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PRECISE LEVELLING BY THE GEODETIC SURVEY

A REVIEW OF THE WORK BEING DONE BY THE GEODETIC SURVEY OF CANADA IN MAKING A PRECISE SYSTEM OF LEVELS.

By F. B. REID, D.L.S., Supervisor of Levelling.

LEVELLING may be defined as the art of determining the relative heights of points on the earth's surface. Precise levelling differs from ordinary levelling in several respects, both as to the instruments used and the field methods employed; finer materials and workmanship enter into the construction of the instruments and special precautions are taken in the field to avoid the accumulation of errors on long lines. One of the most important precautions is the system of duplicate levelling—all work being run at least twice, in opposite directions. To anyone familiar with the practice of ordinary levelling various other differences in procedure will reveal themselves during the course of this paper.

The value to any country of a system of levels of high precision is unquestionable. The exploratory and other preliminary work in connection with engineering projects such as railways, canals, highways, water supply and irrigation systems, etc., is much facilitated by having accurately determined bench marks to connect with at short intervals and is still further facilitated by the use of contour maps of the country, these having been prepared with a line or a net of precise levels as the basis. In this connection it is interesting to note that the Public Works Department, at the time of making the surveys for the proposed Georgian Bay Ship Canal, found it necessary several years ago to run a line of precise levels from Rouse Point, N.Y., to North Bay, Ont., via Vaudreuil and Ottawa, checking this by means of water transfers across Lake Ontario and a line of precise levels from Toronto to North Bay. Again, it is significant that at least two of the leading American railroads—the Pennsylvania and the Baltimore and Ohio—have carried out precise levelling operations of considerable magnitude at their own expense.

Judging from all the above that the work is of considerable practical value to the public at large, let us turn for a moment to its usefulness in connection with the

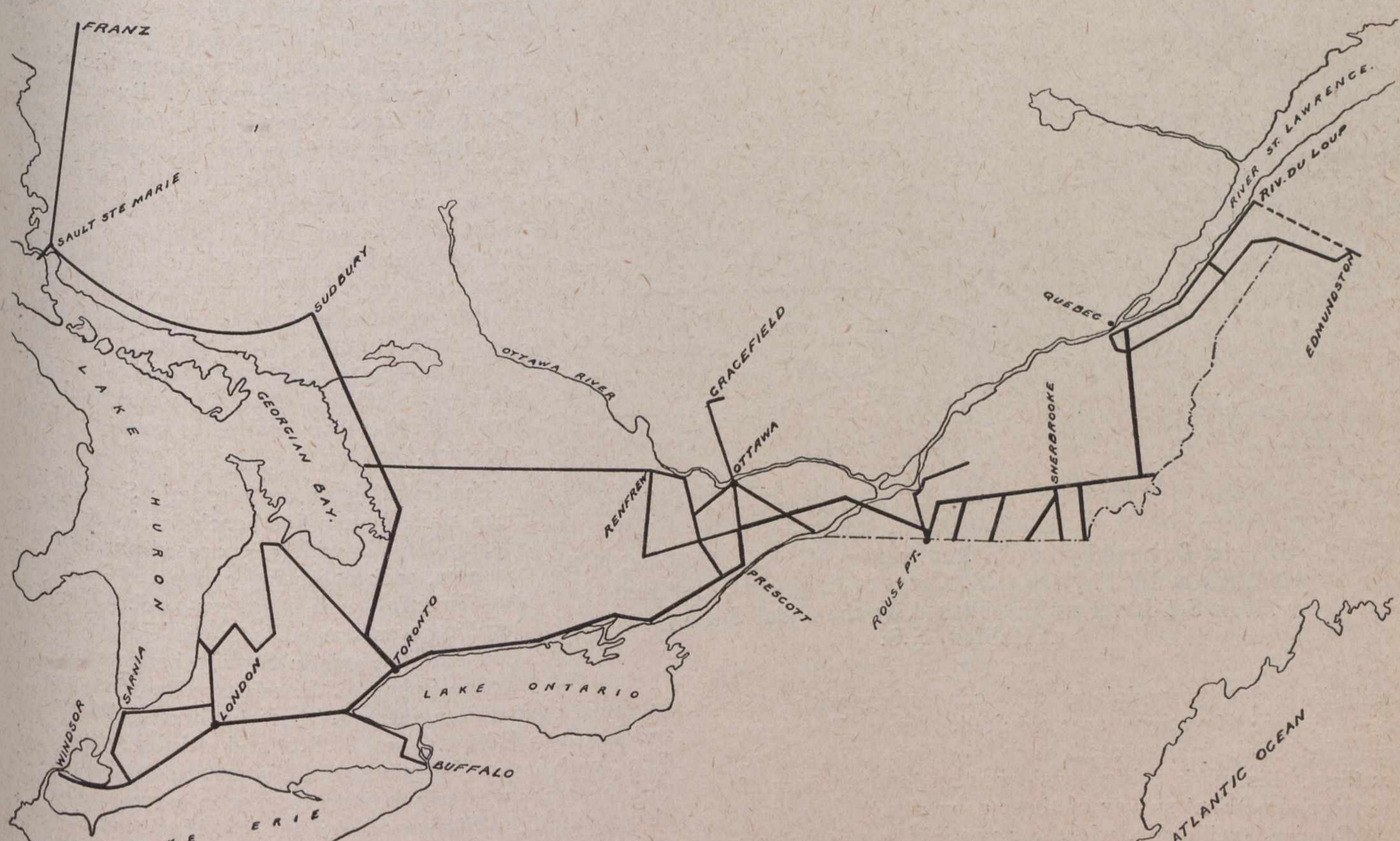


Fig. 1.—District Covered by Levels Run from United States Coast and Geodetic Survey B.M. at Rouse Point.

various topographical surveys carried on by the Militia and other Government Departments, the International Boundary Survey and the triangulation branch of the Geodetic Survey. J. B. Johnson, in his manual of surveying, has the following to say on this latter phase of the subject: "In order that triangulation distances may be reduced to sea-level, the elevations of the bases at least must be found. It is impossible to carry elevations accurately from one triangulation station to another by means of the vertical angles, on account of the great variations in the refraction. Barometric determinations of heights are also subject to great uncertainties unless observations be made for long periods. The only accurate method of finding the elevations of points in the interior above sea-level is by first finding what mean sea-level is at a given point, by means of automatic tide-gauge records, for several years, and then running a line of precise spirit levels from this gauge inland and connecting with the points whose elevations are required. Most European countries have inaugurated such systems of geodetic levelling, this work being considered an integral part of the trigonometrical survey of those countries."

Precise levelling is, whenever possible, carried along railway tracks, rather than along highways or across country, the advantages of this practice being many. The rate of rise and fall of the track is usually fairly uniform and no steep hills are encountered, thus allowing longer average sights to be taken and allowing the backsights and foresights to be easily kept of equal length. The rails furnish excellent supports for the levelling rods and thus the time is saved which would otherwise be consumed in putting artificial turning points into the ground. The masonry structures—bridges and culverts—situated along the railways are utilized for placing permanent benchmarks; this is of advantage both to us and to the railway companies. Again, the use of a hand-car for going to and from work and for moving along from point to point during the day, effects a large saving of time and labor, and the transportation of the camping outfit from camp to camp by freight is cheaper and more convenient than the method by horse and wagon. Against these and other advantages may be set the fact that the refraction and boiling of the atmosphere caused by the sun is considerably greater on a railway track, owing to its exposed character and the materials of which it is constructed.

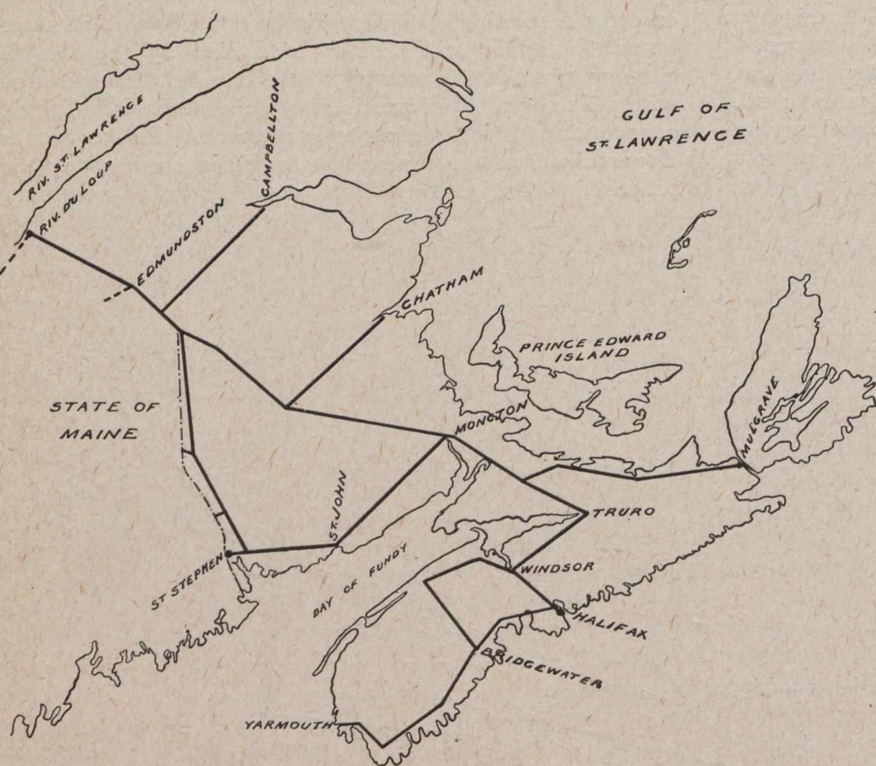


Fig. 2.—District Covered by Levels Run from B.M. at St. Stephen, N.B., Established in 1873 by the U.S. Corps of Engineers, and from Mean Sea-Level as Established by the Tidal Survey at Halifax, N.S.

Datum Planes and Territory Covered.—Geodetic levelling is always based upon mean sea-level as a datum, mean sea-level being assumed to be everywhere the same except insofar as it may be affected by the irregularities of the coast line, as, for instance, in land-locked bays or the estuaries of rivers in which the free entry and exit of the tide may be obstructed. Automatic self-registering tide gauges have been established and are maintained by the Tidal and Current Survey, Department of the Naval Service, at various points on the Atlantic and Pacific coasts; regarding the determination of mean sea-level by the aid of these gauges the superintendent of the survey, Dr. Dawson, has made the following statement: "The value of mean sea-level is found in the first place for a period of one continuous year at a time. It is based upon the height of the tide at every hour (day and night) taken from the autograph record of the tide gauge. By comparison with direct observations for time and height, the record from the registering gauge is reduced to a truly uniform datum from year to year, with relation to a bench mark. The value of mean sea-level in each year is thus the average of 8,760 individual measurements at successive hours without a break. If any serious interruption occurs, a fresh beginning is made. The basis for the final determination is in all cases a series of complete years of this character; and such determinations have evidently a very high accuracy."

The levelling of the Geodetic Survey has been started from five bench marks or reference points, in widely separated parts of the country, each one being connected—more or less directly—with mean sea-level. The first levelling was started from the United States Coast and Geodetic Survey bench mark at Rouse Point, N.Y., and two lines have been extended from this point, one easterly through Megantic and Levis to Edmundston, N.B., and Riviere du Loup, Que., with several branches to the international boundary, and the other westerly to Ottawa, Toronto and Windsor, also northerly to Sudbury and Sault Ste. Marie; at the end of last season this line had been extended 200 miles north of the Soo to Franz, the junction of the Algoma Central Railway with the main line of the C.P.R.; 3,370 miles of levelling are included in this district. The second initial-point was a bench mark at St. Stephen, N.B., whose elevation had been established by the United States Corps of Engineers in 1873; from this our levels have been carried northerly to Riviere du Loup, Que., and easterly to Moncton, N.B., the total amount of levelling, including cross lines and branches, being 1,022 miles. The initial-point for the third district was the automatic tide gauge at Halifax, mean sea-level at this point having been established by the Tidal Survey from their records extending over nine complete years. Two main lines of levelling have been run from Halifax, one extending to Yarmouth, the other to Moncton, the total amount of levelling included in this district being 592 miles. It is satisfactory to be able to state that the two elevations of the junction bench mark at Moncton, as derived from the St. Stephen datum and from the Halifax datum, differ by only two-tenths of a foot. The two elevations of the junction bench mark at Riviere du Loup, as derived from the St. Stephen datum and from the Rouse Point datum, differ by a little over four-tenths of a foot.

The initial-point for the fourth district was the United States Coast and Geodetic Survey bench mark at Stephen, Minn. To utilize this we were obliged to run 45 miles of levels through Minnesota to the international boundary at Emerson, directly south of Winnipeg. From Emerson one line was extended easterly to Port Arthur, the other westerly to Regina, Prince Albert, Edmonton, Calgary, etc. Last summer this line was carried west from Calgary over the summit of the Rocky and Selkirk mountains and was discontinued for the season near Revelstoke, B.C.; 3,279 miles of levelling are included in this district. The initial-point for the fifth district was the automatic tide gauge at Vancouver, mean sea-level at this point having been established by the Tidal Survey from their records extending over seven complete years. Levels from Vancouver extend southerly to the international boundary at two points and also easterly a comparatively short distance; 142 miles of levelling are included in this district.

From the above summary it will be seen that a transcontinental line has been almost completed, only two gaps in the line now remaining, one between Franz and Port Arthur and the other between Revelstoke and the end of the Vancouver line, the length of the gap, by a coincidence, being about 295 miles in each case. It is confidently expected that these will both be filled in during the coming season and we shall then have an unbroken line of precise levels connecting the tide gauge at Halifax with the tide gauge at Vancouver. This line is rapidly being paralleled by a second and in some cases by a third line where this is considered advisable.

Criticism has come from some quarters because the levels have been based partly upon intermediate points like Rouse Point, N.Y., and Stephen, Minn., instead of entirely upon the tide gauges on the sea coasts. At least two answers may be made to this: firstly, when the work was in a more or less experimental stage and the staff was inexperienced it would not have been advisable to conduct the levelling at such a great distance from headquarters; secondly (and more important), the results were required for the use of the International Boundary Surveyors and others, and with the limited organization then available it would have taken a very considerable period of time to carry levels from the Atlantic coast to the Quebec-Vermont boundary, for instance, or from the Pacific coast to the provinces of Saskatchewan and Manitoba.

Instruments.—The instrument adopted is a precise level of the United States Coast and Geodetic Survey pattern.

Great care has been expended on the construction of the rods used upon this work. They are built up of three pieces of white pine, giving a cross-section in the form of a symmetrical cross, this form having been found to offer the greatest resistance to bending and warping. They are boiled thoroughly in paraffin which tends to keep them of constant length under varying conditions of atmosphere and temperature. Silver plugs are inserted in the face of the rod approximately at the three, six and nine-foot points, and the exact positions of these points marked by a fine scratch on the face of the plug; the rod is then subdivided into feet, tenths and hundredths in alternate white and black spaces of one one-hundredth of a foot. When observing the rod the readings are made to thousandths, the hundredth spaces being subdivided by estimation. As it is impossible to subdivide a black space accurately at the distance the rod is usually observed, two sets of graduations are placed, side by side, one on each side of the centre line of the rod, the white spaces of one adjoining the black spaces of the other; thus the observer has always a white space to subdivide by reading on the right-hand or the left-hand set of graduation marks, as the case may be. The bottom of the rod is encased in a brass shoe which is fitted underneath with a hemispherical knob of steel; this is specially suitable for holding on a

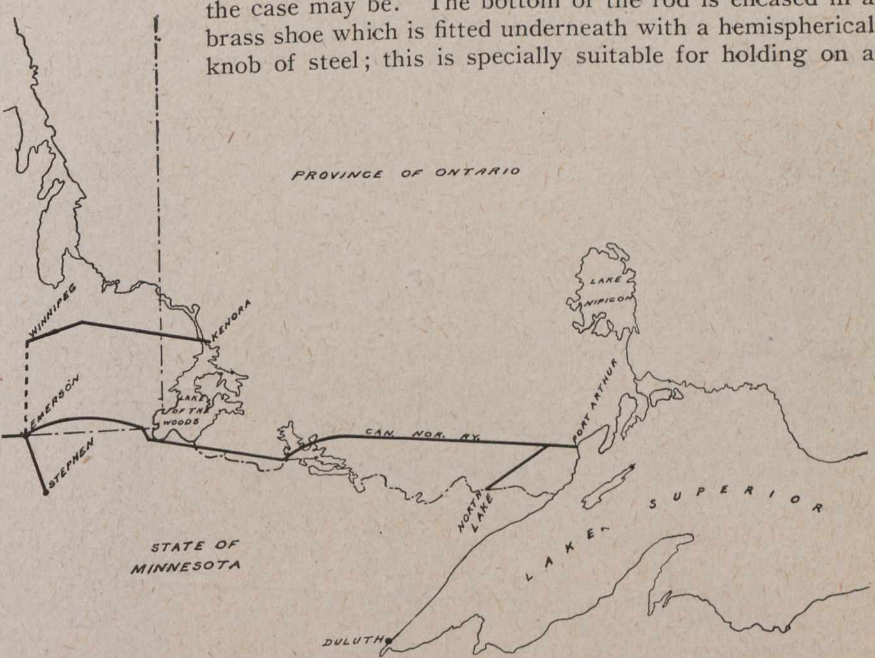


Fig. 3.—District Covered by Levels Run from the B.M. Established by the United States Coast and Geodetic Survey at Stephen, Minn.

flat surface such as the top of the rail of a railway track.

Another piece of apparatus which is very necessary is a large carriage umbrella with a handle about 8 feet long, provided with a spike at the end to insert in the ground. The umbrella is used whenever the sun is shining while observations are in progress, to shade the instrument from its rays; without this the parts would become unequally heated and irregular and unreliable action of the bubble would follow.

While carrying the instrument between sights a cover of duck or cravenette is used for the same purpose; this also is used to protect it when working during a light rain. In a heavy rain the work has to be discontinued.

Field Methods.—The standard bench mark established by the Geodetic Survey consists of a copper bolt ¾ inch in diameter and 4 inches long, stamped on the end with the letters "G.S.C., B.M." (Geodetic Survey of Canada, Bench Mark). The bolt is sunk horizontally in rock or masonry, a hole being drilled of the exact size of the bolt or a shade larger and the latter hammered till it completely fills the hole, the end being flush with the surface of the masonry or projecting slightly. Properly put in, it is impossible for anyone to remove it without destroying the surrounding rock or masonry. After the exposed end has been planed to a smooth surface by means of a file, it is stamped with a steel die containing the above-mentioned letters. Then, by means of a cold chisel, a horizontal cross mark is made, upon which the elevation is taken; finally the number is stamped with other steel dies. Elevations are not marked on because the elevation of a bench mark is a precise levelling net may not be finally decided upon for a long time. The closing of circuits and introduction of new cross lines will call for adjustments which will make changes of greater or less magnitude in the elevations. Also, the computation of the elevations from the field notes is a work of some magnitude and would delay the operations of the parties were it performed in the field. It is, therefore, left to be done in the office after the notes have been carefully checked. I might say, also, that an engineer would not usually attempt to look for the bench marks haphazard, but would set out armed with descriptions of their locations.

Levellers are instructed to aim at getting bench marks at intervals of about three miles when suitable locations can be found, and in no case to run more than eight miles without establishing one. To comply with the latter requirement it has been found necessary to erect, at certain points, concrete piers, specially for bench marks. These piers are 6 feet 3 inches high, 9 inches square at the top and 15 inches square at the bottom, resting on a concrete footing. The whole pier is buried to within about 9 inches of the top, and the copper bolt built in, near the ground surface, having been previously stamped and numbered. The piers are usually built on the railway right-of-way, within 3 or 4 feet of one of the fences and on fairly level ground, where they will not be exposed to danger from future alterations in the railway grade.

Temporary bench marks are placed at intervals of 1 mile or thereabouts. They consist usually of spikes, driven horizontally into telegraph poles, and, as their designation implies, they are used only for convenience while the work is progressing. They are not embodied in the final records.

Besides establishing our own bench marks as above described, it is our practice to connect with any permanent or semi-permanent bench marks of other organizations which may be encountered en route. Engineers are thus enabled, if they wish, to reduce their elevations to our precise datum without any additional field work on their part.

A precise levelling party consists of seven men, the chief or leveller, recorder, two rodmen, umbrellaman, cook and a railway employee, usually a section man, to pilot the hand-car. Camps are made at the stations along the line, the distance apart varying from 10 to 20 miles. The levelling is carried continuously forward, day by day, through the camp and to a point about half-way to where the next camp ahead will be.

General instructions issued to levellers are: "All lines are to be levelled twice, in opposite directions, called forward and backward levelling. Backward shall in every respect be independent of forward levelling and the same turning points shall not be used. If the forward levelling is made in the forenoon, the backward—over the same section—should be made in the afternoon, it being desirable to secure as much difference in atmospheric conditions between the forward and backward measurements as is possible without materially delaying the work for this purpose.

"Other things being equal, it is considered better practice to complete all forward levelling to be done at one camp before making any backward measurements, rather than to run a few sections forward and then backward and repeat this process two or three times before moving camp.

(Read before the Royal Astronomical Society of Canada, at Ottawa, March 31, 1916.)

(To be continued.)

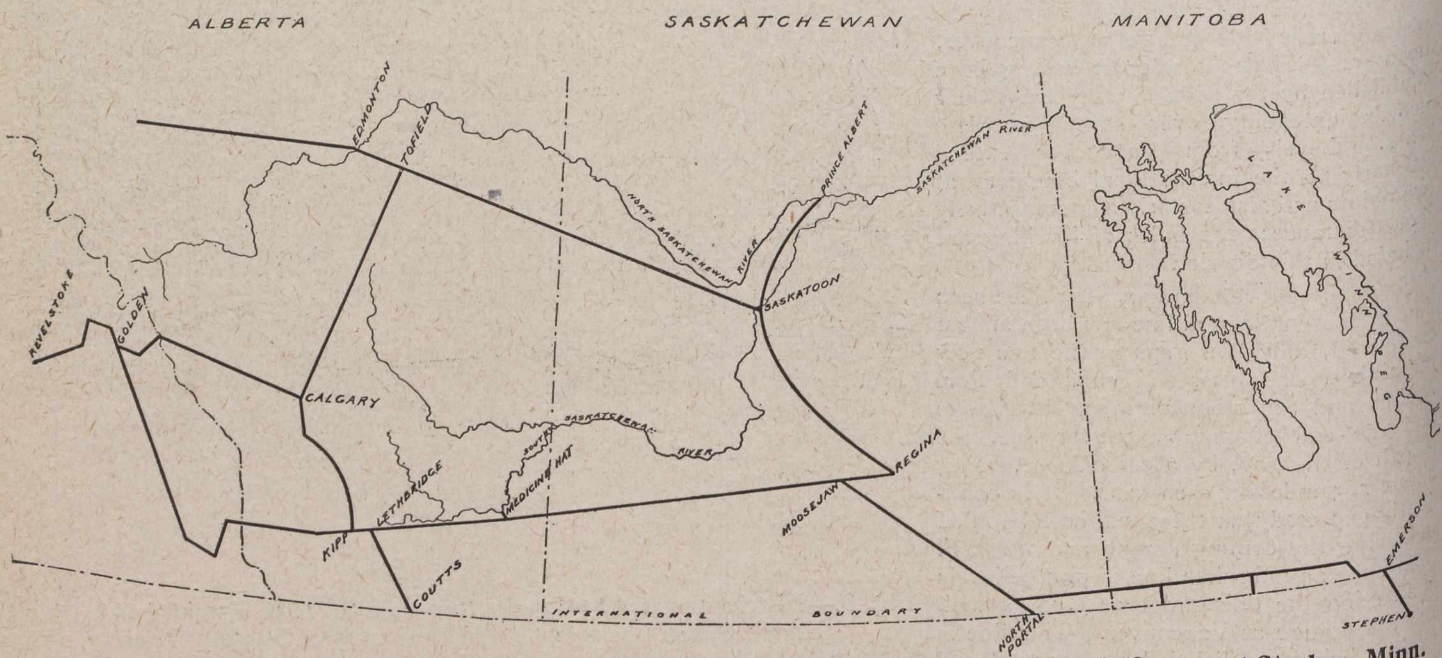


Fig. 4.—District Covered by Levels Run from B.M. of the United States Coast and Geodetic Survey at Stephen, Minn.

Satisfactory accounts have been received of the performance of the ice-cutting car-ferry Leonard which was built by Messrs. Cammell, Laird and Company to convey the National Transcontinental Railway Company's trains across the St. Lawrence from Quebec to Point Levis. Since her first trip in May last the vessel has transferred as many as 90 cars in a single day. The trains are carried on a tidal or upper deck, which has three lengths of track, 272 ft. long and each able to hold three passenger coaches. The vessel has three sets of triple expansion engines, two being for propulsion, while the third drives the ice-cutting propeller, which is fitted at the bow.

SOOKE LAKE PIPE LINE SUCCESSFULLY OPERATES THROUGH A HARD WINTER.

THIS pipe line was built in order to utilize Sooke Lake as a water supply for Victoria, B.C. The contract for the construction of the line was awarded to the Pacific Lock Joint Pipe Company, and the contractors, having the necessary forms on hand for a 42-inch pipe, agreed to put in a 42-inch pipe instead of a 40-inch pipe, as had been suggested by the engineers. The pipe was made of a shell 3 inches in thickness and in 4-foot lengths, except the pipe for syphons, which was more heavily reinforced, the shell being 4 inches thick.

In *The Canadian Engineer* for November 18th, 1915, there was published an illustrated description of the above work as presented before the American Society of Municipal Improvements by Mr. C. H. Rust, the city engineer and water commissioner of Victoria, B.C.

As a piece of municipal engineering work, this job attracted a great amount of attention, and for this reason

Fig. 1.—Circuitous Route followed Owing to the Rough Nature of the Ground.

we feel that it would be desirable to recapitulate some of the details of this plant, and also to give further information which has been supplied to us by Mr. Rust, this information being of particular interest as it has been secured after the work has successfully weathered the winter storms and the particularly cold temperature which prevailed on the Pacific Coast last winter. After nine months of operation the Sooke Lake pipe line emerges victoriously in that no material damage has been done during its first months of actual operation. This is all the more remarkable when it is stated that Vancouver Island has, during the past winter, experienced the coldest weather it has ever known, so far as the recollection of the oldest inhabitant goes. It went as low as 12° below freezing. Luckily, however, the snow was excessive, which probably protected some of the work to a greater or lesser extent.

Owing to the deep snow it was difficult for the patrol men to keep up communication and they suffered a good deal of hardship in getting in supplies. The only damage done to the pipe was occasioned by a small slide which, however, was not serious. Nearly the whole length of

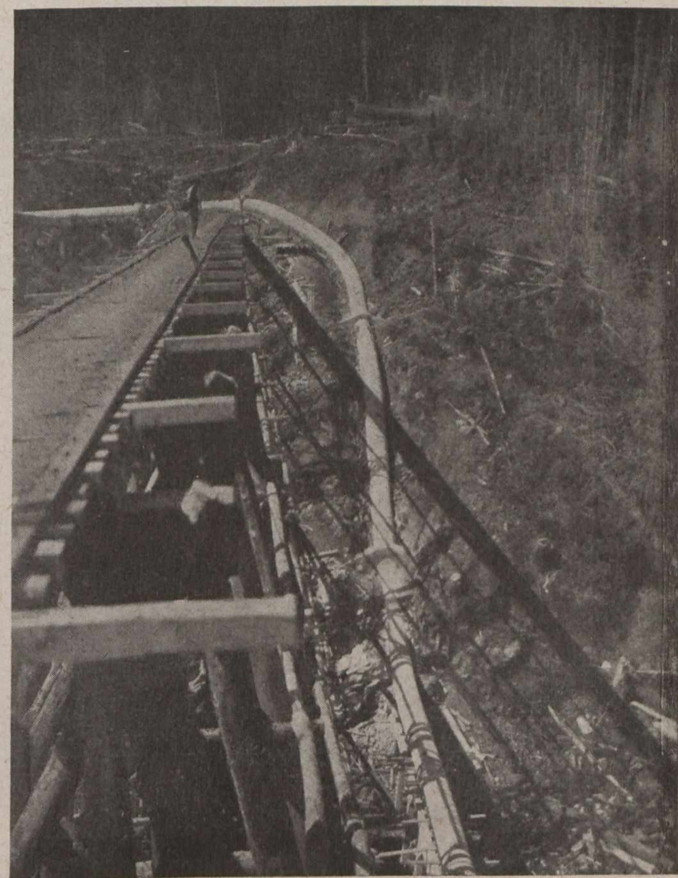


Fig. 2.—Construction Railway Trestle and Syphon Over Ravine.

the pipe, which is 27½ miles long, is laid on the side of a mountain and of the total length of pipe 55 per cent. is in curve; the longest tangent being 600 feet. This will give some idea of the difficulty of the construction work, not only from the point of view of alignment, but from the point of view of the contractor, who had to transport

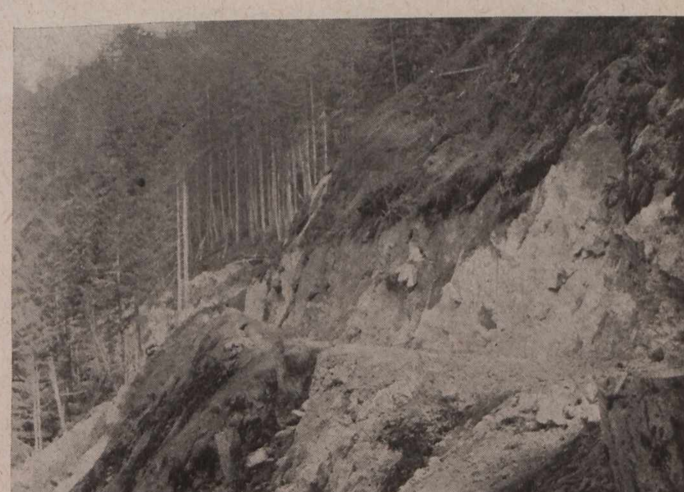


Fig. 3.—View Showing Rough Nature of Ground Over which Pipe Line was Constructed.

material to all parts of the line. A road-bed 8 feet wide was constructed for the pipe, which was built as a flow line conduit. The construction of this road-bed necessitated the removal of about 270,000 cubic yards of material, over half of which was rock. This rock was hard trap except in the 2½-mile section near Sooke Lake,

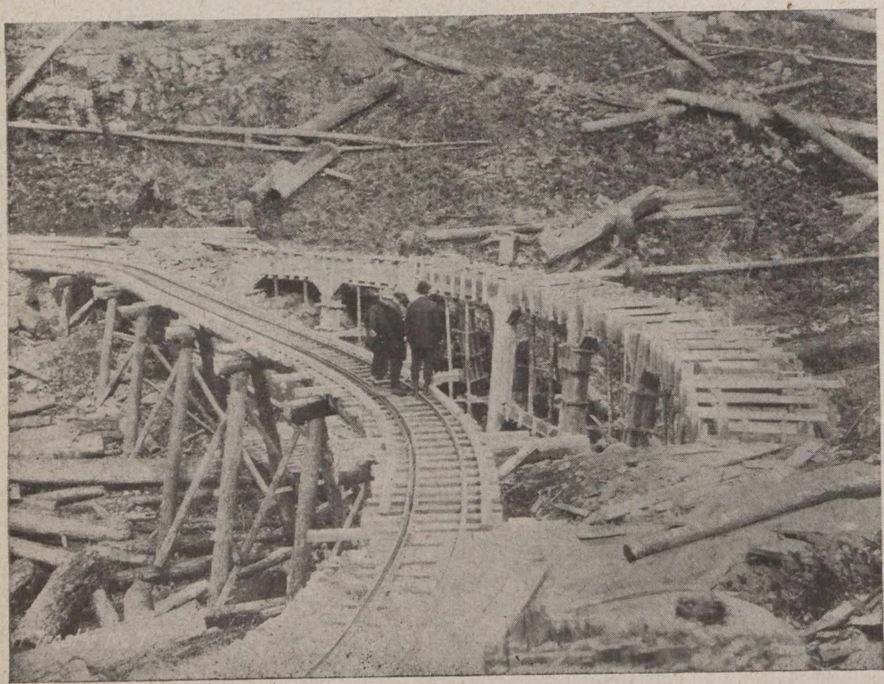


Fig. 4.—View Showing Timber Trestle of Construction Railway and Concrete Trestle for the Pipe Line.

which was schistose. This latter part of the pipe line was covered, as slides were feared. The remainder of the line was left uncovered.

In order to facilitate the work, a narrow-gauge construction railway was built paralleling for the most part the line of the concrete pipe. This was built to flow line grade, temporary log trestles being built over ravines which the pipe line syphoned across. The deepest syphon is 600 feet long and has a head of 90 feet operating. The general grade of the flow line is one in a thousand.

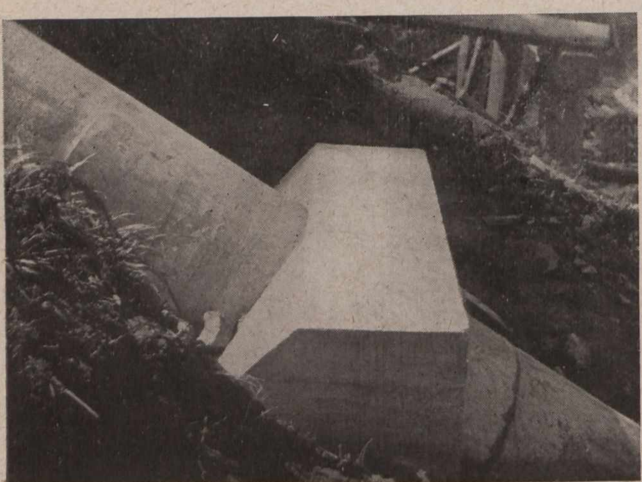


Fig. 5.—Concrete Anchor in a Syphon Section of the Pipe Line.

Particular attention was paid to this railway, the trestles of which were built of the available timber in the locality. Water barrels were installed on the trestles for fire protection. The road-bed in all other places was rock ballasted. The rails used were 20 pounds and were laid on split ties of Douglas fir. Wherever it was deemed necessary for the expedition of the work, side tracks were cut in.

As fast as the railway was available for operation the concrete aggregate, reinforcing, timber, etc., were hauled out and permanent structures started. The concrete trestles, which were generally located on sharp curves, were the chief item.

The pipe, which was manufactured at Cooper's Cove, has been described in these columns before. It was delivered to all parts of the work by the railway. It was found that when pipe had been properly covered there was no danger of it being damaged in transit, and no precautions out of the ordinary were taken to protect the pipe. On the syphons large concrete anchors were cast around the pipe, as shown in the accompanying photograph. At the bottom of the valleys, which were syphoned over, the pipe was laid on concrete trestles and a clear waterway left for floods beneath the pipe. No particular difficulty was experienced in laying the pipe, which was done with a pipe tripod and chainblock, an overhead trolley system proving a failure owing to the crookedness of the lines.

The pipe has withstood the ravages of winter well; no very large leaks developing. It is noteworthy that the specifications for the pipe did not require that the pipe should be absolutely watertight. The specifications stated that "the pipe shall be considered tight, provided that the accumulated leakage at any place does not show greater than as continuous drops leaving the outside surfaces of the pipe at any point. The Pacific Lock Joint Pipe Company, who supplied the concrete pipe and guaranteed it for one year, are repairing the few small leaks which have developed during the winter.

RAILROAD EARNINGS.

The following are the weekly railway earnings for March:—

Canadian Pacific Railway.

	1916.	1915.	
March 7	$2,198,000	$1,667,000	+ $531,000
March 14	2,258,000	1,731,000	+ 527,000
March 21	2,281,000	1,738,000	+ 543,000
March 31	3,491,000	2,564,000	+ 927,000

Grand Trunk Railway.

March 7	$ 992,026	$ 852,151	+ $139,875
March 14	957,542	857,147	+ 100,395
March 21	967,233	857,937	+ 109,296
March 31	1,592,442	1,346,969	+ 145,473

Canadian Northern Railway.

March 7	$ 540,200	$ 428,700	+ $111,500
March 14	538,000	412,000	+ 126,000
March 21	549,000	421,700	+ 127,300
March 31	979,800	637,000	+ 342,800

The following are the railroad earnings for the first week of April:—

Canadian Pacific Railway.

	1916.	1915.	
April 7	$2,482,000	$1,766,000	+ $716,000

Grand Trunk Railway.

April 7	$1,155,486	$1,008,320	+ $147,166

Canadian Northern Railway.

April 7	$ 677,000	$ 457,000	+ $220,000

GRAPHICAL TREATMENT OF ELASTIC RIBS.

I. BEAMS.

THE deflection of curved or straight beams or arch ribs can easily be determined analytically, according to C. S. Whitney, M.C.E., in "The Cornell Civil Engineer," by the use of the calculus for very simple cases, but where the shape of the rib is irregular or the moment of inertia is variable so that it cannot be expressed by a simple equation the treatment becomes

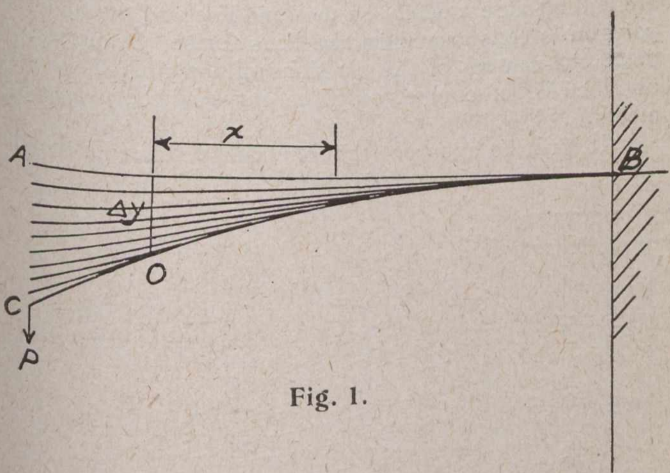


Fig. 1.

quite difficult. By the remarkably simple method explained below it is possible to draw to scale the elastic curve for any rib or beam under any load in a very short time. The method seems to be practically unknown in this country, and although it is original with the writer he has found that it has been in use in Europe for some time.

Although American engineers prefer the theory of least work in solving statically indeterminate structures, the theory of virtual displacements is often much simpler; and, aside from its use in determining deflections, the method here outlined in combination with the theory of virtual displacements affords the simplest of all methods of analyzing such structures as continuous beams, two-hinged arches, or fixed reinforced concrete arches. Asymmetry or irregularity of section does not affect the ease of solution. Results can be obtained by the graphical method with any degree of accuracy which may be warranted by practical considerations.

The deflections are obtained by the graphical integration of the familiar equations

$$\Delta x = \int \frac{M\,y\,ds}{EI},\quad \Delta y = \int \frac{M\,x\,ds}{EI},\ \text{and}\ \Delta \phi = \int \frac{M\,ds}{EI},$$

the derivation of which may be found in Church's "Mechanics of Engineering" and other texts. It must be noted that the integration is from the point of which the displacements are to be obtained to the point where the rib is considered fixed and the displacements secured are relative to the tangent and normal at the point considered fixed.

In the case of the simple straight cantilever (Fig. 1) the y displacement, Δy, of any point O relative to the tangent AB is equal to $\int_0^B \frac{M\,x\,ds}{EI}$ or if the beam be divided into small Δ s's the value of Δy is approximately $\sum_0^B \frac{M\,x\,\Delta s}{EI}$. If the value of $\frac{\Delta s}{EI}$ be made a constant, then

$$\Delta y = \frac{\Delta s}{EI}\sum_0^B M x \qquad \text{Eq. 1.}$$

The simplicity of this equation suggests a graphical summation which may be accomplished by means of the force polygon and funicular polygon, as shown in Fig. 2.

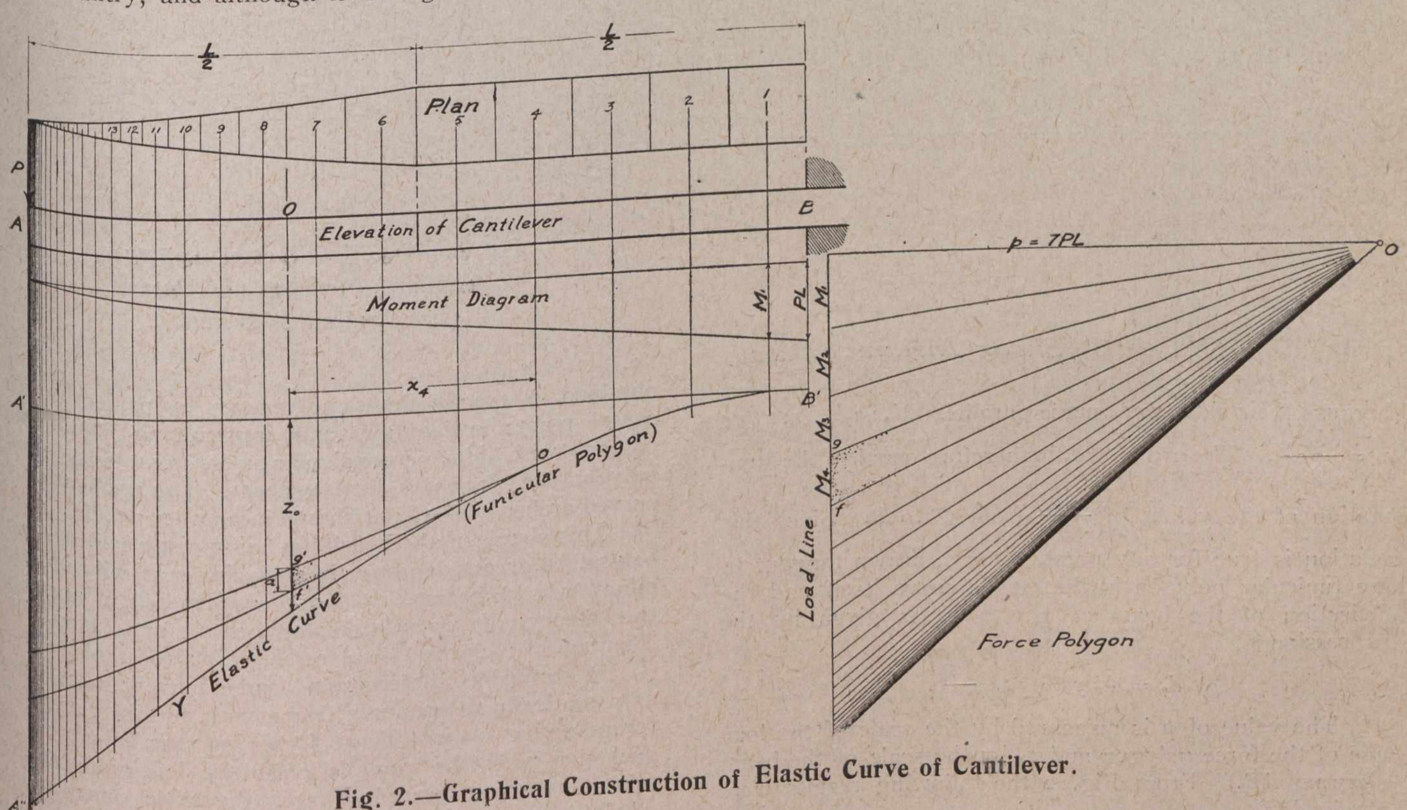


Fig. 2.—Graphical Construction of Elastic Curve of Cantilever.

As an example, we will consider a cantilever beam with a wedge-shaped end. The beam is first divided into small lengths so that $\frac{\Delta s}{EI}$ is a constant. A moment diagram is then drawn for the assumed condition of loading which will be taken as a concentrated load at the end.

The centres of the different divisions of the beam are projected down through the moment diagram and the corresponding moments are laid off algebraically in order on the load line of the force polygon. A pole is then chosen at any convenient distance, p, from the load line and the rays are drawn. The funicular polygon $A''B'$ is drawn with its sides parallel to the rays of the force polygon just as though the moments were forces acting at the centres of gravity of the division of the beam. A consideration of the geometry of the two figures will show at once that the ordinate z_0 is equal to $\sum_0^B Mx$ divided by p, that is $\sum_0^B Mx = pz_0$. This may be seen from the two shaded triangles Ofg and $o'f'g'$ which are similar because their sides were made parallel. $M_4 : a = p : x_4$ or $a = \frac{M_4 x_4}{p}$. The ordinate z_0 is therefore equal to the summation of the values of $\frac{Mx}{p}$ from O to B. Since this relation is true for any point, a curve drawn tangent to the funicular polygon is the elastic curve itself and the deflection of the beam at any point is given by the expression

$$d_0 = \Delta_0 y = pz_0 \frac{\Delta s}{EI}.$$

The value of p is measured by the scale of the load line of the force polygon and z_0 by the scale of the beam diagram AB. From Fig. 2 the following results were obtained:

$$z_A = A''A' = .506L$$

$$d_A = 7\,PL \times .506L \times \frac{\Delta s}{EI}$$

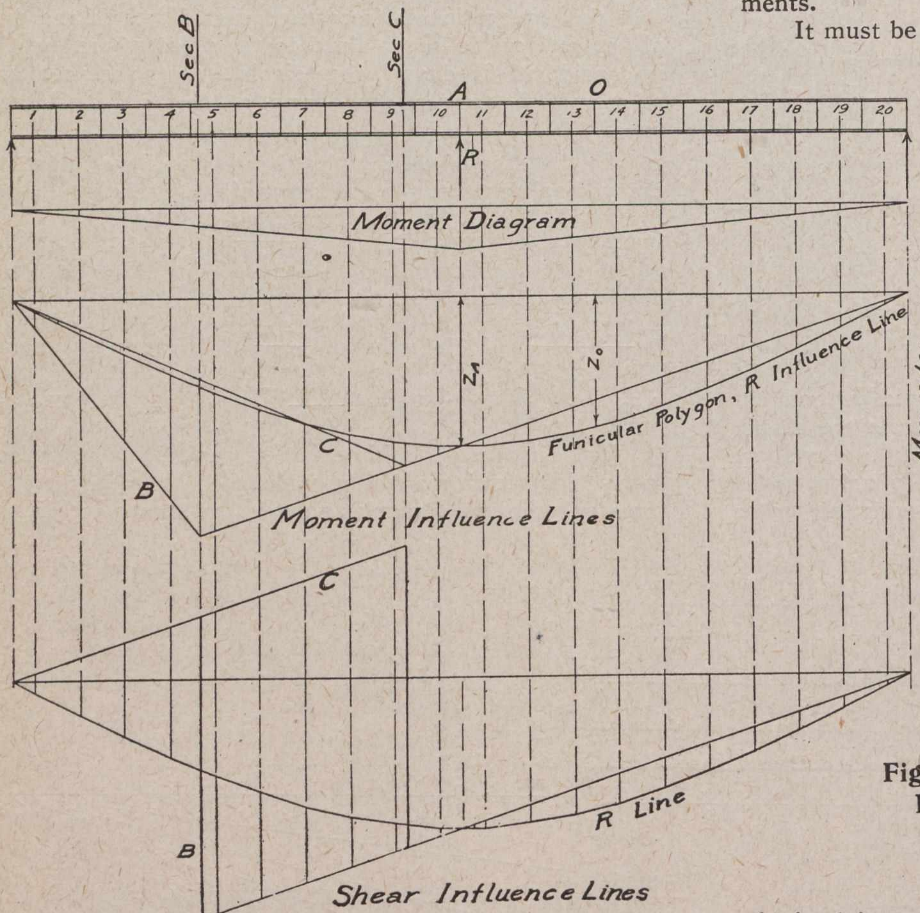
$$\frac{\Delta s}{EI} = \frac{L}{10\,EI_B}$$

$$d_A = \frac{3.542\,PL^3}{10\,EI_B} = 0.3542\frac{PL^3}{EI_B}$$

Church's "Mechanics of Internal Work" gives the value $.3540\ \frac{PL^3}{EI_B}$ for the deflection of the same beam. Eighteen or twenty divisions of the beam or rib are enough for ordinary cases and the scale need not be made large to bring the error within one or two per cent.

Exactly the same method may be applied to ribs with curved or polygonal axes. The moments for any loading are laid off algebraically on the load line and the funicular polygon is constructed on the lines formed by projecting down the centres of the divisions of the rib. The curve obtained is, of course, only the curve of the y displacements.

It must be apparent that the x-displacements may be



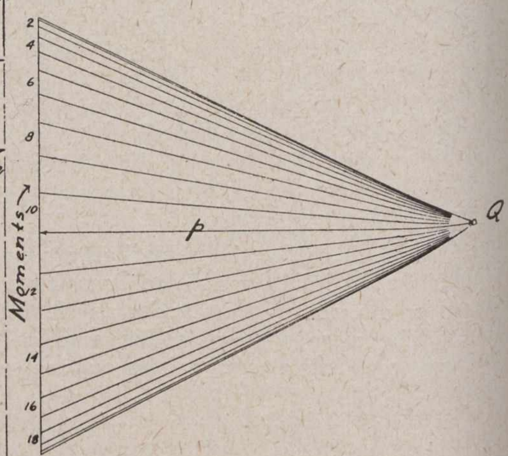


Fig. 3.—Graphical Determination of Reactions, Moments and Shears for Continuous Beams.

obtained in exactly the same manner by projecting the centre points horizontally and constructing a funicular polygon with sides perpendicular to the rays of the force polygon used for the y-displacements. The application to curved arched ribs will be shown in another article.

This simple method of determining displacements may be used to great advantage in analyzing statically indeterminate ribs or beams. It is used as a means of applying the theory of virtual displacements, and Maxwell's Theorem of reciprocal displacements is also employed.

A statically indeterminate frame may be considered as a statically determinate frame with certain redundant forces acting on it. These forces or reactions must be such that when the frame is loaded its deflections at certain points are as desired. That is, the deflections at points of rigid supports must be zero, etc. The deflections of a frame when acted upon by a number of forces are equal to the sums of the deflections produced by the forces acting independently and this makes a simple analysis of a complex structure possible.

Consider the simple case of the cantilever previously treated and let an unyielding support be placed under the free end. The beam then becomes a statically indeterminate beam fixed at one end and simply supported at the other. Neglecting the effect of the redundant simple support, let the deflection of the free end point A produced by the load P concentrated at any point, O, be $\Delta_{AO} = P\delta_{AO}$, δ_{AO} being the deflection at A under unit load at O. The reaction at A must be just great enough to produce an equal and opposite deflection of the point A or Δ_{AA} must be equal to Δ_{AO}

or

$$\Delta_{AA} = R\delta_{AA} = P\delta_{AO}$$

and

$$R = P\frac{\delta_{AO}}{\delta_{AA}}$$

According to Maxwell's theorem of reciprocal displacements the deflection at O produced by a unit load at A is equal to the deflection at A under unit load at O or

$$\delta_{AO} = \delta_{OA}$$

then

$$R = P\frac{\delta_{OA}}{\delta_{AA}}$$

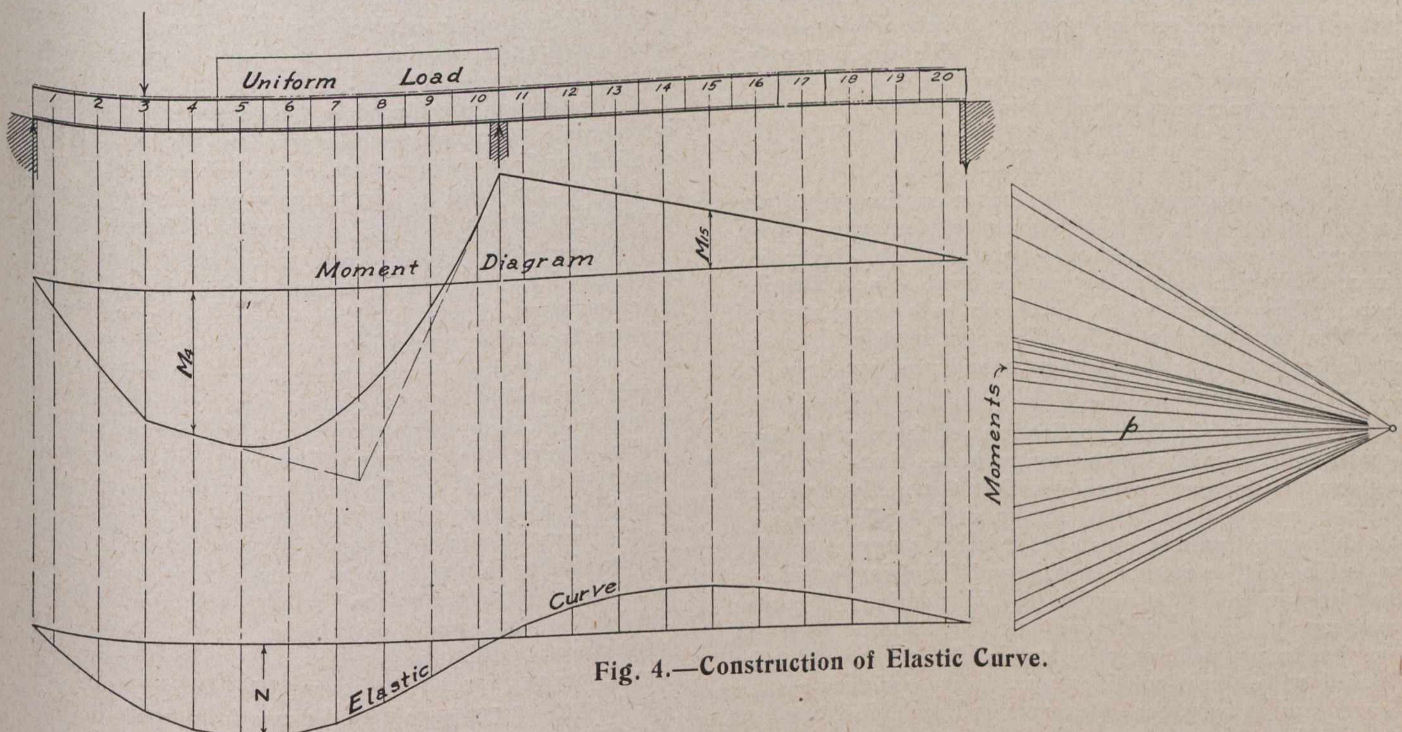


Fig. 4.—Construction of Elastic Curve.

In Fig. 2, the elastic curve of the simple cantilever under a load at A is already found so that when P is unity

$$\delta_{OA} = z_O\, p\frac{\Delta s}{EI} \text{ and } \delta_{AA} = z_A\, p\frac{\Delta s}{EI}$$

or

$$R = P\frac{\delta_{OA}}{\delta_{AA}} = P\frac{z_O}{z_A}$$

from which the reaction at A under a load P at any point may be easily found. The elastic curve previously determined then becomes the influence line from the reaction R since R equals the constant $\frac{P}{z_A}$ times the ordinate of the curve under the point of load.

It should be noted that the solution may be made perfectly general and also that the effect of a displacement of the support may be considered. If the support at A settled an amount d, the reaction would then only have to be great enough to produce the deflection ($\delta_{OA} - d$) at A and the formula for R becomes,

$$R = P\frac{\delta_{OA} - d}{\delta_{AA}} = P\frac{z_O - \frac{dEI}{p\Delta s}}{z_A}$$

The preceding example is of theoretical interest only and is given to explain the method. In order to make the method clearer it will now be applied to the case of a centre-bearing girder swing-bridge which is in the form of a two-span continuous beam. The complete solution, including typical influence lines for shear and moments, is given in Fig. 3.

The girder is statically indeterminate to the first degree and the centre bearing may be considered as a redundant support. Let the centre support be removed and replaced by a unit vertical force. The moment diagram for the resulting simple beam may then be drawn. The girder should be divided into about twenty parts making $\frac{\Delta s}{EI}$ constant. The centres of these parts are then projected down in parallel lines. The ordinates of the moment diagram under these centre points are laid off to scale on the force polygon with a pole at Q and pole length p. The funicular polygon is then drawn with its sides parallel to the rays and the closing line of the polygon is a check on the accuracy of its construction. As before, the curve tangent to the polygon is the elastic curve and the deflection of the beam under central load is $\frac{zp\Delta s}{EI}$. Since the centre is so supported that there can be no deflection there, the deflection of the centre point produced by the centre reaction must be equal and opposite to that produced by the superimposed load or for a load P at any point O

$$R\delta_{AA} = P\delta_{AO} = P\delta_{OA}$$

and

$$R = P\frac{\delta_{OA}}{\delta_{AA}} = P\frac{z_O}{z_A}$$

The curve tangent to the funicular polygon, the elastic curve, is therefore the influence line of the centre reaction. The different values of z can be readily scaled off and tabulated as desired. When the centre reaction influence line has been constructed, influence lines for moment and shear at any section may readily be constructed and the position of load for maximum stresses determined without the use of involved formulae. When the load is on the right of the section considered, the moment at the section is equal to

$$\frac{Pa}{2}\left(\frac{2x}{l}-\frac{R}{P}\right)$$

in which x is the distance of the load from the right end, a is the distance of the section from the left end and l is the total length of both spans. Also for a load P on the right of the section, the shear at the section is equal to

$$\frac{P}{2}\left(\frac{2x}{l}-\frac{R}{P}\right)$$

From these two equations the influence lines may be drawn as shown in Fig. 3.

The ease with which the deflection at any point of a girder of variable moment of inertia under irregular loading may be obtained is shown in Fig. 4. The girder is divided up as before so that $\frac{\Delta s}{EI}$ is constant. For the assumed combination of loading the centre reaction is obtained from the reaction influence line and the moment diagram is constructed. The average moment ordinates for the different Δ s's are laid off algebraically in order on the load line of the force polygon, positive moments downward and negative moments upward. The funicular polygon is then drawn and the deflection of the beam at any point under the assumed loading is equal to

$$d = \frac{zp\Delta s}{EI}.$$

The funicular polygon should be drawn continuously from one end to the other and the long closing line when drawn between the end points should pass through the point directly under the centre support as there is no deflection there. This serves as a check on both moments and graphical construction. The effect of a settlement of the centre support on the moments and reactions can, of course, be considered if desired.

Two of the simplest applications of the method have now been explained and the writer hopes that they have been made clear as he believes that the method will be found very valuable. It is not possible for him to give it a thorough treatment here but it is his intention to give an outline of the method in this and following article so that it may easily be applied to the solution of those ordinary statically indeterminate structures used in practice to which it may be applicable. It may also be applied with slight modifications to trussed frames and braced arches as well as to beams and arch ribs, but that can not be taken up here. Its use for the design of the Sciotoville bridge is explained by Mr. D. B. Steinman in the "Engineering Record" of August 28, 1915, page 258. Many very laborious methods of applying the elastic theory are still in use and the writer is at a loss to know why they have not before been simplified.

The theory of virtual displacements is much simpler in most cases than the theory of least work because by its use the effect of the various forces on the structure can be considered separately as acting on a statically determinate frame while the least work theory requires that the effect of all the forces be combined in one equation and the equation differentiated. The latter method seems to be more popular with teachers as it lends itself to nice mathematical treatment but the writer has found that for any but very simple cases the former method, which involves no long equations, is easier to apply and more practical.

The Panama Canal, which has been closed to navigation since September 18, 1915, owing to landslides, will be reopened for vessels of deep draught, April 15, according to an announcement by the acting Governor of the Canal Zone.

METHODS OF CREOSOTING DOUGLAS FIR.

Some important investigations into the effect of commercial treatments upon the strength of Douglas fir bridge stringers have been described in "Wood-Preserving" by O. P. M. Goss, who was in charge of the Seattle Timber-testing Laboratory of the United States Forest Service. The results of these investigations have recently been published by the Forest Service in Bulletin No. 286, and show that bridge stringers treated by the boiling and steaming processes lost from 33 to 35 per cent. of their original strength. Due to this loss in strength, it was necessary to use low fibre stresses in the design of structures built of creosoted timber. In an effort to eliminate this difficulty a large number of experiments have been made with various treatments.

The most successful treatment yet devised for treating bridge stringers and similar forms without loss in strength is that of "boiling under a vacuum." When green timbers are creosoted by this method the treatment requires approximately 26 hours, and is, in general, as follows:—

The timbers are placed in the retort and creosote oil introduced at a temperature of 160° to 180° F. Heat is applied, and the temperature of the oil gradually raised to 190° F. and held at that temperature for 5 to 6 hours, a sufficient length of time to warm the timbers through.

When the timbers are thoroughly warmed, a vacuum of 24 to 27 in. is drawn on the oil, still holding a temperature of 190° F. This vacuum is drawn through an overhead pipe extending from the top of the retort for 36 ft. vertically into the air and returning to the condenser. The purpose of this pipe is to prevent the creosote oil from boiling over into the condenser while boiling under the vacuum. This vacuum is started at 16 to 18 in., and as the timber seasons, is gradually raised to 24 to 27 in. The full period of vacuum is 12 to 16 hours. It is continued until the rate of seasoning of the timber is 0.1 lb. of water per cubic foot of wood per hour. After this finished rate of seasoning is reached the vacuum is broken and pressure on the oil started, which rises as high as 120 to 135 lbs. per square inch, and continues for 4 to 6 hours. The temperature of the oil during the pressure period drops from 190° to 180° F. By this process 10 to 14 lbs. of oil per cubic foot may be pressed into the wood.

This method is a modification of the Boulton process, and at the low temperatures used seasons the wood even better than the old oil-boiling process, which employed so much higher temperatures. Timbers treated by the method of "boiling under a vacuum" are noticeably easier to press than timbers treated under the old boiling process. The edges of the checks which develop, due to seasoning, are very sharp, showing that the wood is not burned at all.

In a note on new antiseptics *Nature* refers to the use of electrolysed sea-water for the disinfection of hospital ships, remarking that though the production of hypochlorite by the electrolysis of salt solution for bleaching purposes, and the powerful antiseptic properties of hypochlorite so produced, have long been known, the idea of electrolysing sea-water on the vessel which is to be disinfected is a novel one. It is due to Dr. H. D. Dakin, whose apparatus consists of an electrolytic cell, which, with a current of 65-75 amperes at 110 volts, yields a solution of two parts per 1,000 of hypochlorite at a cost of about 3d. per 100 gallons. This solution, diluted with an equal volume of sea-water, is sufficiently strong to sterilize floors, decks, latrines, etc. It has been used on the *Aquitania* on her last two voyages, with excellent results.

FEDERAL PLAN COMMISSION'S REPORT

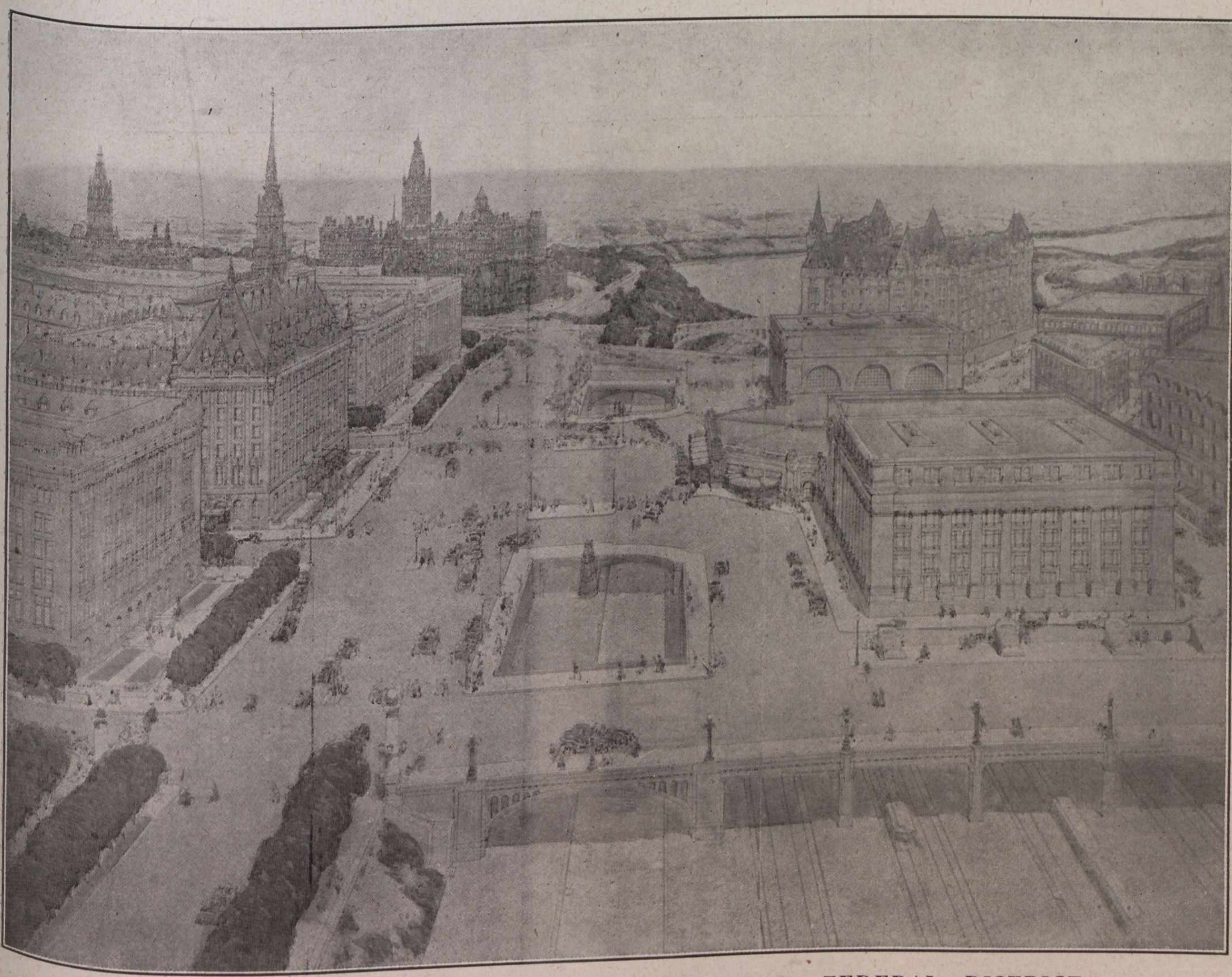
GOVERNMENT RECEIVES RECOMMENDATIONS LOOKING TOWARD THE CREATION OF A TRULY IMPOSING CAPITAL—NEW GROUPS OF GOVERNMENT BUILDINGS, NEW CIVIC BUILDINGS, PLAZAS, BOULEVARDS, PARKS, BRIDGES, TUNNELS, SUBWAYS, ETC., INCLUDED IN PLAN.

SIR THOMAS WHITE, Minister of Finance, last month presented to Parliament the report of the Federal Plan Commission on a general plan for the cities of Ottawa and Hull.

The report is very comprehensive, looking to the future growth and development of the cities of Ottawa and Hull and their environs, and particularly providing for the location and beautification of parks and boulevards, for the location and architectural character of public buildings, and for adequate and convenient arrangements for traffic and transportation.

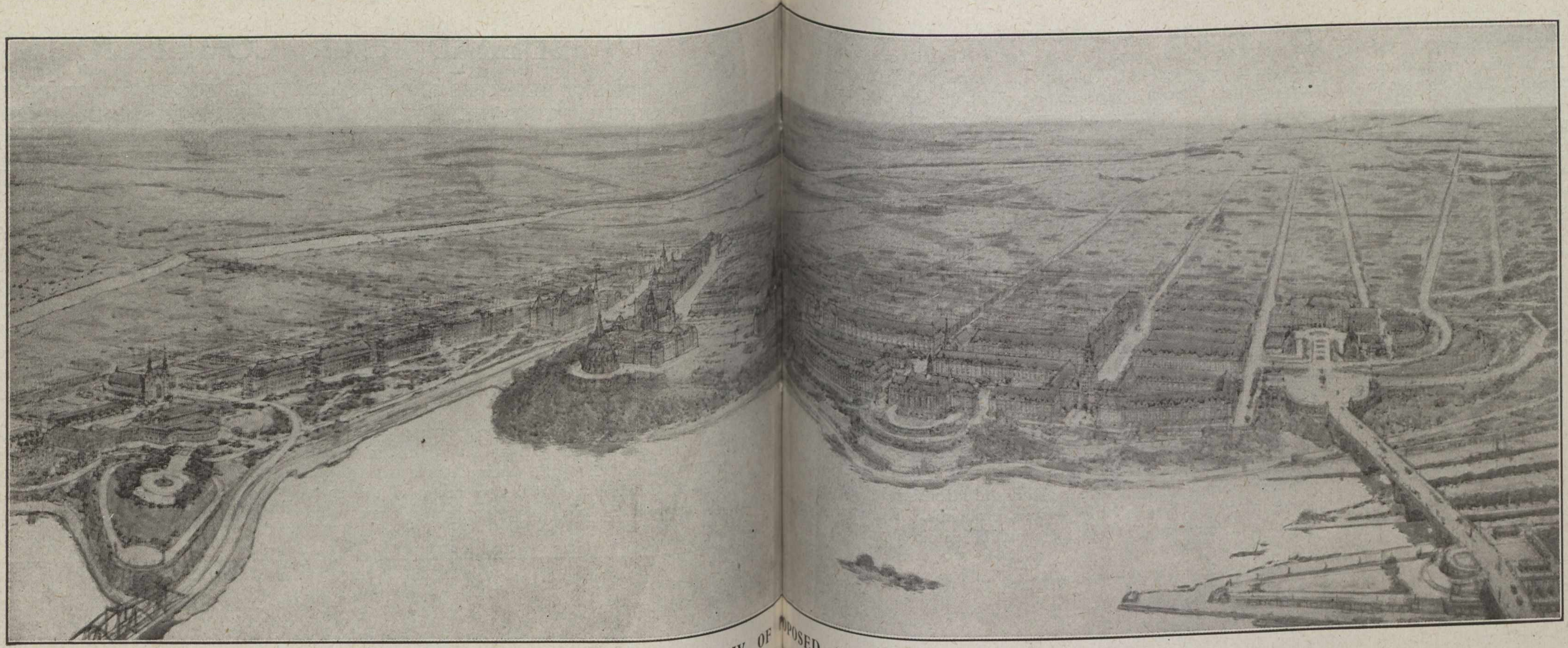
As the first step in the development, the formation of a federal district for Ottawa and Hull is urged by the Commission. In 1858, when Ottawa was chosen as the capital, Canada was merely a union of the provinces of Quebec and Ontario. Neither province was willing that the other should have the capital within its borders, and accordingly for many years the government was migratory. It was soon seen, however, that the government must have a permanent home, and the matter was referred to Queen Victoria, who chose Ottawa. The choice was a happy one, because, while in the Province of Ontario, Ottawa is only across the river from the Province of Quebec, and is much nearer Montreal, the commercial centre of Quebec, than it is to Toronto, the commercial centre of Ontario.

Now that Canada has become a great federal state, however, it appears to the Commission that there is something anomalous in leaving the capital of the whole federation under the municipal laws of one of its provinces. Federal control alone will ensure the carrying out of really adequate plans. Certainly the needs and dignity of the capital are the business of the people of all Canada.



MUNICIPAL AND RAILWAY CENTRE OF PROPOSED FEDERAL DISTRICT.

Reconstructed Central Portion of Ottawa, Ont., as it will be after Federal Plan Commission's Work is Completed, if Government Proceeds with Programme Suggested. View looking north toward the Parliament Buildings, showing Plaza, proposed Post Office on the right and proposed City Hall on the left.



GENERAL VIEW OF PROPOSED FEDERAL CAPITAL.

Looking southward from Hull, showing river front and Parliament Buildings, proposed Departmental and Court Buildings and future extensions.

Moreover, it could not be expected that a municipality would be able to perform such a task on an adequate scale, or that a steady, continuous policy could exist under municipal government.

Improvements Recommended.—The general aspect of Ottawa will certainly be imposing when the proposed improvements are made. The central area in the city will be a great open space running southward from Chateau Laurier and the Plaza Bridge, and at the same level. Canal, railway and cartage traffic will be on a lower level. The present Grand Trunk station will be enlarged into a Union Station. The present post office will be removed and an imposing one erected facing the Plaza. A new city hall and various law courts, registry offices, etc., will also be constructed facing the Plaza.

A great thoroughfare connecting the east and west portions of the city will be made of Laurier Avenue, which will be widened to 90 feet. The grade of this avenue will be improved by a tunnel at the west end and by the lowering of a bridge across the Rideau.

The land west of the parliament buildings will be used for departments of the government. Here, in time, a second group of buildings will be constructed to harmonize with those on Parliament Hill. These buildings will house the chief governmental activities, but bordering on the east of Major Hill Park and stretching along Sussex Street there will be other buildings less ornamental in character and built for practical utility. The various workshops of the government will be placed behind these on the east side.

The plan contemplates the devotion of only about 120 acres to government buildings, over and above that actually occupied by the buildings themselves. For this purpose Washington uses about 300 acres; but so much land is not required at Ottawa, owing to the advantageous position on the high banks of a river.

A drive will be built extending along the banks of the Ottawa River from Major Hill Park to the entrance to the governor-general's residence. At the entrance to the grounds of the government house a spacious circle will be created which will give approach also to Rockcliffe Park.

Five new bridges will be built across the Rideau River and also five across the Rideau Canal.

A tunnel will be built under the city, connecting the railway entrances from east and west, and all trains will operate through this tunnel. Two general freight areas, one at the east and one at the west side, with necessary depots, are recommended.

Industry will be segregated into certain areas, and the height of buildings will be controlled, in order to ensure the government buildings being the dominating groups.

The overflow from the Rideau River will be controlled by the removal from the river channel of the old wooden piers and loose stone, the removal from the river bed of boulders, the dredging of channels through the shoals, the raising of the Minto Bridge, the opening of a channel through the embankment of the Canadian Pacific bridge, and the widening of the channel past Maple Island. These improvements were suggested in the report made upon this subject in 1901 by Andrew Bell, C.E.

It is recommended that the government acquire as a National Park upwards of 100,000 acres to the north of Ottawa.

To provide better connection between the two portions of the business section of Ottawa, a new diagonal street will be constructed which will be carried over the railway and canal by a viaduct.

Somerset Street will be widened and developed as a cross-town artery. Its elevation across the railway tracks at the west end of the city will be lowered, and the bridge will be built across the railway tracks and canal at the east end of the city.

Elgin, Bank, Bronson and numerous other streets and roads will be widened and improved. Street car congestion will be removed wherever necessary. A street car subway under Sparks Street or Wellington Street is recommended, thus removing the cars from Sparks Street, which is narrow and will be greatly congested.

It is recommended that trunk arteries be laid down immediately in proper location, so that outlying areas will be built up to conform properly with them. The present park system is to be improved and other park areas acquired.

The railway passenger and freight station at Hull is to be removed to another point. Various streets are to be widened to 86 feet, and a highway constructed paralleling the railway. It is recommended that certain swamp lands be reclaimed and devoted to industries.

Four new bridges are recommended for construction across Brewery Creek and the Gatineau River. It is proposed to park the banks of Brewery Creek, the Gatineau River and the Ottawa River, interfering as little as possible with existing industries.

Three bridges for the Ottawa River are included in the plan; one being at Little Chaudiere Falls; another, of monumental character, to connect Ottawa with the municipal centre of Hull; and a third just below the mouth of the Gatineau River.

The Commission say that the bridge leading from the municipal centre of Hull should be a high-level bridge, and that it would be desirable to provide two levels, one for transportation and one for general traffic, although this bridge is now shown on the plan as having but one level. The present traffic conditions surrounding Victoria Bridge, say the commissioners, suggest this high-level bridge as an improvement for the near, and not the remote, future.

Specific recommendations are made for water terminals and for the development of the water front for commercial purposes wherever possible, care being taken that no real sacrifice will result to existing business interests.

Considerable highway construction is recommended in the report, including Heyworth Road, Old Chelsea Road, Gatineau Road, Renfrew Road, Carleton Place Road, and arteries leading to the Toronto, Kingston, Prescott, Morrisburg and Montreal trunk highways. Various diagonal and branch roads and streets are suggested. Among the minor recommendations are suggestions too numerous to detail, regarding the widening and extension of streets, building of driveways, bridge approaches, etc.

Survey.—Active field work was commenced in November, 1913, maps being prepared showing all details and desired information in reference to streets, railway and water transportation, etc. The topographical survey was made with sufficient accuracy to enable it to be used for the foundation of an accurate map of 400 feet to the inch. The courses of the principal streets and roads were first run and triangulated within and beyond the city limits, and the courses of the Ottawa and Rideau Rivers and the Canal were determined, and accurate shore lines established.

Elevations with mean sea-level at New York as the datum plane were established along the principal thoroughfares, and contours of the cities were laid down as necessary for particular locations.

Structures belonging to all public utilities were investigated, including sewers, water mains, conduits, pole transmission lines, etc. Tree-planting conditions were examined. Considerable research was made regarding rate of growth of business. Various economic data was gathered regarding the intensity and volume of the different classes of railway business, street railway traffic and facilities, number of government employees, location of government property, etc.

Railway Situation.—The report includes a most comprehensive study of the local railway situation, and recommends that the railways within the district be placed under the control of the governing body of the Federal District. Electrification of the unified system is suggested, with terminal operation and control, the District to acquire by purchase or agreement all trackage and terminals within its territory. Grade separation, requirements for expansion, obstacles placed in the way of growth by present railway situation, present traffic facilities and operation, growth of traffic, future freight handling systems, and numerous other topics also are discussed in the report.

Government Buildings.—The floor area is approximately 3,650,000 square feet, divided as follows: Proposed group west of the western block, 1,500,000 square feet; Sussex Street group, 650,000 square feet; Lyon Street group, on the south side of Wellington Street, 1,500,000 square feet. The area of floor space now owned or rented by the government is 1,750,000 square feet, and there will be required at an early date about 1,000,000 more square feet. Floor areas have been calculated upon the basis of buildings of five stories, areas of basements not included.

District Control.—The practice in the United States and in Europe as regards district control is summarized in the report, and recommendations are made covering railway areas, dockage areas, height of buildings, residential districts, markets, etc. The building regulations suggested will permit of heights ranging from 80 to 110 feet on the principal streets.

The commissioners have made what they consider a fair estimate, that by 1950 Ottawa will have 250,000 inhabitants, and they have, therefore, planned in general for a city of 350,000 people, with an average density of about 30 people to the acre. This would give a built-up area of about 20 square miles.

Parks and Playgrounds.—In planning parks and playgrounds the Commission has provided for a field of from 8 to 10 acres within a half mile of every residence in the city, and the connecting of all parks by means of parkways, so as to make the park system continuous and comprehensive.

The report recommends the acquisition or extension of 13 parks, 11 parkways and 50 playgrounds and small park areas. Existing parks total 850 acres, but under the new plan Ottawa and Hull will have 3,160 acres of parks and playgrounds.

Other Utilities.—It is recommended that as soon as possible the practice of emptying untreated sewage into waterways be abandoned. It is suggested that some method of disposal be secured to render the effluent harmless. A site at the mouth of Green's Creek, east of Ottawa, is approved of for a disposal plant. It is recommended that Ottawa's incinerating plant be removed to the east of the city in the industrial zone and adjacent to the railway, and that large cars be procured to haul the garbage by railway to the incinerator. Locations for stock yards are suggested which will protect the city from nuisance.

The report states that a policy should be adopted immediately by Ottawa, looking to the ultimate removal of all overhead wiring, both in business and residential districts. It is recommended that street car trolley wires be placed on centre poles between the tracks, the street car transmission wires being placed under the street.

The question of water supply is being given study by the civic authorities, so that the Commission makes no recommendation upon this subject, excepting to suggest that in whatever scheme of improvement of supply is decided upon, all towns and municipalities within the limits of the Federal District should be supplied from a common source adequate for the purpose.

Water transportation receives careful attention in the report, as it involves several serious problems. Recommendations are made that the canal be retained in its

HULL CIVIC CENTRE AND PROPOSED MONUMENTAL BRIDGE.

View looking east over the water-front, showing proposed bridge from Wellington Street, Ottawa, to the Hull Municipal Centre. Victoria Island will be improved without interfering with existing industries.

present location; that the clearance for fixed bridges be established at 12 feet instead of 30 feet, as at present; that the canal be developed to afford recreational facilities; that no more industrial developments be permitted to take place along the banks of the canal between the Rideau River and the Ottawa River; and that as soon as possible such industries as now exist along this stretch of the canal be removed to other locations.

Personnel of Commission.—The members of the Federal Plan Commission are Sir Herbert Holt, chairman; Sir Alexandre Lacoste, K.C., of Montreal; Frank Darling, of Toronto; R. Home Smith, of Toronto; and the mayors of the cities of Ottawa and Hull. This Commission was created by an order-in-council on September 12, 1913, it being provided that the government should pay half of the cost of the plan and that the other half should be paid by the two cities ratably, according to population, the municipal authorities having expressed their desire to co-operate with the government in the work.

The Commission selected E. H. Bennett as consultant on city planning and E. L. Cousins as consulting engineer. Mr. Bennett is a town-planning expert, with headquarters at Chicago, Ill. He was formerly engaged with the firm who were responsible for the excellent lay-out of Washington, D.C., and has done much notable work since entering private practice.

Mr. Cousins has become well known as the chief engineer of the Toronto Harbor Board, and also as consulting engineer to the Rapid Transit Commission of Toronto. Having also had experience as division engineer of the Grand Trunk Railway, and as engineer of bridges, railways and docks for the city of Toronto, Mr. Cousins was able to give valuable assistance to the Commission in solving the questions of street and steam railway traffic, which were very prominent among the difficulties facing the Commission.

Mr. Bennett and Wm. E. Parsons, of Mr. Bennett's staff, were in charge of all architectural and town-planning features. Paul H. Lazenby, engineer of Mr. Bennett's staff, co-operated with Mr. Cousins in all matters pertaining to transportation, statistics and other economic features.

A. E. K. Bunnell was the engineer in charge of the Ottawa office, under whose immediate direction all surveys were carried out and data gathered, with the assistance of H. W. Tate, surveys engineer, and H. S. Bedell, chief draftsman. Mr. Bennett was assisted by H. T. Frost and F. C. Walker in the general plan, and by Mr. Jules Guerin in preparing the perspectives, and by A. Stuart, superintendent of the Ottawa Improvement Commission.

A fireless steam locomotive is used for switching cars and tie trams at an Ohio creosoting plant. The locomotive is of a type which was developed in Europe some years ago and is used around distillation plants, where cinders and live ashes would constitute a fire danger. This locomotive operates by steam, the boiler being charged about seven times every 24 hours at the main boiler, at 150 lbs. pressure. The maintenance cost of this type of switching engine is very low, and its use is said to be very satisfactory in a treating plant yard. Its tractive power is fully equal to that of the usual type, and although it weighs only 22 tons it has pulled as many as 12 loaded gondola cars at a time. Perhaps there are construction contracts on which a locomotive of this type would be an economy.

REINFORCED CONCRETE AS APPLIED TO WATERWORKS CONSTRUCTION.

A PAPER read before the Concrete Institute (England) by Chas. F. Marsh, M.Am.Soc.C.E., on this subject explains how reinforced concrete is particularly adapted to construction of works for the conveyance and storage of water. In this connection, also, the paper by W. W. Horner on "Reinforced Concrete in Sewer Design," which was published in *The Canadian Engineer* for March 30th, will be of interest.

In his introductory remarks Mr. Marsh pointed out that concrete used for structures which had to resist the pressure of water should be richer in cement than that used for the generality of structures. For reservoirs, tanks and dams, where there was sufficient thickness, the concrete should be mixed in the proportions of 1 : 1½ to 3, or 810 lbs. of cement to 13½ cu. ft. of sand and 27 cu. ft. of broken stone or shingle; this mixture was sufficiently watertight for any but very considerable heads, but for pipes and structures of small thickness, say, less than 3 ins., a mortar mixed in the proportions of 1 to 1½, or 1,620 lbs. of cement to 27 cu. ft. of sand, should be used. This mixture was, of course, no more resistant to water pressure than a 1 : 1½ to 3 concrete, but in a thin structure there was a danger in the use of stone or shingle, since two pieces might possibly come together, and any failure in the proper consolidation of the concrete might leave a plane of leakage through the concrete. The size of the broken stone or shingle should not exceed such as would pass through a ¾-in. square-meshed sieve, and might with advantage be ½-in. gauge. It was not advisable to use a richer mixture, as rich mixtures shrunk more when drying and expanded more when wet than leaner mixtures, and consequently cracks were more likely to be induced; while it had been proved conclusively that with proper care in mixing and placing a mixture in the proportions of 1 to 1½ to 3 was practically impervious under considerable heads.

For pipes under pressures exceeding about 40 ft. special linings should be used, such as the sheet steel tubing in a Bonna pipe, or other suitable layer of impervious material.

For any structure which had to resist the percolation of liquids it was advisable, in his opinion, to mix some waterproofing compound with the concrete, or otherwise to provide against leakage by the use of a soap and alum wash, paraffin wax, or other suitable protective coating.

For increasing the imperviousness of concrete or mortar, ordinary hydrated lime had been used very successfully, and could be used in proportions up to 10 per cent. of the weight of cement without injuriously affecting the strength of the mixture.

The concrete should always be kept damp for some time after moulding, depending on the richness of the mixture. The period in the case of a 1 : 1½ : 3 mixture should be about four weeks.

In structures of considerable length, which might be alternately wet and dry, and were exposed to the variations of temperature, it was advisable to provide against cracking, which was almost certain to occur. Such structure should have specially constructed contraction joints, not more than 30 ft. apart, leakage being prevented at the joints by the insertion of sheet lead or copper baffles extending well into the concrete on each side of the joint, and bent over at the extremities to form a good key.

In the construction of all structures to resist the pressure of liquids, special care was necessary to provide adequate reinforcement against shrinkage due to the setting of the concrete, fall of temperature, and excessive dryness.

Dams.—When reinforced concrete was employed for the construction of dams, the latter were usually of a hollow form of construction, having up-stream and down-stream slabs supported on cross walls carried upon a foundation slab.

From the foundation slab a core wall must be carried down under the bottom of the up-stream slab, and extended well into a watertight stratum. The provision of an adequate cut-off wall was most essential, as some of the dams already constructed of this material had failed owing to the neglect of this precaution.

The up-stream slab was generally constructed with a flat slope not steeper than 1 to 1, since the flatter the slope the more uniform was the pressure on the base.

With a dam of this type, as the reservoir filled, the line of resultant pressure on the base would at first become farther up stream from the centre of pressure on the base with the reservoir empty. When the reservoir had filled for a certain proportion of its depth depending on the slope of the up-stream slab, the line of resultant pressure on the base moved back towards the centre until under the limiting flood conditions it would generally be found to be slightly on the down-stream side of the centre of pressure on the base with the reservoir empty.

The resultant pressure would in no case move very far from the centre of the base, and consequently the intensity of pressure would never vary greatly between the up-stream and down-stream extremities of the base.

In the case of a solid masonry dam the centre of pressure on the base with the reservoir empty was usually at the up-stream extremity of the middle third of the width, and with reservoir under maximum flood was usually at the down-stream limit of the middle third of the width. The consequence of these limits was that with reservoir empty there will be no pressure at the down-stream toe and a maximum pressure at the up-stream heel, while with reservoir full there would be no pressure at the heel with a maximum pressure at the toe. As the reservoir filled the pressure intensity would vary between these extremes.

Elevated Tanks.—Mr. Marsh remarked that perhaps one of the most economical uses of reinforced concrete was in the construction of elevated tanks, of which there are many examples in existence. A reinforced concrete tank could be constructed at a cost of from 40 per cent. to 50 per cent. that of a tank formed of riveted steel plates, and they would in general be less expensive than tanks of pressed steel or cast-iron plates.

When designing circular reinforced concrete tanks it was, in his opinion, advisable to limit the working resistance of the steel to 12,000 lbs. per square inch, since, although the tensile resistance of the concrete was neglected, the elongation of the steel bars must induce elongation in the concrete, and a higher stress in the steel would in all probability cause the concrete to crack. It was also, in his opinion, advisable to insert two series of circular rings in the walls of the tank, one near each surface, in place of one series at the centre of the thickness. It must be remembered that whereas the interior of the tank was kept at a fairly constant state of moisture, and temperature, the outside was exposed to the variations in temperature and humidity, and consequently the two surfaces were under very different conditions affecting the expansion and contraction of the concrete.

Reservoirs Entirely or Partly in the Ground.—In many cases it was not economical, in Mr. Marsh's opinion, to use reinforced concrete for the walls or floor of reservoirs, but it was almost universally an economical material for roof construction.

If a considerable portion of the depth was below ground, the form of retaining wall construction, with a bottom slab at the back tied to the front slab by ribs, was not an economical form of construction, as the excavations had to be considerably enlarged to accommodate the bottom slab.

A well designed as a cantilever, supported from the floor of the reservoir, would reduce the excavation, but great care was necessary to provide ample support at the bottom to prevent failure between the base of the wall and the floor when the reservoir was empty.

If the reservoir was covered, and the covering could be constructed before an excessive loading was brought upon the walls, the roof beams and similar beams formed in the floor could be constructed to support beams along the top and bottom of the wall, which in their turn supported the ends of vertical beams between which the walls of the reservoir could be constructed as slabs with horizontal reinforcements.

The covering usually adopted for reservoirs was of the beam and slab type, similar to ordinary floors, and supported by columns, but small circular reservoirs might be covered with a flat dome in a similar manner to that frequently employed for elevated tanks.

Aqueducts and Pipes.—Open aqueducts built almost entirely above ground level and those for carrying water over valleys might, with economy, be constructed of reinforced concrete, but for those constructed mainly below ground level this material would not be so economical, for the same reasons as given in the case of reservoirs.

Pipes under small heads, say, up to about 40 ft., might be constructed of reinforced concrete without any special impervious material being embedded in the thickness.

PEAT POWDER AS LOCOMOTIVE FUEL.

Experiments in the use of peat powder on locomotives of the State railways have demonstrated that as heavy trains can be pulled and as good speed be made where this fuel is employed as where anthracite is used, according to a statement issued by the Swedish telegram bureau, which has been received from the secretary of the American Embassy at Stockholm. The statement declares that the powder can technically, as well as economically, take the place of anthracite as fuel for locomotives.

The railway directors have decided to undertake the development of this class of fuel by two different methods for purposes of comparison. Two experts have been requested to give complete estimates of the cost of preparing a certain bog for the manufacture of peat powder, together with estimates of running expenses, by the respective methods. The bog selected is said to be that at Hasthagen, about 1½ miles from the station at Vislanda, with an area of about 500 acres.

The T. L. Smith Company, of Milwaukee, Wis., have just completed the two largest concrete mixers ever turned out. Each of these mixers, which are of the tilting type, has a capacity of 108 cub. ft. of mixed concrete per batch. They were built for the Harderway Contracting Company, of Washington, D.C., and are to be used for the construction of an immense concrete dam at Salisbury, North Carolina.

METHODS ADOPTED IN THE CONSTRUCTION OF ROGERS PASS TUNNEL.*

By J. G. Sullivan, M.Can.Soc.C.E.

THE Rogers Pass Tunnel is in the Selkirk Mountains of British Columbia. It is double tracked, five miles long, and, as shown on Fig. 1, lowers the summit of the former line by 552 feet. It also shortens the line by 4.3 miles, eliminates some 2,300 or 2,400 degrees of curvature and avoids the expense and danger of maintaining and operating 4.5 miles of snowsheds.

In order that the plan adopted in the construction of this tunnel may be properly understood and appreciated, it is perhaps advisable to go somewhat into the history of the case. During the period from 1910 to 1913, the traffic of the Canadian Pacific Railway Company was increased so rapidly that it was evident that if the rate of increase continued, the road would have to be double tracked. A very prominent consulting engineer, who reported favorably on the proposal to construct the tunnel, made a further suggestion that it might be necessary to double-track the present line over the mountain and gauntlet the heavy bridges in order to handle the traffic during the period of construction. It can be readily understood, therefore, that the length of time required to complete the work became a matter of anxiety to the company. The author was aware that tunnels in Europe had been driven at a rate two or three times as fast as any long tunnel had been driven on this continent, and he had, in a superficial way, an idea of the methods employed.

The company sent out letters to the contractors who were bidding on the work, in which they were given to understand that the company who could guarantee to drive the tunnel in the shortest time would be awarded the contract. The contractors were also consulted as to penalty and bonus clauses. The company stated that they were of the opinion that $750 per day would be a fair sum.

Methods were studied in order to find out which would be most expeditious in carrying out the work. A combination of ideas resulted in a recommendation for a small working pioneer tunnel, 8 ft. by 8 ft., underneath the main tunnel.

A pioneer tunnel was driven entirely outside the regular section of the tunnel, and a centre heading was driven along the centre of the main tunnel. The functions of the pioneer tunnel were to provide a means of transporting the material from the heading to a point back of where the enlargement of the tunnel was being made, and to provide for the carrying of high-pressure air pipes, water pipes, ventilating suction pipes, etc. In other words, to provide a means whereby the "shooting" at any one point in the tunnel would not interfere with operations at other points. The idea of carrying the drills on a horizontal shaft held in place by heavy jacks was to enable these shafts and drills to be carried on narrow-gauge tracks so that they could be moved backward and forward as required. It was supposed that heavy drills, such as have been used in the past, would be necessary, but it was found that the Leyner drills actually used were so light that they could be handled by one man. The result has been that all drilling in the enlargement has been done from vertical shafts as shown in Fig. 3.

*Abstract from a paper read before a Sectional Meeting of the Canadian Society of Civil Engineers, January 13th, 1916.

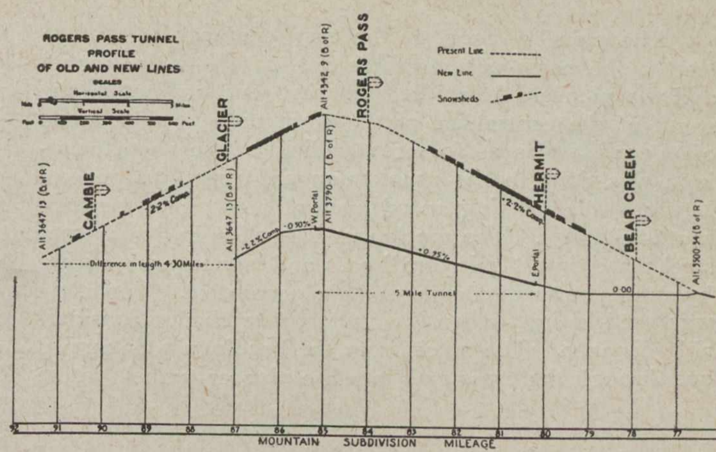


Fig. 1.

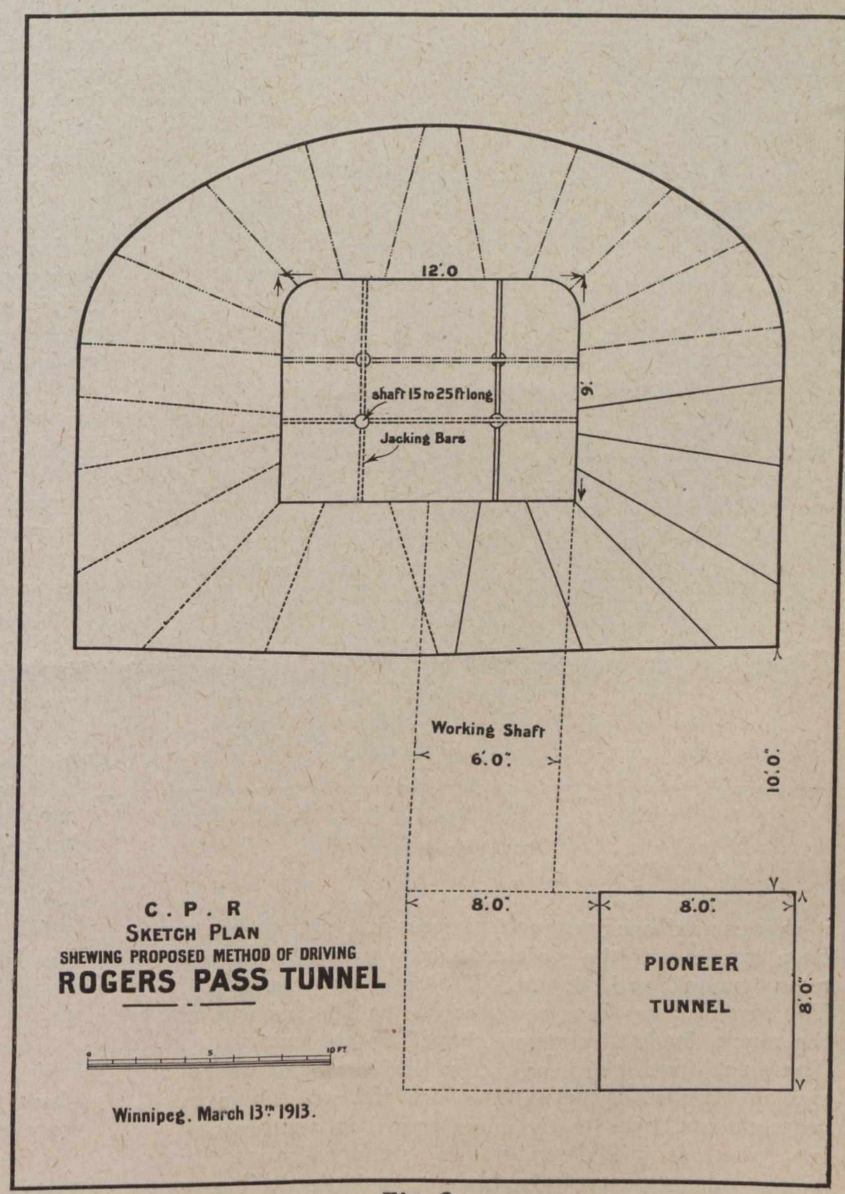


Fig. 2.

The pioneer tunnel at the east end was located 50 feet to the north of the centre line of the main tunnel and the pioneer tunnel at the west end 50 feet to the south of the centre line of the main tunnel. The mode of operation was as follows: drilling in the small headings was done in the usual manner, using in general Leyner drills, making an advance of 6 or 7 feet for each round of holes. The muck was shovelled by hand from steel plates into "half-yard" cars and hauled back, either by a mule or small compressed air locomotive. The latter was used entirely when the haul had reached a considerable distance. The muck from the headings was carried out through the cross-cuts into the pioneer tunnel, where

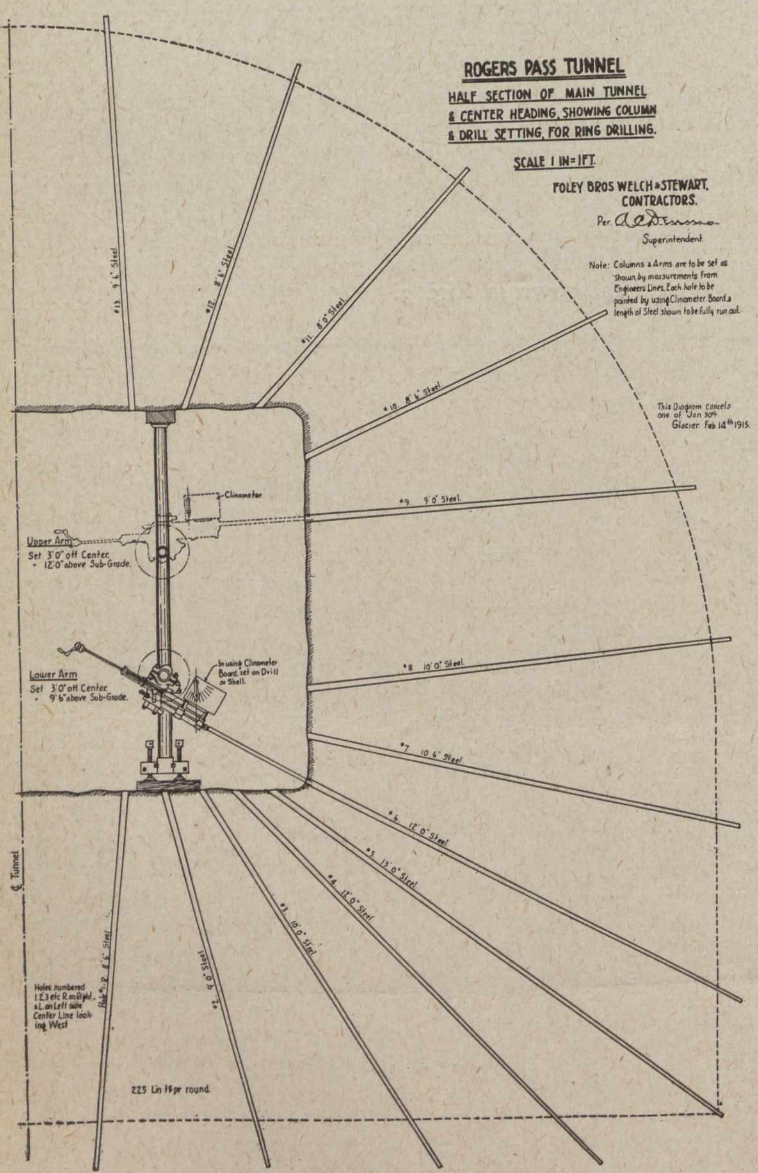


Fig. 3.

it was carried back to another cross-cut, and thence out on a trestle over the standard-gauge tracks through the main tunnel, and dumped into standard-gauge cars. The material was then removed to the fills, as was also the muck, loaded by steam shovels in the enlargement. The muck from the heading on the west end was in a similar manner conveyed into the pioneer tunnel at a cross-cut and back to the main tunnel in another cross-cut, where it was dumped into standard-gauge cars. In the enlargement of the main tunnel the drilling was done well ahead of the shooting. Fig. 3 shows the manner in which the drilling was carried out. The radial holes were at first drilled at right angles to the axis of the tunnel, but the results were not satisfactory, and a change was made. The muck was all loaded by steam shovels into standard-gauge 12-yard capacity dump cars. The shovels had dippers of one and one-half cubic yards capacity and were worked by compressed air. The cars were hauled to the mouth of the tunnel by standard-gauge compressed air locomotives and taken from there to the dumps by standard steam locomotives.

The contract for this work was let on July 1st, 1913. The limit of time for completion was three and a half years, which would end on January 1st, 1917. There was an allowance in extension of time of one day for every ten feet of soft ground encountered, which would require immediate timbering. As there was some 1,660 feet of such ground, the time limit of the contract was extended into June, 1917.

The work completed up to December 19th, 1915, was as follows: 19,610 feet of pioneer tunnel; 24,612 feet of centre heading; 1,660 feet of earth tunnel, and 14,342 feet of tunnel enlargement in rock. At the same date there remained to be driven: 288 feet of centre heading; 10,398 feet of tunnel enlargement.

The best progress made in driving the pioneer tunnel heading was in the month of January, 1915, when 932 feet in the west heading were completed. The best record for a week in the enlargement was 267 feet, and for a month 827 feet. The latter distance was accomplished during the month of August, 1915, in the west end.

From April 1st, 1915, to December 19th, 1915, 12,346 feet of tunnel enlargement was made. This was during the time that the shovels were both working in rock and at a normal rate of speed. Such a rate would require only a little over seven months in which to complete the tunnel. There will, however, be some slowing up in the enlargement between the cross-cuts, which are at the ends of the pioneer tunnels, for the reason that, at present, fans are installed at mouths of pioneer tunnels. Doors were placed in the cross-cuts between the pioneer and the centre heading, and those which were at the back of the shovel were kept closed. When shooting occurred in the enlargement, the door at the first cross-cut beyond the point of shooting was opened and a strong draught was thus created over the pile of freshly-shot muck, making it possible for the men to return to work in ten or fifteen minutes after a shot had been fired. The methods employed in shooting in the enlargement were as follows: One round of holes was shot at a time, the holes in the bottom of the tunnel being shot in advance of the holes on the sides or on top. In some cases the top holes were not shot until all the bottom holes were finished. Usually six or seven rounds of holes were shot before the steam shovel began to take up the muck, thus making an advance of from 30 to 35 feet. The shooting was usually continued until the tunnel became so full of muck that no more shooting could be done. The largest amount shot at one time was 84 feet in eleven hours, which was the record for 20th November, 1915.

All expectations as to speed in the execution of the work have been more than realized. For rock tunnelling, where the rock is of sufficient hardness to stand until the mucking has been completed, the method described can be most successfully worked, and a speed of three miles a year can be easily made at a much less cost than tunnels driven at the same speed by the European method. Furthermore, the practice of radial shooting has given a great deal less overbreak than would have resulted had the holes been drilled parallel to the axis of the tunnel.

The work was laid out and commenced under Mr. F. E. Busteed, M.Can.Soc.C.E., engineer in charge of double tracking, with Mr. J. W. Sheppard as assistant engineer. It has recently been under the supervision of Mr. W. A. James, M.Can.Soc.C.E., engineer of construction western lines, with Mr. H. G. Barber as assistant engineer; Mr. T. Martin, resident engineer at the west end, and Mr. J. R. C. Macredie, M.Can. Soc.C.E., resident engineer at the east end. The contractors are Messrs. Foley Bros., Welch & Stewart. The construction work has been supervised for the contractors by Mr. A. C. Dennis, M.Can.Soc.C.E.

PRESENT STATE OF EUROPEAN TIMBER-TREATING PLANTS.

The effect of the war on the European timber-treating plants in general has not been very great, according to Dr. F. Moll, writing in "Wood Preserving," as most of these plants are situated some distance from the battlefields.

As may be easily conceived, all the Belgian plants have been taken over by the Germans. There are about six plants which are owned partly by private and partly by government interests. In times of peace the government plants were managed by private concerns, and this system has been followed by the German authorities. The Belgian plants are fit for good work, and they are in operation to-day.

In Polonia, scarcely any timber-treating plants are to be found, so we may overlook this country.

In France, the only plants of importance are those that are permanently located, such as the Boucherie, which are mostly small and old. One of the largest creosoting plants in northeastern France is that of Amagne, which has been captured by the Germans. The 150,000 ties found in this plant have been used by German troops for repair and other work, and the plant is not now in operation.

Serbia has one small plant at Chichewash, near Nisch. Dr. Moll visited this plant, and it is now being used as a magazine for the German troops. This plant has two cylinders, 6.5 feet in diameter and 33 feet long, and was constructed by a Hungarian concern known as the Nicholson Actien-Gesellschaft. The process employed is the full-cell with creosote and zinc chloride. The ties found in this plant have all been used for railway track and bridge repairs, and the supply of creosote has been utilized partly for fuel by the German troops.

The following is a list of Canadian patents recently issued through the agency of Ridout & Maybee, 59 Yonge Street, Toronto, from whom further particulars may be obtained: Edwin J. Banfield, plug finishing machine; Toronto Type Foundry Co., Limited, folding plates for folding machines; Gibson Groves, fire alarm system; George Henderson, electro-magnetic signalling apparatus; Fred Rawlings, road planer and surfacer; Gutta Percha and Rubber, Limited, process of moulding and vulcanizing tires; Gutta Percha and Rubber, Limited, tire moulding machine; Samuel Glover and John West, gas producer; Charles O. Bastian, electric incandescent bodies for glow lamps; Edward B. Killen, pneumatic shock absorbing devices.

COAST TO COAST

New Glasgow, N.S.—A new telephone company is proposed, to be owned, operated and controlled by the citizens of New Glasgow, Westville, Stellarton and Trenton.

Brantford, Ont.—E. R. Cross, who has been identified with work in the Alberta oil fields, claims that he has found indications of gas and oil within five miles of Princeton, Ont.

St. John, N.B.—The city has signed an agreement with the Street Railway Company whereby they will do the concreting work of the company at the rate of $5,000 per mile per track.

Hamilton, Ont.—The plant of the Hamilton By-Products Coke Ovens, Limited, will cover an area of 40 acres. The big plant will have a capacity of 10,000,000 cubic feet of gas per day.

Sarnia, Ont.—The cofferdam built around the steamer "Western Star," which foundered last fall, has collapsed. The loss will be in the neighborhood of $32,000. Work will be suspended for the present.

Toronto, Ont.—The cableway over the Whirlpool Rapids at Niagara Falls has been completed at a cost of $60,000. The scheme is financed by Spanish capitalists and has been described before in this paper.

Montreal, P.Q.—Arrangements have been made between Ville St. Laurent and the city of Cartierville, whereby the inhabitants of the former will be supplied with filtered water from the aqueduct of the latter.

Fort William, Ont.—The city council has been approached by the Canada Car and Foundry Company, who located here on payment of a big bonus, with the request that permission be given to dismantle the plant and move it to Vladivostok, Russia.

Toronto, Ont.—A syndicate, said to be backed by the Metropolitan Life Insurance Company, has purchased the entire block of land southwest of the corner of College and Yonge Streets. They propose to establish a new shopping and amusement centre.

Sarnia, Ont.—The electric light plant of the village of Alvinston is to be taken over by the Hydro Commission, according to what can be learned in this city. The engineers from Toronto will inspect the plant and at the same time place a valuation on it.

Lethbridge, Alta.—Drilling operations for oil will be commenced by a British syndicate who until recently have been interested in Galician oil fields. Twelve wells will be drilled and if satisfactory results are achieved the syndicate will erect refineries near here.

Victoria, B.C.—The Minister of Railways has presented figures with regard to the completion of the Pacific and Great Eastern Railway. The cost from Second Narrows, Vancouver, to Prince George is in the neighborhood of eleven and a half millions.

Montreal, P.Q.—The Trail (B.C.) smelter, in which the Canadian Pacific Railway has a large interest, has started construction of a plant for the manufacture of sulphuric and hydrofluoric acid, which is expected to be ready for operation in two months.

Winnipeg, Man.—A circular has been received at the local offices announcing the opening for operation of the

Canadian Northern Railway branch line from Camrose to Alliance, Alta., a distance of 59 miles. This line runs in a southeasterly direction from Camrose.

Toronto, Ont.—The board of control will spend $31,000 on the Humber Boulevard scheme this year. They agreed to spend $25,000 annually for five years and spent only $6,000 last year. The arrangement to reduce the amount has been made with R. Home Smith.

Winnipeg, Man.—At a meeting of the Greater Winnipeg District Water Board the opinion prevailed that the cost of the big work would be less than the estimated sum of $13,500,000. The railway and equipment, which cost $1,535,980, is now a going concern and is at least paying expenses.

Windsor, Ont.—The Chalmers Motor Company, of Detroit, which recently obtained a Canadian charter, with a capitalization of $1,000,000, is to establish its Canadian branch plant at Ford City. A deal has been closed for the purchase of the plant of the Tate Electric Company for that purpose.

Winnipeg, Man.—With two months yet to run, the hydro-electric system of the city of Winnipeg has a surplus of $65,574 to its credit on its year's working. The total revenue for the month of February was $97,327.77 and the operating expenses $71,728.51, leaving a profit for the month of nearly $20,000.

Ottawa, Ont.—According to Sir Rodolphe Forget, the government is going to take over the Quebec & Saguenay Railway. Part of the company's terminals in Quebec have been already taken over and the Quebec & Saguenay will be used as an extension of the Transcontinental to make Murray Bay a winter port.

Vancouver, B.C.—General Manager M. H. McLeod, of the Canadian Northern Railway, announced that on June 1st a daily service would be operated over the company's line in British Columbia. During March more than 1,000 cars of lumber were moved east over the line to prairie cities and this traffic is now growing rapidly.

Sarnia, Ont.—The Mueller Manufacturing Company has just completed and put in operation a melting plant to remelt brass chips. The chips or trimmings are placed in a large melting-pot and fired with coke. As brass has increased in cost about 180 per cent. since the war commenced, this melting of chips will mean a big saving.

Lethbridge, Alta.—A memorial has been sent to Premier Sifton asking that steps be taken to ensure that Macleod and other towns along the Old Man River west of Lethbridge will instal sewage purification plants in order that there may be no recurrence of typhoid outbreak in Lethbridge such as the citizens are now suffering.

Port Moody, B.C.—A number of men with equipment have arrived to start work on the water system installation. They are the employees of the Canadian Pipe Company, Vancouver, who have a sub-contract under the contractors, the Robertson, Godson Company. The contract is for $40,000 and the water will be brought to the city from Scott and Noon creeks.

Victoria, B.C.—Progress on the breakwater has been very satisfactory. There has been placed to date a total of 108,900 tons of granite blocks, while 23,900 cubic yards of concrete, forming the superstructure, has been poured. During the month of March 22,300 tons of rubble was dumped; 7,700 tons of granite blocks were set in place, and 1,700 cubic yards of concrete poured, making five blocks.

Hamilton, Ont.—An increase of over two million gallons of water a day is shown in the report of Engineer Bain of the Beach waterworks, for March. This is attributed to the plants working night and day on munitions. Last March the water used amounted to 278,426,455, whereas this March the total was 343,795,000, an increase for the month of 65,368,545, or a daily increase of 2,108,663.

Winnipeg, Man.—F. K. Herchmer, district inspector of forest reserves, has returned to the city from a trip lasting three weeks in the locality tributary to Port Nelson and The Pas. In commenting upon the progress being made on the Hudson Bay Railway, he stated that the final piece of steel was placed in position on the Manitou bridge, over the Nelson River, thus making possible train service beyond that point.

New Westminster, B.C.—The Canadian Northern Railway Company is preparing to build two car ferries at Port Mann for use in transporting cars between their temporary mainland terminus and Vancouver Island. The material has been ordered, and construction work will be commenced immediately. At the same time a slip will be constructed at Port Mann for loading cars on these barges. Other activities at Port Mann include the construction of two new turntables, the installation of machinery in a machine shop, and the erection of a 1,000-ton ice house. Ice will be brought from Yellowhead Lake to fill this ice house, and the ice used in refrigerator cars.

Vancouver, B.C.—A new traffic arrangement has just been completed by the B.C. Electric Railway Company which will mean that another transcontinental system, the Chicago, Milwaukee & St. Paul line, will be available for lumber manufacturers and other shippers in the neighborhood of Vancouver and New Westminster. Through its connection with the Bellingham Bay & Northern Railway, the Milwaukee line now reaches the international boundary at Sumas. Some time ago a track was built circling that town and connecting the C.M. & St.P. with the B.C. Electric. The connection has been of no value, as permission to handle cars over the Westminster Bridge was not received until just recently.

NEW INCORPORATIONS.

Edmonton, Alta.—The Alliance Power Company, Limited, $250,000.

Govan, Sask.—The Govan Motor and Machine Company, Limited, $20,000.

Corinne, Sask.—The Farmers' Oil and Supply Company, Limited, $6,000.

Calgary, Alta.—Canadian Western Zinc Smelting Company, Limited, $1,000,000.

Cranbrook, B.C.—The Wild Horse Creek Placer Gold Mining Company, Limited, $100,000.

Cobalt, Ont.—National Mines, Limited, $2,000,000. J. A. Rowland, D. H. Stewart, N. D. Tytler.

Toronto, Ont.—Universal Oil Company, Limited, $40,000. L. Sinclair, W. J. Hohlstein, C. Plumb.

Qubec, Que.—Laurentide Sand and Gravel Company, Limited, $49,000. S. N. Parent, A. Lepire, P. A. Galarneau.

Toronto, Ont.—The Crowley Manufacturing Company, Limited, $100,000. T. W. Pinnell, A. W. Gilmour, F. P. O'Hearn; Bournonville Rotary Valve Motor Company, Limited, $500,000. W. Gilchrist, J. Stewart, H. J. Stuart.

The Jeffrey Manufacturing Company has recently organized a contractors' plant department to handle the sale of a line of small rock and ore crushers. Mr. Leroy A. Kling, formerly sales manager of the road machinery and limestone crusher department of the Wheeling Mold and Foundry Company, Wheeling, W. Va., will be in charge of this new department.

Editorial

INTERCHANGE OF IDEAS AMONG ENGINEERS.

The engineering profession, like many other professions, has among its members those who, either from indifference or lack of interest in research work on their own account, unconsciously, perhaps, but none the less surely, continually follow the other man's lead. In most instances he is the man who, always willing to profit from the other man's endeavor, is little disposed to make any contributions by oral or written discussion on subjects of common interest to the engineering profession. Like the proverbial sponge, he takes in all he can; but he is not big enough to give anything in return.

Such an engineer has never thought very deeply as to how the literature of his chosen profession originates. Perhaps there is no man able more adequately to understand this disposition on the part of certain members of the profession, than the editor of a technical paper, one of whose functions it is to draw out engineering discussion along certain specific lines. There are many members of the profession who are reluctant to pass along information of any kind. Every engineer has, or should have, something in the way of information that is of interest to other engineers. No one knows it all, although many of us know a little.

If engineering literature is to fulfil its highest function, then there must be disposition on the part of those who have experience, to impart a little of their own private fund of information for the benefit of others. There should be no exception to the "give-and-take" policy as applied to the engineering profession. The technically trained man who fails to see it in that light will not get the most out of life.

In this connection we would refer to the article by W. W. Pearse on "Stresses in Lattice Bars of Channel Columns," which appeared some weeks ago in these columns, and to a more recent series of articles by E. H. Darling, M.E., on "Impact Formulas for Highway Bridge Design." Both of these articles were the result of much study by their respective authors, and were real contributions to engineering literature, with the expressed wish that they should be of use to the particular branch of engineering to which they referred. Criticism was invited. It came freely, and evidence goes to show that the precipitation of the subjects by Messrs. Pearse and Darling led to a discussion that was worth while, and of value to not only the participants but to a great many others.

One man may spend a great deal of time on a specific problem and believe he has reached a satisfactory solution. Another engineer comes along and will be able, as a result of wider observation or broader experience, to see a phase of the question which probably had not been taken into account by the original investigator. This is all helpful and desirable.

There must be a great deal of valuable information stored away by engineers; information that is being made of no value whatever, either to its owner or anybody else. In many cases there is no very good reason why it could not be let loose without the owner being in any sense of the word a loser.

Engineering societies have rendered very useful service indeed in this direction, and it is to be hoped that during the next few years, when new problems are bound to arise, growing out of the war, there will be a gradually increasing tendency on the part of engineers to be more willing to interchange ideas, and thus contribute, in a real way, to the betterment of the profession.

SOME STATE SECRETS.

Technical papers are public servants, just as are railroads, power companies and many other enterprises. And, like all other public servants, it pays to take the public into their confidence as largely as possible. We therefore feel that our readers should have some idea of how the war has increased the difficulty of publishing a really good technical paper in Canada, so that they can better appreciate whatever slight success we may have had along those lines.

Sheet copper, from which all halftone engravings are made for illustrating the paper, has jumped from 22 cents to 68 cents a pound. Zinc, from which all line cuts are made, is now 48 cents a pound; formerly, 11 cents. Potassium bromide was 45 cents a pound before the war; it is now $7.85 a pound. Yet it is an essential in producing an illustrated paper. Iodine, dragon's blood, hydrochinone, and all other necessary chemicals, have also very greatly increased in cost.

Our white paper costs 57 per cent. more than it did before the war; our red cover paper costs slightly less than five times the former price, is purchasable only in small quantities, and may soon be impossible to secure at any price on account of the dye situation.

However, we're glad we're alive. But when you get your bill for $3 for a year's subscription, just bear these facts in mind, for you are getting a bigger $3 worth than ever before, considering cost of publication.

WATER DISINFECTION.

Standards of water purification have risen considerably the past few years. Physicians recognize that water cannot be too pure. Public health demands more than a palatable potion. It requires a water really free from pathogenic organisms.

H_2O, absolutely pure water, is seldom found in nature. Nearly all surface supplies are polluted to a greater or less extent. The filtration of nearly all drinking water is today a necessity. That is universally acknowledged by most engineers and public health officers.

But even filtration does not yield entirely sterilized water. Modern filter plants operate at a very high efficiency, removing even so much as 99 per cent. of the germs that are in the raw water. Yet, how to get after that stray 1 per cent. is the problem that has bothered the waterworks men.

There are four known ways of accomplishing this, *viz.*: Distillation, disinfection by heat, chlorination and sterilization by ultra-violet rays.

To heat or to distil a public water supply is, of course, impossible from a practical standpoint. Most Canadian cities are chlorinating their supply. This is effective, but frequently unpleasant to the public, unless administered with great skill and through scientifically arranged machinery, as the taste of chlorine is sometimes very noticeable. Also, chemists and physicians differ in their opinion regarding chlorine's effect upon the body.

The one practical method of sterilization without annoyance to consumers is the ultra-violet-ray process. This is comparatively new, having been readily obtainable only during the past couple of years. Moreover, it is costly, compared with chlorination. When the general public becomes fully aware of the fact that ultra-violet rays passed through water will sterilize it as efficiently as does chlorine, it is quite probable that sentiment in favor of the drugless method will prevail over the difference in cost.

The ultra-violet ray method is now in use in several hundred hotels, stores, private houses, bottling plants, etc., and is also gradually becoming popular with municipalities. The largest municipal supply now being so treated is about two million gallons daily, but a plant is at present under construction which will handle five million U.S. gallons daily. Fifteen lamps are required for this amount. To handle a still larger supply is merely a matter of more lamps, more current, more space and more attendants—in short, more money.

PERSONAL.

J. A. CODERRE, federal forestry engineer, recently addressed the Montreal Chambre de Commerce. Mr. Coderre described the forestry laboratory of the Federal Government, which is situated in a building given by McGill University.

Temporary Brig.-Gen. A. C. JOLY DE LOTBINIERE has been gazetted chief engineer, attached to headquarters units, according to a London cable. He graduated at the Royal Military College, Kingston, in 1883.

J. QUAIL, formerly sales engineer of the Manitoba Bridge and Iron Works, has accepted a position with the Canadian Bridge Co., of Walkerville, Ont., as manager of their western office, located in the Garry Building, Winnipeg.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MANITOBA BRANCH.

The regular meeting of the Manitoba Branch of the Canadian Society of Civil Engineers was held on April 6th, when Mr. M. C. Hendry provided a set of lantern slides of the Panama Pacific Exposition. Mr. Victor Guilbault contributed a discussion on the slides illustrating the lecture, while Mr. W. G. Chace explained those that particularly applied to water power developments throughout Canada.

A move to encourage the zinc industry in Canada has been made by the Minister of Finance who in a resolution before the House proposes to pay a revenue of 2 cents per pound on zinc or spelter containing not more than 2 per cent. of impurities which has been produced in Canada from zinc ores mined in Canada. The above bounty to apply when the price of zinc or spelter in London, England, at the time of production is less than a stated sum, when the bounty shall be equal to the difference between this price and the prevailing London price. No bounty will be payable when the producer receives 8 cents or more per pound. The new bounty, if approved by the House, will not come into effect until after the war, and will only last until July 31st, 1917.

TRADE INQUIRIES.

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

284. Presspahn for electrical insulation—A Manchester importing firm wishes to be placed in touch with Canadian manufacturers of presspahn in the following sizes: Sheets about 23½ inches by 31½ inches or larger, in thicknesses from 0.2 m/m up to 4.0 m/m. Quotations are requested per ton of assorted thicknesses. Sample may be inspected at the Department of Trade and Commerce. (Refer File A-769.)

313. Sand, white and silver.—A firm in Glasgow which formerly imported silver sand from Belgium, is anxious to know if suitable deposits are found in Canada. If so, would be glad to receive quotations and particulars.

315. Calcium cyanamide.—A large manufacturing firm in Newfoundland asks for names of Canadian manufacturers of calcium cyanamide.

319. Calcium chloride.—A London firm is desirous of getting into communication with Canadian producers of calcium chloride.

320. Asbestos cement sheets.—A London firm of engineers are in the market for 250,000 square yards of asbestos cement sheets, 3-16-inch thick, and invites quotations from Canadian manufacturers.

323. Belting agency.—A firm in Glasgow which formerly represented large German importing houses wishes to obtain the agency of Canadian manufacturers of rubber, leather and canvas belting. Best references.

324. Brass steam fittings.—A Glasgow firm wishes to obtain the representation of a Canadian house for the above. Satisfactory references.

325. Steel billets and wire rods.—A Coatbridge firm asks for Canadian sources of supply.

326. Rolled steel joists; bars of all sections, rivets and bolts.—A Glasgow house will be glad to receive catalogues and quotations c.i.f. Glasgow quay.

327. Steel joists.—A large Glasgow firm would be pleased to receive quotations for say 150 tons steel joists to the following sections, or nearest procurable sizes: 9-inch by 4-inch by 21 pounds, 8-inch by 4-inch by 18 pounds, 7-inch by 4-inch by 16 pounds, 6-inch by 3-inch by 12 pounds, 5-inch by 3-inch by 11 pounds; all in 40-foot lengths.

328. Galvanized fencing wire.—A Glasgow firm desires to know if galvanized fencing wire can be obtained from Canada. Supplies formerly procured from Belgium.

329. Iron or steel bars.—A Glasgow firm is open to purchase iron or steel bars, notably bulb tee bars 1½ by 1½ equal 2½ pounds per foot, and varillas ¾-inch by ½-inch by $8\frac{\text{oz.}}{\text{ft.}}$

331. Wood screws.—A firm of wholesale hardware merchants at Manchester wishes to be placed in touch with Canadian manufacturers of wood screws from ½-inch to 3 inches.

340. Nails.—A New York firm of exporters desires to be placed in touch with Canadian manufacturers of wire nails, wrought nails, and galvanized wrought nails, to be used for boat building purposes.

345. Carbide.—A South African firm at present importing large quantities of Norwegian carbide are desirous of obtaining c.i.f. quotations on the Canadian product.

338. Machinery.—The director of a railway in India who has made arrangements for the building of a new plant wishes to be put in touch with Canadian manufacturers of saw-mill and veneering machinery.

The Road Board of Great Britain recently advised county authorities of its intention to loan $1,000,000 during the fiscal year 1916-17 to aid in improving road surfaces.