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The Canadian Engineer

A weekly paper for engineers and engineering-contractors

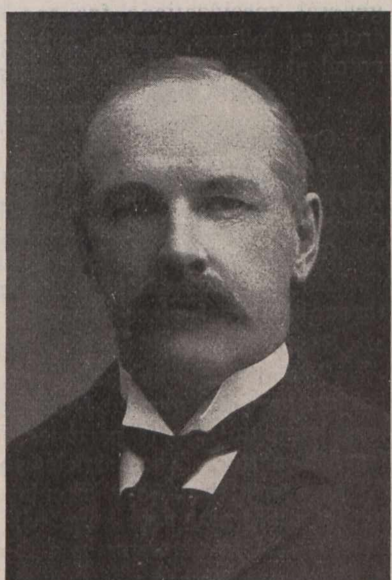
CANADIAN SOCIETY OF CIVIL ENGINEERS

TWENTY-EIGHTH ANNUAL MEETING TO BE HELD AT MONTREAL NEXT TUESDAY, WEDNESDAY AND THURSDAY — M. J. BUTLER IS PRESIDENTIAL NOMINEE—REPORTS OF COMMITTEES—VISIT TO ST. LAWRENCE BRIDGE WORKS

FOR the first time in their new building on Mansfield Street, Montreal, The Canadian Society of Civil Engineers will hold their annual meeting next Tuesday, Wednesday and Thursday. Only a reception was held in the building—which was then only partially completed — during last year's annual meeting. Nineteen - fourteen, therefore, marks the beginning of a new era in the affairs of the Society, the members now formally inaugurating into their service the splendid new building of which the Society can properly be proud. The Engineers' Club of Montreal, at which there will be considerable entertainment for visiting members of the Society, have also greatly enlarged and handsomely remodelled their building during the past year, so the meetings this year will have the advantage of much greater facilities, both for work and pleasure, than have existed at any previous annual meeting.

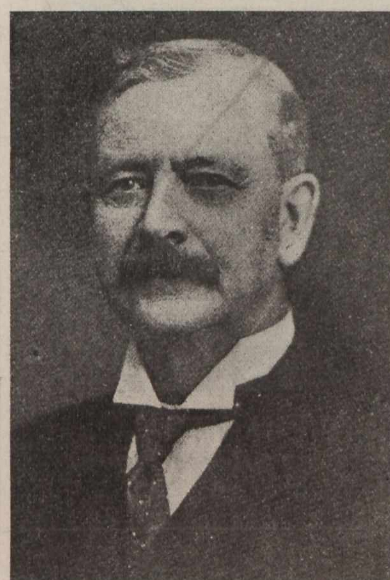
There will be five business meetings—at 10 a.m. and 3 p.m. Tuesday, at 3 p.m. Wednesday, and at 10 a.m. and 2.30 p.m. Thursday. The retiring president's address will be delivered Tuesday afternoon.

All visiting members will be guests of the Montreal members at a luncheon in the Windsor Hotel at 1 p.m. Tuesday. A complimentary smoking concert will be held at 8 p.m. Tuesday in the Society's building. The annual dinner will be served in The Engineers' Club at 8 p.m. Wednesday.



Phelps Johnson

President of the Canadian Society of Civil Engineers in 1913; president of St. Lawrence and Dominion Bridge Co's.



M. J. Butler

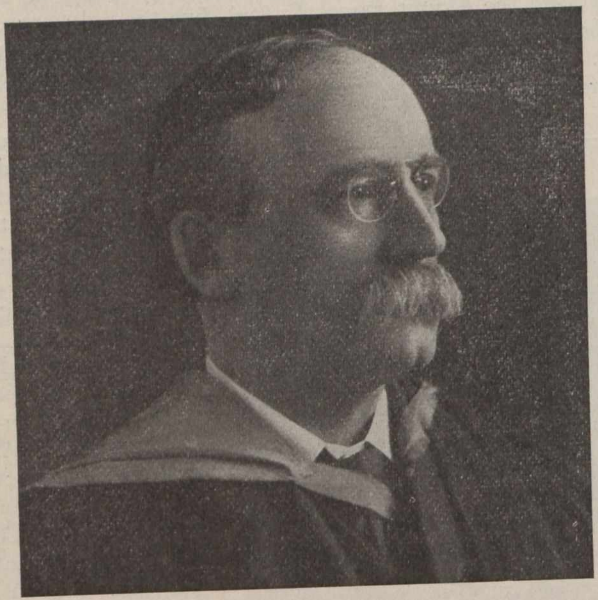
President-elect of the Canadian Society of Civil Engineers for 1914; head of Armstrong, Whitworth of Canada, Ltd.

It is thought that there will most probably be a trip through the Mount Royal Tunnel, but the only excursion officially noted on the programme is to the works of the St. Lawrence Bridge Company, Limited, at Rockfield, near Montreal. The party will leave the Windsor Hotel at 10 o'clock sharp, Wednesday morning. By courtesy of the Montreal Tramways Company, special street cars will be provided to carry the party to and from the works. After the inspection of the works, the Bridge Company will entertain the visiting members at luncheon.

The president of the Bridge Company is the retiring president of the Society, Mr. Phelps Johnson. Mr. Johnson was born in the United States and practised as an engineer for bridge companies for some years before coming to Canada. From 1872 to 1879 he was engineer for the Hawkins Iron Works, at Springfield, Mass. In 1879 he became assistant engineer of the Wrought Iron Bridge Company, of Canton, Ohio.

In 1882 Mr. Johnson went to Toronto as engineer and manager of the Toronto Bridge Company, which afterwards became the Dominion Bridge Company. In 1888 he became chief engineer of the Dominion Bridge Company, at Lachine, P.Q., which position he retained until 1892, when he was appointed general manager of the company. He was elected president of the company at the last annual meeting, succeeding Mr. James Ross, deceased. Mr. Johnson had previously acted as vice-president of the company. He is a member of the St. James Club, the Engineers' Club and the Royal St. Lawrence Yacht Club of Montreal. Mr. Johnson was vice-president of the Society in 1907 and was also a councillor for two terms of three years each. What is probably Mr. Johnson's most notable work was in connection with the design of the new Quebec Bridge, which will be an enduring monument to his ability as an engineer.

His successor as President of the Society will be Mr. M. J. Butler, of Montreal. Mr. Butler, like Mr. Johnson, will be elected by acclamation, as he was the sole choice of the nominating committee. Mr. Butler is well known as the former general manager of the Dominion Steel Corporation. Prior to that he was chairman of the board of management of the Canadian Government railways, and previously deputy-minister and



Prof. C. H. McLeod, Ma.E.

Secretary of the Canadian Society of Civil Engineers since 1891

chief engineer of the Department of Railways and Canals of the Federal Government. He is a member of several engineering societies and of a number of clubs, and has been engaged in some notable engineering projects in various parts of the Dominion. Mr. Butler is now the executive head of Armstrong, Whitworth of Canada, Limited. It was largely through the efforts of Mr. Butler and of Sir Percy Girouard, who is an honorary member of the Society, that there is now being erected at Longueuil, Que., a million-dollar Canadian branch of the well-known English steel-makers, Sir W. G. Armstrong, Whitworth Company, Limited. Mr. Butler was a vice-president of the Society in 1906 and 1907. He had previously been a councillor for two terms of two years each.

The nominees for vice-president are Mr. R. A. Ross, of Montreal, and Mr. A. F. Stewart, of Toronto. The retiring vice-president is Mr. J. G. Sullivan, of Winnipeg, who was a councillor in 1910 and a vice-president in 1911, 1912 and 1913. Mr. Sullivan is the well-known chief engineer of the Canadian Pacific Railway. Mr. H. H. Vaughan, of Montreal, and Mr. F. C. Gamble, of Victoria, will remain as vice-presidents during 1914, Mr. Vaughan having served two years and Mr. Gamble only one year of their three-year terms of office.

Mr. R. A. Ross was a councillor in 1903, 1906, 1907 and 1909. He is a consulting electrical engineer who has built up a national reputation, having been connected with a large amount of very important work.

Mr. A. F. Stewart was a councillor in 1911, 1912 and 1913. He is chief engineer of the Canadian Northern Ontario Railway and one of the chief men to whom credit is due for the success and rapid growth of the Mackenzie, Mann railway systems.

Either Mr. Ross or Mr. Stewart would, together with Messrs. Vaughan and Gamble, make a trio of excellent assistants to Mr. Butler in an effort to make 1914 a notable year in the history of the Society.

COMMITTEE REPORTS.

Among the committee reports which will be considered at the annual meeting, the report of the Committee on Reinforced Concrete is especially notable. The members of this committee are Mr. Walter J. Francis, chairman, and Messrs. S. Baulne, E. Brown, E. Brydone-Jack, J. Galbraith, P. Gillespie, H. M. MacKay, E. S. Mattice, C. N. Monsarrat, Michael Morssen, P. B. Motley and H. Rolph. They present a draft of standard general specifications for concrete and reinforced concrete as follows, certain subsequent modifications being noted at the end of the specifications:

MATERIALS.

1. CEMENT.

"Cement" shall be Portland cement complying in every particular with the "Specification for Portland Cement and Standard Methods of Testing" adopted by the Canadian Society of Civil Engineers.

As far as practicable the same brand shall be used throughout each piece of work.

2. SAND.

"Sand" shall be natural or artificial silicious material having particles graded from fine to coarse. It shall be free from dust, soft particles, vegetable loam or other foreign matter. The particles shall be of such a size that all will pass through a circular hole ⅛" in diameter in a thin plate and that none will pass through a circular hole 1-100" in diameter in a thin plate.

3. CRUSHED STONE.

"Crushed Stone" shall be silicious or calcareous material having fragments graded from fine to coarse. It shall be made by crushing natural rock or boulders having a crushing strength of at least 6,000 pounds per square inch, and be free from flat pieces, dust, soft particles and foreign matter. It shall be clean, hard and durable. The fragments shall be generally uniform in shape and of such a size as to pass through a circular hole 2½" in diameter in a thin plate and that none will pass through a circular hole ⅛" in diameter in a thin plate.

4. GRAVEL.

"Gravel" shall be the naturally produced material corresponding in every particular to the requirements of crushed stone.

5. CINDERS.

"Cinders" shall be hard, clean, vitreous clinker, thoroughly vitrified, crushed to such a size that all will pass through a circular hole 2½" in diameter in a thin plate and none will pass through a circular hole ⅛" in diameter in a thin plate, and be free from sulphides, ashes, coal, coke or any material combustible at a temperature below 1,500° Fahrenheit.

6. Water.

"Water" shall be fresh water and be free from oil, acid, alkalies or organic matter.

7. Steel.

"Steel" shall have the properties set forth in Section 30, and be free from loose mill scale, excessive rust, oil or other foreign matter.

8. Mortar.

"Mortar" shall be composed of cement, sand and water.

9. Concrete.

"Concrete" shall be composed of mortar and crushed stone or gravel, or of mortar and crushed stone and gravel.

10. Cinder Concrete.

"Cinder Concrete" shall be composed of mortar and cinders.

11. Reinforced Concrete.

"Reinforced Concrete" shall be composed of concrete in which steel of small sectional area is systematically embedded at the time of depositing the concrete for the purpose of forming a composite structure in which the component parts act in unison in resisting applied forces.

12. Reinforced Cinder Concrete.

"Reinforced Cinder Concrete" shall be composed of cinder concrete in which steel of small sectional area is systematically embedded at the time of depositing the cinder concrete for the purpose of forming a composite structure in which the component parts act in unison in resisting applied forces.

13. Rubble Concrete.

"Rubble Concrete" shall be the mass obtained by embedding boulders, fragments of rock, or both, in concrete while being deposited in place.

METHODS OF CALCULATION

14. Proportioning of Parts.

Every structure of concrete or of reinforced concrete shall be so designed that any possible combination of loading thereon will not produce stresses of greater intensity than the unit stresses given in this specification.

15. Loading Generally.

The loads to be resisted shall be considered to consist of the dead load and the live load.

The dead load shall be the weight of the structure itself and any other fixed loads.

The live load shall be all loads other than dead loads.

The loads shall be reduced to their static equivalents by a recognized method of design. All dynamic, vibratory and impact effects shall be considered and provided for.

16. Loads on Building Columns.

In the case of columns in buildings which support three or more floors, reduction of live load may be made in accordance with this section, except in the case of buildings such as warehouses in which the floors are liable to be fully loaded simultaneously. For the columns supporting the roof and top floor the full live load shall be taken. For the succeeding columns taken in order, the full live load on such columns may be reduced successively by 5% until a reduction of 50% is reached. For all lower columns the live load shall be taken as at least 50% of that used in calculating the floors.

17. Span of Beams and Slabs.

The span of beams or slabs shall be the clear span plus the depth of beam or slab, but need not exceed the distance from centre to centre of supports. Brackets shall not be considered as affecting the clear span in this connection.

18. Bending Moments of Beams and Slabs.

Taking "w" to represent the equivalent static load per unit length of span of beam or slab, and "l" to represent the span length, the following bending moments shall be used,—

(1) For beams or slabs supported at both ends without constraint, $+\frac{wl^2}{8}$

(2) For beams or slabs continuous over three or more equal spans, $+\frac{wl^2}{12}$ at centres of interior spans and $-\frac{wl^2}{12}$ over their intermediate supports; and $+\frac{wl^2}{10}$ at the section of maximum bending moment in end spans and $-\frac{wl^2}{10}$ over their inner supports.

(3) For beams or slabs continuous over two equal spans only, $-\frac{wl^2}{8}$ over the centre support, and $+\frac{wl^2}{10}$ at the section of maximum bending moment in the spans.

When the spans are of unequal lengths, or when special cases of loading arise, the bending moments shall be computed on statical principles, and due regard shall be paid to the influence of constraint at the supports in determining the maximum bending moments in the spans.

19. Assumptions for Stresses in Beams and Slabs.

The stresses in beams and slabs due to the bending moment shall be determined from the principles of the bending of homogeneous beams, using the following assumptions,—

(a) that the modulus of elasticity of concrete in compression is constant,

(b) that the tensile resistance of concrete is negligible, and the steel reinforcement carries all the tension,

(c) that plane transverse sections of a beam before bending remain plane after bending,

(d) that the steel and concrete are properly bonded together, and that in beams reinforced on the compression side the two materials are stressed in compression in the ratio of their moduli of elasticity,

(e) that initial stress in the beam due to shrinkage of the concrete is negligible,

(f) that the depth of a beam is measured from the extreme compression layer to the centre line of the tension reinforcement.

20. Proportioning of Tee-Beams.

In beam and slab construction the design shall provide efficient bond between the slab and beam. The slab shall be regarded as forming part of the compression area of the beam. The effective width of slab so acting shall not exceed one-fourth of the span of the beam, and the overhang on either side of the stem of the beam shall not exceed four times the slab thickness, nor twice the width of stem of the beam.

Where a tee-beam is continuous, as at a column, and the bending moment undergoes reversal the stresses due to the end moment shall be computed as for a rectangular beam reinforced on both tension and compression sides. The compressive stress in the concrete may be 15% greater than the maximum specified in Section 27.

21. Proportioning of Slabs.

When the reinforcement of the slab runs in one direction only computations shall be made by the formulae for simple beams.

When employing slab systems where the reinforcement runs in two or more directions the designer shall use his judgment in the interpretation of theories regarding stresses therein, and of experimental results obtained from slabs so reinforced.

22. Proportioning of Piers and Columns.

When the unsupported length of a compression member subjected to axial load does not exceed six times the least dimension of its effective area, it shall be deemed a pier, and if its unsupported length exceed the above limit it shall be deemed a column. All columns shall be reinforced.

The effective area of a column shall be the area included within the line circumscribing and touching the outermost reinforcing.

The diameter of a column shall be the least dimension of its effective area.

The length of a column shall be measured between its lateral supports, neglecting bracketing, and shall not exceed fifteen times its diameter.

UNIT STRESSES

23. Ultimate Compressive Strength of Concrete.

In the absence of tests on concrete made from the materials to be used, the following values shall be taken as the ultimate compressive strength of concrete, twenty-eight days after mixing, having the proportions of ingredients as set forth.

[Note.—Reports to the annual meeting of other standing committees of the Canadian Society of Civil Engineers will be published in an early issue of *The Canadian Engineer*.—Editor.]

Proportion of ingredients (cement, sand, crushed stone or gravel).......	Ultimate compressive strength in pounds per square inch 1:1:2	1:1½:3	1:2:4	1:2½:5	1:3:6
Kind of crushed stone or gravel...............					
Granite, trap rock.......	3300	2800	2200	1800	1400
Gravel, hard limestone or hard sandstone.......	3000	2500	2000	1600	1300
Soft limestone or soft sandstone............	2200	1800	1500	1200	1000

24. COMPRESSIVE STRESS IN PIERS AND ABUTMENTS.

The compressive stress in concrete piers and abutments shall not exceed 22.5% of the ultimate compressive strength of the concrete.

25. BEARING STRESS ON PIERS AND ABUTMENTS.

The bearing stress on piers and abutments shall not exceed one-third of the ultimate compressive strength of the concrete, if the compression be applied to a surface of concrete less than one-half the surface of the pier or abutment, otherwise the bearing stress shall not exceed 22.5% of the ultimate compressive strength of the concrete.

26. COMPRESSIVE STRESS IN COLUMNS.

The safe axial load on columns shall be determined by the following formulae,—

(1) Columns with longitudinal reinforcing only,

$$P = Af_c\left[1+(n-1)p\right]$$

(2) Hooped columns,

$$P = Af_c\left[1+(n-1)(2.4\,h+p)\right]$$

in which P = safe axial load, in pounds.
A = effective area of column, in square inches.
A_s = sectional area of longitudinal steel embedded in the concrete, in square inches.
$p = \frac{A_s}{A}$
f_c = 22.5% of the ultimate compressive strength of the concrete, in pounds per square inch.
n = modular ratio of steel to concrete = 15.
$h = \frac{\text{volume of circumferential reinforcing}}{\text{volume of column enclosed}}$

$\frac{P}{A}$ shall not exceed 45% of the ultimate compressive strength of the concrete.

For columns with longitudinal reinforcing only, p shall not be less than 0.01 nor more than 0.04.

Columns shall be deemed hooped columns when h is not less than 0.0075 nor more than 0.015, and when p is not less than 0.01. The value of (h+p) for hooped columns shall not exceed 0.05, and h shall not exceed p.

The length of a hooped column shall not exceed ten times its diameter as defined in Section 22.

27. COMPRESSIVE STRESS IN BEAMS.

The compressive stress at the extreme layer of beams shall not exceed 30.0% of the ultimate compression strength of the concrete. The estimated compressive stress due to the end moment on a continuous beam may be allowed to exceed this value by 15%.

28. SHEARING STRESS IN BEAMS.

The shearing stress, v, in the concrete of beams shall be computed by the following formula,—

$$v = \frac{V}{bjd}$$

in which V = total shear at any section, in pounds.
b = breadth of a rectangular beam, or of stem of tee-beam, in inches.
d = depth of beam, in inches.
jd = distance from tensile reinforcing to centre of compression, in inches.

For beams having tension reinforcing only, v shall not exceed 2% of the ultimate compressive strength of the concrete.

For beams in which part of the tension reinforcing is bent, as opportunity offers, so as to provide inclined shear reinforcing, the value of v shall not exceed 3% of the ultimate compressive strength of the concrete.

For beams in which v exceeds 3% of the ultimate compressive strength of the concrete additional shear reinforcing shall be provided in the form of stirrups inclined or normal to the tension reinforcing and looped around or connected to it. Using the above notation and letting s = spacing of stirrups, in inches, each stirrup shall be designed to withstand a pull of $\frac{2}{3}\frac{Vs}{jd}$ if set normally to the tension reinforcement, and a pull of seven-tenths of this amount if inclined at 45° to the tension reinforcing. The spacing of the stirrups shall not exceed the depth of the beam. Stirrups shall be of such a length that they approach within two inches of opposite faces of the beam, and they shall be so anchored or bonded that they can develop the pull for which they are designed. The value of v for beams so reinforced shall not exceed 6% of the ultimate compressive strength of the concrete.

29. BOND STRESS.

The bond stress between concrete and steel shall not exceed 4% of the ultimate compressive strength of the concrete for plain or deformed bars, nor 2% of the ultimate compressive strength of the concrete for drawn wire.

30. MODULAR RATIO.

The ratio of the modulus of elasticity of steel to that of concrete shall be taken as 15.

31. STEEL.

Steel for reinforcing shall have the following physical properties,—

	Medium Steel Bars Plain	Medium Steel Bars Deformed	High Carbon Steel Bars Plain	High Carbon Steel Bars Deformed	Cold-Twisted Bars from Medium Steel as specified
Ultimate Tensile Strength, in pounds per sq. inch = T.......	55,000 to 70,000	55,000 to 70,000	Minimum of 80,000	Minimum of 80,000	
Elastic Limit, Minimum, in pounds per sq. inch...........	33,000	33,000	50,000	50,000	55,000
Elongation, Minimum, per cent. in 8 ins....	1,400,000 / T	1,250,000 / T	1,200,000 / T	1,000,000 / T	5%
Cold Bend Without Fracture (d = diameter, t = thickness)......					
For bars where d or t is less than ¾"...........	180° d=t	180° d=t	180° d=3t	180° d=4t	180° d=2t
For bars where d or t equals or is greater than ¾"	180° d=t	180° d=2t	90° d=3t	90° d=4t	180° d=3t

For each 1-8" increase in diameter or thickness above ¾" nominal diameter or thickness, and for each 1-16" decrease in diameter or thickness for bars below 7-16" nominal diameter or thickness a deduction of 1% shall be made from the above specified percentage of elongation; but these modifications for elongation shall not apply to cold twisted bars.

Material shall be free from injurious seams, flaws or cracks, and shall have a workmanlike finish.

Bars shall preferably be rolled from billets.

Cold twisted bars shall have at least one complete twist in a length equal to twelve times the thickness of the bar.

Re-rolled bars more than 1" in diameter shall not be accepted.

32. Unit Stresses for Steel.

The following unit stresses for steel shall not be exceeded,—

In Tension,

Medium steel, 16,000 pounds per square inch.

High carbon steel and cold-twisted bars, 20,000 pounds per square inch.

Re-rolled bars, 12,000 pounds per square inch.

In Compression,

All steel, 15 times the specified unit stress for the concrete in which it is embedded.

GENERAL REQUIREMENTS IN DESIGN

33. Limiting Proportions of Ingredients of Mortar Generally.

Not more than three parts of sand shall be added to one part of cement.

To make mortar, the exact proportions shall be determined before the commencement of the work, having in mind the strength and density required and the characteristics of the materials to be used.

34. Limiting Proportions of Ingredients of Concrete Generally.

To make concrete when using a mortar composed of one part of cement and one part of sand, not more than two parts of crushed stone or gravel shall be used; when using a mortar composed of one part of cement to one and one-half parts of sand, not more than three parts of crushed stone or gravel shall be used; when using a mortar composed of one part of cement to two parts of sand, not more than four parts of crushed stone or gravel shall be used; when using a mortar composed of one part of cement to two and one-half parts of sand not more than five parts of crushed stone or gravel shall be used; when using a mortar composed of one part of cement to three parts of sand, not more than six parts of crushed stone or gravel shall be used.

The exact proportions of the ingredients shall be determined before the commencement of the work, having in mind the strength and density required and the characteristics of the materials to be used.

35. Proportioning of Ingredients for Waterproof Concrete.

Where waterproofness is necessary the proportions of ingredients of the concrete shall be determined by experiment to obtain the requisite strength and the maximum density.

36. Limiting Proportions of Ingredients in Concrete for Beams etc.

In building construction one mixture shall be used throughout for girders, beams and slabs. In no case shall there be used a mortar containing more than two and one-half parts of sand to one part of cement, and to this mortar there shall be added not more than five parts of crushed stone or gravel.

37. Limiting Proportions of Ingredients in Concrete for Columns.

In building construction one mixture shall be used throughout for columns. In no case shall there be used a mortar containing more than two parts of sand to one part of cement, and to this mortar there shall be added not more than four parts of crushed stone or gravel.

38. Crushed Stone or Gravel for Fireproof Concrete.

Where fireproofness is necessary, crushed stone or gravel containing more than 5% of limestone shall not be used.

39. Fireproofing.

The steel reinforcing shall be protected by at least 3-4" of concrete in floor slabs, by at least 1½" of concrete in beams, and by at least 2" of concrete in columns.

In concrete piers and abutments which may be subjected to the action of fire the outside concrete for a depth of 1½" shall be considered as a protective covering and shall not be computed in determining the effective area of the pier or abutment.

40. Spacing of Steel.

The distance from centre to centre of adjacent bars shall not be less than the perimeter of the larger of the bars.

In slabs the distance from centre to centre of adjacent bars shall not exceed twice the depth of the slab.

41. Splicing of Steel.

As far as practicable all reinforcing bars shall be in one length. Welds shall be made, and the length of laps determined, so as to develop the full strength of the bar.

42. Minimum Lengths of Slab Reinforcing.

The ends of slab reinforcing shall completely cross the beam or girder on which the slab rests.

43. Reinforcing in Columns.

Vertical reinforcing bars shall be carried into the footings a sufficient distance to transmit the stress in the steel to the concrete of the footing by means of bearing and bond stresses. The bars of the lower sections of columns shall extend above the upper surface of the slab a sufficient distance to enable the bars of the next succeeding section of column to be effectively bonded with them.

Reinforcing bars over 1" diameter may have their ends faced true and be butted with a sleeve not less than 12" long.

The steel ties holding the vertical reinforcing in its assigned position shall not be more than 12" apart.

44. Contraction Joints.

Contraction joints shall be provided unless sufficient steel is embedded to safely withstand temperature changes.

In mass concrete subjected to temperature changes construction joints shall be provided at abrupt changes of section, and preferably at sections not more than forty feet apart.

WORKMANSHIP

Mortar and Concrete

45. Foundations.

The foundations shall be trimmed as accurately as practicable and shall be at least as large as the dimensions on the approved drawings. Form work shall be erected wherever foreign material can become mixed with the concrete or mortar while the same is being deposited.

The bearing stratum shall be cleaned of all foreign material. It shall also be free from water if practicable. Under no circumstances shall mortar or concrete be deposited in running water.

46. Form Work.

Form work shall be substantially and accurately constructed. It shall be plumb and true to line, well fixed, braced and supported to carry the imposed loads, and be rigid enough to retain proper alignment and correct contours until the concrete will have become well set. Form work shall be sufficiently tight to prevent leakage. Immediately before depositing concrete the form shall be carefully cleaned out, after having been finally trued up. A coating of soft soap or oil may be applied to new forms. Such a coating shall be applied in every instance where form work is to be used more than once. Form work that has been previously used shall be thoroughly cleaned before re-erection and given a protecting coat of the same material as that already used on it. Form work shall be so fastened together that it may be removed without injury to any part of the permanent structure.

47. Storage of Cement.

Cement shall be stored in a weather-tight ventilated building. The floor of the building shall be raised above the ground to ensure dryness.

The cement shall be neatly piled in carload lots in the original sacks, and be marked in a distinctive manner for identification purposes.

48. Storage of Sand, Crushed Stone and Gravel.

All sand, crushed stone and gravel shall be piled on a site which has been cleaned free from vegetable and other foreign materials.

49. Measuring of Ingredients.

One sack of cement containing 87½ pounds net shall be taken as equivalent to one cubic foot of cement. All sand, crushed stone and gravel shall be measured by loose volume.

The necessary amount of water to produce the required consistency of mortar or concrete shall be determined from time to time taking into account the atmospheric conditions and the variations of moisture in the sand, crushed stone or gravel before mixing.

All of the materials shall be systematically measured throughout the whole of the work, and the required proportions shall be accurately maintained.

50. Mixing of Ingredients.

All mortar and concrete shall be made in batch mixers unless it is impracticable to do so, in which case it shall be mixed by hand.

Mixing by hand shall be done on a smooth water-tight platform. The sand and cement shall first be mixed dry until the whole mass is homogeneous and of perfectly even color throughout. Sufficient water shall then be added to make flowing mortar. In the process of making the mortar the materials shall be turned over at least five times. If concrete is to be made the crushed stone or gravel shall then be added and the whole mass turned over at least four times and until it has become homogeneous and of even color and consistency.

Mixing by machine shall produce a homogeneous mass of concrete perfectly uniform in color and even in consistency, and the whole mass shall be in continuous motion within the machine for a period of not less than one minute.

The re-mixing or re-tempering of mortar or concrete which has partly set shall not be permitted.

The general consistency of the mortar or concrete shall be such that the mass will flow readily in the forms, and that it can be conveyed from the mixer to the forms without separation of the ingredients.

The temperature of the mixture on completion of the mixing shall not be less than 40° Fahrenheit. The crushed stone or gravel shall be heated artificially, if necessary, to obtain this result. In no case shall crystals of ice either in the sand or in the crushed stone be permitted to reach the mixing platform or the mixing machine.

51. Placing above Water.

The surface on which concrete is to be deposited shall be specially cleaned for the purpose. If the surface be rock it shall be given a coat of grout composed of equal parts of cement and sand well brushed into the surface and all the crevices. If the surface, vertical or otherwise, be of concrete which has set hard it shall be spalled or roughened and afterwards thoroughly brushed over with grout composed of equal parts of cement and sand. If the surface be of concrete which has not set hard the spalling or roughness may be omitted, but grout composed of equal parts of cement and sand shall be applied as specified above.

Mortar and concrete shall be placed immediately after being mixed.

Mortar or concrete which has partly set shall not be used.

Concrete shall be deposited in such a manner that the ingredients will not be separated, and the mass shall be consolidated by being worked after placing. The coarser ingredients shall be removed from contact with the formwork by the manipulation of a special tool.

The depositing of concrete at expansion joints shall be done with the same care and attention as that required to ensure a smooth finish to exposed surfaces.

In all cases laitance which may have formed on the surface of deposited concrete shall be carefully and entirely removed.

Concrete shall be deposited in approximately horizontal masses, and the work shall be stopped only at regular or temporary vertical bulkheads.

During freezing weather concrete shall be taken from the mixer and deposited in the forms so that no part of it shall be frozen and the temperature of the mass when deposited shall not be less than 35° Fahrenheit The concrete shall be prevented from freezing until setting has taken place and until the process of hardening has begun.

Trowelled or floated horizontal surfaces shall be not less than one inch in thickness. They shall be composed of mortar or concrete proportioned according to the requirements for wear. The mortar shall contain at least one part of cement to two parts of sand. The concrete shall contain at least one part of cement to one part of sand and one part of finely crushed rock or gravel.

If possible the surfacing shall be applied immediately after the placing of the mass concrete, but when this is impracticable the mass concrete shall be thoroughly washed and treated with a coat of grout composed of equal parts of cement and sand thoroughly brushed in before the surfacing is applied. In trowelling or floating the surface pure cement shall not be used.

52. Curing.

Concrete shall be protected from the direct rays of the sun for at least three days after being deposited when the maximum temperature is above 60° Fahrenheit in the sun.

For a period of seven days after being deposited concrete shall be kept moistened when the maximum temperature in the shade is above 60° Fahrenheit.

53. Form Removal.

The forms shall not be removed from concrete work until the concrete is safely self-supporting, and, where additional concrete is to be added, until it has sufficient strength to safely sustain the superimposed load.

54. Placing Under Water.

When concrete is to be deposited under water the site shall be cleaned from all foreign matter and all currents of water shall be eliminated. The concrete shall be deposited immediately after mixing in such a way as to displace the water and at the same time to obviate the separation of the ingredients. The work shall be carried on in such a manner as to prevent the formation of laitance between successive masses of concrete.

Reinforced Concrete

55. General.

All the requirements of the preceding sections shall apply to reinforced concrete as far as consistent.

56. Crushed Stone and Gravel.

The largest fragments of crushed stone or pieces of gravel for reinforced concrete shall be of such a size as to pass through a circular hole ¾″ in diameter in a thin plate.

57. Storage of Steel.

Steel shall be stored on skids clear of the ground and protected from rain and snow.

58. Fabrication and Placing of Steel Reinforcing.

All steel reinforcing shall be fabricated and placed in strict conformity with the dimensions on the approved drawings, and it shall be truly lined up and so held in position that displacement shall not occur during the depositing or manipulation of the concrete. All bars shall be free from bonds not specifically required by the approved drawings.

No material shall be permitted to adhere to the surface of the steel reinforcing until the concrete in which it is to be embedded is being deposited.

59. Cleaning of Form Work.

Immediately before depositing the concrete the form work shall be entirely cleaned of all foreign material, preferably by the use of a pressure hose and nozzle discharging water, steam or air

In column forms an opening shall be provided at the bottom of the form work of every column in order that every particle of foreign material may be readily removed.

60. Depositing of Concrete.

The concrete shall be deposited in small quantities preferably as a uniform stream. It shall be manipulated in such a manner as to ensure perfect adhesion to the entire surface of the steel reinforcing and to remove all impounded water or air.

In depositing concrete in columns the work shall be discontinued at the elevation of the bottom of beams for a period of not less than three hours before depositing the beam concrete. In the absence of beams the elevation of the bottom of the slab shall be taken as the stopping plane. Before commencing the depositing of the beam concrete (or slab concrete in beamless systems), every column shall be examined for laitance, which if present shall be immediately removed.

The concrete for slabs shall be deposited continuously with the beams. Special care shall be exercised to procure perfect homogeneity of tee-beam construction.

61. Discontinuance of Work.

Every structural element shall be completed without discontinuance if practicable. Unless completed in one operation, beams and slabs shall be discontinued only by the use of vertical bulkheads placed at the section of maximum bending moment.

62. Freezing Weather.

In protecting reinforced concrete from frost a system which will drive the moisture out of the concrete shall not be used.

63. Form Removal.

The forms shall not be removed until the times named in the following table have elapsed after depositing concrete, not counting periods in which the temperature has been below 35° Fahrenheit.

Part	Minimum number of 24-hour days elapsed after depositing
Posts under beams and girders......	20
Floor slab panels..................	10
Wall forms.........................	2
Column forms.......................	4
Sides of beams and girders.........	4
All other parts....................	10

Cinder Concrete

64. General.

All the requirements of the preceding sections shall apply to cinder concrete as far as consistent.

65. Storage of Cinders.

Cinders shall be stored on a site which has been cleaned free from vegetable and other foreign materials.

Reinforced Cinder Concrete

66. General.

All the requirements of the preceding sections shall apply to reinforced cinder concrete as far as consistent.

67. Size of Cinders.

The largest particles of cinders for reinforced cinder concrete shall pass through a circular hole ¾" in diameter in a thin plate, and none shall pass through a circular hole 1-8" in diameter in a thin plate.

Rubble Concrete

68. Soundness of Boulders and Rock.

All boulders and pieces of rock shall be perfectly sound, impervious and durable.

69. Embedding Rubble.

All boulders and pieces of rock shall be throughly cleaned of foreign material, and after being wetted they shall be either floated into the concrete matrix or placed upon a floating bed with full bearing, in which case the concrete, as it is being raised around them, shall be manipulated in a manner similar to that required for exposed faces of walls. The mortar in the concrete shall be made to adhere perfectly to every part of the surface of the boulders and rock.

TESTS AND INSPECTION

70. Tests of Materials.

All the materials shall be systematically tested in accordance with the recognized rules of the art for each material. The results of the tests shall comply with the requirements of these specifications.

71. Field Tests of Concrete.

Tests shall be made on concrete and mortar as the work progresses to check the density of the mixtures and the rate of setting. The test pieces shall be cubes, rectangular prisms or cylinders, having a volume of about one-fourth of a cubic foot. They shall be poured from the regular run of the mortar or concrete as deposited, and be left to set under the same conditions as the material in the structure. There shall be two such test pieces made from each day's work. The test pieces shall be carefully examined before the form work is removed.

72. Test Loads on Floors.

Test loads may be applied to a floor at any time after sixty days from the hardening of the concrete, but they shall not exceed one and one-half times the live load for which the floor has been designed. If no permanent deformations result from such loading the test shall be considered satisfactory.

73. Inspection.

There shall be constant competent inspection throughout the whole of the work.

MODIFICATIONS AND CORRECTIONS BY COMMITTEE.

Section 7, first line, "Section 30" should read "Section 31."

Section 11, third line, Delete "composite."

Section 12, third line, Delete "composite."

Section 31, first line, Between "shall" and "have" add "preferably be made by the open hearth process and shall."

Section 31, second division, left hand column, Delete "Elastic Limit" and substitute "Yield Point."

Section 31, fourth division, Delete whole division and substitute the following:—

Cold Bend without Fracture, (t=thickness or diameter, d = inside diameter of bend).					
For bars where t is less than ¾".	180° flat	180° flat	180° d=3t	180° d=4t	180° d=2t
For bars where t equals or is greater than ¾"	180° d=t	180° d=t	90° d=3t	90° d=4t	180° d=3t

Section 32, fourth line, Delete "20,000" and substitute "16,000."

Section 36, third line. Place period after "cement" and delete remainder of sentence.

Section 37, Delete first sentence and substitute "In building construction one mixture shall be used for the columns throughout the same story." Third line, Place period after "cement" and delete remainder of sentence.

Section 44, fifth line, Delete "forty" and substitute "thirty."

Section 46, seventh line, Between "A" and "coating" insert "thin, even."

Section 50, seventh and eighth lines. Delete "If concrete is to be made the" and substitute "If concrete is to be made, wetted."

Section 50, twelfth line, Delete "and" after "consistency."

Section 50, fourteenth line, Change period to comma after "minute" and add "and the entire batch shall be discharged before any further materials are placed in the machine."

Section 50, twenty-first line, Between "the" and "crushed" insert "water, sand and."

Section 50, twenty-second line, Delete "artificially."

Section 51, twelfth line, Between "be" and "deposited" insert "conveyed in water-tight carriers and be."

Section 51, after seventh paragraph insert two paragraphs as follows:—

"Arch rings shall be built in sections of such length as will permit of all concrete in any one section being placed without stopping. If circumstances render this impracticable, bulkheads shall be placed normal to the line of pressure.

"In building bench walls or abutments of arches, the tops of such walls shall be finished normal to the line of pressure, and no horizontal joints shall be made."

* * * *

REPORT OF THE COMMITTEE ON TRACK

Mr. C. H. McLeod,
Secretary, Canadian Society of Civil Engineers,
Montreal.

Dear Sir,—

Referring to your letter of May 15th, announcing the creation of a Committee on Track, composed of Messrs. F. P. Gutelius and A. C. MacKenzie and the writer, I beg to advise that, owing to a tremendous pressure of business, we were not able to hold a meeting until the 1st instant. This meeting was attended by Mr. MacKenzie and myself.

The subject assigned to the Committee is a very large and comprehensive one and the work to be carried on should be in accordance with a well defined programme, and, in order to conform to the wishes of the Council as to procedure, it seems to us that the Council should give a general outline of the subjects which should be first attacked.

This is the procedure generally followed in associations of this nature and is the one which we think will obtain the best results from the Committee.

The Committee is so small that we do not think we can carry on effective research work in a satisfactory manner, because in the work associated with track matters it is quite desirable that results obtained by the Committee should be after a very general study by the Committee, which should be representative not only as to individual railroads but locality. We are, therefore, impressed that there should be an increase in the membership of this Committee to at least eight or ten, and a Committee of this size can accomplish much more effective work.

We, therefore, recommend for consideration by the Council the following action:

1. That the Council shall instruct as to the general subjects it would desire given first attention, and we might suggest that two be selected from the following list:

Recommended specifications for tie plates.
Recommended specifications for angle bars.
Recommended specifications for various classes of tie treatment.
Recommended specifications for bolts, [illegible]es, etc.
Recommended practice as to size of ties.
Recommended practice as to character of timber.
Recommended practice as to proper tie spacing.
Economics of Track Labor, embracing the following:

(a) Proper methods of conducting track work.
(b) Proper methods of measuring efficiency.
(c) Equating track values.
(d) Method of educating section foremen, and numerous other subjects could be suggested.

2. That the Committee membership be increased to ten.

We believe in the creation of this Committee the membership should not be entirely confined to railroad engineers, as there will be some features involved where it would be desirable to have the benefit of the views of men connected with steel manufacture, treatment of ties and other subjects which are associated with materials going into track use.

Respectfully submitted,

H. R. SAFFORD,
Chairman.

COMMITTEE

H. R. Safford, Chairman. A. C. MacKenzie.
F. P. Gutelius

MONTREAL, December 18th, 1913.

REPORT OF THE CANADIAN COMMITTEE OF THE INTERNATIONAL ELECTROTECHNICAL COMMISSION

The above Committee begs to report that during the first part of the year 1913 the Commission was very actively engaged in bringing to their final form the reports of the Special Committees on the Rating of Electrical Machinery, on Symbols, and on Nomenclature; in order that they might be presented at the then forthcoming Congress in Berlin, Germany.

This Congress was held as scheduled in the early part of September, and adopted to a large degree the above Reports, and also the recommendations of the National Laboratories of England, France, Germany, and the United States as to the characteristics of standard annealed copper. Through the courtesy of the Honourable W. B. Nantel, Minister of Inland Revenue, the Canadian Committee was able to send a representative in the person of the local Secretary, Mr. A. B. Lambe. A full report of the Meeting, which was attended by some seventy delegates, representing about twenty-four countries, will be issued shortly and will be obtainable on application to the Secretary of the Canadian Committee, but in the meantime, as evidence of the growing influence of the Commission, it might be mentioned that requests were received that the publications of the Commission be issued in German and Spanish as well as in English and French; further, that the Russian government, through the National Committee of that country, has extended an invitation for the 1917 Congress to be held in St. Petersburgh.

The General Secretary of the Commission, Mr. C. le Maistre, expects to pay Canada a visit early next year, on his way through to New York and San Francisco, in preparation for the next Congress, which is to be held in the latter city in 1915.

With the exception of Mr. J. J. Wright, of Toronto, who has resigned owing to business reasons, the membership and officers of the Canadian Committee remain as last year, namely—

L. A. Herdt, Chairman.	L. W. Gill.
O. Higman, Vice-Chairman.	J. Kynoch.
H. T. Barnes.	J. Murphy.
W. A. Duff.	T. R. Rosebrugh.

A. B. Lambe, Secretary-Treasurer.

L. A. HERDT,
Chairman.

OTTAWA, December 31st, 1913.

F SEWAGE DISPOSAL COMMITTEE

820 New Birks Building,
4th June, 1913.

Prof. C. H. McLeod,
Secretary, Canadian Society Civil Engineers,
Mansfield Street, City.

Dear Sir,—

The Committee appointed by the Council, as set forth in your letter of the 14th of March last, to suggest names for the formation of a Committee on Sewage Disposal, and also to outline the duties of such a Committee, beg to report as follows:—

In view of the fact that a Committee on Sewage Disposal, of three years standing, has fully considered the subject and made a report thereon, which report was received at the last Annual Meeting of the Society, and also in view of the fact that since the date of your letter of instructions, a Committee has been appointed by the Council to represent the Society in co-operating with the Committee of the House of Commons in dealing with the same subject and in formulating legislation thereon, we are of the opinion that the appointment of any other committee is unnecessary until after the enactment of the proposed legislation.

Yours truly,
WILLIS CHIPMAN,
JOHN KENNEDY,
R. S. LEA.

SUPPLEMENTARY REPORT OF SEWAGE DISPOSAL COMMITTEE

On the invitation of Mr. George Bradbury, M.P., Chairman of the Committee of the House of Commons on the Pollution of Navigable Streams, Messrs. John Kennedy and R. S. Lea attended a Session of the Committee at the House of Commons, Ottawa, and gave evidence as to the problem in hand.

Professor C. H. McLeod, who was also present at the Committee meeting, testified as to the establishment of special courses in the universities on sanitation and allied problems.

R. S. LEA,
Chairman.

REPORT OF THE CONSERVATION COMMITTEE

In March last, the Chairman of the Committee on Conservation addressed a circular letter to the members of the Committee. Replies were received from a number of the members and are appended to this report.

Last year the Committee presented a report respecting Mr. Sauder's recommendation that the Society "urge strongly upon the Dominion Government the importance of making the necessary appropriations and providing the necessary staff to undertake in an intelligent manner the gauging of all streams of water supply and the location and survey of all sites suitable for reservoirs for the storage of water."

The Committee, in its report, enumerated briefly the requirements for adequate gauging of streams, the principal gauging operations that have been carried on in Canada, and its importance in connection with all water power developments. The collation and subsequent publication of all available data was strongly recommended.

On April 14 the Secretary wrote that Council were of the opinion that the Commission of Conservation should undertake the work of compiling and publishing the stream data above referred to. The pressure of other work did not, at the time, permit the staff of the Commission to undertake the work, but it is hoped that it will be commenced next spring and that all engineers will co-operate by supplying all available information.

The communication of Mr. R. O. Sweezey, Montreal, is as follows:—

"In so much as I am supposed to represent Northern Quebec on this Committee, I prefer to confine my suggestions for discussion to questions affecting that part of the country.

"WATER POWERS.—While I quite realize that the water powers of

Quebec are under Provincial control, I think that nevertheless the local government is open to receive recommendations from this body.

"Immediately north of the city of Quebec is an area of some 3,000 square miles set apart as a game reserve and known as the Laurentides National Park. This area lies between the waters of the Saguenay and St. Lawrence and comprises the headwaters of a number of important streams, including the Jacques-Cartier (drainage area 1,100 square miles), St. Anne de Beaupre (350 square miles), Batiscan and several others.

"In connection with the development of Seven Falls on the St. Anne River under a head of 430 feet, a minimum development of about 6,000 horse power is possible. The head waters of this river offer excellent opportunities for storage, which would increase the minimum available power to at least 12,000 horse power. But here the difficulty arises which seems diametrically opposed to ideas of conservation. The National Park authorities stubbornly resist any move to create storage within the Park, claiming damage to game by flooding areas and thus disturbing caribou, moose etc. It is hard to understand such arguments when it is a well known fact that the beavers, which are so plentiful in this park, do a great deal more damage by flooding than any possible engineering storage could do, yet no effort is made to remedy that evil. Moreover the important storage localities to be flooded are usually in deep valleys and burnt areas where the flooded areas are absolutely valueless. Considering that the city of Quebec is greatly retarded in its manufacturing growth by the lack of cheap power (steam power is now used for city lighting), and, further, in view of the fact that the tract of 3,000 square miles thus reserved is, apart from the timber rights, quite unproductive an area owing to its rough and mountainous nature, one of the least benefits that might be expected from it is the utilization of its natural value as a storage basin for augmenting its water powers.

"There seems to be a strong tendency, both in Dominion and Provincial forest park regulations, to forbid the establishing of artificial storage within park limits. I would like very much to hear any arguments which might be offered in defence of such a policy.

"INDIANS.—As a natural resource the Indians of Northern Quebec and Northern Ontario are important. They are fast dying off and no effort is being made to alleviate their sufferings or to provide means for their livelihood. In this connection I have recently written to the Rt. Hon. R. L. Borden. Copies of this correspondence are attached hereto.

"I should very much like to have a discussion of this subject by the members of this Committee."

Mr. W. H. Breithaupt, Berlin, Ont., has made a special study of flood conditions on the Grand River, Ont. He has promised a fuller report at a later date, but in the meantime has contributed the following:

WATER CONSERVATION

CONTROL OF THE GRAND RIVER, ONTARIO

"In the way of preliminary investigation of the economic practicability of control of the flow of the Grand River, Ontario Peninsula, by means of storage, sufficient in volume to impound a large proportion of flood flow, and thus prevent excessive floods and give a well sustained flow in the low yield periods, the Hydro-Electric Power Commission has during the past month carried on, and is still continuing, a survey and various investigations throughout the river valley. A lineal survey from outlet to headwaters, establishing of bench marks with elevations and distances from outlet of the river, flow gaugings, and topographical delimitations of possible storage basins, have been the lines of work. Investigation of the basin in Pilkington township on the main river remains to be completed, and a satisfactory site for a sufficient reservoir on the Conestoga tributary, which empties into the main river a short distance below Pilkington township, remains to be found.

"The unfinished present stage of this work has prevented any conclusion being reached as yet. It is hoped that for a later report information that has long been wanted will be available.

"The various cities, towns and smaller communities in the drainage area of the river have made large growth during the past year. To many of them, flood diminution and sustained flow of the river are of vital importance. The spring flood this year was again very high, only slightly under the record flood of 1912, and did much damage along the entire course of the river.

"The rapidly growing manufacturing town of Galt on the river made an extended investigation during the past summer with a view to enabling passage of flood waters without local damage. The river channel is narrowed by encroaching buildings, and obstructed by piers of short span bridges and by small boulders and detritus on the bottom and along the sides. A plan for a smooth, well defined and unobstructed channel was prepared, but for various reasons no action has yet been taken."

Mr. A. E. Doucet, Quebec, writes as follows:

"I am sorry to say that I have not been able to devote very much time to look into possible suggestions for inclusion in the annual report of the Committee. As a railroad man, however, and familiar with the operation of railways through timber country, I am more than ever convinced that our generally accepted width of 100 feet for right of way is very much too limited. I know that this point has already been brought up before the Committee, but it seems to me that in future the right of way through bush lands should certainly not be less than 200 feet, and a law should be passed to this effect for all future construction work."

Mr. J. B. Challies, Ottawa, has contributed a very interesting memorandum respecting the proposed forest reserve in the basin of the Winnipeg River. He says:—

"In response to your request this morning for my views regarding the work of the Conservation Committee of the Canadian Society of Civil Engineers, I would submit the following:

"Engineers both in the Government Service and in private practice have for many years been seriously handicapped in their endeavour to secure quick and authentic information respecting the results of surveys, investigations etc. of the different departments of the Dominion Government and of the several Provincial Governments, by the lack of some central office to which enquiries could be addressed. The situation in the United States has been partially met by the creation of an office for the distribution of public documents issued by the various departments of the United States Government, and a monthly catalogue issued by the Superintendent of Documents. A similar office would meet the situation here.

"The question of the adverse effect on stream flow of the denudation of forest cover is probably one of the most important matters occupying the attention of engineers interested in water power, irrigation, water supply, navigation, or any other activity depending on water. Not only must the question be considered from a remedial point of view but also with a view to preventing existing forest cover at the headwaters of important streams from being burnt or improvidently logged.

"The particular situation in which I am officially interested is that in connection with the water powers of the Winnipeg River. The headwaters of this river are in the province of Ontario, and include the Lake of the Woods district. Fortunately this district abounds in large lake areas suitable for storage purposes and the land areas are, so far as I am able to learn, fairly well covered with forest growth. Owing to the location of this forest cover in close proximity to the prairie country, it has already become a prey to the unscientific lumberman, and it is only a matter of time until the commercial timber will be removed. Unless the lumbering operations are properly supervised and restricted and reforestation provided for, the present facilities that this district offers for storage and conservation of run-off will be dissipated.

"I am not aware that there is at the present time any forest reserve in the vicinity of the Lake of the Woods district, and am convinced that it would be in the best interest if the whole area were placed in a forest reserve in order that all logging operations may be under strict supervision of trained foresters, and also that adequate reforestation may be arranged for. Recommendations from the Conservation Committee of the Canadian Society of Civil Engineers to the proper authorities that such a reserve be created in the interest of the maximum advantageous use of the water resources flowing through and from the Lake of the Woods would surely be a matter worthy of consideration.

"There has been considerable discussion by the Conservation Committee regarding co-ordination or co-relation of the different hydrographic survey organizations of the various departments of the Dominion Service, and also of the Provincial Services. While the matter of internal organization of the hydrographic survey propaganda in Canada might not be one for the attention of the Committee, I do think the Committee might very well consider the advisability of recommending some systematic method of making the results of the various hydrographic survey organizations available to the public quickly and uniformly. My own opinion is that this could best be done by having one representative from each

Department of the Dominion Government connected with the hydrographic survey work (a member of the Society) placed on a sub-committee of the Conservation Committee, with a view to giving this question special consideration."

Mr. A. J. McPherson, Regina, suggested the following matters and has promised a report thereon at a later date:

1. The development of methods of treating the large resources in the way of lignite scattered throughout Saskatchewan to make it more serviceable for the use of the people of the Province.

2. The collection and provision for industrial and commercial purposes of the sources of water supply in sections of the Province where the local supplies are shown to be becoming inadequate.

3. The development of the highways of the Province and the direction of the forces making for this so as to produce the largest results for the efforts expended.

4. The reclamation of various areas throughout the Province by drainage.

Mr. McPherson also enclosed an interesting report by Mr. R. O. Wynne-Roberts which deserves wide circulation as a very practical measure of conservation.*

Mr. C. E. W. Dodwell, Halifax, refers to a number of important matters as follows:—

"There is one very important matter that no doubt has engaged the attention not only of our Committee of the C. S. C. E. but the Commission of Conservation, of which you are Assistant Chairman; also I am aware that the Federal Government has done and is doing something in the matter, though I regret to say I have no definite knowledge and no official reports or blue books describing the work done or progress made. I refer to the question of forestation, of which the importance is hard to over-estimate.

"If our C. S. C. E. Committee is not already in possession of full information in regard to the notable work that has been accomplished in Germany in forestation, I would suggest that steps be taken immediately to secure such information, with a view to the perfecting of a Forestry Bureau in Canada on similar lines. No doubt you are aware that forestry in Germany is a source of considerable revenue.

"In view of the rate at which timber is being used and our forests depleted, we should have thoroughly efficient and energetic forestry bureaus at work in every Province of the Dominion.

"I know that the Forestry Bureau of the United States Government at Washington is doing good work in the dissemination of literature and information in regard to forestry, and some months ago I obtained from the Forestry Office in Boston a number of interesting pamphlets on the subject.

"One very interesting feature of the question is the influence of forestation upon the climate of our North West. The whole matter is one of such great importance and interest that I feel under no obligation to apologise for mentioning it, though perhaps I should do so for my ignorance of what has been and is being done by the Federal Government.

"There is another important matter, that, so far as I am aware, has not engaged the attention of the Government and which certainly ought to do so.

"I dare say you often use alcohol in your domestic economy, for the purpose of making coffee or heating a chafing dish etc., and that you send to the druggist and pay 25 cents for about a pint or less of so-called methylated spirits, which when burning is often so evil smelling as to be almost unusable.

"In the United States, and I believe in most other civilized countries, denatured alcohol can be bought for about 50 cents per gallon, and it is coming into very general use for domestic cooking and heating purposes, and also for the production of power. There is a concern in New York called, I think, the Alcohol Utilities Company, which makes all kinds of utensils for the use of alcohol in cooking and heating as well as lamps for lighting purposes. The lamps are, of course, of the incandescent mantle type, and they are made of all powers, ranging from about 10 to about 500 c.p., the higher power lamps being, as they claim, very much cheaper in operation than electric lamps. I went through the place about a year ago and was amazed at the variety, simplicity and usefulness of the many utensils seen. Denatured alcohol in the United States is in fact a tremendous boon to the people, and I was told that some four or five immense distilleries in the United States, which, a few years ago were turning out whisky, are now confining their operations exclusively to the production of denatured alcohol, showing that, besides being a tremendous boon to the people, it is a profitable industry and no doubt one capable of very considerable expansion. Such an industry would, I think, be fully as suitable to Canada as it is to the United States, and there is no question whatever that it would be as great a boon here as it is proving to be in the States.

"I have discussed this matter with one or two Members of Parliament, who were all very favourably impressed with it, and they agreed with me that it was a matter that might very properly and profitably be taken up by the Government. My first suggestion would be that in any tariff revision that may come before the Government in the near future, the duty should be removed, in whole or part, from denatured alcohol for domestic, industrial or power purposes, and that encouragement in some way be given to the home production of this valuable article.

"If the Committee deem this matter worth an investigation I shall be glad to do what I can in procuring available information, so that we may be able at an early date to make it the subject of a report that will command the attention and interest of the Government and the people.

"Another matter of minor importance to the above has occurred to me as capable of development. There are in the country to-day many thousands of tons of sawdust lying in huge heaps at and around saw mills and up to the present time almost absolutely useless. It seems to me that some use should be found for this material. For instance, it might be mixed with a small proportion of some adhesive combustible substance, such as coal tar, crude oil or the refuse from oil distilleries, and compressed into briquettes for fuel; possibly some process might be discovered by which it could be converted into paper, but at any rate it might be given some value."

COMMITTEE ON CONSERVATION

James White, Chairman	M. G. Henniger
G. A. Bayne	H. F. Laurence
W. H. Breithaupt	R. S. Lea
E. E. Brydone-Jack	R. W. Leonard
H. J. Cambie	A. J. McPherson
J. B. Challies	R. McColl
John Chalmers	W. McNab
C. R. Coutlee	C. H. Mitchell
J. S. Dennis	W. R. W. Parsons
C. E. W. Dodwell	E. T. P. Shewen
A. E. Doucet	R. O. Sweezey
J. B. Hegan	T. H. Tracy

*NOTE.—Mr. Wynne-Roberts' paper is entitled "The Utilisation of the Coal Deposits of Saskatchewan." This report is published by the Government of Saskatchewan, and copies of the same may be obtained by those interested on application to Mr. A. J. McPherson, Chairman, Highway Commission, Regina, Sask.

THE ST. LAWRENCE BRIDGE COMPANY'S SHOPS

DESCRIPTION OF THE PLANT BUILT AND EQUIPPED SPECIALLY FOR THE FABRICATION OF THE QUEBEC BRIDGE AND OF THE FIELD EQUIPMENT FOR ITS ERECTION

THE St. Lawrence Bridge Company, Limited, was incorporated August 5th, 1910, with an authorized capital stock of $3,000,000, one-half of which was subscribed for by the Dominion Bridge Company, of Montreal, and one-half by the Canadian Bridge Company, of Walkerville, Ont. Its directors are Messrs. Phelps Johnson, Chas. Cassils, G. H. Duggan, F. L. Wauklum, and J. F. Weber, of Montreal; and Messrs. F. C. McMath, Willard Pope, and B. S. Colburne, of Walkerville. The president is Mr. Phelps Johnson; vice-president, Mr. Chas. Cassils; secretary and treasurer, Mr. J. F. Weber; superintendent, Mr. W. P. Ladd.

The company was organized to tender for the fabrication and erection of the superstructure of the Quebec Bridge, and was awarded the contract in April, 1911. This contract, at a figure approximating $8,650,000, was awarded on the basis of designs submitted by the company, differing from those of the Board of Engineers which had been appointed by the Dominion Government in 1908 to draft designs for a new structure at substantially the same location as stood the partially erected structure which collapsed on August 27th, 1907.

Articles dealing in a comparative way with the accepted design have appeared in *The Canadian Engineer* and elsewhere, as have also descriptions of the design and construction of the substructure. The accepted design, being larger and heavier than that of the old structure, necessitated the construction of new piers and abutments throughout. These are now completed and the approach spans are also in place.

Before giving a description of the company's fabricating plant, the outstanding features of the design of the bridge will be briefly reviewed, to outline the immensity of the problem which devolved upon the company with the award of the contract.

The Quebec Bridge will cross the St. Lawrence River at Neilsonville, about 8 miles above Quebec. It will have a total length of 3,239 ft. between abutments, with clear height of 150 ft. above high tide, while the main posts will rise to a height of 343½ ft. above water. Besides two 515-ft. anchor arm spans 310 ft. deep, it will have a 1,800-ft. centre span consisting of two 580-ft. cantilever arms connected by suspended trusses 640 ft. long. The superstructure will have two lines of pin-connected trusses, in vertical planes 88 ft. apart. It will be made of carbon and nickel steel, with members of a maximum shop length of about 90 ft. and shop weight of 140 tons.

Realizing that the erection of the superstructure was the chief problem connected with it, and that the peculiar design of the bridge would evolve many unprecedented engineering features; and fully cognizant of the effect of the stresses introduced by erection in the old structure, the St. Lawrence Bridge Company decided to build and equip a shop specifically for the work. The great size and weight of many of the truss members, the accuracy of workmanship, and the rapidity of construction required, left little alternative. The result is the present plant, which has cost about $1,000,000 to build. It is situated between Montreal and Lachine, about one mile from the plant of the Dominion Bridge Company, and on the Grand Trunk and the Canadian Pacific Railway. The accompanying figures, some of which are taken from an article in June 7th, 1913, issue of *Engineering Record*, illustrate the shop in plan and elevation. To this article we are also indebted for much of the following information descriptive of the works.

The plant is equipped for the fabrication of 2,000 tons per month of heavy riveted members. It has machine tools for precise work in finishing bearing surfaces up to 10 ft. square and boring long pin-holes up to 4 ft. in diameter through compression members and eye-bars. All fabrication is done in a single long shop, with receiving and shipping storage yards at both ends, with a comprehensive system of surface tracks and traveling cranes. Electric drive is used throughout, individual motors driving most of the principal machine tools and groups of smaller tools.

General Design of Main Shop.—The main building is 660 ft. long, and 160 ft. wide, for 440 ft. of its length and 190 ft. wide for the remainder, with a lean-to to be described later on. It has a concrete roof carried on transverse trusses spaced 20 ft. apart. At the receiving end these trusses have bottom-chord runways for girder cranes and are themselves supported on the wall columns of the building and on a line of centre longitudinal trusses of 100-ft. span, thus eliminating all but three interior obstructing columns in a length of 400 ft. At the other end of the shop all of the roof trusses are supported directly on columns, which support also the crane runways, parallel to the axis of the building.

The columns rest on concrete piers, with footings proportioned for the maximum pressure on bedrock at a depth of about 4 ft. below the surface. The roof trusses have spans of 60, 75 and 80 ft. and are of heavy construction, with riveted connections at panel points and full-depth connections to the columns. The structural steel-work weighs about 2,000 tons and was fabricated by the Structural Steel Company and erected by the Dominion Bridge Company.

The exterior walls are of brick, with concrete foundations, with a stone water table about 8 ft. above the surface of the ground. The floor is of concrete, with timber sleepers for the track rails and provisions for anchoring or clamping movable equipment.

The shop has a great window surface area and is provided with arc and incandescent lighting. It is heated by exhaust steam in a fan blast system designed to maintain a temperature of 50 deg. with the mercury at 20 deg. below zero outside.

Construction was commenced in 1911, and the foundations were finished before the end of the year. The erection of the steel-work was commenced in 1912, and fabrication of steel for the bridge commenced in the spring of 1913.

The plant arrangement provides for the entrance of raw material at one end of the main shop and the performance of successive fabricating operations as it passes continuously through the shop parallel to the longitudinal axis, until the finished members are delivered at the opposite end. The equipment is arranged for the amount of the different classes of work in the order of the successive operations, so that the average proportion of different classes of work will keep the shop uniformly

Note:—Pu. = Punch; Pl. = Planer; La. = Lathe; Dr. = Drill; Gr. = Grinder; A. = Furnace; B. = Forge.

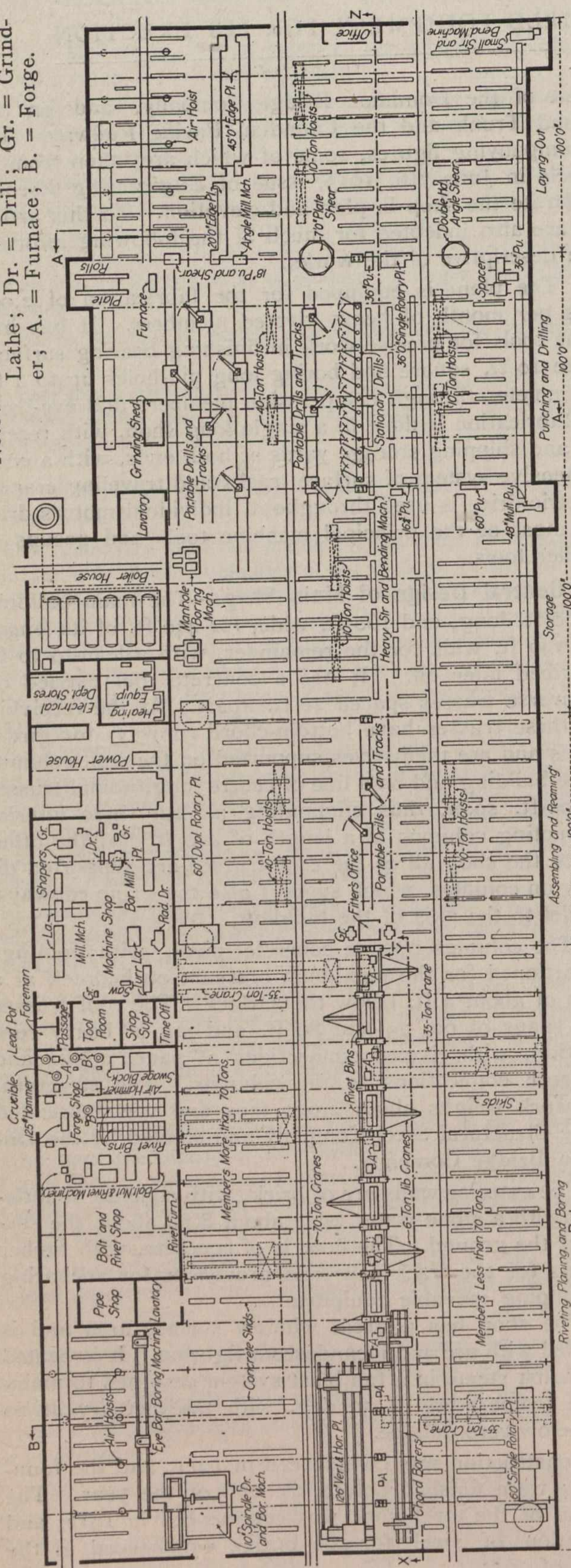


Fig. 1.—Floor Plan of Main Shop, Showing Position of Tracks, Columns, Trusses, and Machines.

busy with a constant progress of material and little lost motion or interference. Materials and supplies are received and products shipped on two tracks running through the plant parallel to the main building and commanded at both ends by cranes traversing the building. These serve the receiving storage yard at one end and the shipping storage yard at the other end of the shop.

Material is handled in the receiving yard by two 7½-ton trolley hoists on a 15-ton electric traveling crane, of 90-ft. span, with runways 500 ft. long, crossing three lines of narrow-gauge service tracks which enter the shop, two of them passing through to the other end and across the shipping yard.

Description by Panels.—The material entering the shop from the storage yard is placed on wooden skids with concrete foundations transverse to the shop axis, which occupy a large portion of the first 100-ft. panel. This panel is 160 ft. wide between main columns, besides a 30-ft. lean-to on one side, as shown in Fig. 2. It has a clear height of 21 ft. from the floor to the underside of the 80-ft. roof trusses, carried at one end of the centre-longitudinal truss. This construction is duplicated in the next panel. In the next two panels the width of the lean-to is increased to 60 ft., giving the entire shop a width of 220 ft.

In the first panel there is on one side a straightening machine with 80-ft. roller tables at each end and three large edge planers. They are served by two 10-ton assembling hoists traveling the full width of the panel on the bottom chords of alternate pairs of roof trusses. In the lean-to there is a 60-ft. roller table at one end of a set of rolls for straightening plates up to 120 in. wide, which are commanded by five 3-ton pneumatic trolley

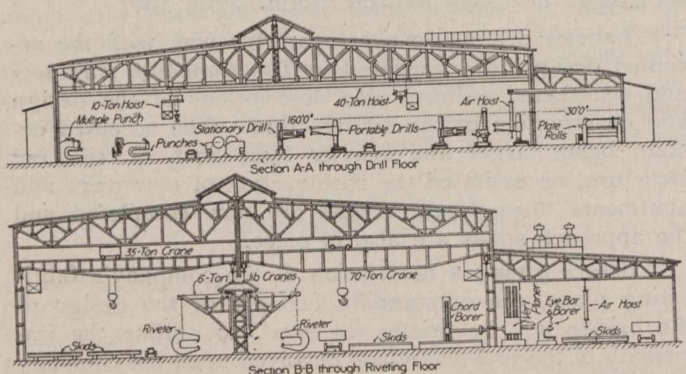


Fig. 2.—Sectional Elevations Through Main Shop.

hoists, running on the bottom chords of the lean-to roof trusses, which cantilever 8 ft. into the main aisle to transfer to the assembling hoists and command one set of skids there. This panel is devoted to straightening, shearing, edge planing and laying out, and to crimping and milling stiffening angles.

The second 100-ft. panel is devoted on one side of the centre longitudinal truss to punching and on the other side to drilling, and is served by two 40-ton and two 10-ton assembling hoists arranged, as are all of the others in this end of the building, like those in the first panel. The punching equipment is quite standard, and the machines, together with the shears, are arranged principally on the transverse lines at the ends of the panel so as to leave the interior space as much unobstructed as possible between main columns.

The special drilling plant includes 16 stationary heavy radial drills mounted on a long foundation, parallel to the shop axis under the centre truss, and 24 similar portable drills, each mounted on an individual truck, which travels on a portable track that can be clamped to the concrete floor. All of the drills have 6-ft. arms with vertical adjustments, have locking devices to the track, and are driven by variable-speed motors. There are also 12 horizontal drills mounted on trucks to work in conjunction with the radial drills and for later use in drilling the field splices in the main members. It is the intention to assemble the members in temporary sections up to 40-ton weight and drill the rivet holes en masse.

In the third 100-ft. panel, as in the remainder of the shop, except the last 125 ft., the lean-to is separated from the main shop by a solid wall, reducing the width of the shop itself to 160 ft. In the third panel there are located two manhole boring machines to rough-cut pin-holes from 10 to 45 in. in diameter. The remainder of the space there is occupied by longitudinal and transverse skids for the storage of drills and punched materials, which are handled by two 10-ton assembling hoists.

On one side of the fourth 100-ft. panel there is installed a 60-in. duplex rotary planer with a bed 110 ft. long. Provision was also made for the installation as required of the portable drills forming the reeming plant, and the remainder of the space in this panel is devoted to assembling members up to 80 tons, which are handled by two 10-ton and two 40-ton assembling hoists.

Beyond the fourth panel there is a centre longitudinal row of columns, 20 ft. apart, dividing the shop into a 75-ft. and an 85-ft. aisle, and the height of the roof is increased to 38½ ft. from the floor to the under side of the

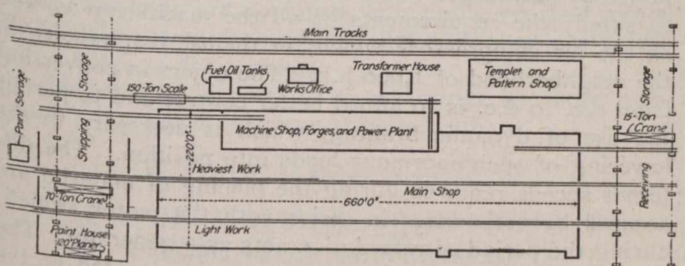


Fig. 3.—Arrangement of Buildings and Tracks.

roof trusses. Both of these aisles are 260 ft. long, and the width of the 85-ft. aisle is increased to 145 ft. for a distance of 100 ft. at the extremity by the inclusion of the lean-to space, the dividing wall being here removed and the addition thus provided being occupied by a duplex eye-bar boring machine with a bed 100 ft. long. The 85-ft. aisle is equipped with two 70-ton and one 35-ton cranes of 85-ft. span, traveling the full length of the aisle and serving to handle members weighing above 70 tons each, which will be fabricated here. At the end of this aisle there is a special horizontal boring machine for large shoes and main members, with a capacity for a 45-in. hole 11 ft. long. Each saddle has a vertical movement of 12½ ft., while the main column has a horizontal traverse of 23 ft., thus enabling it to bore several holes in the same piece at one setting.

Opposite the boring machine in the same aisle is a duplex vertical and horizontal planing machine for finishing the ends of large compression members for which rotary planing is not permissible. One of its heads is stationary, while the other has a power traverse on the 25 x 100-ft. bed, to enable it to be set for various lengths of members. The heads can make a 10-ft. cut in either a vertical or horizontal direction and are equipped with patent tool holders for cutting in the four directions, on both direct and return strokes. This machine will finish the 7 x 10-ft. bottom-chord pieces 42 ft. long, which weight 140 tons each.

The 75-ft. aisle is equipped with two 35-ton traveling cranes, one single-headed, 60-in. rotary planer with a 50-ft. bed and a duplex horizontal-chord boring machine with two movable heads on a bed 100 ft. long. This aisle is intended for the fabrication of members weighing less than 70 tons each.

Members in both the 75-ft. and 85-ft. aisles will be riveted by various pneumatic yoke machines with gaps of from 24 to 72 in., handled by 6-ton traveling jib cranes, with runways 180 ft. long on both sides of the centre row of columns. These cranes are 20 ft. high above the floor, with a clearance of about 18 ft. beyond the columns, and are special in that the bottoms are provided with vertical bearing wheels to carry the weight and with inclined reaction wheels in the planes of the braces to receive the thrust on special T-shaped tracks, inclined about 45 deg. to the vertical.

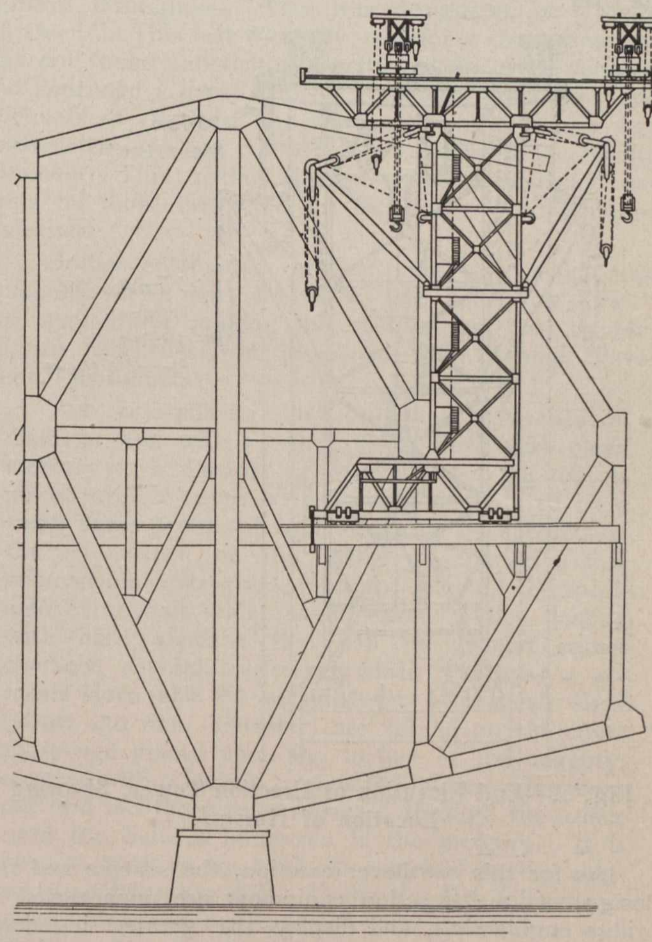


Fig. 4.—Side View of Erection Tower, on Cantilever.

The 60 x 340-ft. enclosed portion of the lean-to is occupied by the bolt and rivet shop, forge shop, the 60 x 80-ft. machine shop, generator and compressor room, boilers, coils, and fans for the heating plant, and by store-rooms, lavatory, offices, etc.

At the end of the shop there is a storage yard for finished members, which is commanded by a 70-ton crane of 80 ft. span, with runways 500 ft. long. One end of the runway is enclosed by a shed 140 ft. wide and 180 ft. long, open at one end, which provides shelter for painting and for a 120 x 120-in. x 30 ft. surface planer for finishing the larger shoes.

Opposite the laying-out panel of the shop is the 60 x 176-ft. two-story brick and steel template and pattern shop, equipped with power-driven wood-working tools and having benches nearly 100 ft. long. There is also a 30 x 50-ft. transformer house and a 25 x 45-ft. office building. The designing offices of the company are in Montreal.

Equipment at Bridge Site.—This reference to the equipment for the fabrication of the Quebec Bridge would not be complete without an outline of some of the methods which have been adopted for the placing of the various members after they arrive at the site. From foregoing descriptions of the design, it will be remembered that it was the intention to erect each of the cantilevers as an entirely separate structure, with its individual erection equipment. The centre span, weighing about 6,000 tons, will be completely assembled on barges at the river bank. When the time arrives for its erection, all navigation will be stopped at this point on the river. The span will then be floated into position, and will be hoisted by hydraulic power into its proper place, 150 ft. above the river.

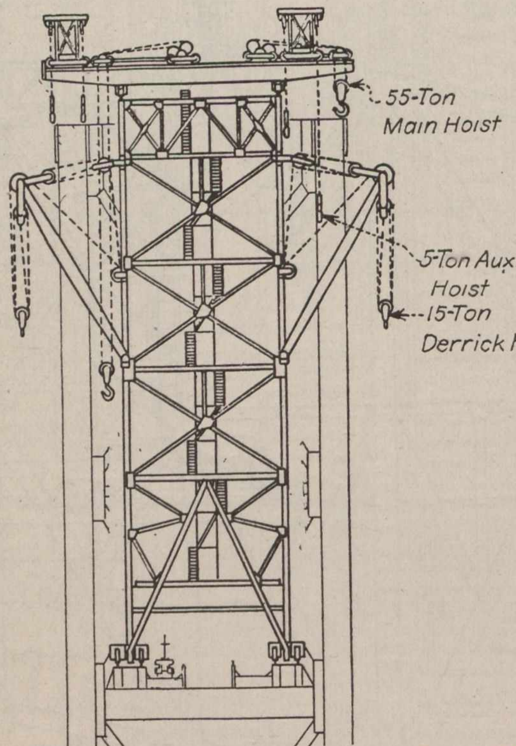


Fig. 5.—End Elevation of Erection Tower, Showing Location of Hoists.

As for this cantilever erection, the scheme and the design of the erection equipment are unparalleled in bridge engineering, and display the greatest ingenuity and exhaustive scientific investigation for the solution of the problem.

The erection of each cantilever of the bridge will be executed by means of a huge erection tower which will be carried by the cantilever itself, and moved outward along the bridge structure as its length extends from shore. These towers are of heavy steel construction with a height of 200 ft. from the carriage to the summit. Each travels by four trucks of six wheels each, spanning a double-track railway spur for the bringing in of bridge material. Each tower weighs approximately 840 tons. At this the weight is a minimum, careful experiment having been carried out to secure requisite strength without undue weight. The crane girders which project over the travellers are of nickel steel.

Each erection tower is equipped with a 90-ft. 15-ton derrick hoist on each of its four corners. Two traveling cranes, each of which carries two 55-ton main hoists and two auxiliary gantry cranes, operate at the top of the tower. Each of these gantry cranes is equipped with two 5-ton hoists, making eight 5-ton hoists for each tower.

With the exception of the travel of the four auxiliary gantry cranes all operations are electrically driven. The motor equipment of each tower is shown in Table I.

Table I.—Motor Equipment for Each Erection Tower.

Crane.	Service.	No. of motors.	Motor h.p.
15-ton derrick hoist	Hoist	4	50
	Swing	4	5
55-ton main traveler	Hoist	4	80
	Bridge	2	16
	Trolley	4	5
5-ton auxiliary gantry	Hoist	8	20
Total		26	752

This does not include, however, the motive drive of the main erection towers themselves along the cantilevers, this movement being accomplished by two of the 50-h.p. motors, which form the hoisting power for the 15-ton derrick hoists.

The electrical energy for these motors is brought to the site on each side of the river by high-tension transmission, where it is stepped down and converted by motor-generator sets to 250-volt d.c. Each sub-station receives its supply from separate systems and they are joined by submerged cables. Each is of sufficient capacity to supply the requirements of all the machinery as well as the air compressors which, in themselves, require in the neighborhood of 1,600 h.p. The object in converting from a.c. to d.c. is to afford better control and to permit the use of dynamic braking, which is necessary in the lowering of such enormous loads into position. The different speeds required during the placing of material are secured by resistances in series with the motor, which, during the period of retardation acts as a generator. The resistances are in the form of cast grids located at the base of the tower where their weight and size do not interfere with operations. Over 5,000 grids are required for this method of regulation.

The dynamic braking action is available for use only in retarding motion, while the motor armature is still rotating. When motion ceases the load is held stationary by magnetic brake. Safety devices on the important hoists prevent the load to over-travel when it nears its position.

Fig. 4 shows part of an uncompleted cantilever carrying one of these erection towers. Fig. 5 is an end view of the tower alone. These views are reproduced from the *Engineering Magazine* for December, 1913, containing an article by H. F. Stratton, descriptive of the erection equipment for the Quebec Bridge. The method of procedure, as described by Mr. Stratton is as follows:

It is planned to erect the north anchor arm over staging by what might be designated, purely for convenience, the first erection tower. When the north anchor arm has been erected, work will start on the south anchor arm by the use of the second erection tower. While the south anchor arm is being erected, the first erection tower will be at work on the north cantilever arm, and this will be finished substantially when the south anchor arm is completed. The first erection tower will then be taken down and reassembled at a point two miles below the bridge site, where it will be again set up for assembling the suspended centre span on barges. During the building of the suspended span, the second erection tower will be assembling the south cantilever arm, and these processes will be completed at substantially the same time. There then remains merely the transportation of the centre span to the bridge site, and its subsequent elevation into place.

On each erection tower there will be built an operating platform at about the second-floor level, from which a clear view can be secured of the material as it comes in on flat cars and as it is later elevated by the cranes and finally properly placed in its permanent position. A house will be built in the centre of this platform for protecting the control apparatus from the weather, except that portion of it which is actually manipulated by the workmen, which will be out-doors on the platform. Six men will be stationed on the operating platform and two men on each of the main cranes at the top of the tower. To secure the proper co-operation by quick, effective communication between these widely separated workmen, a complete telephone system is to be installed with a central switchboard and permanent connections to the shore. An electrically operated passenger elevator will regularly serve the different floor levels.

The following is a brief description of the method of erecting any typical part of the structure. The member is brought in on flat cars underneath the erection tower, and by proper manipulation is elevated and located by two, or possibly four, of the 55-ton main hoists. The pin is then placed and suspended in position by means of one of the 5-ton auxiliary hoists, and a large ram for driving the pin is suspended from another 5-ton auxiliary hoist. The pins are equipped with hardened steel pilots which guide them through the links as they are being driven home to their places.

The date of completion of the bridge has been estimated to be either the year 1917 or 1918.

VALUE OF MELTING POINT TEST OF BITUMINOUS MATERIALS.*

By H. B. Pullar, Assoc. Am. Soc. C.E.
of the H. B. Pullar Co. (Detroit), Engineering Chemists

As in the case of a number of other tests for bituminous materials, the value of the melting point test has been much questioned, and there is considerable variation of opinion among engineers and chemists interested in the testing of bituminous materials as to the value of this test. Some believe that it is an important one in determining the quality and suitability of a bituminous material, some merely use it in conjunction with other tests as a means of identification, while still other authorities do not use the test in their work, and strongly recommend its total elimination from all bituminous work.

On account of bituminous materials being mixtures of hydrocarbons and not true solids, they have no true melting point, and some arbitrary method must be adopted. As nearly all bituminous materials must be heated before being used in actual work, the melting point was naturally one of the first tests to be thought of and many different arbitrary methods were used by chemists for running this test. One of the first of these methods and the one which the writer first used, was what is known as the "Capillary Tube" method. This method consists of using a capillary tube about six inches long, having an outside diameter of about 5 mm. and an inside diameter of about 3 mm. The capillary tube was drawn to a point and sealed at one end. A piece of the bituminous material to be tested was then rolled out until it was small enough to be inserted into the capillary tube. The tube with the material inserted was then placed in a bath of cotton-seed oil or sulphuric acid and the temperature raised at the rate of about 5° F. per minute. When small specks of melted material were noticed on the sides of the tube the first reading was taken and this was designated as "Starts to Melt." The next reading was then taken when the small specks of melted material began to run together and this was designated as "Starts to Run." The third and last reading was taken when the tube was entirely coated with the material and was uniform throughout. This was designated at "Melts All Over." This test was only used for a short time and was not found satisfactory as the results were variable and depended a great deal on a personal equation. The thickness of the tube and the method in which it was constructed also had considerable to do with the results obtained. This method has now been abandoned entirely by those interested in the testing of bituminous materials.

Another of the old melting point tests which was commonly used, was known as the "Mercury Test." The method for making this test is described by Mr. Clifford Richardson in his book "The Asphalt Pavement," as follows:—

"A crystallizing dish, about 2¼ inches in diameter and with 1½-inch sides, filled with clean mercury to a distance of ¼ inch from the top, is placed over a 20-mesh wire gauze and heated by a small flame protected from draughts by a chimney. On the surface of the mercury is placed a thin microscopic cover-glass, No. 2-0, carrying the specimen of asphalt under examination. When dealing with hard asphalts that can be ground rather coarsely, several fragments which will pass a 40-mesh sieve and be retained on a 50-mesh sieve (about .50 mm. diameter) are spread on the cover glass and placed upon the surface of the mercury, covered with a funnel, from which the stem has been cut and the thermometer passed through the orifice until the bulb is immersed in the mercury. It is held in position by a clamp attached to the ring-stand, holding the dish. Under the dish a burner is placed that can be regulated to a small flame and heat so that the rise of temperature will be from three to five degrees per minute. In a short time it will be noticed that the specimens will have changed from the brown or brownish-black color of the powder to that more nearly approaching the original, with a slight rounding of the individual grains. On further heating these globules flow together and form a thin sheet on the glass. The point at which the specimen begins to flow, as indicated by the thermometer, is noted as the melting or flowing point.

"Asphalts that cannot be ground are softened and pulled out to a thread and cut into small pieces, about 1 cubic mm. Several pieces should be placed on the glass together, as one will serve as a check on the other, and thereby lessen the chance of error. The softening point may be noted by the rounding of the particles and the beginning of the flow, or when the specimen begins to spread out, which is always at the point of contact with the cover-glass,

*Paper read before the convention of the American Association for the Advancement of Science at Atlanta, Ga., Dec. 31st, 1913.

is set down as the flowing point or the temperature at which the specimen will melt."

This test was a big improvement on the capillary tube method, but there were also many objections, and as in the case of the capillary tube test, the results were dependent to a great extent on a personal factor.

On account of the rapid development in the bituminous industry new and more scientific methods of testing were desired, and as the result of investigations and tests, two new methods for the taking of melting point have been developed. These methods are more scientific and different chemists in various parts of the country are able to obtain comparable results on the same sample or on the same class of bituminous materials. These two methods are known as the "Cube Method" and the "Ring and Ball Method." The "Cube Method" was recommended for use by a special bituminous committee of the American Society of Civil Engineers, and at the present time is probably used more than any other method. The determination of the melting point by the cube is as follows:—

> A ½-in. cube of the material is placed on the short arm of a No. 12 B. & S. gauge wire bent at right angle and placed in a 400 c.c. Jena glass beaker, tall form. The bottom of the cube to be placed 1 in. from the bottom of the beaker on which is a small piece of filter paper. The beaker is placed in a 600 c.c. common form beaker containing cotton-seed oil. The temperature is raised at the rate of 5° C. per minute. When the cube just touches the bottom of the beaker the melting point is read from a thermometer placed within the bulb even with the cube.

The "Ring and Ball" method has been used by a number of chemists and is used more extensively in the testing of tars than asphalts. This determination is made as follows:—

> A brass cylinder ¼ in. high and ⅝ in. inside diameter is supported by wire in beakers as in cube method. The cylinder is filled with bitumen and a ⅜ in. bicycle ball placed on top. The temperature is raised at the rate of 5° C. per minute and when the ball falls to the bottom of the beaker the melting point is read from the thermometer.

There are a number of other methods in use by various chemists throughout the country and in different localities, one of the most popular of these being known as the "Thermometer Test," which consists of placing the sample of bituminous material around the bulb of the thermometer, inserting the thermometer in a test tube and emersing the test tube in an oil or acid bath. The bath is then heated at the rate of about 5° F. per minute, and the temperature at which the bituminous material drops from the thermometer, is taken as the melting point.

Another of the well-known tests is what is known as the "Kramer & Sarrow" method, but on account of its being little used, details will not be given.

As can be seen from the foregoing statements, there are a number of methods used for making melting points. Most of them have been developed during the last five years. On account of the many different methods which have been used and the fact that until very recently none of the methods were of sufficient scientific accuracy to make the results dependable, the value of the melting point test can well be questioned, and in the opinion of the writer, the results which have been obtained are absolutely of no value unless the details of the method used are given.

The results obtained by using the different methods of taking the melting point, are not comparable, and in a recent patent suit this was brought out very clearly; the results on the same sample varying considerably, depending upon the method used and the chemist making the test. On the same sample three different chemists varied more than 60° F. on a material having a melting point of 300° F. With this wide variation in results on the same sample, the melting point test is of little or no value.

In the writer's opinion, the melting point test, like other tests for bituminous materials, if properly used, is of considerable importance. The melting point test indicates in a large measure the lowest possible temperature at which a bituminous material must be heated before using; for instance, a blown oil product having a penetration of about 75 and having a melting point of 200° F., will require heating to at least 350° F. before using in a practical way, whereas an asphalt obtained by the direct distillation of oil having a penetration of 75 but a melting point of only 130° F. would require a heat of not more than 250° F. to 275° F. to be the proper temperature for use, and at a higher heat would likely be injured.

The melting point also is of considerable importance and value in identifying different bituminous materials or the different processes used in the production of these materials. This point is clearly brought out by Mr. Prevost Hubbard in his interpretation of the melting point test which is as follows: (Blanchard & Drowne's Text Book on Highway Engineering).

> "A determination of the melting point of solid bitumens is mainly of value as a means of identification and for control work on the part of manufacturers. The melting point of a bitumen is directly related to its hardness and brittleness, but the relations are not the same for all classes. Thus, at normal temperature, a blown oil with a melting point of 50 degrees Centigrade is neither hard nor brittle, while a tar pitch is both. As the melting point rises, however, they both become harder and more brittle. The climate under which a bitumen is to serve as a road binder, should be considered in connection with its melting point and this is particularly true of tar products."

In view of the fact that there are now two tests which are comparable and which are recognized as being capable of giving uniform results, the value of the melting point test from the present time should be of greater importance than ever before, and will enable intelligent comparisons of materials to be made.

In conclusion, the writer would state that in his opinion, the melting point test is of considerable value and should not be eliminated as one of the tests for bituminous materials, that when properly used, it is of importance in identifying different materials, that when properly used, it tends to give certain indications as to the quality of the bituminous materials under examination. It must, however, be understood that the results obtained at the present time with this test are not comparable with the results obtained even a few years ago, and that in all cases where the melting point is given, the method of testing should be indicated.

With these points in mind the melting point test is of importance and will be of greater importance in the testing of bituminous materials.

THE UNDERGROUND SURVEY WORK FOR THE MOUNT ROYAL TUNNEL

PRECISE ALIGNMENT AND LEVELLING METHODS THE ACCURACY OF WHICH WAS SO CLEARLY MANIFESTED AT THE MEETING OF THE HEADINGS ON DECEMBER 10TH, 1913—THE REWARD OF PERSEVERANCE IN THE ELIMINATION OF ERROR—INSTRUMENTS AND ACCESSORIES USED

By J. L. BUSFIELD, B.Sc., A.C.G.I., A.M. Can. Soc. C.E.

At 7 o'clock on the morning of December 10th, the culmination of the precise surveying and aligning of the Canadian Northern Mount Royal Tunnel was reached by the meeting of the bottom headings from opposite sides of the mountain, with an error of only $\frac{3}{4}$ in. in alignment and $\frac{1}{4}$ in. in grade. This exactitude is the result of over $1\frac{1}{3}$ years' careful surveying, many calculations and much patience.

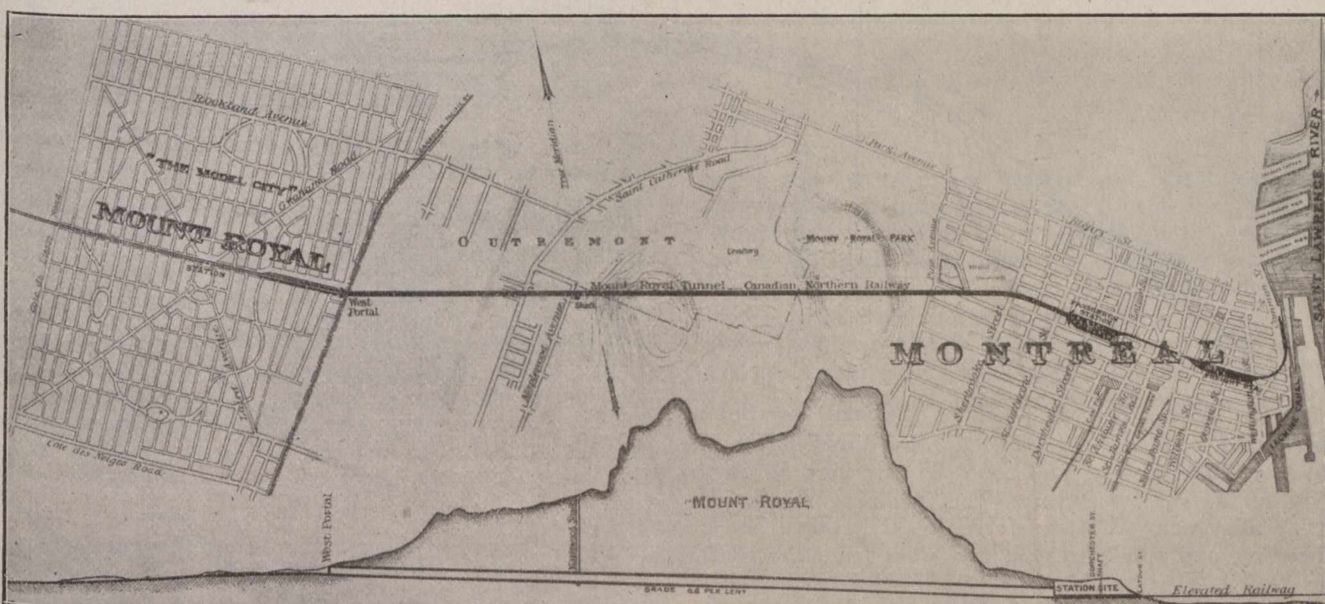


Fig. 1.—Plan and Profile of Tunnel Location.

In order to fully understand the nature of the alignment work performed it will be necessary to refer to Fig. 1, which shows the location in plan and profile of the tunnel. It will be seen that the tunnel is located on two tangents, connected by a 2-deg. curve in the neighborhood of Sherbrooke Street. The main tangent through the mountain is 2.8 mi. long. The method adopted for the construction of the tunnel was that of driving a bottom heading approximately 8 ft. high and 12 ft. wide. With the object of driving the headings from as many points as possible, one was driven towards the city from the West Portal; a shaft was sunk at Maplewood Ave. a depth of 250 ft. to the level of the tunnel, and headings were driven both ways from this shaft; and, at the city end a fourth was started westwards from the bottom of a 55-ft. shaft close to Dorchester and St. Monique Streets. The location of these shafts and the West Portal is shown in Fig. 1.

Previous to the actual commencement of the construction work, the relative location of the important points along the route of the tunnel was obtained by base line traverses around the mountain.* The long tangent was also very precisely located over the mountain, and permanent monuments established at all the transit points. (These were finally reduced to three in number between the West Portal and Sherbrooke St.) East of Sherbrooke Street the centre line of the tunnel was to be coincident with the centre line of McGill College Ave., but as the shaft at Dorchester St. was to be located to the north of this centre line, as shown in Fig. 2, it was found best to reference a line 33,678 ft. to the north of, and parallel to, the centre line of the Avenue, by means of points on the roofs of the most solid structures intersected by this line. It intersected the main tunnel tangent at a point on the roof of Strathcona Hall on Sherbrooke St., and the angle at this point was read a number of times with a 10-second transit until the final intersection angle of 21° 15′ 48″.6 was adopted. The location of this point was tied in to the co-ordinated survey lines. In this way its distance from the West Portal and from the location for the Dorchester Shaft was computed.

The actual work of driving the headings was commenced in July, 1912, when an opening was made under the C.P.R. tracks at the West Portal. In order to give

* For description of these base line traverses and of the precautions against inaccuracies in them, see *The Canadian Engineer* for February 27th, 1913.

line for this heading, a concrete monument was built in the open cut west of the Portal at a point so located that it was possible for a transit to be sighted over the C.P.R. tracks on to the mountain to a foresight, and the depressed and sighted along the centre line of the heading (see Fig. 3). Shortly after this heading had been commenced, the Maplewood and Dorchester shafts were started. The former of these could not be located immediately over the tunnel centre line, so a parallel line 24 ft. to the south of it was established by carefully measured offsets, one on the side of the mountain above the shaft, the other on the flat roof of a convenient building between the shaft and West Portal. A transit

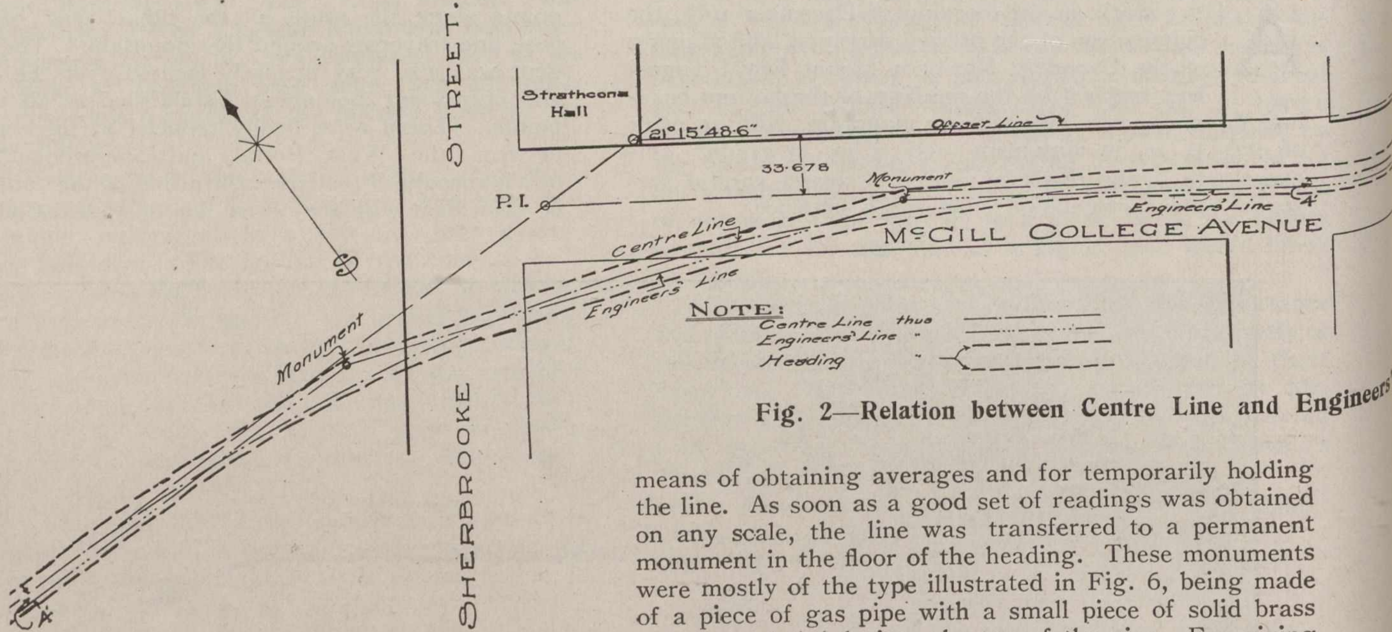


Fig. 2—Relation between Centre Line and Engineers' Line.

tower (Fig. 4) was built adjacent to the shaft so that a transit could be set on the offset line by direct sights on to the two offset points, and could be also sighted on to the top of the shaft for setting the plumbing wires.

The alignment was transferred to the centre line of the heading and run both east and west from the shaft. After the westerly heading had been driven 2,100 ft., a junction was made with the one from the West Portal, meeting with an error of less than 1-16 in. in alignment. After this junction had been made, the centre line was carried through from the West Portal to the working face in the heading, being driven east from the shaft. At the city end, as shown in Fig. 2, it was found advisable to run an engineer's line in the heading independent of the centre line. This enabled the alignment to be transferred up McGill College Ave. and around the 2-deg. curve onto the main tangent with a minimum of 4 angles.

Monuments and Scales.—Before proceeding with a description of the methods used in laying out the lines described above, note should be made of a piece of apparatus used very frequently, and found almost invaluable in the alignment work. This was a brass scale fitted with a sliding vernier, as shown in Fig. 5. Whenever it was necessary to obtain the average of a number of points set by a transit, one of these scales would be used. Whenever required for this purpose they were rigidly attached to the roof timbers or to plugs set into the roof of the heading, as shown, with plumb-bobs suspended from the sliding verniers in front of "light boxes" or illuminated screens. These scales were only used as a means of obtaining averages and for temporarily holding the line. As soon as a good set of readings was obtained on any scale, the line was transferred to a permanent monument in the floor of the heading. These monuments were mostly of the type illustrated in Fig. 6, being made of a piece of gas pipe with a small piece of solid brass rod rivetted tightly into the top of the pipe. For giving the centre line at the working face, "spads," also illustrated in Fig. 6, were set in the roof every 50 or 60 ft. throughout the tunnel. They were also used for giving elevations and chainage.

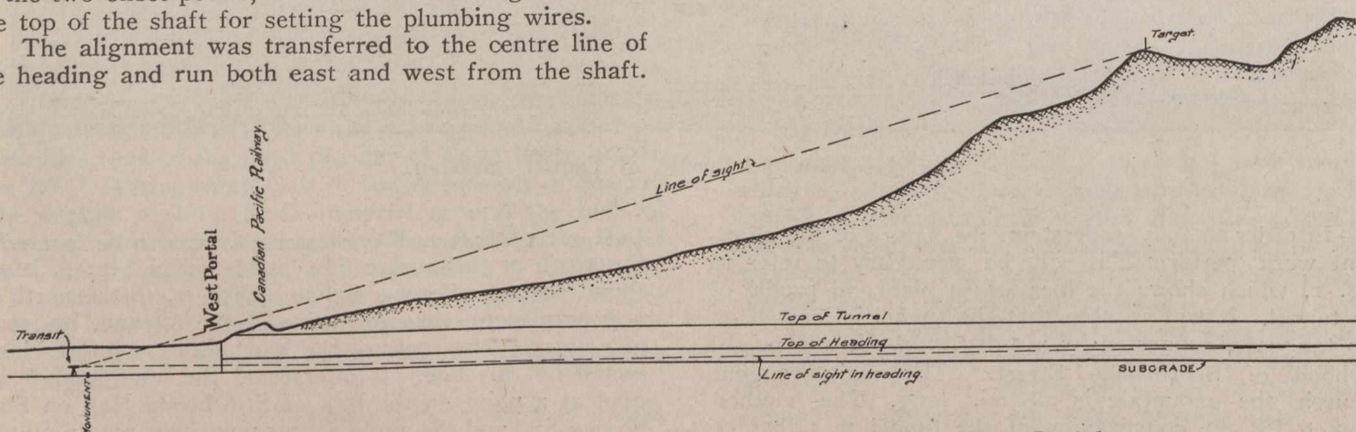
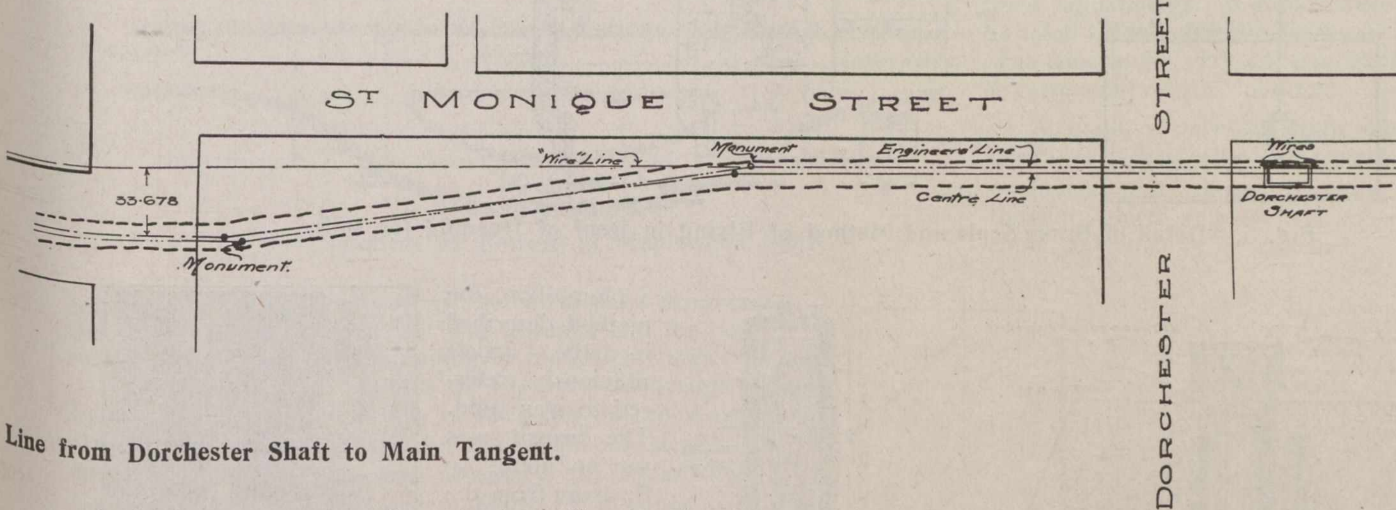


Fig. 3—Method of Transferring Line into Heading at the West Portal.

Shaft Plumbing.—For transferring the survey lines down the shafts, No. 8 steel piano wires were used, being suspended as far apart as the limits of the shafts would permit. They were hung from reels attached to solid wooden frames, as shown in Fig. 7, and were passed over a notch in a tangent screw on the front of the frame by means of which they were finally adjusted to their exact position at their upper ends. The two wires were very carefully set on line at the surface by a transit, and an instrument man was kept on watch throughout a series of observations. This precaution was fully justified, as frequently the wires would be jarred very slightly off line by a careless laborer or by some other cause. At the lower ends of the wires, 12-lb. and 30-lb. weights were attached at the Dorchester and Maplewood shafts, respectively. The weights were immersed in water and covered over, as shown in Fig. 8, in order to reduce the vibrations to a minimum. It was impossible to eliminate the oscillation entirely, and the centre of the swing of the wire always had to be estimated by the instrument man. In producing the line into the heading, the instrument man set the transit on line as close as he could estimate by eye, about 10 ft. from the nearest wire, and would then proceed to buck into line until, when he had sighted on the near wire (taking the centre of swing) and produced the line of sight on to the further wire, the latter would be bisected by the transit cross hair. It must be understood that in doing this when one wire was in focus the other was so much out of focus it was entirely invisible. At least 2 scales had been previously set up at each shaft, one being as far away as possible from the wires. When the instrument man had got the transit set on line he would proceed to set the plumb-bob at each scale on the line of his cross hair. When this was done the reading at each vernier would be recorded to the nearest 1,000th ft. This operation was repeated at each shaft a great many times. The observers at transits and scales were frequently changed, and the transit was reversed and set off line between readings. A lateral adjuster was frequently used to facilitate bucking into line. Care was always taken in placing the light boxes and plumb-bobs so that the minimum amount of movement of the telescope was necessary. At the Dorchester shaft it was possible to locate these in such a way that the telescope could be clamped to the verticle circle, and the only movement necessary was that of the focusing screw.

Fig. 4.—Transit Tower at Maplewood Shaft.

At the foot of the Maplewood shaft it was only possible to locate the scales about 80 ft. apart (Fig. 9), and it was necessary to measure the 24-ft. offsets to the north at each scale on to monuments on the tunnel centre line. The precision of the 24-ft. distance was not so important as it was to have the two offsets absolutely identical. A variation of only one 100th ft. in one of these offsets would have meant an error of 3 in. at the meeting point 2,100 ft. away. This, added to a possible error from an inaccuracy in the wire line, might have made quite an appreciable error at the meeting point. A rigid wooden frame was made with needle points set 24 ft. apart and set up at each offset monument. The line was then transferred on to the monuments by means of a transit.



Line from Dorchester Shaft to Main Tangent.

Turning Angles.—In the heading from the Dorchester shaft, 4 angles had to be turned off very precisely, as the exactitude of the main tangent depended largely on the accuracy of these angles. In setting off one of these angles a 10-sec. transit was first set up over the angle point, and in order to eliminate any errors due to inaccurate centering of the plumb-bob, etc., another transit was invariably used to set up the larger transit vertically over the angle point. The transitman would then turn off the angle roughly and have a small mark made on the foresight monument. The precise angle to this rough point would then be obtained by "wrapping up" the angle 5 times, thus giving a reading approximately to 2 seconds. The method of "wrapping up" is as follows: Clamp the plates at zero, sight on to the backsight; (2) unclamp the upper plate, sight on to foresight, and take the first reading of the angle; (3) leaving the upper plate still clamped at the first angle, unclamp the lower plate and turn back on to the backsight again; (4) unclamp the upper plate again and turn to foresight. Repeat the whole operation until 5 readings have been obtained. The last reading, divided by five, should be very close to the first reading and will be a value of the angle practically to 2 sec. if the work has been carefully performed.

After the precise angle to the rough point had been obtained in this manner, by taking the difference between this angle and the angle required, and also knowing the distance between the angle point and the foresight, it was possible to calculate the amount the true point should be to right or to left of the preliminary mark made on the monument. After a new point had been obtained in this way, the angle was again wrapped up five times by different observers, and the whole operation repeated until there was no possibility of error of even 1 sec. in the angle.

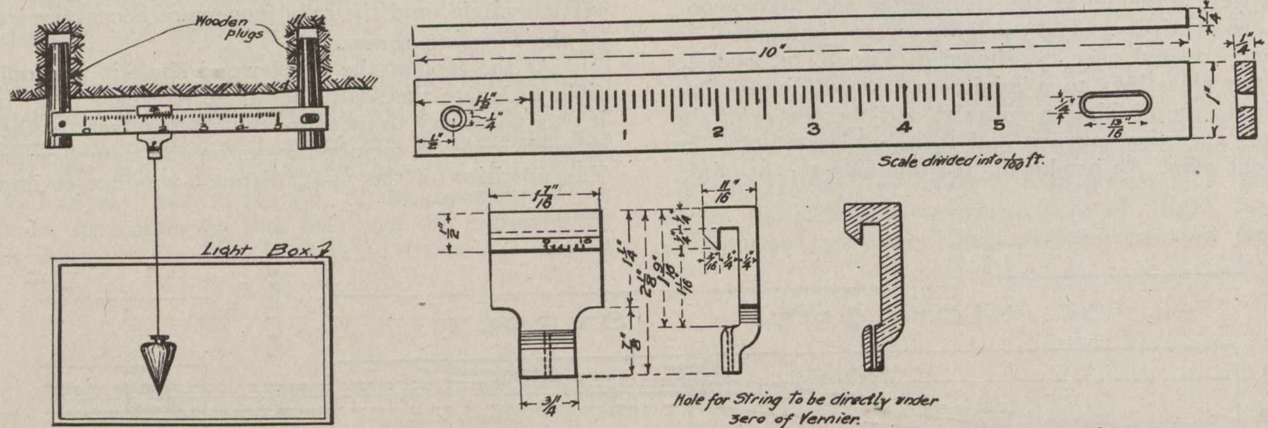
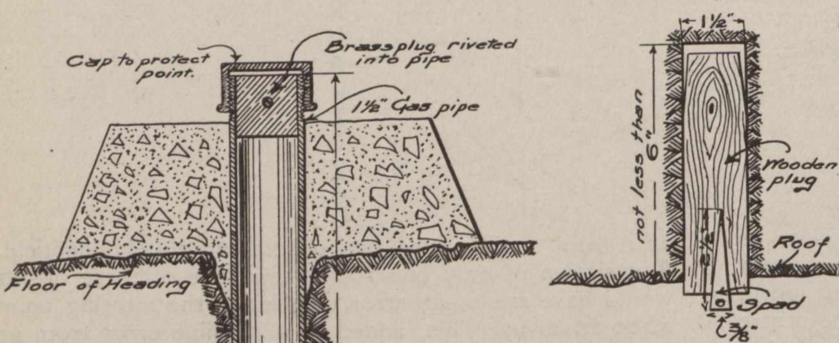


Fig. 5.—Detail of Brass Scale and Method of Fixing in Roof of Heading (on left).



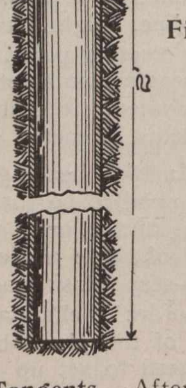


Fig. 6.—Detail of Monument (on left) and Spad (on right).

Producing Tangents.—After the last angle had been turned off to a point as far away as possible, the tangent had to be produced westwards. At the same time the tangent was being gradually prolonged eastwards from the West Portal. In producing a line from any 2 monuments a scale was set up at the foresight and the transit was set up adjacent to the intermediate monument. Instead of being set up over this monument by means of a plumb-bob, the method described in the article previously referred to was used. The transit was set up about 10 ft. away from the monument and bucked into line until the cross hair bisected both the backsight and the punch mark at the monument at which the transit was set up. After this was done the line was thrown ahead to the scale and a large number of readings were taken. By reversing the instrument between each set and having different transitmen take readings, instrumental and personal errors were reduced to the minimum.

Fig. 7.—Setting Wire on Line at Surface.

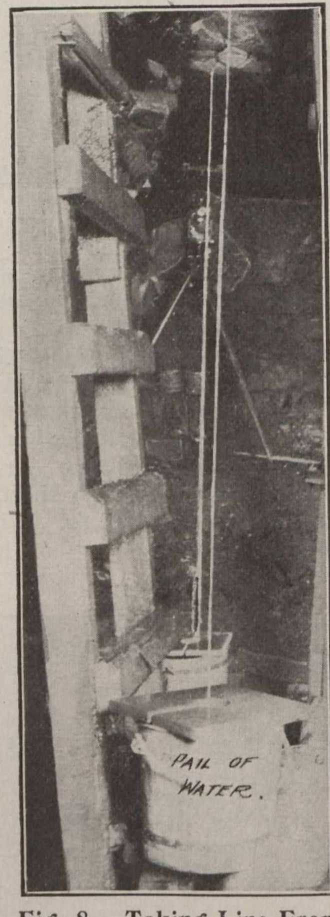


Fig. 8.—Taking Line From Wires at Foot of Shaft.

Targets.—In producing the tangents it was naturally advisable to use as long sights as possible, and for sights of over 1,000 to 1,200 ft. the ordinary plumb-bob was not satisfactory. For taking these long sights 2 types of targets were used, from both of which good results were obtained on sights as long as ½ mile, in a smoky heading. The one shown in Fig. 10 was used at points where a fixed backsight was required. The other, shown in Fig. 11, was used at foresight stations where a movable target was required, being attached to a sliding vernier at a scale. The former was made by cutting square holes out of a piece of sheet tin, with their diagonals located exactly on a straight line, and the tin attached to a piece of wood with similar, but larger, holes cut in it. This target was attached with horizontal and lateral adjustments to the front of a large, light box, containing sockets for about 15 lamps. In practice this box and target were set up so that the centre line was exactly over the punch mark on the monument, and was

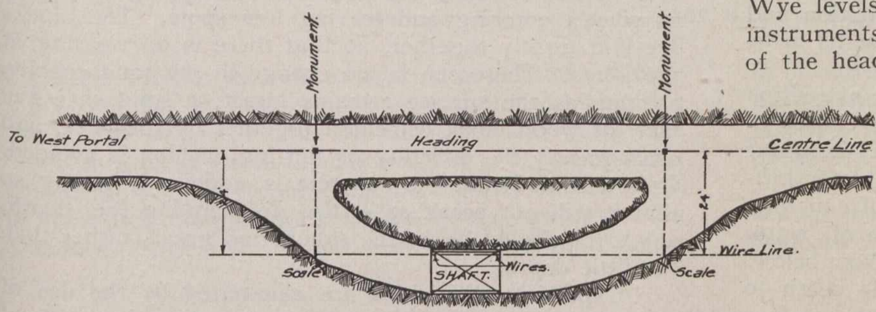


Fig. 9—Alignment at Bottom of Maplewood Shaft.

set vertical by means of a transit set up a short distance away. Once set up the target was clamped and the box kept steady by rocks or by nailing to convenient timbers.

The type of target shown on Fig. 11 was designed by A. F. Duguid, transit man of the party on the Western Division, as a substitute for the plumb-bob in places where a movable target was necessary. Canadian and United States patents have been applied for in connection with it. The one originally used was made from an 18-in. length of 2½-in. seamless steel pipe, by cutting in it pairs of slots 2 in. long and 180° apart at regular intervals. These slots were accurately cut to one 100th in., and the hole in the cap through which the suspending cord was passed was very accurately centered. The ends were weighted with lead in order to give the target stability. When suspended in front of a light box, this target presents a silhouette which encloses a series of bright areas, varying in width. If the vertical cross hair of the transit is made to bisect the bright areas, the line of sight will be in the same vertical plane as the point of suspension. It is immaterial from which direction the target is sighted, as there will always be a number of bright areas in view.

Levelling.—Although the work of levelling through the tunnel, and of keeping the floor of the headings to the correct grade, was not so difficult to carry out as the alignment work, it was even more essential that it should be carried out accurately. An error of 3 in. in line would not have been a very serious matter, but 3 in. difference in grade would have meant 3 in. to have been taken off one heading floor, or an additional amount of concrete or ballast to have been used on the other side. The permanent monuments already described were used for bench marks throughout the tunnel. In levelling between 2 monuments the level was set up equidistant between turning points about 100 ft. from the instrument. The difference in elevation of the turn points was taken by 3 independent operations of setting up, and a mean of all three readings taken. New York rods with sliding targets reading to one 1,000th ft. were used. All elevations were run separately by different observers, and differences of 100th ft., or more, were not accepted. For the working face elevations were taken on each spad. Their chainage being known, the height of the spad above sub-grade could be computed, and by sighting across footrules, or by any other method the foremen might prefer, a line could be marked across the working face a certain number of feet above sub-grade. All elevations were referred to the datum of the Montreal Harbor Commissioners.

Instruments, Etc.—For ordinary work, such as putting in spads and rough surveys, a 30-second transit with a 6¼-in. plate was used; but for all precise work, turning off tunnel angles, etc., a 10-second instrument with a 7-in. plate was used. The levels were all taken with 18-in. Wye levels. Considering the rough use to which these instruments were subjected, due to the dirt and drippings of the headings, it was remarkable how well they kept their adjustments. It should also be borne in mind that the great majority of the work was done under very adverse conditions of atmosphere and surroundings.

A great variety of light boxes was used, all of simple construction, being made from empty boxes, tin cans, and anything to which lamp sockets and reflectors could conveniently be attached.

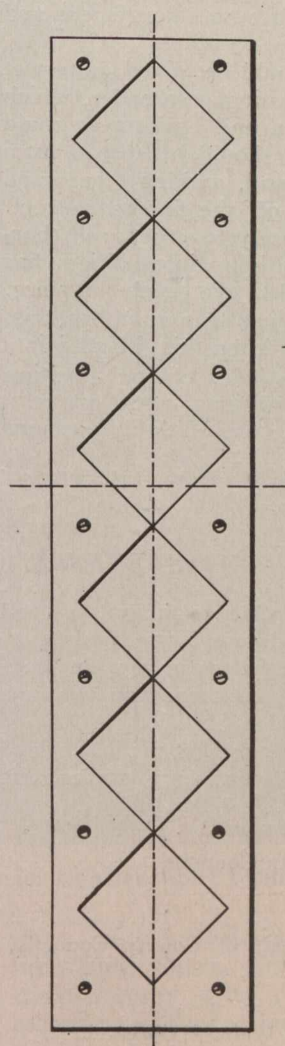


Fig. 10—Target for Fixed Back-sight.

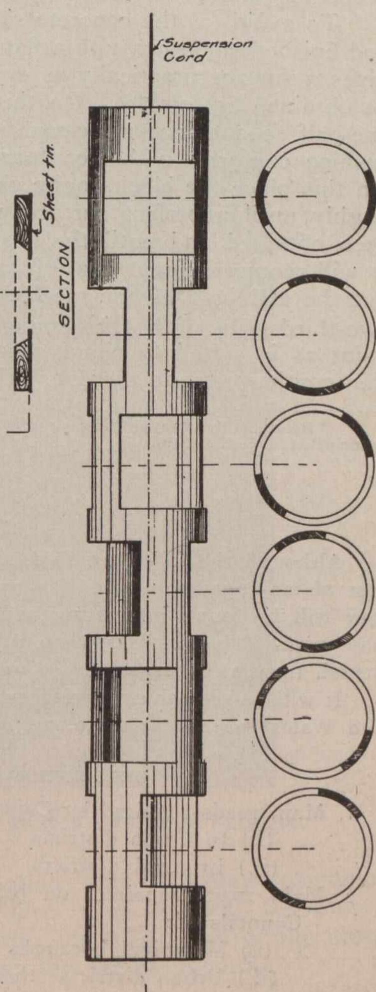


Fig. 11—Target for Movable Fore-sight.

Personnel.—The whole of the alignment work was carried out under the direction of Mr. Howell T. Fisher, M. Can. Soc. C.E., Tunnel Engineer; Mr. R. S. Basset, Asst. Engineer, was in charge of the alignment and survey work for the Western Division and the writer for the Eastern Division.

THE CONSTRUCTION OF CREOSOTED WOOD BLOCK PAVEMENTS.*

By R. S. Manley.

A CREOSOTED wood block pavement should show no evidences of wear for many years if the proper materials are used, and if they are assembled in the proper way. The correct depth of base, or foundation, varies with the soil conditions, but the materials forming this concrete foundation and the methods of mixing are in such common use as to be standard and easily secured.

We are interested principally in the construction placed on top of the concrete. The principal causes of defects of more or less serious nature are (1) irregular or uneven surface due (a) to careless laying, (b) to shifting of sand cushion, (c) breaking or settling of concrete. (2) Expansion difficulties due to the entrance of water into the blocks, either by way of the joints or from below.

The first (irregular or uneven surface) is death to any paving material, because a depression in the surface holds water, and repeated churnings of wagon wheels in the depression are bound to cause an enlargement and deepening of the depression.

To avoid (a) the concrete should be mixed quite wet and finished smoothly with a flat wooden spreader, which gives a surface practically as even and uniform as could be obtained by templet. On this should be spread from one-half to one inch of clean sand, making the sand cushion conform to the contour of the finished street. On this place the blocks quite closely together, roll thoroughly until a perfect surface with no inequalities has been obtained and until the blocks are firmly in place. It will require a great deal of rolling to accomplish this, but the end justifies the means. After this fill all joints two-thirds full of hot bituminous filler of such melting point as is suited to climatic conditions, and spread a thin coating of sand thereon. The use of the bituminous filler is, in my estimation, the most important of all. It converts the street into an effective watershed which, without absorbing any of the water, directs it into storm sewers or other drainage paths. Should any water remain on the surface the wind and the sun, both good evaporative agencies, will rapidly dissipate it.

Now you have an absolutely even surface, waterproofed and converted into a watershed. This surface cannot be worn by traffic, because the pressure of wheels is even and regular, and there is no dropping or jolting of wheels entering and leaving low spots. The blocks are laid tightly together, so that there is no wearing at the joints. There can be no change in the sand cushion as long as the surface remains intact, a solid sheet, in fact, of wood block cemented together by the filler, and consequently the difficulty of shifting cushion is avoided. It is assumed that the concrete is sufficiently strong so that it will not break or settle. In planning the depth, any error should be on the side of too great, rather than too little depth.

Expansion difficulties are eliminated by the use of bituminous filler, for there can be no expansion without absorption of water, and no absorption of water when all rainfall is conducted quickly to drainage sewers. In addition to this it must be remembered that with the bituminous filler each block is surrounded by an individual expansion joint.

The other way of constructing wood block surface which is sometimes recommended is to provide a mixed sand and cement cushion and sand-filled joints or interstices. The sand and cement cushion does not give the opportunity for absolutely smooth surface that the sand cushion gives and is considerably more costly. The sand filler in the joints allows moisture to be absorbed in the pavement, and ultimately this moisture gets into the blocks and trouble ensues. It is only on extremely heavy traffic streets that sand can be used as a filler without expecting some expansion difficulties sooner or later. The proof of the pudding is the eating, and the proof of theories of wood block construction lie in the actual occurrences on the street.

* Read at the annual meeting of the American Wood Preservers' Association, Jan. 22nd, 1914.

MAINTENANCE OF ENGLISH ROADS.

Although the following figures relate to the mileage and cost of maintenance of English roads are for the year 1911, they will be found interesting nevertheless by men in highway work. They appeared recently in connection with the British taxation returns.

It will be seen that the total mileage of roads in England and Wales in 1911 was 150,671, of which 27,754 miles were main roads, the cost of maintenance and repair of which amounted to $14,365,750. Some 122,917 miles were ordinary or district roads which cost, in maintenance and repair for the year, $28,396,000. These sums are exclusive of works of road improvement, and if such be added the total outlay on the roads for the year under review was $73,862,000.

DESCRIPTION OF ROADS.	Mileage Year 1910-11.	Expenditure on Maintenance and Repairs 1910-11.	Average Per Mile. 1910-11.	Average Per Mile. 1909-10.
1. Main roads repaired by County Councils:				
(i.) In urban districts	631	$ 728,873.64	$1,156.68	$1,108.08
(ii.) In rural districts	17,723	7,594,036.74	427.68	388.80
2. Main roads repaired, on behalf of County Councils, by Councils of:				
(i.) Municipal boroughs	1,243	1,368,532.26	1,103.22	1,074.06
(ii.) Urban districts other than boroughs	2,315	2,375,533.98	1,025.46	967.14
(iii.) Rural districts	5,842	2,298,726.59	393.66	364.50
3. Roads (not being main roads) repaired by Councils of:	4,871	2,626,062.12	539.46	515.16
(i.) Municipal boroughs	11,411	4,712,275.44	413.10	379.08
(ii.) Urban districts other than boroughs	95,077	11,239,158.24	116.64	111.78
(iii.) Rural districts	9,366	6,257,133.36	665.82	631.80
4. Public roads and streets repaired by:				
(i.) Councils of county boroughs	2,144	3,387,084.66	1,579.50	1,545.48
(ii.) Councils of metropolitan boroughs	48	174,289.32	3,630.42	3,965.76
(iii.) Corporation of London				
Total	150,671	$42,761,706.30		

HAMILTON WEST END SEWAGE DISPOSAL WORKS

DESIGN AND CONSTRUCTION DETAILS OF THIS PART OF AN EXTENSIVE SEWERAGE SYSTEM FOR ENTIRE CITY—OUTLINE OF THE SYSTEM AND ITS CHIEF COMPONENTS

By BERNARD E. T. ELLIS, C.E.
Assistant Engineer, in charge of Main Drainage Works, Hamilton

THE City of Hamilton, with a population of over 100,000, is situated at the head of Lake Ontario. The sewers are all on the combined system, as a result of which the discharge of sewage fluctuates considerably. The topography of the city is such that at least two main outfalls are necessary, owing to the Dundurn Ridge, which runs north and south, dividing the city into western and eastern drainage areas, which may be classed as residential and manufacturing districts respectively. In 1911 the west end main trunk sewer was built to calculations for the combined system of drainage, with a maximum drainage area of 1,225 acres.

Upon this area the calculation for these disposal works was principally based. Allowing, for the area being fully built upon, owing to the rapid growth of the city, a total daily dry-weather flow of 5,880,000 gal. of sewage was the volume considered for treatment. Calculations from weir gaugings, taken at the outfall in the main sewer, gave the present daily dry-weather flow to be approximately 3,000,000 gal. In character the sewage to be treated is purely a weak domestic one. As it is to be carried to the disposal site by gravitation, in sewers having sufficient grade to ensure a good self-cleaning velocity, it will be discharged at the works in a comparatively fresh condition.

The new disposal works were designed to treat the sewage from this entire west end drainage area. They comprise: coarse screens; grit chambers; continuous flow, 2-story sedimentation tanks; dosing chambers; sprinkling filters, provided with nozzles, throwing a circular spray under a variable head given by the dosing chambers. Fig. 2 shows the general layout.

Fig. 1.—Sedimentation Tank Bottom and Sump Under Construction; Clear Water Drainage Scheme.

For the present, only part of the original scheme is being carried out, to remove the suspended solids from the whole of its sewage, to reduce the bulk by septic decomposition. The final treatment of the clarified effluent by filtration, after further consideration was abandoned, as the effluent discharging in a marsh as a considerable distance from its inlet through the Des Jardines Canal to the Bay, was considered to be sufficiently oxidized before reaching it. The secondary filtration may be added at some future date if found necessary by local changes in the district.

Treatment of Sewage—Main Intake Chamber.—The main intake chamber off the 6½-ft. main sewer leading into the site of the disposal works was designed with a storm overflow weir, at such an elevation that during storms anything above 3 times the normal dry-weather flow would discharge over it, into the existing brick sewer, which is at present the main outlet for the untreated sewage from the West End drainage area into the marsh. The connections are shown in Figs. 3 and 4. When the new disposal plant is in full operation this old brick sewer will act as a storm overflow sewer only.

The end of this chamber is constructed as an inspection manhole, fitted with sluice gate for closing down the works whenever necessary.

Screening Chamber.—The C.I. screen consists of bars spaced at ½-in. centres, placed at an angle of 45° to the flow, and only intended to arrest the bulky floating mineral matter, which can easily be removed, by means of hand raking, into the steel channel iron supporting it.

Grit Chambers.—The grit chambers, as shown in Figs. 6 and 7, are built in series of three, each 30 ft. x 4 ft., and a variable depth (minimum being 4 ft.). They are equipped with a by-pass arrangement, controlled by penstocks for diverting the flow as required when in operation.

The normal velocity of these grit chambers is calculated for not less than 1 ft. per sec., and stop-logs have been inserted in the main walls to regulate the velocity according to the variable flow. They were designed with the object of being operated separately. They are not intended to remove putrescible organic matter, but simply for the settlement of sand, and any other heavy mineral matter. A large percentage of streets drained in this district are at present paved with macadam, and, being on the combined sewerage system, a considerable amount of sand, silt, and street washings will find its way into the sewers after heavy storms.

The cleansing of these chambers may be done whenever required, being easily accomplished in the following manner: The sewage is drained off by means of the 6-in. unjointed, vitrified pipes, covered with broken gravel, laid in the V-shaped channels, leading from a main sump to the manhole where each draw-off pipe is fitted with a separate valve. This manhole is connected to the temporary 9-in. effluent pipe, through which the sewage is discharged to the main effluent pipe emptying into the marsh. The chambers are then cleaned out by hand. It is intended to use the sand, after washing (if necessary) for the finished layer required on the filter media for the sludge beds.

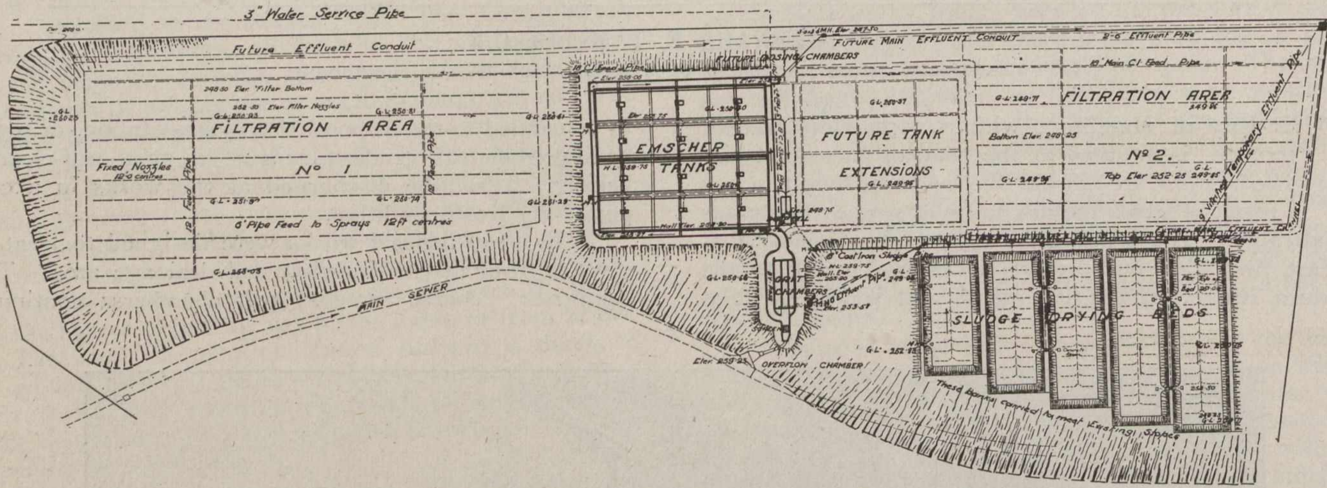
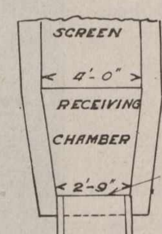


Fig. 2.—General Layout of West End Disposal Works, Hamilton.



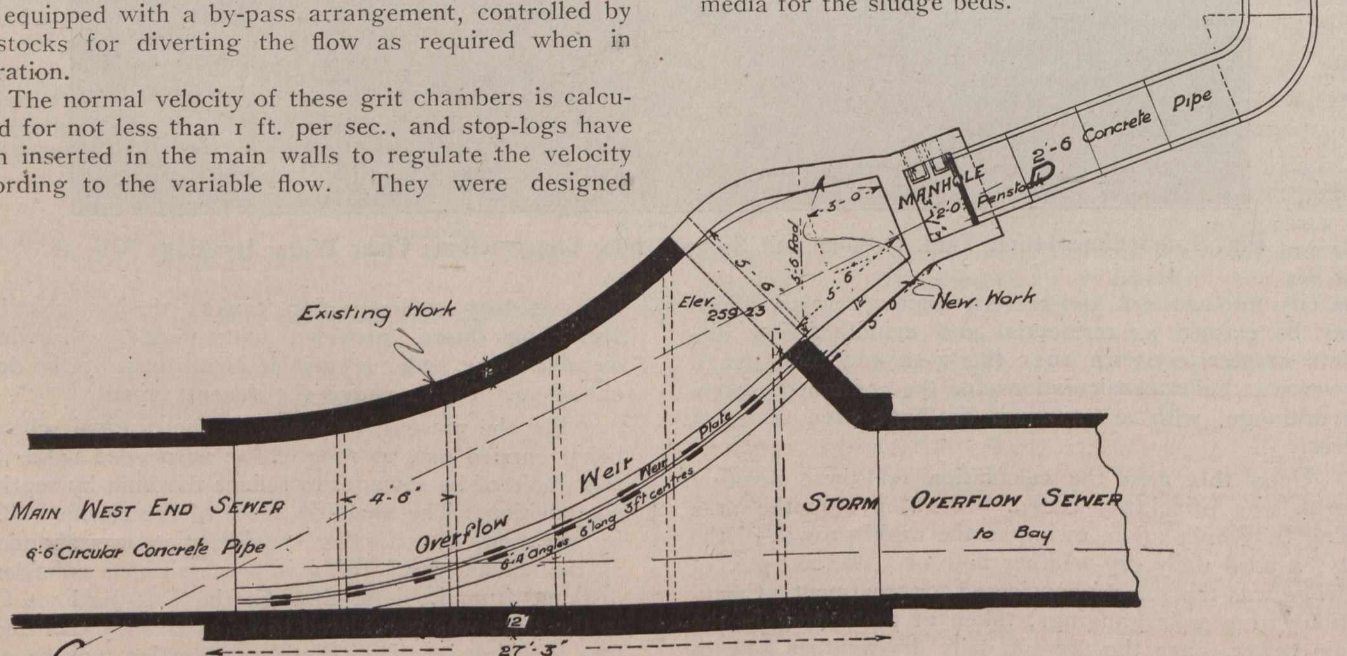


Fig. 3.—Plan of Overflow Chamber and Connection to Tanks from Main Sewer.

porary 9-in. effluent pipe, through which the sewage is discharged to the main effluent pipe emptying into the marsh. The chambers are then cleaned out by hand. It is intended to use the sand, after washing (if necessary), for the finished layer required on the filter media for the sludge beds.

Sedimentation Tanks.—After depositing the mineral matter, the sewage passes along the feeder conduits to the 2-story sedimentation tanks, and by means of the different gates located at the positions shown in Fig. 5, the direction of sewage flow can be reversed, that is, fed from either end of the tanks, every month, or as required. By this means it is possible to equalize to a large extent the depth of deposited sludge in all 3 digestion chambers before cleansing has to be undertaken.

These tanks are in series of four, split up into 3 digestion chambers to each tank, and the sewage passes over a weir the full width of the tank, to insure a uniform flow of sewage, and thus eliminates any dead space in the upper compartment, and passes under scum boards at both ends into the clarified effluent conduit, which discharges into the main effluent pipe leading to the marsh.

Each tank is rectangular in shape and consists of a sedimentation tank and a sludge digestion chamber. The one is separated from the other by means of a reinforced concrete sludge apron, at an angle of 60° to the horizontal in order to facilitate the automatic discharge of sludge into the lower compartment. These overlap each other, and have an 8-in. horizontal opening, which is supported by means of reinforced concrete beams having their supports on the walls, dividing the sludge digestion chambers into three. They are carried up and act as baffles to the upper compartment, which assists considerably the lighter solids to deposit on the inclined aprons, and slip down into the lower sludge digestion compartment, staying there until decomposition is complete. The cross-section shown in Fig. 9 illustrates the above features.

To minimize the passing of gases from the lower to

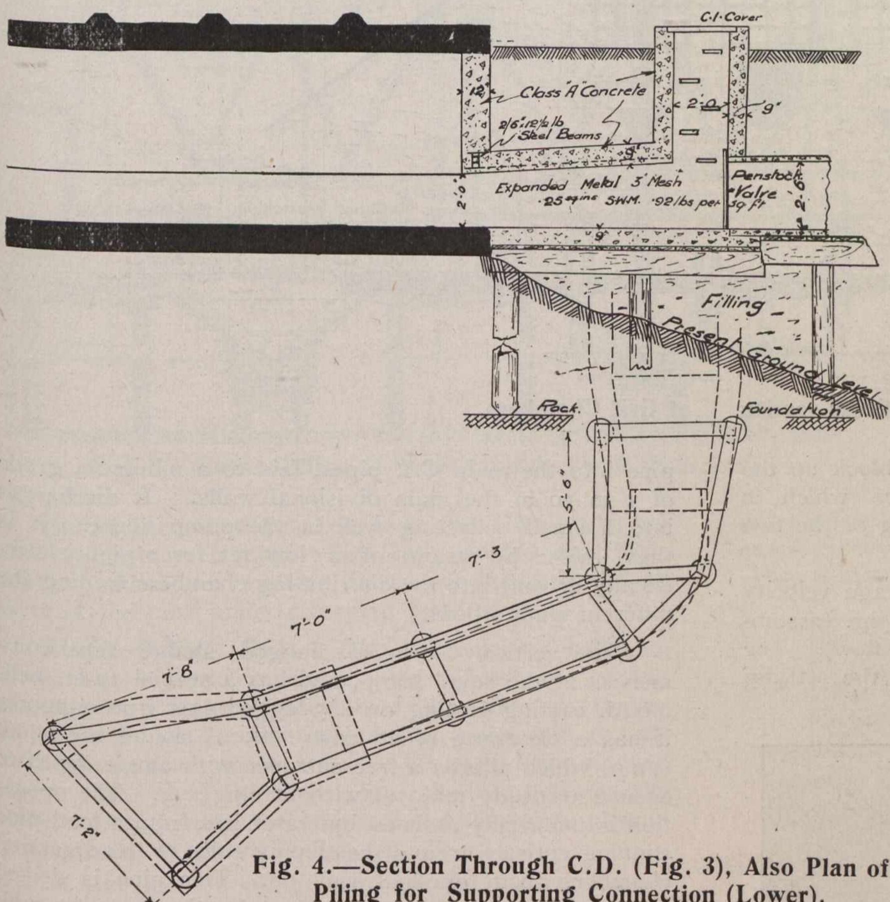


Fig. 4.—Section Through C.D. (Fig. 3), Also Plan of Piling for Supporting Connection (Lower).

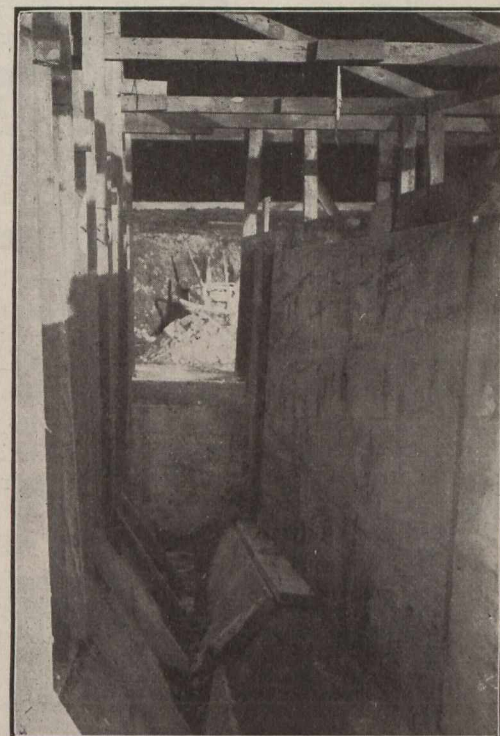


Fig. 5.—Showing Formwork and Drains; One Grit Chamber Under Construction.

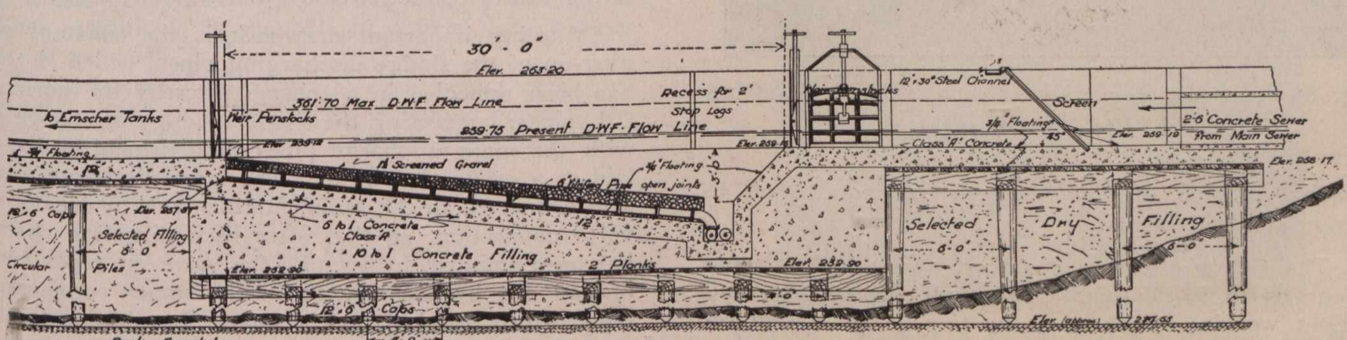


Fig. 6.—Longitudinal Section of Grit Chambers.

the upper compartment, and to adequately provide for ample ventilation for the many gases given off due to the putrefactive decomposition of the settled solids, which goes on continuously until cleansing times, these aprons were placed at a minimum space of 15-in. from the main walls, which should allow for the clogging and scum formed. This scum would otherwise block up the smaller spaces and prevent the ventilation which is absolutely necessary for the efficient working of the two compartments.

These tanks were designed for an average velocity of 1.75 ft. per min., with a retention of 2½ hr. (assuming the hourly flow as 1/18th of the daily flow). The upper compartment is well baffled to assist the settling capacity, and all exposed surfaces are rounded off to prevent sludge deposits.

The sludge digestion chamber, owing to local conditions as to foundation, expense of construction, and efficient working depth of tanks (for better sludge results), was designed for 5 to 6 months' storage capacity. The bottom slopes to a central 3-ft. square sump at variable inclinations, the minimum being 2 ft. horizontal to 1 ft. vertical.

The sludge removal pipes are C.I., 8 in. diameter, and have an outlet connection 6 ft. below the flow line of the upper compartment. Thus on opening the gate, the sludge flows by gravity up the central vertical sludge pipe into the main C.I. pipes, laid to a minimum grade of 1 in 30 in the main divisional walls. It discharges into a small collecting well in the pump house. It is then raised by means of a low set force pump (electrically driven) into the distributing chambers feeding the different sludge beds.

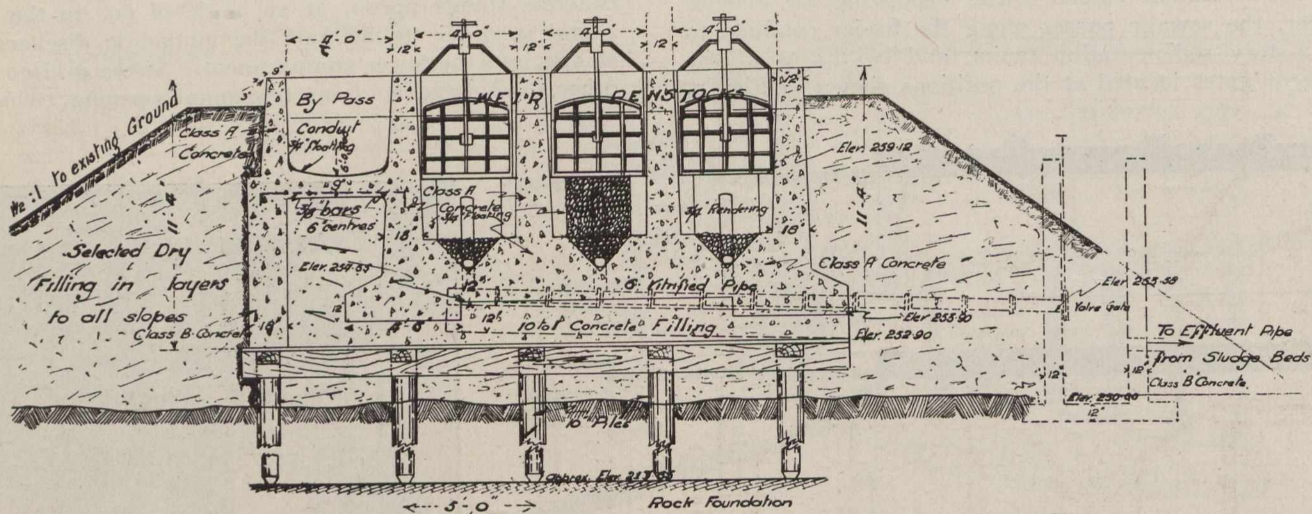


Fig. 7.—Cross-section of Grit Chambers.

The vertical 8-in. C.I. flanged sludge pipe commences at the small sump, and has a special 12-in. bell-mouth casting resting on a 3-legged cast iron support; it has a clearance of at least 1 ft. all round the small sump, which affords a free entrance with ample depth to ensure a speedy removal without clogging. The operation is materially assisted by water jets from a lead pipe running entirely around the sloping sides of the digestion chamber, about one-half way up. This pipe is drilled with ⅛-in. holes at 15-in. centres. On the digestion tank being emptied, the valves regulating the sludge pipe and water service are opened, ensuring a thorough agitation of all the sludge in the digestion chamber to be emptied. In this way the chamber is efficiently cleansed, overcoming the obvious evil of the old sludge being left around the sides of tank, and the new sludge working down from the top. In the latter case the operation would clean out only a small pocket around the vertical sludge discharging pipe, and (besides leaving behind the old sludge) would considerably reduce the capacity of the digestion chamber, unless cleansed by hand labor, which owing to depth, etc., would prove a costly item.

Fig. 8.—Grit Chambers Under Construction—Showing Formwork, Etc., and General Method.

Another important drawback is the constant clogging-up of the sludge discharging pipes, which, I think, has been remedied in a scheme whereby the horizontal C.I. pipes, connecting the vertical sludge discharge pipe with the main discharge pipes in divisional walls, are laid at a grade of 1 in 36. The main discharge pipe is also connected to the sedimentation tank by means of a valve connection, so that after each digestion chamber has been emptied, by opening the valve the pipes can be flushed out by the sewage in the upper compartment under a 6-ft. head of tank sewage. In addition to these arrangements all the extreme ends of the vertical and horizontal sludge discharging pipes (wherever possible) are carried through the walls into inspection manholes, and fitted with a fire hose connection for cleansing purposes. Sufficient space is left for rodding, general cleansing, and inspection purposes. Manholes, carried

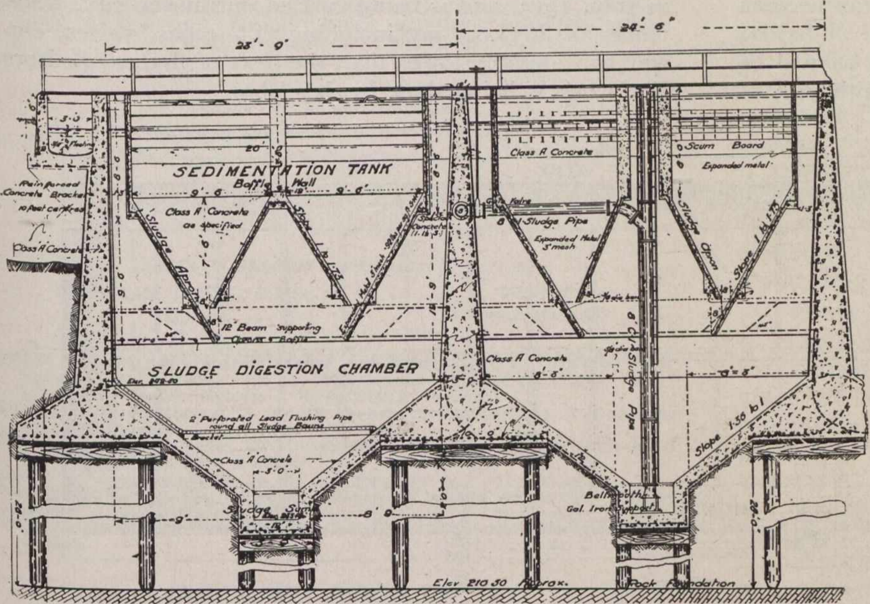


Fig. 9.—Cross-section of Sedimentation Tank (Emscher).

on reinforced concrete brackets from the baffle walls, are constructed to each tank, which are provided with W.I. built-in ladders, to facilitate the proper inspection of all parts of the tank under cleansing periods.

Sludge-Drying Beds.—The sludge-drying beds are of earthwork construction, in series of five of varying length, with a standard width of 25 ft. They are underdrained with 3-in., unjointed, vitrified pipes, laid at 6 ft. centres, and at an angle of 90° to the main 6-in. vitrified pipe. This pipe discharges into the 9-in. temporary effluent pipe, joining the main effluent discharge pipe in the manhole, as shown in Fig. 11.

At the junction of the 9-in. effluent pipe and main carrier from each bed, an open manhole is constructed, to provide for ample inspection of the water from the sludge beds, which will pass directly into the marsh.

These filters have a minimum depth of 12 in. of graded gravel, with a 1-in. layer of fine sand. Under each sludge discharging trough a concrete apron will be constructed to prevent damage to the filtration surface in times of operation.

The sludge is discharged into the different C.I. branch pipes leading to each bed by means of valves and movable wooden troughs from the distributing chambers to the beds. It is then spread over the filtration surface to a depth of approximately 1 ft., and, according to weather conditions, is spadable in 3 to 4 days without nuisance or smell.

Manholes are constructed at each branch feed pipe on the 8-in. C.I. main rising from the pump house to the sludge beds and all necessary valves. Inspection boxes are fixed for rodding and cleansing purposes.

The filtration area of these beds was calculated for 550 sq. ft. per 1,000 population, as the combined sewerage system is in vogue in the West End district.

General Construction Details.—The site purchased for the disposal works was in low-lying ground, its level being approximately 5 ft. above the level of the Bay. The geological formation consisted chiefly of stratas of very wet, blue and brown clay, intermixed with fine gravel. The 3-in. auger borings taken for guidance to the tenderers, indicated rock at 22 ft., but on excavation it was found to be a thin strata of hardpan, varying from 1 to 2 ft. thick. This discovery necessitated a complete change in the foundation plant.

The originally intended concrete piers under the walls and sumps were discarded in favor of pile foundation which, to safely withstand the load, called for 12-in. piles, 30 ft. long.

The whole of the works, owing to the low-lying nature of the site, and the difficulty of providing sufficient head to operate successfully the fixed sprays intended to be used for future filtration beds, had to be built on a trestle pile foundation in reinforced concrete.

On account of the spongy nature of the soil, together with the fact that the low elevation of the sump bottom is 14 ft. below lake level, a great amount of water had to be contended with. This rendered the excavation, setting out, pile driving and general foundation work a little more difficult to accomplish; and, as the sides of the excavation were sloped back without sheet piling or timbering of any kind, a great deal of extra excavating and filling-in had to be done owing to sides continually caving in. This, together with the

Fig. 10.—Method of Running Concrete from Mixer. Also Shows Reinforcement in Main Walls.

previously mentioned conditions, seriously retarded the quick progress of the work.

The structural walls and sumps are built of Class A concrete (4, broken stone of 2-in. gauge : 2, sand : 1, Portland cement), reinforced with ¾-in. and ⅝-in. commercial round steel rods. Expanded metal was used in the sludge aprons.

The interior concrete work of the tanks, as will be noted from the accompanying illustrations, although of the entire city, including an east end disposal plant and main drainage system, and a storm overflow sewer to relieve the central area of the city in storm time. All these works have been designed and approved. The west end development, described above was commenced in July, 1913, and is being carried out by the city, whose tender of $63,000, not including C.I. pipes, valves, etc., was considerably lower than the next of five competitors. The work is being done by day labor.

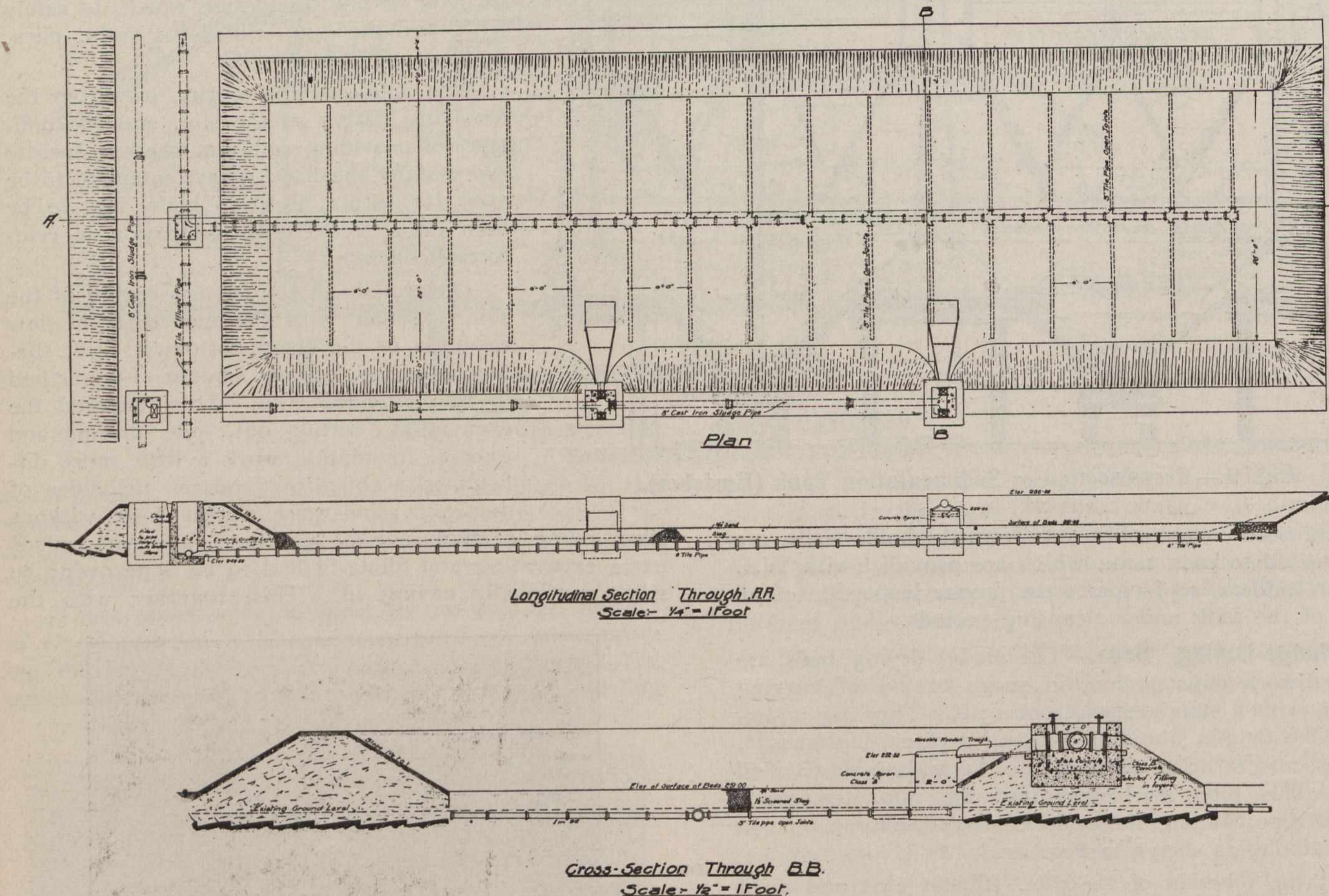


Fig. 11.—Plan and Sections of Sludge-drying Beds.

a complicated nature, furnished no special engineering difficulties, except some intricate form work, which is shown in part.

The works were designed by the author as a part of an extensive scheme to solve the sewage problem for

Late in the fall operations were discontinued, owing to severe weather. Construction is well under way, and should commence in the early spring.

The author has acted as engineer-in-charge, under the direction of A. F. Macallum, C.E., City Engineer.

IRON AND STEEL PRODUCTION IN ITALY.

The completed statistics of the production of iron and steel in Italy, for 1912, have been announced. The production of iron ore was 582,066 tons, which compares with 373,786 tons in 1911 and 551,259 tons in 1910. Imports of iron ore in 1912 were 18,551 tons and exports were 12,313 tons. The production of manganese ore was 2,641 tons. There was also produced 248,612 tons of iron pyrites, of which only 2,144 tons were exported, while 70,762 tons were imported.

The make of pig iron and direct castings in 1912 was 418,675 metric tons, which compares with 342,586 tons in 1911. The output of steel ingots, largely from imported pig and scrap, was 922,000 tons, a gain of 186,000 tons over 1911. The production of wrought iron from pig was only 1,500 tons, but there was a large quantity made from scrap, some of it imported material.

The total production of finished material was as follows, in metric tons:—

	1912.	1913.
Wrought iron	303,223	179,516
Steel	697,958	801,907
Total	1,001,181	981,423

The principal items of finished steel in 1912 were 392,263 tons of bars and shapes, 130,067 tons rails and 89,905 tons of plates and sheet. The output of tin plates was 28,916 tons.

In 1912, there were in operation in Italy, 64 open-hearth furnaces, two Bessemer converters, two Robert converters, five electric furnaces and two crucible furnaces.

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ANNUAL MEETING—CANADIAN SOCIETY OF CIVIL ENGINEERS.

The twenty-eighth annual meeting of the Canadian Society of Civil Engineers will be held in Montreal, January 27th, 28th and 29th. A detailed programme appeared in last week's issue of *The Canadian Engineer.* It includes the presidential address, the election of officers and members of Council for 1914, the reception of the report of Council, the reception and discussion of the reports of the various standing committees, and the transaction of general business of the Society. A visit to the works of the St. Lawrence Bridge Company at Rockfield will form a part of the second day's proceedings. The annual dinner of the Society will be held in the Engineers' Club on Wednesday evening.

Every engineer belonging to the Society, whether to the class of member, associate member, or junior member, should be in attendance, and it remains for each to make all possible effort in that direction. Each member is a unit in the organization representing the engineering profession in Canada, and this evolves a sense of duty to exercise his initiative and influence in the unifying and strengthening the forces working among these 2,700 engineers for the betterment of his profession.

A society does not need to be of a highly specialized nature to find plenty of important and labor-requiring work for it to do. Specific problems in various engineering lines are accumulating, and the conscientious work of committees will bring even greater results and speedier solutions if the committees have behind them a willing co-operation and a desire on the part of the members of such a society to be of as much assistance as they can. Besides, each member must feel that his part should become, in early years, if it is not the case now, one of activity in the direction of the tendencies of the profession and of the representative society.

A good deal will develop in the course of the coming meeting of the Canadian Society of Civil Engineers to recompense any member for what sacrifice of time and business he may find it necessary to forego in order to spend January 27th, 28th, and 29th in Montreal.

BOUNDARY WATERS AN UNSAFE SUPPLY UNLESS TREATED.

A report laid before the International Waterways Commission last week has to deal with the sewage pollution in the boundary lakes and rivers between Canada and United States. The conditions which obtain in all localities, from Rainy River to Cornwall, with the exception of the already investigated waters in the district around Toronto, come within its scope.

It is observed that every municipality within the area investigated, on the Great Lakes and their connecting rivers, avails itself of the opportunity open to it of discharging its sewage in an untreated state into these waterways. Navigation has likewise been the cause of dangerous pollution in some localities, while the run-off from surrounding watersheds during spring floods adds materially in that season.

The results of the investigation indicate that there is not a municipality using these boundary waters as a source of supply, that is immune from danger of water-borne diseases, unless the supply is previously treated. It is claimed that the high death-rate from typhoid, along the boundary, has been directly due to 3 conditions, viz., unrestricted discharge of sewage; failure to purify the supply; and inefficiency of purification.

Although the report makes no formal recommendation, leaving that for the Commission to embody in its report to the two Governments concerned, it clearly shows the need for legislation and restrictive regulations that will require all municipalities dumping sewage, directly or indirectly, into boundary waters to previously subject it to a purification process. It also points to the advisability of a careful purification of every water supply, demonstrating that the presence of pollution for but a few days is a serious menace to public health.

CONTRACT vs. DAY LABOR IN MUNICIPAL WORK.

The engineering departments of a number of our cities have found it good policy to carry out their civic extensions, such as pavements, sewers, distributing water mains, etc., themselves. These cities have developed quite an extensive plant which enables them to carry out such work efficiently. With such plants well located and working under good organization, these improvements can be done at a figure against which contractors cannot compete, and make a reasonable profit. General construction work, however, is largely open to competitive tendering, the city engineer submitting a bid, allowing, of course, a fair margin of profit on each of his tenders. On such work, it is found that contractors are often in a position to underbid the city engineering department, sometimes to the extent of 25%. With properly qualified and adequately paid inspectors, such work is done better and cheaper than the municipality could do it. Besides, the city engineer, already overburdened, is not carrying the additional responsibility and is enabled to better superintend the details of construction of the work which his department is doing This is largely owing to the fact that the average city cannot keep up an organization to the same efficiency as a contractor's organization. It is not sufficiently elastic to handle the variation in quantity of work which develops in a growing city of any size. Again, a city finds itself handicapped in obtaining and retaining the most efficient foremen and laboring men. Our cities are subjected to a climate that curtails civic work in winter, and foremen cannot be given work the year round. This gives the wide-awake contractor an opportunity to secure the good foremen from the city forces, and to retain them by paying them better than the average city engineer is permitted to do. Generally speaking, our cities pay the lowest wages, resulting in more expensive and less satisfactory work.

It would appear that our cities are materially benefitted by subjecting all their work to competitive tendering. Notwithstanding the fact that the city engineering department generally secures those improvement works for which it is specially adapted, the competition gives the contractors their chance of tendering, thereby removing an important stumbling block that public opinion frequently finds in the foreground of the civic administration. It also adds a certain stimulus to the city engineering staff that is important. Otherwise the city, because of the fact that low wages are paid, builds up a laboring force of a class of men to which few other employers would give work for the simple reason that they are not worth what they have to be paid. Such men, regularly employed by a city, get an idea in time that the city is bound to provide work for them. The constant stimulant afforded by the competition of tendering, prevents such deterioration of organization. This prevents the involved increase in the cost of work. It also establishes a formidable reason for the employment of the best men, paid accordingly.

TORONTO WATERWORKS EXTENSIONS—THE OLD REPORT AND THE NEW.

The question of water supply gets little rest in the City of Toronto. For years civic authorities have studied over it unceasingly, and the citizen has frequently had cause to assume a share of the worry when his business or his household was jeopardized by uncertainty or unsuitability of supply.

Our readers will remember the 1912 report of a Board of Water Commissioners, which recommended as a solution to the problem, the installation at Scarborough Heights of an intake, tunnel, filtration plant, and reservoir, with gravity feed mains to the city. The proposal evoked an editorial discussion in these columns prior to the submission of a by-law to authorize the necessary expenditure. This discussion included many criticisms, chief among which being:—

(1) That, since Lake Ontario water as a Toronto supply must necessarily undergo filtration before use, the quality of the water off Scarborough did not justify the heavy expenditure involved in bringing it 12 miles to the centre of the city, or in serving West Toronto from such a distant source.

(2) That pumping the supply to a height of 370 feet into a reservoir on the Scarborough plateau was unnecessary, and meant greater cost of construction and a heavier continuous cost of operation, a considerable percentage of the head thus acquired being lost in the gravity flow mains to the city.

(3) That to guard against interruption of electrical operation of pumping station by using an independent electrical supply, preferably from the Trent Valley or some other source, to supplement Niagara power, was not adequate provision. The difficulties of electrical supply being mainly those of transmission, a storm which would cause interrruption of service on the Niagara line would probably have a similar effect on any other long transmission line.

(4) That the recommendation to duplicate the slow sand filtration plant on the Island was not warranted by its performance, and that the proposal of a mechanical filter at Scarborough and a slow sand filter at Toronto Island to treat water of practically the same quality was anomalous.

(5) That the estimated cost, $5,320,000, was much too low, to carry out the work proposed.

The Canadian Engineer strongly voiced its belief that the Scarborough scheme was not an adequate return for the amount of money which the citizens of Toronto would be asked to spend, as it did not assure an abundant supply of pure water at the lowest possible cost.

With the report open to such criticisms as these, the by-law which was submitted to the ratepayers on Jan. 1st, 1913, did not specify the nature of the waterworks extension. It read: "for additions and extensions to the waterworks pumping and distributing plant." It carried, authorizing an expenditure of $6,677,000. Unsatisfied with the report, the city proceeded forthwith to investigate the whole problem for itself, and the new report is the outcome.

It is interesting to read the criticisms of the old report that are embodied in the new.

REPORT ON PROPOSED EXTENSIONS OF TORONTO'S WATERWORKS SYSTEM

EXTRACTS FROM REPORT RECOMMENDING A 60,000,000 GALLON PER DAY ADDITION OF MECHANICALLY FILTERED STEAM PUMPED WATER SUPPLY FROM AN INTAKE IN 49 FEET OF WATER ONE MILE OFF VICTORIA PARK—ESTIMATED COST $6,033,700

A REPORT, prepared by the Department of Works of the City of Toronto, and dealing with the proposed extension of the waterworks pumping and distributing plant, is presented herewith in extracted and summarized form. Its chief features are: A forceful condemnation of the Scarborough scheme as recommended in the 1912 report of the Commission appointed by the city in 1911 to investigate the problem; and a proposal covering the installation of a plant at Victoria Park to filter and pump directly into the mains water drawn through a 9-ft. tunnel 2 miles in length from a 110-ft. intake crib in 49 feet of water.

4. A tunnel two miles long, driven to a point where a depth of 100 feet of water is obtained, is unnecessarily long, and no essential purpose is served in procuring such depth of water. The estimate for the tunnel is low.

The depth at which it was proposed to drive the tunnel was so great that if resort to compressed air working became necessary, the tunnel would have to be abandoned.

5. The proposal to install electric pumps without steam reserve, is imprudent.

6. The proposition to pump the whole water supply to a height of 370 feet, when 75% of it need only be

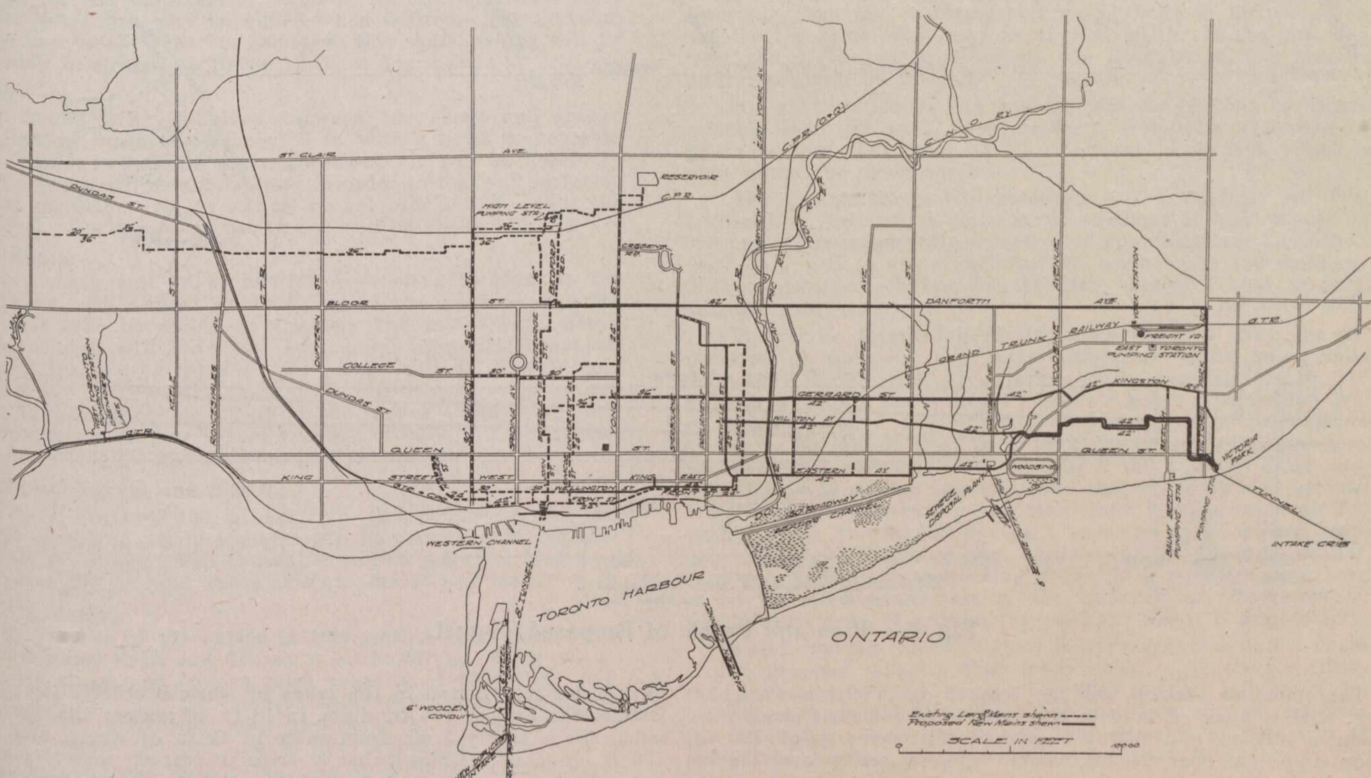

Fig. 1.—General Plan of Existing and Proposed Water Mains in Toronto.

pumped against a head not exceeding 275 feet, is wasteful.

The previous report (extracted in *The Canadian Engineer*, May 30th, 1912) was met with the following summary of essentially questionable features:—

1. The basic information essential to the proper, economical and serviceable design of such a system was not procured.

2. The location, aside from the impossible hydraulic conditions it creates, considered in conjunction with our present pumping system, was ill chosen, and altogether too far east of any probable future centre of distribution.

3. The intake crib proposed, at an estimated cost of $500,000, to be located in 100 feet of water, does not follow proved practice, and is too costly an experiment.

7. The suggestion to install and operate a reservoir at the elevation proposed, to work in conjunction with the present city system and Rose Hill reservoir, is faulty, inasmuch as it would cause the latter to overflow, thereby wrecking same, together with the property in the vicinity.

8. The provision of one steel supply main, only, to the city, is unwise, as in case of breakdown outside the city limits, there would be an entire cessation of supply.

9. The hydraulics of the problem were evidently not carefully considered, and their effect upon the existing system realized, inasmuch as the pressure developed

would render the John Street station, tunnel, filtration plant and intakes useless, unless the aforesaid station was equipped with new machinery, capable of operating against the pressures developed by gravity.

10. The booster stations suggested are unnecessary.

The Proposed Works at Victoria Park.

In the new report, it is proposed to build an intake crib off Victoria Park, 5,100 ft. from shore, in 49 ft. of water. The crib will be approximately 110 ft. in diam., constructed of steel and concrete, and surmounted by a house, the main part of the crib rising 19½ ft. above the lake. The crib will contain the necessary ports for the admission of water.

The inside of the crib will contain a vertical steel shaft, lined with cement or brickwork, running down to a proper depth below lake level, so as to connect with a tunnel 6,380 ft. long, running horizontally to the shore at Victoria Park. The internal diam. of the shaft will be 11 ft., that of the tunnel 9 ft., the latter to have its invert 105 ft. below mean lake level. At the shore, there will be a vertical shaft 10 ft. in diam., rising above the normal lake level at this point. From the vertical shore shaft there will be 2 horizontal 7-ft. tunnels, one on each side and parallel with the shore. One of these tunnels will supply the suction side of the pumps in the station to be erected, the other will act as a reserve to be used in case the size of the station is increased later.

1. A system which will supply an additional quantity of water equal to that now being used during maximum draft, thus practically duplicating the present plant. Therefore, in the event of accident at any time to the sewage purification plant, or either filtration or pumping plants, the use of either plant could be discontinued, and the safety of the supply still maintained. By reason of the proposed plant being a duplicate in capacity of the existing plant, with provision for future increase, the continuity of the supply is assured.

2. A system which will operate in exact harmony with the existing plant, thus enabling both to work in conjunction.

3. An arrangement which can be doubled in capacity without doing unnecessary work.

4. A supply which is unfailing, in so far as human agency can make it. It will not be deleteriously affected by storms, ice, shifting sand, etc.

5. A supply of water, which is as pure as it is possible to obtain in the vicinity of Toronto, and which after treatment will be perfectly safe and satisfactory.

6. An improved service throughout the entire city.

7. An attractive park on the waterfront.

Intake Crib.

The intake crib is in a sense the most important, and, in some ways, the most difficult part of the work. On account of the nature of the elements to which it is exposed, the design should be worked out from the experience of others. Cribs

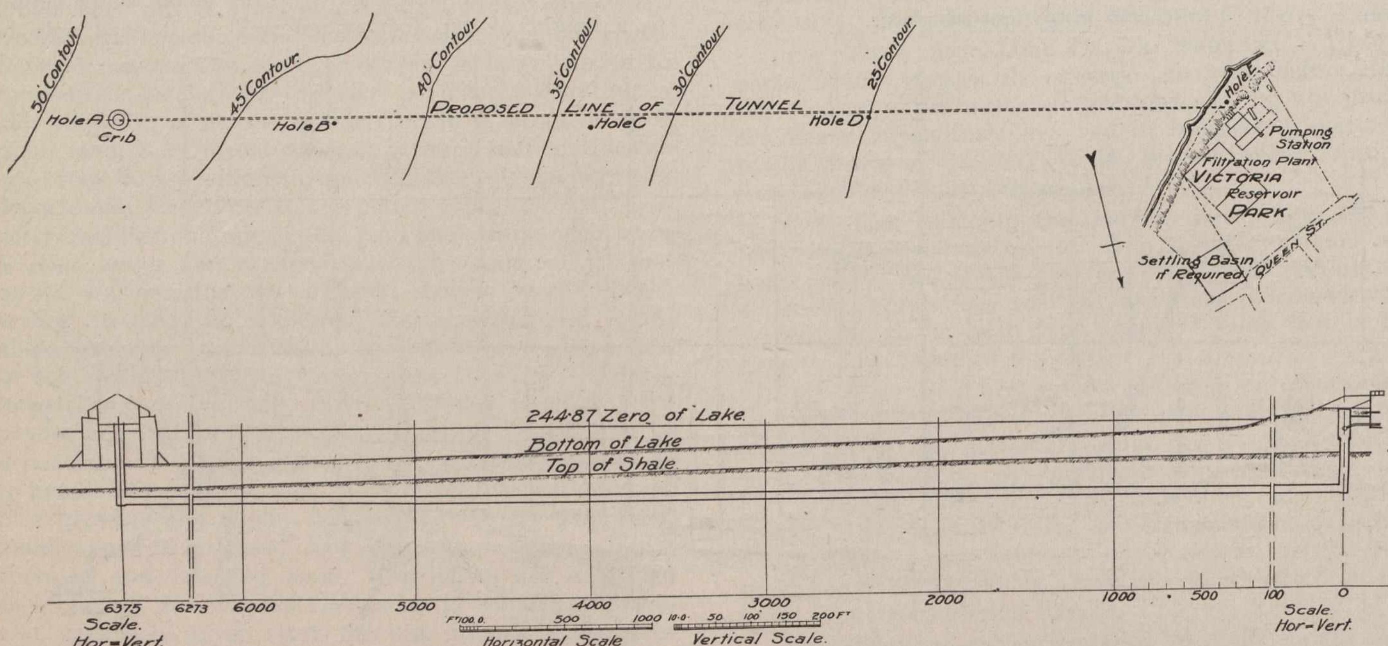

Fig. 2.—Plan and Profile of Proposed Tunnel.

The pumping station will be located in Victoria Park, which, with a piece of land to the east, is of sufficient size to contain a station and filtration plant of a capacity of 120 million Imp. gal. per 24 hr., should such capacity ever be required.

The pumping station will have a capacity of 60 million Imp. gal. per 24 hr., but is being so designed that this may very easily be increased to 120 million gal. if desired. Since the water will have to be filtered, the station must be divided into 2 parts, viz., low-lift and high-lift, the former taking the water from the tunnel shaft and delivering directly to the filters, while the latter will deliver the filtered water direct to the city mains. Each part will have a capacity of 60 million Imp. gal. The low-lift pumps will work against a head of approximately 75 ft., while the approximate head on 3 of the high-lift pumps will be 220 ft., or 95 lbs. per sq. in., and that on the fourth pump about 315 ft., or 137 lbs. per sq. in. The exact pressures against which the low-lift pumps will have to work cannot be determined until the make of filters is known.

The mechanical type of filter is recommended, and in connection with this it is proposed to install a reservoir with a capacity of 2½ million Imp. gal., and to provide space for a settling basin should the make of filter require it.

From the station, four 36-in. pipes will deliver water to four new 42-in. mains which join the present distribution system.

In short, the plan contemplates:

have been constructed in the lakes by various other cities; at Buffalo the crib is 110 ft. diam. in 18 ft. of water; the Cleveland crib is nearly 5 mi. from shore in 49 ft. of water, and is 100 ft. in diam. Chicago has 6 cribs of varied construction, some with surrounding breakwaters, and the latest designed without. Of the latter, the Harrison crib is 112 ft. in diam. and is in 34 ft. of water, while the new Dunne crib is 111 ft. in diam. and in 33 ft. of water. The Milwaukee crib is under 60 ft. in diam. and is in 25 ft. of water, but from a study of conditions, it appears to be inadvisable to adopt so small a size.

From a study of the experience of these cities, it is concluded that the Toronto crib should be 110 ft. diam.

The depth of water in which the crib can be set depends upon the method of placing it, and the forces to which it will therefore be subjected. This crib, made of a steel shell, will be constructed in the harbor and floated to the desired location and sunk. On account of the depth of water in the bay, the shell could not be floated to a greater depth there than 17 ft. It is clear that the success of such an undertaking will depend, to a very large extent, upon the relative amounts of the shell above and below the water surface when floating, and as the depth below is, in this case, small, the total height of the structure is limited. So far as is known, no city in America has installed a crib under such conditions as those existing at Toronto, in water deeper than 50 ft., the Cleveland intake being the deepest. Since the cost of this part of the work will be great, and hence any unsuccessful experiment would be very serious, it is not advisable to attempt anything that has not been done successfully elsewhere, so that the depth of water in which this crib will be placed is 49 ft. The water entering such a crib will be quite as good for drinking purposes as if taken at much greater depth.

The intake crib will consist of two concentric steel cylinders, set on end and firmly braced together, so as to be rigid and stiff, the outer cylinder being 110 ft. diam., and the inner 60 ft. diam. Plates set radially between these shells will divide the annular space into compartments, which will be constructed with bottoms so as to make them watertight. The compartments will then be sufficiently filled with concrete to make the draft of the structure 17 ft., after which it will be towed into the desired position and sunk, the lake bottom having been previously levelled and otherwise prepared for its support. After sinking, the annular space will be filled with concrete, and the structure built up above the water to provide living quarters for men, with lights and signals for mariners.

Properly constructed ports in the crib will admit water to the inner 60-ft. well. These ports will be controlled by gates which may be closed at pleasure, but the water will never be pumped from the inside of this well. An arrangement has been provided, however, so that it will be quite possible at any time to pump all of the water out of the tunnel for cleaning or other purposes, should this be desired.

Intake Shaft.

Through the centre of the intake crib, a vertical steel shell will be sunk to a depth to meet the tunnel. This shell will rise inside the crib above lake level, and will have proper openings for the admission of water to its interior; these ports to have gates that may be closed when desired. The material will be excavated from the inside of this shaft, which will be lined with brickwork to finish 11 ft. inside diam.

Tunnel.

A tunnel will be driven between the shore and intake shaft, having an inside diam. of 9 ft. with a brick or concrete lining. As it is possible that compressed air will be necessary in the driving of this tunnel, and in order to make it perfectly safe for workmen, the invert will be not over 105 ft. below the lake level. The length of the tunnel will be about 6,380 ft.

Shore Shaft.

This shaft will be of similar dimensions to that at the intake, but with a diam. of 10 ft. inside the brick or concrete lining. It will be closed at the top, and at 13½ ft. below zero lake level will have two 7-ft. diam. horizontal branches, to which the suction pipes of the pumps will be directly connected. The cover on the shore shaft will be quite high enough to prevent damage from surges in the tunnel, these being very small, owing to the low tunnel velocity of only 1.71 ft. per sec. when delivering 60 million Imp. gal. per 24 hr.

Capacity of Tunnel and Shafts.

With a draft of 100 million Imp. gal. per 24 hr. the loss of head in the tunnel and shafts will be under 2.5 ft., so that the capacity will be much above 100 million gal. if it is desired to increase the demand above this amount at any time.

Low-Lift Station.

The purpose of the pumps in this station is to take water from the tunnel shaft and deliver it to the filters. They will be driven by steam and have a total capacity of 60 million Imp. gal. per 24 hr. The lift at zero lake level may be approximately 75 ft., depending upon the make of filters used. In order to procure the best use of the tunnel, the floor of this station should be at lake level. An excavation will be made and the station built with watertight walls and basement. In order to insure safety, there will be two 48-in. delivery pipes to the filter plant, each conduit carrying away the water from two pumps.

High-Lift Station.

This station will also contain steam-driven pumps, having total capacity of 60 million Imp. gal. per day, three having a total lift of approximately 220 ft., and the fourth with a lift of about 315 ft. The precise lift is yet to be determined. The floor level of this station will be at the ground level of Victoria Park.

Filtered water will be delivered to this station through a single 7-ft. pipe, the suction of each pumping unit being connected directly thereto. There will be 4 separate discharge pipes, each 36 in. in diam., one from each pump, and connected to the distribution system.

Boiler Room, Coal, Storage, etc.

The boiler room will be located between the engine rooms. This arrangement brings the boilers close to all pumps, thus giving good steam connections, and also precludes any interference whatever between the boiler and engine foundations and the water pipes. This latter matter is of the very greatest importance. Much attention has been given to the security of the system, and the prevention of damage to the pipes from any cause. It is essential that they must always be easily accessible for examination and repairs.

The boilers will be equipped with mechanical stokers, and the boiler room will be furnished with coal and ash handling machinery, so as to reduce the cost of operating the plant to a minimum.

Coal will be conveyed to the plant in railroad cars drawn by electric motor, along tracks laid to York Station, a distance of 1½ miles.

The coal bunkers will have a storage capacity equivalent to one week's supply.

Reservoir.

The matter of an additional reservoir is one requiring careful study. There is no convenient location for a reservoir in the eastern part of the city, and it would have to be located far beyond the city limits if placed in this direction.

An additional reservoir for the city of Toronto is by no means essential, and not at all requisite. It is desirable that there should be some water storage to provide for fluctuations in demand from time to time. This storage has already been adequately provided for in the Rose Hill reservoir, which has ample capacity for all the present and proposed pumping equipment, and will readily suffice for the needs of Toronto for some time to come.

Since a proposition has been made to establish a second reservoir in connection with plans of the Commission of 1912, it may be well to point out, that if a second reservoir were to be used on the same supply mains as the present Rose Hill reservoir, then the new reservoir would have to be placed on exactly the same level as that at Rose Hill. If the new one were the higher, as proposed by the Commission, the present reservoir would be flooded.

An examination of the country has shown that to secure suitable land for such a reservoir, it would be necessary to go so far out that much of its effect would be lost. Such a plan cannot be recommended.

The present Rose Hill reservoir has a capacity of 39¼ million Imp. gal., which corresponds to about 20 hrs.' supply at the present average daily pumpage of approximately 50 million Imp. gal., and is quite sufficient to compensate the ordinary fluctuations of discharge, due to fires, excessive heat or cold, and other causes.

It will be interesting in this connection, to give the experience of some of the larger American cities using lake water. Buffalo, with an average daily consumption of 117 million Imp. gal., has a single reservoir holding 98 million gal. or 20 hrs.' supply. Detroit, with an average daily consumption of nearly 88 million Imp. gal., has no reservoir. Chicago does not possess a reservoir. In Cleveland, the average daily consumption is 63 million Imp. gal., and the city is divided up into 3 districts for distribution purposes, there being a reservoir for each district, the largest having a capacity of 67 million Imp. gal. Milwaukee has a present consumption of about 79 million Imp. gal., and is now increasing its pumping capacity, but there is no intention of increasing the capacity of the reservoir, which holds only 17 million Imp. gal., or about 6 hrs.' supply.

The foregoing examples show that Toronto has now a much larger reservoir capacity than many other of the larger cities, the size of reservoirs being evidently largely influenced by local conditions. The experience of the cities quoted, confirms the conclusion otherwise reached, that there is no necessity at present to increase the reservoir capacity for this city.

Distribution System.

From the pump house there will be four 36-in. pipes, with Venturi meters, running a short distance from the station, after which they will be enlarged for distribution purposes, and will feed four 42-in. mains, all of these pipes being cross-connected and controlled by valves in such a way as to make a perfectly flexible arrangement. These four mains will then run across Queen St., their locations being approximately as follows (see Fig. 1):

1. One 42-in. main will run across Queen St., up Victoria Park Ave. to Danforth Ave., along Danforth Ave., over the new Bloor St. viaduct to Bloor St., and along Bloor St. to St. George St. At the corner of Bedford Rd. this main will be cross-connected to the present 36-in. main., valves being provided so that the connection may be closed as desired. For the present this main will be placed on the service of the middle district, and hence the connection at Bedford Rd. will be closed, but should it be desirable to serve the low level district, this valve would be opened, and all connections with the middle district closed.

This main will be used on the middle district, and will, therefore, be connected to the 12-in. main at Coxwell Ave., to the 12-in. main at Broadview Ave., and to a new main included in this project at Sherbourne St. It will also be connected with the 16-in. main on St. George St. All of these connections will have valves.

The discharge pressure on the pumps at the High Level Station supplying the middle district is 65 lbs. per sq. in., and hence, after making allowance for friction and difference of level, the pressure at the Victoria Park Station on the pump supplying the above 42-in. main will be approximately 137 lbs. per sq. in. While this pressure is higher than usual, yet the pipe rises rapidly after leaving the station, and there will be only about 2,000 ft. of it subjected to a pressure of over 100 lbs.

2. The second 42-in. main will run from the park across two lots to Kingswood Ave., then up Kingswood Ave. to Kingston Rd. to Heyworth Cres. to Woodbine Ave., across two lots to Patricia Rd. and through two lots to Small St., to Gerrard St., and then along Gerrard to Sackville St. This main will connect with the 12-in. main on Beach Ave., the 12-in. main on Leslie St., the 12-in. main on Carlaw Ave., the 12-in. main on Broadview, the 24-in. main on Sumach St., and the proposed 42-in. main on Sackville St.

the 12-in. main at Sherbourne St., the 12-in. main at Jarvis St., the 12-in. main on Yonge St., and the 24-in. and 36-in. mains on Simcoe St.

5. In order to make this system most effective, a new 42-in. main will be laid up Sackville St. from the corner of Eastern Ave. and Cherry St. to Wellesley St., thence along Wellesley St. to Parliament St. or Rose Ave., to Howard St., to Sherbourne St., to Bloor St. This main will connect with the proposed new 42-in. main at Cherry St., Wilton Ave., Gerrard St. and Bloor St., but at the latter point there will be a closed valve normally, as the Bloor Street main will work on the middle district. It will also connect with the present system at the 12-in. main on Queen St., the 12-in. main on Wilton Ave., the 36-in. main on Gerrard St., the 12-in. main on Carlton St., and the 12-in. main on Wellesley St.

A study of Fig. 1, showing these mains, and their connections to the present system, will make it perfectly obvious, that this distribution plan will give ample accommodation for the water from the new station to reach all points of the city, and will enable the new station to work in perfect harmony with the present plant.

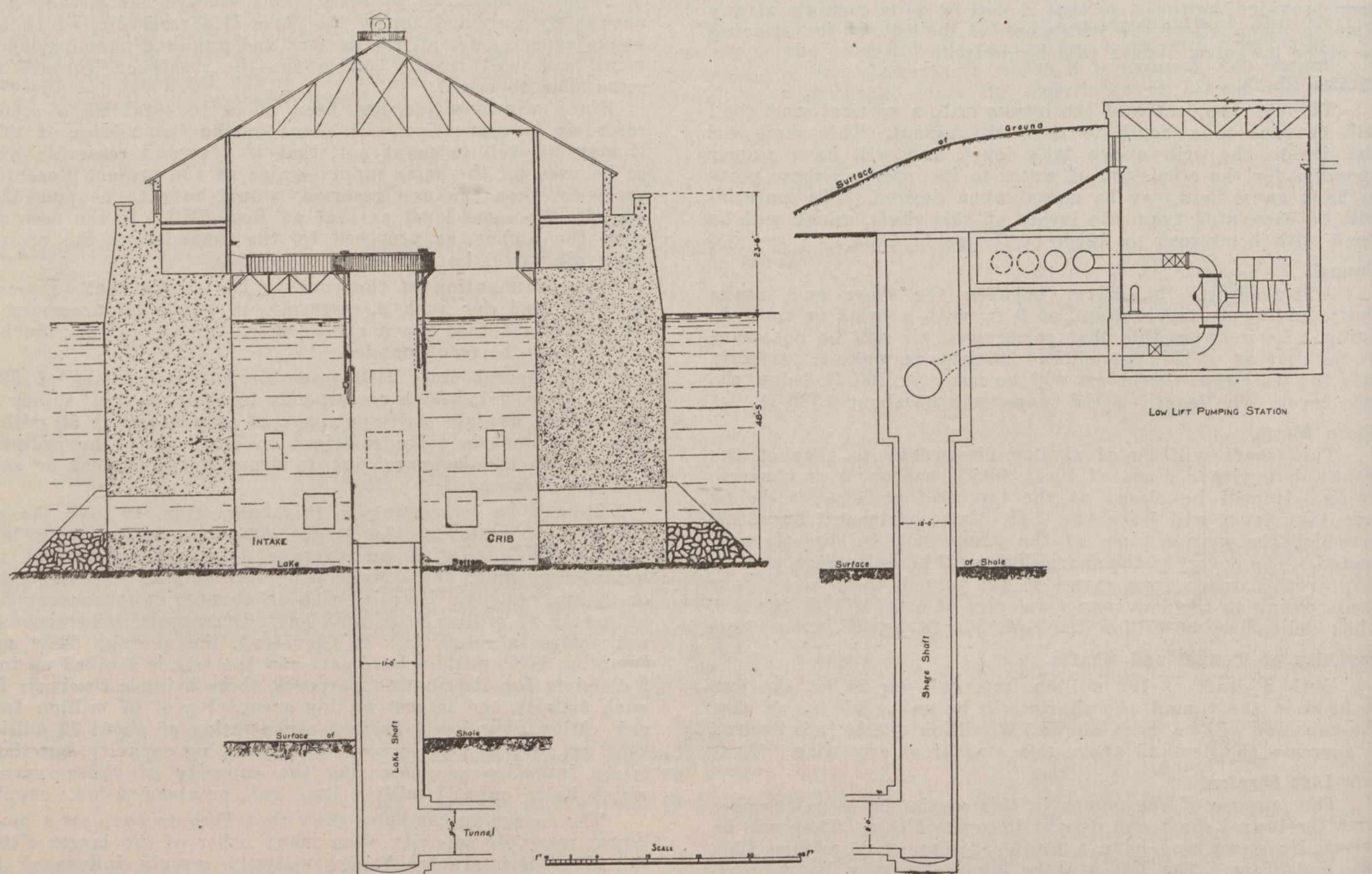

Fig. 3.—Section of Proposed Intake Crib, Lake and Shore Shafts.

3. The third 42-in. main will run from the park across the lots mentioned south of Queen St. to Scarborough Rd., north to Pine Ave., to Balsam, to Pine Cres., to extension of Williamson Rd. to Lee Ave. It will then run north on Lee Ave. to the proposed extension of Norway Pl., along Norway Pl. to Woodbine Ave. to Dixon St., across Kingston Rd. to Edgewood, to Hemlock, to Maughan Cres., to Ashbridge, to Applegrove, to Wilton Ave. extension, and along Wilton Ave. to Sackville St. This main will connect with the 12-in. main on Coxwell Ave., the 12-in. main on Leslie St., the 12-in. main on Carlaw Ave., the 12-in. main on Broadview Ave., the 24-in. main on Sumach St., and the proposed 42-in. main on Sackville St.

4. The fourth 42-in. main will run along the same streets as the third, to Maughan Cres. It will then run south to Orchard Park Rd., across Queen St., through a corner of the Ontario Jockey Club grounds to Eastern Ave., and along this street to Cherry St., thence to Front St., to Wellington St., to Simcoe St. This main will connect with the 12-in. main on Kingston Rd., the 12-in. main on Leslie St., the 12-in. main on Carlaw Ave., the 12-in. main on Broadview Ave., the 24-in. main on Sumach St., the proposed 42-in. main at Sackville St.,

An examination of the report of the Commission indicates that they contemplated only one supply main, and that through the northern section of the city a considerable distance removed from the point at which maximum consumption occurs. Therefore, even if their scheme were workable, it would be necessary for the municipality still to spend upwards of $2,000,000 upon a distribution scheme within the city limits, and $250,000 for additions and steam reserve at the high level pumping station.

In this project, in addition to the supply feature, provision is made for 32 miles of large distributing mains, at a cost of approximately $2,393,000. This will provide an almost ideal system of distribution, covering the needs of the city for many years to come.

Estimated Cost of Project as Recommended.

Lake crib—complete and placed	$ 400,000 00
Lake shaft, tunnel, and shore shaft	800,000 00
Site and buildings	500,000 00
Pumping equipment	380,000 00
Boilers and stokers	80,000 00
Coal and ash handling machinery	30,000 00

Tracks and overhead equipment from York to pumping station	35,000 00
Motor and equipment for handling cars	5,000 00
Electric lighting unit at station	2,000 00
Twenty-six miles of distribution mains	2,040,000 00
Specials and valves	60,000 00
Filtration plant	600,000 00
Levelling, grading, etc.	5,000 00
	$4,937,000 00
Add 10% for engineering and contingencies	493,700 00
	$5,430,700 00
Six miles of distribution main—High Level pumping station to West Toronto, for part of which contracts have been awarded	353,000 00
Additions to High Level pumping station, and provision of steam reserve sufficient for ultimate output of this station, for part of which contracts have been awarded	250,000 00
Total	$6,033,700 00

Recapitulation.

Expenditure authorized by ratepayers (January 1st, 1913)	$6,677,000 00
Estimated cost of project as proposed	6,033,700 00
Balance to meet debenture discount and financing.	$ 643,300 00

Outstanding Features of the Report.—Claiming that Lake Ontario is the only natural source of water supply for Toronto, the report passes the following observations upon the 3 possible locations for the new installation, which are:—

1. At Toronto Island adjacent to the present system.

2. At some point west of the present works, e.g., west of Humber Bay.

3. At some point east of the Island, which would mean at least as far east as the Woodbine.

The Island Location.—Site: Bed of lake slopes gradually for 1,700 ft. from shore to depth of 23 ft.; then falls with grade of over 10%, making problem of construction of intake difficult and uncertain.

Reliability: Essential that extension be placed at some distance from present system, else the same local cause might readily affect both.

Purity: Quite possible to treat present supply so as to make it perfectly safe and very desirable.

Distribution: Rapid expansion of city demands additional distribution centres conveniently situated for economy. Distribution from single source imprudent.

Western Location.—Site: Not fully investigated.

Reliability: No definite opinion advanced. Indications favorable.

Purity: Water around Humber Bay and to the west, polluted.

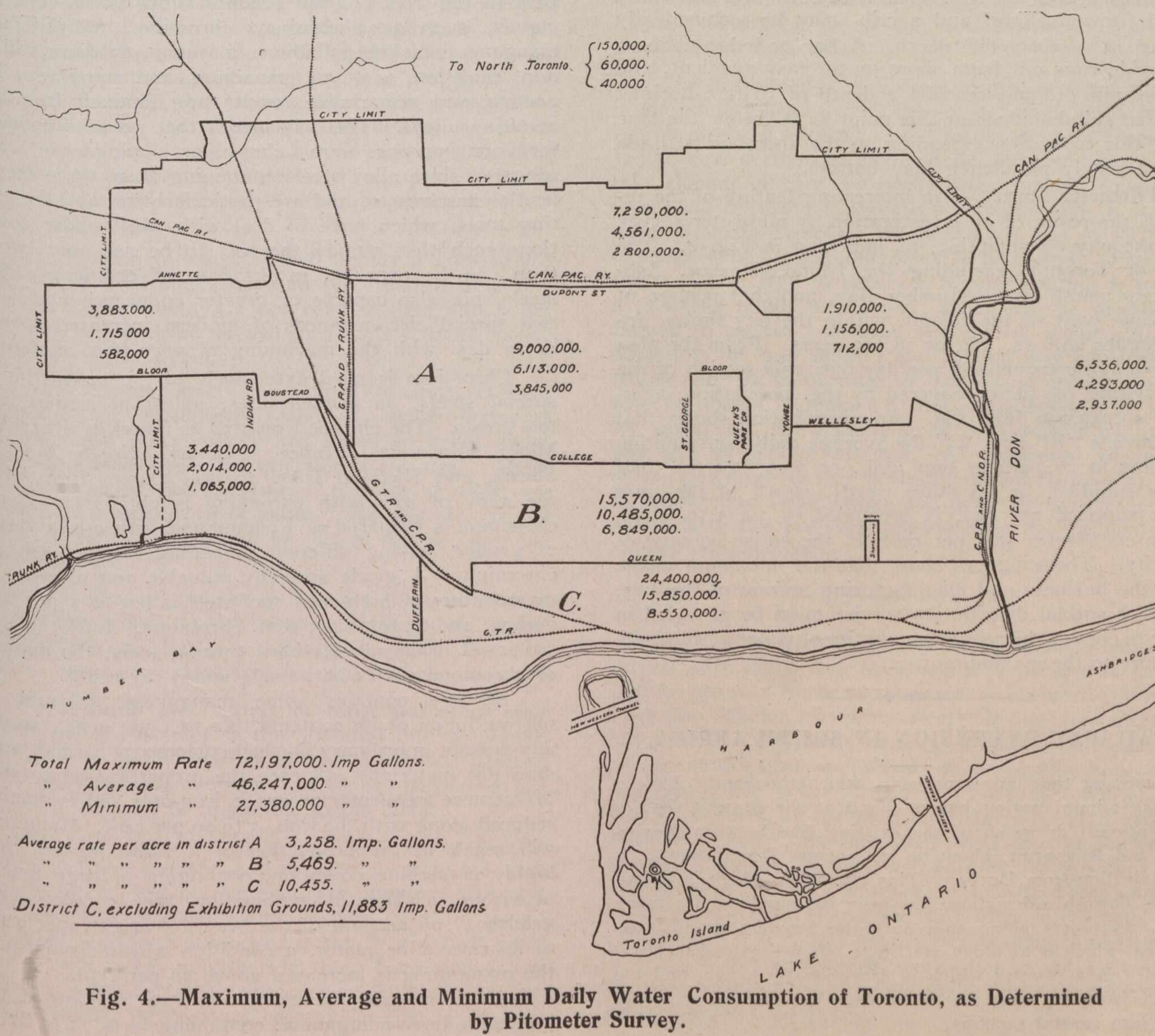

Fig. 4.—Maximum, Average and Minimum Daily Water Consumption of Toronto, as Determined by Pitometer Survey.

Distribution: Serious objection, in that heavy piping expenditure would be entailed.

Eastern Location.—Site: Effluent from Morley Ave. sewage disposal plant necessitates a location to the east. No advantage in site east of Victoria Park.

Reliability: Borings indicate feasibility of driving tunnel in good shale at favorable depth; also splendid location for intake. (See Fig. 2). Victoria Park "an almost ideal location."

Purity: Water from a point one mile from shore (2½ miles from Morley Ave. outlet) and 40 ft. below lake level, quite satisfactory, with after treatment; and fully as desirable as that taken from further east. Vastly superior to the present supply as regards turbidity.

Distribution: Admirable position for connection to present system. Distribution begins immediately upon leaving plant.

The report supports the choice of Victoria Park as the site for the proposed plant on the ground that it is most favorable from a distribution standpoint. The extensions can work in harmony with the present John St. station, constituting as well a duplication to serve the entire city in the event of interruption of the present plant. As the city expands eastward it will be logically situated for distribution. The supply there is comparable in quality with that of Scarboro' Heights, and 4½ miles nearer the city. The lake bottom is admirably suited for tunnelling and a crib may be conveniently located at a reasonable depth. A bar or ledge about a mile wide runs out from shore on an easy gradient, and at one mile out has reached a depth of 50 ft. Borings revealed suitable shale at this point 82 ft. below the lake level, this formation extending to the shore on a grade approximately paralleling lake bottom.

Pitometer Survey.—An interesting feature of the report is the result of an investigation by pitometer survey into the city consumption, as indicated in Fig. 4. The area of Toronto, excluding the Island, Harbor, Ashbridge's marsh lands, Humber Bay, and that portion of the Lake west of the Island, within the city limits, approximates 29.6 sq. mi., or 18,949 acres. From the plan the average consumption per day over this section of the city, within the period covered by the compilation, averaged 46,247,000 Imp. gal. An examination shows that in Districts "B" and "C" the average daily consumption amounts to 26,335,000 Imp. gal., or 56.9% of the total water supplied, or, in other words, 56.9% of the total water supplied per day, is consumed in 3,433.19 acres, which constitutes 18.1 per cent. of the entire acreage of the city. These figures show that the maximum usage is in the business and manufacturing section of the city, and that special distribution service must be provided in order to convey the requisite quantity of water at adequate pressure to the maximum user.

RAILWAY EXTENSION IN SOUTH AFRICA.

Amongst the larger projects which the South African Railway administration has on hand at the present time is an important deviation of the existing line between Maritzburg and Rietspruit, about 70 miles from Johannesburg on the main line from Durban. This alteration, which is known as the Town-hill deviation, has been contemplated for many years, its object being to reduce the heaviest gradient on the line, which is as much as 1 in 30. It will extend to about 12 miles in a country which is exceptionally heavy, and the work is so great that the department has decided to divide it up into several sections.

STEEL HARDENING AND TEMPERING.

The hardening of steel has been thoroughly studied by metallurgists, who have given a great deal of time and thought to their investigations with a view to establish a satisfactory theory to account for this very marked phenomenon in connection with steel. The theories brought forth are both numerous and varied. Mr. R. B. Hodgson, of the Crooks-Roberts Company, Sheffield, recently read a paper before a meeting of the Institute of Mechanical Engineers of Great Britain, containing some interesting and practical notes on the hardening process. The following is abstracted from his paper:

In connection with the heat treatment of steel, microscopical evidence has proved most valuable, and it is believed that if two samples of carbon steel selected from two different and distinct sources, but each giving approximately the same chemical analysis, be prepared for microscopical examination under normal conditions, their appearance will be practically the same.

In reviewing carbon steel we find that an increase in the percentage of carbon is attended with increased hardness. In these days, however, we cannot base the definition of steel entirely on the peculiarity due to carbon, since there are other elements that can confer hardness to the iron. Iron readily alloys with different metals, such as aluminium, chromium, molybdenum, manganese, nickel, palladium, platinum, thodium, titanium, tungsten, uranium, vanadium, and many very important and remarkable results are obtained from the resulting alloys. The only metals that we need consider for our purpose are chromium, manganese, and tungsten since alloy steels containing these three metals lend themselves to, and are particularly suitable for cutting tools, which have to deal with work under conditions such that require the tool to be not only harder than can be expected in the case of ordinary carbon steels, but also capable of greater endurance under the two special circumstances of modern increased speeds, or to deal with the machining of very hard materials.

Chromium is used extensively in the production of special steels, as armourplates, axles, projectiles, and tool steels. The chrome iron-ores as found in either Asia Minor, Bohemia, France, Norway, North America, Silesia, and Shetland Isles, are the sources from which the alloy of iron with chromium is obtained. Ferro-chromium is prepared as a commercial article in a variety of grades, having different percentages of carbon and chromium. A grade specially valuable and used in the manufacture of high-class tool steel is 0.5 to 1 per cent. carbon, and 65 to 70 per cent. chromium. In the finished tool steel, such as very hard turning tools, the quantity of chromium varies between 2 and 3 per cent.

All steel contains some manganese, although the narrow limits of its contents, 0.2 to 1 per cent., as usually present in ordinary finished commercial carbon steels, does not materially influence the properties of the steel. Manganese frequently occurs in iron-ores and is partially reduced along with the iron, 5 to 20 per cent. Manganese will result in the production of a white pig-iron in a highly crystalline condition, containing a large amount of carbon in chemical combination, this is called "spiegeleisen," on account of the beautiful bright appearance of its crystalline plates, a condition which disappears if the manganese is increased above 20 per cent.

An alloy used extensively in steel making is that known as ferro-manganese, containing from 75 to 87 per cent. manganese alloyed with steel. Manganese produces a material that is hard, tough, strong, and non-magnetic, and gives varying results according to the percentage. If 1 to 3 per cent. manganese be present the steel is brittle and unworkable, and up to 7.5 per cent. the steel may be likened to glass for brittleness, and beyond 7.5 per cent. the extreme hardness begins to disappear, but all manganese alloys possess extraordinary qualities of hardness combined with toughness, such as do not occur in the case of any other alloy. Manganese steels are so hard that they cannot be machined, but may be forged into various shapes as easily as very mild steel, and the ordinary process of quenching in water toughens but does not harden manganese steel. Sudden quenching at a high heat will improve the tensile strength and elongation.

Tungsten is chiefly prepared from wolframore, and the metal readily alloys with iron to form ferro-tungsten. When alloyed with carbon steels tungsten plays an important part in helping to confer great hardness upon the steel, but in the absence of carbon, the presence of tungsten will have very small influence on the physical properties of the steel. Further, whilst tungsten has practically no appreciable effect on the magnetic properties in low carbon steels, it is of great value in high carbon steel, since by its coercive-power with regard to magnetism it greatly increases the power of the steel to retain the magnetism, consequently tungsten is an important metal in connection with special magnet steels, and a high percentage will improve the magnetic properties of the steel very considerably. The composition of the steel used for permanent magnets is somewhat similar to a special tool-steel, but as a magnet steel is not required for cutting purposes, its composition is arranged so as to make most effective its properties of retaining magnetism.

The addition of tungsten will impart a fine-grained structure to a carbon steel, and the fracture of a tool steel containing about 1.3 per cent. carbon and 3 per cent. tungsten may be likened to a mole's back, so fine and velvety is the grain.

Self-hardening steels are alloys of iron, carbon, tungsten, and manganese, and in some instances chromium and other metals are added to bring about certain improvements in the qualities of the steel. These steels are called self-hardening, because if they are heated to a temperature of about 1,200 deg. C. (nearly a welding heat) and allowed to cool in the air, they become very hard.

The hardening and tempering of a piece of steel is an operation which, to the casual observer, may appear a very simple one, but it is undoubtedly one of the most delicate operations in connection with mechanical art.

The quantity and variety of tools and other steel articles that are handled in the Midlands, are so numerous that it is hardly possible to give a detailed description of the rules and methods for forging, hardening and tempering that can be applicable to the whole.

There are certain fundamental laws and principles relating to these matters, and if these are duly and properly observed, and correct methods adopted, they will invariably lead to satisfactory results. In my book, "Machines and Tools Employed in the Working of Sheet Metals," which was published in 1903, I mentioned how necessary it is to exercise special care in heating a tool to the required temperature before plunging it into the cooling bath for quenching, the principal points of importance to remember being gradual and uniform heating, and the quenching to be done in a plentiful supply of fresh clean water and brine, or rain water and brine.

A steel high in carbon will harden at a low heat as compared to the temperature necessary for a steel containing a low percentage of carbon, which fact makes it essential for the workman to have some knowledge as to the carbon content of the steel he is handling; also, he should at least have an approximate idea as to the correct temperature to which the steel had best be heated. What an important item the latter is—will be seen when we come to consider the actual application of the recalescence curve for fixing the correct hardening temperature.

At all stages in its manipulation, steel should be thoroughly and uniformly heated; that is, in the forge and rolling mill, in the smith's shop, as well as in the hardening and tempering shop, for if a piece of steel is hotter in one part than another, the expansion is necessarily variable, consequently contraction in hardening will also vary, there being higher tension in one part than another, resulting in either a warped or cracked tool.

In the forge, irregular heating means irregularity in forging, consequently inequality of tension in the article when in the rough forged state. But a reasonable amount of care on the part of a blacksmith will prevent trouble from this cause.

The difficulties of uniformly heating a piece of steel in an ordinary blacksmith's fire, or in a coal-fired furnace, are far too well known to need much comment from me. In the case of the coal-fired muffle, by exercising a certain amount of care, by occasionally turning round the steel, and by using a pyrometer in the muffle, it is possible to partly overcome the difficulties, but at all times experience and good judgment is necessary. Probably the next best way to ensure a regular heating is to use a gas-fired muffle or furnace, which can be readily arranged to maintain an even and correct temperature by adjusting the gas supply, and in this way considerably reduce the risk of burning the steel; and should a workman be unable to remove a tool immediately it is ready for quenching, the application of a pyrometer will guide him and so prevent disaster. An incidental advantage of the gas-fired furnace is the increased cleanliness, due to the freedom from smoke and dust, which are inseparable where the ordinary blacksmith's fire or coal-fired muffles are employed.

The International Marine Signal Company, Limited, of Ottawa, have closed their shop, and it is rumored in Ottawa that the company has been purchased by Mackenzie, Mann & Company. When a representative of *The Canadian Engineer* called at the company's office in Ottawa last Friday, an official of the company would neither confirm nor deny this rumor, but stated that Mr. Thomas L. Willson, the former president of the company, has resigned from the Board of Directors, and that Mr. Lewis Lukes, of Mackenzie, Mann & Company, Toronto, had been elected president of a new Board of Directors, which would have their headquarters at Toronto. When interviewed this week at Toronto, Mr. Lukes stated that he was not yet in a position to discuss the matter, and that he would be unable to give out a statement for a few days as to just how the affairs of the company would be arranged for the future.

COAST TO COAST.

Port Arthur, Ont.—A new telegraph line has been completed which now affords direct communication between Port Arthur and Toronto. In its construction over 800 miles of copper wire were used.

Winnipeg, Man.—The earnings of the Winnipeg Electric Railway on actual street car operation in the city of Winnipeg for 1913, were $2,384,597.28, an increase of $269,604.48 over the earnings of 1912.

Winnipeg, Man.—The financial statement issued by the provincial department of public works shows Manitoba's Government elevator system to have had a surplus of revenue over expenditures to the extent of $329.84 for the year ending November 30th, 1913. Receipts totalled $58,770.71, and expenditures, $58,440.87.

Weston, Ont.—A recent improvement has been effected at Weston by the Water, Power, and Light Commission in its endeavor to make Weston the best lighted village in York County, Ont. Every pole on each side of the business section of Main Street now bears a heavy-powered light; and on the east side, the lamps are encased in large frosted globes.

Winnipeg, Man.—The report of the public utilities commission shows the condensed earnings of the Manitoba Government telephones for the twelve months ending November 30th to have been as follows: revenue, $1,707,149.74; expenses, $1,269,909.90; and net earnings, $437,239.84. The interest charges for the year were $406,975.20, leaving a surplus of $30,264.64.

Ottawa, Ont.—Some of the improvements at Ottawa effected by the civic council of 1913 are the following: the provision of a good temporary water supply in the form of 11 artesian wells; a reduction in the Municipal Electric Commission's rates; the prevention of increased street railway rates; a civic financial surplus; and a greater mileage in the construction of granolithic walks and pavements than has been accomplished in any previous year.

Toronto, Ont.—The definite announcement has been made by Sir William Mackenzie, president of the Canadian Northern Railway, that September 1st next, will see the completion of the C.N.R. transcontinental from Quebec through to the Pacific Coast; and the early fall, the operation of a passenger service that will require an equipment for the operation of 15 trains each way daily. He states, also, that $50,000,000 were expended last year in construction upon this continental line.

South Vancouver, B.C.—Mr. H. B. A. Vogel, secretary of the North Fraser harbor commission, stated, while addressing municipal ratepayers recently, that progress is being made by the commission. Harbor commissioners in the United States and European countries have been requested for information, and the appointment of a competent engineer is to be made shortly. Until the engineer shall have examined the specifications of the contract, the Dominion government is holding up the jetty and dredging project for the mouth of the North Arm and a distance of five miles inward.

Montreal, Que.—Comprehensive schemes of extension, improvement and double-tracking formed the basis of procedure by the C.P.R. in 1913; but the present year will have to be devoted to the completion of these schemes, rather than to the projection of any extensive new program. Thus, the expenditures estimated for the western appropriations of 1914 are almost entirely confined for the present to the completion of track-laying, etc., on grades already built, on branch lines, extensions and double-tracking, the latter of which will eventually connect Winnipeg to Vancouver; and to the building of the Rogers' Pass tunnel.

Victoria, B.C.—Of the E. & N. Railway company's new line on the east coast from McBride Junction to Courtenay, a stretch of 45 miles, 15 miles have been completed; and when the bridge being erected over the Big Qualicum river is finished, steel work and ballasting will be continued over another 15 miles, upon which grading is complete, and should be concluded by the middle of next April. The road will then have reached the Sable River, in the vicinity of Baynes Sound, where another steel viaduct will be erected, material for which is already on hand. It is estimated that the road will reach Union Bay in May; and on the 10 miles between that point and Courtenay, the Trent river must be spanned. This is not expected to delay the completion of the entire road beyond next July.

Winnipeg, Man.—Since January 1st, 1913, the C.P.R. has completed the largest construction programme ever undertaken by this company on lines west of the lakes in any one year. Eight hundred and fourteen miles of grade have been constructed, 753 miles of steel laid, and 878 miles ballasted, making a grand total of 2,472 miles of additional trackage either completed or partly done. Besides this new construction the new yards in Transcona, with 100 miles of track, have been completed, the new double-track bridge connected over the Red River, and 4,000,000 bushels of capacity have been added to the elevator at Fort William. Besides progress in double tracking the company has made considerable headway with the Weyburn-Lethbridge line, the Swift Current-Bassano line, and the 5-mile tunnel under the Selkirks, which will be completed in three years. Double tracking west of the lakes now totals 860 miles.

Montreal, Que.—A large annex has just been completed to Windmill Point Elevator at Montreal. The main elevator, which was completed and put into operation in the spring of 1906, has a capacity of 1,080,000 bushels. The capacity of the annex is 1,070,000 bushels, which makes a net accommodation of 2,150,000 bushels. There are in the new building 28 concrete tanks, 25 feet in diameter and 100 feet in height, arranged at right angles in four rows, with seven tanks in each row. The tanks are constructed of reinforced concrete, having their adjacent sides rigidly united so that the four-pointed, star-shaped spaces between the circular tanks may be used for storage as well as the circular tanks themselves. The large tanks hold approximately 33,000 bushels apiece, and the star-shaped or interstice bins hold approximately 8,000 bushels each. On the Grand Trunk system, the Windmill Point Elevator is now second only in size to the 5,700,000-bushel elevator situated at Fort William.

St. Catharines, Ont.—The city engineering department has had an exceptionally busy year in 1913, so much so that a second assistant has been required by City Engineer Near for clerical work. Mr. Near, moreover, has undertaken to improve the system of the office department so as to satisfy more fully the requirements of the Legal Department of the Court of Revision in connection with the Local Improvement Act. To this end, he has introduced a card index system giving the history of each local improvement from its recommendation to its completion. Another improvement instituted is printed certificate forms for all payments, giving the required information as to by-laws for the City Treasurer. A third is a file and index to all contracts, by-laws, and agreements. A retention book has also been introduced, giving readily the date when final inspection of such work shall be made to release the guarantee drawbacks. Finally, a system of filing and indexing all plans of sub-divisions, local improvements, etc., is gradually being perfected.

Vancouver, B.C.—The work completed by the B.C.E.R. Company during the past year, shows a total of 9½ miles of new track. Other large works outside of the city, constructed during the year include the logging railway from Port Moody to Coquitlam dam; and on Vancouver Island, the

Saanich line extending 22 miles from Victoria to Deep Bay. Work on the construction of Coquitlam dam, which has been in progress since 1908, has been ended and the Jordan River dam on Vancouver Island has also been finished, both works which have cost millions of dollars. The Kitsilano car barns have been erected since the opening of the year; new car barns were added to those already in existence at New Westminster; and the facilities for handling cars have also been greatly improved there by the building of a large interurban freight yard. The No. 2 power house on the North Arm has been fully completed and when fully equipped will have a capacity of 42,000 horsepower. One unit of 14,000 is already practically installed. Work is started, although not finished, on the new power-receiving station in the District Lot 118, Burnaby, and on the building of an extension to the Jordan River power house on Vancouver Island that will double its capacity.

Vancouver, B.C.—It has been announced by Mr. Cameron of the Pacific Dredging Company that of the 4,000,000 cubic feet of material which will have to be removed to make the waterway navigable and provide a turning basin for large ships, 800,000 cubic feet have been already transferred to the site of the Canadian Northern Pacific terminals on the other side of the Main Street bridge. A dipper dredge is being installed to supplement the operations of the hydraulic suction plant; and it is now expected to remove twice the amount of material each day. The hydraulic dredge is working in the narrow arm of the creek adjoining the G.N.R. station. The dipper apparatus will commence operations near the Connaught bridge. The pipe lines from the suction dredge were concentrated for some time on a big hole, 1,000 feet by 1,000 feet, immediately east of the bridge. This had to be filled before any appreciable difference was made on the large area to be reclaimed. The dirt deposited in the creek extends over an area of eighty acres, and already a fair-sized island has been formed east of the bridge. A temporary barrier has been constructed across the creek near the bridge to prevent the material from seeping back into the main portion of the waterway.

Toronto, Ont.—Another discovery of natural gas in Toronto, though not of a pressure to foretell any commercial value, was made while boring operations for a pure water supply were being carried on beneath the new Dominion Bank Building, corner King and Yonge Streets. Indications of a high pressure were at first reported, but they have been discredited by the statements of Dr. A. P. Coleman, Professor of Geology at the University of Toronto, and of Mr. G. G. Grist, General Manager of the Canadian Stewart Company, which is erecting the building. Dr. Coleman stated that, though a gas flow of 700-pounds pressure as had been reported was not impossible, yet the result of numerous boring tests made in Toronto had shown the gas flow found to be very weak. Mr. Grist claims that the vein of gas discovered under the Dominion Bank Building was small and of little consequence. The boring for water had attained a depth of over 1,100 ft., when indications of gas in the shaft caused a cessation of operations, through fear of tapping a voluminous flow at high pressure. The shaft was hurriedly filled with concrete, to a depth of about 300 ft., and thereby a stop was put to the endeavor of the builders to provide the building in this way with a water supply that would obviate the use of the present city supply, and its deleterious effect upon valves, pipes, etc.

Revelstoke, B.C.—Mr. J. P. Forde, district engineer of the public works department, Revelstoke, says in connection with the Columbia river survey, concerning which inaccurate statements have recently been published, that two parties are engaged in the work, and have been in the field for the past two summers. These are in charge of Mr. W. F. Richardson and Mr. H. F. Muerling. While they have not yet completed their work, it is expected that they will do so within a few weeks, and make their report to the Minister of Public Works on the engineering features of the work of making this river a western wheat route to Portland. The report of the minister will not be complete until the economic features of the scheme have been considered. During the season of 1912-13, Mr. Richardson's party was engaged in surveying the river between Golden and Revelstoke, and the report on this work has already been sent to Ottawa; and during the season of 1913-14, that party has been engaged on surveys between Revelstoke and Waneta on the international boundary, and is still engaged on those surveys. The work being carried on under Mr. Muerling has been confined to special surveys in the vicinity of Burton, which is at the lower end of the Columbia river narrows, connecting the Lower and Upper Arrow Lakes. These surveys are being made with the view of improving navigation at the narrows, where improvements will be required in the immediate future, even if the larger scheme of making the river navigable to the Pacific coast should not be put in process. The reports of the field engineers are expected to be complete some time in March; and the report covering both the engineering and economic aspects of the scheme will then be prepared by the Government engineer's department for the consideration of the minister of public works.

Montreal, Que.—Mr. A. S. Baxendale, managing director of the Universal Radio Syndicate, which is carrying out a contract to establish a wireless telegraphic service between Canada and the United Kingdom, while in Montreal, made the following interesting statements: "There will be in connection with the Newcastle installation 6 wooden towers, 300 feet high, and one of steel with a height of 500 feet, while the number of kilowatts will be 300. The San Francisco station, which connects with Honolulu, has but 100; and when it is considered that the range is about the same distance, about 2,000 miles, the power of the Canadian station and its possibilities for a superior service will be understood. The station on the other side of the Atlantic is at Bally Bunion, in County Perry, Ireland, and from there the company will have a line to London, which will be leased from the English post office department. It is expected that arrangements will be successfully completed with the C.P.R. to handle the land business of the Universal Radio Syndicate. Mr. Baxendale stated further that the contract with the Canadian Government calls for 80 words a minute, while the Newcastle and Bally Bunion system will be equal to at least 150 words a minute. He stated also that the United States government in a piece of test work had been most successful at a range of 3,000 miles from the Arlington station, near Washington, and that with only 30 kilowatts and mostly at night. Consequently, one can easily measure the possibilities of the Canadian system. In arranging for 300 kilowatts, the company are looking for the very highest rate of speed yet obtainable. Experimental tests will be commenced at Newcastle in February; but it will probably be early spring before the line is opened for regular transoceanic business.

PERSONAL.

J. LANNING, B.A.Sc., has been appointed superintendent of the sintering plant of the Mond Nickel Company, in their smelter works at Coniston, Ont.

C. KRUMBIEGEL, resident engineer of the Deutsche Maschinenfabrik A.G., has returned from Germany and joined the staff of the company's Canadian agents, Messrs. Gerald Lomer, Limited, Montreal.

JAMES COWIN, formerly Winnipeg manager of C. A. P. Turner's office, and E. F. FEE, of Winnipeg, have formed a partnership and will make a specialty of reinforcing steel. Their office is at 701 Canada Building, Winnipeg.

J. STOKES, of the firm of Ashmore, Benson, Pease & Company, Limited, Stockton-on-Tees, England, called at *The Canadian Engineer* office last week on his way to England after having spent several weeks in Canada.

HAROLD C. STEVENS, principal assistant engineer to JOHNSON & FULLER, consulting engineers and sanitary experts, New York City, has been admitted to membership in the firm, the other members being George A. Johnson and William B. Fuller.

H. B. TAYLOR, M. Am. Soc. M.E., read a paper, illustrated by slides, on "The Present Practice in Design and Construction of Hydraulic Turbines" before the Montreal mechanical section of the Canadian Society of Civil Engineers on January 15th.

B. E. T. ELLIS, whose article on the West End sewage disposal works at Hamilton, appears elsewhere in this issue, and STANLEY M. OBORN, Toronto, have formed a partnership as consulting and civil engineers, specializing in main drainage works of all kinds, with two offices, one in Toronto, in charge of Mr. Oborn, and one at 158 Cumberland Street, Hamilton, under Mr. Ellis' supervision.

B. E. T. Ellis, C.E.

Mr. Ellis has had 14 years' experience in municipal engineering, in Canada and England, chiefly main drainage work, but including roads, bridges, street railways, sewers, etc. Besides designing the East and West End disposal works, on the 2-story sedimentation tank principle, in Hamilton, he has prepared plans and estimates for the East End main drainage scheme (combined system) for that city, as well as for the new storm-overflow sewer to relieve the existing sanitary sewers in the central part of the city.

Previous to specializing in main drainage work Mr. Ellis has acquired a thorough training in the city engineering departments of West Bromwich, Birmingham, and York, England; and of Toronto and Hamilton, Canada. For three years he was an assistant to Mr. Albert D. Greaterox, M. Inst. C.E., a past-president of the Institution of Municipal and County Engineers.

F. C. GAMBLE, one of the vice-presidents of the Canadian Society of Civil Engineers, and chairman of the Victoria branch of the Society, gave an illustrated lecture to that branch recently on engineering work in British Columbia during the past half century.

W. A. McLEAN, Provincial Highway Engineer for Ontario, was in Nova Scotia last week, where he gave two addresses at the Provincial Agricultural College, Truro. One was based upon the principles of road organization, and the second dealt with road construction in Ontario.

WILLIAM H. CONNELL, Assoc. M. Am. Soc. C.E., chief of the Bureau of Highways and Street Cleaning, Philadelphia, Pa., on January 15th delivered an illustrated lecture on "Organization and Methods of Street Cleaning Departments" before the Graduate Students in Highway Engineering at Columbia University.

S. WOLFF, formerly manager of the Cleveland office of the Allis-Chalmers Manufacturing Company, has been appointed Chicago manager for the DeLaval Steam Turbine Company, manufacturers of steam turbines, centrifugal pumps, centrifugal air compressors, speed-reducing gears, etc., with offices in the Peoples' Gas Building.

C. H. RUST, C.E., of Victoria, B.C., is spending a few weeks in Eastern Canada and New York. Last week he attended the annual meeting of the American Society of Civil Engineers, of which he is vice-president, and next week he will attend the annual meeting of the Canadian Society of Civil Engineers, of which he is a past president.

G. R. B. ELLIOTT, of Vancouver, has been awarded the prize for the best paper read before the Pacific North West Society of Engineers during the year 1913. His subject was "The Fraser River Delta." The membership of the organization extends from San Francisco north, the headquarters being in Seattle. Mr. Elliott who is the first Canadian to secure the annual award, is believed to have won it largely because of the volume of original information on the subject contained in his article.

EDMONTON'S NEW COMMISSIONERS.

The City Council of Edmonton has dismissed the entire city commission board, composed of A. G. Harrison, A. J. McLean, and John Chalmers, and has appointed commissioners, each with specific duties. M. S. Booth was chosen commissioner of health and safety, and Bryce J. Saunders, commissioner of public works. John Chalmers was re-appointed and given charge of operation.

COMING MEETINGS.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Annual meeting will be held in Montreal, Que., January 27-29, 1914. Secretary, Prof. C. H. McLeod, 176 Mansfield Street, Montreal, Que.

CANADIAN CLAY PRODUCTS MANUFACTURERS' ASSOCIATION.—Annual Convention to be held at King Edward Hotel, Toronto, Jan. 27th, 28th, 29th, 30th. Secretary, J. R. Walsh, 40 Blake Street, Toronto.

AMERICAN CONCRETE INSTITUTE.—**Tenth Annual Convention to be held in Chicago, February 16th to 20th, 1914. Secretary, E. E. Krauss, Harrison Building, Philadelphia, Pa.**

NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.—**Meeting will be held in Chicago, Ill., February 12th to 14th, 1914. Secretary, J. P. Beck, 72 W. Adams Street, Chicago, Ill.**

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.—**Annual Meeting to be held in New York, January 21st to 23rd, 1914. Secretary, E. A. Scott, 29 W. 39th Street, New York City.**