows the greater scope of the power resources to meet varying demand, but must only be applied with discrimination. What might be called the dependable commercial power available can be placed at well above the half-million mark.

Summary of Capital and Operating Costs.—The data respecting the estimates of the various schemes have been condensed into Tables 4 and 5 for the purpose of ready reference and comparison.

Table 4.—Estimated Capital Cost of Developing the Proposed Power Sites on the Winnipeg River in Manitoba. Power Placed on the Low-tension Switchboard in the Power Station.

Site	Capital Cost on low tension switchboard in Power Station — Total Cost 12,000 sec. ft.	Total Cost 20,000 sec. ft.	Per H.P. on Basis of 75% Efficiency 24 Hour Power 12,000 sec. ft.	Per H.P. on Basis of 75% Efficiency 24 Hour Power 20,000 sec. ft.	Per H P. on Basis of Installation 12,000 sec ft.	Per H P. on Basis of Installation 20,000 sec. ft.
1	2	3	4	5	6	7
	$	$	$	$	$	$
Pine Falls..........	3,057,000	4.407,000	80.66	69.84	50.95	44.07
Du Bonnet Falls....	*4,624,000	6,551,000	80.70	68.60	53.80	46.79
McArthur Falls.....	2,031,000	2,740,000	110.38	89.25	73.88	64.47
†Lower Seven Sisters.		3,409,000		89.95		56.82
†Upper Seven Sisters.		2,724,000		92.03		56.75
Upper Pinawa......	1,280.000	1,280,000	104.07	104.07	71 11	71.11
Slave Falls	2,327,000	3,436,000	87.50	77.39	58.20	52.86
Total	13,319,000	24,547,000				
Mean (based on power output)			87.30	78.30	56.60	42.80

*Proportional Capital Cost of development of 12,000 second feet at 56 foot head.

†Upper and Lower Seven Sisters Sites are not feasible of development until the river flow is more systematically regulated.

The Du Bonnet plant, in view of its high head, will prove the most economically efficient of the series, the capital cost per horse-power being $68.60, and the McArthur plant, in view of its low head and the long dam and headworks required, is actually the most costly as measured by the output, the cost being $89.25 per horse-power. The two Seven Sisters and the Upper Pinawa sites cannot be directly compared with the other four as each receives only a portion of the river flow, with a consequent comparative decrease in the power produced. However, under a regulated flow of 20,000 second-feet in the river their unit capital costs of $89.95, $92.03 and $104.07 respectively, will prove very attractive from a commercial viewpoint.

A consideration of the total costs shows the following: The total final output of the seven proposed developments is 313,500 horse-power at a total capital cost of $24,547,000, *i.e.*, an average cost of $78.30 per horse-power or $42.80 per horse-power based on machinery installed.

The annual operating costs are probably of greater interest than the above capital costs, and are summarized in Table 5.

The results tabulated in Table 5 bear out the general conclusions as to comparative economic efficiency that have been noted from a discussion of the capital costs. They are listed in terms of initial and final development, corresponding to present regulated run-off, respectively. The costs per kilowatt hour, considering a 50% load factor, as shown in column 11, indicate in all cases highly desirable commercial undertakings.

While the annual operation costs quoted may appear low, a review of the estimates and of the general underlying principles upon which they are based will establish the conservativeness of the conclusions. The figures represent operating conditions which possibly would not be met upon the immediate completion of the undertakings; that is to say, the initial market would possibly not warrant the initial installation proposed. This would result in higher initial capital and operating costs than are submitted above. At the same time, it would be a simple matter to present the unit costs published herein in a much more favorable light than has been done. Considering the ample pondage facilities which exist, the general run-off conditions of the river, and the general opportunities of an industrial market, twenty-four-hour power is a most conservative basis on which to establish final figures.

As illustrative of this, the Pine Falls site may be briefly considered. The continuous twenty-four-hour power available here is 63,100, and the annual cost per

Table 5.—Estimated Annual Cost of Operation of the Proposed Power Developments on the Winnipeg River in Manitoba. Power Placed on the Low-tension Switchboard in the Power Stations.

Site	Annual Operating Cost on low tension Switchboard in Power Station — Total Annual Cost 12,000 sec. ft.	Total Annual Cost 20,000 sec. ft.	Per H.P. on basis of 75% Efficiency 24 Hour Power 12,000 sec. ft.	Per H.P. on basis of 75% Efficiency 24 Hour Power 20,000 sec. ft.	Per H.P. on basis of Installation 12,000 sec. ft.	Per H.P. on basis of Installation 20,000 sec. ft	Per K.W. Hour 100% Load Factor 12,000 sec. ft.	Per K.W. Hour 100% Load Factor 20,000 sec. ft.	Per K.W. Hour 50% Load Factor 12,000 sec ft.	Per K.W. Hour 50% Load Factor 20,000 sec. ft.
1	2	3	4	5	6	7	8	9	10	11
	$	$	$	$	$	$	cents	cents	cents	cents
Pine Falls..........................	303,000	447,000	8.00	7.08	5.05	4.47	0.122	0.108	0.244	0.216
*Du Bonnet Falls......	*433,000	635,000	*7.56	6.65	*5.04	4.54	*0.116	0.102	*0.232	0.204
McArthur Falls........................	199,000	272,000	10.82	8.86	7.24	6.40	0.166	0.136	0.332	0.272
†Lower Seven Sisters Falls............		328,000		8.65		5.47		0.132		0.264
†Upper Seven Sisters Falls............		268,000		9.05		5.58		0.138		0.276
Upper Pinawa..........................	128,000	128,000	10.40	10.40	7.11	7.11	0.159	0.159	0.318	0.318
Slave Falls...........................	228,000	338,000	8.58	7.62	5.70	5.21	0.131	0.117	0.262	0.234
Total.................................	1,291,000	2,416,000								
Mean (based on power output)........			8.47	7.71	5.48	4.21	0.130	0.118	0.260	0.236

*Proportional Annual Cost of development of 12 000 second feet at 56 foot head.

†Upper and Lower Seven Sisters Sites are not feasible of development until the river flow is more systematically regulated.

horse-power on this basis is $7.08, or 0.216 cent per kilowatt hour on a 50% load factor. The average load carried by the Pine Falls plant could, under a regulated river flow, be maintained at 63,000 horse-power and readily carry a peak load of 126,000 horse-power. The actual cost per kilowatt hour is therefore probably more truly represented by the figure 0.108 cent than by 0.216 cent.

These remarks apply with equal force to the estimates of the other projects along the river.

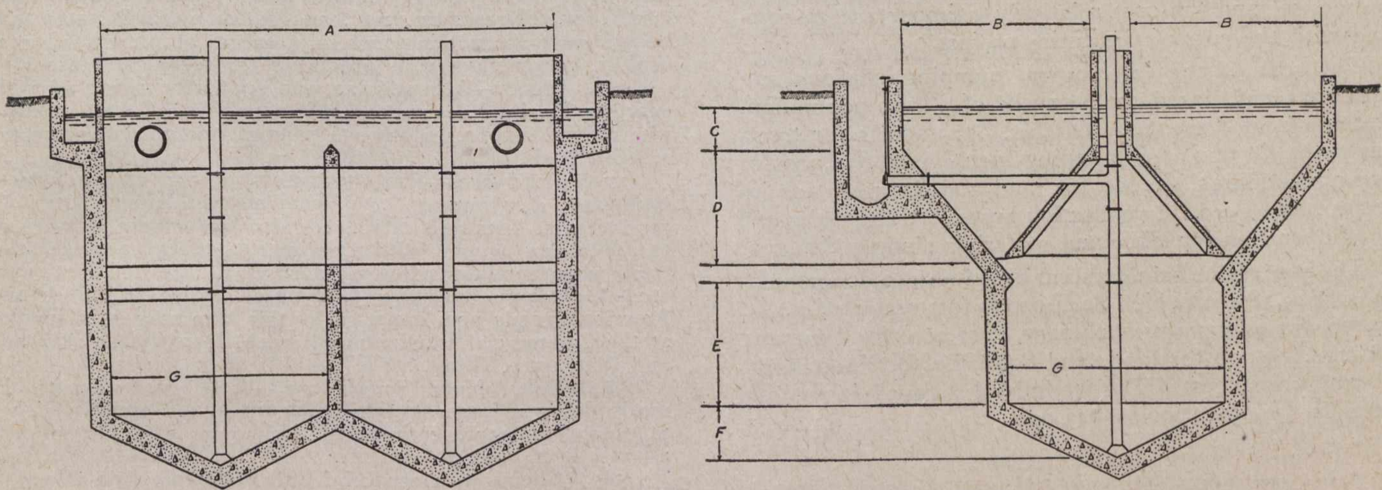
[Part III. (final) will cover the details of a typical concentration as treated in the report.]

WINDSOR DISTRICT SEWAGE DISPOSAL.*

FORD CITY, Walkerville, Windsor and Sandwich, Ontario, are municipalities lying adjacent to one another in the order named and form one large community, which extends for five miles along the Detroit River, directly opposite Detroit, Mich. There are two ferry lines, one in Windsor and one in Walkerville, which make regular trips to Detroit during nearly 18 hours of the day. Passenger and freight connection with the east and west is provided by the Michigan Central, Grand Trunk, and Pere Marquette Railroads. Because of their close contact with one another these municipalities have common interests, regardless of the formal political divisions that exist, and while many of their activities may well be administered by the individual governments without conflict, their drainage problems can be more readily solved by united rather than individual effort. Hence this group of municipalities have been treated collectively as one large community.

There is no sanitary system in Ford City and no complete storm-water system, though there are a few drains which have been provided by the covering over of old ditches. Sanitary sewers are needed and very much desired by the citizens. The municipal authorities, in fact, had a plan prepared in 1914, which was disapproved by the Ontario Board of Health on sanitary grounds, because it called for discharge into the Detroit River above the Walkerville and Windsor waterworks intakes. The main existing sewers of Walkerville, Windsor and Sandwich are all combined sewers and follow streets perpendicular to the course of the Detroit River. They discharge at levels approximately corresponding to normal river stages. There are none that discharge above the Walkerville waterworks intake, but the three which discharge in Walkerville are all above the Windsor intake.

The total population was approximately 12,000 in 1890, 15,000 in 1900, 22,600 in 1910, and 33,000 in 1915. It is evident that the district as a whole has been a rapidly growing one during recent years, Ford City having been stimulated by the automobile industry, Walkerville by automobile and distilling interests, and Windsor and Sandwich by a general increase in industrial development of their own, combined with that of Detroit. Owing to the large territory now covered by Detroit, there are at the present time an increasing number of people who find it convenient to live in Windsor, though they work in Detroit. Furthermore, the excellent traffic facilities, combined with the industrial spirit manifestly present on both sides of the river, should stimulate manufacturing developments so that it is extremely probable that future growth will be rapid also. All things considered, it seems probable that the district will have a population of 100,000 or more within 30 or 35 years.



Typical Sections of Imhoff Sedimentation Tank.
Amherstburg: A = 33, B = 14, C = 4, D = 8.4, E = 9, F = 4, G = 16.
Sarnia: A = 67, B = 14, C = 2.25, D = 8.4, E = 6.5, F = 4, G = 16.

The water records indicate that there is at present a daily per capita water consumption of over 200 U.S. gallons, which no doubt includes considerable waste of various kinds. It does not seem reasonable that this district, when it becomes larger, so that more careful supervision is exercised over water mains and plumbing, will use as much water per capita as the Detroit district with its greater predominance of manufacturing. An assumed future consumption of 180 U.S. gallons per capita per day has therefore been used in this study, this quantity being taken to include the water used for both domestic and industrial purposes, and as contributing 144 U.S. gallons of sewage per capita per day. In addition, a ground-water allowance of 1,000 gallons per acre per day has been used in calculating the size of interceptors.

The territory in and around this district is, in general, possessed of easy slopes, with the river front section of Windsor forming a hump between two lower lying sections, one to the east in Ford City and the other to the west in Sandwich. These sections present the most favor-

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

able locations for treatment plants, and have both been considered. The Ford City section was abandoned, however, because of its being located above the existing waterworks intakes. The low land along the river front in Sandwich is ample in extent, and considerable latitude may be exercised in locating a treatment plant in this section. The site selected was chosen, after careful study, as being the most economical from the standpoint of interceptor cost, which is apparently the controlling factor. There are sites otherwise suitable farther down the river, but their use would necessitate a considerably longer interceptor line.

An interceptor has been designed to collect all the sewage of the district upon the basis of 20 persons per acre for 400 acres in Ford City and 30 persons per acre in most of Windsor, Walkerville and Sandwich. Pumping stations assist in decreasing the lift of the entire quantity of sewage when delivered at the treatment works. This interceptor will be large enough to take all the sewage of the district for many years. At some future time other high-level interceptors will be required. The course of future development of Ford City is so uncertain, and the field data so incomplete, that it is difficult to predict at all accurately what requirements the future may bring forth. It is possible that there may be a pumping station required at some future time to lift a small amount of sewage into the proposed high-level interceptor. The lift will be low in any case, and the cost relatively unimportant as compared with the cost of the entire project.

The cost of the interceptor, pumping stations and treatment plant, based on the needs of 55,000 population, is estimated at $404,786. Of this, $123,000 is for treatment plant, $15,800 for pumping machinery, $11,900 for pumping buildings, $9,000 for land and $245,086 for interceptor and Ford City collection system. The estimated cost of operation for labor and materials alone is $16,000.

The cost of the same system based on 110,000 population is $829,187, of which $244,000 is for treatment plant, $15,800 for pumping machinery, $11,900 for pumping buildings, $9,000 for land, and $548,487 for interceptors and appurtenances. The estimated annual labor and materials for operation is $25,000.

TRADE INQUIRIES.

The following inquiries relating to Canadian trade have been received by the Department of Trade and Commerce, Ottawa. The names of the firms making these inquiries, with their addresses, can be obtained only by those especially interested in the respective commodities upon application to: The Inquiries Branch, the Department of Trade and Commerce, Ottawa, or the Secretary of the Canadian Manufacturers' Association, Toronto, or the Secretary of the Board of Trade at London, Toronto, Hamilton, Kingston, Brandon, Halifax, Montreal, St. John, Sherbrooke, Vancouver, Victoria, Winnipeg, Edmonton, Calgary, Saskatoon, Chambre de Commerce de Montreal and Moncton, N.B. Please quote the reference number when requesting addresses:—

448. Iron Steel Merchant Bars, Hoops and Bands, Sheet Steel Rods (Iron and Steel).—Quotations requested c.i.f. Glasgow.

452. Steel Wagon Axles.—A Yorkshire firm desires the addresses of Canadian manufacturers who can supply military wagon steel axles.

453. Bauxite, Asbestos, Silicia, Steatite, Soapstone, French Chalk, Graphite, Plumbago, Carbon, Vegetable Mineral and Animal Charcoal Chrome and other Ores.—A Glasgow firm would be very glad to enter into communication with Canadian exporters of the above.

464. Iron and Steel.—A Birmingham merchant is open to purchase rods and steel billets. Prices c.i.f. Liverpool.

502. Cement—A firm in Barbados handling cement would like to communicate with firms in Canada in a position to export.

503. Electrical supplies—A well-known firm in Barbados would like to get in touch with Canadian exporters of electrical supplies.

506. Bar iron—A Barbados engineering firm wishing to import bar and other iron asks to be put in communication with Canadian manufacturers.

508. Hardware—A Demerara commission merchant asks for names of Canadian hardware manufacturers, with a view to securing an agency.

512. Hardware—A commission firm in Demerara, with good foreign connections, desires to represent Canadian manufacturers of hardware.

525. Railway and mining supplies—A Johannesburg firm of engineers is open to take up the representation in South Africa for Canadian manufacturers of mining and railway supplies.

526. Fertilizers—A Durban manufacturers' representative is prepared to take up Canadian fertilizer agency.

530. Agency—A Durban firm of manufacturers' representatives with branch office in Johannesburg is prepared to take up agencies for Canadian manufacturers on commission basis only.

531. Representation—A Johannesburg manufacturers' representative is seeking agencies for Canadian wire nails, barbed and plain wire, handles of all kinds, wheel valves and gun-metal steam fittings.

535. Molybdenum and metals—A gentleman in Paris, France, is anxious to get in touch with producers of molybdenum. He also desires to open connections with a large wholesale house dealing in metals in order to import soft lead, copper, brass, tin, zinc, and antimony, and states that he prefers to be put in touch with a firm of wholesale metal dealers, rather than with producers for technical reasons.

536. Agency—A gentleman who is shortly taking up residence in England desires to get in touch with Canadian firms who require a representative to handle their goods on a commission basis.

574. Hardware.—The proprietors of one of the largest hardware distributing establishments in India desire to receive price lists and catalogues from Canadian shippers of the following articles with a view to opening up trade relations when conditions become normal: Galvanized iron pipe, etc. A catalogue showing the type and price of British and American goods now imported by this firm may be inspected at the Commercial Intelligence Branch, Department of Trade and Commerce, Ottawa.

584. Bolts, Nuts, Screws, etc.—A Glasgow house formerly doing a large importing business in Germany wishes to obtain the representation of Canadian exporters of the above. Best bank references.

585. Chemical Sheet Lead and Malleable Iron Plugs.—A Glasgow firm, hitherto supplied from Germany and the United States, will be pleased to purchase in Canada if price and quality are right. Particulars of specifications will be supplied on application to the firm making the inquiry.

586. Electrical Dynomas, Electrical Switch Gear, Electrical Cable, etc.—A Glasgow firm desires quotations from Canadian manufacturers of the above articles.

598. Representation in New Zealand.—A New Zealander who is at present in New York desires to represent in New Zealand Canadian firms interested in the following lines: Hardware, electrical goods, etc. He will leave for England shortly, and before going will be glad to call on Canadian houses that desire a representative in New Zealand.

599. Builders' Supplies.—An important St. John's firm dealing in builders' supplies asks to be placed immediately in communication with Canadian manufacturers of asbestos shingles.

600. Roofing Felts.—A Newfoundland firm asks for the names of Canadian manufacturers of asbestos roofing and the ordinary one, two and three-ply felts.

614. Wire rods.—A Bradford firm, which has used about 700 tons of wire rods per annum, for overseas since the war began, wishes quotations from Canadian shippers on wire rods and thick sizes of wire.

616. Mild steel plates.—An inquiry is made by a firm in Rotterdam, Holland, for the addresses of Canadian manufacturers of mild steel plates suitable for the manufacture of expanded metal. Full specification of requirements is obtainable on application to the Commercial Intelligence Branch, Department of Trade and Commerce, Ottawa.

WASTE.

By R. O. Wynne-Roberts, Mem.Can.Soc.C.E.

THERE are few subjects which occupy such a prominent position in the discussions relative to our Imperial economy as waste, and there will be no problem that will demand such concentrated attention in the immediate future. Commissions have been appointed by different governments to investigate this matter in connection with the natural resources, commerce, etc. Waste does not necessarily mean the wanton abandonment or destruction of things which can be put to any other use by changing their character. It includes inefficient production, inadequate foresight, lost motion in machinery or operation, redundant labor, etc. Waste is not confined to any particular profession, craft or business; it obtains, in a more or less degree, in almost every sphere of activity, and therefore cannot be attributed, specifically or entirely, to any special reason for it is the outcome of our national methods. Waste, however, has in the past occupied the attention and energy of men, for cities have been built on the profits derived from utilized waste, decaying industries have been revived by the recovery of products from what was previously dumped as waste. Waste gases have been converted into power on a huge scale. But there remains an immense field for further development along these lines. Engineers are probably more concerned in this problem, inasmuch as they, in the aggregate, handle more materials, control more work and spend more money than others, and to them the public must look for the practical application of discoveries by chemists, metallurgists, etc. The subject will be considered from the engineer's viewpoint.

Power is an important factor in connection with most undertakings. Where power cannot be derived from water then it is necessary to obtain it by other means, and, if possible, on the co-operation principle. Ontario is, in a large measure, enjoying the benefits of cheap power which is generated and distributed under a comprehensive communism. With adequate conservation and utilization of the available water power of the province, it is possible for the towns and cities collectively to accomplish that which would be impossible for them to do individually, and further, the cost of the energy is much less by this communistic plan than it would otherwise be. In other words, waste has been reduced. Moreover, waste has also been minimized by "the construction of storage reservoirs scientifically located and operated," for this "is the most effective and only practical method of controlling flood waters in winter and increasing the flow of the stream during the summer droughts" (Walter McCulloch). Although water power is an attractive proposition, there are some conditions and features which render such schemes unremunerative with the result that, although the United States have at command an available energy of 36 million horse-power, possibly five-sixths of it now runs to waste. The water power available in Canada is estimated at about 25,000,000 horse-power but only 2,000,000 of it is now harnessed. There is, therefore, ample scope for development in this direction.

Take another line of thought. Dr. Frank D. Adams stated in an article published in *The Canadian Engineer* of February 18th, 1915, that "less than 1 per cent. of the coal resources of the Dominion are situated in Nova Scotia and New Brunswick, while 87 per cent. lie in Alberta," and that as much coal is wasted as is extracted owing to the methods adopted and that "this waste amounts to very many tens of millions of tons." Furthermore, the Commission of Conservation stated that "Canada's dependance on the United States for its supply of anthracite coal is a point strikingly indicated in the report issued by them on the 'Conservation of Coal in Canada.' Practically all of the most populous portion of Canada lying between Montreal, Que., and Moose Jaw, Sask., relies solely on the United States for its supply of anthracite coal."

It is clear "that Canada should carefully husband her coal resources and, so far as possible, check all wasteful methods of mining and handling coal. With this end in view, the report suggests greatly needed changes in the form of coal-mine leases, the provisions of which should be carefully enforced by a competent engineering authority. This would go far towards preventing the careless practices followed at present in many coal mines. In addition to this, it is urged that the government should carry on investigations with a view to determining the suitability of slack and low-grade coals for use in gas producers for generating power, and their adaptability for the manufacture of briquettes for domestic use. By utilizing these inferior products in this way, not only would there be less waste, but the value of the public coal lands would be considerably increased."

The lignite coal fields of the West are mined to a very insignificant extent. There are about 20,000 million tons of lignite lying in the prairie provinces which are not wasted but are not adequately utilized. This coal is most suitable for gas producers and some day huge central power plants will be located at the mine mouths to generate electrical energy for transmission to many parts of the provinces. Meanwhile, fuel is transported from the United States and from distant west Canadian coal mines at considerable cost, constituting another form of waste. Whilst many Canadian works have relatively efficient power plants, the majority cannot be placed in this category. Consequently central plants would be productive of great savings. It is worthy to note that there is a movement in Britain for great conservation of waste heat. The following is a cutting from the Engineering Supplement of the London Times for April 28th, 1916:

"The growing attention that is being paid to methods of utilizing the large quantity of surplus heat which is a by-product of our manufactures is a hopeful sign. The public discussion on the question which has just taken place at Sheffield was remarkable for the fact that it attracted the attendance of representatives of the iron and steel trades and scientific men, as well as those associated with gas, electricity, and colliery undertakings. The suggestion that there should be established a government department to control the supply of power and electric current on national lines is a somewhat drastic one, and a very strong case would have to be made out before it would be likely to find acceptance. But the proposal to harness all the waste energy of the South Yorkshire coal field and employ it in the form of gas or electricity in the iron and steel trades of the district is certainly attractive, the broad lines of the scheme being that the individual manufacturer in the Sheffield district should cease to provide his own power plant in favor of drawing supplies from a huge central station which would generate current from the waste energy available in the local coal field. It is suggested that if this plant met with general acceptance it would be possible to supply manufacturers over a wide area in the West Riding with current for power purposes at the low rate of .25d. per unit. There are many directions in which economies can be effected in manufacturing operations, and the provision of a source of cheap power supply would be least among them."

Whilst the idea of governmental control of power is new, the principle is old. For example, there is a large central power scheme which has been in very successful operation in the vicinity of Newcastle-on-Tyne for many years. The capital invested amounts to a large figure, in the neighborhood of $50,000,000. Another instance is the large central power plant for the Rand, in South Africa. In both instances waste has been eliminated to a very great extent. The waste of fuel at individual power plants will in the aggregate amount to a large figure. It is highly desirable that the engineers in charge should be given every inducement to operate gas-testing instruments so that the gases passing to the chimney stacks should contain the minimum of combustible constituents.

Another cause of waste is the method of producing metallurgical coke. There are nearly 3,000 coke ovens in Canada, but only 730 of them are constructed to save the valuable by-products, such as gas, tar, ammonia, etc. The gas from coke ovens should be available for power and heating, and if used in gas engines there is sufficient surplus gas from every ton of coal to provide 250 horsepower-hours. The quantity of ammonia will suffice to produce about 20 pounds of ammonium sulphate, which is valuable for fertilizing the land. The ammonia may be reduced to concentrated crude ammonia for refrigerating purposes, or utilized for cleansing. These are only a few uses to which the ammoniacal liquid may be applied. The tar is one of the very valuable complex by-products of coal, which can be distilled for several hundred uses. Creosote for preserving wood, constituents for high explosives and dyes are the pressing needs of the hour, but in 2,000 ovens in Canada the tar is not recovered and the Empire has to buy elsewhere. The Minister of Munitions is urging every possible producer of tar in Britain to concentrate on the production and conservation of that commodity for the manufacture of trinitrophenol, commonly known as picric acid, which is required for the manufacture of high explosive shells. While the fact is very unpalatable to us, we must, nevertheless, recognize that the Prussian autocracy managed in a remarkable manner to marshal all the economic forces of the German empire, and many outside of that country, for its use. We know that in ante-bellum days science was applied to almost every German process and business, and that the doctrine of efficiency was persistently advocated on practically every hand, under the direct influence of the government and state authorities, so that waste was at its minimum and production at its maximum, and German power in all lines became international and phenomenal. Any efforts made in this and other countries to emulate them in the conservation of resources, if it had any tendency to interfere with their secret plans, were promptly met by German commercial competition, so keen and effective and methods not always scrupulous and fair, that reduction of waste outside Germany was often made impossible, or nearly so, and thereby highly advantageous to Prussian military ambitions. Those interested in the effect of German policy on the American chemical industries and how American consumers were influenced during the last few years, can with advantage peruse a paper by Mr. H. W. Jordan, read at the Baltimore meeting of the American Institute of Chemical Engineers. German policy and science resulted in their building up huge industries at our expense. They made it unremunerative for others to reduce or convert waste because it manifestly would jeopardize the Prussian military programme. Tar and other by-products of coal distillation became the most important raw materials of the immense German chemical industries. Their coke ovens were almost entirely of the recovery type, so that all by-products were conserved; the public had been educated to use gas, and to keep up the consumption during the war; farmers had been taught to fertilize the land with sulphate of ammonia. Synthetic dyes were sold to the world—at a loss, if it was necessary, to stifle a budding local industry. So that when the time arrived, Prussia had the necessary picric acid, etc., for military use and the equipment to produce them. Meanwhile, the waste of coal and its by-products in North America was stupendous. It requires time, capital and skill to change the methods and plant, and consequently the highly desirable alteration cannot be made in time to be of the greatest service to the Allies, but the lesson should be borne in mind.

The waste of wood in Canada is estimated by Mr. W. B. Campbell, B.Sc., to be from $10 to $15 per year for every man, woman and child in the country. The chemical engineer has here a great scope for his skill and ingenuity.

Water waste in our towns and cities is an important matter. There are no statistics available which will indicate the annual loss incurred in this way. But the magnitude of the waste may be illustrated by a simple calculation. The population of Canada is about 8 million, of which about one-half dwell in the towns and cities. The average daily consumption of water may be placed at 80 gallons per capita—this figure is conservative. It is quite reasonable to assert that 50 gallons should suffice, and therefore there are 30 gallons per head per day which might be saved. The excess quantity is equal to 43,800 million gallons per annum. We may assume that it has to be raised 100 feet, which is a low lift, and that the fuel alone costs only 2 cents per million foot-gallons, which is the lowest published cost in North America, then the excess cost will be about $87,600 per annum. This is a respectable sum to consider, but it is by no means the total cost, for labor, capital charges, maintenance, etc., have yet to be added; and, furthermore, the excess volume of water has to be disposed of as sewage. So that the grand total cost to the ratepayers will be many times the above sum.

Apart from waste in water and its inherent expenditure, there is the other side of the problem. The sources of supply are not always beyond doubt as to their purity. It is essential that every precaution should be taken to safeguard the health of the consumers. A large daily consumption of water necessarily entails great systems of water treatment. It is unnecessary to postulate that an abundant supply of pure water is a modern necessity and costs less than do violent outbreaks of typhoid and other water-borne diseases. There have been sufficient instances to prove this statement. Yet, the fact does not seem to be impressed home, for the papers continue to announce waste of life due to this cause. Preventable waste of life is deplorable. Dr. E. F. Campbell, of the Ohio State Board of Health, stated that "carefully prepared tables show tuberculosis as 75 per cent. preventable, typhoid fever as 85 per cent. preventable, diphtheria as 70 per cent. preventable." If some of the older nations can afford to sacrifice life because of unsanitary conditions, new nations cannot afford to do so, for their greatest asset is vigorous life. But older nations have mostly learnt by experience that to conserve life by supplying pure water and providing efficient sanitation is an excellent investment. The marvellous health records at the front prove that this fact has been firmly and permanently established. It is stated that a person is worth to the community the difference between his or her earning power and the individual's cost of maintenance, which sum represents 6 per cent. of the total value. Whether this statement has a reasonable basis is not under discussion, but assuming its correctness, then a person earning $1,200 per annum and spending $900 for maintenance, is worth $\frac{(1,200 - 900) \times 100}{6}$ = $5,000. The waste of life due to typhoid, therefore, represents a great loss to any municipality. Such waste cannot be tolerated where the public appreciate the economy of pure water. The other losses due to waste of life are not referred to because they are not pertinent to the question under discussion.

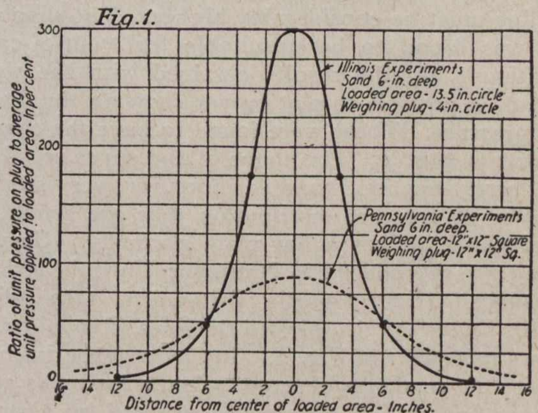
Mr. Thomas Adams has frequently referred in his addresses on town planning and allied subjects, to the question of street widths. This question has engaged the attention of engineers in many parts, and it has been discussed at international road congresses, but not always from the same viewpoint as that taken by Mr. Adams. He points out that the number of streets in any city that constitute the main arteries for traffic are relatively few, and yet, as present, the widths and construction are virtually the same in busy commercial quarters and in purely residential districts. Where the traffic is great, the street should be wide, but where the traffic is small it is unnecessary to provide similar traffic accommodation, at any rate until it is actually required. The lines of communication are fixed by various conditions, and it is often impossible and always exceedingly expensive, to change them, or create new ones, after the area has been built upon. Moreover, with easy and rapid means of transportation the people are migrating to the rural parts of the towns and cities. They desire to enjoy the quietness and beauties of nature after their daily toil in the noisy city. Many, however, cannot afford to travel far away from the centre of employment and have to dwell in the parts which are as desirable as possible. It, therefore, is not essential to urbanize all parts by constructing streets of an expensive character. The expenditure of money beyond what is actually required to accommodate the locality is waste, and renders the cost of living higher than it should be. It also spoils the desirability of the locality as a purely residential district.

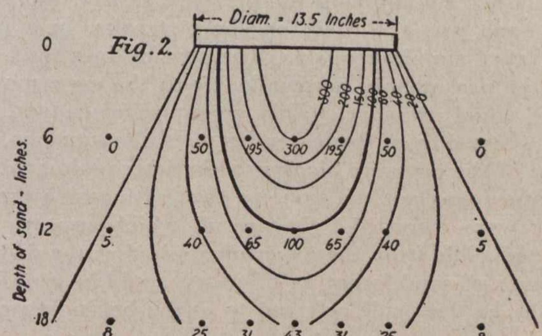
Municipal engineers in particular are concerned in the problem of how to minimize the waste by fire. The Monetary Times for January 7th, 1916, published statistics showing the losses incurred during the last five years. The average annual total for Canada was $21,740,000, but, fortunately, in 1915 it was less—$13,670,000. The average number of houses burnt per year was 692; stores, 317; factories, 102; business sections and blocks, 70; warehouses, 47. The average loss of lives was 221 per annum. It is worth noting that in 1915, 55 fires were caused by electrical defects, 51 by defective and overheated stoves and furnaces, 62 by defective and overheated pipes, chimneys, etc. These and other causes suggest great preventable waste, that adequate prevention would have cost but a mere fraction of the losses incurred. No one wants to live in a district where certain diseases are endemic, neither do manufacturers and tradesmen want to build factories, stores and houses where fires are frequent. So that building by-laws and their administration have a direct influence on the ultimate prosperity of a town. Fire insurance rates are based on experience and are more or less proportional to the hazards involved.

Waste might be discussed in its relation to many other matters but for the present the foregoing will doubtless suffice to draw attention to the urgent need of the time. Canada has a golden opportunity to develop the waste or by-products of various industries, and to adopt measures to prevent waste of every form.

THE DISTRIBUTION OF PRESSURE BY GRANULAR MATERIALS.

VERY little is definitely known as to the way in which the pressure of a wheel on road metal or a sleeper on its ballast is transmitted to the underlying foundation. It is generally held that the intensity of the pressure due to an isolated load diminishes as the depth increases, and the assumption is sometimes made that at any depth the pressure is uniform, and confined to the base of a cone having the load at its apex and with its surface inclined at an angle of 45 deg. to the line of the load. Some definite information on this head is provided by some experiments recently carried out in the engineering laboratories of the University of Illinois, a description of which is contributed by Professor M. E. Enger to a recent issue of the Railway Review. The experiments were made by applying a local load to a bed of sand supported on a concrete floor. An opening in the floor 4⅛ ins. in diameter was closed by a plug 4 ins. in





Lines of equal vertical unit-pressure - expressed as the percent which the average vertical unit-pressure on the 4-in. plug is of the average unit-pressure applied to loaded area.
(4684)

diameter, which rested by a knife-edge on a lever, the outer end of which was borne by the platform of a weighing-machine. The load was applied to the upper surface of the sand by means of a circular plate, the diameter of which ranged in different experiments from 9 ins. up to 21 ins. In the first instance the load was applied centrally over the plug already mentioned, and the weight borne by the latter was recorded. The pressure-plate was then shifted a little to one side, and the observation repeated. By proceeding in this way sufficient data were obtained to make it possible to plot a curve showing how the pressure on the sand varied with the distance from the line of load. The sand was thoroughly compacted before taking a reading. If, for example, it was intended to determine the pressure distribution at a depth of 12 ins., the plate was started on a layer about 15 ins. deep and forced down to 12-in. depth. The load was then released and reapplied several times in succession, readings of the pressure borne by the plug being taken during each of these reapplications of the load. The interesting fact was established that at shallow depths the intensity of the load on the plug might be very considerably greater than the average pressure applied at the surface of the sand. Thus in one series of experiments in which the pressures were measured by a diaphragm gauge 6 ins. in diameter, instead of by means of the 4-in. plug aforementioned, the following figures were observed:

	Depth below Surface. 6 in. p.c.	12 in. p.c.	18 in. p.c.	Diameter of Load-Plate. in.
Average pressure on 6-in. gauge	72	43	19	9.0
" " " "	160	90	40	13.5
" " " "	—	195	92	21.0

The figures given show the average pressure per square inch on the 6-in. gauge, as compared with the average pressure per square inch on the load-plate when this is concentric with the gauge. Obviously, since the pressures given are averages, the maximum pressure along the centre line must be considerably higher. The diaphragm gauge was found to be unsuitable for "out-of-centre" observations; but the results obtained with the wooden plug made it possible to plot curves showing the distribution of pressure. These were found to have the character illustrated in Fig. 1. The shape of the curve recalls that of the "error function," and is, moreover, very similar to the curves of pressure distribution that are found when a jet of water strikes a flat plate normally. Curves of this kind are reproduced in Professor Unwin's article on "Hydraulics" (Encyclopædia Britannica, 11th edition). Professor Enger has also plotted the lines of equal pressure which we reproduce in Fig. 2. In further experiments the motion of the sand was observed when a load was applied to a mass one side of which was retained by a sheet of plate glass. By applying the pressure slowly, the motion of the sand was recorded, as short streaks, in a photograph taken simultaneously. The stream lines thus found should be presumably perpendicular to the corresponding lines of equal pressure. This presumption cannot, however, be tested from Professor Enger's photographs, since the size of the pressure block used in determining the lines of pressure was not the same as that with which the lines of flow were recorded. One result which appears to be fairly deducible from the experiments is that the distributing power of sand is not as great as would be anticipated from the 45 deg. rule referred to at the beginning of this article.

The House bill at Washington, D.C., providing for the reclamation by the Government of 2,300,000 acres of Oregon land granted the Oregon and California Railroad, has been passed by the Senate. The lands, valued at about $30,000,000, are alleged to have been forfeited by violations of the terms of the grant, which required their sale to settlers at $2.50 an acre.

According to the annual report of the Ontario Workmen's Compensation Board there were 7,600 accidents which came under its jurisdiction during the year. Arranged according to counties, York, Wentworth, Algoma and Sudbury had the largest number of accidents in the order named. The reason for this is evident, all four of them containing large industries, thus making the hazard greater. The report also shows that 27.61 per cent. of accidents were due to machinery and its parts, 2.74 per cent. to hoisting apparatus, 8.20 per cent. to dangerous substances, 34.04 per cent. to falling, rolling and flying objects, 6.08 per cent. to the use of tools, 1.03 per cent. to runaways and animals, 3.55 per cent. to moving vehicles, 14.47 per cent. to personal falls, and 2.29 per cent. to all other causes.

ROAD MAINTENANCE, MATERIALS AND METHODS.*

By William H. Connell,
Chief, Bureau of Highways and Street Cleaning, Philadelphia.

A GOOD organization is essential, particularly in so far as maintenance is concerned, as it is practically impossible to continuously and systematically maintain pavements and roads in first-class condition in an economical manner, without a good working organization built up along the lines best adapted to cope with the conditions involved in this important branch of work coming under the jurisdiction of a highway department. By this it is not intended to give the impression that the maintenance organization should be separated from the construction, as separate organizations are apt to result in an overlapping of jurisdiction and a tendency to shift responsibility, and open up a field for unlimited excuses, as to whether the construction or maintenance division is responsible for any unsatisfactory conditions that may arise relative to the pavements. Furthermore, it is obvious that the logical organization to maintain the pavements is the one that saw them laid and is familiar with every detail of the construction, as very often a knowledge of apparently trivial conditions in connection with the construction bears an important part in the future maintenance.

It is the intimate knowledge of the details of both construction and maintenance, not considered separately but in their relation to one another, that is so desirable as a future guide in highway engineering; consequently the combination of the two organizations in one will accomplish far better results than they would working more or less independently of one another, each with a limited responsibility. Highway engineering may be considered a specialty, but further specializing in construction and maintenance is not logical, as the two are dove-tailed and cannot be considered separately. Every engineer engaged in highway work appreciates the fact that there is no such thing as a permanent pavement for either city streets or country roads, consequently, in addition to the cost of construction, the maintenance repair charges during its life must be included in the final cost, and is a most important factor in the selection of a pavement.

The main and most perplexing problem of a highway department, no matter whether the department be a state, municipal, county or town department, is, or eventually will be, that of maintenance. If a large percentage of the roads or pavements are constructed, which is usually the case, then the maintenance predominates, and in fact it is only in localities where there are practically no roads or pavements, that the maintenance is subordinated to the construction.

The activities coming under the jurisdiction of the municipal and state highway departments are not similar in every respect, but the principal functions do not differ sufficiently to affect the problem in the main.

A large municipal department embracing street cleaning, collection and disposal of ashes, garbage and rubbish, and snow removal, together with the general problems, such as construction and maintenance of pavements, etc., embraces a greater variety of work than does a state department, but principally of a nature that is essentially maintenance work. Likewise in a large state department with an active organization controlling a large area of

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

improved highways, the maintenance problem is more involved and complicated than in a county or state department with a less mileage of pavements or roads under its care, so that the perplexity of the problem increases not only with the number and variety of activities, but with the area of the territory and the mileage of roads and pavements coming under the jurisdiction of the department. It is, of course, a much simpler matter to cope with this problem where the work involved is such that it can be controlled from a central office, without delegating the responsibility to divisions and sub-divisions of the organization. This is especially true in maintenance work, as there is always a tendency among engineers to be lax in attention to details of an apparently simple and routine nature. They are apt to overlook the fact that it is no trick to construct a pavement, as in supervising this work they are simply following more or less standard, and well-defined principles, where, in maintenance work, there is no set specification to follow, the success depending upon attention, to a certain degree, to daily routine and principally to petty details that present themselves in the actual physical work, and in this there is an unlimited field for initiative. Personal experience in observations of the wear and peculiarities of the different types of pavements and road surfaces is invaluable as a guide in research work, as there is not a pavement to-day that cannot and should not be improved upon. The difficulty of impressing upon the supervising force the importance of this close personal attention to detail in connection with the care of the pavements is probably the most important single factor in the operation of a large highway department, and must be reckoned with, and especially in these times when the public are becoming more and more exacting and virtually demanding that the roads and pavements be kept continuously in good repair. This should be obvious to all engineers in charge of highway organizations.

For convenience the different branches of maintenance work will be grouped under the following classifications:

1.—Routine maintenance.
2.—General maintenance.
3.—Emergency maintenance.

Routine maintenance includes such work as the regular street cleaning in municipalities, and the cleaning of country roads and gutters, and any other work of this character that is more or less routine, and should be performed under a definite schedule. The streets in the thickly populated sections of the city should be cleaned every day; in less thickly populated sections, every other day; every third, and so on until we come to the country roads, which should be cleaned once a week, once every two weeks, and some only once a month, depending upon the amount and character of the traffic which largely governs the frequency with which the cleaning should be done. The amount and schedule of work and the force necessary to perform it can be determined upon in advance and carried on in a systematic manner under a regular organization, more or less military.

General maintenance includes repairs to streets and roads, and involves different characters of work, each requiring special knowledge on the part of those engaged in the actual performance of the physical work for which special gangs have to be organized. Stone block, wood block and brick repairs, for example, require skilled laborers who have made a specialty of this work, and are employed under the title of pavers and rammers; while repairs to asphalt and bituminous pavements must be performed by men specially trained in this line of work, in addition to the necessary force engaged at the mixing plants. Macadam road repairs, the care of earth roads, the bituminous surface treatments, also require men specially trained, and while it is desirable to train the gangs for each particular branch of this work, such, for example, as bituminous macadam built by the penetration method, waterbound macadam, bituminous surface treatments, and the care of earth roads, the three classifications, namely:

1.—Block pavement repairs.
2.—Bituminous pavement repairs (mixing method), sheet asphalt, bituminous concrete, etc.
3.—Country roads, macadam, gravel, etc.; bituminous surface treatments, and earth road repairs,

represent the three branches into which the organization is usually divided. Further subdivisions can be handled by those directly in charge of the different classes of work coming under these divisions by training the laborers for the particular character of work to which they are assigned.

This illustrates the difficulty of handling the work coming under the heading of general maintenance, which not only requires separate organizations made up of men specially trained in the different branches of the work, but the character and amount of the work itself is of such an indefinite quantity that it is very hard to control, and, furthermore, can only be performed in seasons of the year when weather conditions are suitable, all of which tends to make it difficult to maintain a good working organization, as is always the case when men are not regularly employed all year round.

The principal element leading to success in this work is the application of the theory that a "stitch in time saves nine." This not only applies to the patching of different characters of pavements, but to bituminous surface treatments, particularly when the treatment only consists of a paint-coat lightly covered with washed gravel or chips, which is only intended to last for a year or two. Very often when a treatment is required on a road, and the performance of the work is postponed for a couple of weeks, the road will deteriorate and require resurfacing, so that it not only necessitates a more or less flexible organization for the actual performance of the work, but a very thorough study of the probable amount of material required, which should be purchased sufficiently in advance to avoid any delay in furnishing the material. This requires in addition to an efficient overhead organization, composed of engineers well versed in the art of carrying on the work, a thoroughly systematized procedure suited to bring about the best results under the conditions to be met.

The third classification, or emergency maintenance, consists of such work as snow removal and taking care of extensive washouts, both of which require an emergency force, as work of this character must be performed at once, and necessitates putting on an indefinite number of men, depending upon the volume of work, usually for only a short period of time. This makes it necessary for the organization to keep in touch with all available sources where men can be employed on short notice.

These are some of the reasons why the maintenance problem is the most difficult one in a highway department. Construction work, in the first place, is usually carried on under contract, and all the cares and troubles relative to the labor situation are up to the contractor. The department requires the contractor to perform a specific piece of work under definite conditions, and is only charged with the inspection, and the responsibility of seeing that it is performed in accordance with the requirements of the specifications. While, in the maintenance work the burden of the responsibility is up to the officials of the department not only in so far as the character of the work is concerned, but for the control of the organizations engaged in its performance.

The details of the different characters of repair work including the methods and materials used are, of course, very important, but nothing like as important as the length of time that elapses between the origination of the necessity for the repairs and the performance of the work. Repairs should be made as soon as the defects, no matter how slight, present themselves, and not weeks afterward. The secret of success in highway work is continuous and systematic maintenance. The upkeep is the real problem. The highways should be patrolled every week, and oftener if necessary, and all defects reported and repairs made at once.

The general methods employed to maintain a system of highways in good condition are the patrol method and the gang method. The patrol method usually consists in having a man with a team and the repair equipment patrol, and be responsible for making repairs to a certain, definite length of highway. The gang method consists in sufficient gangs being employed, equipped with all the materials to make repairs where ordered; the difference between the two methods being that in the first method the man who makes the repairs also patrols the highways, while the gang method is dependent upon the reporting of defects being made by special patrolmen, who may be inspectors, engineers, etc. There is some difference of opinion as to the better method, but it would seem that the reporting of the necessity for repairs by a special patrol inspector and the making of these repairs by a specially trained gang would be the better method. A detailed description of the methods of making repairs to the various types of roads and pavements would constitute quite a voluminous document. Consequently, it will only be possible to discuss the fundamental principles.

Dirt roads should be well crowned and drained. The shoulders should be kept clear, and the drainage ditches open. Road drags and road scrapers must also be used from time to time in order to keep dirt roads in good condition. An application of about a 20 Baumé gravity road oil once a year will not only lay the dust, but will help to compact the road surface under travel and form a sort of crust.

Gravel and waterbound macadam roads should be well crowned, well drained, and the shoulders and drainage ditches kept clear. The most effective method of maintaining gravel and macadam roads is through the use of bituminous surface treatments. The method and type of treatment used, however, will depend upon whether it is to be used for a gravel or macadam road, and the character of gravel and stone used in the construction of the respective types of roads. On other classes of roads and pavements, such as bituminous pavements by the mixing and penetration methods, cement, concrete brick and stone block pavements, it is also important to keep the roads well drained, the shoulders clear, and the drains and ditches open. The methods of bituminous surface treatments used on the city of Philadelphia suburban and country macadam and dirt roads are as follow:

The suburban and country streets and roads receive bituminous surface treatments of the character best suited to the respective roads, which are selected only after making a study of the type of construction, the traffic and social and local conditions in each instance. Generally speaking, two methods of treatment are used on the roads. For convenience they are divided, first, into bituminous surface treatments, intended to eliminate the dust nuisance and preserve the roads, and secondly a cheaper method of bituminous surface treatment, used simply for the purpose of laying the dust on macadam, cinder and dirt roads, and not intended to preserve the road to any great extent.

The first method of treatment is used only on macadam roads that have been put in good condition, as it is a waste of money to put a high-class bituminous surface treatment on a road that is full of ruts and pot holes, and not properly shaped up. The bituminous materials used in the city of Philadelphia consist of coal tar treatment, hot application, known as Tarvia A, coal tar treatment, cold application, known as Tarvia B, water gas tar treatment, hot application, known as Ugite No. 2, water gas tar treatment, cold application, known as Ugite No. 1, and asphalt cut-back treatments which consist of a mixture of 60 to 65 per cent. of 80 to 100 penetration asphalt, conforming to specifications adopted by the Association for Standardizing Paving Specifications at Pittsburg in 1913, and 35 to 40 per cent. of 53 to 60 commercial naphtha. All of these materials are applied in quantities just sufficient to paint the road and to avoid possibilities of building up a pad. In other words, the purpose is simply to have a film coat of bituminous material on the surface of the road and to re-treat the road as often as is necessary to maintain the film coat, and in this way eliminate the pushing and rolling under traffic, which occurs with bituminous pads.

The method of applying these bituminous materials, when the road is in proper condition to receive such a treatment and the material to be used on the respective roads has been selected, is as follows: The roads are first lightly sprinkled with water and then swept with a horse-drawn broom. They are then swept with hand brooms until the surfaces of the stone are free from dust. This sweeping, however, should not be done in such a manner that the stone dust or binder will be removed from between the stones. The bituminous material is then applied with a pressure distributor at a certain rate per gallon, which varies on different roads, depending upon their condition, and also whether it be a first, second or third treatment. The bituminous material is then allowed to remain on the road for about twelve hours, or over night, after which fine washed gravel—

Passing ½-inch screen	100 per cent.
Passing No. 4 screen	50 to 60 per cent.
Passing No. 6 screen	20 to 30 per cent.
Passing No. 10 screen, not over	10 per cent.

is spread over the road at the rate of 13 to 18 pounds to the square yard, depending upon the amount of bituminous material applied. In some cases clean trap rock chips passing a ⅝-inch ring and maintained on a ⅛-inch ring are used.

The theory of using fine washed gravel in place of stone chips is two-fold; first, to provide a covering that will not grind up and pulverize before the bituminous material has set up, and thus incorporate with it and build up a pad, such as is the case with the stone chips as they pulverize very quickly under any appreciable amount of traffic; second, it only contains 10 per cent. of the fine sand and the pebbles constituting the rest of the material are so hard that they do not grind up and pulverize for from three weeks to two months, depending upon the traffic. The process of pulverizing is so slow that the fine material is washed off the road after each rain, thus doing away with the necessity of sweeping the road to eliminate the dust, which is necessary where stone chips are used.

These treatments last for a year and have proved to be not only the most economical method of preserving roads of this character, but the cost is less than the cost of sprinkling with water, provided the roads are sprinkled three times a day and this, by the way, is not sufficient to lay the dust, and, of course, it must also be understood that the sprinkling with water will not preserve the roads under automobile traffic.

The second class of treatment generally used consists of asphaltic road oil from 18 deg. to 23 deg. Baumé gravity. This material is applied to all of the macadam roads that are not in fit condition for the first-class bituminous surface treatment, and to all dirt roads, and is applied at the rate of 2/10 to ¼ gallon to the square yard. On some roads, depending upon the amount of traffic and whether or not the road is shaded, it is necessary to treat the road in May and treat it again in September. Such roads, however, are the exception. In most cases this method of treatment will last for one season. The roads as a rule are not swept before the application, nor is any covering put over this bituminous material, as it is applied in such small quantities that there is scarcely any necessity for covering. The purpose in putting on this small quantity is to insure its disappearing from the road before the winter sets in, in order to avoid the mushy condition that prevails when there is too much oil on the road in this season of the year.

The paint coat method of tar bituminous surface treatments on first-class macadam roads has been a success for seven or eight years in this country, and it has also been used to a very great extent for a number of years in England.

The asphalt cut-back paint coat treatments are somewhat new, and have been largely developed in Philadelphia during the last four years. The successful results in Philadelphia have led to its use in other localities in the east this year, notably by the Highway department of the State of Pennsylvania, where a large mileage of roads have been treated using this method.

The asphalt cut-back bituminous surface treatment was evolved through research work carried on with a view to finding some way to utilize an asphalt in the paint-coat method of treatment which had been so successful with the tars. In order to do this, it was necessary to use a comparatively stiff asphalt so that it would set up quickly on the road. This necessitated cutting back an asphalt of about 100 per cent. penetration with from 35 to 40 per cent. of naphtha. The purpose of the naphtha is to make the material of such a consistency that it can be applied to the road when it is moderately warm. In other words, the naphtha simply acts as a carrying agent, and after it has done its work, it evaporates and leaves the paint coat of asphalt on the road.

This material has proved to be a success under a four-year test, re-treating, of course, every year or two, or as often as is necessary, as is also the case with the tars.

The methods of bituminous treatments described, however, are not applicable to all conditions. The roads treated must be built of comparatively hard stone, and the traffic conditions must be taken into consideration.

The method of bituminous surface treatment described for macadam roads built of hard stone and in good condition can also be used on gravel roads constructed of materials similar to what is commonly called Poughkeepsie gravel, which consists of large and small sized stones with fine gravel for a binder. Where the gravel is composed of any appreciable amount of clay, this method of treatment would not give very satisfactory results. The dust layer referred to, however, would benefit such roads to a considerable extent. In discussing these bituminous surface treatments it will be noted that great stress has been laid on a paint coat or film coat to be renewed each year or so, or as often as necessary. The object of this paint coat or film coat is to avoid the formation of a pad, but where the road is built of soft stone that would naturally be affected more by traffic than would the hard stone, this paint coat or film coat would not be satisfactory. In such cases, it would be necessary to use a larger amount of bituminous material and build up a ⅜ to ½ inch pad. It is practically impossible to give any general description for bituminous surface treatment work that will apply to all conditions, but there is no road that cannot be benefited by the application of bituminous surface treatments. It is, however, very important that all the details of the cleaning, etc., previously described, should be given very careful attention, and the roads should be re-treated before they have gone into a condition of bad repair. After these re-treatments have been applied, that does not mean that they will not require any attention until the following year. Some roads, of course, will not require any attention until the time for the re-treatment, but a great many of the roads where the traffic is heavy will require patching all through the winter. The methods used in patching these bituminous surface treated roads in Philadelphia are as follow: Where the surface treatment has worn off in spots and there is likelihood of a pot-hole forming, the road is painted with tar used for cold treatments or asphalt cut-back, depending upon the character of material the road was originally treated with, and chips or gravel spread over the area of the surface that has been painted. Where pot holes have formed, a mixture of ¾-inch stones and a heavy tar somewhat similar to Tarvia A or an asphalt of about 100 penetration is placed in the hole and tamped, and dry gravel or chips spread over the surface. This can be done by heating the tar or asphalt on the road and mixing it with the stone, but a more effective and better way to handle this kind of patching is to make up a mixture of the tar and stone, and asphalt and stone and place it at different locations along the line of the system of highways. By the use of a suitable mixture of asphalt or tar cut back with naphtha, it is possible to prepare large quantities of patching material which will not set up so that it cannot be rehandled and used for repair work during the winter, without the necessity of reheating. This is known as the cold mixing method of patching bituminous macadam and bituminous surface treated roads. Such materials as Amiesite and Bicomac are also adapted for winter patching, and have given very satisfactory results. The main point that should be, and has been, brought out in connection with repairs to roads and pavements of all descriptions is to make the repairs promptly when there is the slightest indication of the necessity for repairs, and thus avoid pot holes in the country roads and necessity for making extensive repairs to roads and pavements of all descriptions.

Now that you are building a large mileage of highways in Canada, it will not be long before your maintenance problem predominates as it will be looming up larger each year, and you have a splendid opportunity to avail yourself of the experience gained by the failures in other localities where there has been a great deal of highway construction. In conclusion, it will not be an unfair statement to say that the failures in highway construction have been very much exaggerated. The trouble has been principally, however, the failure to maintain the roads and pavements after their having been constructed.

SURGES IN AN OPEN CANAL.*

By R. D. Johnson.

SYNOPSIS.

This paper points out a rational theory upon which to base research into the rise of water in a canal, following an interruption of flow, due, for example, to a shut-down of a water-power plant. It calls attention to the analogy between this surge and the phenomenon known as the "hydraulic jump."

THIS interesting subject always comes up in connection with the problem of how high to build forebay walls to avoid overflow in case the motion of the water in a canal is suddenly arrested by a short circuit. Trouble from this source seems to be very infrequent, and yet a sound theory for the computation of the height of the surge wave has never come to the writer's attention. The reason that wash-overs have not been more common seems to be due to the fact that, for ordinary velocities, the surge is comparatively small, and a good fair guess usually proves a sufficient safeguard; nevertheless, it may be interesting to set forth what appears to be the beginning of a sound theory, applicable to such cases.

Neglecting friction, in a smooth, rectangular flume, the sudden dropping of a gate would seem to cause a backward rolling wave which consumes a part of the energy of the oncoming water in eddy losses, and accounts for the remainder in an increased depth behind the wave, the water standing still and level between the wave and the gate. On this theory, an equation from which the depth of the water may be determined is expressible through recourse to the well-known law that force is equal to the rate of change of momentum; for, if the depth of the water in motion is d and that of the water at rest is D, the total free force acting (for unit weight of fluid and unit width of flume) is $\frac{D^2 - d^2}{2}$ and, in the time, t, during which Qt cubic feet of water passes, with a velocity, v, and also Qt cubic feet of water is projected backward over the top, so to speak, of the oncoming stream, the quantity of water brought to rest is Dt multiplied by the velocity of propagation of the wave, or,

$$Dtv_3 = Dt \times \frac{Q}{D-d},$$

the change of momentum is

$$\frac{DQtv}{g\,(D-d)},$$

and the rate of change of momentum is

$$\frac{DQv}{g\,(D-d)},$$

whence,

$$\frac{D^2 - d^2}{2} = \frac{D\,d\,v^2}{(D-d)\,g} \quad \ldots\ldots\ldots\ldots (1)$$

from which D may easily be determined by trial.

It may be observed that as velocity is only relative, the height of the "jump" which takes place in this case should agree exactly with the formula for the "hydraulic jump," if the proper corrections are made in the velocities relative to the earth, in such manner that the wave would "stand still" in the ordinary acceptation of the term. In other words, no error in theory is introduced if, while the above phenomenon is in progress, the whole flume is regarded as moving bodily, with a velocity, relative to the earth, equal and opposite to that of the wave propagation; and such modifications ought to, and do, reveal the formula for the ordinary "hydraulic jump."

In this case, the absolute velocity of the water approaching the wave would be

$$v + \frac{Q}{D-d} = v_2$$

and the absolute velocity of the deeper water, at depth D, would be

$$\frac{Q}{D-d} = v_1, \text{ and } v_2 - v_1 = v, \text{ as before.}$$

The new quantity, $Q' = D\,v_1 = \frac{Q\,D}{D-d}$.

The formula for the hydraulic jump is,

$$\frac{D^2 - d^2}{2} = \frac{Q'}{g}\,(v_2 - v_1)$$

and as D and d are unchanged, we may substitute for the foregoing values of v_2, v_1, and Q', their equivalents in terms of Q and v, as follows:

$$\frac{D^2 - d^2}{2} = \frac{Q\,D\,v}{g\,(D-d)} = \frac{D\,d\,v^2}{(D-d)\,g},$$

thus disclosing the identity of the two formulas and justifying, to some extent, the reasoning outlined in the premises.

To complete the analogy, it may come to mind that, as water cannot "jump" unless it has a velocity greater than $\sqrt{gd}$, it would be well to demonstrate that the sum of the velocities, v and v_3, is always greater than $\sqrt{gd}$.

Note, from Equation (1), that,

$$\frac{v^2}{g} = \frac{(D+d)\,(D-d)^2}{2\,D\,d}$$

and we are to show that

$$v + v_3 \text{ or } \frac{v\,D}{D-d} > \sqrt{gd},$$

that is, that

$$\frac{v^2}{g} > \frac{d\,(D-d)^2}{D^2}$$

or, eliminating $\frac{v^2}{g}$, that

$$\frac{D+d}{2\,d} > \frac{d}{D},$$

which is obvious so long as $D > d$.

The surge, S, above the level of the quiet water previous to its acceleration into the canal entrance is evidently equal to $D - d - \frac{v^2}{2\,g}$, and it may be shown by calculus methods that the maximum possible value of S is equal to $0.714d$, which occurs for a critical velocity of $v = 7.448\sqrt{d}$.

Modifications Involving Friction.—It now seems clear that Equation (1) represents the relation between the depths on each side of the backward rolling wave when friction is neglected. Without attempting to go further into the subject at this time, it may be stated, nevertheless, that the surge probably cannot exceed the value of S derived from this equation, when friction is taken into account. On the other hand, there would seem to be little danger of extravagance if the height of the canal and forebay walls was regulated by the foregoing considerations.

*Proceedings of the American Society of Civil Engineers, May, 1916.

The Swiss Federal Government has definitely decided to electrify the whole of the Swiss railways. The first line to be electrified will be the Erstfeld-Bellinzona section of the St. Gothard line. The cost of electrifying the Federal railways is estimated to be £20,000,000.

Editorial

ANSWERING ONE'S MAIL.

COURTESY: Politeness exercised habitually; an act of good breeding.

That is the gist of a long dictionary definition of the word "courtesy." The meaning of the word is not altered by prefixing "business." Business courtesy shows good breeding. Conversely, people who are well bred always exercise business courtesy.

Are Canadian engineers lacking in business courtesy? Let us most certainly hope that they are not. But certain evidences point to the fact that they frequently come dangerously near business discourtesy. It is discourteous to ignore a civil letter. Yet, how frequently is one compelled to write time and again to Canadian engineers and engineering firms before a reply of any kind is received!

However, we had not thought that this was any more true of Canadian engineers than of engineers in any other country. But an instance just called to our attention gives food for reflection. A well-known business firm wrote to thirty-four municipal engineers in the United States, politely asking for certain easily given information. Twenty-four prompt responses were received. A second letter brought eight more. Seventy-one per cent. answered the first letter; ninety-four per cent. answered either the first or second letter.

Practically the same letter was mailed simultaneously to one hundred and fifteen municipal engineers in Canada. Thirty-two fairly prompt answers were returned. A second letter brought four more. Twenty-eight per cent. answered the first letter; thirty-one per cent. answered either the first or second letter.

Comparisons are invidious, but we feel that the circumstances fully justify the above comparison. This result is absolutely due to carelessness. At heart the average Canadian engineer is as courteous as any other man. But carelessness of this sort is likely to make a very bad impression.

Every civil letter that calls for an answer should have one and have it promptly. Otherwise its recipient is clearly open to a charge of downright discourtesy.

NO FURTHER WATER POWER INVESTIGATION AT PRESENT.

On page 666 of this issue there appears a letter from the secretary of the Economic and Development Commission, giving assurance that the Commission has no intention *at the present time* of conducting any *independent* investigation regarding water powers, as the information now available on this subject will be quite adequate *for present purposes.*

We are very glad that the Commission has decided, for the time being at any rate, not to go into this field. Tremendous scope is afforded the Commission for doing vitally important work along economic lines without delving into engineering subjects at all.

As the Commission obviously was not constituted with a view to doing or reviewing engineering work, the assurance is most pleasing that the lines along which it will exercise its efforts will not be of an engineering nature.

TONNAGE AND SHIPBUILDING.

Of the total tonnage of sea-going ships of the world, namely, 33,531,503, only 62 per cent. is available to-day for the ocean trade of all nations. The nations of Europe engaged in war own over 21,000,000 tons. Of the 17,000,000 tons comprising the merchant marine of the Entente Allies, 65 per cent. is owned by Great Britain. Of the 21,000,000 tons owned by the belligerents, over 4,000,000 tons belonging to the teutonic allies are bottled up in neutral harbors and elsewhere. Of the 17,000,000 remaining, over 50 per cent. has been commandeered to act as transports and supply ships. These are some of the factors which have caused ocean freights to rise to the highest level in history.

In addition, since the outbreak of war, 2,031,000 merchant tonnage has been sunk. New tonnage launched in approximately the same period has been 1,201,638, giving a net tonnage loss of 829,000. Little, if any, increase can therefore be expected in ocean ship space during the war. Even after the war, with a certain amount of tonnage released by various governments, there will be a great scramble for ships for use during the coming commercial campaign.

Therefore, the development of Canadian shipbuilding is receiving considerable attention from capitalists and manufacturers. In an address before the annual meeting of the Canadian Manufacturers' Association, Mr. Thos. Cantley dealt most interestingly with this subject. He pointed out that Canadian shipping carried only a small portion of the lake freights and about one-tenth of the whole produce sent from Canadian ports. He outlined the history of the railways in the Dominion, and deplored the fact that the Government had not carried out a similar policy of assistance in regard to marine transportation.

The canal system has cost over $100,000,000 since Confederation, but it is open to competitors, and over four-fifths of the traffic passing through the canals originates in the United States, while less than one-third of the vessels are Canadian. The Dominion has also spent $150,000,000 on aids to navigation on the coast and inland waters, which are used by all in common, but the Government has done practically nothing towards encouraging the shipbuilding industry. There are a few Canadian shipyards equippped for the building of steel vessels, but they are all on the Great Lakes, and none on the Atlantic seaboard.

Mr. Cantley gave statistics regarding the output of wooden ships in the Maritime Provinces from 1874, when 190,756 tons were built in a year, and the tonnage on the register was 1,158,363, up to 1914, when the vessels built in the year were 43,436 tons, and the tonnage on the register was 932,422. He declared that he had no faith in any scheme for providing greater or more efficient transportation through Government ownership, time charter or operation of a tramp steamer fleet, or by any other form of attempted control of ocean traffic by the Government, but considered that the Government would be justified in making a considerable expenditure to aid in the development of shipbuilding at present.

The iron and steel industry of Canada could never have reached the present output capacity save for the fostering influence of the combination of tariff protection and bounty. Steel shipbuilding on a comprehensive scale can be developed if the Government is prepared to grapple with the matter in a farsighted and liberal manner. It is generally admitted that it requires from five to ten years to build up any good manufacturing organization, and this makes it necessary that any plan of assistance should be guaranteed for a period long enough to enable new yards to get their organization well established.

TWO-INCH WOOD BLOCK PAVEMENT.

In October, 1913, a 100-foot strip of experimental paving was laid in one of the residential streets of Tacoma, Wash., using creosoted wood blocks only 2 inches deep. Inquiry last month by *The Canadian Engineer* brought a reply stating that the pavement is, in general, in good condition. "There has been no heaving. A portion of the pavement which was laid on a concrete base that had a sidewalk finish, has apparently separated from the foundation, but this could be prevented in future work. The blocks showed excessive bleeding, but this also could be prevented by different treatment.

"The street receives very heavy traffic for a residential street, inasmuch as it is the only one used for carting between the two main streets of Tacoma, and it is on the right-hand side leading out of the city, thus getting the traffic of the heavily loaded teams. With the exception of where the joint was made with the asphalt paving, and which slipped up over the blocks, necessitating the cutting away of the asphalt, no expenditure has been made for up-keep on this experimental pavement."

If creosoted wood block only 2 inches deep proves practical, a new field will be opened for this type of paving on account of the great reduction in cost that will be possible. The blocks laid at Tacoma were only 1⅞ inches wide by 3⅝ inches long. They were Douglas fir, treated with approximately 18 lbs. per cubic foot of creosote. On account of the small size, excellent penetration and uniformity of grain were more easily obtained than with blocks of standard size.

The blocks were laid on a concrete base 14½ feet wide. The pavement was divided into four sections, each 25 feet long, as follows:—

(1) Blocks laid with long axis at right angles to the line of traffic, on a 1" sand cushion; broken joints, blocks rammed tight.

(2) Blocks laid at an angle of 67½ deg. to line of traffic, on a 1" sand cushion; rammed tight and joints broken as in Section 1.

(3) Blocks laid on a 1" cushion made of one part of cement to three parts of fine sand, mixed and spread dry; blocks laid with long axis parallel to the curb, making unbroken joints along the line of traffic; at right angles to the curb, joints are broken.

(4) Blocks laid in the same manner as in Section 3, excepting that they are bedded in grout of 1 part cement to three parts sand, mixed wet enough to take a smooth trowel finish.

The crushing strength of 2-inch blocks is said to be approximately as great as the crushing strength of the larger blocks, and as there is not likely to be two inches of actual wear during the lifetime of the pavement if the blocks do not rot, break or crack, the 2-inch block would seem to be feasible with proper treatment, provided that they are made so small that the impact of traffic will not break them. The cost of laying the smaller block would, of course, be somewhat higher than the cost of laying the larger block, but this would undoubtedly be far more than offset by the reduced cost of the materials. The further progress of the Tacoma experiment undoubtedly will be watched with interest by municipal engineers.

LETTER TO THE EDITOR.

"Another Water Powers Investigation?"

Sir,—My attention has been called to your editorial in June 1st issue, "Another Water Powers Investigation," in which you expressed the belief that the Economic and Development Commission was about to investigate the water powers of the Dominion.

In justice to your readers who may be interested in this matter, I should be obliged if you would state that the Commission has no intention at the present time of conducting or having conducted any independent investigations regarding water powers.

Cognizance has been taken of the results obtained by the Water Power Branch of the Department of the Interior, and by provincial authorities who have conducted similar investigations. It is evident that the information now available on this subject will be quite adequate for present purposes.

Yours very truly,

(Signed) W. J. BLACK,

Secretary, The Economic and Development Commission.
Ottawa, June 14th, 1916.

UNDERGROUND CANAL DUG.

Despite the war and the tremendous burden it has put upon France, a tremendous undertaking, which was started long before any one suspected that there would be a war, has just been completed and France now possesses the longest underground waterway in the world. This is the Rove Tunnel from Arles to Marseilles, which was inaugurated last week.

This wonderful waterway runs through a mountain and below two communes. It is 72 feet broad and from the canal bottom to the summit of the vault its height is 46 feet. There will be ten feet of water in the canal, so from its surface there will be a clear space overhead of 36 feet. To put it otherwise, the section of the tunnel is six times that of our ordinary tunnel. To add another touch, it may be said that twice as much detritus has been shovelled out to make this underground passage as came from the Simplon Tunnel.

The canal is not yet finished. As yet the bed of the Rove Tunnel is dry, though it is pierced through all its length. It will take three years before it is ready for traffic, but when the work is done Marseilles will join hands with Havre for the first time.

WILL DOUBLE PLANT.

The Armstrong-Whitworth of Canada, Limited, has awarded contracts for the doubling of its already extensive plant at Longueuil, Que., at an estimated cost of $750,000. The new plant will comprise a plant for the manufacture of steel tires for locomotives and passenger rolling stock, as well as for the rolling of steel wheels and the manufacture of forged axles. The company will also add a rolling mill and provide for the making of special rounds and shapes, all made for electric smelted steel, while rough drills and material of that class will also be made. This is the first time the manufacture of steel wheels has been attempted in Canada, but this is done to meet the now heavy demand for such wheels, which are necessary to carry cars of 75 tons weight.

MONTREAL AQUEDUCT SCHEME.

Controller Villeneuve, of Montreal, whose motion to appoint experts to report on the proposed aqueduct power development was defeated by his fellow controllers, is making a strong endeavor to get the desired information in another manner. Taking advantage of his "parliamentary privileges," he has given motion that he will ask a certain series of questions regarding the aqueduct, at a future meeting of the board. Mayor Martin stated that if necessary the whole staff of the various departments interested would be set to work to answer the questions. It is expected that answers will be ready within a fortnight. The questions asked by Controller Villeneuve are as follows:—

1.—Names of the experts, and date of their appointment, who have approved, or only examined the figures on the debit of the tailrace, as planned for the new enlargement, contract No. 2?

2.—By whom were those figures calculated, verified, and at what date? Do such figures show the depth, width of section of tailrace, its slope in longitudinal profile, and that the back water of the St. Lawrence has been studied well enough in 1913 so as to establish a permanent flow of all the water passing through the turbines, without changing the height of the waterfall at the power-house and the amount of power? and without an excess of current that would be damageable to the tailrace?

3—If such calculations have not been made or verified as exact by experts, was it possible to determine the measurements of the enlargement of the tailrace and how can one be assured that the tailrace will be able to take care of all the water coming from the canal, without causing eddies that will be dangerous to the plant?

4.—On what basis, on what calculation, on what type of plant, on what selection of machinery and equipment, on what dimensions of plant, buildings, installation, are based the figures for the settling basis at the wheel-house? When was that basin excavated?

5.—Whether the kind of plant, the type of machinery, the power of installation, the plans for a plant, have or have not been studied, calculated and prepared, how was it possible to give contracts for excavating the basin and the tailrace, and have the basin dug out on imaginary measurements?

6.—On what selection of machinery, on what kind of plant and electric installation, on what disposition of buildings, on what plans, specifications, studies and projects, were based the estimates of the approximate cost of the power-house, pumping plant and electric plant, and the figures reported to the Board and the Council to the support of a demand of a credit, showing the total cost of the undertaking and the cost price of one hydraulic h.p.?

7.—After the study made up to this date, by the engineers of the aqueduct as to the plant of a power-house, a pumping house and a central electric station, can the department estimate, within a million dollars, the probable cost of the work and the installation to the plant to be erected and equipped?

8.—If no serious and careful estimate was ever made, how can the superintendent of the aqueduct estimate the probable cost of a hydraulic h.p. and the cost price of lighting, declare it advantageous and economical, that is, municipally not prohibitive under local conditions at Montreal?

9.—To what did the department estimate the annual expenditure of the operation and maintenance of the new power? These permanent charges are:—

(a)—Salaries of operators and guardians.
(b)—Maintenance, lubrification, repairs to machinery, buildings and canals.
(c)—Sinking fund on buildings, machinery, transmission lines, canals, bridges, fences and roads.
(d)—Interest on capital invested since 1906 or 1907 (not including filtration plant).

10.—What is the gravity of the accident to the intake? What soundings had been taken before ordering that structure? By whom? What was the nature of the soil in the foundations? Who has superintended, inspected and accepted that work? Who signed the orders for payment? Were any extras paid to the contractors for rock excavating? When will be made the necessary repairs?

11—What is the amount payable by the city, for repairing the concrete conduit after the accident of 1913? Has the amount been paid? Who was it paid to?

Who was found responsible for the accident? Who passed judgment on the damages and the responsibilities?

12.—What is the annual salary for engineers, draughtsmen, chainmen, surveyors, inspectors, clerks, etc., paid by the department to parties employed permanently in connection with the enlargement of the aqueduct (not including the filtration plant): (1) for 1913, 1914; (2) for 1915, for the five months of 1916.

13.—Are the engineers in charge of the filtration plant also in charge of the aqueduct? On what scale are they paid; what is the monthly total expenditure on the aqueduct and the filtration plant?

14.—At what was ever estimated the project of municipalizing the lighting, the cost of aerial or underground lines for transmission and distribution of electricity?

15.—What are the fixed charges per month, for operating the Laval pump (pump No. 8) and the boiler connected with it? (a) Salary of engineer and fireman; (b) Cost of coal for boilers operating that pump; (c) Lubricating and light; (d) Maintenance and repairs of machinery; (e) Wear and tear and sinking fund.

16.—What is the number of bridges to be erected on the canal and what is their approximate cost?

17.—What will be the approximate cost of the boulevards? How much land was given free of cost to the city and how much there is to be expropriated? Where are we at with the whole expropriation of the boulevards?

18.—Has the cost of an auxiliary steam plant been calculated?

19.—What will be that cost?

20.—Has an adequate study been made of the work to be done at the intake to prevent obstruction of the canal frazil and to insure the deviation of floating ice. What was the estimated cost of that work in 1913; on what mode of construction and on what calculation was based the estimation? Were any experts consulted on the subject?

Controller Villeneuve requested the city comptroller and auditor to supply the following information to the Board:—

(a) A statement of the accounts spent since 1906 for the aqueduct.

1. The concrete lateral conduit. 1, contract for conduit and accessories; 2, purchases of land or expropriations for the conduit; 3, salaries of engineers, inspectors, office clerks, etc., for 1906-1909; 4, compensating basin, for twin conduit; 5, gate basin at the intake; 6, intake in the River St. Lawrence.

2. Widening the canal (contract No. 1); 1, Quinlan and Robertson, contract and extras; 2, salaries of engineers, inspectors, offices, instruments, etc., 1909-1913.

3. Widening the canal (contract No. 2), Cook Construction Co. 1, amount of tender; 2, amount paid to date. Amount claimed by the Cook Construction Co. for extras and damages.

4. Salaries of engineers, inspectors, offices, instruments, etc., (1913 to date).

(b) What is, to date, the capital engaged in the widening of the aqueduct (not including the filtration plant).

What is the amount of interest already paid on that same capital, either engaged or spent? What is the average rate of interest?

What is the amount still available on the loans authorized to that end?

(c) What round figure is represented by the capital engaged in the steam pumping station of Centre Street (complete)? (a) buildings and chimneys; (b) machinery (pumps and engines), bridges; (c) steam tubing. Is there a sinking fund for depreciation and renewal?

(d) What are the total and fixed charges per annum for the operation of the low level steam pumping plant? (a) Salaries; (b) oil, upkeep, repairs; (c) total annual disbursements for coal. The above covering the year 1915.

(e) What was the cost of the last thirty million gallon pump installed? (a) Complete cost of machinery, installed; (b) cost of buildings and foundations; (c) cost of the last row of boilers; (d) cost of the boiler house; (e) cost of the last brick chimney.

(f) What is the total annual amount of charges paid by the city to electric light and power companies for (a) for lighting streets, parks, etc.; (b) for lighting municipal buildings; (c) for motive power in pumping stations, shops, etc.?

PERSONAL.

Capt. G. H. BLACKADER, a member of the firm of Barott, Blackader & Webster, architects, Montreal, has been reported wounded in the recent fighting.

C. C. JOHNSTON, formerly resident engineer at London, Ont., for Chipman & Power, of Toronto, has joined the Canadian Copper Co. at Sudbury, Ont.

H. G. ACRES, B.A.Sc., hydraulic engineer of the Ontario Hydro-Electric Power Commission, has received the degree of M.E. from the University of Toronto.

W. G. CHACE, chief engineer of the Greater Winnipeg Water District, has been elected chairman of the Winnipeg branch of the Canadian Society of Civil Engineers.

Lieut.-Col. RAMSAY, engineer, C.P.R., was among those who received birthday honors conferred by King George, receiving the C.M.G. for organizing the railway construction corps.

E. HANSON, city electrical engineer, Saskatoon, Sask., recently read a paper entitled "Power Development in Saskatchewan" before the members of the Utilities Engineering Society of Saskatoon.

J. T. JOHNSTON, Assoc.Mem.Can.Soc.C.E., chief hydraulic engineer of the Water Power Branch, Department of the Interior, received the degree of C.E. from the University of Toronto last Friday.

LEONARD METCALF, consulting engineer, of the firm of Metcalf & Eddy, Boston, has been elected president of the American Waterworks Association, to succeed Nicholas S. Hill, Jr., whose term of office expired.

J. C. JOHNSTONE, town engineer, Port Alberni, B.C., now in France with the Canadian Engineering Corps, has won his commission on the field. In the latest report he expected to return to England for a short time on leave.

JOHN J. DEWHIRST, a prominent engineer and road builder of Essex County, has tendered his services to the Canadian Government to head a construction corps now being recruited to build railways, bridges and roads in the war zone.

J. A. McCULLOCH, formerly sales manager of the Manitoba Bridge and Iron Works, Limited, Winnipeg, has been appointed general superintendent of the company, to succeed Mr. E. Stewart, who has been compelled to resign owing to ill-health.

C. D. HOWE, chief engineer of the Dominion Grain Commission, will deliver an address this evening on "Terminal Grain Elevator Construction" at a joint banquet of the Regina Engineering Society and the Regina Branch of the Canadian Society of Civil Engineers.

Lieut.-Col. A. CLYDE CALDWELL, commanding Royal Canadian Engineers in the 2nd military district, has been promoted to the important post of officer administering Royal Canadian Engineers for the whole Dominion. His headquarters will be at 215 Simcoe Street, Toronto.

OBITUARY.

JOSIAH MASON, a well-known Brampton (Ont.) contractor, died recently at his home in that town.

JOHN W. MESSACAR, building contractor, passed away recently at his home in Hamilton, Ont., at the age of 59 years.

CHARLES R. SCOLES, a prominent railroad man of New Carlisle, Que., died recently in Bermuda. The deceased was born at Grantham, England, in 1856. He was connected with various railway enterprises in Eastern Canada. In 1890 he was appointed manager of the Salibury & Harvey Railway. In 1900 manager of the Atlantic and Lake Superior Railway and in 1911 manager of the Quebec Oriental and Atlantic, Quebec and Western Railways.

S. H. REYNOLDS, M.Can.Soc.C.E., chairman of the Greater Winnipeg Water District Commission, died suddenly last Friday night in Chicago. Mr. Reynolds had seemingly been in perfect health, and it is thought that death resulted from an acute attack of heart trouble. He was appointed to the Winnipeg commission early in October, 1913, and was the first member of the commission to be appointed. At that time he was a resident of Victoria, B.C., and had been engaged for a number of years in mining pursuits. He had been assistant city engineer of Winnipeg for some years under Col. Ruttan, resigning from that position in 1907. He was elected to full membership in the Canadian Society of Civil Engineers on March 12, 1908.

DUST.

The following very good editorial appeared in a recent issue of The Ottawa Journal:—

It is time Ottawa took up in earnest the matter of oiling the roadways. This is a beautiful city, but a dirty one; and not mud but dust does the worst mischief.

Dust is bad for the lungs.

Dust is bad for the eyes and ears and nose.

Dust is bad for the skin.

Dust is bad for the temper.

Dust is bad for shop goods, and bad for shop windows.

Dust is bad for housekeeping.

Motor cars are desperate dust-producers. Dust gets back at them with grit and dirt, injures them and worries their owners.

If this dust infliction had to be endured—if there were no recourse against it—all of us could go on grumbling as we do now, and no one would be just to call us silly. Much of it does not have to be endured. Sprinkling the streets, or some of them, with oil will stop a great deal of the nuisance. Sprinkling with water stops some, of course. But sprinkling with oil is a very great deal more effective; nor is it much more expensive. It is not so expensive but that the Ottawa Improvement Commission, which is careful and sensible with its money, is able to oil the park driveways. It is not so expensive but that many cities are able to practise it.

Oiled roadways in this city would add vastly to the comfort, the health and the pleasure of the people. The Board of Control should take a real try at this question.

Mr. Paul Janoushevsky, of the Vladicaucase Railway, Russia, has been visiting Vancouver, B.C., and Portland, investigating the construction of bridges. On his return to Russia he will superintend the construction of the first direct lift bridge to be erected in that country.

The Jeffrey Manufacturing Company of Columbus, Ohio, announce the re-opening of their Northwestern Branch Office at Seattle, Wash., and the appointment of Percy E. Wright, Consulting Mechanical Engineer, as District Manager for British Columbia and Alberta.