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The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

CENTRE STREET BRIDGE, CALGARY, ALBERTA*

SKEW BRIDGE WITH GRADE OF NEARLY FOUR PER CENT. AND TRAFFIC ON TWO LEVELS—COST APPROXIMATELY $400,000—ONE OF THE MOST IMPORTANT REINFORCED CONCRETE BRIDGES IN CANADA.

By GEORGE W. CRAIG, City Engineer, and JOHN F. GREENE, Bridge Engineer.

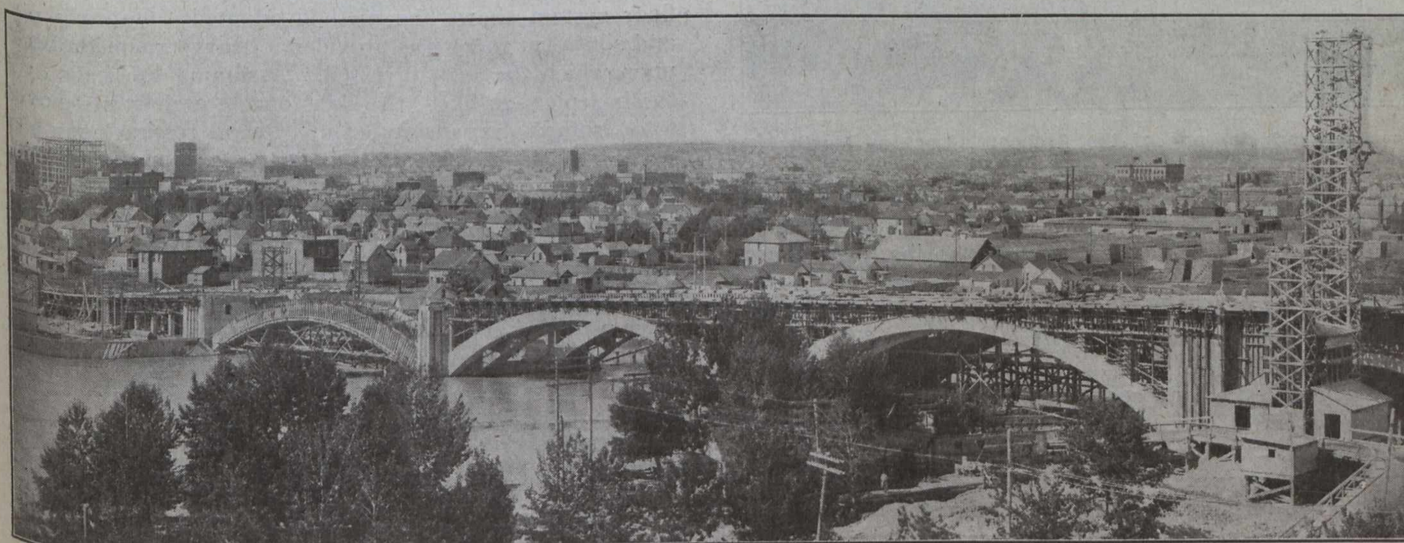
THE Centre Street Bridge improvement in Calgary, Alberta, consists of three parts: 1st, the bridge proper and its south approach with a total length of 1,300 ft.; 2nd, a fill and cut extending 2,100 ft. north from the bridge; 3rd, a side hill cut, forming a road which meets Centre Street at the face of the hill, extending west for 2,800 ft. (of which 2,300 ft. is in cut). The south end of the bridge lies five blocks from the business centre of the city.

The improvement provides a convenient avenue for traffic between two parts of the city; the one a residential section lying north of the river, and 120 ft. above the business portion which stands on the former flood plain on the south side of the river. The roadway has a maximum grade of 3.85% with a minimum width of 42 ft. on the bridge, and provides for two lines of street car traffic, and contains two sidewalks each 7 ft. wide.

A low-level roadway, 18 ft. wide, slung from the bridge deck, provides for highway traffic to a residential section lying on the flood plain north of the river below the bluff which commands the city, while the sidehill cut provides a means of communication between the low and hill levels north and west of the bridge.

The Bow River, which passes the bridge at an angle of 60° with the centre line, has a flood volume of about 55,000 second-feet, and is about 500 feet wide at the bridge site.

The problem from the viewpoint of the designer may be stated as follows: Given a height of 29 ft. from the water line to grade at the south bank, 47 ft., or 18 ft. more at the north bank, with a skew of 60°, to obtain a structure which shall provide for all probable traffic requirements on a high and low level during its life, and at the same time present an appearance in keeping with the dignity which should characterize public works of a monumental character, and this for a predetermined amount of money. We were impressed with the importance of lending to the structure the grace of proportion and of suitable ornament. The irregularities of grade and skew contributed much to the complexity of the problem, and it was only after numerous trial elevations based upon radically different conceptions, that we arrived at a final arrangement that seemed satisfactory. We went to the expense of constructing a wooden model of a portion of the bridge to be assured that the treatment would produce the desired effect.



Centre Street Bridge, Calgary, Alta. Photograph, August 21st, 1916.

The various parts of the bridge were designed for the following live loads:—

Floor, concentrated loads: Car beams and slab, 50-ton cars on both tracks; road beams and slabs, 20-ton motor trucks.

*Paper read before the Canadian Society of Civil Engineers, Montreal, February 8th, 1917.

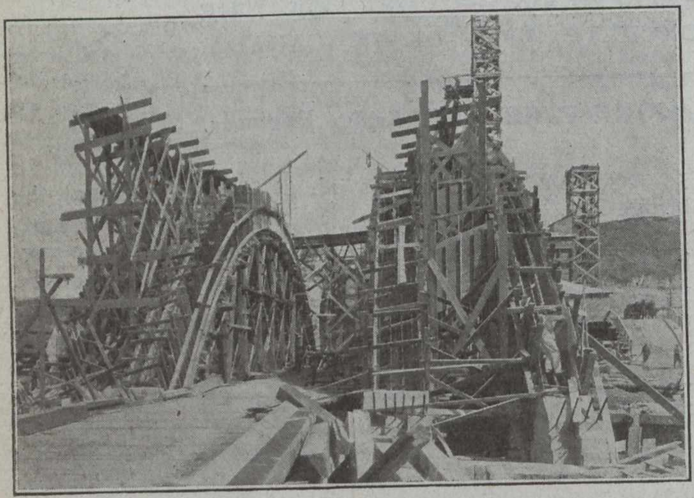
Uniform loads: Road, 100 lbs. per square foot; sidewalk, 100 lbs. per square foot on outside four feet, 40 lbs. per square foot on remainder.

Low level: Concentrated load, 20-ton motor truck; horizontal load, 300 lbs. per lineal foot of structure.

Arches: Concentrated loads, four 50-ton cars per 150 ft. span, with uniform loads on roadway and sidewalk, same as for the floor.

Temperature: Rise of 50° and fall of 70°.

Maximum stresses—Concrete: Floor, compression, 530 lbs. per square inch; arches, maximum compression



Falsework for one of the Arches. Looking North.

(live load and dead load) 540 lbs. per square inch; rib shortening, 677 lbs. per square inch; maximum tension, full load with 70° fall of temperature, 30 lbs. per square inch.

Steel: Maximum tension per square inch, 16,000 lbs.

Foundations: Maximum pressure upon rock, 12,300 lbs. per square foot.

Owing to the high cost of concrete materials, and to the depths of the piers and abutments, it was economical in obtaining the required carrying capacity in the arches to use deep, narrow ribs. Assuming a crown thickness of 5 ft., and placing the springing line of the flattest arch at low-water level, we found that there would be required two inner ribs, each 6 ft. wide, and two outer ribs, each 4 ft. wide.

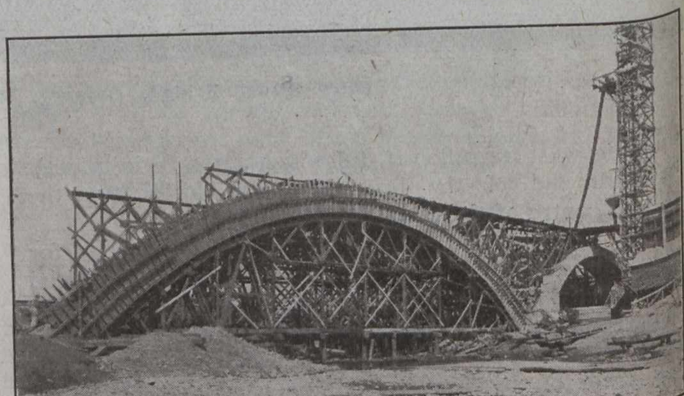
On the second arch retaining the same crown thickness and the same distance below the floor for the extrados at the crown, it was possible by taking advantage of the grade and increasing the rise of the arch, to reduce the width of the ribs, using two inner ribs at 5 ft. instead of 6 ft., and two outer ribs at 3 ft. 3 ins. instead of 4 ft. At the same time, by raising the springing line of the arch, we increased the moment arm of the thrust from the higher and narrower ribs, about the pier base, enough to offset the moment of the greater thrust from the lower and wider ribs. Again, on the third span, by increasing the rise we were enabled to use ribs 4 ft. wide and 2 ft. 6 ins. thick instead of 6 ft. and 4 ft. as on the shallowest span.

The piers are of the cellular type, the supports for the arch ribs resting on a concrete pedestal 5 ft. thick, extending over the entire area within the cofferdam. Those supports for the arches are connected by reinforced core walls 2 ft. thick, those between inner ribs constituting supports for the low-level deck, and those between inner and outer ribs rising to the upper deck, the whole pier presenting the appearance of two solid shafts. Manhole slabs have been provided in all piers and abutments for the convenience of the power, gas and telephone companies which have service mains on the bridge.

The retaining wall at the north end of the bridge is 48 ft. from base to top. The upper 12 ft. of the wall is of the cantilever slab type, the lower portion consisting of counterforts and slabs. The reaction from the cantilever slab portion is carried by the adjoining three feet of slab to adjacent counterforts, extra steel having been provided to carry this load.

The retaining wall at the south end has an umbrella-shaped top, the 4-inch sidewalk slab projecting several feet on both sides of the wall. Expansion joints have been provided at regular intervals in the wall, with lead strips 10 ins. wide to prevent seepage through the joints. The steel was of exceptional quality for re-rolled steel; the average ultimate tensile strength was 68,000 lbs. per square inch, and of 1,300 rods bent cold on tthe job, but four rods broke.

The problem of expansion joints for the floor was an unusual one, owing to the peculiar conditions. The spandrel ribs were designed as T-beams, with the floor slab for the flanges of the T. All floor beams are perpendicular to the centre line of the bridge, while the piers and abutments are skew. The accompanying plan of the floor system shows the method adopted. On each pier and abutment there was provided a heavy expansion beam upon which the system rested. Assuming the slabs over the box piers as fixed, the slabs on the arch spans moved to or from the expansion beam. Beams resting upon pier walls moved on steel plates in open pockets; slabs over piers rested only on the beams, a layer of clay 1 in. thick interposing between the wall and the bottom of the slab. Joints over the arch spans were made in the slab midway between beams, the slabs in these expansion panels having been designed as cantilevers. Troughs covered with lead were provided at all expansion joints, these troughs draining into pipes provided in the piers. Passing from the utilitarian to the aesthetic aspect of the design, one must bear in mind that the treatment of the parapet, piers and abutments should please and impress favorably both the distant observer, who will view the structure *in toto*, and



Another View Showing Falsework.

also the more frequent observer, who will view it from the sidewalk or from the passing automobile.

For the close-ranged observer we have provided four ornamental kiosks, and a massive concrete parapet of premoulded concrete balusters, base and rail. The kiosks span the sidewalk and open on observation balconies cantilevered from the side walls. The east and west faces expose shields containing the emblems of the various parts of the British Empire, the maple leaf for Canada, the rose for England, the shamrock for Ireland, and the thistle for Scotland. Above the north and south faces and over the walks are buffalo heads, emblematic of Western Canada; the whole forming a pedestal of a massive British lion, 13 ft. long by 7 ft. high. The ensemble is symbolical of the permanence and stability of the British Empire supported by its component parts.

The piers are surmounted by slotted battlements treated with steel grill work. The plan of the pier parapet is a half hexagon. Inasmuch as the skew of the bridge is 60° an angle of the hexagon forms a nose or cut-water at the upstream face of the pier, while at the same time presenting a symmetrical elevation to the passing observer.

The illumination of the bridge will be effected through the agency of fluted cast-iron standard on the piers, and four torch bracket lights on each kiosk. All iron work will be painted of a gray color, which will nearly match the concrete.

For the distant observer viewing the bridge as a whole, an attempt has been made to break up the dull flat surfaces which from their extent and from the sameness of color impress one unfavorably. Working from the hypothesis that it is neither expedient nor economical to eliminate board marks from concrete faces, we have adopted the policy of substituting grooves and pilasters which will serve both to withdraw the eye from the necessary minor irregularities of the concrete surfaces, to break up the surfaces, and to heighten the effects aimed at, whether of depth by the use of vertical lines or of breadth by the use of horizontal lines. The faces of the piers have been panelled and grooved; the faces of abutments have been pilastered and the form sheeting has been run up and down to convey an impression of greater height. The arch rings were grooved at regular intervals, serving the double purpose of breaking up the rib face, and of offering suitable locations for construction bulkheads. The face of the north retaining wall was broken up by horizontal grooves and by battered pilasters, marking the locations of the counterforts on the back of the wall, and carried up above the rake of the wall, breaking the skyline.

The 62-ft. arch spanning the boulevard on the north side of the river supported deep spandrel walls, the faces of which were marked with pilasters, and the arch was crowned with a large date stone, and a seal of the city of Calgary 6 ft. high by 4 ft. wide.

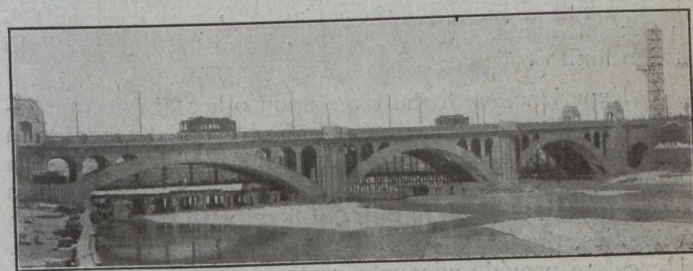
The low-level structure with a roadway 18 ft. wide, consists of a structural steel frame, with a concrete floor slab, and an asphaltic concrete wearing surface. It is suspended by hangers, each consisting of two steel angles engaging a pin, and linked to steel bars with an eye on one end and a thread upon the other. The threaded end passes through a yoke consisting of two 7-in. channels with top and bottom cover plates. These yokes are embedded in the main floor beams with the bottom of the yoke 18 ins. from the bottom of the beam.

The concrete slabs for the low-level consisted of premoulded blocks suitably reinforced, 4 ft. by 3 ft. 8 ins.; each slab was a double T with flanges 3 ins. thick, and the stems projecting 4 ins. below the slab. These blocks rest on the top flanges of the steel I-beam stringers. This unusual type of slab was adopted for two reasons: 1st, to reduce the dead load weight of the structure; 2nd, to permit of the completion of the erection in the dead of winter with a temperature at zero or less.

From the standpoint of economics with cement at $2.40 a barrel and structural steel at $80 a ton, the adopted design cost 40c. per square foot against 58c. per square foot for the standard design, with a 6-in. slab and I-beam stringers.

The spandrel arches were designed as beams continuous over three spans, all moments and shears being worked out for concentrated loads by means of the three-moment equation. Expansion joints have been provided in these spandrel walls, layers of three-ply roofing intervening between adjacent parts.

Joints at the one-third points in the arch spans allow for the opening due to the rise of the arch with a rise in



View from the East, Centre Street Bridge. Photograph, January 15th, 1917.

temperature, and joints at the piers and abutments provide for the fall of the arch with a drop in temperature, and the consequent drawing away of the spandrel walls from the piers.

Economic depths of beams and slabs as determined by the local costs of cement, sand, gravel, lumber and steel have been ascertained by the well-known principles of maxima and minima of differential calculas, the process entailing the writing of an equation for the cost of the material for the beams in terms of money and depth, and solving for the depth which will make the cost a minimum.

The concrete for the arches, beams, slabs and retaining walls was prepared in the proportion of one part of cement, two of sand, and four of gravel; the foundations and all pier and abutment walls 1:2.5:5; the handrail 1 of cement to 2.5 of sand.

The cement was purchased upon the specifications of the Canadian Society of Civil Engineers, with the exception of the tensile strength requirements for 1:3 mortar; these were raised from 150 to 200 lbs. per square inch for 7 days; and from 225 to 275 per square inch for 28 days. The product of the Canada Cement Company met this requirement.

A washed screened sand was required according to the specification with grading clauses, rejecting sand with more than 40%, by weight, passing a No. 30 screen; or more than 3% passing a No. 100 screen. The gravel, washed and screened, was purchased upon a void specification, the maximum not to exceed 40%. The maximum diameter of particles for use in piers, arches and walls was approximately 5 ins., this limitation being due to the efficiency of the mixing machine, not to a probable diminution in the strength of the resulting aggregate. In the floor system, owing to the intricate network of steel, it was necessary to limit the maximum diameter to 2 ins. Whenever expedient, as in piers and abutments, boulders were embedded in the concrete.

Active construction work upon the bridge began in April, 1915; in June the Bow River went into a flood, reaching a peak on the 26th, the highest since 1897. On this day the temporary bridge used as a traffic way during the construction of the bridge was washed out. Mr. Craig and City Commissioner Garden were on the structure at the time. The former made his way to shore by climbing a panel of the deck, one end of which was in the water. Mr. Garden was swept downstream, pursued by two of the bridgemen who had put off after him in a boat provided for such an emergency. They succeeded in landing him on an island about a mile downstream.

Soundings at the piers disclosed the following sub-strata: In pier No. 1, gravel and large boulders, 5 ft.; clay, 3 ft.; soft shale, 4 ft.; sandstone, 4 ft.; clay, 3 ft.; hard shale, 15 ft. to limit of drilling. In pier No. 2, gravel and large boulders, 5 ft.; clay, 2 ft.; sandstone, 4 ft.; soft shale, 5 ft.; sandstone, 5 ft.; hard shale for 15 ft. to limit of drilling.

Experience with the river upon other bridge foundations taught us that we must guard especially against a possible great scour. Shifting gravel bars situated both above and below the bridge tend to restrict the flow to certain channels, and in times of flood with attendant high velocities, there is a considerable scour in these channels. Hence, to provide adequate protection against scour, we carried our excavation through the bottom layer of sandstone and well into the hard shale rock beneath. The shale rock was of a quality such that there could be no question of exceeding the allowable bearing power.

The cofferdams consisted of two layers of Wakefield sheet piling, with an 8-ft. puddle. The sheet piling was driven to refusal in the gravel, centrifugal pumps were installed, the dam pumped dry, excavation commenced on the general plan of removing the material under the sheet piling first, driving the latter home and then removing the material in the middle. When the sheet piling had penetrated the clay underlying the gravel, a layer of 3-in. plank was driven approximately to the sandstone level. The material was broken up by blasting and removed in skips by a derrick. There was considerable leakage from the gravel and boulders, the water rising between the sheet piles and the planking; and at the beginning it was necessary to operate four centrifugal pumps to keep the water down to a working level. After penetrating the clay one could hold the water ordinarily with one pump.

In the construction of pier 2 work was discontinued in the middle of January after a cold spell in which the temperature had dropped to 46° below zero. The excavation was still in the gravel.

Upon recommencing work late in March it was found that the ice had so disrupted the cofferdam that it was impossible to lower the water to a working level. The puddle was frozen solid, and the ice inside the cofferdam was approximately 4 ft. thick. The choice of action lay between digging out the entire puddle, replacing it with a new one, or digging out only such portion as was necessary to stop the worst leaks. Proceeding on the assumption that it was cheaper to risk a few blow-outs than to remove and replace the puddle, we adopted the latter mehod, and completed the excavation after various mishaps, including three minor and one major blow-out, the latter flooding the hole so quickly that there was not sufficient time to accomplish the removal of the four pumps which were sitting below water level; one of these, with its motor, was flooded. We found that after plugging a blowout the dam would hold tight for about 72 hours; the jar resulting from the operation of the steam drill and from the blasting together with the gradual melting and disintegration of the frozen puddle, would start new leaks, which quickly attained sufficient proportions to require attention. The pumps, all centrifugals, were operated with check valves on the exhaust pipes, under an average suction lift of 19 ft. and a maximum of 23 ft. The pier work was a continuous operation carried out in three shifts dails of 8 hours each. Work upon this pier began on March 23rd and the concreting of the pier had begun on April 14th. It was evident that in order to prepare the bridge ready for traffic in 1916 it would be necessary to complete the concreting of two of the river arches before high-water, thereby permitting the completion of the superstructure of most of the bridge before the subsidence of the water. A conservative estimate of the earliest probable date of the flood, made after an examination of the records of the Irrigation Department and after conferences with those most familiar with the local river conditions, placed it as June 1st.

The work was so conducted by the employment of double shifts of carpenters working from dawn to dark, that the concreting of the key of the second arch had been completed on May 19th. The removal of falsework on this span began after four weeks, on June 13th. On June 19th, when all the falsework above the pile caps had been removed, the flood came, reaching an elevation within a foot of the record flood of 1915, and washing out five bents of piles in arch No. 3.

Each pair of ribs in an arch span was concreted in eight sections, four on each side of the crown, beginning with a section at the crown, to prevent a rise of the falsework in the middle, and then working up from the haunches. This method of concreting in small sections not only reduced the initial stresses due to contraction of the concrete in hardening, but also lessened the excessive load due to the 60° skew of the piers upon the forms on the low side of the arch ribs. This load was so great that we found it, upon trial, inexpedient to use No. 6 wire and necessary to resort to ⅜-in. rods spaced about 3 ft. centres, to hold the side forms.

All concrete, both in the arches and in the deck, was transported from a mixing plant located at the north shore in hand-pushed buggies run on temporary runways. As a matter of economics the cost of placing concrete in the arches, including charges for plant and shop, was $1.02 per yard.

The design of the bridge was such that a high-speed plant for conveying concrete was inexpedient and uneconomical. With a total length of approximately 1,000 ft. and a yardage above ground of 7,000 yards, the cost of distribution per yard by a system of towers and chutes would have exceeded that of the method adopted. The construction of an economically designed reinforced concrete bridge proceeds in a series of well-defined steps; the concreting of sections of the arch rings, the spandrel columns, the spandrel arches, and the floor, run in sections from expansion joint to expansion joint. The maximum run for a day was 173 yards, the average daily run about 60 yards.

The allowable stresses assumed for the design presupposed an excellent grade of concrete. Such a concrete may be obtained after a proper proportioning and mixing, only by a careful supervision of the final disposition of the material, after release from the conveyer. Proceeding upon the assumption that the concrete shall contain the least quantity of water consistent with the quality of being "alive," that mortar pockets and rock pockets are points of weakness; that no vehicle will deposit concrete in forms in a proper condition; it followed necessarily that every batch of concrete deposited in its final resting place required testing and handling to insure the quality desired. Previous experience with the chuting system on bridge work disclosed the existence of two great attendant evils—the temptation to grease the chute with an excessive amount of water, and the tendency to operate the mixing and conveying portion of the plant at maximum capacity, regardless of the capacity of the placing crew to handle the material properly. By a judicious combination of both evils the material may be placed at a minimum of expense, but the resulting aggregate may have a compressive strength of less than half that of a properly handled concrete. Conveying the concrete by the push-buggy method, we not only remove the incentive for sweetening the concrete with water but also deposit the material of a proper consistency in small batches at regular intervals in such a manner that the final handling is facilitated greatly.

The concrete handrail, consisting of a top and bottom rail with a turned baluster, was made by the dry process. The bottom rail was moulded in place; the top rail was cast upon the sidewalk adjoining its panel; the balusters were made in the construction yard, and the posts were cast in place after the assembling of the above-mentioned precast parts. The best production record in making balusters with two men working with one cast-iron mould was 65 balusters in 11 hours.

The ornamental work, consisting of the panel 6 ft. by 4 ft. containing the seal of the city of Calgary, the small shields on the kiosks, and the lions, were made by the dry process. A full-sized model of the lion, 13 ft. long by 6 ft. wide by 7 ft. high, was done in clay; a plaster cast, consisting of a shell about an inch thick, and containing over 400 pieces, was fitted over this model; and a heavy 4-in. coat of plaster forming large supports for the smaller pieces of the inner coat of plaster, was cast upon the outside. The lions were then cast each in five pieces. All artistic work in connection with the modelling and making of plaster casts was done by J. L. Thompson, of Calgary.

The second portion of the improvement, consisting of a cut and fill extending north from the bridge 2,100 ft., was started in the fall of 1914. The first cut was made with an outfit consisting of two elevating graders with teams and wagons. The work was difficult and expensive in that it was necessary to build up a dump at the edge of a steep cliff.

During the following summer a 60-ton "Marion" shovel was installed in the cut; the loaded dump cars were lowered down on the dump, controlled from a steam hoist set at the north end of the cut. The building of the dump was accomplished without the aid of a construction trestle, the raising of the tracks going on simultaneously with the building of the dump. Work was discontinued in the fall of 1915; the Centre Street cut and the side hill cut, 2,800 ft. long, were completed during 1916. The total yardage of earth moved was approximately 220,000.

The total cost of the improvement, including $34,000 for condemnation and right-of-way, was $400,000.

The improvement was conducted under the direction of George W. Craig, city engineer, with John F. Greene as bridge engineer in charge of the design and the construction of the bridge. The writers were assisted in the design by Frank Lawson, lieutenant, 56th Canadian Overseas Contingent, who was killed at St. Eloi in April, 1916, and by J. Bernard Richards.

The construction work was done under the day-labor method with James Patterson as construction superintendent. The earthwork north of the bridge and a portion of the foundation was carried on under C. M. Arnold as resident engineer in 1915, and the balance of the grading work was carried on under C. LeB. Miles in 1916.

In discussing the above paper at the meeting of the Canadian Society of Civil Engineers held at Montreal last Thursday evening, Col. J. S. Dennis called attention to the phrase, "whenever expedient, as in piers and abutments, boulders were embedded in the concrete," and asked whether that method of construction was approved. What percentage of boulders would one be justified in using? he asked.

Mr. J. A. Jamieson replied that, other things receiving due consideration, it might be better to have a certain amount of boulders in the concrete, provided that they are well embedded, but this has to be done with a good deal of care so that the boulders shall be pretty evenly distributed, otherwise the stress in the concrete would be uneven. The more stone that can be put into the concrete, provided it is well embedded, the better. It would be difficult to name any given percentage of stone to be used, because there are so many factors that enter into the problem.

Mr. Jamieson also called attention to the fact that the question had been raised in this paper of the relative merits of spouting concrete, compared with other means of distributing it. He said that his experience had been that, with very great care, a thoroughly good job may be made by spouting concrete, but that it is so rarely accomplished that, generally speaking, he is very much opposed to this method. As a rule, altogether too much water is used in order to get the concrete to spout well.

Mr. Jamieson also noted that the cement for this bridge was required to pass mortar tests for seven days and twenty-eight days that were different than those called for by the Society's specifications. Personally he thought that the changes were not advisable, as they tended toward a cement that might retrogress. All cements that give a very high test on short periods are apt to retrogress. He expressed a preference for cements which are comparatively low at short periods and show good increases at greater age, along the lines of the British standard specifications.

Chicago's big drainage scheme, which tapped Lake Michigan and started the waters of the Great Lakes flowing towards the Mississippi, has proven inadequate for her present needs, and now she proposes deepening the drainage canal and drawing much more copiously upon the waters of Lake Michigan. The State of Illinois sees in this new deep-water canal project a boom for Illinois shipping and has voted $20,000,000 for the purpose, and is now asking the consent of the United States Government to the project. It is not yet certain just how much this diversion of the waters of Lake Michigan would affect the levels of the Great Lakes, but the issues at stake are too great to permit running any great risk. The State of New York and the Province of Ontario are both vitally concerned in the matter, as the lowering of the levels of Lake Erie and Ontario would affect every harbor upon them and might seriously interfere with the Welland Canal, and even with the St. Lawrence canals, and might make the Detroit River channel almost useless for big boats. Whether the project will be held up by Congress is yet to be seen, but if it goes through, then both the State of New York and the Province of Ontario will have to hold the United States Government responsible for any damage which may result.

STONE-FILLED SHEET ASPHALT PAVEMENT.

By **Charles A. Mullen,**
Director of Paving Dept., Milton-Hersey Co., Montreal.

STONE-FILLED sheet asphalt pavements have been laid in Montreal on Mountain Street up the steep grade north of Sherbrooke Street, on a section of Sherbrooke Street in Notre Dame de Grace west of Westmount, on Mansfield Street between Sherbrooke and Burnside Streets in front of the University Club and the Canadian Society of Civil Engineers' building, on Smith Street between McCord Street and Murray Street, and on many other streets carrying light, medium or heavy traffic. On Smith Street, it is subjected to the numerous and intensively heavy traffic of a destructive character that crosses the Wellington Street bridge from the freight yards and docks.

These pavements are not of the very highest quality, as the municipal plants of Montreal have not yet been organized fully so as to get the best possible results, but they are fairly good types of this construction and will probably give service for a number of years to come. The surface on Mansfield Street was laid over an old bituminous macadam.

The stone-filled sheet asphalt surfaces are apt to look somewhat rough when first laid, but this initial roughness passes away after one or two summers' traffic, and leaves a surface almost as smooth as that of the usual sheet asphalt, and has a pleasing mosaic appearance when clear enough for the stone-chips in the surface to be seen.

The construction of these stone-filled asphalt pavements in Montreal was the result of the writer's recommendations to the city engineer.

There is nothing radical or new about these pavements. The altered mixtures and the methods of laying are rather a getting back to earlier practices that have, in the light of experience, proven both correct and economical. What has actually been done is to eliminate entirely the so-called binder course, and to introduce into the surface mixture, as formerly laid, sufficient ¼-inch stone chips to have in the completed mixture between 25 and 30 per cent. of this material. The two items should be considered entirely independent of each other, as either change might be made to advantage even without the other.

As regards the stone-filled mixture, it has been in successful use to a limited extent for more than forty years. De Sales Avenue in Washington, D.C., was laid with such a mixture in 1875; and about a million square yards were laid in Pittsburg about 1890. The writer first laid it extensively in Milwaukee during 1910 and 1911, and in Schenectady during 1912 and 1913. Similar mixtures, not always carefully executed, are now being used extensively in all parts of the United States and in some parts of Canada.

Noteworthy instances of this type of asphalt surface of which the writer has personal knowledge are the pavements laid upon Riverside Drive, New York City, and South Centre Street, Schenectady. The Riverside Drive pavement carries very heavy autobus and fast automobile traffic in large numbers; and the South Centre Street pavement carries heavy draying between freight stations and industrial plants on a roadway but 20 feet between curbs. Both of these streets were laid during the season of 1913, and neither has yet given any indication of failure.

The stone-filled sheet asphalt pavement has demonstrated its ability to withstand both heavy slow-moving traffic on iron-tired, horse-drawn vehicles, and heavy fast-moving traffic on rubber-tired, self-propelled vehicles. It is both desirable and economical for use on the heavy-traffic business streets of a city, and its actual cost is so low that it is the most economical pavement for light residential streets and boulevards. It should therefore be adopted by most cities as the standard form of pavement construction, and varied from only where a too steep grade or other special condition makes it imperative to do so.

Roughly speaking, the differences in the proportioning and the costs of the materials entering into the two mixtures, figured for a square yard two inches thick and weighing about 200 pounds, are about as follows:

	Sheet asphalt.		Stone-Filled.	
Material and costs.	Lbs.	Cost.	Lbs.	Cost.
Asphalt cement .... @ $.01 per lb.	25	$.25	20	$.20
Inorganic filler .... @ $.0025 per lb.	30	$.075	20	$.05
Graded sand .... @ $.0005 per lb.	145	$.0725	100	$.05
Clean stone chips ...... @ $.0008 per lb.	none		60	$.048
Total weight	200		200	
Total cost		$.3975		$.348

The costs of materials vary in every locality, and the exact proportions vary with the characteristics of the local supplies. There is always a slight difference in the specific gravity of the two mixtures. These and other interesting variables, however, are not of sufficient importance to be considered here.

It may be assumed that in nearly every case the stone-filled sheet asphalt mixture will cost about five cents per square yard less than the mixture without the stone-filling. While such a saving is well worth consideration, it is not on that account that the writer has advocated the use of the mixture containing the stone chips, but because, even at the same or a slightly higher cost, he considers it a better and more economical pavement surface than the other. It retains the merits of the usual sheet asphalt and combines with them certain other features that are very desirable and well worth considering.

The advantages of the stone-filled sheet asphalt mixture over the mixture without the stone chips, are as follows: (1) It is less slippery; (2) it marks up less in summer; (3) it is easier of traction in summer; (4) it is less liable to displacement; (5) it costs less.

The pavement should be looked upon as a standard sheet asphalt mixture to which has been added a certain percentage of fine stone chips, not in any case exceeding 30 per cent., to act as a reinforcement and thereby produce the physical results noted above. It is not a true asphaltic concrete, nor is it intended or desired to be such.

Eliminating the Binder Course.—The best reason for the elimination of the so-called binder course used as an intermediate course between a sheet asphalt pavement and a concrete foundation is that no legitimate reason has yet been advanced why it should be there; and it costs, laid in place, about 25 cents per square yard. It would seem that before a city laid out such a sum of money on each square yard of its asphalt paving, it would know why it was doing so, and that it would get value for the money. The writer has asked many city engineers the reason they were laying the binder course, and has not yet received a good answer from any of them; he has asked many of the country's best experts, and they have also failed to enlighten him. Several have attempted laborious and far-fetched excuses for its existence, while others, principally the older practical men who grew up in the industry, have "just smiled."

In the first place, let us understand that the so-called binder course is not, properly speaking, a binder course at all, but an intermediate course that will have to explain its being on some other grounds. The paint coat is the only real binder course, and that is not good practice for several reasons, the principal of which is that it is not needed. The so-called binder course does not adhere to the concrete foundation any more than does the wearing surface proper when that is laid upon it direct. Either can be removed with equal ease, there being no bond at all between them and the concrete foundation; and in fact, none is required.

The development of intermediate constructions between sheet asphalt pavements and their concrete foundations has been as follows:

First, we had the so-called cushion coat, which consisted of a layer of the top course put in place and tamped before the final layer was placed. The principal reason for this construction seems to have been to secure proper compression on a greater thickness at that time believed to be required. Other theories were developed for its use; but all have since proven fallacious, and the cushion coat has been abandoned everywhere. It differed from the top mixture only in that less stone dust and proportionately more asphalt cement were used, and, as it was to be buried at the bottom, no one thought it necessary to bother making it very good.

Then we had the paint coat, which was exactly what its name implies,—a coat of naphtha and asphalt paint applied to the concrete foundation before the surface was laid. This coat of asphaltic paint penetrated a short way into the surface with the naphtha and then melted again under the hot asphalt surface and bound to that. It was a real binder course, as any one knows who has had to make repairs on streets where it had been used. Finally, some one seems to have tumbled to the fact that the asphalt surface was quite willing to remain upon the concrete foundation without being bound there, and the paint coat has not been laid to any great extent for a number of years. A useless expense and a good riddance.

Next we had the open binder, which consisted of ¾-inch crushed stone coated with asphalt cement and laid in a course 1 inch thick upon the concrete foundation before the asphalt wearing surface was placed. This was useful in covering up the incompetence of contractors and engineers when they had laid such a poorly lined-up concrete foundation that wearing surface could not be laid upon it until some cheaper mixture had first been used to level it up, so the cities on this continent invested several millions of dollars in this needless material. Then some bystander, who had a presentiment of a large special assessment on the way, happened to ask why the so-called binder course was being bought and paid for with his money.

The question was a poser. It would not do for the engineers and experts to admit that they had been squandering public money on something the reason for which they did not know, so they improved the open binder course by putting a little sand in it and calling it a closed binder course. Now, the open binder course is quite universally condemned as being an actual detriment to asphaltan pavement, and the virtues of the closed binder course are freely extolled, without being very definitely stated.

The so-called closed binder course, when well laid, is a "bitulithic" pavement. When used as a wearing course, it is covered by certain letters patent that have created a new and useful monopoly in the paving field. It appears to be quite customary to lay asphalt wearing surfaces on top of such pavements and then call them closed binder courses, thereby making sure they won't wear out and at the same time avoiding the patents.

Actual Size Photograph of Surface of Stone-filled Sheet Asphalt Pavement, as Laid in Montreal, After Being Rubbed Down on Marble Bed.

Possibly some one can state a sound reason for laying a second-rate pavement surface under a first-rate one; the writer cannot.

The most commonly advanced argument in favor of the use of the so-called binder course is the claim that it prevents the surface from shoving. The writer has seen many instances of shoved or displaced pavements, but he has never seen a properly constructed asphalt pavement shove, nor has he seen an instance where a binder course has kept a poorly-constructed pavement from shoving; and certainly he has seen a number of poorly constructed asphalt pavements shove, both with and without binder courses. But even if a so-called binder course would keep a poorly constructed pavement from shoving, as some of its advocates claim, there seems no reason why a city should pay 25 cents or more per square yard to secure a result that would be equally obtained by an additional expenditure of not to exceed 5 to 10 cents per square yard for additional materials and services to secure a high-grade asphalt pavement without such a binder course.

There is one other reason for not using a binder course. The future maintenance of asphalt pavements will very largely be accomplished by the re-use of the old surface materials, and thereby at greatly reduced costs. When we get to that, the binder course will prove itself an unmitigated nuisance; but that is a subject for another story.

HYDRO-ELECTRIC POWER PLANT OF THE CEDARS RAPIDS MANUFACTURING AND POWER COMPANY.*

By Henry Holgate, M.Can.Soc.C.E.

BEFORE going into the details of this work, it will be well to study some of the larger physical elements which govern conditions on the St. Lawrence River, and to consider what may be called the legal and political conditions governing the use of the river for purposes other than navigation, as well as the factors that control the acquisition of property necessary for the development of power.

The data published in the report of the International Waterways Commission for 1910 shows clearly the prominent characteristics of the area drained by the St. Lawrence River.

An extract from this report is as follows:—

"The Great Lakes constitute a series of enormous natural reservoirs, each of which serves to regulate the flow in the river constituting its outlet, and to maintain the lake below. They are interdependent. The study of one, to be complete, must include the study of all. The total area drained by them is about 287,688 square miles. Of this total, about one-third is occupied by the lakes themselves; that is, is devoted to reservoir purposes. The result is a uniformity of level and a uniformity of flow which is truly wonderful. In Table A are given the areas of the lake surfaces and of the drainage basins.

Table A.

Lake.	Area of lake surface in sq. miles	Drainage area including lake surface in sq. miles.	Ratio of lake to drainage area.
Superior ...	32,060	76,134	1; 2.37
Michigan ...	22,336	65,799	1; 2.95
Huron	22,978	72,008	1; 3.13
St. Clair	503	6,194	1; 12.31
Erie	9,968	34,573	1; 3.47
Ontario	7,243	32,980	1; 4.55
	95,088	287,688	1; 3.02

Authority: 1906 U.S. Lake Survey Report.

The areas of the small lakes and streams are taken as a part of the land area.

In Table B are given the average and the extreme variations in the levels during the period from 1860 to 1907.

"No work of man ever has approached or ever will approach this perfection of regulation."

Comment on the above is unnecessary, but we must be impressed by the fact that the flow of this great river is regulated by nature within such narrow limits, as to justify the claim that "no work of man has ever approached or ever will approach this perfection of regulation." Nature having provided us with this great river, already perfectly regulated, with vast storage reservoirs, it is incumbent on us to make the most efficient use of it.

Primarily the river must serve both present and future demands regarding navigation. Thus the probability of the deep navigation channel being in the river itself, and not wholly in a system of lateral canals, must be kept in mind, and no works must be permitted which would prejudice future development of navigation on a deep-water scale as set by the dimensions of the new Welland Canal now being constructed.

The St. Lawrence River, after passing Cornwall, expands into Lake St. Francis, and this lake discharges at Coteau through the Coteau Rapids, where there is a fall of about 17 ft. Then follow the Cedars Rapids with a fall of about 32 ft., and the river enters Lake St. Louis through the Cascade and Split Rock Rapids, having a further fall of about 17 ft. The difference of elevation between Lake St. Francis and Lake St. Louis is about 81.5 ft. The distance from the outlet of Lake St. Francis to the entrance of Lake St. Louis is 11 miles. The whole of this stretch of river is in Canada, but a small part of the shore of Lake St. Francis, below the 45th parallel of latitude, is in the State of New York.

The rapids are navigable down stream for seven months of the year for boats of 5 ft. 6 ins. draft. The Soulanges Canal on the north side of the river affords navigation from Lake St. Francis to Lake St. Louis for vessels of 14 ft. draft, and is a portion of the 14-ft. channel from Lake Ontario to Montreal. The Cedars Rapids are about 30 miles west of Montreal.

Table B.

	Superior Ft.	Huron Ft.	Erie Ft.	Ontario Ft.
Extreme range, 1860-1907	3.32	4.64	3.89	5.54
Maximum range in 1 year	(1869) 2.67	(1876) 1.94	(1892) 2.28	(1867) 3.65
Minimum range in 1 year	(1891) 0.49	(1879) 0.59	(1895) 0.87	(1907) 0.79
Average annual range	1.18	1.21	1.56	1.93

In Table C are given the average and the extreme variations in the discharge of the outlets for the period 1860 to 1907:—

Table C.

	St. Mary's River. c. f. s.	Detroit River. c. f. s.	Niagara River. c. f. s.	St. Lawrence River at its head. c. f. s.
Average discharge for entire period	82,000	204,200	212,200	254,500
Greatest excess average for any one month.	46,700	71,200	45,600	96,800
	Sept., 1869, 57%	July, 1883, 35%	June, 1876, 21%	May, 1862, 38%
Greatest excess average for any one year ...	19,100	30,200	26,500	49,000
	1876, 23%	1885, 15%	1876, 12%	1862, 19%
Greatest deficiency average for any one month	33,800	98,900	43,500	102,200
	Feb., 1893, 51%	Feb., 1874, 48%	Mar., 1896, 20%	Feb., 1902, 40%
Greatest deficiency average for any one year	16,900	30,600	31,800	62,800
	1879, 21%	1896, 15%	1895, 15%	1895, 25%

*Abstract of paper read before the Canadian Society of Civil Engineers, Montreal, November 4th, 1915.

The St. Lawrence being a boundary river, and its relation to Canada and the United States having been defined in various treaties between Great Britain and the United States, all questions in regard to it are international questions, and are now referred to the Joint High Commission under the treaty of 1910.

In my communication to the Society dated March 16th, 1911, the international features which control the St. Lawrence River were described, and though the Cedars Rapids development is on a part of the river entirely within Canada, yet on account of the river being an international highway from the Great Lakes to the sea, it was necessary to submit the company's proposals to the International Waterways Commission, so as to ensure that nothing detrimental to either country was contemplated. This Commission, which was the predecessor of the present Joint High Commission, examined the project and reported favorably on it. Such action was necessary before the government of Canada would consider the granting of any privileges.

The Cedars Rapids Manufacturing and Power Company was incorporated by Act of Parliament of Canada in 1904, the Act being amended in 1909, and has power to expropriate land under the terms of the Railway Act. The incorporators proceeded to acquire the necessary land on the north side of the river, along a frontage of 1½ miles, from Point du Moulin at the foot of the rapids, to Cedars Point at the head. Two islands in the river. Isle Bedard and Isle aux Vaches, were also acquired.

An agreement was made with the government of Canada in 1909, after the International Waterways Commission reported favorably on the project, whereby the company was permitted to divert 56,000 c.f.s. for its power development, this being the amount allowed by the Commission so as not to interfere with navigation.

Under the existing interpretation of the law, the St. Lawrence being a navigable river, the bed belongs to the Crown, and no riparian owner can construct works in the river bed without consent of the Crown. The Crown is represented by the province in which the river lies. The province also assumes the ownership of the water flowing over the river bed, but will not grant rights in a navigable river until the Federal Government approves on the ground of non-interference with navigation.

The company therefore applied for and obtained a lease for 99 years of the bed of the river from the province of Quebec, at an annual rental, and agreed to pay also for the use of the water at fixed rates per horse-power output of the power house, these rates increasing as the output increases, so as not to burden the initial development with too heavy a fixed charge. The agreement with the government of Canada did not give authority to place structures in the river, except in the sense that the placing of such structures and the diversion of the quantity of water, as approved by the Commission, would not obstruct navigation.

The above measures placed the company in good legal standing, and the acquisition of lands was completed with the exception of three properties belonging to one estate: (1) certain "reserves" on Point du Moulin covering water power and mill site, roadways, etc., the land itself, however, having been deeded to the company subject to such reservations; (2) Isle Bedard, having an area of 3½ acres; (3) Isle aux Vaches, having an area of 28 acres.

The company proceeded under the Railway Act to expropriate these properties and offered for the "reserves" on Point du Moulin $1,700; for the Isle Bedard, $200; and for Isle aux Vaches, $2,800, these figures being based on the value of similar land for agricultural purposes. Two of the arbitrators signed an award agreeing that the company's offer was ample, while a third fyled a minority award stating that he would have been prepared to award $80,000 for the "reserves," $34,000 for Isle Bedard and $62,000 for Isle aux Vaches, the basis of the valuation differing completely from that of the company.

The matter in dispute has been the subject of litigation in the Superior Court, and before the Privy Council, and is still unsettled. Many different views have been put forward in regard to the proper basis of valuation for such properties when they form an integral part of an engineering project, and these, together with the final judgments, will prove of great interest to the profession.

The various legal steps necessary to complete the title and rights were taken in good time, so that there were no legal obstacles to hinder progress when financial arrangements had been made, and the time for construction had arrived.

The country adjacent to Cedars Rapids is typical of the St. Lawrence Valley. The subsoil consists of stiff clay, containing large and small boulders, overlying limestone formation. The river bed is formed generally of boulders resting on hardpan, with outcroppings of rock in the rapids. The land is level and well settled, and being close to a large city and accessible by rail and water, the difficulties generally met with in developing water power in remote localities do not arise.

Railway communication to the vicinity of the site is rapid and frequent, highways are numerous and fairly good, and the Soulanges and Lachine Canals give communication with Montreal by boats of 14 ft. draft during the navigation season. Westwards, the Soulanges and other canals communicate with the Great Lakes. The canals are operated by the Dominion Government, and are free of tolls.

At Cedars Rapids the greatest recorded variation between high and low-water levels in one season is four feet, the usual variation being two feet. Between the highest and lowest recorded levels there is a difference of seven feet.

The Cedars Rapids are situated about midway between the Coteau Rapids above, and the Cascade Rapids below. The former will break up heavy ice coming down stream from Lake St. Francis, so that the works will not suffer from the action of ice, and the latter provide an ample, easy and natural deep outlet for the tail water, so that no ice blockade will occur below the power house. The rise and fall are the same in head water and tail water, so that the total head is constant.

The average flow of the river is about 260,000 c.f.s., of which about 80,000 c.f.s. flowed naturally between Isle aux Vaches and Cedars Point. Of this, 56,000 c.f.s. will be used for power development purposes, the balance of 24,000 c.f.s. being diverted so as to flow south of Isle aux Vaches in the main channel of the river.

The low discharge from Lake Ontario during navigation season was in November, 1895, and was about 185,000 c.f.s. This would be augmented by water reaching the river below Lake Ontario, so that 190,000 c.f.s. may be taken as low-water flow in the river during navigation period. Of this, 8,000 c.f.s. flows in the south channel, 102,000 in the navigation channel between Grande Isle and Isle aux Vaches, and 80,000 c.f.s. between Isle aux Vaches and the north shore. The diversion of 24,000 c.f.s. of the latter amount into the navigation channel, 56,000 c.f.s. being taken for power purposes, will make the flow in the navigation channel 126,000 c.f.s. under maximum operating conditions. The experience of pilots shows that navigating conditions have been improved by the company's works.

The period of minimum flow corresponds with the low-water stage adopted which is equivalent to 9.5 ft. on the sill of former Lock 14 (now demolished) of the Beauharnois Canal at Valleyfield, but this condition only existed once for a few days in November, when all passenger traffic had ceased. Navigation ceased entirely on the 25th of the month.

The power available at Cedars Rapids under the above conditions is the equivalent of a flow of 56,000 c.f.s. under a head of 32 ft., *viz.*, 150,000 h.p. at the outgoing terminals of the power house. It should be noted that minimum conditions of river flow have been considered on account of navigation requirements, but that such minimum conditions only occur at long intervals, and then not during the navigation season, which is from about May 1st to November 1st in these rapids. The full amount of power will be available throughout the year, a condition unique in hydro-electric development.

One of the most important questions in water power development in Canada is the interference arising from ice in some form or other, and steps are necessary to prevent stoppages of the power plant.

If a river were entirely covered with ice, there would be no bad effects from anchor ice or from frazil. This condition cannot occur for the whole of the river above the Cedars Rapids, but it will occur in the section which would be apt to cause most trouble.

The construction of a dam or dyke between Isle aux Vaches and Point des Cedres, a distance of about 1,000 ft., creates a large pond or bay in which the velocity of the water is low, and this will freeze over in the early part of winter to a point well up to the shore. Surface ice will also form readily in the head race. These conditions will prevent the formation of anchor ice or frazil in the vicinity of the entrance to the canal, and the only frazil to be feared is that flowing down the river from open water above the rapids. This will be carried in the upper four or five feet of water, and before reaching Isle aux Vaches will be moving generally in the direction of the main channel, so that it will not tend to enter the upper bay. Though the velocity in the main channel between Isle aux Vaches and Iberville Islands, which has been increased somewhat by the diversion of water not used in the development, is considered sufficient to carry ice in that direction, some piers have been built between Isle aux Vaches and the north shore to ensure more positive results. No ice troubles were experienced during the mild winter of 1914-15, but to guard against future possibilities a deflecting structure is being built out from the north shore towards Isle aux Vaches to direct the course of ice coming from Coteau Rapids towards the main channel. Should any ice enter the upper bay it will tend to lodge in the northeast corner and can be flushed out through sluice gates provided in the main dyke. The water will be drawn into the head race nearly at right angles to the direction of flow, so that only small quantities of ice could possibly be carried down, and that chiefly late in the season, when it is in a condition least likely to cause trouble. A second set of sluice gates has been provided on the dyke at the lower end of the head race to allow further flushing of ice from the head race if necessary.

The solid ice from Lake St. Francis, much of which will come down in the spring, will be broken up in the Coteau Rapids and the various islands in mid-stream will act as breakwaters protecting the works against damage from ice.

I have every reason to believe that adequate protection has been provided against ice troubles.

The canal or head race has been excavated through Cedars Point, the Pointe du Moulin and a part of the river bed between these points. At the head of the rapids it has been excavated to the required depth throughout, whereas at the lower end at Pointe du Moulin it has been brought approximately to the level of the river bottom, giving a depth of about 35 ft. The cross-section is everywhere ample for the flow required at moderate speed.

The earth, boulders and rock excavated were used in the construction of the dyke, and sufficient material, clay mixed with boulders, was found in the cut to make a reliable, economical dam of very generous dimensions. The slopes are protected by rip-rap and no fear of erosion or damage by ice need be entertained. On the north side it was necessary to build a bank for some distance to form the head race, and to provide drainage for the land.

The power house is built across the lower end of the head race, and has its foundations on rock. The substructure is monolithic concrete, the building itself being a steel frame combined with concrete slabs built by the Unit Construction Company, as described already in a paper read before this Society by Mr. Conzelman on October 22, 1914.

The buildings and equipment have been designed so as to enable additions to be made as the business expands. Nine units, each of 10,500 h.p., have been installed, and a tenth is being completed. The turbines are single runners, set vertically, and are the largest units that have yet been used.

There were no special contingencies in connection with the construction, and continuity of work resulted.

The principal items of uncertainty in the cost of an hydraulic work are due to the nature of the foundations and the difficulty of unwatering. Over the whole site lies good limestone rock, overlaid with clay and boulders, and the materials were suited to the most exacting requirements. The unwatering, while on a large scale, was a simple operation. The natural material was left in place at the head of the canal to form a cofferdam, and a crib was built downstream on the outer line of the dyke to protect it during the early stages of construction.

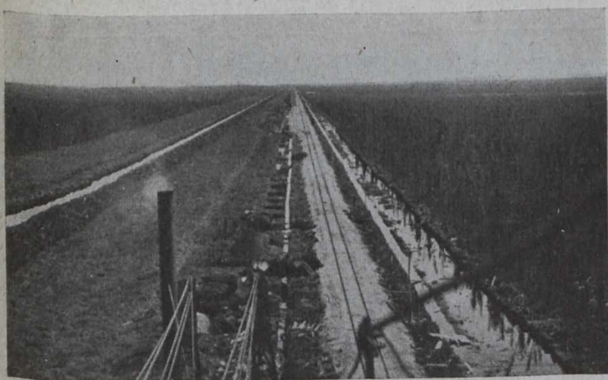
ENGINEERS' CLUB OF TORONTO.

Following are the officers of the Engineers' Club of Toronto for the year 1917:—

President, E. L. Cousins, chief engineer of the Toronto Harbor Commission; first vice-president, L. V. Rorke, of the Ontario Government Survey Department; second vice-president, C. W. Power, of the Canadian Stewart Co.; third vice-president, J. R. W. Ambrose, chief engineer of the Toronto Terminal Railways Co.; secretary-treasurer, R. B. Wolsey; directors, H. G. Acres, W. A. Bucke, Alfred Burton, J. B. Carswell, A. G. Cumming, Arthur Hewitt, T. S. Young, Chas. H. Heys, Tracey D. LeMay, T. S. Stevens and M. P. White.

WINNIPEG AQUEDUCT EXCAVATION.

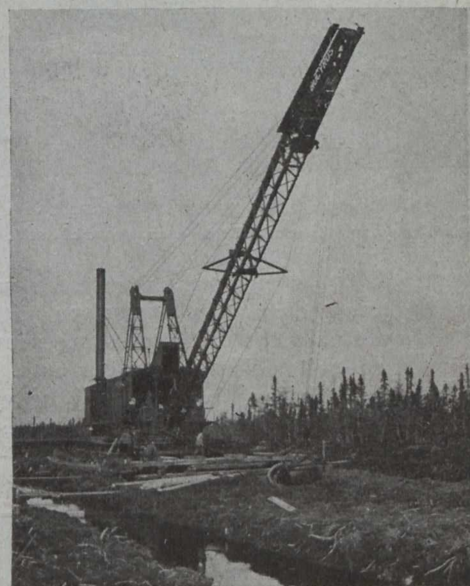
IN the January issue of The Excavating Engineer, a monthly paper published by interests associated with The Bucyrus Co., of South Milwaukee, Wis., appears an article by William Smaill, general superintendent of the Winnipeg Aqueduct Construction Co., Limited, showing the progress of excavation work on the Winnipeg Aqueduct. This article includes considerable general information of interest regarding the difficulties encountered and methods adopted in overcoming them. Through the courtesy of Bradlee van Brunt, editor of The Excavating Engineer, is printed the following abstract of the article and its illustrations:—



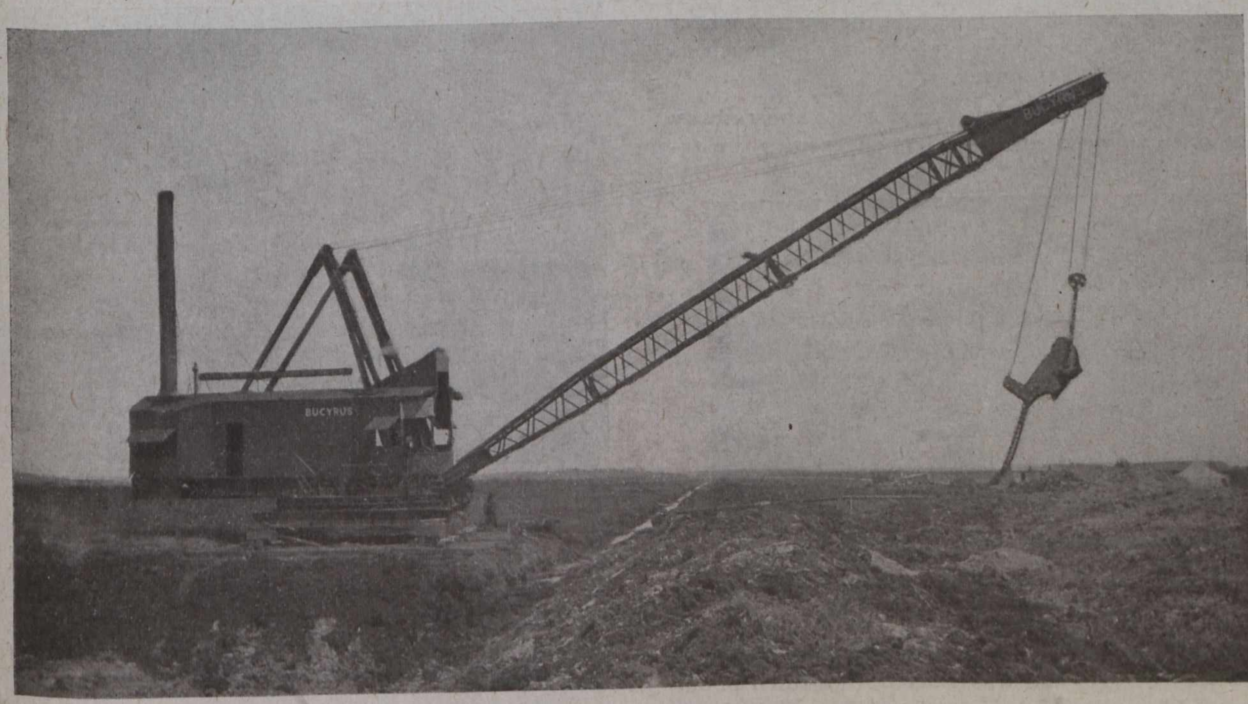
View of the Cleared Right-of-Way.
District railway track and pilot ditch at one side.

The Bucyrus draglines that are at work on the eastern end of the aqueduct, between Camps 1 and 5 of the aqueduct ditch proper, encounter nearly all kinds of soil. At Camp 4 there is about a three-mile stretch of hard pan. Last year this was loosened up with dynamite ahead of the dragline, but this year, after some experimenting, by giving the teeth a sharp narrow chisel point and considerable more rake than usual, the contractors have excavated through the hardpan without explosives. The bucket teeth in this hardpan require dressing every three or four days.

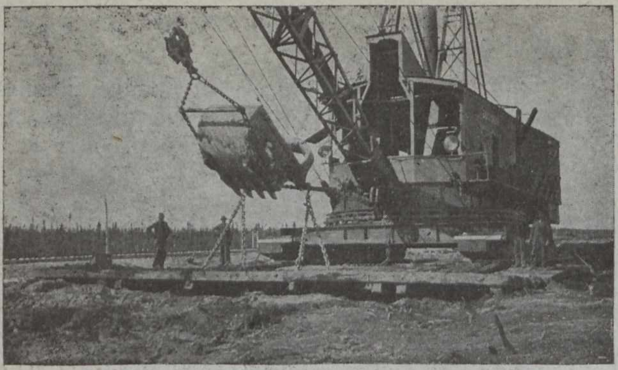
Handling Muskeg at Camp 6.—In Camp 6 the class-14 machine is in operation. This larger machine was purchased for places where the cuts ran from 12 to 17 feet in depth, in order that the necessary amount of daily lineal feet of progress could be maintained. This season the 60-foot boom was lengthened 10 feet in order to get a little longer reach. This machine had to go through a stretch of muskeg averaging about 15 feet deep. The excavation was handled by digging to such a depth that the sides would just hold up. This would probably average 5 to 7 feet. The dragline would excavate a stretch at this depth, then return and excavate the trench



Dragline Ready to Excavate.
Drainage ditch in foreground. Pilot ditch is on other side of the dragline. Between these two ditches is the core that is dug to the final excavation line.



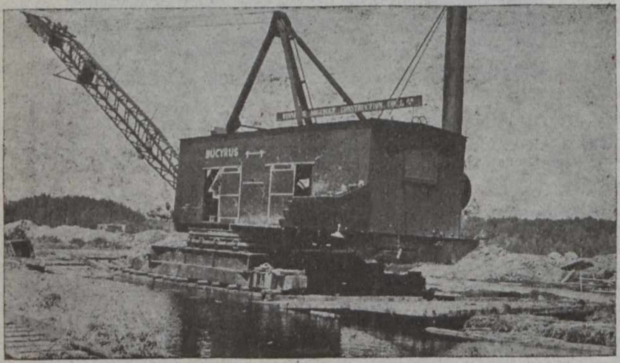
Excavation in Progress at Mile 90.
This view shows the depth of muskeg overlaying the sandy clay; also shows pilot ditch.



Dragline Moving into Position.
Placing pads, weighing over 7 tons each, ahead of itself.

a little deeper. Between cuts the sides of the cut would get a chance to drain and compact themselves a little more each time, and eventually the ditch could be excavated to grade. In most cases it took three to four cuts. In one stretch, owing to slides, mostly caused by heavy rains, the machine had to go over the ground eight times.

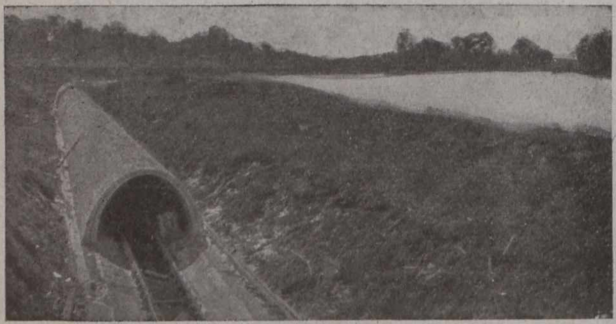
At Camp 7 two new class-7's, and one class-24 have



Crossing Falcon River on Cribbing.
The cribbing was made from wind logs that originally stuck about two feet out of the river. The machine is a class-20 Bucyrus.

been erected. The class-24 has a 10-foot boom and a 3½-yard bucket and is intended for work in the big cut where the top width of the trench will probably run as much as 90 feet, with a depth of 26 feet.

All three machines were erected close to the railway track at mile 89. The class-24 was moved across the 15-



Completed Aqueduct Before Backfilling.
View along the shore of Indian Bay. The intake is just over the rock ridge in the middle centre. The dike is holding out about 3½ feet of water that would otherwise float the surface.

foot pilot ditch which was dug with a small gasoline dredge the year before, and was started on a ditch about 70 feet top width, and 20 feet bottom width, with a depth varying from 16 to 20 feet.

The machine started on May 9th and has been working east. It was originally intended to place all the muskeg on the north and clay on the south side of the cut. On starting the excavation it was found that the heavy sandy clay would have to be deposited as far as possible from the sides of the trench, as material in the bottom of the cut was a rather soft clay, and any extra weight deposited near the edge of the cut would cause the bank to settle down and clay to raise up in the cut.

Backfilling.—First Operation.
Depositing sandy clay alongside the aqueduct.

For this reason all heavy material was placed away from the sides of the cut to the limit of boom reach. A small amount of light muskeg was placed on the edge of the cut at the south side, to make grade for concrete track and balance of muskeg was placed on north side. This method got rid of all slides with the exception of those caused by heavy rains. In one storm, six inches of rain fell during the night.

A couple of these slides were bad enough to make it necessary to move the dragline back in order to be able

General View of Machine Backfilling.
Sandy clay is placed alongside arch, filling in nearly to crown. Then a few feet of muskeg is placed, the whole being topped with sandy clay.

to dig them out. The class-7's were used to dig a continuous drainage ditch north of the dump on the north side of the cut, through the muskeg country, for the future protection of the work.

Work at Camp 8.—The class-20 was erected at Camp 8, on the shore of Indian Bay near the intake. This machine has an 85-foot boom and 2½-yard bucket and is to work west towards the class-24, and on excavation where the cut does not exceed eighteen feet, and top width of trench, sixty-five feet. The first work it did was to cross a swampy arm of Indian Bay near the intake. The best bottom occurs near the edge of the water following the shore line. The machine started excavating April 20th. A shell of frost in the swamp materially aided in holding up the machine.

As excavation proceeded, the clay that came from the bottom of the cut was placed on the lake side of the cut to aid in preventing water from coming into the trench. Owing to heavy rains, the lake later rose to a height that would have brought three to four feet of water over the part where the trench was excavated, but by protecting this dyke with brush, etc., water was kept out and concreting was successfully placed.

On the west of the Falcon River the aqueduct follows along the shores of Snake Lake, a body of water lying in a muskeg bog, about three miles long, the muskeg being from five to fifteen feet deep. The extraordinary high water this summer raised this lake so that there was three to four feet of water over the line of the aqueduct, with most of the bog floating in the water.

Backfilling.—Second Operation.
Depositing muskeg on top of the sandy clay.

To get through this, a small gasoline dredge was mounted on a scow, making a cut on the lake side of the aqueduct line, and depositing the spoil, making a dyke around an area, taking in about a quarter mile of aqueduct line at a time. This was pumped out, by means of centrifugal pumps, low enough to get the class-20 on the surface of the muskeg.

This machine deposited enough heavy spoil from the bottom of the trench on top of that placed by the dredge, to compress the muskeg sufficiently so that the trench could be pumped out and the aqueduct placed therein. About two miles of trench remain to be excavated on this stretch.

Machine-placed Backfill.—These draglines are now backfilling the concrete that was placed in the summer. The backfilling placed by machines had to be placed carefully so as not to cause any shock to the concrete structure, but the material spilling out of the bucket in a continuous stream, even from a small height, makes a much more homogeneous and compact mass than can be secured by any means of hand tamping.

At Camp 7 the scheme of placing spoil and replacing backfill, worked out exceptionally well. The difference between the machine and hand work was well illustrated here. The specifications for backfilling call for the first four feet to be hand-placed and hand-tamped, the balance of the work not requiring tamping. A section two hundred feet long, which was hand-placed, was carefully inspected and observed. Later on, a section adjoining this was placed by machine, and after it had been allowed to settle for some weeks, the difference between the hand-placed and the machine-placed was very noticeable. The hand-placed backfill had settled badly, with a continuous deep crack over the centre of the arch, and other cracks on the sides, while the machine-placed backfill had settled very little and with practically no cracks.

Backfilling at Indianhead Bay.
View between Falcon River and the intake. The material deposited directly over the arch is muskeg.

The class-24 places the clay along the sides of the arch up to the crown, then takes the muskeg material (which makes a fine insulation medium) from the place where the concrete track was located, placing it over the crown of the arch to a depth of two feet or more, and then covering the whole with the remainder of the sandy clay from the cut.

Backfilling.—Third Operation.
Placing sandy clay on top of the muskeg.

The electric furnaces already placed in the United States represent the utilization of 125,000 to 135,000 electrical horse-power. This means an output of about a million tons of ingots or castings per annum. The Heroult system represents some 70 per cent. of the total tonnage.

Railroads were introduced in Switzerland in 1844 with the construction of the Basle-St. Ludwig line. The Zurich-Baden line followed in 1847. By 1860 there were 1,000 kilometres (621 miles) of normal-gauge lines in use, and in 1912 their length reached 3,500 kilometres (2,175 miles).

WATER POWERS OF THE PRAIRIE PROVINCES

THE Dominion Government controls the water resources of the Prairie Provinces and, during the past three or four years, has been particularly active in investigating them. The Water Power Branch of the Department of the Interior administers the water powers which come under the jurisdiction of the Dominion Government. In the territory under its jurisdiction it has sent out field parties to investigate many of the water powers and to establish numerous gauging stations, where regular observations are taken. This branch has been in active operation since 1908, and, during the past three years, has covered most of the rivers in the southern portion of these provinces. Particular attention was paid to the Winnipeg River, in eastern Manitoba, and to the Bow River and adjacent basins on the Rocky Mountain slope.

The Irrigation Branch of the Department of the Interior has also been actively investigating the water resources in certain portions of these provinces. Field investigations and irrigation surveys of various characters had been carried on since 1894, but systematized investigation really began with the organization of the Irrigation Branch in 1908. The progress reports published annually contain general information respecting streams investigated, together with results of stream measurements, which have become a distinct feature of the work.

The southern or more settled portion of the Prairie Provinces is fairly well covered by the work of these two branches of the Department of the Interior. As the northern portion had not been investigated by any other organization, the Commission of Conservation undertook exploratory surveys of the principal rivers in this region. The rivers were traversed, generally, by canoe, the descent of the falls or rapids being levelled, flow measurements taken, and other details connected with the feasibility of development noted.

For the rivers further north, information was obtained from the reports of explorations made by the Geological Survey, the data being compiled from reports and maps of this branch and from the explorers' notes. In this region, generally speaking, the information available respecting the different rapids and falls is confined to a statement of the vertical descent, but, in many cases, the geological formation and distances from head to foot of the rapids are also given.

The southern portion of the Prairie Provinces may be divided into three sections, having widely different water-power characteristics:

1. The portion in the vicinity of Lake Winnipeg, in the east.
2. The more level portion in the centre.
3. The mountain and foothill country in the west.

In the first, or eastern portion, the Winnipeg River is the main feature. This river, with its drainage area of 53,500 square miles, has a well-regulated flow and affords numerous water powers of immense value. Two of the sites have already been developed and supply the city of Winnipeg with its electrical energy, while construction work on some of the other sites has either been commenced or is on the eve of starting. Numerous smaller streams in this eastern portion also afford splendid opportunities for water power development, some of them being actually utilized on the Minnedosa and Shell Rivers. This section also includes the Grand Rapids of the Saskatchewan River, where a head of 80 feet is available, affording an exceptionally good power site.

The second, or middle portion, is traversed by two main arteries, the North Saskatchewan and South Saskatchewan Rivers. These, with their main tributaries, flow with an even, moderate current with no concentrated descents of importance. Although, strictly speaking, this portion is not entirely without water powers, yet the possibilities of such are rather unfavorable. In almost every case the total head would have to be created and several proposed developments have already been abandoned on account of the high cost of development.

The third portion, of which the Bow River is typical, has many valuable water powers. There are none of unusual size, those on the Bow River itself probably being the most important. The slopes of the streams, characteristic of a mountainous region, are generally very steep, and, while the flow of water is subject to fairly large variation, good opportunities for storage and artificial regulation are afforded.

Among the special measures taken by the Dominion Government in connection with the administration of the water powers in the southern portion of the Prairie Provinces, may be mentioned the setting aside of the eastern slope of the Rocky Mountains as a forest reserve, known as the Rocky Mountains Forest Reserve. This step was taken on the recommendation of the Commission of Conservation, and, as a result, an area of 17,900 square miles has been assured protection from such denudation as has already taken place in some of the older provinces. All the upper tributaries of the North Saskatchewan and South Saskatchewan Rivers have their sources within this area, and the beneficial effect of conserving its forest cover is evident as far east as the Grand Rapid on the main Saskatchewan River. With a similar object in view, the Commission has recently recommended that steps be taken to segregate, as a forest reserve, the upper portion of the drainage area of the Winnipeg River. This recommendation will doubtless be acted upon shortly, and will prevent the useless dissipation of the present facilities which this district offers for storage and conservation of run-off. This step is of particular significance, as the Winnipeg River affords the only water powers of importance susceptible, under present conditions, of being economically developed and transmitted to the city of Winnipeg and the surrounding district, an area that will undoubtedly become thickly populated within a very few years.

Among other measures may be mentioned, also, the policy adopted by the Dominion Government, of reserving, on the recommendation of the superintendent of the Water Power Branch, all vacant Dominion lands which may be valuable for the development of water power. The land is thus held from the hands of speculators and kept for promoters of *bona fide* power development. Reservations of this character have already been made on the Winnipeg, Saskatchewan, Bow, Elbow, Athabaska, Peace and other rivers.

*Abstract from introduction to "Water Powers of Manitoba, Saskatchewan and Alberta," published by the Commission of Conservation.

Sir Adam Beck, in giving information relating to the Ontario Hydro-Electric System for the year ending October 31, 1916, says that the total average horsepower used in the system was 109,583, at an average cost of $9.10 per horsepower. The total receipts were $2,038,792. As regards the Severn system, the total expenses, including generating, amounted to $54,438, and the revenue to $94,694.

CANADA'S RAILWAY PROBLEM AND ITS SOLUTION.

By William Francis Tye, C.E.,
Formerly Chief Engineer, Canadian Pacific Railway Co.

(Concluded from last week's issue.)

Cost of Operation on the Intercolonial.—The Intercolonial is the most extensive public-owned system on the continent. As shown in the beginning of this paper, in the year 1913 (which was a very favorable one for the Intercolonial) it cost the owners of this road—the people of Canada—including interest on the cost, $25,832,136, to earn $12,349,296, while it cost the owners of the Canadian Pacific (the shareholders) $90,562,161 to earn $129,481,885, or, in other words, on the Intercolonial it cost $209 to do $100 worth of business, while on the Canadian Pacific it cost $70 to do $100 worth of business.

Freight Rates.—It is usually supposed that the low rates charged are responsible for this condition.

Let us see just how these rates do compare:—

The latest tariffs—both passenger and freight—show that on all business, not purely local, the rates are exactly the same. This is, of necessity, true, as such rates are fixed by competition, and not by the needs of a political party. The private-owned competing road, which is much shorter, or the water-carriers, set the through rates and the Intercolonial must follow.

The through rates per mile are undoubtedly much lower on the Intercolonial, but this is because it is so much longer, the distance from Montreal to St. John being 740 miles by the Intercolonial, and 480 miles by the Canadian Pacific Railway, and from Montreal to Moncton by the Intercolonial 651 miles and by the Canadian Pacific 572 miles.

In purely local and non-competitive business the freight tariffs show the class rates, as follows: As nearly as possible similar conditions and distances were selected so as to make a fair comparison.

MAIN LINE

Canadian Pacific—	Miles.	Basic Rate per 100 lbs.	Intercolonial—	Miles.	Basic Rate per 100 lbs.
St. John to:			St. John to:		
Grand Bay	9.9	10c.	Rothesay	8.5	10c.
Westfield	13.9	12c.	Quispamsis	12.0	12c.
Welsford	23.8	16c.	Hampton	22.0	16c.
Enniskillen	34.3	20c.	Apohaqui	39.3	20c.
Macadam	84.3	32c.	Moncton	89.3	30c.

	Miles.	Basic Rate per 100 lbs.		Miles.	Basic Rate per 100 lbs.
St. John to:			Moncton to:		
Megantic	329.0	54c.	St. Fabian	328.2	48c.
Sherbrooke	373.0	54c.	Tobin	349.9	48c.
Magog	393.4	58c.	Riviere Ouelle	408.6	54c.
Adirondack Jct.	472.7	58c.	Chaudiere	497.0	54c.
Foster	412.2	58c.	St. Nicholas	501.0	58c.
			St. Lambert	644.4	58c.
			Levis	488.4	54c.
			Drummondville	586.4	58c.

BRANCH LINE RATES

	Miles.	Basic Rate per 100 lbs.		Miles.	Basic Rate per 100 lbs.
McAdam to:			Truro to:		
Cottrell	6.6	10c.	Union	8.4	10c.
Benton	33.1	20c.	Hopwell	34.6	20c.
Newburg	55.3	26c.	Merigonish	56.1	24c.
Florenceville	74.9	30c.	James River	74.9	28c.
Aroostook	105.7	36c.	Lenwood	108.6	32c.
Grand Falls	124.8	36c.	Mulgrave	122.3	34c.
Edmundston	168.8	42c.	McKinnon	162.3	36c.

It will be seen that for distances up to about 35 miles, the rates are identical; for distances of 35 to 75 miles, C.P.R. rates are about 7½% higher than on the Intercolonial; from 100 to 125 miles they are about 12% higher; on distances of 165 miles 17% higher; on distances of 320 to 350 miles 12½% higher; on distances of 400 to 475 miles 7½% higher, or an average of about 10%.

The rates from St. John or Moncton to points in the same longitude, such as Levis on the Intercolonial, and Megantic on the Canadian Pacific; or to Drummondville on the Intercolonial, and Foster on the Canadian Pacific, are the same, though they are much less per mile on the Intercolonial, showing the very bad effect of the long uneconomical location of the Intercolonial as compared with the Canadian Pacific Railway.

In the commodity tariffs, the rates per mile quoted are exactly the same.

In the case of bituminous coal, of which the Intercolonial handles a large tonnage, the through rates are fixed by the water-borne traffic. In strictly local business, the Intercolonial rates from such points as Sydney are practically the same as Canadian Pacific rates on American coal from such points as Adirondack Junction up to a distance of about 100 miles. Beyond that distance the Canadian Pacific rates are higher in about the same proportion as in the class rates.

On cement, all of which originates on roads other than the Intercolonial, the rates from Montreal to all New Brunswick points are the same, on local business out of Montreal the Canadian Pacific rates per mile are the lower.

It thus appears that on all through or competitive business, on all business originating on or destined for other lines, the rates are fixed by agreement, and are the same. On all purely local business not affected by other competition, the Canadian Pacific rates per mile are apparently on an average about 10% higher, some portion of this being due to the uneconomical location of the Intercolonial.

Canadian Government Railway Statistics do not divide traffic between competitive and non-competitive, but they do show that in 1913, 36% of the traffic originated on other roads. When we add to this the amount destined to other roads, and that between competitive points, it seems a fair statement to make that at least 50% was competitive business, and, therefore, at the same rates as private companies gave.

In 1913 the freight earnings were	$8,206,110
The total saving to the shippers would be 10% of half of this	410,305

The passenger tariffs show much the same conditions as the freight tariffs. Competitive business is at the same rates regardless of distance. Local rates per mile for short distances are practically the same, but gradually drop on the long round-about route via the north of New Brunswick, and as they approach the competitive points where the total rates must inevitably be the same.

As in the case of the freight tariffs, in strictly non-competitive local business, the Canadian Pacific passenger rates per mile appear to be on an average about 10% higher than those of the Intercolonial.

There is no way in which the amount of business effected can be ascertained, but it is believed it cannot be more than 50% of the total gross passenger earnings.

In 1913 the total gross passenger earnings amounted to	$4,037,531
The total saving to the travelling public would be 10% of half of this	201,687
Or a total saving for passengers and freight of	611,993
In 1915 the total saving would be	512,513

The results for 1913 and 1915 are thus:

1913.	
Gross earnings	$12,349,296.00
Actual cost, including interest	25,832,136.00
Saving by lower rate	611,993.00
Net cost	25,220,143.00
Cost for each $100 earned	204.20

1915.	
Gross earnings	$11,259,710.00
Actual cost, including interest	25,653,907.00
Saving by lower rate	512,513.00
Net cost	25,141,394.00
Cost per each $100 earned	220.60

The justification put forward for this remarkable state of affairs, is that the Intercolonial was built for political purposes to bring the Maritime Provinces into Confederation, and any attempt to make the road pay would be looked upon as breaking faith with the people of the Maritime Provinces, who look upon the Intercolonial as an offset to the canals in the Upper Provinces, which are operated without any tolls. It must not be forgotten that the Canadian Pacific, too, was built for a political purpose, to bring British Columbia into Confederation, and it has been as great a financial success under private management as the Intercolonial has been a failure under government management.

Whether the reasons advanced for the failure of the Intercolonial be sufficient or not, they certainly do not apply to the western roads, and there are no similar questions to complicate the problem of how best to dispose of the Transcontinental lines.

We have thus seen that both government construction and management have been extremely extravagant and wasteful. While Canada has been rich enough to stand such wasteful and extravagant methods, when applied to a small road like the Intercolonial, it could not possibly stand them when applied to the huge transcontinental systems.

Proposed Consolidation.—The remedy which the writer proposes for this state of affairs, and the only one which he believes has any hope of success, is to combine the Grand Trunk, Grand Trunk Pacific and National Transcontinental and Canadian Northern under one company.

Canada Should Follow Example Set by Sir John Macdonald.—Canada now stands at the parting of the ways, just as she did in 1879. The grave question then at issue was whether the Canadian Pacific should be constructed and managed by the government or by a private corporation. No one looking at the question can now fail to be struck by the wisdom displayed by the greatest of all Canadian statesmen, Sir John Macdonald, when he decided that the road should be turned over to a private corporation.

Can any sane person imagine for an instant that any government could have made anything like such a success as the company has made of the Canadian Pacific? The same question is at issue to-day. Shall we follow the wise example set by Sir John Macdonald, organize a new company composed of men of the best financial and practical ability, give them the necessary safeguards and allow them to develop another Canadian Pacific, or shall we turn the roads over to the government, knowing the wasteful and extravagant methods of the government construction and management, and develop another and vaster Intercolonial?

It should be no more difficult to get a private corporation of the very best class to take over our present roads, than it was for Sir John Macdonald. The present conditions are much more favorable. At that date neither the Canadian nor the American Northwest had been proved to be capable of supporting a large population. The only railways in the country north and west of St. Paul were a small portion of the Northern Pacific, which up to that time had proved to be a financial failure; the St. Paul & Pacific, some 400 miles in length, which only the year before had been taken out of the hands of the receivers and reorganized by Mr. Hill, under the name of the St. Paul, Minneapolis & Manitoba, and a few miles of the Canadian Pacific under construction west of Lake Superior.

Since that time the country has been occupied by such systems as the Northern Pacific, Great Northern, St. Paul, Minneapolis & Sault Ste. Marie, and the Canadian Pacific, among the most prosperous roads in the world; by thousands of miles of extensions of more southerly roads; by the Canadian Northern, prosperous as long as it remained a purely western road, and by the only failures to date, the National Transcontinental and Grand Trunk Pacific Railways, and they are failures as the result of a standard of construction far in advance of their needs, and the lack of feeders without which no road can succeed.

The part of Western Canada traversed by the proposed combination is equal to that traversed by any transcontinental road either in Canada or in the United States, and is decidedly superior to that traversed by most of them.

So far, Western Canada has hardly been scratched. In 1906 the whole grain output came from an acreage of less than 5% of the area within five miles of the Canadian Pacific lines, and at the present time it comes from an acreage of less than 10% of the arable land in the three Prairie Provinces. The writer does not see how there can be the faintest doubt as to the ultimate success of the proposed consolidation, if put into the hands of a strong private corporation, when one takes into consideration the character of the country, its similarity to the country traversed by the other successful American and Canadian railways, the continued and rapid increase in the traffic of the whole Canadian railway system, and the fact that most of the other roads, in the same or similar territory, have had similar troubles, and that they are now, in a very few years, among the most successful roads in the world.

Immediate Success Impossible.—The consolidation could not hope to be financially successful at first, as the net revenue could not possibly be sufficient to pay the fixed charges, and a series of deficits are sure to result. These deficits, I believe, would not extend over a period of more than eight or ten years at the most.

The necessary capital should be raised by an issue of common stock, with a guarantee of 5% interest for ten years by the Canadian government, the amount guaranteed being limited to, say, $200,000,000. The legislation constituting the company should be on the same lines as that which constituted the Canadian Pacific; that is, it should be an actual contract between the government and the company, setting forth in detail the respective rights of each party. One of the clauses in this contract should be (as was in the Canadian Pacific contract) that until such time as the company was earning 10% on the actual cost to it of the road, equipment, etc., the government should have no right to regulate rates.

As the various governments, Dominion and provincial, have guaranteed most of the cost of the lines forming the proposed combination, they should be willing to agree to these terms, as if the company could not meet its fixed charges the government would have to meet them.

The situation has arisen owing to the unwise policy of duplication of lines, encouraged and bonused by the government, and to its extravagance in construction. If there is a penalty to be paid for the indulgence in this policy, the country must be the one to stand it. It is sure and certain, if the government nationalizes the roads and assumes the management, that the deficits will be many times as great as if the roads be operated by a private company, and in this event the deficits would have to be met by the government. Canada should be well satisfied to get out of this mess by paying deficits (is such there be) for a few years. It is quite in line with what we have been doing ever since Confederation, first of all, giving money and land, then money only, and lately, and worst of all, guaranteeing bonds for the construction of railways.

A new company sufficiently strong to finance such a consolidation should be formed to take them over. In this new company the government should have a 40% interest, should own 40% of the stock, furnish 40% of the money, have 40% of the directorate, should have an active voice in the policy, but should not have any say in the actual management of the road.

This would give the government a direct voice in the policy of the road; would enable it to mould its future, and would give all the benefits, without any of the evils, of government ownership

At present there is only one place—New York—where the bulk of the money for such an enterprise could be secured, but there seems to be no reason why at least 11% or 12% should not be raised by private capital in Canada. With 40% held by the government, and at least 11% or 12% by private Canadian capital, the actual control would be in Canadian hands.

If such a combination were made the roads should be connected in several places. The most important would be, as shown on the map, in Northern Ontario, at some point east of Lake Nepigon, probably from the north end of Long Lake on the Canadian Northern to a point near Titania on the Transcontinental. The map shows how this connecting would give the shortest and most direct route from Winnipeg to Montreal and Toronto. They would also have to be connected at the Yellowhead Pass, where they are side by side; at Montreal; at some point, say, Napanee, on the lines between Toronto and Ottawa, and, no doubt, at many points on the prairie.

Main Lines.—The main lines would then be: (As shown on accompanying map.)

Prince Rupert to Quebec and Moncton: Grand Trunk Pacific and National Transcontinental.

Vancouver to Montreal: Canadian Northern, Vancouver to Yellowhead Pass; Grand Trunk Pacific, Yellowhead Pass to Winnipeg; National Transcontinental, Winnipeg to Titania; new line to be built, Titania to Long Lake; and Canadian Northern, Long Lake to Montreal.

Toronto to Ottawa: Grand Trunk from Toronto to, say, Napanee, and Canadian Northern from Napanee to Ottawa. The various main lines of the Grand Trunk would remain the same.

Such a combination would have a first-class system in Ontario and the east, reaching every important centre; a main line to Chicago, with good local branches in Michigan; a main line to Portland (the natural winter port of Canada); the shortest line to St. John and Halifax (the two Canadian winter ports); a good connection with the New England States by way of the Central Vermont; a very good local system in the prairie provinces—Manitoba, Saskatchewan and Alberta—and, by far, the best line across the mountains connecting the Pacific ports with the prairie provinces.

Advantages of Consolidation.—There are many advantages which would be had from the consolidation, which cannot be had separately.

Main Line Distances Reduced.—The following table, giving the mileages from different points in the east to Winnipeg and Vancouver, shows how the distance could be reduced below similar distances on the individual roads, and how the new mileage would compare with the Canadian Pacific. In the case of St. John to Winnipeg, a new line down the St. John valley would be necessary to get the reduction in distance if such a connection were found to be desirable.

Railway	Montreal to Winnipeg	Toronto to Winnipeg	Quebec to Winnipeg	St. John to Winnipeg	Halifax to Winnipeg	Portland to Winnipeg
Can. Pac.....	1,411.6	1,232.3	1,563.4	1,882.0	2,157.2	......
Can. Nor.....	1,455.7	1,312.5	1,607.5	......	......	......
Grand Trk. / Gr. Tr. Pac. / Nat. Trans.	1,425.0	1,255.9	1,350.3	1,804.0	1,990.7	1,719.3
Prop. Consol.	1,347.7	1,204.5	1,350.3	1,804.2	1,990.7	1,645.0

	Winnipeg to Vancouver	Edmonton to Vancouver	Edmonton to Prince Rupert	Montreal to Vancouver	Toronto to Vancouver
Can. Pac.....	1,483.5	840.5	....	2,895.1	2,715.8
Can. Nor....	1,599.7	....	....	3,055.4	2,912.2
Grand Trk. / Gr. Tr. Pac. / Nat. Trans.	1,760.6	967.7	953.2	3,185.6	3,016.6
Prop. Consol.	1,555.9	763.0	....	2,903.6	2,760.4

	Quebec to Vancouver
Can. Pac.	3,406.9
Can. Nor.	3,207.2
Grand Trk. / Gr. Tr. Pac. / Nat. Trans.	3,110.9
Prop. Consol	2,906.2

Thus the distance from Montreal to Winnipeg would be 64 miles shorter than by the Canadian Pacific, 108 miles shorter than by the present Canadian Northern and 78 miles shorter than by the present Grand Trunk connection.

From Toronto to Winnipeg the new route would be 28 miles shorter than by the Canadian Pacific, 108 miles shorter than by the present Canadian Northern and 51 miles shorter than by the present Grand Trunk connection.

From Winnipeg to Vancouver the new route would be 44 miles shorter than by the present Canadian Northern, 205 miles shorter than the proposed Grand Trunk connection and only 72 miles longer than the Canadian Pacific. For winter haul of wheat it would have a decided advantage over the Canadian Pacific as the distance from Winnipeg to St. John would be 78 miles shorter and to Halifax 167 miles shorter than by that road, and the haul would be 237 miles shorter, by the new consolidation, from Winnipeg to Portland than from Winnipeg to St. John by the Canadian Pacific. It would also decidedly improve the Grand Trunk Pacific connection between the prairie provinces and the Pacific, as the distance between Edmonton and Vancouver would be 190 miles shorter than the distance from Edmonton to Prince Rupert.

Main Line Grades.—The grades on the main lines of the new consolidation from Montreal, Toronto and Quebec to Winnipeg and Vancouver would be truly remarkable for such a length of line, and one through so many hundreds of miles of mountains. From Edmonton to Montreal, Toronto and Quebec, there would be no grades steeper than 0.4% against eastbound and 0.6% against westbound traffic. From Edmonton to Vancouver there would be no grades steeper than 0.7% against the eastbound and 0.4% against westbound traffic.

The main lines, as now constructed, have many miles of 1% grades, or steeper.

The Grand Trunk from Montreal and Toronto to Cochrane has grades of 1% or steeper against both eastbound and westbound traffic.

The main line of the Canadian Northern in Manitoba, Saskatchewan and Alberta, and from Port Arthur to Winnipeg, has many grades of 1% or steeper against both eastbound and westbound traffic.

The Canadian Pacific has, on its main line between Montreal and Fort William, in Alberta, and from the Columbia River to Vancouver, many grades of 1% and steeper against both eastbound and westbound traffic, and in the Rocky and Selkirk Mountains many miles of 2.2% grades against both eastbound and westbound traffic.

Thus the new consolidation would have the shortest line, and the best grades from all such points as Halifax, St. John, Portland, Quebec, Montreal and Toronto to Winnipeg.

It would also have a shorter line, with much better grades, than either the present Grand Trunk or Canadian Northern between Winnipeg and Vancouver, and while the Canadian Pacific would be eight miles shorter from Montreal to Vancouver, and 45 miles shorter from Toronto to Vancouver, the new route would have decidedly better grades, no snowslides, much less rise and fall, and would require less train-miles in its operation.

Less Cost to Complete.—The National Transcontinental and Grand Trunk Pacific, as now built, consists of a main line of 3,550 miles long, with only about 1,200 miles of branches.

MONTREAL AQUEDUCT COMMISSION.

Montreal's Board of Control has outlined the information that it expects from the St. Laurent-McRae-Vautelet Commission which will investigate the aqueduct scheme. The following resolution has been adopted by the Board, upon motion of Controller Villeneuve:—

That for the purpose of obtaining from experts a report on the value, as a whole, of the enlargement of the aqueduct for the development and municipalization of motive power, and in order to avoid all misunderstanding and controversy in the future, these gentlemen be asked to state clearly and firmly, their opinion as experts in the form of answers to the following questions, which they may add to whatever expression of personal opinion they deem expedient and interesting to make:—

(*a*) What is the value of the capital cost of the first enterprise, chargeable (that is, the total capital engaged plus the interest accumulated during the ten years that this undertaking has been under way, as well as interest that may accrue until completion) to the installation, as it will be when fully completed and in course of operation:

1—For the production of hydraulic motive power.

2—For pumping 100,000,000 gallons per 24 hours.

3—For electric lighting of all the city (distribution and lighting).

(*b*) The same question, under the same three heads, regarding annual operating cost, including financial charges for interest, sinking fund, depreciation, etc.

(*c*) To establish by a comparison of the respective figures for the cost of the first enterprise and annual operating cost, the advantage or disadvantage (pecuniary profit or loss) to the municipal treasury, by continuing to full completion this undertaking of the development of the aqueduct under present conditions of the project in course of execution. The comparison should be made showing respectively each item, for each of the following alternative propositions:—

1.—Present project of municipalization, continued as a whole up to the point of service and operation.

2.—Present conditions of annual cost of pumping by steam (low-level station) and by electricity (high-level station) of yearly lighting of the whole city by virtue of the contract in force with the companies. Taking into account the relative capacities of pumping and lighting between the conditions and needs of the present and those which are claimed will be realized by the project under way.

3.—An hypothesis of a central steam plant, assuring at the same time pumping and lighting, on the basis of modern operation and installation, with the respective yield and capacity of the project in course of execution—in a word, the substitution of steam for hydraulic power.

4.—Pumping assured, purely and simply, by acquiring power from one of the companies which produce it. The present low-level station being in this hypothesis, utilized as much as possible by the judicious adaptation of the existing turbine pumps, and by merely substituting the motors, the cost of operation to be at the expense of the city. In which the lighting will remain, as at present, supplied and ensured by a company.

(*d*) A table, giving for an average year, the yield minimum minimorium, month by month, in kilowatts, of the development of the aqueduct in course of construction.

(*e*) A statement of the effect of frazil ice on the production of hydraulic power under conditions existing at the site of the project under discussion, taking into consideration the difficulties experienced by other power development companies in the district contiguous thereto, and what difficulties may be reasonably looked for from ice conditions based on the actual experience of a number of years past.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

A general section meeting was held at the Society's rooms, Montreal, Thursday evening, February 8th. Col. Arthur Mignault, M.D., formerly in charge of the Laval University Hospital Unit, addressed the meeting, relating some experiences at the Front. The paper by G. W. Craig, city engineer, and J. F. Greene, bridge engineer, both of Calgary, on the construction of the Calgary Centre Street Bridge, which paper was presented to the Society at the meeting on January 9th, was read and discussed.

NITROGEN FROM SEWAGE.*

By Dr. S. Rideal, F.I.C., F.C.S.

Copeland, at Milwaukee, has recently discussed the question, "Is the Recovery of Nitrogen in Sewage Sludge Practicable?" and shows the nitrogen changes of Milwaukee city sewage by Imhoff and activated treatment as follows:—

Parts per 1,000,000.

		Sewage.	Imhoff effluent.	Activated effluent.
August	N as NH_3	14.6	16.2	3.8
September		13.5	15.4	5.7
		14.0	15.8	4.7
August	N as N_2O_5	.13	.13	6.0
September		.14	.09	5.01
		.135	.11	5.5
August	N as Organic	29	27	6
September		29	27	9
		29	27	7.5

At Milwaukee 0.25 cub. ft. of air per minute per square foot of tank surface, with a period of four hours' aeration with a sludge content of 25 per cent., is being adopted.

We see that (these are parts per 1,000,000, but, as American sewage is ten times weaker than English, the foregoing figures are comparable with ours at part per 100,000) the Imhoff effluent is very similar to the raw sewage, but that the activated effluent has more than half its ammonia oxidized, while only 25 per cent. of the organic nitrogen is retained. The sludge is richer in organic nitrogen by this latter amount, but some of the ammonia—about 5 parts—must be removed by the air.

If air be passed through the sewage or the Imhoff effluent without nitrification taking place, 10 parts per 1,000,000 of ammoniacal nitrogen should be present in it. Experiments are required to ascertain the conditions which have prevented the removal by the air of the residual 4.7 parts of ammonia in the activated sludge working.

Its subsequent recovery as sulphate of ammonia should present no difficulty, as the absorption of gaseous ammonia from the exhaust air by sulphuric acid is common practice in gasworks.

Mr. Copeland points out that the organic nitrogen of the original sewage passes away in the effluent from the Imhoff tank, but is retained by the activated treatment in its sludge.

This sludge is, therefore, the richest in nitrogen, and has the greatest manurial value. From the point of view we are now discussing, there is little possibility by any of the known processes of converting the organic nitrogen of sewage directly into ammonia or nitric acid in a form available for explosive manufactures, except destructive distillation.

Dried activated sludge (with 10 per cent. moisture) contains, according to Copeland, 5 to 9 per cent. of nitrogen, and such a sludge if retorted should give higher yields of ammoniacal liquor than are obtained in gas-works from ordinary coal.

Nitrates from Effluents.—My last suggestion deals with the recovery of nitrates from effluents.

The American weak sewage gave us 5 parts per 1,000,000 of nitric nitrogen in the activated effluent. In England our best bacterial beds give us up to 10 parts per 100,000.

In 1898 I made my first analyses of a camp effluent, that from the Caterham Barracks, where we then had a raw sewage with 17.2 parts of total nitrogen, and after a very efficient filter (put in by one of your past-presidents, Mr. Moncrieff) I found over 50 per cent., viz., 9.0 parts of nitric nitrogen in the effluent. There were still 5.0 parts of unoxidized ammonia, and this could easily be oxidized, making 14.0 parts of nitric nitrogen, or 14 lbs. per 10,000 gallons, equivalent to 85 lbs. of nitrate of soda per 10,000 gallons.

The natural concentration of sodium nitrate solutions in Chili might give us suggestions for the evaporation of this large volume of water. A filter-bed with no effluent drain protected from rainfall, if irrigated with such an effluent, would gradually concentrate the nitrate, and this season at each works we could ascertain the rate of evaporation under our climatic conditions.

If in a cucumber frame, 6 ft. by 4½ ft., 3 gallons could be evaporated per day, the earth at the end of a year would contain 9.3 lbs. of nitrate of soda. Drying sheds can also be heated by waste steam from the destructors, and a few degrees is often sufficient to raise the temperature above the wet bulb and thus ensure constant evaporation, even on days when the air is saturated.

America, although not fighting, has grappled with the problem this year, and is determined to create her own nitrate supply. I understand the Government have granted $20,000,000 towards founding the new industry.

*Abstract of paper read before the Association of Managers of Sewage Disposal Works.

T. R. DEACON ADDRESSES MANITOBA BRANCH OF CANADIAN SOCIETY OF CIVIL ENGINEERS

"A View of Necessary Action for After-the-War Conditions," was the subject of an address by T. R. Deacon, C.E., ex-mayor of Winnipeg and manager of the Manitoba Bridge & Iron Works, delivered before the regular February meeting of the Manitoba Branch of the Canadian Society of Civil Engineers.

Mr. Deacon pointed out the necessity for action to meet the conditions in Canada arising from the war. He believed that in the solving of a great number of problems, and in carrying out the industrial work after the war, the engineers would have a very considerable part. That there would be a large demand for engineers would be due to the work which of necessity must be carried forward to utilize the energy represented by the 400,000 men now in the army and 80,000 to 100,000 men engaged in munitions and kindred work.

In brief, said Mr. Deacon, the problems Canada must face at the close of the war are:—

1. Payment on a national debt which will probably amount to $5,000,000,000.

2. An annual pension fund.

3. The utilization of some 80,000 to 100,000 men at present engaged on munitions and kindred employment, who will be immediately thrown out of work on the cessation of hostilities.

4. The return of some 400,000 men from the front, comprising some of the best blood and energy of the country.

If these 500,000 men engaged in the war or in industries arising from the war, are to be retained in the country and given work in order to prevent their emigration to the United States, a comprehensive program should be undertaken by the government. That the work must be of a manufacturing or an industrial nature did not require proof, as it would require the wildest stretch of imagination to believe that these men will turn to pioneer farm work when manufacturing and industrial work would be available south of the Canadian boundary.

In place of allowing the raw products of the soil, forest, fisheries and mines to be exported from the country, Mr. Deacon believed that it is not only practicable but assuredly possible to provide industrial work which would utilize these raw materials, and which in turn would not only utilize the energy of these 500,000 men but would also help materially towards reducing and meeting the payments on the national debt.

The most feasible method of utilizing each of the natural resources appeared to him to be to copy the German plan of state co-operation with the manufacturers. That there would be many difficulties and many obstacles in the working out of such a scheme he admitted, but believed it was the most practicable method of meeting the conditions.

COMING MEETINGS.

MID-WEST CEMENT USERS' ASSOCIATION. Annual convention, Omaha, Neb., March 6-10, 1917. Frank Whipperman, secretary, 28th Avenue and Sahler Street, Omaha.

CANADIAN MINING INSTITUTE. Annual meeting in Montreal, March 7-9 at the Ritz-Carlton Hotel. Secretary, H. Mortimer Lamb, Ritz-Carlton Hotel, Montreal.

DIXIE HIGHWAY exposition and convention at Cincinnati, Ohio, May, 1917.

AMERICAN WATERWORKS ASSOCIATION. Thirty-seventh annual convention, "The Jefferson," Richmond, Va., May 7-11, 1917. President, Leonard Metcalf.

THE SOUTHWESTERN WATERWORKS ASSOCIATION. Annual convention at Topeka, Kan., June 11-14, 1917. Information from E. L. Fulkerson, Waco, Texas.

Manitoba's total railway mileage at the end of 1916 was 4,672.52, according to the annual report of the Provincial Department of Railways. The report says that notwithstanding the scarcity of labor, satisfactory progress has been made during the year on the Hudson's Bay Railway. Track has been laid to the Kettle Rapids, on the Nelson River, 330 miles from The Pas. It is intimated that the whole line, including all bridges, will be completed and ready for traffic by the end of 1917.

Electrically operated excavators are being used on a large drainage scheme in Idaho, U.S.A. Energy is obtained at a pressure of 44,000 volts from an overhead line; the average power consumed is 0.88 kilowatt-hour per cubic yard of material excavated, varying with the material excavated, being as low as 0.39 kilowatt-hour in light sandy loam, including all line and transformer losses.

The Department of Trade and Commerce, Ottawa, has received information from Petrograd, Russia, to the effect that the Murman Railway, from Petrograd, to the ice-free port of Alexandrovsk, on the Arctic Ocean, has been completed. The road is of great importance for the import of munitions. The line, nearly 700 miles long, has been constructed in the face of most formidable engineering difficulties owing to the swamps and other features of the country, and has been completed before the anticipated time.

TRADE INQUIRIES.

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

434. Galvanized steel wire ropes.—A Buenos Aires firm of importers require f.o.b. New York prices on 56 coils of galvanized special flexible patent improved steel wire ropes with one main and six auxiliary hemp hearts. Specifications may be had on application to the Department of Trade and Commerce, Ottawa.

435. Hardware.—A firm distributing hardware in Western Siberia are open to receive quotations, if possible c.i.f. Vladivostok, from Canadian manufacturers of various kinds of hardware with a view to the execution of trial orders.

438. Street Cars.—An Italian street railway wishes to secure in Canada rolling stock for an extension of its line as follows: Four carriages with motors, 10 goods cars, 3 third-class cars, 3 first-class cars. Specifications are as follows: Motor carriages: Four motors; 70 horse-power; 1,650 volts, continuous current, Westinghouse brake with hand-brake, brakeman's compartment at end, height buffers 855 centimetres, width of motors 95 centimetres, multiple system Sprech at 800. Goods wagons or flat cars to carry ten tons, low sides to carry sand, etc. Passenger cars with 40 places, of which 14 should be at ends (7 at each end); distance between axles, 4.000 centimetres; length of frame, 9.770 centimetres; total length with buffers, 10.770 centimetres; width, 2 metres 20 centimetres. Electric motors must be able to pull 50 tons weight on grades of 60; 1,000 weight of the wire is 9 metres, falling to 4.20 metres where passing under bridges. Speed of motors up to 50 kilometers per hour. Speed of train is usually up to 30 kilometres. Cars must be able to go round a curve of 50 metres, radium.

440. Supplies for Siberia.—The New York office of a firm distributing goods throughout Western Siberia is desirous of receiving quotations from Canadian manufacturers of articles suitable for this market.

444. Steel Shafting.—A manufacturers' agent prominently connected with and favorably known to the wholesale trade of St. John's desires to be put in touch with Canadian manufacturers of cold-rolled steel shafting.

445. Steel Bars.—Canadian exporters of iron and steel bars are asked to communicate with a Newfoundland inquirer.

446. Copper Wire.—A Newfoundland inquirer desires to purchase Canadian copper wire—r.c. and bare.

447. Iron Pipe.—A Newfoundland importer asks for Canadian manufacturers of iron drain-pipe, 2-inch and 4-inch.

NEW INCORPORATIONS.

New Carlisle, Que.—The New Richmond Mining Company, $290,000. J. F. Marcotte, F. Marcotte, F. Blois.

Sherbrooke, Que.—The Dominion Metal Company, Limited, $20,000. N. B. Pritchard, H. Irwin, G. E. Borlase.

Windsor, Ont.—Bolton Mining Company, Limited, $500,000. E. J. Robinet, C. Robinet, L. Robinet.

Montreal, Que. — Hygienic Construction Corporation, Limited, $25,000. P. Richer, R. Lanctot, A. Savard; Montreal-East Construction Company, Limited, $40,000. T. K. Walton, C. H. Waugh, C. J. Kirlin; the Mack Brick Company, Limited, $500,000. R. T. Heneker, H. N. Chauvin, H. E. Walker.

Stanley, B.C.—Cariboo Chisholm Creek Mining Company, Limited, $300,000.

New Westminster, B.C.—Marsh, Bourne, Powers Contracting Company, Limited, $45,000.

Kamloops, B.C. — Branch Ranch Mines, Limited, $100,000.

Vancouver, B.C.—Texada Mines, Limited, $10,000; the Deeks Gravel and Rock Company, Limited, $10,000; the Lone Star Mining and Milling Company, Limited, $1,000,000.

Editorial

MORE CANADIAN REFINERIES NEEDED.

Canada, and the whole British Empire, would be strengthened industrially and martially by the establishment of more refineries and metallurgical plants within the Dominion, so that Canadian ores can be utilized without the aid of foreign refineries. This is one of the most important steps required in meeting after-the-war problems. It is to be hoped that the Dominion Government will help to establish more Canadian refineries at once. Careful inquiry should be instituted to reveal the best form in which such help can be given, whether by legislation forbidding exports of unrefined ores, or by bonuses or loans to refineries. The views or ore-producers, managers of existing refineries, owners of undeveloped ore properties, metal merchants and consumers, and bankers should be obtained by the government without further delay. A good start has been made in the policy adopted toward nickel refining in Ontario, but this policy should be extended to other ore resources and to other provinces.

The mining committee of the Vancouver Board of Trade has submitted a resolution to the government asking for legislation that will assist in the treatment of the many mineral products in which that province is so rich. The assistance should be given at as early a date as possible consistent with judicious enquiry as to whether the aid can best be rendered in the form of legislation.

British Columbia now refines but a small portion of the ores that could be produced from that province were adequate metallurgical works built to aid development. The present annual production of British Columbia lead is about 32,000 tons, most of which is refined at Trail, but the Vancouver committee states that there are important deposits of lead ores on the coast and along the route of the Grand Trunk Pacific which cannot be treated economically for want of smelting accommodation on the coast.

The copper production of British Columbia will soon be about 70,000 tons per annum. There are only two small copper refineries in the province, and at the present time six-sevenths of the copper produced must be shipped to foreign refineries.

About 5,000 tons of zinc ore are mined each year in British Columbia in excess of the present refinery capacity, and there are important zinc deposits on the coast and tributary to the Grand Trunk Pacific Railway which could be developed were spelter refining works available. Such plants could also handle Australian and other imported zinc ores, of which about 15,000 tons recently passed through the port of Vancouver en route to foreign spelter works.

Among the other metals which can be produced in British Columbia in greater quantities were adequate facilities provided for their treatment, are antimony, chrome, iron, mercury and molybdenum.

The Vancouver committee, which has rendered a public service in calling the attention of the government to these important facts, also suggests that an investigation be made of the refractory earth and clay deposits available for the manufacture of retorts suitable to the Belgian process for zinc ores not adapted to electro-chemical processes.

The essential requisite for most of these refineries, however, is cheap hydro-electric power, which is abundantly available in British Columbia. There are a number of hydro-electric plants already in operation in that province which cannot find a suitable market for all of the energy that they can readily produce, and the establishment of more refineries would do much toward placing some of these companies upon a more profitable basis, and would also mean the early development of more water powers.

RE THAT SWAIN DISCUSSION.

In a letter concerning the appointment of Prof. Swain to the Railway Board of Inquiry, a correspondent refers to "an interview with Sir Henry Drayton which you got and which was published on page 239 of your issue of September 21st, 1916."

Upon referring to the interview above mentioned, we regret extremely to note a serious error in the printing of that "interview," *viz.*, that we overlooked stating the fact that the interview had not been obtained from Sir Henry Drayton by *The Canadian Engineer*, and that it was merely a reprint of an interview which Sir Henry Drayton had given out to the Canadian press and which had been previously published in the daily newspapers.

The interview published in *The Canadian Engineer* was copied verbatim from The Toronto Globe of Wednesday, September 13th, 1916, and The Toronto Telegram of Tuesday, September 12th. *The Canadian Engineer* had not been in touch in any manner with Sir Henry Drayton or any other person regarding this appointment. The oversight in not crediting the above "interview" to the Toronto newspapers has evidently led to one or two misunderstandings which we trust this explanation will rectify.

FLAT-SLAB CONSTRUCTION.

The collapse of a flat-slab reinforced concrete building in the recent Quaker Oats fire at Peterborough, caused many engineers to question the fire-resisting qualities of that type of construction. The flat-slab type was first officially recognized in a building code by Chicago only as recently as 1914, so that, while it was claimed to be as fireproof as any other type of construction, the Peterborough fire caused some apprehension.

As thirteen flat-slab buildings (with a total permit value of $1,872,000) had been erected or started in Toronto during the past year, T. D. Mylrea, assistant city architect of Toronto, made a thorough investigation into the causes of the Peterborough collapse.

Mr. Mylrea found that it would be easier to explain why the Quaker Oats warehouse fell than why the Edison buildings stood. Evidence showed that temperatures of over 2,000° F. had penetrated two inches of concrete, and that the working strength of the steel had been reduced by about 80%. "In the columns this would not be of such grave importance as in the floor slabs," says Mr. Mylrea, "but it is probable that the floors failed first and carried the columns with them. It is possible that the depth of the beams and girders and the short spans of the floor slabs in the Edison buildings offered a more effective resistance to collapse, even were the working strengths temporarily reduced."

Mr. Mylrea concludes that it would be incorrect to demand excessive fireproofing simply because one building collapsed under unusual fire conditions. "If a fire is of sufficient intensity and duration to heat a nine-inch floor slab through," he says, "it is evident that even four and one-half inches of fireproofing would have availed nothing. * * * The wiser course would be to have just such an amount of fireproofing as would prevent the steel from being overheated in an ordinary blaze."

The newspaper reports of the fire and the views of the insurance companies' engineers and inspectors confirm Mr. Mylrea's opinion that the Peterborough fire was unusually severe, so there would seem to be no reason for considering it a sign of any deficiency in the flat-slab type of construction.

PERSONAL.

J. W. ADAMS has been re-appointed acting city engineer of Chatham, Ont.

A. R. McVICAR, of Brantford, Ont., has been appointed county roads superintendent for Brant County.

E. W. MOORE, of Cleveland, Ohio, has been elected president of the Street Railway Company, London, Ont. Mr. Moore is a former Londoner.

Lieut. COULSON N. MITCHELL, Jr., a 1912 engineering graduate of Manitoba University, was recently awarded the Military Cross for bravery in action.

R. W. MacINTYRE, of Victoria, B.C., has been appointed supervising engineer of construction work now being done on the Pacific Great Eastern Railway.

JOHN H. BUNTING, who for the last four years has been joint manager of Bruce Peebles & Co. Limited, Edinburgh, Scotland, has been appointed general manager of the company.

W. G. MURRIN, who since April, 1913, has been acting as general superintendent of the British Columbia Electric Railway, with headquarters at Vancouver, is now assistant to the general manager, George Kidd.

THOS. TAYLOR, designing engineer of the Bloor Street Viaduct, Toronto, gave an address before the Engineers' Club of Toronto last evening on the design and construction of the viaduct. His remarks were illustrated by lantern slides. Mr. Taylor's address was supplemented by remarks by other engineers connected with the work.

Major HAROLD L. TROTTER, formerly a partner in the Henry Holgate firm of consulting engineers, Montreal, is in command of a field company, Canadian Engineers, and has been in action at the Somme. Major Trotter graduated with honors in 1903 at the Royal Military College. He is a son of Col. W. C. Trotter, president and general manager of the Standard Clay Products Co., Limited, St. Johns, P.Q.

Another son of Col. Trotter, Major CLIFFORD T. TROTTER, is also at the Somme. At the outbreak of war he was engineer in charge of construction at the Standard Clay Products plants at New Glasgow, N.S., having designed and built the company's large sewer pipe factory at that place. He graduated at the Royal Military College in 1907 and later received the degree of B.Sc. at McGill University. He went overseas as a captain in March, 1915, and after being engaged in severe fighting on the Ypres salient was mentioned in despatches by Sir Douglas Haig and was promoted to be senior major of a division of engineers, having command of a field company.

OBITUARY.

J. G. TAYLOR, general superintendent of the C.P.R. for Saskatchewan from 1912 to 1916, died recently in Edmonton, aged 55.

JOHN JOYCE, one of the founders of the Shawinigan Water and Power Company, died at his home in Boston recently. Mr. Joyce was a director of the company for many years.

Lieut. J. W. BOYD, formerly employed as an engineer by the Toronto Harbor Commission, has died of wounds received in active service. Lieut. Boyd was born in Stratford, Ont., and educated in Toronto.

J. G. MACKLIN, M.Can.Soc.C.E., who six years ago left Canada to reside in England, failing health obliging him to seek a milder climate, died on February 5th. An Englishman by birth and education, Mr. Macklin came to Canada as a young man, and began his professional career in association with the late Col. Sir Casimir Gzowski, of Toronto, on the construction of the cantilever bridge spanning the Niagara River. Later he was employed by the Grand Trunk Railway Co. in building a branch line between Ottawa and Prescott, his headquarters being then at Ottawa. Subsequently, he organized the Midland Division of the Grand Trunk Railway and resided in Peterborough as chief engineer of that division for many years. The last important work on which he was engaged was the planning and construction of the dam in connection with the power plant on the Richelieu River, at Chambly, P.Q. Mr. Macklin was a member of the Canadian Society of Civil Engineers from its inception. He is survived by his widow, a daughter and a son, 1st Lieut. F. C. A. Macklin, Royal Engineers.

WILLIAM LYON MACKENZIE, bridge engineer for the Canadian Northern Railway, died at his home in Winnipeg on February 8th, aged 57 years. Mr. Mackenzie formerly was connected with the C.P.R. and Grand Trunk Railways in an engineering capacity and for twelve years had charge of all bridges on the Canadian Northern from Lake Superior west. He was a native of the township of South Dumfries, South Waterloo, Ont., and after attending Galt Collegiate Institute he was graduated as a civil engineer at Toronto, since which time he had a large and varied experience in railroad location and construction work. The first work to engage his attention was the building of the Canadian Pacific Railway from Toronto west through Galt and Woodstock and eastward via Peterborough to Smith's Falls, also the main line through North Bay. His services with the Canadian Pacific terminated with the completion of the Crow's Nest branch in 1899, when he joined the engineering staff of the Canadian Northern Railway. Mr. Mackenzie was a member of the Canadian Society of Civil Engineers, and 1917 chairman of the Manitoba branch. He formerly made his home in Galt, Ont., where his family resided for some years before moving west about ten years ago. He is survived by his widow, one son and two daughters.