PAGES

MISSING

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

ERECTION METHODS, BLOOR STREET VIADUCT, TORONTO

BRIEF REVIEW OF METHODS ADOPTED BY THE HAMILTON BRIDGE WORKS CO., LIMITED, IN ERECTING THE SUPERSTRUCTURE OF THE DON SECTION.

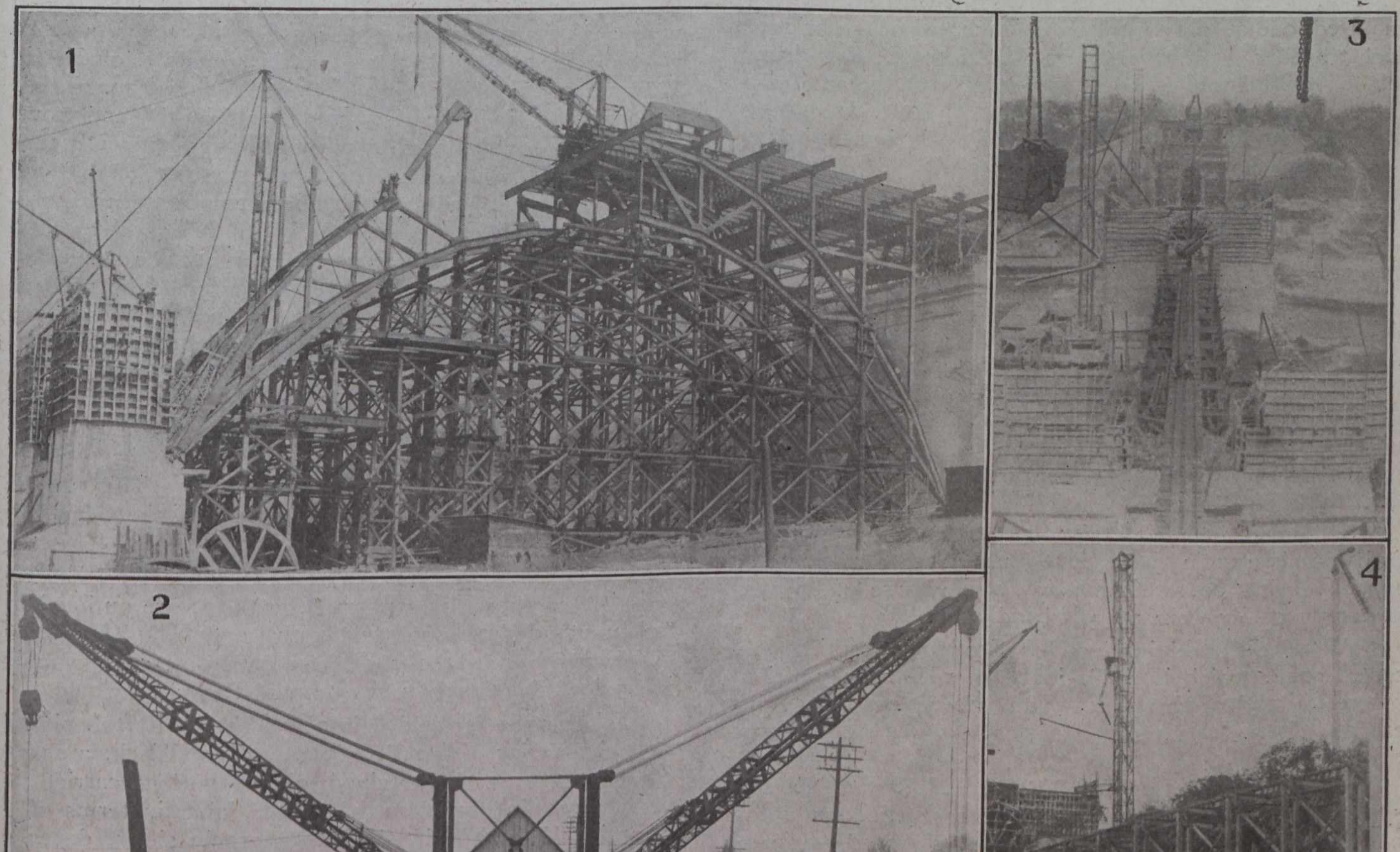
By J. GORDON JACK,
Resident Engineer, Don Section, Bloor Street Viaduct.

THE bridge forming the Don Section of the Bloor Street Viaduct, Toronto, comprises five three-pin arch spans and two approaches, double-deck type, with a maximum width for sidewalks of eighty-six feet. The general design of this bridge, and also of the bridge forming the Rosedale Section of the viaduct, has been previously covered in *The Canadian Engineer*—in the issues of October 29, 1914, December 17, 1914, December 16, 1915, and September 28, 1916.

The unloading of material at the east end of the bridge was a comparatively simple matter, owing to the close proximity of the Canadian Pacific Railroad tracks. The material was handled at this point by a 20-ton guy derrick which was afterwards used in the same position to erect steel on the west side of the 158-ft. span.

At the west end of the bridge the nearest railroad track was 700 ft. from the west abutment. Steel for the west approach, to the amount of 450 tons, was unloaded and transported by an aerial cableway to a point beyond the west abutment at an elevation 125 ft. above the level of the tracks.

As many of the sections on the west 158-ft. and 240-ft. spans weighed from 11 tons to 17 tons, the material for these two spans was unloaded in the manner indi-



1—Grey derrick helps traveller in erection of steel; 2—Type of traveller used; 3—Temporary track for conveying materials; 4—Crane lifts material onto trucks at unloading point.

cated in Figs. No. 4 and No. 3. The falsework under the centre ribs was raised to a certain elevation and then a standard track was laid thereon for a distance of 360 ft. A 20-ton guy derrick was erected and placed in such position that it could erect steel at a later date, and by means of this derrick the material was unloaded and raised to a temporary track where two standard gauge tracks, operated by a 6-in. x 12-in., two-drum hoisting engine, carried same to a point which enabled the travellers to hoist the material to the floor level of the bridge. Although this method involved two operations, a small force of men were able to unload and distribute 130 tons in nine hours.

Sections of the falsework have already been shown in *The Canadian Engineer* in Figs. 1 and 5, September 28th, 1916, issue. Standard 20-ft. platforms were adopted. Caps and sills were also standard, consequently maximum service with minimum waste was obtained. Douglas fir was used exclusively, in sections 12-in. x 12-in. and 10-in. x 18-in. Five-eighth inch bolts were used throughout in bracing. Under each panel point provision was made for raising or lowering the ribs by means of jacks. The maximum reaction on the falsework under the centre ribs when certain steel sections were being placed was 160,000 lbs.

Erection travellers were used to a considerable extent in raising the falsework, but where this means was found impracticable a stiff-legged derrick was used. All bents were framed before being raised.

Fig. No. 2 shows the type of erection traveller which was used, one of these working on each end of the bridge. Each traveller is operated by an 8-in. x 10-in., four-drum hoisting engine and is fitted with two 60-ft. booms built in three sections. The centre section of 20 ft. was taken out when handling heavy loads. The 60-ft. booms had a lifting capacity of 12 tons in any position. After the centre 20-ft. section had been taken out, the 40-ft. booms had a capacity of 20 tons in any position. The centre to centre measurement of the trucks in cross-section was 18 ft. 6 ins.

The steel on the west 158-ft. span was placed entirely by traveller. For the 240-ft. spans the traveller was used in conjunction with a 20-ton guy derrick, as shown in Fig. No. 1. Owing to the length of these two spans it was necessary to raise a sufficient amount of steel at the westerly side of the spans by the aid of the guy derrick in order that the traveller could reach out far enough to form the complete arch.

Settlement had to be taken care of from time to time, dudgeon hydraulic jacks being used, those of 70 tons capacity being operated in pairs, while those of 80 and 90 tons capacity were operated individually.

All of the steel in the Don Section, excepting the centre span, which is a 281-ft. span, will be in position before the end of this year. The centre span will be erected from each side simultaneously, using only travellers.

The bridge crosses the C.P.R., G.T.R. and C.N.R. systems, but the work to date has been carried out without in any way interfering with traffic on any of the three systems. Under the east 240-ft. span special care had to be taken to protect six of the Ontario Hydro-Electric Power Commission's high-tension lines, carrying a total of 78,000 volts.

Railway electrification work is planned by the Great Northern Railway, according to reports from Washington. The company intends to alter to electric traction all its lines in that State at an estimated cost of $16,000,000.

PARTITION OF LOAD IN RIVETED JOINTS.

RIVETED joints occur in many types of construction, and it is, therefore, of considerable practical importance to determine the exact manner in which they act, in order that a rational basis may be given for their design. The subject has attracted the attention of many experimenters, their investigations being mainly directed to a determination of the resistance of joints to rupture and of the frictional resistance to slip. Attempts have also been made to determine the tension in the body of a rivet due to its contraction on cooling, and Frémont has made an exhaustive study of the actual process of riveting and its effects upon the strength of the joint. None of these experiments, however, have indicated very clearly the action of a riveted joint under working loads; *i.e.*, before permanent deformations of the plates or rivets have occurred. Very few attempts have been made either experimentally to determine or theoretically to estimate the partition of the load among the rivets under working conditions. It is usually assumed, in designing a riveted joint, that the load is equally divided among the rivets. That this cannot be true in joints as usually designed has been generally recognized by writers on bridge design, and illustrated by experiments on the distortion of lath and india-rubber models.

The attention of Mr. Cyril Batho, assistant professor of applied mechanics at McGill University, was directed to this subject by the results of a few readings taken with a Howard gauge on the cover plates of a large riveted splice tested by Prof. H. M. Mackay, of McGill University, for the Quebec Bridge Commission. These appeared to indicate that the rivets in the end rows received by far the greater portion of the load, and suggested to Mr. Batho that the actual partition of the load in any joint could be determined by extensometer measurements on the cover plates of the joint. It was first necessary for him to determine whether or not the strains of the outer surfaces of the cover plates could be used to obtain the mean strains in the cover plates. This was shown to be the case by experiment, and further experiments were commenced upon a series of butt joints having a single line of rivets. While making these experiments it occurred to Mr. Batho that the results might be interpreted and the partition of load worked out theoretically by means of the Principle of Least Work. This proved to be so, and further experiments verified the theory in every particular.

The results of these experiments and the theories based upon them, or confirmed by them, are outlined in full in an admirable and exhaustive article by Mr. Batho which appears in the current number of the valuable journal of the Franklin Institute of Philadelphia.

The article is divided into two parts. Part I. shows how, by means of the Principle of Least Work, a series of equations may be obtained, giving the load carried by each rivet in any form of riveted joint in terms of a quantity K, which, if the rivets are in shear, depends upon the manner in which work is stored in the rivets; or, if they act by frictional hold on the plates, depends upon the work stored in the parts of the plates thus held. Part II. gives the results of a series of experiments upon different forms of joints having a single line of rivets and loaded in tension, which confirm and illustrate the theory and show how the quantity K may be determined.

(Continued on page 400.)

QUEBEC HARBOR IMPROVEMENTS.

By C. V. Johnson, A.M.Can.Soc.C.E.,
Consulting Engineer, Quebec, P.Q.

DURING the recent visit of the members of the Dominions Royal Commission to the city of Quebec, a very strong plea was made by J. G. Scott, president of the Board of Trade, for means to develop the possibilities of the magnificent harbor of which this city is so justly proud. Mr. Scott placed before the commission a full and clearly written report,

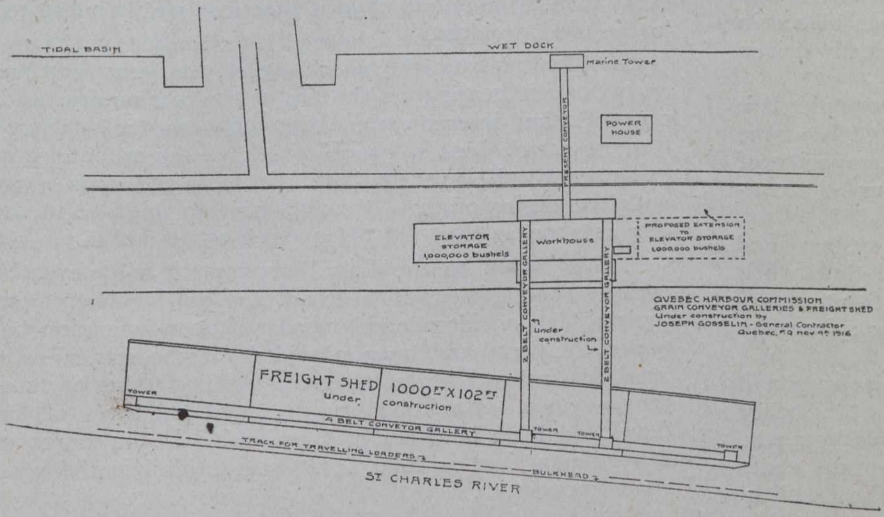


Fig. 1.—Plan of Quebec Harbor Grain Conveyer Galleries and Freight Shed Now Under Construction.

setting forth in no uncertain terms the advantages of using the port of Quebec as a summer terminus for the grain shipments on the National Transcontinental Railway. In this report it was shown that the Quebec harbor is capable of accommodating the largest vessels afloat for a period of seven months in the year, and has an abundance of deep-water frontage for the erection of docks, elevators, etc.

It must be conceded that Quebec is the natural outlet for the vast flow of grain from Western Canada, by reason of being the nearest Atlantic port by rail from the centre of the great grain-producing area, with the exception of the port of Montreal, which is not capable of accommodating the largest vessels. In addition to this, the port of Quebec is, in fact, the first at which the main line of the National Transcontinental Railway, that most recent and greatest artery of Canada, touches, and should, by reason of this fact, be excelled by none in facilities for the transfer of the country's output to the ocean-going vessels.

At the present time it would appear that the principal obstruction to the advancement of the port to the place it should occupy, is the large marine insurance rate as compared to that in force for the terminals situated on the coast, this probably being directly responsible for retarding the growth of the port.

It is not, however, the purpose of this article to discuss a matter which has already been placed before the proper authorities, and which it is to be hoped will be remedied in the near future. At the same time, it will be as well to point out to the engineers, contractors and others directly interested in the building up of the country, that the development of the Quebec harbor on a scale in keeping with its advantages, is not to be regarded as a matter of mere local interest, but is a national undertaking which will be of untold benefit to the country at large, as tending to keep Canadian shipments, both incoming and outgoing, where they rightfully belong—in Canada.

In spite of the many difficulties encountered there has been in the last few years, and still is, a considerable amount of work going on about the harbor in a quiet and unobtrusive manner; and although it is not on so large a scale as might be desired, it is nevertheless tending gradually toward the end in view.

Amongst the items of work undertaken and successfully carried out, may be mentioned the construction of a reinforced concrete elevator having a capacity of one million bushels, and the reclaiming from the St. Charles River of some twenty acres of ground by means of the construction of bulkheads, and filling with material dredged from the river bed.

In addition to this work there is now under construction a freight shed 1,000 feet long by 102 feet wide, and a very complete system of grain conveyers from the elevator to the new dock front on the northern extension of the Louise embankment. An illustration of these works is shown herewith. This system of grain handling is proposed to be further augmented by an addition to the present elevator storage of another million bushels in the near future.

The grain conveyers, a portion of which will be completed and in operation for the opening of navigation in the spring of 1917, are designed to transfer the grain direct from the elevators to the ocean-going vessels, instead of having recourse to the grain boat which is at present in use for the larger vessels. As the water at the mouth of the St. Charles River at this point is 35 feet in depth at low tide, the largest boats will be able to load

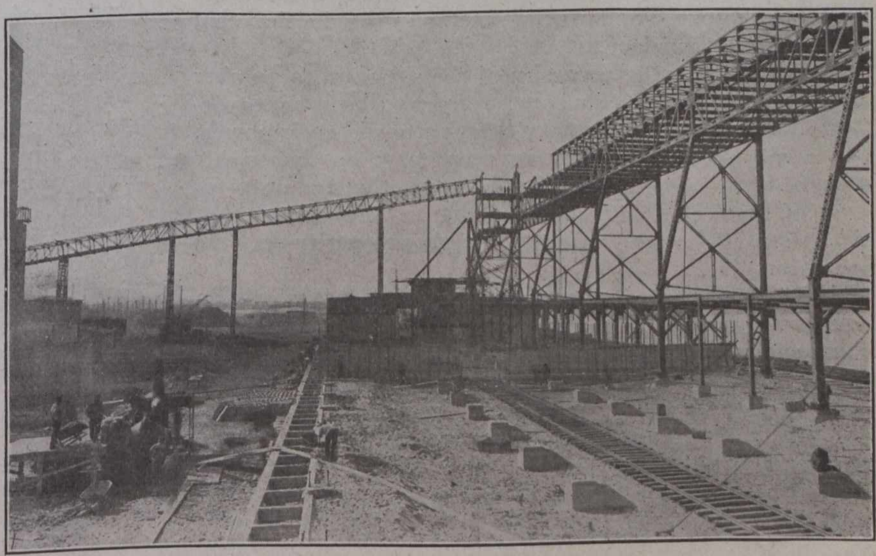


Fig. 2.—Portion of Freight Shed and Conveyer Galleries Under Construction.

direct from the elevators, while the large increase in storage capacity for miscellaneous freight will enable the handling of this material with much greater facility.

The conveyers themselves, consisting of four 36-inch rubber belts, will be electrically operated from the present power plant, the belts being driven by motors placed in the various towers, and the system being so designed that by means of movable trippers, the grain may be discharged to the loaders at various points throughout the length of the galleries.

Four travelling loaders will be constructed to travel on rails along the front of the galleries, thus allowing the loading of boats at any point desired without the necessity of moving the vessels after they have been placed in position. These travellers will also be electrically driven by means of an overhead trolley.

When the work at present under way is completed it will be possible to load two of the largest vessels at the same time, and with great rapidity, as the capacity of the conveyers is some 60,000 bushels per hour at a conservative estimate.

Further extensions to this conveyer system and freight storage will be made at some future time when conditions warrant, as the scheme allows of future development only limited by the amount of dock frontage available.

For the works completed, and those under way and in contemplation, great credit is due to St. George Boswell, chief engineer of the Harbor Commission, who has been indefatigable in his efforts to develop and equip the harbor, and to whom lies the credit for the excellent system described above. Mr. Boswell is ably assisted in these works by Messrs. Taylor and Fellows, assistant engineers.

GOOD ROADS NECESSARY FOR DEVELOPMENT*

By A. C. Emmett,
Secretary of the Manitoba Motor League.

GOOD roads are an economical necessity essential to all phases of our social and commercial intercourse and a prime factor in the development of the province.

Appreciating the necessity of the situation, a number of organizations have for some years past been endeavoring to foster the movement by every means in their power, but it will not be till public opinion has been thoroughly aroused to the advantages of good roads that the development of Manitoba will proceed along the broad lines that are essential to the progress and prosperity of the province.

The success of the good roads movement depends on educating the public to its many great advantages and convincing them that every dollar wisely and efficiently spent for this purpose is an investment that will pay an interest that cannot be computed in dollars and cents.

The value of good roads to the agricultural community is just as great as it is to the dwellers in the towns and cities. To the farmer it means a greatly lessened cost of transportation and the ability to market his crop at any time. Under present conditions he is dependent to a very great extent on the weather, as with continued rain the roads become practically impassable and the whole business of the farm comes to a standstill. With a good road, weather which puts a stop to work on the land will not prevent his reaching town and taking care of work in the direction of the purchase of supplies that would otherwise require time when the land can be worked and every minute is of advantage in preparing or harvesting the crop.

Good roads also have a direct bearing on the high cost of living in regard to which we have seen so many discussions in the columns of the public press. In countries where good roads are the rule and not the exception, the average cost of hauling per ton-mile is 8 to 12 cents, whereas in this province it is not a cent less than 25 cents per ton-mile, so that it will readily be seen what a tribute we pay to a poor road. A reduction in the cost of transportation means a reduced cost of living, and every man, woman and child is therefore vitally interested in the road problem.

Looked at from the social aspect, the poor road has an important bearing on the life of the community, as it prevents that intercommunication between the scattered farmers which does so much to relieve the monotony of existence to the average farmer's wife and does away with the desire of the boys and girls to migrate to the city as soon as they are old enough to do so.

The "Back to the Land" movement will never be entirely successful until the road question has been more thoroughly considered and means of communication between the farm and town provided for the settlers who are being asked to take up farms in the various parts of the province. Manitoba has thousands of acres of undeveloped farm land and will be behind in the march of development just as long as it stays behind in the good roads movement.

The present road system is not in the best interests of the people, and no work of a good and permanent character will be done until the system is changed. This can only be brought about by the division of the roads of the country into three classes, *viz.*, the Dominion, Provincial and Municipal highways. With the first class of road, only the Dominion government should be concerned, and they should consist of the leading highways east and west and north and south. The cost should be borne from the consolidated revenues of the Dominion and the work of construction and maintenance placed under the control of the Dominion engineers. The second class of road, which would be known as Provincial Highways, should consist of the roads which, while not being classed as inter-provincial roads, would yet be of direct benefit to the entire province and should be constructed and maintained under the supervision of the provincial highway commissioner, the cost being borne from the consolidated revenue of the province. The third class of road would be known as the Municipal road and would consist of the market roads running between and connecting the main travel routes. These should be the only ones placed under the control of the municipal councils and paid for out of the local taxation revenue.

With this system in force a great deal of the wasted effort and expense would be eliminated and the entire Dominion would benefit from the development which would follow the adoption of a policy of this nature.

*From Manitoba Free Press.

Maximilian Groten, mechanical engineer of the Imperial Russian Railways, last week told the members of the American Road Builders' Association, at their annual meeting, that there is great lack of means of communication in Russia, as only about 40,000 miles of highways exist in the entire huge empire. Mr. Groten spoke of the wealth of Russia in the soil, but stated that the absence of a proper system of highways interferes seriously with its development. He wished to enlist the interest of British and American engineers and capital in Russian highway construction.

LETTER TO THE EDITOR.

The Design of Steel Stacks.

Sir,—Referring to an article by Mr. W. A. Hitchcock, instructor in engineering mathematics in the University of Colorado, published in your issue of September 28th, the results as given seem very misleading.

The loads and working stresses are those usually used in structural design, except the unit compression stress, 16,000 lbs. per square inch. However, since the unit tension stress is limited to 16,000 lbs. per square inch and this is on the *net* section at a circumferential splice, the maximum compression is not more than about 11,000 lbs per square inch, (this being based on an efficiency of 69 per cent.) which is quite reasonable.

The equations given under the heading "Minimum Thickness of Plates" are evolved from those usually used in the design of Stacks, the equations being simplified by the elimination of all unknowns but two, by neglecting some and expressing others accurately, or approximately in terms of the remaining two. The errors introduced by these approximations are relatively small and the result as given in the curves is in a very convenient form for use. However, since the diameter of the stack is not always constant the value of S^1 which the author gives as

$$S^1 = 0.053\,\frac{PH^2}{D} \qquad (4)$$

is more conveniently expressed

$$S^1 = .106\,\frac{M}{D^2} \qquad (4a)$$

In which S^1 = minimum stress in pounds per lineal inch along circumference.

M = overturning moment in ft.-lbs.

D = diameter of stack in feet at the section being considered.

The value of S^1, as given in equation (4a) clearly demonstrates that the stress per lineal inch along the circumference of the stack varies inversely as the *square of the diameter* and not inversely as the *diameter*, as would appear from a casual glance at equation (4). That the form given by the author in equation (4) invites this wrong conclusion is made evident by the fact that he himself has twice fallen into error, *viz.*, in equations (40) and (44) when deriving formulæ for the size of anchor bolts and the riveting in the anchor angle. Under the heading "Minimum Size of Foundation," the author discusses the subject and evolves his equations by what he apparently considers two methods. The first of these methods is theoretically sound and except for the approximations which he mentions, the results are correct. In his second solution he falls into serious error. The first solution rightly assumes that for the minimum size of foundation the resultant pressure on the foundation is at the leeward edge of the kern or $\frac{D}{8}$ from the centre.

Since the structure is in equilibrium the centre of gravity of the supporting upward pressure of the soil is this same distance, $\frac{D}{8}$, from the centre, and is on a straight line, at right angles to the direction of the wind, *i.e.*, the structure would be in equilibrium if supported on this line. Clearly, then, to calculate the maximum resisting moment of the foundation, moments must be taken about an axis $\frac{D}{8}$ from the centre and, expressed as a fraction, this resisting moment equals $W_t \times \frac{D}{8}$. But the author, continuing after equation (18), says: "Taking moments about an axis tangent to the leeward side of the foundation, and neglecting the resisting moment due to W_0 and W_1 as small compared with equation (17), the resisting moment is $M = W_t \times \frac{D}{2}$." This is decidedly at variance with the result just derived from the first solution, and clearly indicates the first error in this second solution.

The next sentence, regarding a "safety factor," is hardly reasonable enough to invite comment. The author is, apparently, endeavoring to make the result for the second solution correspond to the first solution and introduces this ludicrous statement to cover the error already mentioned. His conclusion, after equation (22), that a "safety factor" of approximately 2¼ gives identical results with the first solution, has not even the justification of arithmetical accuracy. To obtain the same result as the first solution a "safety factor" of 4 must be introduced, which is what one would expect since the moment of resistance is calculated in this second solution on a moment arm $\frac{D}{2}$ instead of $\frac{D}{8}$. The second solution, then, is not a different solution from the first, but rather the same one incorrectly applied.

In both the first and second solutions under the heading "Minimum Size of Anchor Bolts," the author has fallen into error similar to that referred to above in the second solution for minimum size of foundation, *i.e.*, he has calculated the moment of resistance about the wrong axis. In the first solution the moment of resistance is taken about the centre of the stack, which would be correct only if the total pressure on the foundation, which balances the pull of the anchors, were concentrated on a line, at right angles to the wind pressure, passing through the axis of the pipe. In the second solution the moment is taken about the leeward edge of the pipe, which assumes the pressure on the foundation, due to overturning, concentrated at a point on the edge of the pipe. Clearly these assumptions are both wrong. What would be reasonable to expect is that each bolt-pull is balanced by a pressure the centre of which is an equal distance on the other side of the centre line of the bolt circle. Then the moment of resistance of the anchors is $t\Sigma X^2$, where X is *twice* the distance of the bolt from the centre line in feet and t is the stress on a bolt for which $X = 1$ foot. For the case considered in equation (24), *i.e.*, 12 bolts in the circle,

$$M = t\Sigma X^2 = t\left[\left(2\,\frac{B}{2}\sin 30^\circ\right)^2 \times 2 + \left(2\,\frac{B}{2}\sin 60^\circ\right)^2 \times 2 + B^2\right] = 3\,B^2 t$$

but $M = \frac{1}{2}\,PDH^2$ (25) and $t = \frac{M}{\Sigma X^2}$

$$\text{Therefore, } t = \frac{PDH^2}{6B^2} \qquad (26a)$$

The stress in bolt 3, which is the maximum stress in the group of bolts, is $t \times B$, and is therefore equal to

$$\frac{PDH^2}{6B} \qquad (27a)$$

If unit stress in a bolt = f lbs. per square inch

$$0.7854 \times f \times b^2 = \frac{PDH^2}{6B} \qquad (28a)$$

Solving for b

$$b = .46\,H\left(\frac{PD}{fB}\right)^{\frac{1}{2}} \qquad (29a)$$

Equation (29) was incorrectly derived from (28) in the original. Correctly calculated from (28) it should have read $b = .652\,H\left(\frac{PD}{fB}\right)^{\frac{1}{2}}$

For the general case of n (number of) bolts,

$$\Sigma X^2 = \frac{nB^2}{4}$$

Stresses in outermost bolt $= t \times B = \frac{M}{\Sigma X^2} B = \frac{2PDH^2}{nB}$

Then, equating actual to allowable stresses as before

$$0.7854 \times f \times b^2 = \frac{2PDH^2}{nB}$$

from which

$$b = 1.595 H \left(\frac{PD}{nfB}\right)^{\frac{1}{2}} \qquad (31a)$$

If the third solution had been correctly applied the same equation as (31a) would have been derived, as follows:—

$$S^1 = .053 \frac{PH^2}{D} \cdot\cdot \quad (4) \qquad S^1 = .106 \frac{M}{D^2} \cdot\cdot \quad (4a)$$

Here S^1 is *maximum* stress per lineal inch *on circumference of pipe*. The author's statement that the stress in the *outermost* anchor $= S^1p$, is true only when S^1 is the stress per lineal inch *on anchor bolt circle*.

From (4a) we have for the general case (where B is not equal to D)

Stress in outermost anchor $= .106 \frac{M}{B^2} \times p$.

or, equating allowable to actual stress;

$$.7854 \times f \times b^2 = .106 \frac{M}{B^2} \times p.$$

Now, $M = \frac{PDH^2}{2}$ and $p = \frac{12 \pi B}{n}$

Substituting, we have $b = 1.595 H \left(\frac{PD}{Bnf}\right)^{\frac{1}{2}}$ (41a)

which is the same result as obtained in equation (31a) above.

The author states that the assumptions made in his solutions (1) and (3) give the same results if $D = B$. There are two reasons why this does not follow from the original article, *viz.*, (a) through the error in equation (41) due to the form of equation (4) and referred to above, neither B nor D occurs in the results obtained from solution (3), *i.e.*, in equations (41), (42) or (43).

(b) The coefficient in equation (31), obtained from solution (1), is different from the one in equation (41) solution (3). However, as we have shown, solutions resembling (1) and (3) do, when based on correct assumptions, accurately applied, give the same results for *all* cases.

Continuing from (31a) or (41a) we can get the value of b.

Using $f = 15{,}000$ and $P = 20$

$$b = 1.595 H \left(\frac{20 D}{15{,}000 nB}\right)^{\frac{1}{2}}$$

$$= .0582 H \left(\frac{D}{nB}\right)^{\frac{1}{2}} \quad (32a), (38a) \text{ or } (43a)$$

The author's conclusion that *his* results from solutions (1) and (3) were too high and results from solution (2) were too low is quite true, even though the evidence for his conclusion does not appear in his article.

With regard to riveting, the author has omitted to mention a very important point, *viz.*, that the joints should be designed primarily to develop the stress S^1 per lineal inch. The author's contention that his recommended rivet spacing and joints will give ample strength in any section will not hold true in *critical* cases.

In equation (44) the author retains the error of equation (41) due, as we have stated, to the form of equation (4).

Correctly derived from equation (4) or (4a) this equation should read

$$S^1 = .053 \frac{PH^2D}{B_1^2} \text{ or } = .106 \frac{M}{B_1^2} \qquad (44a)$$

in which B_1 is the diameter of the shell where it connects to the base plate.

In concluding, it seems that beyond expressing the results of equations (9), (10) and (15) in curves the author has presented nothing new, except the unusual conclusions due to the above-mentioned errors.

H. M. WHITE,
Designing Office,
Dominion Bridge Co., Ltd., Montreal.

Montreal, November 7th, 1916.

INCREASING TANK CAR EFFICIENCY.

THE application of heat is necessary in unloading a tank car of asphalt. It takes a few hours to raise a full head of steam in the coils and to begin to affect the solidity of the asphaltic material. In fact, approximately 24 hours generally has been found necessary to unload the average tank car in severe weather. Any reduction of this time tends to greater efficiency, as it might save demurrage, and would certainly reduce the expense of fuel and attendants.

A portable cover has been invented by a well-known manufacturing concern, for the purpose of reducing the amount of heat lost by radiation while heating the tank. By the use of this cover it has been found that the time of unloading a car in severe weather is reduced about one-half. The cover is in blanket form and is equipped with lashing ropes and grommets for the purpose of making it fast to the running board, and also with grommets and lacing rope so that the sections may be laced together, avoiding the possibility of the cover being blown away by the wind.

Insulating Cover Partly in Place on Asphalt Tank Car. This New Cover Reduces Time of Unloading the Car.

The stitching in both directions makes it impossible for the asbestos insulating material to wad in the canvas. The manufacturers use 8-oz. canvas next to the shell of the tank, and 7-oz. canvas, paraffin treated, on the outside. The covers are being manufactured for 6,500, 8,000 and 10,000-gallon tank cars. The present price of the 6,500-gallon cover is about $260, and of the 8,000-gallon cover, about $300, f.o.b. New York. The accompanying illustration shows one section of the cover in place on a tank car.

PHOTOGRAMMETRY FOR TAKING TOPOGRAPHY OF WATERSHED.

By Douglas H. Nelles, D.L.S., M.Can.Soc.C.E.
Geodetic Survey of Canada.

[NOTE.—Readers of *The Canadian Engineer* will remember Mr. Nelles as the author of the valuable article on "Mapping of Canadian Cities," which he wrote for our issues of January 6th and 13th, 1916. The following article was prepared by Mr. Nelles for "Engineering News" of New York.—Editor.]

PHOTOGRAMMETRY, on this continent at least, has been made use of principally by governments where large areas were to be mapped in rough, rugged, mountainous regions. In Canada 22,750 square miles has been mapped by this method; and if to this is added the 31,000 square miles mapped by the Canadian International Boundary Commission in Alaska, it makes the total of approximately 53,750 square miles to date.

The recent use of photogrammetry for mapping 163 square miles of the Thirty-one Mile Lake watershed, Quebec, was, however, of an entirely different nature. This presented a mass of irregular, bush-covered hills from 500 to 1,000 ft. high. Running through the centre of the watershed are two main lakes, Thirty-one Mile and Pemichangan, and in between the hills on either side are 101 small lakes.

The Geodetic Survey of Canada had two primary triangulation stations established in this vicinity, one in the centre of the watershed and one on the outside of the southern edge, from which a secondary triangulation was thrown over the watershed, comprising 24 stations. Ten of these stations were in the southern portion of the watershed, containing 93 square miles.

To these 10 stations were tied 83 photo-topographic stations, and from each station was taken a set of photographs forming a panorama of the country that could be seen from each station. Plotting from photographs taken during the summer was not a success, as enough points could not be identified to control the topography. Another set of photographs was therefore taken during February, from which very successful results were obtained.

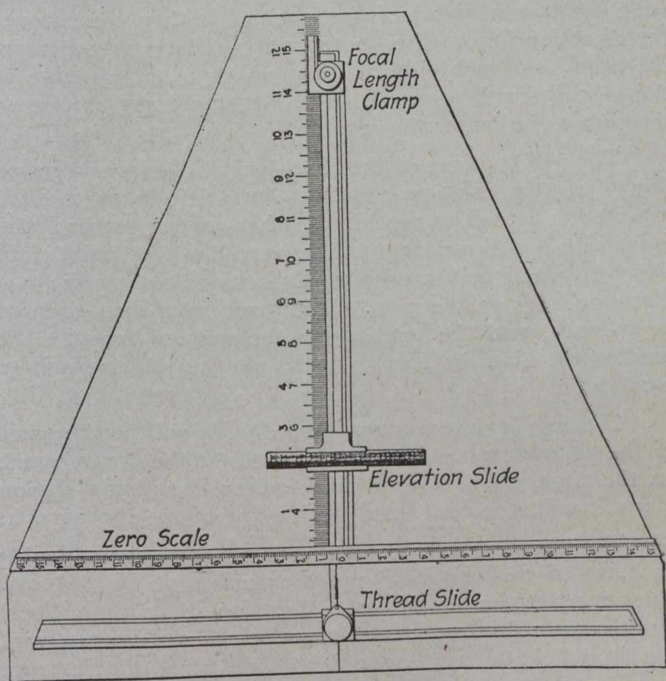
All the lake outlines, creeks, farms and clearings were surveyed by plane table, and the roads by transit and stadia. All these detail surveys were tied to the triangulation and camera stations. The rest of the topography was filled in from the photographs.

Office Work and Methods.—The office routine consisted of computing the positions of stations; drawing a polyconic projection on the scale chosen; plotting triangulation and camera stations; transferring and adjusting the plane-table topography to the map; drawing the horizon and direction lines upon the photographs; identifying and marking direction points; choosing and marking topographic control points on photographs; plotting the photograph traces on the map, as explained later; plotting control points; determining their elevations and finally sketching in contours and other detail.

The ordinary methods of plotting from photographs are generally known and will not be described. In this work a special machine, shown in the accompanying illustration, was used entirely for taking out elevations. The credit for the original idea of determining elevations by the method to be described is due to W. H. Boyd, chief topographer of the Canadian Geological Survey. The machine designed by the writer and made in the Dominion Observatory machine shop, besides giving elevations, measures the focal length of a photograph and plots the photograph trace on the map.

The focal-length clamp has a double action. The larger screw clamps the scale in position. Inside of this screw is a smaller one with a fine steel point on its lower end. The smaller screw serves the purpose of lifting the needle point so that it will not touch the paper when the machine is being used for determining elevations. This point is inserted at the station point when the machine is being used to plot photograph traces or to determine focal lengths.

The focal-length clamp has a vernier with two zeros, one at the forward edge, from which the thread swings, and one opposite the centre of the needle point. The vernier reads to 0.01 in. In the centre of the forward edge of the focal-length clamp is a small hole in which a



Simple Device for Plotting Topography from Photographs.

fine silk thread is fastened by a wooden plug. The other end of this thread is attached to a spring that serves the purpose of keeping it taut. The spring is attached to a ring placed around the screw of the thread slide. The thread-slide clamp is kept tight enough so that the slide will stay at any position.

Use of Plotting Machine.—To determine an elevation: Set the focal-length clamp at the focal length of the photograph, using the line of the zero scale as zero (see illustration). Set the altitude scale of the elevation slide so that the part of it opposite the centre mark of the slide will read the altitude of the station plus the height of the camera. Now measure the distance between the control point and the photograph trace and make the distance between the elevation slide (on the focal-length scale) and the zero scale equal to it. Measure the distance of the control point above or below the horizon line and set this distance off on the zero scale above or below the zero. Move the thread to cut the point so obtained, and the thread will also cut the altitude scale of the elevation slide at the elevation of the station.

When working on small scales and in a region of high altitudes such as the Rocky Mountains, points are very often plotted at a distance of from 5 to 15 miles from the station. This would only be done when nearing the limits of the country controlled by the survey, and in these cases it becomes necessary to take into consideration the correction of curvature and refraction, which is 14.4 ft. for 5 miles, 57.4 for 10 miles and 129.1 for 15 miles. This is done by computing and plotting a curvature and refraction scale for the particular scale of the map, and so placing it on the machine that the forward edge of the elevation slide will cut it at the proper point each time that it is set. Then to get the true elevation of the control point, the curvature and refraction reading is mentally added to the thread reading.

To determine the focal length of a photograph with the machine, a photograph is selected that has two well-defined points in it, to which instrumental directions have been read from the camera station. These two directions are plotted on the plan. The centre mark of the forward edge (bottom in view) of the machine is then placed over the direction line of the photograph; and the distances of the points on each side of it are marked on the edge of the machine with a pencil. The larger the angle between the points the better the results.

The needle point of the focal-length clamp is screwed down at the station and the clamp left loose to slide longitudinally. The machine is then swung around and moved up and down about the clamped needle point until the two pencil points on the edge coincide with the two direction lines on the plan. The machine is then oriented in azimuth, and the reading on the vernier opposite the needle will give the focal length of the photograph to 0.01 in.

If a line is drawn along the edge, it will be the trace of the photograph. If a dot is made at the centre mark on the edge and a line drawn between it and the station mark, it will represent the direction line of the photograph.

The photographs were generally enlargements, double the size of the original, and measuring 12 by 8½ ins. They were all made the same size, so that their focal lengths were the same; but before being used for plotting, the focal length was checked by measuring the distance between the cone marks that control the location of the horizon and direction lines. All recent surveying cameras have marks placed at a distance apart equal to the focal length, which are photographed upon the negative so that the focal length of any photographic print or enlargement can be measured directly.

Photographic Surveying with an Ordinary Kodak.—It so happened that a map being plotted under the direction of the writer was found to have what is officially termed "a hole in it"; that is to say, there was a small valley which could not be plotted for lack of photographs. It was known that the valley contained a small lake that had not been surveyed by plane table, so that it was necessary to get accurate information.

An officer of the survey could not be sent to the locality to get the required photographs, so it was decided to ask the superintendent of a fish and game club who lived near the valley to take the photographs for the survey. He understood how to use a kodak, but not a surveying camera, so a No. 4 Eastman kodak was sent to him with a map showing the hills surrounding the valley and the two places from which the photographs were to be taken, together with minute directions for exposure, etc.

In order to use these photographs it was necessary to locate from them the position on the map of the two places from which they were taken and the position of their traces on the map. To do this, a photograph trace was drawn upon a piece of tracing cloth. This was taken to represent the trace of the photograph on the right side of the panorama from one station. The trace of the photograph next to it was then plotted in its proper position by making use of a common object in the overlap of the photographs, and the other three traces plotted in the same way. There were eight known points shown in the different photographs which had been plotted on the map from other sources. Direction lines were drawn through these points on the tracing cloth, which was then placed on the map and the position of the station located by the three-point problem, or in this case, an eight-point problem, that is, a position was found for the tracing cloth so that every direction line cut through its respective point on the map. When this position was found, the position of the station point was pricked through on the map and also positions of the photograph traces.

VANCOUVER HARBOR AND ITS IMPROVEMENTS*

By C. E. Cartwright, M.Can.Soc.C.E.,
Consulting Engineer, Vancouver.

THE city of Vancouver possesses one of the finest natural harbors in the world, which with proper development can be made to handle an enormous traffic. This traffic will certainly come if proper organization, and facilities, are provided.

Mr. N. Thompson, chairman of the Vancouver Board of Trade, writing on "Vancouver as a Railway and Shipping Terminal," in The Vancouver World of October 25 last, quotes approvingly an eminent writer in the London Statist as stating that in the next ten years the value of Canada's productions of all kinds will show a three-fold increase, and believes that the war will delay this result for a very short time, and in the end may probably hasten instead of retarding the progress.

Reasons for Development.—There are many reasons for expecting a more rapid increase for Vancouver than for Canada as a whole. Within the last year have been completed two lines of railway tributary to this port, *viz.*, the Canadian Northern and the Kettle Valley. The first, with its extremely easy grade, should become a large factor in grain shipments from Alberta and Saskatchewan, and open a larger market for our timber, fish and other products. The second gives Vancouver a direct connection with the Boundary and Kootenay mining districts, and with the Okanagan fruit-growing district.

Within a few months the Pacific Great Eastern Railway will be in operation from Howe Sound to Fort George, making accessible the Cariboo district which is capable of great development both in agriculture and mining. Within a few years this railway will no doubt be continued northward into the Peace River country, "The Last Great West," where there are 60,000,000 acres of excellent wheat-growing land. These railways and also the Great Northern and Chicago, Milwaukee and St. Paul will require additional facilities to be provided for ocean-going commerce and local industries as well as that necessary for the growth of our old friend, the Canadian Pacific Railway. There is also the rapid develop-

*From the Vancouver World.

ment of our coastwise shipping and lumbering, mining and fishing generally.

Is Public Enterprise.—If these private interests are left to provide their own terminal facilities it will mean a vast expenditure and duplication of works that will have to be repaid by the people in higher freight or terminal charges, and a sacrifice of the industrial interests to the commercial interests of the port. To prevent this conflict and arrange for the development of the port on proper and economical lines requires organization. Hence the need of a harbor commission.

In planning for the future the existing conditions have to be considered as well as the future. In the case of Vancouver we have a good natural harbor to start with, the fact that nearly all the waterfront is privately owned, and a large portion of the development due to the Canadian Pacific Railway.

In the past the interests of the Canadian Pacific Railway and the city have been in a great measure identical but in the future there will be several other large corporations to be provided for as well as the industrial functions of the harbor.

Two Main Functions.—A harbor such as Vancouver has two main functions to perform, industrial and commercial. An industrial harbor best serves its purpose when it extends far inland and spreads out over a large area of the city, enabling ships and railways to reach many widely scattered factories bringing cargoes of raw material and fuel and carrying away their finished products. The industrial functions deal mainly with local industries and distribution and it is this function that especially serves the interest of the city.

The commercial function, on the other hand, deals mainly through freight coming down or going into the interior and merely passing between rail and water carrier.

In general, good harbor organization would place the through freight terminals at relatively outlying parts of the harbor. The passenger traffic should be as central as possible. In Vancouver the Canadian Pacific Railway wharves and railway stations are admirably located for passenger traffic—the south shore of Burrard Inlet affords many excellent sites for industries, with rail and deep-water facilities.

Ideal Sites Available.—False Creek provides sites for industries with rail and light draft water navigation. Up to the present these facilities have been nearly equal to the requirements but in the near future further sites will be required for industries as well as for deep-water terminals for railways. The present sites on Burrard Inlet are more limited than generally supposed. In many places the deep-water channel is too close to the railway to permit of suitable wharves, and the land rises abruptly on the land side of the railway.

Where are these sites best obtained?

A considerable area can be obtained at Port Moody by reclamation, which will be an admirable site for grain elevators and the Heaps' mill property at Cedar Cove, permits of land being reclaimed for industrial sites. Next there is the north shore of the Inlet which at present lacks railway connection. This can be made available for full use by railway tracks connected with a belt line railway on south side by car ferry.

North Shore Sites.—There is a considerable area of suitable sites for large industries adjacent to North Vancouver and extending east to the North Arm of the Inlet. In the past there is no doubt that several industries have been prevented from locating on Burrard Inlet by the high price asked for water front property and if the harbor commission provides railway and harbor facilities without any control on the price of water front, the city will fail to secure its full share of these industries in the future, as in the past.

It is, therefore, a matter of necessity that the commissioners should have possession of water front that can be leased at a sufficient price to pay reasonable interest on the cost. It is easy to understand that an industry may often be deterred by having to add $100,000 to its capital for land purchase that would not feel a rental of $6,000 per annum. By a selection of property that can be extended by reclaiming, the price per acre can often be considerably decreased. The property proposed to be purchased by the harbor commissioners is generally the most suitable for this purpose and should be obtainable at the present time at a less cost than at any future time. The water front that can be made available on Burrard Inlet is not sufficient to provide both the freight terminals and industrial sites that will be required in the next few years, especially as the freight terminals require to be directly connected with the railways by which they will be used, and some other site has to be sought. The harbor commissioners have decided upon the Kitsilano Reserve site. Mr. Nichol Thompson is in favor of a site further west with a breakwater at Spanish Bank with a railway along the North Arm of the Fraser around Point Grey from New Westminster.

Favors Kitsilano Site.—Against the Spanish Bank scheme can be put its enormous cost. The breakwater to be efficient would have to extend into very deep water, about 150 feet, and would cost enough without wharves to provide extensive docks at the Kitsilano site and it does not fulfill the requirements for extension of Vancouver harbor unless railways were extended direct from Vancouver. If it is not directly connected with Vancouver's railways why build the railway around Point Grey? A harbor on Lulu Island would serve Vancouver equally well. The objections made to the Kitsilano site are not well founded. The breakwater required will be moderate in cost as the depth of water would not exceed 40 or 50 feet. The wharves can be placed far enough out to avoid rock dredging and land behind reclaimed to provide room for trackage. The Kitsilano site is very centrally situated as regards Vancouver, can be easily connected with a belt line railway and can be designed so that when in future the growth of business warrants an extension westwards or the harbor requires the proposed breakwater at Spanish Bank, the breakwater at Kitsilano can be utilized as part of the wharf construction and no expenditure wasted. The Kitsilano site possesses the further advantage of being capable of extension after the first unit is constructed as required until some six miles of wharf face are provided.

A belt line railway connection between water and connecting railways and, as far as possible, the local industries, is an essential to a properly equipped harbor and it is very desirable that this belt railway should be independent of any of the connecting railways. With freight terminals and industrial sites at Kitsilano it becomes almost a necessity that such a railway should be operated by the harbor commissioners.

Space for Double Tracks.—The route proposed for the belt railway is at present to a great extent occupied by railway spurs owned by the Canadian Pacific Railway and Great Northern Railway. As these spurs are utilized to reach industries and not as direct dividend payers it should be possible to make reasonable arrangements for use of the right-of-way for a double track. Some additional right-of-way will be required and adjustments of adjoining buildings will be necessary. The cost will be considerable but it will be less now than in the future. An essential part of a belt railway will be a car ferry service on Burrard Inlet connecting with tracks on the north shore. The route proposed for the belt railway is the only practicable one by which the railways terminating in Vancouver and vicinity can be connected with each other, with water terminals and industrial sites. The railway is a necessity for the proper development of the harbor; the land proposed to be acquired on Burrard Inlet at Port Moody and Heaps' Mill is the best available land for development into industrial sites for leasing on reasonable terms; water front is required in the vicinity of the point where the belt railway meets Burrard Inlet for transfer purposes and car ferry and the Kitsilano site is the best available point for extension of the harbor at economical cost for use in the near future.

Growth Will Be Large.—The cost of the lands, railways and wharves proposed will be considerable, but will probably at the present time be less than estimated for in future years and any less comprehensive plans would probably be quite ineffective and a very much larger scheme such as the Point Grey breakwater would involve a larger expenditure than could be incurred at this time and cause a serious delay. The growth of the business of Vancouver harbor in the next few years will undoubtedly be very great and long before the proposed works are fully completed the revenue from the leases of completed portions should pay interest on the capital required and on completion provide a surplus for use in extensions as required and by the time the harbor has outgrown the plans outlined, the financing of extensions towards Point Grey should be comparatively easy. If these works are not carried out there is little doubt that industries will go elsewhere—where sites can be obtained cheaper and that industries now here will lose business they would otherwise obtain. By beginning now on the plans outlined we will ultimately see Vancouver one of the best equipped harbors in America, as it ought to be by reason of the excellent natural harbor it has to commence with, and by reason of the good equipment, one of the busiest.

PARTITION OF LOAD IN RIVETED JOINTS.

(Continued from page 392.)

"It is felt," says Mr. Batho, "that much of the usefulness of the theory given depends upon whether the rivets in a joint are in shear or whether they act by holding the plates together by friction. The later experiments on the slip of rivets seem to show that at working loads the latter is the case, and the results of the experiments described in the present paper seem to bear this out. The writer has in hand experiments which he hopes will give definite information on the subject."

The following is a resumé of the principal contents of Mr. Batho's article, as summarized by him:—

1. It is shown that a riveted joint may be considered as a statically indeterminate structure, and that a series of equations may be obtained for any joint by means of the Principle of Least Work, giving the loads carried by each of the rivets in terms of a quantity K, which depends upon the manner in which work is stored in, or by the action of, the rivets.

2. This theory is applied to various types of joints, and the modifying effects of non-uniform distribution of stress in the plates, unequal partition of the load between the two cover plates, and a difference in the modulus of elasticity of the middle plate and the cover plates are also considered.

3. It is shown experimentally that extensometer measurements on the outer surfaces of the cover plates of a riveted joint are sufficient for the determination of the mean stresses in the plates, and that the partition of the load among the rivets may be determined from such measurements. It is also shown that, at any rate after the first few loadings, the distribution of strain in the plates of a joint is not altered by repeated loadings.

4. It appears that if there is any frictional hold between the plates, it acts only over those portions in the immediate neighborhood of the rivets. All the experiments tend to show that friction does not play an important part, but further experiments are necessary on this point.

5. Experiments made on a number of specimens having a single line of rivets and loaded in tension give results in close agreement with the theoretical considerations. They also show that the longitudinal stresses in a portion of the cover plate between two consecutive rivets are a minimum along the line of rivets, rising to a maximum at the edges of the plates.

6. The experiments show that the value of K for a joint having a given ratio of width of cover plate to rivet pitch and a given number of rivets varies approximately directly as the load and inversely as the area of the rivets. An empirical rule is given for its value in joints similar to the experimental specimens, but a more general rule cannot be given until further experiments have been made. A theoretical estimate is made of the value of K for a rivet acting in shear, and the result is shown to be within the range of the experimental values.

7. Both the experimental results and the theoretical deductions show that:—

(*a*) In a double-cover butt joint having a single line* of rivets, the two end rivets and the two rivets on each side of the junction of the middle plates take by far the greater part of the load at all loads within that, causing permanent deformation of the plates or rivets, the actual proportion decreasing slowly as the load increases;

(*b*) If, in such joints, the total area of cross-section of the cover plates is equal to that of the middle plates, these four rivets take equal loads, but if it is greater the end rivets take greater loads than the others, the difference increasing as the area of the cross-section of the cover plates increases;

(*c*) If two plates of uniform width and equal thickness are connected by a single line of rivets to opposite sides of a gusset plate of uniform width, the first and last rivets take the greater part of the load, but if the gusset plate increases in width from the first to the last rivets, the partition of load is more uniform.

The results already obtained allow the general manner of partition of load in any riveted joint, in which there is no eccentricity of connection, to be estimated, and it is hoped that, when further experiments have given general laws for the value of K, it will be possible to predetermine the exact load that will be carried by each rivet. The practical value of this is obvious.

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*By "line of rivets," meaning a number of rivets arranged in a straight line parallel to the axis of load, as distinctive from a "row of rivets," meaning a number of rivets arranged in a straight line perpendicular to the axis of load.

WINNIPEG-SHOAL LAKE AQUEDUCT CONSTRUCTION

LOCATION, DESIGN, CONSTRUCTION METHODS AND FEATURES OF THE $13,000,000 GRAVITY PIPE LINE THAT WILL SUPPLY GREATER WINNIPEG WATER DISTRICT WITH OVER EIGHTY MILLION GALLONS DAILY.

IF all contracts are completed according to schedule, one-half of the Shoal Lake-Winnipeg aqueduct will be completed by the end of this month. By December 1st, 1917, eighty-five per cent. of the aqueduct must be finished, and it is expected that the whole work will be done by September 1st, 1918.

The progress of the work during the 1915 season was described and illustrated in *The Canadian Engineer* October 21st, 1915, issue, but the accompanying later photographs are of additional interest.

On account of the criticisms that have been made from time to time in Winnipeg regarding the design of the aqueduct, the following description of location, preliminary design, special features, etc., which has been abstracted from a paper presented to the Canadian Society of Civil Engineers by W. G. Chace, the chief engineer of the aqueduct, and D. L. McLean, assistant to the chief engineer, are of particular interest:—

Location of the Aqueduct Line.—The engineering force for the carrying out of the work was organized in the late fall of 1913, and work in the field and office was actively pushed forward to establish the final line. Five field parties were sent out on location for the purpose of obtaining a line with a continuous down-grade as near the average slope as possible between Shoal Lake and Winnipeg. It may be stated here that a line was secured in which more than 36 per cent. was practically on the average slope, while the actual increase in the length of the line over a direct air line is only 8 per cent. The difference in elevation between Indian Bay and the surface of the water in McPhillips Street reservoirs is 293 feet, and the length of the line 97 miles approximately—so that the average slope is 0.57 feet per 1,000 feet of length.

The comparative flatness of this slope and the necessity for holding the line as near to the average slope as possible rendered it extremely important to have even the preliminary field work carried out in an accurate manner. For this reason one field party was sent out with instructions to establish a line of precise level bench marks, which bench marks were located, as a rule, on the north and south provincial range and section lines at or near the intersections with the preliminary location. The other field parties then ran lines of levels along the north and south section lines, by means of which the general slopes of the country were quickly established. Contours plotted from these results showed that the country has a very gentle drop towards the northwest. When this mass of data was sent in to head office several trial lines were laid down and the field parties were instructed to run them out. At the same time cost curves were made up in head office showing the variation in the cost of the aqueduct structures at varying depths of excavation, and for varying sizes of aqueduct, the slopes ranging from one-tenth of a foot per thousand feet to one and one-half feet per thousand feet. By this means the separate field parties were then enabled to adjust the various lines to a minimum cost, taking into account all the varying items affecting such cost, such as the depth of cut, slope and length. Owing to the unsettled nature of the country the camps were practically isolated as communication had to be made by means of runners and supplies packed in on the backs of porters or by canoe up the Brokenhead and Whitemouth Rivers.

Owing to the flatness of the surface of the country the rain water does not drain off, and on account of the impervious subsoil, which consists of a sandy clay, large

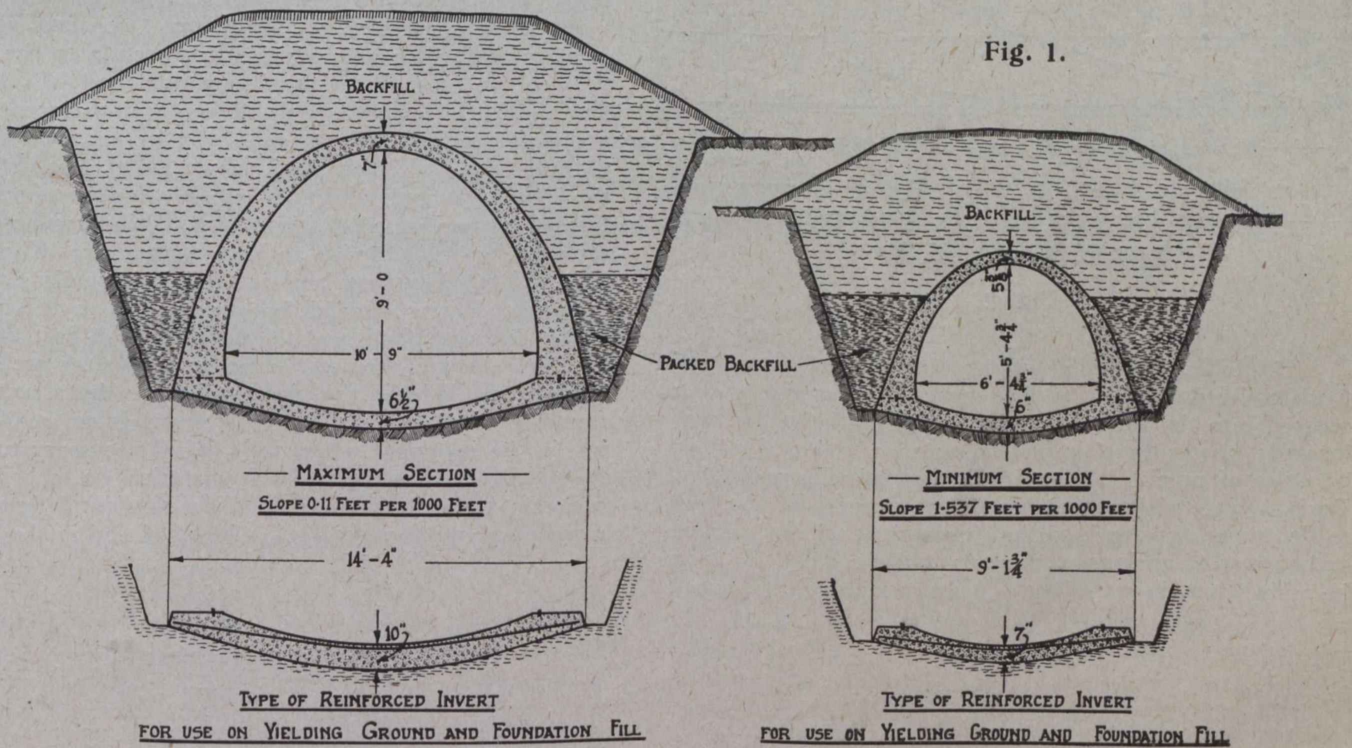


Fig. 1.

areas of swamps, sloughs and muskegs have formed, making the country inaccessable, except in winter time. It was thus necessary to carry the location work forward with the greatest dispatch during the first winter season. The line was located, except for certain short portions, by the beginning of spring in 1914.

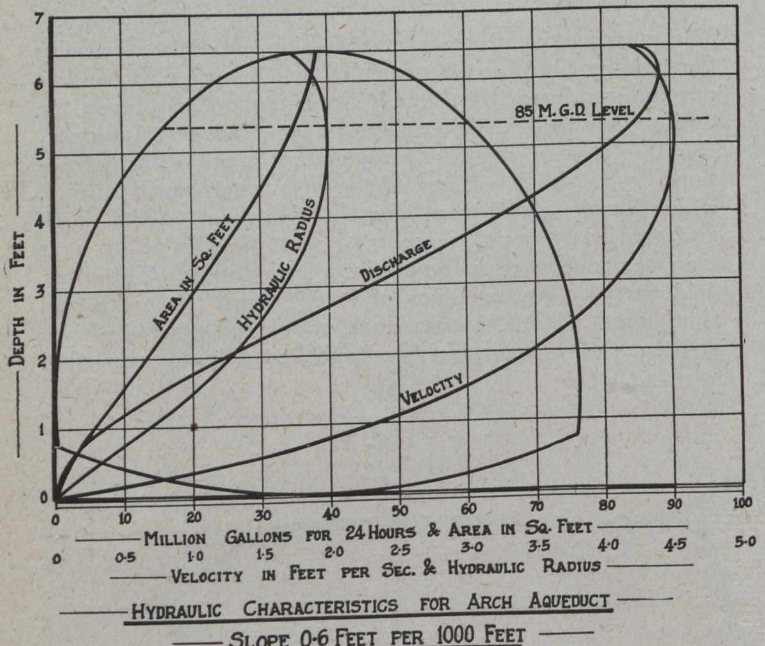


Fig. 2.

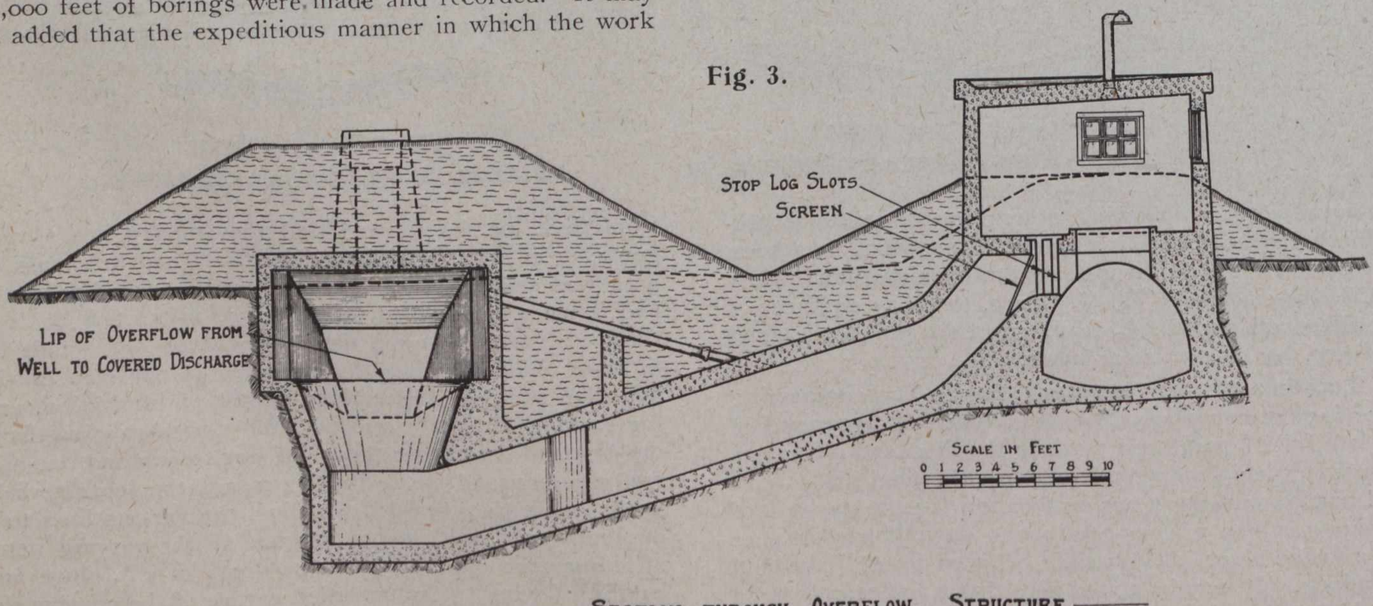
The following figures show generally the amount of work covered by the five field parties during the winter season from the time they started out until the line was located: 362 miles of transit lines; 1,317 miles of levels; 95 miles of precise levels; 380 square miles topography. Borings were also made during the process of location to determine the depth of the overlying muskegs. Some 12,000 feet of borings were made and recorded. It may be added that the expeditious manner in which the work was carried out reflects great credit on all of the field parties engaged.

The necessity for active co-operation between head office and the various field parties can readily be seen in order that the results obtained might be co-related before any one party had gone too far. The cost curves mentioned above were of material assistance in this regard.

Preliminary Design.—While the field work was in progress active work in head office was carried out on the details of design and layout. It was soon recognized that the utmost refinement in design was required to keep the cost of the work within bounds; for example, it may be pointed out in this regard that the addition of one inch thickness to the aqueduct section would add over $400,000 to the cost of construction.

To determine on the type of aqueduct structure to be adopted, studies were made of the economic and hydraulic characteristics of various concrete arch types and of a reinforced concrete box type. This latter had some advantages from an economic point of view, but the question of the life of reinforcing steel with thin concrete covering threw doubt on the desirability of its use for an aqueduct to deliver a permanent supply to a rapidly growing city like Winnipeg, and such a type would be much less rapidly built than an arch or self-supporting type. If the concrete sections were thickened up sufficiently to furnish an undoubted protection to the steel, the economies of this type disappeared and left the advantage to the concrete arch. The varying slopes of the aqueduct required different sizes of sections to accommodate the varying velocities. In analyzing the arch stresses the maximum and minimum sizes were examined and treated for various conditions of backfill loading both with the aqueduct running full and standing empty. The backfill consists of varying types of soil, principally clay and muskeg. It was decided that the type of arch lying between the semi-circle and the parabola was best fitted to resist the backfill stresses. The extreme sizes are shown in Fig. 1. Where the foundation for the structure is found to be of a rigid nature the invert is not reinforced, but in the instances where it is found necessary to place foundation fill to replace soft material, or to bring the aqueduct up to grade line, or where the foundation is not unyielding, reinforcing steel is being placed in the invert.

Fig. 3.



Section through Overflow Structure

In order to arrive at the proper sizes of sections for the varying slopes the curves for area, velocity, discharge and hydraulic radius were plotted for the maximum and minimum sections and for several intermediate sections. A typical curve sheet is shown in Fig. 2. As the sections from which these curves were plotted correspond to definite slopes, a series of curves were then plotted on the basis of slope in feet per thousand as abscissae, and the dimensions of the sections and hydraulic characteristics as ordinates. By plotting up points from the individual curves at the 85,000,000-gallon level and joining these up with smooth curves the dimensions of the aqueduct sections were then readily obtained for any slope. Similar curves were laid out for all the governing dimensions entering into the design of the sections.

For determining the discharge of the various sections, the values of coefficients as stated in several published reports on other similar structures were studied. Those of Fteley and Stearns made on the Sudbury aqueduct were used as a basis for determining the value of "C" in the Chezy formula, as the general conditions and size of this structure seemed to correspond most nearly to the Winnipeg aqueduct. The values used were determined by plotting the Sudbury results on the basis of variation of hydraulic radius to the value of "C." A conservative curve was then plotted for "C" for the Winnipeg aqueduct on the basis of the Sudbury curve, less five per cent.

Special Features.—The aqueduct structure itself has been designed to be built in two operations, first the invert, and second the arch. Alternate sections of the invert are built in lengths of 15 feet, and after several of these have been placed, the intermediate or closure sections are completed. Steel end forms or "profiles" shaped to the curve of the invert are accurately set to line and grade on 15-foot centres, and the concrete of rather dry consistency is placed between them and then screeded to shape with an angle iron screed. After this operation the surface is floated and surfaced to a smooth hard finish. Between adjacent 15-foot sections of invert a water-stop, consisting of a No. 20 gauge copper strip 6 inches wide and of a length equal to the width of the invert, is placed. Each strip has a V-shaped groove one-half inch in depth crimped in the centre of the strip, running its full length, thereby allowing the joints to open without breaking the bond between the concrete and copper.

After the invert concrete has become hard, the arch forms are then erected by means of a steel traveller running on a narrow-gauge track placed on the invert. These forms are of the Blaw collapsible type made in

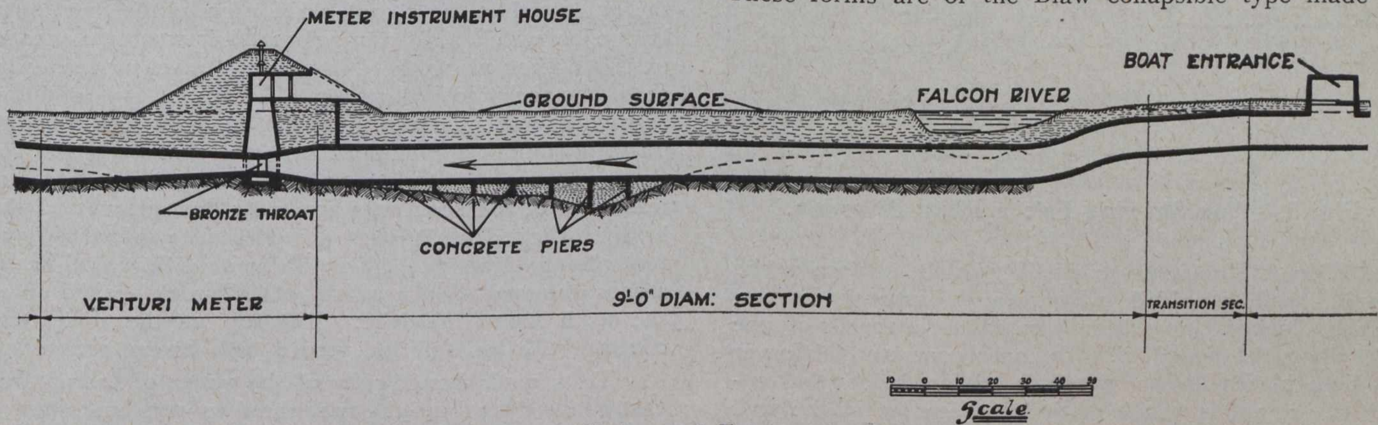


Fig. 4.—Venturi Meter and Falcon River Crossing.

After the sections corresponding to the various slopes had been determined, the whole system was laid out in profile, and the hydraulic grade was plotted for various discharges, the 25,000,000-gallon grade being carried from the easterly end of the pressure section to the McPhillips Street reservoirs, and the other discharges to the site of the future reservoir at Deacon. In order that the effect of the transition sections between the various sizes of aqueducts could be taken into account, as well as the velocity heads, this hydraulic grade was plotted back step by step by means of arithmetic integration. The manner in which this grade was plotted can be briefly described as follows: Starting from any point at which the water level is known, the depth in the aqueduct is thereby fixed and consequently the velocity and hydraulic radius are known as well as the value of "C." With these three known quantities the value of the slope is then calculated from the Chezy formula and a line is drawn upstream from the water surface for a short distance. If this line is not parallel to the aqueduct grade new values for "v," "r" and "C" are then determined upstream a short distance from the first point, and the process is then repeated and a new slope is obtained and plotted from the last point determined. In this way the surface slope is carried back step by step, giving the final hydraulic grade shown. Where a large change of section occurred between two adjacent portions of the aqueduct this method of plotting the surface slope gave some interesting results, showing up a wave in one instance at the foot of the transition section.

lengths of 5 ft. 0 in., bolted together to give a total length of 45 ft. 0 in., which is the standard length of arch poured at one time. Water-stops similar to those in the invert are placed at 45-foot centres in the arch to protect against leakage at the contraction joint. At the horizontal joint between the arch and invert a continuous strip of soft wood ⅞ in. x 1¼ ins. is placed half in the invert and half in the arch concrete. Numerous tests made on the sections of the aqueduct already built show that these provisions for making the joints watertight are satisfactory. At no point has any leakage been observed other than a slight dampness in a few instances at the junction of the four joints between arch and inverts.

The aqueduct in its course crosses several streams and rivers and in all cases the crossings are made by depressing the structure beneath the river beds. These sections being under pressure are made circular of reinforced concrete. Overflow and blow-off structures have been provided in the aqueduct at the upstream sides of most of the river crossings, which will serve the purpose of governing the discharge as well as for providing outlets for the water and drainage thereof for emptying portions of the aqueduct for cleaning. The discharges from these overflows enter into the rivers. A general drawing of such an overflow structure with its discharge outlet is shown in Fig. 3. It will be noted that provision has been made for the entering and removal of a small-sized boat which can be used in the aqueduct for purposes of inspection at times of partial discharge. These overflow structures have all been designed for withstanding a heavy backfill in case it may be found necessary as a protection against frost. It is not anticipated, however, that such protection will be required, as the walls have been provided with double windows and doors, and all openings into the aqueduct are provided with movable covers, the building itself thus forming a closed air space between the aqueduct and the outside air. The exposed metal work in these structures as well as all metal work pertaining to the aqueduct subject to corrosion is of bronze. Boat entrances, separate from the overflow structures, have been provided at various points along the

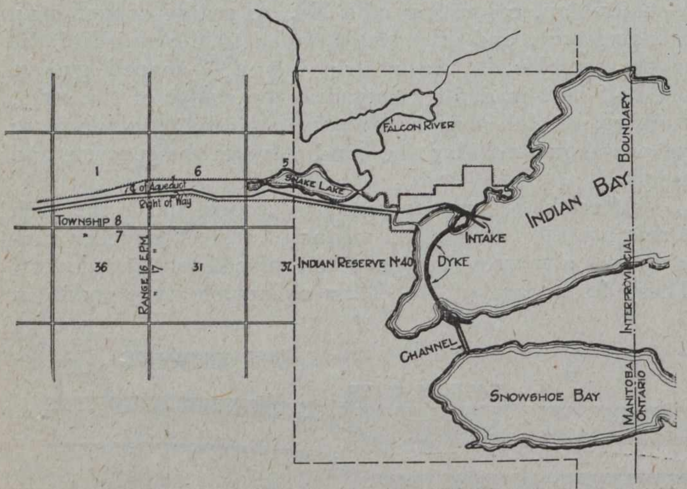


Fig. 5.—Plan Showing Falcon River Diversion.

line. Concrete manholes carried up to the surface of the backfill, and provided with heavy cast-iron covers, specially locked, have been located at intervals of one mile along the aqueduct. An inner concrete slab cover has been placed in each manhole 18 ins. below the outside cover, and a bench mark has been set in the wall provided with a brass tag on which the station and elevation can be stamped.

Two Venturi meters have been laid out—one downstream from the intake, and forming part of the depressed section under the Falcon River, and one immediately adjacent to and east of the site of the future reservoir at Deacon. These meters will be formed generally of reinforced concrete, provided with bronze throat rings. Instead of using a continuous ring for the upstream piezometer casting, separate bronze plates spaced equi-distant about the periphery at the upper end of the entrance cone, have been designed, each plate being connected by a separate pipe to a central manifold or header located in the adjacent chamber erected for the recording and integrating apparatus. It is believed that several advantages are obtained by the use of the separate plates over the continuous ring, not the least of which is the less cost. In meters of similar description it has always been found difficult to maintain a large ring in a true circle, and when the necessary bracing has been erected it interferes greatly with the form construction, so that it has been difficult to get a smooth and unobstructed joint between the concrete and the face of the bronze ring. By the use of separate plates it is believed that this difficulty will be entirely obviated, since the forms can be first trued up to accurate shape and then the plates bolted to the form without danger of displacement. Another advantage in this arrangement lies in the fact that by having a separate pipe between the chamber and each piezometer, any one hole that becomes blocked up can be simply blown out. Fig. 4 shows the general arrangement of the Venturi meter which is being built at the Falcon River crossing.

Intake and Falcon River Diversion.—The most suitable location for the intake was found to be at the westerly end of Indian Bay, which is an arm of Shoal Lake, about six miles long and from one mile to three miles wide, with an average depth of water over the whole area of twenty-five feet.

Falcon River formerly emptied into Indian Bay at the extreme west end, and, being a muskeg stream, the water was naturally of a brown color, which discolored the water of Indian Bay. In order to overcome this objectionable feature the Falcon River was diverted into Snowshoe Bay, an arm of Shoal Lake parallel to Indian Bay, and separated therefrom by a peninsula five miles long. The diversion was made by constructing a dyke 7,500 feet long across Indian Bay, and excavating a channel from behind this dyke through to Snowshoe Bay as shown in Fig. 5. The Falcon River water is thus cut off from Indian Bay by the dyke and discharged into Snowshoe Bay by the channel.

The dyke was built in 1914 by means of the scow and bridge method. The scow was held in position beyond the end of the work by means of spuds and connected to the outer end of the completed portion of the dyke by a bridge on which a narrow-gauge track was erected and extended back along the dyke to the gravel pit located a short distance from the shore. Trains of 4-yard dump cars filled with sand and gravel by a steam shovel at the pit were run out and dumped from the connecting bridge, the empties being backed upon the scow. As the dyke was formed, the scow was gradually pushed out and the bridge dragged along with it. The face of the dyke towards the lake was rip-rapped with a layer of heavy stones obtained from a quarry of trap-rock opened up at the north end of the dyke. The top of the dyke was covered with top soil and seeded with Brome grass.

Tests made periodically of the water of Indian Bay east of the dyke from the time the dyke was built show a progressive reduction in color until at the present time the water of Indian Bay is as clear as that of Shoal Lake itself. With this layout even should the water from the Falcon River find its way through Snowshoe Bay into Indian Bay it will require several years for it to complete its course, and in that time the color will have entirely disappeared through the natural bleaching agencies.

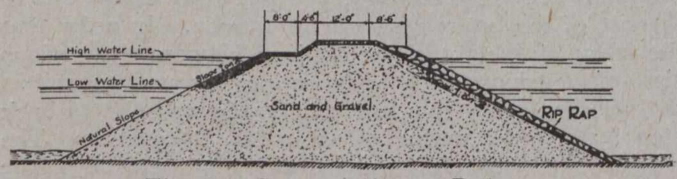


Fig. 6.—Cross-section of Dyke.

The intake will be located on the rock shore of the bay near the north end of the dyke, and it will be provided with fish screens, stoplogs and head gates. Two gathering walls will be carried out from the intake to the deep water of the bay.

Supply Line Between Reservoir Site and Winnipeg.—The construction of a reservoir of 250,000,000 Imperial gallons capacity, to be located at a point "southeast of Transcona," was recommended by the consulting engineers, not as a present requirement, but for some future date when warranted by the growth of the District. It was also alvised that the aqueduct at the present time be extended from this point known as "Deacon" to the present McPhillips reservoirs in Winnipeg as a 5-ft. 0-in. diameter steel pipe line capable of giving a discharge by gravity to the District of 25,000,000 Imperial gallons per day, which later on could be increased when this demand shall be exceeded by pumping at Deacon, or by the installation of additional pipe lines. Deacon thus marks the west end of the gravity aqueduct.

All the conditions entering into this arrangement have been carefully analyzed during the past two years, and these studies have shown the advisability of using a

Fig. 7.—Contract 31, Mile 40, Brokenhead River Siphon, Laying the Invert.

Fig. 8.—Contract 32, Mile 51, Backfilling in Wet Trench with Wet Material

reinforced concrete pipe 5 ft. 6 ins. in diameter in place of the 5-ft. 0-in. steel pipe as recommended.

The pipe will be carried in practically direct line from Deacon to the outskirts of St. Boniface in a trench excavated to a depth of from ten to sixteen feet. It will be extended to the east bank of the Red River under the streets of St. Boniface, crossing underneath the Seine River en route. The line will be carried under the Red River through a tunnel excavated well down in the rock beneath the river bed. Borings are now being made to determine the nature and depth of the rock strata underlying the river. From the west bank of the river the line will be extended to McPhillips Street reservoir, probably as a 4-foot cast-iron main laid under the streets of Winnipeg.

A pumping plant will be located at a future date at the Red River tunnel, and from this point future lines can be extended when the capacity of the gravity supply beyond this point shall have been exceeded. By this arrangement the pumping plant will be located near the centre of gravity of the District.

It may be mentioned here that the location of the reservoir is some two miles further east than contemplated in the consulting engineers' original layout, due to the location of the final aqueduct line.

General Features of Construction.—The right-ofway, three hundred feet in width (except for the easterly twelve miles which is five hundred feet in width), was cleared by contract in the winter and early spring of 1914.

A standard gauge railroad was constructed forty feet from the south boundary of the right-of-way during the season of 1914 at a total cost of $1,325,000. The construction of the railroad presented no unusual difficulties, and was carried out with such dispatch that trains were operating over the whole of it in January, 1915. The present equipment consists of four 60-ton Mogul locomotives, forty 20-yard air dump steel cars, twenty-five 16-yard air dump steel cars (now under contract), twenty flat cars, ten box cars, three cabooses and two passenger coaches. Additional equipment is being purchased.

The road, which is operated by the District, is connected with the Paddington Transfer Yard, meeting there all the railroads running into Winnipeg, so that contractors' shipments can be made direct to their camps without reloading. Railroad headquarters have been established at Deacon, where the operating staff is located, and where a machine shop, forge shop and engine shed have been erected. A station building containing offices for the operating department and for one of the division engineers has also been erected at this point, as well as a cement shed, pumping plant, coal dock, oil house, camp buildings and electric light plant. Nine sidings and five 12,000-gallon water tanks have been located at nearly equi-distant points along the line.

A telephone line has also been erected from end to end of the right-of-way, which is used both for train dispatching and for communication between the division engineers and headquarters at Winnipeg. A circuit for use of one of the contractors has also been erected on the District's poles.

Methods of Aqueduct Construction.—There is considerable variation in the methods of handling the work. On Contract No. 30 the excavation is carried out with teams and scrapers and by means of a walking dredge, the cut on this section being comparatively shallow and on the open prairie. The final trimming of the bottom of the trench is done by hand immediately before the invert concrete is placed. This hand trimming is required on all contracts and is done to prevent any possibility of the soil drying out and cracking, and thus forming a spongy bed for the foundation. The walking dredge is a heavy timber trussed structure spanning the trench and provided with a forward dumping dipper excavator. It is provided with six timber pads, one on each corner and one intermediate pad on each side. By means of chains and winches the weight is shifted from the corners to the centre pads and the whole structure is pushed forward by chains working on the legs of these pads. The dredge is driven by a gasoline engine operating, through clutches

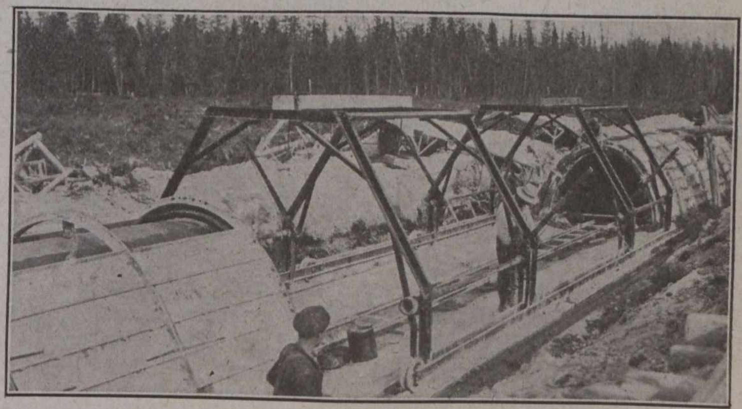


Fig. 9.—Contract 32, Mile 57, Traveller for Moving Outside Forms.

and belts, the various movements. The concrete plant on Contract No. 30 is placed on a flat car operated on a track built alongside the trench. Materials are fed to the mixer from the storage piles beside the District track by means of a travelling, stiff-legged derrick operating on a track midway between the railroad and the aqueduct trench.

A somewhat similar method of mixing and placing concrete is carried out on Contract No. 31, but the excavation in this case is being done partly by stationmen and and partly by Thew steam shovels, mounted on trucks and specially built to work in the narrow trench and to deposit the excavated material on the side.

The excavation on Contracts Nos. 32, 33 and 34, most of which is in clay overlaid with muskeg material, is carried out by means of specially designed drag line excavators. These excavators are provided with superheaters in order that full economy may be obtained from the coal. The drag lines stand at the end of the trench and work backwards, the bucket being dragged towards the machines and then swung out to the side of the trench. They dump the material along the south side in most cases to form an embankment upon which a narrow-gauge construction track is placed for carrying trains of cars containing mixed concrete to the work. The draglines are supported on the bogs by means of plank platforms made in sections each 8 ft. 0 in. x 20 ft. 0 in. Concrete mixing plants, in the case of Contracts Nos. 32, 33 and 34, are located adjacent to the contractors' storage platforms on the District railway. Narrow-gauge tracks are built from the mixing plants along the aqueduct trench on the spoil bank left by the dragline for a distance of about one-half mile in each direction. Concrete is conveyed to the work by small dump cars drawn by gasoline-driven locomotives. Chutes deliver concrete from the cars on the construction track to the forms in the trench.

Engineering Organization.—For carrying out the engineering direction of the aqueduct, five division headquarters' camps, one for each contract, have been established, each with a division engineer in charge, having under him an assistant who is responsible for the lines and grades, an office man to look after field records and sketches, an instrument party, a stenographer and senior and junior inspectors. These inspectors, in order that they may be present at all times on the work, live in tents at each point where work is in progress.

Each division engineer is provided with a light gasoline-operated track speeder, and each party with a large speeder capable of carrying six men with instruments, so that even on Contract 30, which extends over a distance of twenty miles, the work is handled with expedition, and by means of a comparatively small staff of men.

The engineering work is under the direction of James H. Fuertes, consulting engineer. M. V. Sauer is assistant chief engineer in charge of designs. The division engineers in charge of construction under the different contracts are: C. J. Bruce, Contract 30; R. T. Sailman, Contract 31; G. F. Richan, Contract 32; W. R. Davis, Contract 33; A. C. D. Blanchard, Contract 34. F. G. Haven is an assistant to the chief engineer.

[NOTE—This paper was supplemented by studies regarding concrete mixtures employed in the work. An abstract of these studies appeared in *The Canadian Engineer* in the October 26th, 1916, issue.—EDITOR.]

The exhibition of enemy samples loaned to Canada by the British Government will be taken to Halifax and St. John. During the two weeks in Toronto the exhibition was attended by 2,600 people. It was in charge of Herbert Kershaw of the British Board of Trade, assisted by A. E. Bryan and A. W. Kennedy, both of whom are graduates of the University of Toronto. Messrs. Bryan and Kennedy will make a tour of Canadian industrial centres next summer, after which Mr. Bryan will likely go to Japan and Mr. Kennedy to South America as Canadian trade commissioners.

QUEBEC BRIDGE DISASTER.

On the opposite page are shown a number of views pertaining to the Quebec Bridge disaster. These particular photographs have not previously been published in any other paper, and are printed here by courtesy of Mr. John Nash, of Quebec, P.Q., who was in a position to take same from points of vantage not available to some of the other photographers.

Fig. A586 was taken at 7.45 a.m., and shows the connection of the hoisting links of the central span at the northeast corner. This photograph marks the second stage of the lifting operations as the strain is just coming onto the chains. The six scows were named after the chief engineers, and the name "Duggan" can be seen on the nearest scow.

The structure in the centre of Fig. A582 is one of the two mooring frames which served no purpose other than to act as mooring bases for the floating span until it could be lifted clear of the scows. This photograph was taken from directly below the end of one of the cantilevers, and shows the chains drawn back to allow the tugs to place the span. These chains consisted of links 30 ft. long, made up of two strips 30 in. x 2¼ in., with 12-in. holes at 6-ft. intervals, these holes taking the pins that held the weight as the span was lifted.

The car ferry, which was to have been replaced by the Quebec bridge, is shown in Fig. A592. This ferry was present during the morning of the accident, bearing private cars of Canadian Government Railway officials.

Fig. A577 is an end view of one of the cantilevers which well illustrates the arrangement of the hoisting jacks and chains for one end of the central span. The jacks work in pairs between the short box-girders at the top of the chains. As explained in previous articles in *The Canadian Engineer*, the lower box-girder was held at a fixed level and carried the two jacks which alternately lifted and lowered the upper girder (in lifts of 2 ft. each). On the up-stroke the chains were attached to the upper box-girder and so lifted the span, while on the down-stroke they were released from the upper girder and held by the lower girder while the jacks were being lowered for another lift.

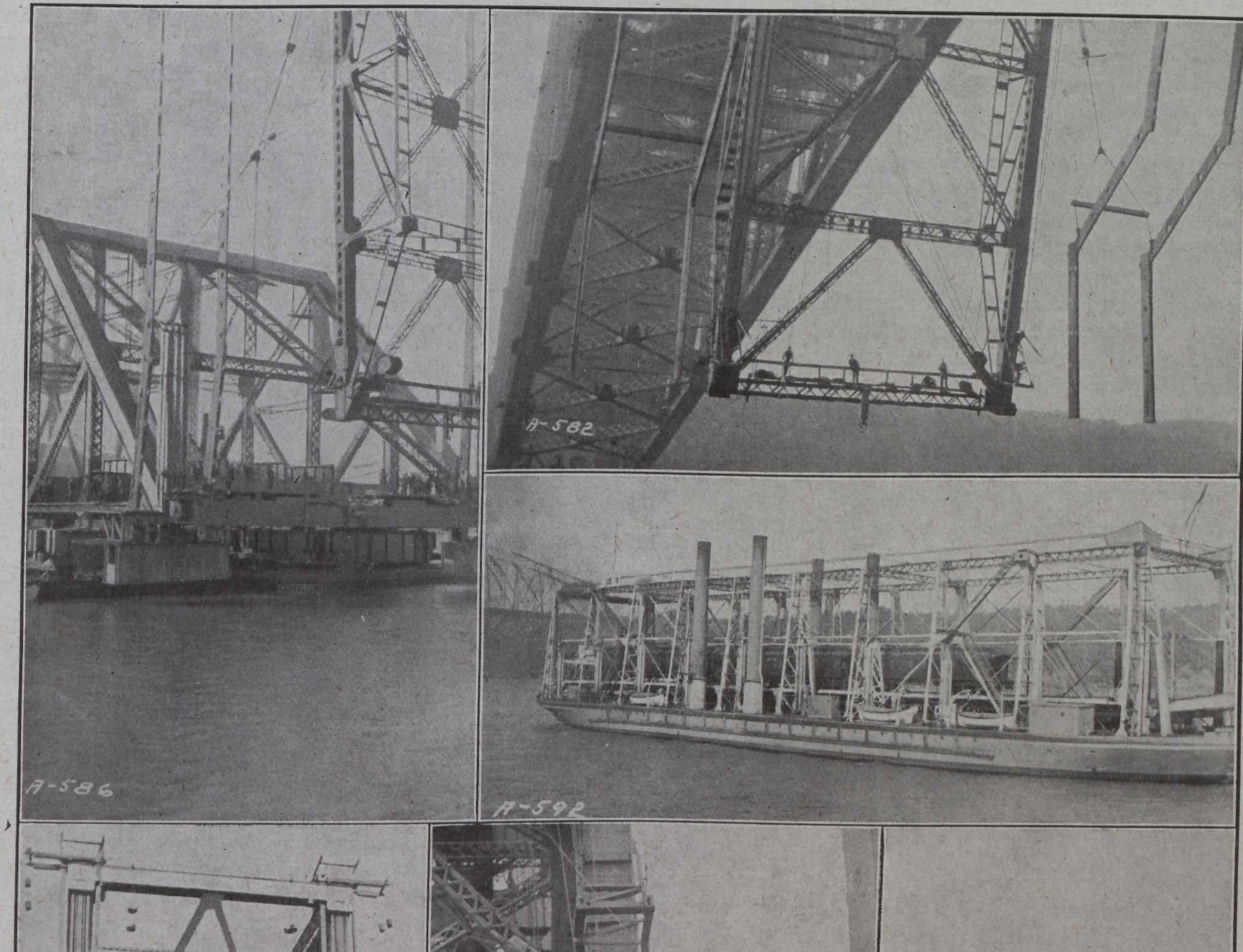
About an hour after the collapse of the central span, Fig. A604 was snapped, showing the broken gear trailing in the water. One of the hoisting chains, slightly damaged, can be seen at the extreme right of this view. The water in the middle of the river is 200 ft. deep, and the fallen span, as shown by soundings, is all more than 150 ft. below the surface of the water, which shows that the span is a wreck. It is at a depth too great to permit of any salvage operations.

Fig. 581 is a view of the hoisting apparatus, looking up-stream just as the central span was being drawn into position by the tugs. Workmen and engineers may be seen on the operating platforms connected to the box-girders.

These views are six of a set of twenty-two unmounted photographs, each 3⅛ ins. x 5⅜ ins., which are being offered by Mr. Nash for $1.00 per set. Each set is accompanied by a folder which describes each picture, and the set makes a very good souvenir of this unusual and unlucky engineering enterprise. Mr. Nash's address is P.O. Box 112, Station B, Quebec, P.Q.

What is claimed to be the tallest chimney stack in the world will be completed soon at the Kuhara refinery, Saganosekei, Japan.

MORE VIEWS OF THE QUEBEC BRIDGE DISASTER



By courtesy John Nash, C.E., Quebec.

A586—Connections at north-east corner of span; A582—View from beneath cantilever showing chains drawn back while span was being floated into position; A592—Car ferry which will have to carry the traffic for at least a year longer than was expected; Lower left corner—End view of cantilever showing hoisting apparatus; A604—After the accident; Lower right corner—Another view of hoisting apparatus.

BREAKS IN CAST IRON PIPE LINES.*

By R. DeL. French,
Lecturer in Municipal Engineering, McGill University.

THERE is scarcely any community of size on this continent which has not, at some time or other, had failures in the mains of its water distribution system, which were, or seemed to be, inexplicable. It is apparent that the prevention of such breaks is an important matter, and a study of the incidents leading to these disasters will help us to understand the reasons for them. Knowing these, the search for remedies may begin.

Sometimes a pipe line seems to be afflicted with an epidemic of failures. These are generally confined to large pipes, usually supply mains. In such cases it would seem natural to suspect that the character of the pipe was at fault. Isolated breaks may, of course, be due to defective pipe, but they are more likely to be caused by defective workmanship in laying, or by local influences, such as settlement or excessive loading.

To the credit of the pipe founders it must be said that there is now seldom any fault to be found with the quality of the material of which their pipe is made. Between the foundry and the job there is an opportunity for pipe to become damaged in transportation. Care in packing for shipment, and inspection at the destination while unloading, will prevent transportation cracks, or detect them if they occur.

Once the pipe is delivered alongside the trench, the responsibility for a first-class piece of work rests with the engineer. Of course, it is a prime requisite that the pipe shall be of proper thickness for the pressure and loads to which it will be subjected. There is not much room for choice on this point, as practically all pipe is now made to conform to one of the standard specifications, which provide proper thicknesses for different pressures. After this, it is a matter of care in laying.

All pipe should be well bedded and have holes dug for the bells, so that they will be evenly supported throughout their entire length. There should be a space of a quarter-inch or so between the ends of the spigots and the bottoms of the bells, to allow for expansion. Failure to observe this precaution is thought to have been partly responsible for the very serious break in Cincinnati in 1913. The pipe should be securely anchored at changes of direction. The backfilling should be carefully and thoroughly rammed around the pipe to a point well above its top, for a pipe that is well supported by the earth at its sides will carry a much greater external load than will one in which such support is lacking. The location of the trench itself should be so chosen that the pipe will not be subjected to heavy loads from traffic or from other sources. The Cincinnati pipe line was located in ground which had been subject to land slips, as shown by the broken and folded strata through which the trench passed. It is possible that a fresh disturbance of the ground had something to do with this failure.

Water hammer is frequently blamed for pipe failures. This action is present in some degree and at some time in practically all systems, and may be due to faulty design or to faulty operation. A certain minimum amount is probably inevitable. In small direct-pumping systems the fluctuations in pressure are often very marked. Hydraulic elevators drawing from a small system will also produce similar fluctuations.

If water hammer alone were responsible for breakage to any great extent, one would expect to find such breaks in the small pipes near the source of the pressure fluctuations, and also that the breaks would be recurrent, unless the cause of the water hammer were removed in the meantime. As a matter of fact, failures in series have been most common in large supply mains and under circumstances which preclude the possibility of water hammer being responsible for them. Moreover, the accepted formulas for the thickness of cast iron pipes all make a liberal allowance for the effect of water hammer, so that, although the final touch may be given by it to a pipe which is already cracked, it is not likely that it is solely responsible for many failures of well-laid pipe of good quality.

To sum up, it is the writer's opinion that the answer to the question, "How shall breaks in cast iron pipe lines be prevented?" is to be found in inspection. Such inspection should cover:

1. The manufacture of the pipe, including the control of the mixture of the irons by analysis, the molds, the usual hydraulic tests, and particularly the drawing of the pipe from the molds and the subsequent cooling. Just what rate of cooling is permissible is a matter which should be within the knowledge of the foundryman. The best man for a position such as required by this inspection would be one who had served his time at pipe founding. The analyses should, of course, be made by a competent chemist. Such inspection is now required by some of the larger cities.

2. The inspection of the loading of the pipe into cars or vessel, to be sure that it is as well packed for shipment as is practicable. On arrival at its destination the pipe should be given a hammer test on unloading, and, if the work is of importance and the pipe is large, another inspection at the trench side would be quite in order.

3. Inspection of laying, which should be preferably in the hands of an engineer, or in those of a "practical" man under the immediate control of the engineer.

A complete system of inspection, as advocated above, will cost more than is now commonly thought allowable, but it appeals to the writer as being the only way in which it is possible to guard against inferior pipe and inferior workmanship. A city's water-supply is one of its best assets, and interruptions to it, even though they be unaccompanied by actual monetary damage or loss of life, expose the health of the citizens to grave dangers and their property to a greatly increased fire hazard, as well as contributing to an indirect financial loss through the stoppage or curtailment of industry.

*From a paper presented at the 1916 annual convention of the American Society of Municipal Improvements.

During the fiscal year ended June 30th, 1916, there was exported from the United States railway material to the value of $74,729,000, made up as follows: Railway cars, $26,660,000; rails, $17,687,000; steam locomotives, $12,666,000; electric locomotives, $455,000; engine parts, $7,274,000; switches and track material, $5,262,000; sleepers, $2,435,000; railroad spikes, $1,399,000; car wheels, $742,000; telegraph instruments, $149,000. Two years ago the year's exports of railway material amounted to $34,919,000. Until recently Canada and Cuba were the principal markets for freight cars; Cuba, Canada and Brazil for locomotives, and Canada, Australia, Japan, Brazil, Argentina and Cuba for rails. Just now freight cars and other materials are also going to Russia, and important consignments to France and Spain. In June alone the freight cars for Russia valued $1,086,000; the rails to France $1,188,000, and the locomotives to Spain $272,000.

GRAVITY WATER SUPPLY SCHEME FOR CALGARY

ABSTRACT OF REPORT PREPARED FOR PURE WATER COMMITTEE OF CITY COUNCIL, ADVOCATING GRAVITY EXTENSION, WITH SEDIMENTATION RESERVOIR, AT CAPITAL EXPENDITURE OF ABOUT $380,000.

By **GEORGE W. CRAIG,**
City Engineer, Calgary, Alta.

WATER is at present delivered, for consumption in Calgary, from the Elbow River by means of a 30-in. wood-stave pipe line, having its intake at a point approximately 10 miles west of Calgary; also from the Bow River at a point within the city limits where a pumping station, containing two 7½ million gallons direct-connected centrifugal pumps, has been erected.

Elbow River Intake.—Owing to the nature of the Elbow River intake, it has been found impossible to maintain a full head on the pipe all the year round, with the consequence that the full discharge, which is about 8 million gallons under certain adverse conditions, is cut down to half, and sometimes less than half, which in turn compels the pumping station to assume a greater part of the burden than otherwise would be required, with a consequent higher power consumption.

Bow River Pumping Station.—The pumping station consists, as before mentioned, of two centrifugal pumps direct connected to two 450-h.p. motors, with an individual capacity of 7½ million gallons per 24 hours, coupled in parallel, and in series a combined maximum discharge of 10,000,000 gallons per 24 hours with a 25 per cent. overload on motors, and a pressure of 145 lbs. There is, further, an Inglis pump of 5 million gallons capacity which is occasionally used, mainly to secure high pressure for fire purposes.

The annual expenditure for the operation of this pumping station was, for the year 1915, $30,119.19,

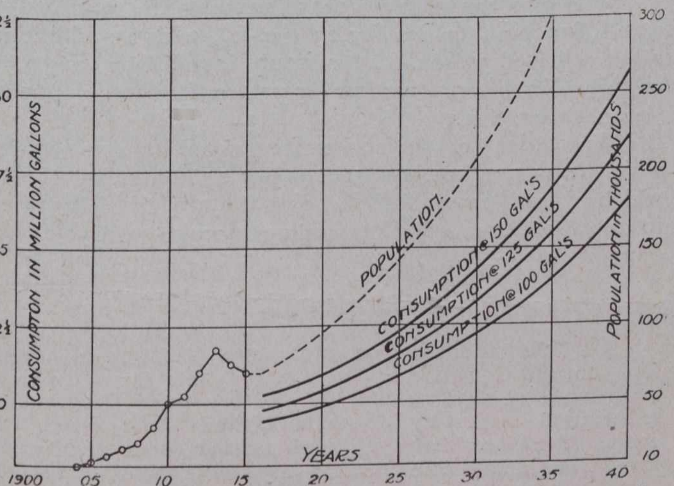


Fig. 1.—Curves Showing Prospective Population and Water Consumption, City of Calgary.

which amount, the writer understands, is considerably less than expenditures of previous years. This expenditure, as stated above, is dependent solely on the discharge of the gravity.

Comparative Merits of Pumping and Gravity.—Other things being equal, and generally speaking, it can be stated that a gravity scheme, well designed and of permanent construction, can nearly always supply water for distribution cheaper than one or several pumping units.

When, as in the case of the city of Calgary, there is a distinct advantage in taking the water solely from the Elbow River, and considering the annual expenditure of the pumping station, and the already invested capital in the pipe line from the Elbow River, it seems that any proposed improvement and extension would naturally be undertaken in connection with the now existing gravity line from the Elbow River.

Elbow and Bow Rivers.—The Elbow River has a drainage area of 482 square miles, with a scattered population for the first 8 miles west of the intake. From here the river traverses the Forest Mountain Reserve, an extremely wild and mountainous country, devoid of any settled population.

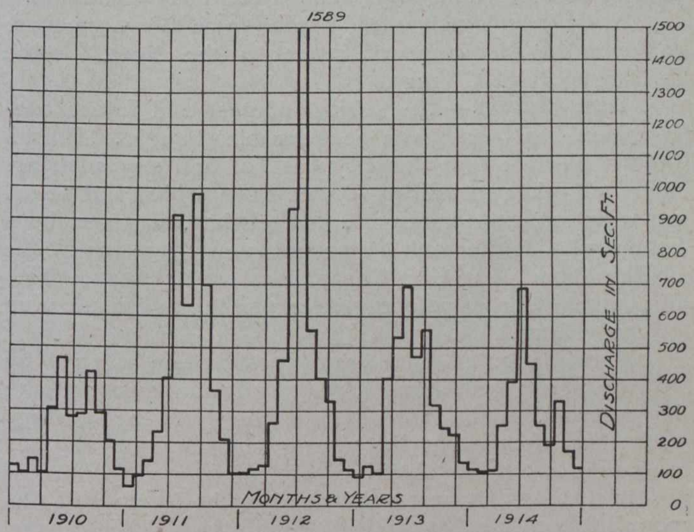


Fig. 2.—Hydrograph of Elbow River.

The Bow River has a drainage area of 3,200 square miles above Calgary, and for a distance westerly of about 90 miles it has on its drainage area a fairly large farming community, interspersed with several small towns and villages.

I would here quote an abstract from the city chemist's report of September 28, 1916, as follows:—

"The turbidity and pollution curves do not coincide exactly, thus furnishing a part of the evidence available in proving that the pollution does not have its source identical with that of the flood waters.

"Also the popular belief that the muddy waters indicates the period of dangerous pollution is not likely true.

"The pollution curve reaches its maximum after the turbidity curve has receded to a comparatively low point.

"The point of highest degree of pollution occurs August 3rd. The highest degree of turbidity occurs during the month of July. Comparative analyses of Bow and Elbow River waters show a higher degree of pollution for the Bow than for the Elbow River water. This is borne out by all tests made during the past three years. This is further plainly indicated by the fact that the entire Elbow River basin above the intake does not have a population in excess of five hundred people.

"The Bow River basin above the intake has during the summer season a population in excess of six thousand. In addition to this the travellers and crews of the Canadian Pacific Railway trains operated through the Bow River basin mean an additional population of approximately two thousand people.

"During the winter months the washings from the car lavatories are deposited along the river banks for many miles above the intake. With the opening of spring the rains wash this accumulated filth into the river, from which it is drawn directly into the supply mains of the city. The filth accumulations of the winter months amount to considerable, as during this time one hundred and fifty thousand people or more are carried through the Bow River basin on these trains.

"Pollution from such a source can well be looked upon as being of a greater danger than from a like population in a fixed location.

"The travelling public are from many localities, it amounts to a new chance each day, and can well be adjudged as more dangerous than a resident population."

From the above it would appear to be the wise course to favor the Elbow in preference to the Bow, for the future supply of Calgary.

Consumption.—The subject of past and future consumption has been given considerable thought. It is a regrettable fact that this city has not had any adequate meter or other measuring device from which the actual consumption could be ascertained. It has, however, been estimated that the total consumption in 1915 was in the neighborhood of 10½ million gallons per 24 hours, which for a population of 70,000 gives a per capita consumption of 150 gallons.

A tabulation of the average consumption as given by 19 meters in private houses, ranging from mansions, with large lawns, to the more modest house of the average consumer, shows that the average consumption is 57.02 gallons per capita. Another tabulation, giving Venturi meter readings for water delivered to the North Hill (the population on the North Hill, according to police census, is 14,787 people) shows an average consumption per capita of 150 gallons during most severe weather conditions when a number of taps most likely were running, and of 135 gallons during the summer time when lawn watering would be probable.

We have here two figures, *viz.*, 57.02 gallons at final point of deliverv, and 135 gallons at point of intake, which the writer offers in support of the contention that a considerable loss takes place in transit, which can only be interpreted as "leaky mains."

Whatever the leakage may be, it is certainly a serious one, and should at the very earliest opportunity receive attention. The writer recommends that a waste detective survey be carried out in order to conserve the life of utility of the scheme with which this report deals.

The consumption for which this scheme has been designed is that of 100 gallons per capita, which should give a wide margin for public purposes, and for a reasonable amount of wastage. The city of Winnipeg has adopted this figure for its new water scheme. In his report on the Hetch-Hetchy water supply for San Francisco, John R. Freeman states:—

"The quantity of water actually used per capita is found to increase from year to year in substantially all growing cities in the United States, and is showing a similar although slower rate of increase in most European cities. This comes naturally with the higher standards of comfort, with more bath-tubs and more water fixtures in the dwellings, and in most American cities the rate of increase has far outrun the expectations of twenty years ago. Even when a meter is installed on every tap, soon after the immediate drop, the curve of per capita consumption again begins to rise and, so soon as the water supply of a city is put on the rational basis of sale only by meter, there is no reason why the city should not encourage the most liberal use, particularly if it very properly adjusts its schedule of rates so as to make this a source of income which could be applied to the embellishment of the city.

"The writer, having had occasion to study this question of future per capita increase in relation to the water supplies of Boston, New York, Baltimore, and other cities, cannot regard it as prudent to estimate on a smaller supply for the San Francisco of, say, fifty years hence than from 125 to 150 gallons per capita per day, although by that time substantially every system is metered."

The proposed scheme has a life of utility of from 20 to 25 years, or even longer, depending on the energy with which the waste detection survey is carried out, under which conditions 100 gallons per capita may be said to be a reasonable allowance.

In referring to Fig. 1, showing population and consumption curves, it will be noticed that 13 million gallons, which is the capacity of the present pipe line from the new intake, intersects consumption curve at 100 gallons at year 1924, when it will be necessary to parallel the present pipe line.

From this year (1924) the whole of the proposed scheme is extremely flexible, inasmuch as the intake is designed to accommodate any size pipe within reason. Suppose we wish to accommodate population up to 1934, when it is 282,000, we see that 1934 intersects the 100-gallon curve at 28,200,000 gallons. Having already provided 13,000,000, our new pipe line must therefore have a capacity of 15,200,000 gallons. A similar reasoning can be adopted for any subsequent year.

Hydrography of Elbow River.—In referring to Fig. 2 it will be noticed that the average minimum discharge for the 5-year period (1910-1914) is 100 sec.-ft. with an absolute minimum of 62 sec.-ft.

The city has now a license pending the approval of right-of-way and plans for 25 sec.-ft., with an additional reservation of 50 sec.-ft. for future installation, and ultimately a further reservation for 25 sec.-ft. if requirements should demand it.

The total license is therefore equal to 100 sec.-ft., which equals 54,000,000 gallons per 24 hours, an amount which should prove sufficient for the city of Calgary up to 1950, without any impounding storage reservoir.

(Continued in next week's issue.)

A swifter and more comprehensive operation of an All-Red route in Canada after the war adds interest to the statement made at the meeting of the Liverpool Geographical Association regarding another All-Red route, which the events of the war have rendered possible, and which would bring Australia within fourteen days of London. When the Cape-to-Cairo Railway is completed it will be joined on to a railway system through Palestine already partly constructed by the Germans. Brindisi, the Italian port, will no longer be the terminus for the Australian line, but the new railway system will run down to the Ægean Sea, and the journey to Australia occupy fourteen days. There will also be direct lines from Petrograd to the Cape. Aleppo is likely to be the central city of these interesting developments in the eastern hemisphere. Though no aggressive military operations are yet reported from Mesopotamia, the British there are getting on with a railway from the Persian Gulf towards the north of Bagdad. Sir William Wilcox, the irrigation engineer, is planning to make Mesopotamia one of the finest wheat fields in the world, and Sir John Jackson has already built a barrage for diverting the waters of the Euphrates.

Editorial

CONTROL OF THE NORMAN DAM.

Many of the problems which enter into the Lake of the Woods investigation are approaching decision by the International Joint Commission. Some of these essentially admit of adjustment upon a monetary basis. With such phases of the investigation the citizens of neither country are very seriously concerned, because any reasonable adjustment of compensation decided upon by the commission will doubtless be acceptable to both countries. There are, however, other phases of the investigation which involve questions of principle or public policy of the individual countries and which necessarily will have to be decided upon national, rather than international, grounds. For example, a problem in which the Canadian public is most vitally concerned now that its import is being generally understood, is the question of national or international control of the Norman Dam—a structure on the Winnipeg River, wholly in Canada, and some 60 miles to the north of the international border.

It has always been fully expected that the commissioners for each country would safeguard the national assets of the other country. But if there should be any effort to compromise the national status of the Norman Dam in Canada, the Canadian members of the Commission are not expected to sacrifice Canadian rights.

It is well known to those of our readers who have followed the Lake of the Woods discussion that the control of the levels of the lake rests very largely with the operators of the Norman Dam. The first public intimation of the stand taken in regard to these operators was a "Letter to the Editor" written by the Hon. Commissioner Jas. A. Tawney, and published in the July 6th, 1916, issue of *The Canadian Engineer.* Leaving aside all question as to whether Mr. Tawney intimated by this letter that he had formed judgment in respect to a matter on which the evidence was not yet entirely presented, the suggestion made by Mr. Tawney that much of last spring's flood damage on the Lake of the Woods watershed might have been avoided by international control of the Norman Dam, was a most surprising expression. Hesitating to "rush in where angels fear to tread," *The Canadian Engineer* at the time made no editorial comment in regard to Mr. Tawney's letter. But we understand that the commissioners have now proceeded so far in their discussions of this phase of the Lake of the Woods case, that reticence in regard to it is no longer necessary or advisable; therefore this journal wishes to place itself clearly upon record as being utterly opposed to any arrangement which will place—in any degree whatsoever—a Canadian structure, located entirely within Canada, in the hands of the people of any other country, even those of our most esteemed and friendly neighbor.

In our opinion, dams such as at International Falls, extending from the main shore of Canada to the main shore of the United States, could be under international control, but in no sense is the Norman Dam an international structure.

If the Commission were to designate the highest and lowest levels to be permitted, the Dominion Government (either directly or co-operatively with the Ontario Government) undoubtedly will be prepared to give assurance that the specified levels will be maintained and that the dam will be operated according to such findings of the Commission as may be acceptable to both governments. Complementary to this operation an international consulting board might well be organized; the members of this board to keep accurate record of conditions on their respective sides of the boundary. Such an organization could make certain that the operators of all the structures on the watershed are at all times thoroughly conversant with existing data and also with what the board might regard as the probabilities. The office of this board would become a reference centre at which all data would be deposited and from which any information could be secured quickly. Attached to the board could be operating engineers through whom the board would administrate the international structures. Such international assistance doubtless would be received most kindly, but the physical control of the Norman Dam—that is, in actually carrying out the recommendations of the Commission—should be a national matter made effective by co-operation between Canada and Ontario.

In any discussion of the policy attaching to purely national structures, a word may be said upon the subject of national honor. When either the United States or Canada pledges its word that certain matters will be attended to in order to conform to the findings of the International Joint Commission, surely that should be sufficient. In a matter like the control of the Norman Dam, the people of Canada will regard their national status and honor of much more value than are the millions of dollars of shipping, power, lumber, farming and other interests involved. They will cheerfully contribute their share of any reasonable monetary settlement in which the members of the Commission may acquiesce; but when the force of the statements in Mr. Tawney's letter above referred to, is fully appreciated by the people of Canada, they will fully expect that any recommendations approved by the Canadian commissioners will ensure no compromise of Canada's national honor or of this country's actual rights in the ownership of its own structures.

The Canadian Engineer has ascertained the opinions of many of the members of the engineering profession, and in addition to this has been able to obtain representative opinions of many citizens who are not engineers, and it is found that the latter opinions coincide with those of the engineering profession: namely, that if a public vote were to be taken in Canada upon this question, there would be a landslide against international control of the Norman Dam.

PLANNING AHEAD.

When Sir George Foster some months ago issued a call to action to the business men of Canada, they failed to respond.

We as a people are surprisingly slow in our work of planning ahead at this important period in the history of Canada and the British Empire. One is inclined to believe sometimes that the triple task of operating a nation, conducting part of a great war and planning for the peace period, is too big for us. Great Britain is per-forming the task, although it has had to make the nation into one vast organized war institution.

In the United States, banks, traders, governments and other units are planning for the peace period in a way which we might well emulate to at least some extent.

PERSONAL.

C. H. WITHERS has been appointed manager for Escher Wyss & Company's Canadian head office in Montreal.

W. E. SKEAD has been appointed city purchasing agent, Brandon, Man., and will make purchases for the Brandon Municipal Railway.

Lieut.-Col. C. H. MITCHELL has been gazetted as a general staff officer of first grade, according to press dispatches from London, Eng.

J. F. MacGREGOR has been appointed a member of the Hydro-Electric Commission, Galt, Ont., to fill the vacancy caused by the resignation of H. W. D. Browne.

J. E. MORAZAIN has been appointed superintendent of District No. 1, Canadian Government Railways, with office at Levis, Que., succeeding R. Colclough, transferred.

DENIS MURPHY, president of the Ottawa Transportation Co., and one of the Timiskaming & Northern Ontario Railway Commissioners, has been seriously ill at his home in Ottawa for several weeks.

ELWOOD WILSON, Jr., who studied forestry and engineering at Cornell and McGill Universities, has enlisted with the 242nd Forestry Battalion, C.E.F., and has been given a commission as lieutenant.

Professor W. J. DORSEY, of the University of Manitoba, read a paper on "Cut-out System on Party Telephone Lines" at the monthly meeting of the electrical section of the Manitoba branch of the Canadian Society of Civil Engineers.

R. E. SPEAKMAN, city engineer, Brandon, Man., is leaving in a few weeks' time to return to his home in England. Mr. Speakman has suffered severely from rheumatism during the past two years. He was city engineer at Calgary when the street paving was put in there and left that city to go to Brandon.

F. L. FELLOWES, city engineer of Vancouver, B.C., attended a meeting of the executive of the Union of British Columbia Municipalities, held at Vernon, B.C., on October 10th, and delivered an address at the annual convention held on the two succeeding days.

C. A. AMIRAULT, who for 25 years has been connected with the engineering department of the city of Montreal and is at the present time engineer of the sidewalks and sewers division in the office of the chairman of the Board of Assessors, will shortly resign. Mr. Amirault is one of the oldest engineers in the civic employ. For many years he was chief engineer in charge of the northern division of sewer work.

OBITUARY.

DUNCAN McINTYRE, vice-president of McIntyre, Son and Company, Limited, founded by his father, Duncan McIntyre, a member of the syndicate which constructed the C.P.R., died in Montreal on November 5th, at the age of 50 years.

Lieut. CARL J. BEATTY, of the Royal Flying Corps of the British Army, was recently killed in action. Lieut. Beatty was in the employ of the engineering department of the British Columbia government for some time before he enlisted. Previous to that time he had been a member of the engineer corps of the Northern Pacific Railway.

CANADIAN SOCIETY OF CIVIL ENGINEERS TORONTO BRANCH MEETS.

Mr. William Storrie, chief engineer of the John ver Mehr Engineering Co., last Thursday evening addressed the Toronto Branch of the Canadian Society of Civil Engineers, explaining the design and construction of the Toronto rapid sand filtration plant. The meeting was well attended and a vote of thanks was accorded Mr. Storrie for his interesting review of the principles upon which the plant was designed.

Mr. William Gore, the company's consulting engineer, lead the discussion. He said that the impurities and foreign matter that must be filtered out of a water supply vary from one two-millionth of an inch in diameter all the way up to one-quarter inch. The art of filtration has been developing for a hundred years, said Mr. Gore. At first it was simply a straining action; then the "dirty layer" theory was the basis of all progress; now, in the Toronto plant, the absorption theory supplants the dirty-layer theory. The absorption theory brings in the principle of electrostatic equilibrium. To introduce a solid into the raw water disturbs the electrical equilibrium of the small particles, which must either go to the solid or away from it.

Filter alum is electrically positive to most particles, said Mr. Gore, and the impurities are drawn electrically to the coagulant, both impurities and alum being removed by the filter. The effective cleansing area of the Toronto filter, he said, is not dependent only upon the actual net area of the sand, but is the area of the cones of fixed sand. This fact, together with the grading of gravel which dispenses with screens between the sand and gravel, are among the chief features of the new plant.

The annual excursion of the Toronto branch will be held next Saturday, November 18th. The members are to assemble not later than 2 p.m. at the Yonge Street dock. The tug "Geary" will take them to the Island for an inspection of the plant described by Mr. Storrie.

MANITOBA BRANCH MEETING.

On the evening of November 2nd Mr. S. Bylander addressed the Manitoba Branch on "Shop Details of Steelwork for Buildings." The speaker drew upon his own experience and methods, discussing the subject under the following heads:—

First, American methods, as introduced into England many years ago; second, Old English methods; third, Modern English methods.

Mr. Bylander explained quite fully his methods of detailing steelwork for fabrication, and they are very similar to those practiced by structural engineers in Canada. Some phases of the paper (for example, his methods of obtaining dimensions of skew members) would be of interest to any one engaged in structural work, so it is likely that the entire paper will be published by the Branch at a later date.