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The Canadian Engineer

A weekly paper for engineers and engineering-contractors

POWER DEVELOPMENT AT WASDELL'S FALLS, ONT.

A LOW-HEAD PLANT OF EXTREMELY INTERESTING DESIGN—INITIAL UNDERTAKING OF THE HYDRO-ELECTRIC POWER COMMISSION OF ONTARIO IN THE FIELD OF POWER PRODUCTION.

THE approaching completion of the plant at Wasdell's Falls will mark the beginning of a new epoch in the history of the Ontario Hydro-Electric Commission, meaning as it does the entry of the Commission into the field of actual power production at cost as an adjunct to the policy of cost price transmission and distribution heretofore pursued.

The result of this expansion of policy in the present instance will be that connected consumers will derive the utmost economic benefit which can result from the development of a water-power.

The development project arose out of the necessity of meeting requests from a number of municipalities on the east shore of Lake Simcoe to be supplied with power through the Commission, investigation having indicated conclusively that the Wasdell's Falls site was the only source of power from which the present and immediate future needs of this district could be adequately supplied. Following the receipt of signed contracts from five of the municipalities involved, covering the supply of about 625 h.p., plans and specifications were prepared and authority to proceed with the work was obtained from the Provincial Government.

Natural Conditions.—Wasdell's Falls is located on the Severn River, about three miles below the outlet of Lake Couchiching. Owing to backwater effects the natural head was subject to considerable variation throughout the year, ranging from about six feet at extreme high water to ten feet at low water. It was determined, however, that with the forebay levels which would result from development, the head under the worst anticipated backwater conditions would never be less than 9 feet. Similarly the maximum head was determined to be 15 feet. Apart from the low head, the topographical conditions at Wasdell's Falls are most favorable for development, and the solid granite formation on which the works are founded has nowhere developed serious faults or fissures.

The drainage area of the Severn River above Wasdell's Falls is about 2,075 square miles. About 700 square miles of this area is included in the basin of the Black River, which joins the Severn about midway between Wasdell's Falls and Lake Couchiching, while the remaining 1,375 square miles of watershed is practically all tributary to the immense storage basin of Lake Simcoe, 297 square miles in extent.

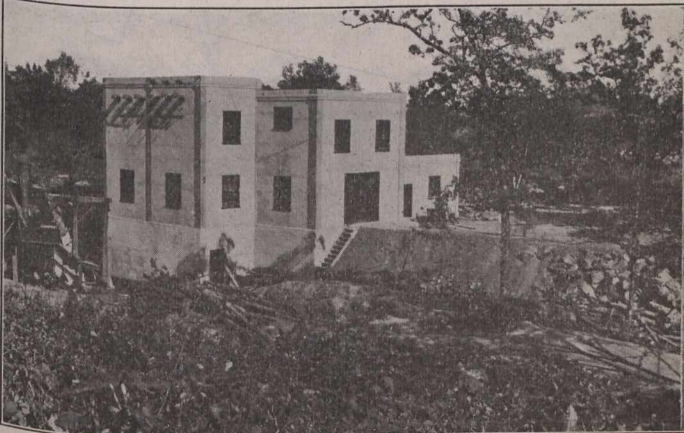

Fig. 1 (left) View of Wasdell's Falls Power House, Showing High-tension Line Outlets. Fig. 2 (right) View Showing Dam.

The maximum discharge of the Severn River at Wasdell's Falls, as so far determined by gauge records and discharge measurements, is 9,050 sec.-ft., which is equivalent to a run-off of 4.36 sec.-ft. per square mile of watershed. The minimum flow, 260 sec.-ft., is equivalent to a run-off of .13 sec.-ft. per square mile, and the average flow for 1913, 2,489 sec.-ft., corresponds to a mean annual run-off of 1.2 sec.-ft. per square mile.

Other figures relative to the flow characteristics of the river are shown in the following table:

Table I.—Monthly Discharge of Severn River at Wasdell's Falls for 1913.

Month	Discharge in second-feet Maximum	Minimum	Mean	Discharge in second-feet Per square mile Maximum	Minimum	Mean	Run-off Depth in inches on drainage area
Jan. ..	4,840	1,840	2,419	2.33	.89	1.17	1.39
Feb. ..	3,120	2,050	2,432	1.51	.99	1.17	1.26
Mar. .	8,785	1,640	4,231	4.24	.79	2.04	2.42
Apr. ..	9,050	5,600	7,790	4.36	2.70	3.76	4.20
May ..	5,525	3,375	4,175	2.66	1.63	2.01	2.32
June ..	3,375	2,225	2,680	1.63	1.07	1.29	1.44
July ..	2,200	1,175	1,644	1.06	.57	.79	.91
Aug. ..	1,075	800	937	.52	.39	.45	.52
Sept.. .	1,025	700	815	.49	.34	.39	.43
Oct. ..	875	260	570	.42	.13	.27	.31
Nov. ..	1,475	450	897	.71	.21	.43	.50
Dec. ..	1,505	905	1,276	.73	.44	.62	.73
Total..	9,050	260	2,489	4.36	.13	1.19	16.43

It may be mentioned that some doubt attaches to the figures for minimum flow as shown in Table 1. owing to the extremely low velocities which obtained at the metering station during periods of very low water. The actual minimum discharge is doubtless somewhat greater than indicated above, but in the interests of safety the figures relative to minimum flow have been left exactly as recorded.

The dams now being constructed at the outlet of Lake Couchiching in connection with the Trent Canal project will make available at least 12 inches depth of storage on Lake Simcoe. Properly regulated flow from this storage alone would meet the maximum requirements of the Wasdell's Falls plant for a period of six months in any ordinary dry year, while the records to date show that the period of deficient flow in an abnormally dry year is not of more than three months duration.

Permanent Works.—The dam is of the pier and stop-log type with six 14-foot sluices and a central overflow section 25 feet long which can be used during the high-water periods for driving logs. This section of the dam is closed by vertical needles, which will sustain a head of about 4 feet at maximum headwater level. When wide open, the dam can safely pass a discharge of 15,000 second-feet.

The power-house foundations, including inlets, wheel-chambers and draft tubes, are of mass concrete, only the wheel-chamber and generator arches and a portion of the draft-tube arches being reinforced. The whole of the superstructure, including the roof and crane-girders, is of reinforced concrete. The panel sections between the main columns consist of two layers of hy-rib reinforcement so placed as to provide a 4-inch air-space. The outer layer is plastered with a 2-inch coat of 1 : 2½ cement mortar and the inner layer with a coat 1¼ inches thick. The forebay walls, and the partition wall between the generator room and the forebay, consist of a single coat of plaster 2½ inches thick laid on hy-rib. The hy-rib was set in 2-inch checks left in the columns and girders and was further supported by light 4-inch channels set vertically in the air-space on 5-foot centres.

The wheel-chamber inlets are divided by a centre pier and in each of the four openings is placed a wooden head-gate spanning a clear waterway of 12 feet 1½ inches. These gates are built of 8-in. x 8-in. and 8-in. x 10-in. yellow pine, and in one gate of each pair is placed a 16-in. x 16-in. wicket gate for filling the wheel-chambers. The head-gates are not intended to be opened under full static pressure under normal conditions, although the operating mechanism is sufficiently powerful to admit of such operation if necessary.

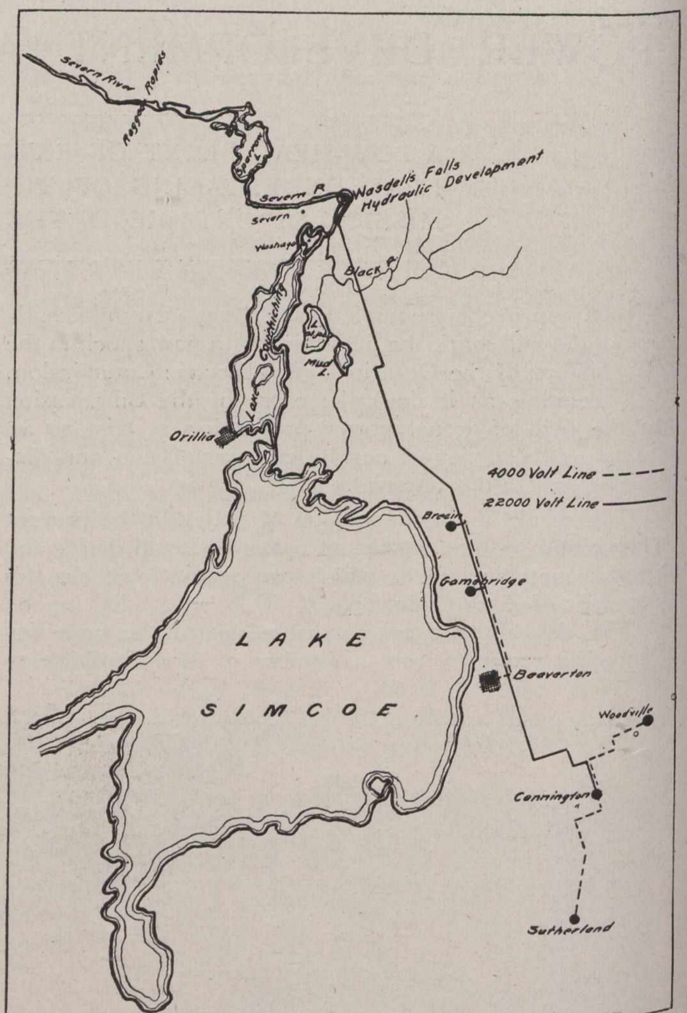

Fig. 3.—Location of Development on Severn River and Main Transmission Lines.

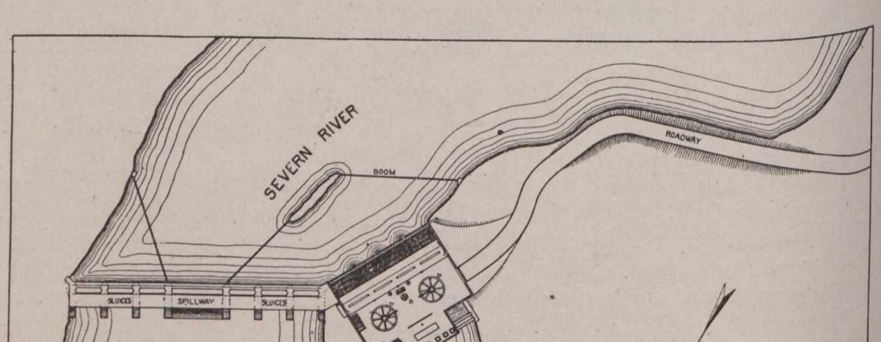

Fig. 4.—Layout of the Development at Wasdell's Falls.

As will be seen in the accompanying illustrations, the racks are entirely enclosed, making it possible to exercise a certain amount of control over rack temperature as a means of coping with frazil trouble.

It will also be noticed that the forebay curtain wall is located approximately parallel to the natural stream lines, so that by opening the sluices next the power-house, a deflecting current can be utilized to clear the outer forebay of debris, floating ice and frazil.

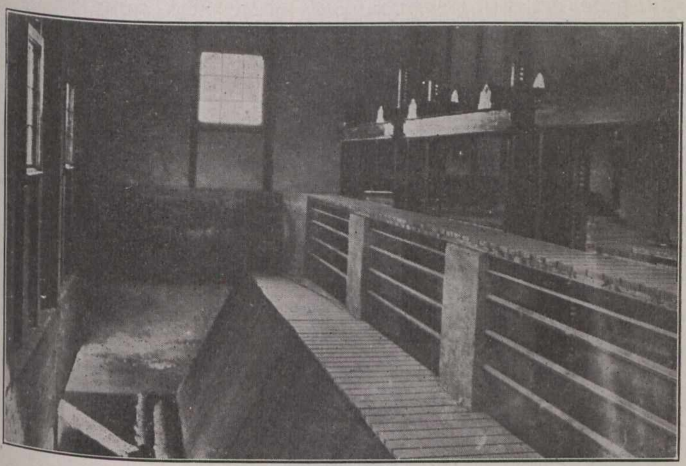

Fig. 5.—Racks and Head Gate Mechanism.

Hydraulic Equipment.—The hydraulic equipment was manufactured and installed by the Boving Company of Canada, Limited, having comprised the first order filled from the company's new plant at Lindsay, Ontario. The two main units are of the vertical, double-runner, mixed flow, open flume type with separate draft-tubes, and are designed to operate at best efficiency under a 12-foot normal head, at 90 r.p.m. Under normal head, each unit has a guaranteed three-quarter gate capacity of 600 b.h.p. and a full gate capacity of 500 b.h.p. under a 9-foot head.

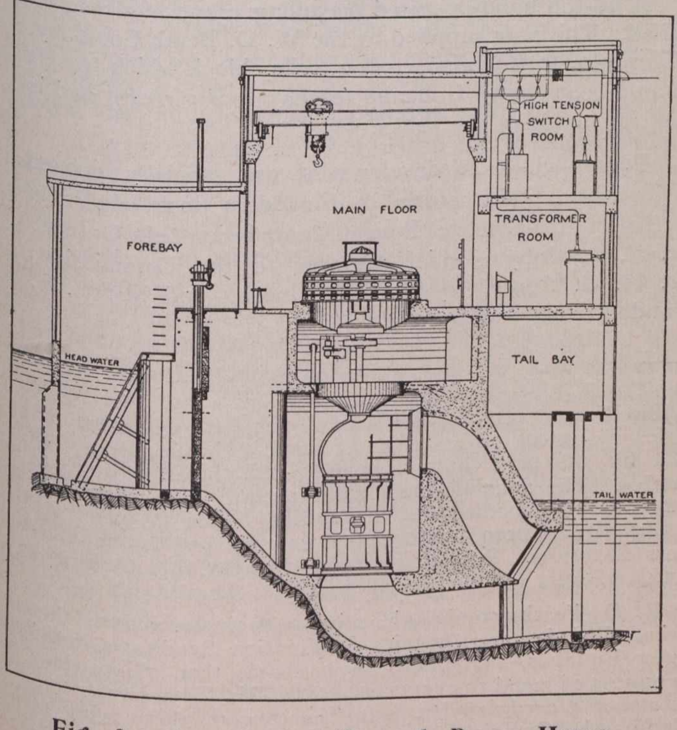

Fig. 6.—Cross-Section Through Power House.

The guaranteed efficiencies for ½, ⅔, ¾, ⅞ and full gate are 75, 80, 83, 85 and 80 per cent. respectively, at 12-foot head. Maximum output, and not efficiency, is the governing factor under low-head conditions, owing to the abundant supply of water then available.

The exciter turbine is of the same general type as the main units, but has a single runner only. It is designed primarily to produce sufficient power for full plant excitation under an 8-foot head. The operating speed is 190 r.p.m. and the ¾ and ⅞ gate efficiencies under normal head are 81 and 83 per cent. respectively.

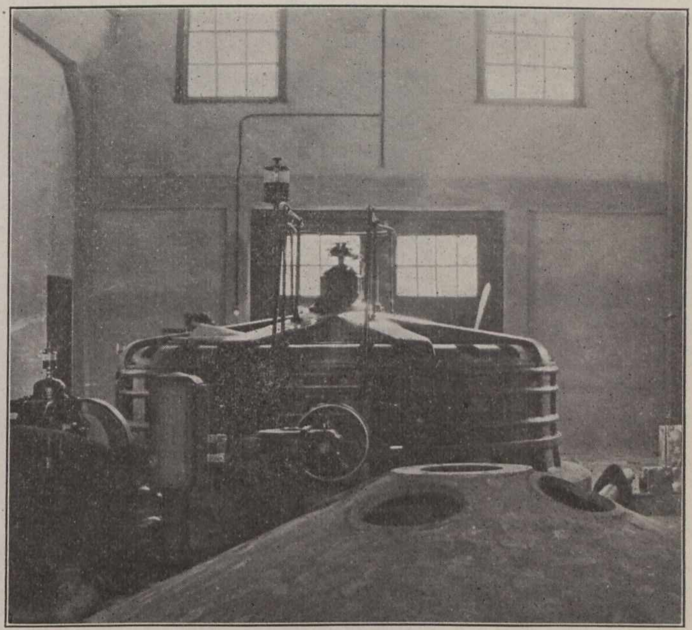

Fig. 7.—Main Generator.

The governors of the main units are of the self-contained oil pressure type, with a hand regulating attachment. Each governor is provided also with an electric servo-motor which enables the operator to make speed adjustments from the switchboard.

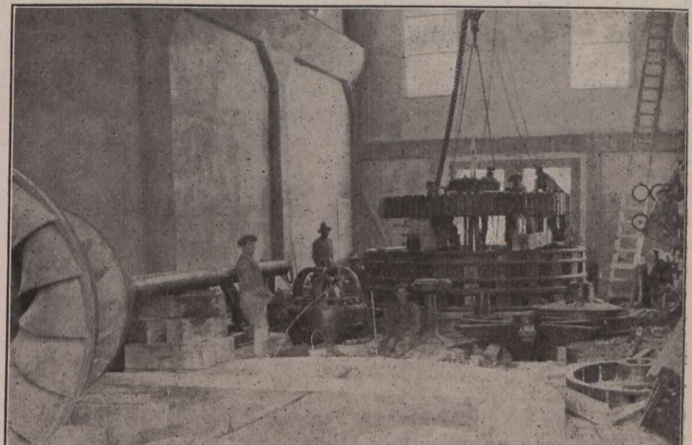

Fig. 8.—Erection of No. 1 Generator. The View Also Shows the Shaft and Lower Runner of No. 2 Turbine.

The governors are adjusted for 1½ seconds closing time and will handle a momentary fluctuation of 25% of full load with a speed variation not exceeding 6½ per cent.

Electrical Equipment.—The main generators and exciting equipment were manufactured and installed by the

Swedish General Electric Company. The equipment supplied under this contract comprised two main generators each of 400 k.v.a. capacity, vertical water-wheel type, 3-phase, 60-cycle, 2,300-volt, 90 r.p.m.; one 20-kw., 125-volt, 190 r.p.m. direct current water-wheel type exciter generator; and one 30-kw. motor generator set.

The total revolving weight of the main generators and exciter is carried on specially designed ball thrust bearings mounted on the top of the generator frame, and connection is made to the turbine shaft by means of flexible couplings.

The transformer and switching equipment was supplied by the Canadian Westinghouse Company. The present transformer installation consists of three single-phase, 60-cycle, 150-k.v.a., oil-insulated, self-cooling transformers wound for 1,900 to 2,500 volts on the low-tension and for 22,000 to 25,000 volts on the high-tension side, both sides being connected in delta. One spare transformer is also supplied.

In the high-tension switching gallery are located two 25,000-volt, 3-pole, remote control oil switches, the high-tension busses, two 25,000-volt electrolytic lightning arresters, and a choke coil on each outgoing line.

Auxiliary Equipment.—The stop-log winch was installed by the Wm. Kennedy Company, of Owen Sound, being their No. 1 type of 17 tons capacity. This winch is at present arranged for hand operation, but is so designed that a motor drive can be added at any time. The head-gate operating mechanisms were also supplied by the Kennedy Company.

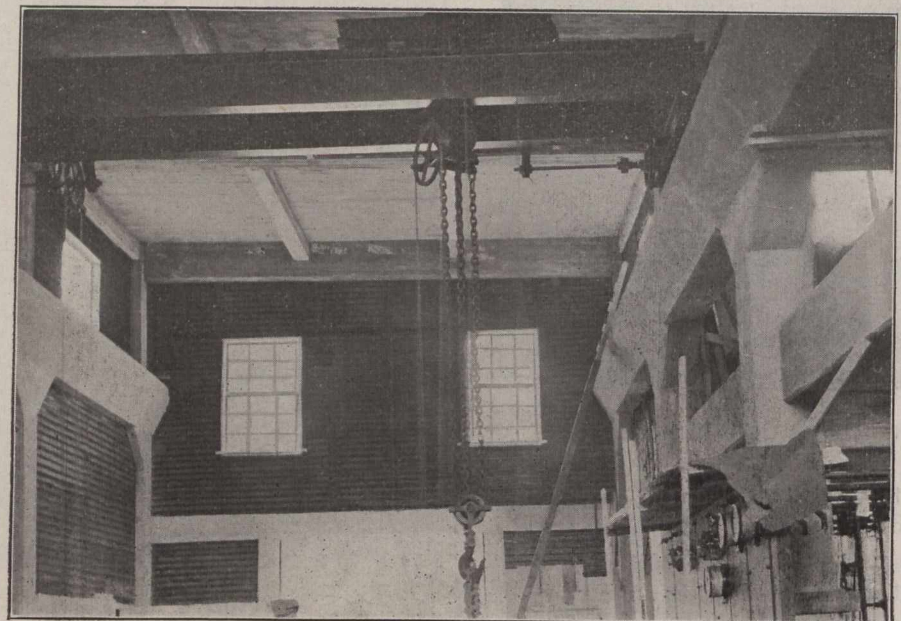

Fig. 9.—Crane Girders and Hy-rib Reinforcement Previous to Plastering.

A 10-ton hand-operated travelling crane has been installed. This was supplied by the W. D. Beath Company, of Toronto, as was also a 1-ton trolley block which travels on an I-beam hung from the forebay roof girders, and is used for handling the racks.

Personnel.—The development was officially opened on Tuesday, October 6th, by Sir Adam Beck, chairman of the Hydro-Electric Power Commission of Ontario. Mr. F. A. Gaby is chief engineer to the Commission; Mr. H. G. Acres, hydraulic engineer; and Mr. E. T. Brandon, electrical engineer.

At the present time there are in India 2,331 miles of railway in course of construction or planned for construction during the year 1914-15. Of this total 1,575 miles are already under way and 856 miles are merely proposed. Of the former 220 miles are being constructed by the state and 1,355 miles by private companies. Of the latter, 173 miles will be constructed by the state and 583 miles by private companies. The total cost of the 2,331 miles of line is estimated at $80,000,000.

Steel railroad ties are being extensively used in Switzerland. At present 65 per cent. of the Federal railways employ them. They have the form or profile of a trough into which shape they are rolled at the mills. The ends are bent down, the profile of the trough being thus closed. Holes are provided for the attachment of the rails by means of clamp plates, and no tie-plates are used under the rails. The weight of the trough profile is 55.47 lbs. per metre; and the ties complete, with holes bored, weigh 159.84 lbs. each. According to the requirements of the Federal railways the steel in these ties must have a tensile strength of about 59,000 to 64,000 lbs. per sq. in., and an entire trough piece shall admit of being bent together on its back without showing any breaking fissures.

Pittsburgh manufacturers have received numerous inquiries for prices on all kinds of steel. The inquiries have come for the most part from England, Japan and South America. The announcement made recently that manganese would be manufactured in the United States to offset the closing of European ports was a welcome one to manufacturers generally. Pittsburgh firms now say that their production of steel will not be hampered by the war.

R. D. Featherstonhaugh, mining engineer, reports that he has filed for the Omenica Exploration Syndicate of the Tegler Building, Edmonton, silver claims that will produce 600 ounces of metal to every ton of ore. Mr. Featherstonhaugh has staked 5 dredging leases for the concern, these being 15 miles on the Omenica River, 5 miles on the Findlay River, and 3 miles on the Ospica River. Three copper and silver claims were also filed at Lake Tacla; 10 mineral claims on Mount Selwyn, located off the banks of the Peace River. According to the engineer, the latter promises to develop into an important and extensive proposition. Anthracite coal claims were also filed upon by Mr. Featherstonhaugh for the Edmonton syndicate, which are so rich that samples have proved to contain 90 per cent. carbon, the richest of the reported anthracite coal claims in the west.

INFORMATION RESPECTING PATENTS OF INVENTION.

A FEW weeks ago a reader of this journal favored us with some useful information as to the position of an applicant for the patent, or a patentee, who has volunteered for active service and is thus unable to attend to the prosecution of his case.

It is generally known that in all patent offices certain rules are laid down restricting the length of time in which certain documents may be filed, renewal fees paid, and so on.

In Great Britain, he stated, an act has now been passed under which the comptroller of patents has the authority to grant extensions of time for the filing of such documents, the duration of such extensions being governed by the particular conditions of the case. This provision is made for the benefit of applicants or patentees who are absent from their country on active service or for any other justifiable reason are prevented from attending to their cases by circumstances arising from the present state of war.

The extension may be also granted when it is shown that the documents could have been filed, but under the circumstances arising from the state of war this would be prejudicial to the rights or interests of the applicant or patentee.

"The provisions apply only to patents in Great Britain and it remains yet to be seen whether a similar act will be passed in Canada and other British possessions.

"The British Patent Office has also made arrangements regarding documents intended for countries at war, in which the lodging of documents may be difficult. These documents should be filed through the British Patent Office, when the comptroller will date-stamp them and retain until such time as conditions would make it safe to forward to their destination. By this means, official evidence will be shown that the papers were duly executed and forwarded for filing on specified dates. Foreign renewal fees, etc., may also be paid in a like manner."

A copy of a special Act which has been passed to govern conditions due to the present trouble in Europe, and applying to patents in Canada, has since been received. Its principal clauses are as follows:

Orders and Regulations respecting patents of invention, made under the "The War Measures Act, 1914."

1. "Commissioner" means Commissioner of Patents and includes the Deputy Commissioner of Patents.

2. The Commissioner may, on the application of any person, and subject to such terms and conditions, if any, as he may think fit, order the avoidance or suspension, in whole or in part, of any patent or license, the person entitled to the benefit of which is the subject of any State at war with His Majesty, and the Commissioner, before granting any such application, may require to be satisfied on the following heads:—

(*a*) That the person entitled to the benefit of such patent or license is the subject of a State of war with His Majesty;

(*b*) That the person applying intends to manufacture or cause to be manufactured, the patented article, or to carry on, or cause to be carried on, the patented process within the Dominion of Canada;

(*c*) That it is in the general interests of the country or of a section of the community, or of a trade, that such article should be manufactured or such process carried on as aforesaid.

The fee payable on such application shall be ten dollars.

The Commissioner may at any time, in his absolute discretion, revoke any avoidance or suspension of any patent or license ordered by him, but if any person during the period of such avoidance or suspension begins to manufacture, use or sell in Canada the invention covered by said patent, such person may continue to manufacture, use or sell such invention in as full and ample a manner as if such revocation had not been made.

Provided always that the Commissioner may at any time, if in his absolute discretion he deem it expedient in the public interest, order the avoidance or suspension in whole or in part of any such patent or license upon such terms and conditions, if any, as he may think fit.

3. The Commissioner may, at any time during the continuance of these Orders and Regulations, avoid or suspend any proceedings on any application made under the Patent Act by a subject of any State at war with His Majesty.

4. The Commissioner may also, at any time, during the continuance of these Orders and Regulations, extend the time prescribed by the Patent Act or any rules made thereunder, for doing any act or filing any document, upon such terms and subject to such conditions as he may think fit in the following cases, namely:—

(*a*) Where it is shown to his satisfaction that the applicant, patentee, or proprietor, as the case may be, was prevented from doing the said act, or filing the said document, by reason of active service or enforced absence from this country, or any other circumstances arising from the present state of war, which, in the opinion of the Commissioner, would justify such extension.

(*b*) Where the doing of any act would, by reason of the circumstances arising from the present state of war, be prejudical or injurious to the rights or interests of anv applicant, patentee or proprietor as aforesaid.

Such extension of any prescribed time, if granted after its expiration, shall have the same effect as if granted prior thereto, provided such expiration occurred on or after the fourth day of August, 1914.

5. The Commissioner may refuse to register the assignment of any patent made by a subject of any State at war with His Majesty, and filed in the Patent Office on or after the fourth day of August, 1914, unless satisfied that such assignment was made in good faith and not for the purpose of evading any of the provisions of the foregoing Orders and Regulations.

CEMENT USED IN TURKEY.

Cement is scarcely known in Turkey, but very good results are said to be given by a substitute consisting of slaked lime, linseed oil, and cotton fiber. The oil being poured on a small quantity of cotton and the lime dusted in, the mixture is kneeded thoroughly. The dough-like mass is used for filling crevices in water-pipes, covering cracks in stone floors, and for various other purposes. The material resists water, though it must be thoroughly dry before submerging.

The Taghum bridge, an ordinary type steel highway bridge over the Kootenay River, about five miles from Nelson, B.C., has recently been completed. The structure consists of three steel truss spans and two girder spans, supported on concrete piers and abutments. The bridge was designed by the Public Works Department of the Province of British Columbia and was erected for the Government by Hodgson, King and McPhalen Brothers, of Vancouver, at a cost of approximately $100,000. On account of difficulties in erecting the falsework, occasioned by the swift current of the river, so much time was lost in the early stages of the work that the contractors were obliged to employ three shifts of eight hours each in order to complete the structure before the coming of the spring freshets.

WIRELESS STATION AT NEWCASTLE, N.B.

THE most powerful wireless station in the world is just being completed at Newcastle, N.B. Its main tower is 500 ft. in height and is surrounded by six 300-ft. auxiliaries. The antenna forming the network around these towers comprise 120,000 ft. of silicon bronze wire, while over 140,000 ft. of wire have been laid in trenches around the station to secure proper ground connections. The operating house is at the base of the main steel tower, while the power house is situated outside of the line of towers. The latter is equipped with two 225 h.p. motors direct connected to two 1,000-volt d.c. generators. The total cost of the station is about $175,000. The sending and receiving instruments which are of the type known as the Poulsen System, were manufactured in Copenhagen, Denmark. The distance across the Atlantic to the corresponding station at Ballybunion, Ireland, is about 2,700 miles.

It may be stated that among wireless systems now in use are the Marconi, Poulsen, Goldschmidt, Lodge-Muirhead, Slabyarco, Braun-Sienens-Halske, Braney-Popp, Rochefort, Dueretet Popoff and the Guarini.

The system used in Newcastle was invented in 1905 by Dr. Poulsen, a Danish scientist, and while fundamentally like the other systems, differs materially in many essential features. The Marconi system makes signals by closing and breaking on electric circuit. Every dot and dash signal represents an independent electric current impulse transmitted through the air. The Poulsen system makes signals by varying—at the will of the sending operator—the electric wave length in a continuous current. The Marconi system opens the line of transmission for each separate signal. The Poulsen system opens the line once and keeps it open by continuous electric impulses, while the signals are being transmitted.

In the Marconi system, the question whether these intermittent waves sent out reach a certain point depends upon the energy of each initial impulse. In the Poulsen system the waves not all preserve their original form, but as the energy is being sent out constantly, one wave reinforces the other. This system operates night and day with the same efficiency, sunlight having very slight effect on transmission. A drawback to which other systems are subject is their efficiency—as far as distance is concerned—is three or four times greater at night than in the day time. Stations that can reach a ship 1,000 or 2,000 miles at night cannot reach over 200 or 300 in the day time. This is caused by the electrification of the ether by the sun's rays, which presumably makes it more difficult for the artificially created waves to travel through the ether, and also causes a greater absorption of energy by the earth.

Duplex sending and receiving have been accomplished by this system, which means that two messages can be sent or received by the same antenna simultaneously.

The commercial speed expected from the wireless station at Newcastle is 150 words a minute, while the greatest speed worked by cables across the Atlantic is 50 words a minute.

The Washington bureau of statistics of the American Iron and Steel Institute gives the production of all classes of ingots and castings in Canada in 1913 as 1,042,503 tons, an increase of 189,472 tons over the previous year. All kinds of finished rolled iron and steel produced are placed at 867,097 tons against 861,224 tons the year before. Pig iron production in Canada for the first six months of 1914 is placed at 442,430 tons against 469,137 tons for the last half of 1913.

PAVEMENT ECONOMY.*

THE economical pavement is a subject of much discussion, but like the proverbial fountain of youth it still remains undiscovered. Many claims have been made for the different types of pavements on the market and almost any promoter, material man or contractor, believes that he can, if given the proper amount of time, convince you that his is the only economical pavement. The truly economical pavement is the one best suited to meet the local conditions which will withstand the ravages of time and traffic with the least possible maintenance, first cost considered.

The old Roman roads with their foundations two or three feet, and in some cases as much as six feet in thickness, were economical roads and pavements for their time, for they not only met the conditions of their time, but have stood the traffic of centuries. To build a Roman road in modern times, however, would not be economical or wise. An administration attempting to lay a Roman road would probably not only start a vigorous protest of abutting property owners but would find a quick demand for a change in administration. While the history of the old roads of the Roman Empire, France and England, is interesting and they have been of great service in the development of modern type of pavements, they can no longer be used as models.

Americans, with their nervous, progressive and energetic spirit, must solve their own paving and road problems to meet their own particular conditions.

The principal considerations in determining the economical pavement are the traffic and climatic conditions to which the pavement must be subjected, available materials and their cost, assessed valuation of abutting property, and the probable result of the improvement.

Before a pavement is laid the climatic and traffic conditions should be given most serious consideration and should be a big factor in making the final determination. In the large cities where traffic is heavy, granite or wood block are very largely used. This is because these two types of pavement have been found to withstand heavy traffic more satisfactorily. Where the question of excessive noise is not material, the long life and small difference in cost, and the ease of repairs and low cost of maintenance, make granite block the favorite; while on a heavy traffic street lined with office buildings or stores, where the question of noise must be taken into consideration, wood block is constantly increasing in favor. It would be folly indeed to lay a concrete pavement, bituminous or water bound macadam, or any other cheaper type of construction under such conditions. In considering the traffic conditions to which a pavement must be subjected, it is always necessary to take into consideration the probable increase in traffic after the pavement has been laid, and in many instances it is advisable to take traffic census for the proposed improvement. It is not uncommon for the traffic of a road or pavement to double in volume after the improvements are made.

Another very important matter in considering the traffic conditions, is the kind of traffic. Where horse-drawn traffic prevails, a pavement should be made to aid this class of traffic; and where motor traffic prevails, a different type of pavement entirely may prove to be the most economical. Probably one of the best examples of

* Notes from a paper read by H. B. Pullar, Engineering Chemist, Detroit, before a recent meeting of the League of Michigan Municipalities.

this kind can be cited in Wayne County, Michigan. Almost everybody interested in paving has heard more or less favorable comments as to this large mileage of concrete roads. The traffic on the Wayne County roads has been reported as being over 80 per cent. motor traffic, and a large per cent. of this motor traffic is pleasure vehicles. The roads are and have been constructed by the most up-to-date methods and repairs are made immediately any defects appear. Were these conditions reversed, and the concrete roads in Wayne County compelled to withstand over 80 per cent. of horse-drawn traffic or even a much higher per cent. of heavy commercial car traffic, they would probably not prove to be the most economical, and the reported low cost for repairs and maintenance would be considerably increased.

Climatic conditions should be given consideration when determining upon the most suitable type of pavement. In England it was found that asphalt pavements laid similar to those in America deteriorated rapidly, and the cause was found to be the heavy fogs. A higher percentage of asphalt was used to overcome this trouble and more successful results were obtained. The southern part of this country requires a bituminous material of different consistency than that used in the northern section.

Bituminous pavements to give most successful results must have suitable drainage, and while this is true of other pavements it is specially true of all bituminous work. The climatic conditions of Michigan permit the use of many and various types of pavements, and they are not as important a matter as in other parts of the country.

The availability of materials is often given but slight consideration in determining the type of pavement to be constructed, and yet it is of the utmost importance in some localities. Where good sand is available at a low cost and where other conditions are equal, how foolish it is to import brick from another state in preference to laying sheet asphalt pavement, which is composed of about 80 per cent. of sand, whereas the reverse would be true if it were necessary to import sand into a town in which there is a brick plant turning out high quality brick. There are conditions in different cities which make it advisable, even at a much higher cost, to favor one type of pavement over another, but where the truly economical pavement is desired and other conditions are equal, the availability of materials should be given careful consideration.

In determining the most economical pavement the assessed valuation of the property is too often considered to be of minor importance, and politics and real estate promoters are frequently the cause of sheet asphalt pavements being laid out in the country, while the old unreliable water-bound macadam pavement remains in the heart of the city. We find many instances where wooden block pavements are laid on light traffic residence streets with heavy assessments made against the abutting property owners, who can ill afford them, while in the main business strees a cheaper type of construction is used with a heavy maintenance coming out of the general taxation fund. This practice is certainly contrary to all ideas of economy, and there has been much waste of public funds in cities where such conditions exist. A careful consideration of the needs of a street and the assessed valuation of the abutting property will not only result in better streets, but will cause a much lower general maintenance charge on all paving in the city and a more equal and just distribution of the paving fund.

The medical profession, with its great scientists and students, is continually finding new cures for what have been previously considered incurable diseases. Likewise the engineering profession, by its scientific studies and research work, will continue to overcome the numerous and difficult problems of paving construction. The economical type of pavement is distinctly an engineering problem and its solution for any particular street or locality will depend upon the efficiency of your engineer. The time is coming when the city engineer will be given more authority to direct and more opportunity to study and work out to advantage his paving problems. A successful manufacturer would soon lose his business and turn his dividends into losses were he to employ a new superintendent each year; as he would, also, if he should employ a capable superintendent to look after his business and then only spasmodically assist him in his work, or fail to give him authority to go ahead. So the choice of the economical pavement must be left with a capable engineer, receiving a big compensation and with full authority to direct his work, and in this he should receive the co-operation and help of all officials and citizens.

While I have endeavored to give you a general idea as to some of the important features to be taken into consideration when deciding upon the economical pavement for your city or town, I will endeavor to give you a short description and history of what we believe to be one of the coming types of economical bituminous construction. This is known as the open type of asphalt or bituminous concrete.

With the advent of the automobile and the demand for a more permanent type of construction than the water-bound macadam, the bituminous macadam laid by the penetration method was one of the first to be considered and has been most extensively used. For a time it seemed to have solved the problem, but failures have been too frequent and costly. While there are many good bituminous macadam roads which were constructed by the penetration method, the many small details which must be carefully looked after in order to get successful results have made the proportionate chances of failure so numerous that it is always with more or less uncertainty of results that a penetration job is constructed. The principal causes of the failure of bituminous pavements laid by the penetration method are the impossibility of thoroughly coating each particle of stone and the segregation of the stone, making it impossible to obtain an even distribution of the bituminous material. The result of this is that there are numerous spaces in the road which allow water to penetrate, causing the pavement to disintegrate rapidly.

Another type of bituminous pavement which has found great favor, is the bituminous concrete, which is a mixture of asphalt, sand and stone. This type of pavement would find greater favor were it not for the fact that certain patents to cover practically all mixtures of stone and sand have been held valid in some of the courts; and on account of the undesirability of getting into any patent litigation cities have hesitated in adopting this type of construction.

Because of the uncertainty as to the results obtained from the penetration work and because of the desirability of getting a cheaper type of bituminous pavement than the asphaltic concrete or sheet asphalt, the open type of asphaltic or bituminous concrete has been developed and has met with much favor in different sections of the country. This type of pavement, however, is not a new one, having been used many years ago with a tar binder. The pavement consists of a mixture of stone and bituminous cement acting as a binding medium.

The stone is heated to a suitable degree of temperature, depending upon the bituminous material used, and then mixed with bituminous binder in suitable proportions. It is laid similar to sheet asphalt or asphaltic concrete. The mixture is laid from 2 to 3 inches in thickness and properly rolled. After rolling there is applied a squeegee coat of pure asphalt cement and while the coating is still hot stone chips are thrown over the surface. The whole pavement is then re-rolled so the squeegee coat is forced into the voids, making a tight, uniform, waterproof and durable surface. Heating the stone and then mixing in asphalt so that each particle is thoroughly coated, prevents the trouble which causes so many failures in the penetration method and prevents any segregation of stone.

The city of Lansing last year tried out this type of pavement on some of the principal streets with excellent results at a very low cost. On account of the results obtained the State Highway Department of Michigan will put in a strip of this same type of pavement in Oakland County, which is an extension of the Woodward Avenue pavement of Detroit. This section of pavement will join the concrete road of Wayne County and will afford an excellent opportunity for a comparison of the two different types for the same traffic. There are a number of other cities in the state which have already laid considerable yardage of this open type, and which contemplate laying in the future a large amount of this work.

The open type of asphaltic concrete pavement is free from infringing on any patents, thus removing any cause for litigation. Although there are about 35 per cent. of voids in the mix as it comes from the mixer the stones key in together giving the wearing surface stability, thus preventing shoving and rutting. In fact, the finished pavement is similar to water-bound macadam with the exception that each stone is bound together with asphalt cement. The asphalt cement prevents any dislodgement of the stone from either horse-drawn or motor traffic.

The first cost of this pavement is very nominal compared with other types, being slightly higher than that of the penetration and considerably less than the closed type of bituminous concrete or sheet asphalt. With average conditions these pavements can be laid by contractors for from $1.10 to $1.40 per square yard, including 6-inch concrete foundation, but if the pavement is put in by the day labor plan, under the supervision of the city engineer, the cost should be considerably lower. In fact, I believe the total cost of the paving at Lansing did not exceed $1.10 per square yard, and the city used crushed cobble stone instead of limestone, which added considerably to the expense.

The open type asphaltic concrete pavement after traffic has been on it for some time looks almost the same as the closed type, or like bitulithic. It is easy to repair, pleasing in appearance and makes a sanitary and noiseless pavement. There are many cities and towns throughout Michigan, especially in the residential sections, where this type of construction would be advisable. I think it would prove to be the economical pavement and I believe that it will constantly grow in favor with engineers and officials in charge of paving work.

There is another item to be taken into consideration in discussing the economical pavement. No type of construction and no materials, no matter how high the quality or how successful they have been in other places, will be satisfactory in any locality unless they are properly constructed. Just because a pavement or a particular type of construction has given successful results in one town or one locality is no indication that it will be equally successful in your city or town unless every precaution is taken to see that the numerous small but important details are carefully looked after. The best of materials cannot give good results unless properly handled, while better results can be obtained with poor materials properly applied.

It is not, by any means, always economical to award contract to the lowest bidder and a difference of 5, 10, or even 25 or 50 cents per square yard in the original cost may in the end prove most economical.

In conclusion, I would state that the economical pavement of to-day is not any particular type or any particular material, nor is it a pavement put in at any particular cost. It is a pavement carefully selected after an exhaustive preliminary examination by an efficient engineer to best meet the demands of the particular locality in which it is to be constructed. It is a pavement laid in direct accordance with the requirements of carefully prepared specifications, which should be reasonable and just to both the city and contractor. It is a pavement in which only the most suitable available materials for its particular type of construction are used; a pavement laid under the direction of an efficient and capable engineer, with authority to direct and supervise the many details of construction and to appoint inspectors for their efficiency and ability to carry out his orders, rather than for their ability to obtain votes at the next election. The city or town in which this condition exists, while it may continue to have a failure now and then, and while it may not find the one economical pavement, will come nearer to solving the problem and satisfying the taxpayers, to whom all public officials in the end must look for commendation.

WATER RIGHTS LAW PROBLEM.

The American Society of Civil Engineers has recently appointed a special committee, composed of eminent engineers, to ascertain the need for a national water law in the United States to protect existing rights and future engineering developments from interstate difficulties.

The enumeration of possible difficulties, as prepared by this committee, is of interest in Canada, where some of them may exist as interprovincial difficulties. Some of the interstate difficulties may be caused as follows:

1. From taking water across state lines;

2. From the use of water in an upper state which may jeopardize the quantity and quality for use in a lower state;

3. From approximations on border streams where the controlling works are in two states;

4. From the storage of water in an upper state for transit in stream channels through several states and use for navigation, power, etc., at the lower end of the stream;

5. Because of judicial decisions in one state prohibiting the diversion of water from one drainage basin into another, or across state lines;

6. From the construction of unsafe works in one state which menace lives and property in adjoining states;

7. From the drainage of swamps or lakes in one state which removes the natural regulation of flow and which may cause destructive floods in adjoining states;

8. From the pollution of water in one state to the detriment of lower states;

9. Because of international treaties and controversies where state or federal jurisdiction is questionable.

THE MECHANICS OF REINFORCED CONCRETE UNDER FLEXURE IN BEAM AND SLAB TYPES.*

By C. A. P. Turner, M.Am.Soc.C.E.

THE co-operation or combined action of the two materials, concrete and steel, to resist bending, depends solely on the bond between the two. In the case of plain rods this bond is in reality a shrinkage grip which prevents the steel from sliding through the hardened matrix in which it is embedded and the resistance afforded is subject to well-defined laws which may be stated as follows:

The bond shear is zero wherever the tension in the steel is constant. It passes through zero where the increment of the moment passes through a maximum or minimum. It must be depended upon whether the reinforcement is in one direction only as in a beam, or in multiple directions in the slab.

Bond shear generates stresses emanating from the surface of the bars which may be treated as lines of force. These lines of force follow the general laws of distribution of force through any medium; that is, their intensity is inversely as the square of the distance from the surface of the steel on which they are generated.

These general laws enable us to investigate or follow out the part played by bond shear in the mechanics of a slab or beam. In the case of a simple beam, in accordance with the law stated, the intensity of the bond shear is zero at the centre for uniform load and a maximum toward the end of the beam, and it is the bond shear or the lines of force generated thereby to which we may attribute the difference in the failures of an over- and an under-reinforced beam. In the case of the beam with light reinforcement, failure takes place at the centre by the yielding of the steel. With heavier reinforcement, however, failure is more liable to occur toward the end by diagonal tension induced by web stresses, which are greater toward the ends of the beam and which may rupture the concrete across the lines of tension in it. Perhaps the largest part of these web stresses originate in the bond shear at the surface of the reinforcement.

The deportment of the simple beam as affected by the stresses set up by the bond shear is of interest. In a newly cast beam, in the preliminary stages of the loading, the stress in the steel, as determined by the extensometer, is much less than that figured on the assumption that the steel only resists tension. In fact, it is only about one-half as great as we should compute the stress to be on that basis, until the steel is stressed up to four or five thousand pounds per square inch. When this point has been reached there is a rapid increase in the stress in the steel, with no corresponding increase in the load until, when the steel is stressed up to twelve or fifteen thousand pounds per square inch, the concrete has relieved itself of a large portion of its tensile resistance and the measured stress in the steel corresponds closely to the computed stress in the steel, assuming that the steel is not assisted by the concrete in tension.

With the slab reinforced in two directions, however, the phenomenon differs from that observed in the beam. Take for example the case of such a slab, bent in such manner that the rods in both directions are brought into tension at the same time. The indirect stresses generated by the two sets of rods will, under this condition, react upon each other, since the lines of force diverge from each rod they may meet, and coact through the concrete as a medium of transmission of the stress, which is not possible in the beam with one-way reinforcement, since in the beam these stresses cannot coact with each other, there being one kind only, and not two kinds acting in different directions. This fundamental difference in the induced stress generated by the bond shear in the case of a beam and slab render the two types of structure mechanically different, and necessitates their treatment in a manner which takes into consideration the difference in the mechanical operation of the indirect stresses referred to.

A crack in the slab would not materially interfere with the operation of these indirect stresses in each segment of the multiple-way reinforced slab, while a crack in a beam normal to the direction of the steel would intercept any indirect tensions induced by the bond shear at the section checked, and prevent the accumulated resistance afforded by these indirect stresses from being effective in direct resistance to moment.

In treating the combination of the two materials, it has been customary to consider their combined action as determined by the elastic properties of each taken separately, that is, by considering the ratio of the modulus of elasticity of the concrete in compression and tension to the modulus of elasticity of the steel in tension and compression. In a homogeneous elastic slab, such as steel in the form of a plate, there would be taken into consideration in addition to the modulus of elasticity of the metal in tension and compression in one direction, the additional coefficient of modulus of lateral deformation known as Poisson's ratio. This ratio, or lateral effect, in a combination of steel and concrete which is sufficiently fine-grained to be regarded as acting like a homogeneous material, as is the case with reinforced concrete slabs, cannot be correctly considered as an elastic property of either the concrete or the metal, but on the contrary must be treated as a coefficient expressing the efficiency of the lateral action of the indirect stresses induced by the bond shear in the case of multiple way-reinforcement in the slab, which coefficient, for the reasons above explained, must be zero in the case of the beam type, with reinforcement in but one direction, or the case of the slab in which the reinforcement under strain runs in but one direction only. Although transverse reinforcement mav be introduced in a beam, it can perform no useful function in reducing the stress on the carrying-rods, since the indirect stress induced by one series of rods under strain cannot converge to react upon another set of rods not under stress, but can react with that set of rods only when both are generating indirect lines of force arising from bond shear.

The indirect stress from bond shear to be depended upon must react upon other indirect stress and be held in equilibrium by these stresses generated by the steel. Otherwise, we are depending upon the direct tensile resistance of the concrete for bending, which is not considered permissible by those experienced in reinforced concrete design.

In the case of the beam with one-way reinforcement, there is no way for these stresses to react upon each other and be held in equilibrium by each other. The slab, however, furnishes a condition by which this desirable end is obtained.

The law governing the generation of bond shear indicates clearly that if this element of strength is to be

*Read before the Boston Society of Civil Engineers, on September 16, 1914.

utilized, wide-spreading reinforcement must be used. Otherwise, its efficiency is negligible. This law eliminates from consideration as an economic and successful flat slab, any arrangement of narrow belts or strips of reinforcement in a flat slab of uniform thickness which does not permit, by virtue of the arrangement, efficient operation of the forces outlined.

That the performance of a flat slab with multiple-way reinforcement is essentially different from the mechanical operation of one-way reinforcement in a beam is apparent if we consider that as a mechanism its operation is governed by the fundamental law known as the law of conservation of energy and its various corollaries. As a substantially elastic structure—and we are dealing with an elastic theory—the external work of the load must equal the internal work of deformation. It is true, of course, that the slab is not perfectly elastic because of shrinkage stresses, and because the concrete does not completely fulfil the conditions of a perfectly homogeneous elastic solid, but when the slab is thoroughly cured and of good concrete, its deportment for practical purposes may be treated on this basis.

The utility of the flat slab, as compared with beam construction, depends on lateral resistence, enabling the same resistance to be secured with a smaller thickness.

"The external work of the load equals the internal work of deformation, or the product of the force multiplied by the distance through which it moves is a measure of the internal work of resistance of the structure withstanding this force."

This statement (Clapeyron's Theorem, 1866) gives a basis for ascertaining the manner of the storage of potential energy in a reinforced concrete structure by which can be demonstrated the difference between the circumferential cantilever action, as in a Turner slab, and the lineal cantilever action, such as that of Hennebique, of the beam type. In considering this matter we will assume a Hennebique structure with the slab of the same thickness as the Turner floor-slab, and assume the same amount of cross-section of steel in the two cases.

Since the steel runs in multiple directions in the belts of Turner, having substantially uniform spacing, and since the material is strained circumferentially as well as radially, and in such a way that the circumferential and radial deformation must, from the geometry of the slab, be equal, it can be shown that the energy stored circumferentially about the cantilever head in the belts of rods is equal to that which is stored radially. Now if half our energy is stored circumferentially and half radially, it is evident that while the circumferential deformations are coincident with, and their magnitude dependent on, the radial deformations, it is the radial deformations or extensions along a meridian line which determines the vertical geometry of the slab. In other words, as half our energy is stored circumferentially, we have established a different method of storage of energy in the circumferential cantilever of Turner from the lineal cantilever of Hennebique. In the lineal cantilever no energy can be stored circumferentially, because the steel does not run in that direction; there is no reservoir, so to speak, in which to store it.

Suppose we assume that the same quantity of energy (symbolizing it by Q) is stored in each respective structure. Then, if the load be applied gradually, and we use W_1 to represent the load and H_1 the mean deflection of the lineal cantilever, we have

$$Q = \frac{1}{2} W_1 H_1 = \frac{1}{2} W_2 H_2,$$

W_2 and H_2 referring to the load and the deflection, respectively, of the circumferential cantilever. Now, if half the energy in the circumferential cantilever is stored circumferentially, and half radially, and that stored circumferentially produces no deflection, then $H_2 = \frac{1}{2} H_1$. That is, the mean deflection of the circumferential cantilever, represented by H_2, is only one-half the mean deflection of the lineal cantilever, represented by H_1. Likewise, Q being the same for each, $W_2 = 2 W_1$. But if we assume for purposes of closer comparison that the deflection be the same with each, instead of the quantity of energy stored being the same in each, then W_2 (the load of the circumferential cantilever) must equal $4 W_1$ or it will require *four* times the load to produce the same deflection with a circumferential cantilever, it being assumed, of course, that the same amount of steel is used that it will require with a linear cantilever in each, and that the same depth of slab is employed.

From this relation of the storage of energy, it is evident that a circumferential cantilever and suspended span slab of half the thickness will present the same rigidity as a continuous beam construction of double the depth, being a measure of the difference in deportment of beam action and slab action.

Bending Moments.—Regardless of the manner in which the load is carried to the support, it is an invariable or fundamental law for uniform loading that half the sum of the bending moments over the support, plus that at mid-span, equals a constant, equals $\frac{1}{8} WL$. This is true for a continuous beam, simple beam, a continuous slab, or a simple slab, or one fixed at one end and free at the other. From this relation we would have for a slab of indefinite extent, supported at points, as the magnitude of the moment at the support, $WL/12$, and the moment to be resisted at the centre, $WL/24$, and we are now in position to consider the modification due to the size of the capital. For the usual proportions this would reduce the moments just given to $WL/15$ and $WL/30$, respectively, for a single panel, but in the cantilever portion about the column these external moments or apparent moments, as Dr. Eddy treats them, are resisted in two ways—by true moments, in the steel radially, assisted by the bond shears coacting with each other and by true moments in the steel circumferentially, also assisted by the bond shear. Thus the radial moment in a line at the critical section about the cap to be resisted would be $WL/30$, which in the mushroom type is provided for by the combined radial rods and slab rods.

In the discussion thus far I have dealt generally with slabs of uniform thickness, and it is in order now to make a few remarks applicable to slabs not presenting this characteristic—that is, with a thickening up of the concrete at the column.

The general principle of rigidities must apply to this case. This principle may be stated as follows:

Where there are two or more paths by which the load may travel to the support, the load divides itself between the paths in proportion to their rigidities.

Increase of the rigidity of the cantilever portion throws the line of inflection outward, increasing the moment at the support and decreasing the moment at mid-span to the extent that the load is a balanced load and the column rigidity permits its action in this manner. As the writer views this modification of the slab, it is not an altogether desirable modification, for the reason that it involves increased bending at the column, a large increase in the apparent moment to be resisted over the support, decreased toughness and ability to resist unbalanced load.

I have pointed out the comparative stiffness and strength of a linear cantilever and a circumferential cantilever. It is next in order to show that in the suspended span-portion covered by crossed belts in a diagonal direction, the same relation holds true because of coaction between the two belts. In the direct belt there is no such action at the centre. The moment there, however, is reduced by the stress in the diagonal belt crossing and assisting it where there are four belts used. This assistance in the standard mushroom design with the proper width of belt, half the distance between columns will amount to practically six- to seven-tenths of the efficiency of the direct belt, so it is evident that, if the diagonal reinforcement is to be eliminated, the side-belts must be increased very largely or to nearly double the cross-sectional area required for the four-way system. This increase is brought about not only by reason of the relation just pointed out, but for the further reason that with a four-way arrangement, the resistance to circumferential stress by the steel is more complete than with a two-way arrangement.

In a short paper of this kind, a complete discussion of all phases of the problem would be beyond its scope. To point out the fundamental difference between beam action and slab action and to offer a simple explanation thereof is the object which has been aimed at. Of the large amount of work which has been constructed giving perfect satisfaction, there is required some explanation more consistent and rational than to say that the uncertain and unreliable tensile strength of the concrete has brought about such satisfactory result. For those who are inclined to consider that the direct tensile strength of the concrete can be credited with these results, such experiments as the writer has made, in which the slab when loaded carries the load by concrete tension very well at first but in the course of a week or ten days failed completely under the load, would carry conviction to those who would take the time to investigate. The difficulty, as the writer views it, of arriving at a scientific analysis of the slab, has been the confusion of the properties of a composite material with those of a homogeneous elastic body.

Reinforced concrete is not a homogeneous material, but consists of radically different elements, steel and concrete. The properties of these materials are radically different. They work together only by virtue of the bond shear or shrinkage grip between the two, and it is the property of this connecting link or lateral efficiency thereof which has been successfully treated as Poisson's ratio by Dr. Eddy in his mathematical analysis of the continuous flat plate.

The Poisson ratio with which Dr. Eddy deals, as I understand it, is not a property of either concrete or steel, and has absolutely no relation to any property of the two materials, but is nothing more nor less than the coefficient of the lateral efficiency of the indirect stresses induced by bond shear in their coaction with each other, which coaction occurs in such manner that the direct tensile strength of the concrete is not overtaxed, as would be the case where dependence is placed upon the energy stored by indirect stress in a one-way reinforced beam.

The difference in operation of one-way and two-way structures as machines for storing up of the energy developed by the load in its descent during deflection of the slab, is of interest. In a newly cast beam, the deflection for small loads is much less than we would figure by the ordinary theory. The energy stored by the indirect stresses arising from bond shear in tension, however, is not stored in a stable manner, because the concrete soon becomes overtaxed or cracks, and energy thus stored leaks away and is dissipated. Further energy is developed by the load in its future descent through increased deflection, which is stored in turn by the steel. This phenomenon is sometimes incorrectly described as the concrete relieving itself of the stress and throwing it upon the steel. As a matter of fact, no such interchange occurs. The energy stored in the concrete is lost and dissipated and new energy is developed by the load in its descent through increased deflection, which energy is stored up in the steel in a dependable manner. In the slab, on the contrary, where energy is stored by the coaction of one set of indirect stresses with another, the storage is a dependable one, for the reason that these stresses are not cumulative, since they are merely transferred through one set of rods to the other through the concrete as a conductor, and do not have any cumulative effect on the structure, as in one-way reinforcement.

Certainly a theory such as that of Dr. Eddy, which enables us to compute deflections accurately, and which gives the steel stress in accord with experiment, cannot be lightly dismissed, no matter with what disfavor Poisson's ratio, the basis of the computation, may be viewed.

In conclusion, I believe that a clean-cut understanding of the nature of the fundamental relations which I have pointed out may help clear up some of the mystery with which slab design has been obscured, and that a more complete discussion of the fundamental laws of mechanics applicable thereto will eliminate the many errors and inconsistencies in its design into which those have fallen who have given the subject insufficient study. One of the gravest mistakes and the most common one, has been that of using too high a percentage of steel, with the confident belief that this excess of steel would add materially to the strength of the structure. The performance of the scientifically designed flat slab under test, places the burden of proof upon the critic, to show wherein the method of design is in error, and it would seem that thus far all criticism of the successful flat slab had been based upon the gratuitous assumption that reinforced concrete is such an anomalous mechanism that its operation as a machine is totally independent of the law of conservation of energy and the principles of least work. Further, our critics would have us believe that its innumerable manifestations of strength should cause us to lose all confidence in the dependence usually placed on the law of gravitation as a proper basis for load tests.

Treating the scientific flat slab as a machine on the theory of work, we can readily check up Dr. Eddy's conclusions regarding the performance of the machine in respect to its deflection. We have shown that the circumferential cantilever is four times as stiff as the linear cantilever. Now the successful flat slab is a continuous construction and it would be four times as stiff as the continuous beam. The continuous beam, in turn, is five times as stiff as the simple beam. Hence, the continuous flat plate is twenty times as stiff as the simple flat plate, but in order to build a flat slab supported on columns we have to have support of, generally, two-tenths of the span in diameter. This reduction of the span to eight-tenths would render the slab forty times as stiff as a simple slab on knife-edge supports, were it not for the fact that the resisting section grows smaller in a continuous slab on posts as the post is approached. This difference reduces the relation from forty to approximately thirty times for the above ratio of metal to span.

It seems to the writer that the average structural engineer in the consideration of his structures, is more inclined to feel that he is dealing with a mere problem of static equilibrium than to consider the structure as a true machine in which all of the elements are put in motion by every change of load.

Looking at it in the true light of its operation as a machine, or mechanism, the theoretical error of disregarding the vital elements or parts of the machine in treating its operation becomes apparent. We would not consider it practical to expect satisfactory operation of an engine with the connecting-rod left off, and why should we consider any theory as applicable to the operation of the flat slab in which the connecting link between the concrete and the steel is left out of consideration? Such a theory must evidently be as unsatisfactory in application as the engine with the connecting-rod removed.

Failure to consider the continuous flat slab as a mechanism accounts for the strange misconception of its character by the great majority of the engineering profession. They look at the commercially successful flat slab as one which is merely flat on top and bottom. Certainly the writer was not a pioneer in flat-slab construction of this ancient and useless variety.

In the construction of the reservoir at Bridgewater, Mass., a slab flat on top and bottom was used, and strips of expanded metal marked "lintels" on the working drawing were stretched from column to column in two directions and expanded metal was spread in the bottom layer. The operation of this structure as a machine, however, would not be the mode of operation which I have outlined by the preceding theory of work. It is a different mechanism entirely. No useful circumferential action could occur in the upper zone about the column, while the difference in rigidity of the expanded metal in the two directions, longitudinally and transversely, would prevent any material circumferential resistance in the bottom between columns. The performance of other slabs, flat in form as machines, may be referred to here.

Mr. George Hill, of New York, in the "Architectural Record" of September, 1902, described the construction of a warehouse with columns 16 feet centres, slab 11 inches thick, designed to carry 400 pounds working load, or 52 tons per panel. Failure occurred under approximately half this supposedly safe load, and the floor is now supported on alternate brick piers and concrete posts 8 feet centres, or nine times as many points of support per panel, 16 feet square about the column, as originally designed.

A reservoir roof on a similar plan was attempted, with columns about 22 feet centres, slab between seven and eight inches thick. Instead of seven posts it now rests securely on somewhat over forty posts.

The performance of these structures as machines when the thickness of the slab is reduced so that stability must depend on the slab action was unsatisfactory, for the reason that the general laws necessary to secure satisfactory results were not complied with. The type of flat slab outlined in Taylor and Thompson's work would come somewhat under the same category as regards width of belt and proper distribution of the material over the columns, to secure the most effective reduction of the radial moment by circumferential action. Its glaring defects in this respect the writer has noted with surprise, but they seem not to be generally appreciated by the profession at large.

To undertake in a short paper the discussion of wall panels, column flexure, and other more intricate phases of the flat slab problem, while as yet the simplest and most elementary form of the problem, the interior panel, is not generally understood, would be, as the writer views it, a waste of effort. When there is more general agreement on the simplest form of the problem, then the more complex and interesting phases of the question are in order for discussion.

OPPORTUNITIES FOR CANADIAN PRODUCTION.

The following is a partial list of articles not manufactured in Canada, but all of which are imported. It has been compiled by the Department of Trade and Commerce, Ottawa, and may serve as suggestions to manufacturers of engineering machinery and equipment.

Asbestos pipe coverings; carbons, electric light; copper tubing, seamless; galvanized wire netting, 14 x 15 gauge; galvanized wire netting, any gauge, ¾ mesh and smaller; miniature electric incandescent lamps; pipe coverings of cork for cold storage insulation; rolled edge steel plates; safety fuses, not metallic; seamless steel boiler tubes; oil engines; sheet copper and seamless copper tubing; sheets, Bessemer; slag trucks; sockets, incandescent for street lamps, 1½-inch inside diameter and over; steam steering engines for equipment of ships; steel squares; telephone carbon protector blocks, carbon discs and glass lenses used in manufacture of telephone; tubing, seamless steel.

PROPOSED EXHIBIT OF U.S. STEEL CORPORATION AT PANAMA PACIFIC INTERNATIONAL EXPOSITION, 1915.

The announcement is made that the United States Steel Corporation and subsidiary companies propose to have a comprehensive exhibit of their operations at the Panama-Pacific Exposition in San Francisco in the year 1915. It will begin with the ore fields and carry on an educational picture of operations in ore mining, rail and water transportation, dock operations, coal, coke and pig-iron production, steel manufacturing in its various lines, and will also present in a displayed way the processes of manufacturing many of the subsidiary companies' products, also how their by-products are utilized, and the display of many of the uses in which their general products are employed, typifying the advancement in the uses of this country's resources. In addition to the material exhibits before mentioned the corporation intend to illustrate in a comprehensive manner, by moving pictures, their operations throughout all departments, showing the ramifications of the processes of the corporation's operations. It is proposed as well to set forth to the world the work which the United States Steel Corporation has done towards the social welfare of its employees and dependants. The corporation will also exhibit many forms of safety devices that have been conceived by its officials and employees, and in the installation of which large sums have been and are being expended. In this social welfare department will also be shown the methods employed by the corporation in the aid and care for the injured, and the welfare of employees' conditions at work and the benefits that are aimed to be afforded to employees at their work and in their surroundings.

MATERIALS AND SUPPLIES FOR SOUTH AMERICA.

United States Consuls reporting on the immediate necessities of Latin countries state that there will be opportunities for the sale of the following: Para, Brazil=cement and manufactured iron; Rio de Janiero, Brazil=cement, hardware, iron and steel wire; Montevideo, Uruguay=cement; Lima, Peru=cement, steel rails, tools, machinery, explosives; Bogota, Colombia=machinery, railroad supplies, engines, cars, rails, bridges.

GRAPHICAL METHOD FOR BEAM DEFLECTION

PRACTICAL SOLUTIONS TO COMPLICATED PROBLEMS IN THE DEFLECTION OF BEAMS, OBTAINED BY THE APPLICATION OF THE FOLLOWING GRAPHICAL METHOD.

By I. F. MORRISON, S.B.,
Department of Structural Engineering, University of Alberta.

The well-known formula for the deflection of a beam (due to the bending moment caused by the load), $\frac{d^2y}{dx^2} = \frac{M}{EI}$, where the values of x are horizontal and those of y vertical, M is the bending moment at any point, and E and I are the usual constants, affords a practical solution of such problems by a graphical method. Except for the simplest cases, the differential equation above is, at best, cumbersome to handle by the calculus, and, therefore, inefficient for practical purposes.

From this equation, $\frac{dy}{dx}$, which represents the slope of the elastic curve of the neutral axis at any point x, equals $\int \frac{Mdx}{EI}$, and y, which represents the vertical deflection at any point x, equals $\iint \frac{Mdx^2}{EI}$. Also observe that $M = \int S\,dx$ and that $y = \iiint \frac{S\,dx^3}{EI}$, where S is the shearing force at x. If E and I are constant the following graphical method will be found valuable for complicated cases:—

Given a 6-in., 12.25-lb. I-beam, with the span and loading shown in Fig. 1, E = 30,000,000 lbs. per sq. in. I = 21.8 inches^4. Required the maximum deflection.

The method is as follows: The shearing force curve was first plotted as shown in Fig. 1, and from this the bending moment curve was obtained as follows: Vertical strips 1 foot wide to scale were taken and the middle ordinate of each strip was laid off on a vertical line at the right-hand end of the beam. The point P was chosen as a convenient pole, and the curve constructed in the same manner as an equilibrium polygon. Note that the edges of the strips were connected by the strings and not the middle ordinates.

Again, taking the middle ordinates of the bending moment curve, in the same way a new curve, the slope curve, is constructed. The ordinates to this curve give the slope at any point. Here, it is to be noted that to draw these curves in their proper position they must be made to conform to certain known conditions. The value of the bending moment is zero at the end of the beam; therefore, its curve must pass through zero at that point. The slope of the deflection curve is zero at the middle of the beam; therefore the slope curve must pass through zero at that point; and it has been so drawn. Finally, from the slope curve the deflection curve has been drawn in the same way, passing through zero at the ends of the beam, because the deflection here is known to be zero from the conditions of the problem.

Care must be taken with the scales, but there is no difficulty involved if they are put down as follows:—

First Scale: Horizontal, 1 in. = 2 ft.; vertical, 1 in. = 500 lbs.; pole distance = 6 ft.

For the Second Scale multiply the pole distance into the vertical scale of the First Scale.

Vertical, 1 in. = 3,000 foot-pounds.
Pole distance = 6 feet.

In the Third Scale the vertical is obtained in the same way.

Vertical, 1 in. = 18,000 pound-feet^2.
Pole distance = 6 feet.

For the Fourth Scale, the vertical scale,
1 in. = 108,000 pound-feet^3.

The deflection at any point is now obtained by scaling the vertical ordinate at the point to the deflection curve in inches (use a scale graduated to 100ths of an inch). Multiply this by 108,000 ft.-pds. and by 12 to

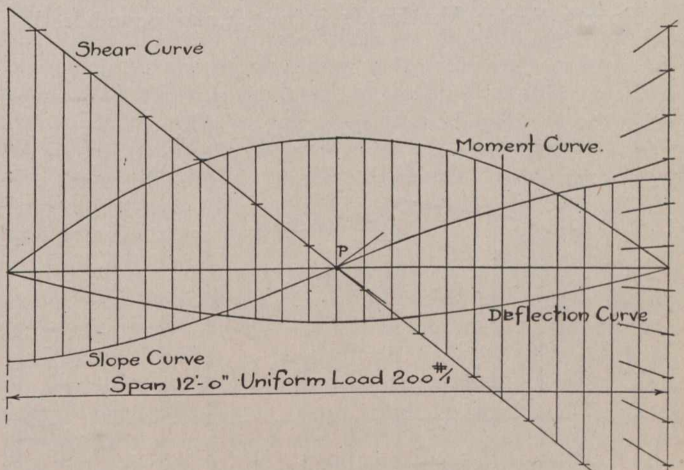

Fig. 1.

obtain the deflection in inches. The product EI in the denominator must also be inserted.

The results for this case are as follows:—

Scaled maximum ordinate on the deflection curve at centre = .50 inches.

$$\text{Deflection, } \frac{108,000. \times .50 \times 12^3}{30,000,000. \times 21.8} = .1427 \text{ inches.}$$

From the formula—

$$\text{Deflection, } \frac{5 \times 200. \times 12^4 \times 12^3}{384. \times 30,000,000. \times 21.8} = .1429 \text{ inches.}$$

Such extreme accuracy as this is due more to good fortune than to anything else, but it goes to show that the results so obtained are sufficiently accurate for practical purposes.

Let it be required to find the deflection of any point, "a," of the beam, with its loading, shown in Fig. 2. Fig. 3 shows the shearing force, bending moment, slope and deflection curves. The slope curve is not in its correct position, due to the fact that the constants of integration are determined by conditions imposed on the deflection curve, and, therefore, are not determined until this curve is drawn. These conditions are that the deflection curve shall pass through zero at each of the reactions. The slope curve could easily be shifted to its

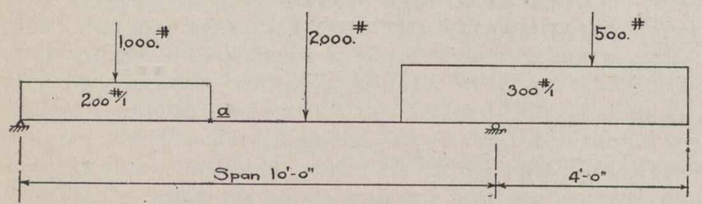

Fig. 2.

proper place, but that is hardly necessary, since the deflection curve is all that is desired in this instance. The deflection curve was made to pass through the required points by one of the several well-known methods for passing a polygon through two points. The choice of the last pole for this curve, therefore, was not wholly arbitrary and had to be scaled.

The scales work out as follows:—

First Scale: Horizontal, 1 in. = 2 ft.; vertical, 1 in. = 500 lbs.; pole distance, 4 ft.

Second Scale: Vertical, 1 in. = 2,000 foot-pounds. Pole distance, 4 feet.

Third Scale: Vertical, 1 in. = 8,000 pound-feet^2. Pole distance, 2.88 feet.

Fourth Scale: Vertical, 1 in. = 23,040 pound-feet^3.

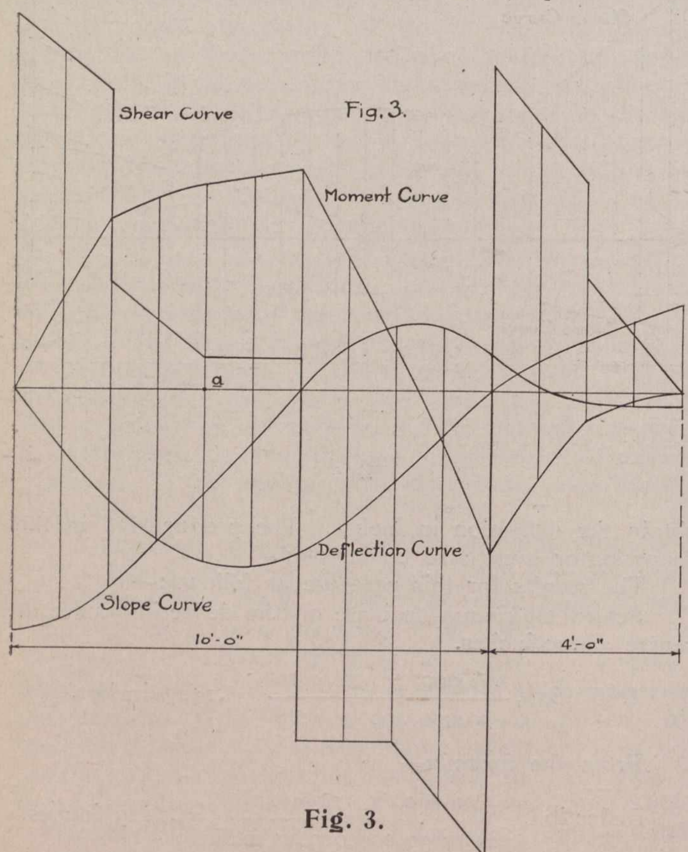

Fig. 3.

The scaled distance in inches to the deflection curve at "a" = 1.80 inches.

$$\text{Deflection}, \frac{23{,}040. \times 1.80 \times 12^3}{30{,}000{,}000. \times 21.8} = .1095 \text{ inches.}$$

Suppose that the beam shown in Fig. 2 is continuous over three supports and that the third support is at "a." To determine the reaction there it is required to find the single force which will cause a deflection at "a" of .1095 inches in the same beam. Substituting the numerical values in the formula for the deflection of a point on a beam with a single load and solving for the unknown load, it becomes in this case equal to 2,160 pounds. If this force of 2,160 pounds were to act upwards at point "a" in Fig. 2 it would deflect that point back to zero and the deflection curve for the beam over three supports would pass through zero.

In order to plot the deflection curve, plot first the deflection curve for the upward reaction in the same manner as demonstrated above. Observe that the same pole distances and the same scales should be used, so that the scale of this deflection curve will be the same as the previous one above. The final curve may be plotted by taking the algebraic sum of the ordinates of each curve at each point.

A fourth reaction might now be considered and treated in the same manner, but the solution would be much more complicated and laborious. It would require the drawing of a deflection curve for the beam over three supports and loaded with this fourth reaction. No new methods would be involved, however, and the work has, therefore, not been extended.

Besides being valuable as a practical application, those who are teaching the subject of the deflection of beams will find the above method very instructive. It shows graphically to the student the relations of the shearing force, bending moment, slope and deflection curves to one another.

TORONTO ELECTRIC DISTRIBUTION SYSTEM.

A quantity of underground work in connection with the Hydro-Electric distribution system has recently been under construction in Toronto. This consists of building a 15-duct run on the south side of King Street from John Street to Jarvis Street. Single 3-in clay ducts are laid three wide and five high, the top layer being square bore distributer duct. Several difficult channels have had to be made under car tracks—namely at York Street, Bay Street, Yonge Street, and Church Street. A single fibre duct of 3-in. diameter is used to connect run to all service boxes in the old run in the sidewalk. The ducts are encased in three inches of concrete and are laid with a minimum cover of 30 ins. from top of pavement.

In addition to the above work six large concrete transformer pits are being built. The dimensions of these pits are 9 ft. x 20 ft. deep, inside measurement. The pits will have 13-in. concrete walls and will be provided with special ventilation chambers. These pits are of sufficient size to take care of additional load in future years.

RAILWAY EXTENSION IN CHILE.

The Northern Longitudinal Railway of Chile is now in full operation, the work being entirely completed connecting Pisagua in the north of Chile with Valparaiso, Santiago, and Puerto Montt, well to the south of the country, a distance of about 1,960 miles. The new portion from Iquique to Calera, a distance of about 750 miles, has been constructed within the past three years; has cost about $40,000,000; and is to be operated for 50 years by the Chilean Northern Railway Company, Calera, Chile, an operating company organized by the Howard syndicate, which supplied the money under a guaranty from the Chilean Government. The gauge of this line is 3.28 feet, while the gauge of the old portion of the Longitudinal Railway is 5 feet 6 inches. A full description of this railway appeared in *The Canadian Engineer* for March 19th, 1914.

C. S. Cameron, secretary and treasurer of the Sydney Steel plant, has gone to England to investigate tne opportunities for trade in the British market.

REINFORCED CONCRETE DOCK FAILURES.

THE subject of reinforced concrete dock construction has been given considerable study in these columns. In our issues of August 27th and October 1st, the extent of this form of dock construction was outlined as regards practice in England and America respectively. In reviewing what has been done thus with reinforced concrete, it is necessary to state that it has not withstood in every instance subjection to the action of sea water. For the results of an extensive investigation into the effect of alkali and sea water upon concrete structures, the reader is referred to an article on the subject in *The Canadian Engineer*, July 31, 1913, page 233. The following, which is a continuation of the subject of reinforced concrete dock construction, outlines the failures that have occurred, and it is to be noted that they are due chiefly to the above cause.

In discussing reinforced concrete docks, the fact that there have been failures among them must not be overlooked. In Massachusetts waters, north of Cape Cod, a number of serious cases of deterioration of concrete have been caused by the disintegrating effects of sea water, wave action, and frost, especially in Boston Harbor, where nearly all the concrete structures standing in sea water have been affected badly between high and low tide, the most notable instance of which is the concrete pier at the Charleston Navy Yard. Although that part of the pier which is constantly submerged has given but little trouble, the part exposed alternately to the sea and air has been seriously affected, many large pieces having broken completely away, making it self-evident that some other agent than the chemical action between cement and sea water was at work.

As is well known, winter temperatures on the whole eastern front of the New England Coast run far below zero. In Boston Harbor 12° below zero is not uncommon. In the same way that hard earth and porous rocks are broken up by frost action, permeable concrete in freezing water will gradually be destroyed between wind and sea, as the water which gets into the concrete simply exercises its natural expanding function in freezing, which *a priori* is detrimental to the concrete structure. It is generally admitted that the exterior concrete in these Boston structures, especially in the Navy Yard pier, has failed almost entirely from the effect of the alternate freezing and thawing with each tide during the winter, due to permeable concrete.

A number of failures similar to that already cited have occurred in Boston, the disintegration taking place in all cases between low and high tides. In the case of the Dover Street draw-bridge pier, built in 1894, the disintegration had extended 1.4 ft. into the pier at the end of 17 years, the greatest damage being just below high-tide level. The pier was built of 1 : 2 : 5 concrete, with a 1-in. plastered mortar facing. English Portland cement was used throughout. Whether the 1-in. facing mortar was expected to act as a waterproof shield to the interior concrete is not apparent. Evidently, it did not act thus, as might have been expected.

As all the concrete in these disastrous cases seems to have been placed in the wet, that is, the sea water was allowed to come in contact with the concrete before it had become thoroughly cured and hardened, such results are not to be wondered at, for one of the axioms of a successful use of concrete in sea water is that it must be kept from contact with sea water for such a period of time as to enable it to become thoroughly hardened, especially that part between tides in freezing climates.

In several cases in Boston Harbor where the concrete was placed inside of a coffer-dam, or used in the form of pre-moulded, driven, concrete piles, the concrete does not seem to have been affected as in the other cases cited. These successful cases go a long way toward substantiating the truism that concrete, to be used successfully in sea water, especially in freezing water, must be made impermeable in the process of making, with full consideration given to the brand of cement used, the mixture, the sand, and stone (or gravel), the skilled labor of placing, as well as keeping it from contact with sea water until it has set and hardened sufficiently. It is very apparent, from a study of the method used in placing the concrete in the disintegrated structures in Boston Harbor, that that method was far from possessing the essential features necessary for a successful solution of the problem, viewed in the light of present-day knowledge.

In comparison with these Boston failures, it is fitting to state that at Dundee, Scotland, where the climatic conditions are said to be worse than at Boston, and where there is a rise and fall of the tide of about 12 ft., the combined action of the sea, waves, and frost has had no ill effect on the concrete docks in that harbor, the concrete piles of which were allowed to harden for 30 days before being put in place.

Another noted case of the destruction of concrete by frost and sea action is the large concrete sea wall along the water front of Lynn, Mass.—a massive concrete sea wall exposed to the pounding of the winter storms and seas. The steps to the beach in the front of this wall were destroyed to such an extent as to be hardly recognizable as steps. It might be of interest to state that this wall and some of the damaged structures in Boston harbor have apparently been repaired effectively by the cemen gun process.

In reviewing these failures in Boston and vicinity, it is well to consider the results obtained in using concrete in another port subject to freezing and ice conditions, viz., New York Harbor. In addition to freezing conditions, New York Harbor has to contend with a strong tidal effect, which results in large solid ice floes and fields of broken ice moving back and forth with a tide of considerable velocity, ice floes of such size coming down the Hudson as at times practically to compel abandonment of all transfer traffic in that river. This is an effect from which Boston docks are perhaps free, as no large rivers flow into that harbor, the Charles being kept under control by the so-called Charles River Dam.

In discussing this additional handicap and destructive force at work on New York City's 8¼ miles of concrete sea walls, some of which have been in existence for 41 years, Charles W. Staniford, M. Am. Soc. C.E., Chief Engineer of the New York Department of Docks and Ferries, states:

"Up to the present time (August, 1911), no disintegration has been discovered that can be attributed to the existence of the structure in salt water. The concrete itself is in an admirable state of preservation, absolutely hard, and is undergoing no regular process of disintegration." * * * "this sea-wall which has been under construction * * * for 41 years, is at the present time an excellent piece of work and is subject to the same climatic conditions as all cities on the Northern Atlantic Coast with the attending ice, cold and rain characteristic of this latitude."

In many instances, parts of this wall above low water are faced with granite blocks. This is a noted example of what can be expected in the way of using mass concrete in sea water if properly made, though perhaps some repair work has been necessary in order to maintain the excellent condition of the wall.

In some of the earlier sections of this wall the concrete was placed "*en-mass*-in-site," but, since 1876, most of the wall has been built by the concrete block method. Only under specially favorable conditions is it possible to place concrete successfully *in situ* under (sea) water, as it becomes disintegrated "through the chemical action of the sulphate of magnesia on fresh concrete or through the resulting porosity of concrete due to the impossibility of tamping under water";* the viscosity and weight of the mass not being sufficient to produce such a dense material as obtained in block work.

To discuss an opposite case in New York Harbor, viz., Dry Dock No. 2, New York Navy Yard, originally built of timber in 1890, the history of which it is not necessary to relate here: In 1900 this dock was rebuilt, concrete being used very extensively. During 1913 a large sum was expended in repairing and replacing the concrete altars and floors. As it has been stated that the difficulties of using concrete in sea water have been so great at this yard as to indicate that this is not a permanent material for use in sea water structures, it would be of deep interest to learn the facts as to the chemical composition of the cement used, of the sand and stone, as to the mixture thereof, and the precautions taken in mixing and placing; also as to whether the dock is kept flooded when not in use, especially during the winter. If, as has been stated, the concrete "has deteriorated and disintegrated to such an extent that it was possible to use a pick and shovel in removing it," it is apparent that it was lacking in one or more of the essential features that are deemed absolutely necessary for a successful use of concrete in sea water structures.

Whether any of the concrete pile docks on the Great Lakes have shown any signs of deterioration due to frost action, the writer does not know, but trusts that some facts covering this question will be brought out in the discussion. As the water level is practically the same all through the winter, only a very short length of the pile would be affected, and not some 10 ft., as in Boston Harbor.

One of the first concrete docks built in San Francisco is said to have failed in part due to poor construction. The early method of building the concrete columns of San Francisco concrete docks was to use a wooden cylinder, strongly built, as a column form, into which, it has been stated, the concrete was poured, apparently without any attempt to pump out the cylinder. As long as the wooden cylindrical forms remained in place around the supposedly concrete column, the dock was pronounced a success. When the teredo had finally destroyed the forms, the columns began to collapse and the dock became a pronounced failure, because, in pouring the concrete, the heavier material—the stone or gravel—settled first, then the sand, and finally the cement. The result was that throughout the length of the concrete columns there were alternate layers of uncemented stone and sand, with the cement in between the sand of one batch and the stone of the following one. Concrete can be and is successfully dropped through a height of 50 ft.—and even up to 100 ft. in one noted case in Arizona—but, if the receptacle into which it is dropped is full of water, disaster alone awaits the unfortunate engineer.

*This subject is discussed further by the writer in an article entitled "Chemistry of Salt Water Cement," Metallurgical and Chemical Engineering, January and February, 1914.

In another of the San Francisco docks, where wooden piles supported the concrete columns, the concrete was not carried down below the mud line a sufficient distance to prevent the teredo from destroying the piles below the concrete.

The question has been raised: Has any deterioration taken place in concrete structures standing in sea water in the harbors of the Southern States, where frost action is unknown? The most prominent concrete structure thus situated is the famous viaduct across the Florida Keys, built of Alsen cement, imported from Germany. It is possible that some of the members of this society are in a position to give complete information regarding the action of salt water and the waves of the Gulf on this structure.

In order to guard against the disintegration (irrespective of its cause) of mass concrete placed *in situ* above low water, or to repair any damage that has been done, besides the cement gun process, various methods have been used, all based on the fundamental principle of using an impermeable material for the facing of the structure. Below low water, properly made block work has given most satisfactory results. Carefully made, fully cured pre-moulded concrete piles seem to resist the action of the sea and frost successfully. In Holland, hard, impermeable brick have been used to prevent any further damage to one of the breakwaters above low water. In England, the upper parts of massive breakwaters are mostly faced with granite or some other hard suitable stone. In Nova Scotia, both brick and pre-moulded blocks of concrete of small size were placed on the face of a concrete sea wall after the disintegrated concrete had been removed. A still more recent device is the use of hollow, vitrified, salt-glazed tile blocks filled with concrete after being put in place. Experiments thus far seem to have proved that:

"Vitrified salt-glazed tile is impervious to any deteriorating action of sea water, and has an effective structure against the battering of ice; it is so dense as to preclude the possibility of any water entering and freezing in it to the consequent destruction of the tile."

Though oiled concrete is being used as a waterproof material in certain cases, it is possible that the refuse, oil, gases, etc., discharged from certain classes of buildings, etc., might have a destructive effect on the concrete foundation piles or other parts of the building, especially in sea water heavily charged with sewage. It is a well-known fact that concrete sewers will not perform their duty properly for any length of time unless they have a brick lining invert, over which flows the heavy sludge. In time of flood the surface water is so great as to dilute the sewage and prevent injurious effects. The writer would be pleased to hear opinions on this point, as it is possible that a destructive effect might have been caused by sewage in connection with one of the most seriously affected cases in Boston.

Although poor results seem to have attended quite a number of the reinforced concrete structures standing in sea water in America, the opposite appears to have been true in foreign countries. Still, a few failures are on record as having occurred in England and Germany, due mostly to permeable concrete.

GERMANY ELIMINATED FROM THE IRON AND STEEL TRADE.

THE German export business in iron and steel and manufactures thereof is rapidly being distributed among other nations, chiefly Great Britain and the United States. How extensive this transformation is, and to what degree these two countries may be relied upon to adequately supply the demand occasioned by the suspension of German exports, appear from the following comparative figures. It is to be noted that the figures pertaining to Germany and the United States include not only iron and steel, but also manufactures thereof, such as machinery and hardware, whereas the British figures comprise iron and steel alone:

Year.	Germany. (in marks)	United States. $	Great Britain. Tons.	Great Britain. £
1912 ..	1,275,053,000	259,709,399	4,814,005	49,800,000
1911 ..	1,100,133,000	230,725,351	4,515,905	44,800,000
1910 ..	923,705,000	179,133,186	4,588,009	42,976,671
1909 ..	780,760,000	144,951,357	4,210,799	38,192,142
1908 ..	772,673,000	183,982,182	4,096,521	37,406,028
1907 ..	852,650,000	181,530,871	5,152,227	46,563,386
1906 ..	715,043,000	160,984,985	4,682,200	39,840,595
1905 ..	639,934,000	134,728,363	3,721,382	31,826,438
1904 ..	582,322,000	111,948,586	3,262,842	28,066,671
1903 ..	634,361,000	96,642,467	3,564,601	30,399,261
1902 ..	603,375,000	98,552,562	3,579,104	28,877,337
1901 ..	517,259,000	117,319,320	2,897,719	25,008,757
1900 ..	479,609,000	121,913,548	3,540,689	31,623,353
1896 ..	337,540,000	41,160,877	3,550,398	23,462,793

Because of the difference in classification methods, comparisons drawn from these figures are somewhat unfair to Great Britain in that British exports of iron and steel and manufactures thereof increase more rapidly than her exports of iron and steel alone. However, it is still true that Germany has been increasing her iron and steel export trade more rapidly than Great Britain, but less rapidly than the United States.

Since the panic of 1907 German exports have increased in value 65.01%, while those of the United States have grown 110.14%. British exports of steel and iron, in tons, meantime increased 17.51%. But if the British figures included manufactures of iron and steel, they would show a gain of about 30% or 35%. From 1907 to 1912 the gain in British exports of iron and steel alone, as measured in pounds sterling, was 33.15%, as compared with 64.81% in German exports likewise classified.

Great Britain, Germany and the United States are the world's great steel makers; and with Germany eliminated for an indefinite period there should be a large opportunity for her two great competitors. The value of her exports in 1912, when reduced to our money, was $303,462,600; and much of this foreign trade was in steel products and, therefore, competitive merchandise. The largest single item of steel and iron themselves was malleable iron bars, and next to this came steel rails, then rough bars and ingots, iron wire, plates and sheets, and angle iron. The other countries produce large quantities of all of these; and what is more to the point is that the plant capacity of their steel mills has been so vastly increased during the past few years that if allowed to do so they could probably supply all of Germany's foreign customers in these products, as well as their own.

Water-Bound Macadam is being used in the Panama-Pacific Exposition for most of the streets and driveways, the total wearing surface of which is about 444,000 sq. yds.

SOME TUNNELING COSTS.

(Continued from last week.)

Stilwell Tunnel.

Location: Telluride, Colo.
Purpose: Mine drainage and development.
Cross-section: Square, with ditch at side.
Size: 7 by 7 feet.
Length: 2,950 feet.
Character of rock penetrated: Conglomerate and andesite.
Type of power: Purchased electric current.
Ventilator: Fan.
Size of ventilating pipe: 10 inches.
Drills: Started with electric drills, finished with pneumatic piston drills, using 2 in the heading.
Mounting of drills: Vertical columns.
Number of holes per round: 16.
Average depth of round: 6 to 6½ feet.
Number of drillers and helpers per shift: 2 drillers and 2 helpers.
Number of drill shifts per day: 1.
Explosive: 40 per cent. gelatine dynamite.
Number of muckers per shift: 3.
Number of mucking shifts per day: 1.
Type of haulage: Horses.
Wages: Drillers $4.50, helpers $4, muckers and trammers $3.50, blacksmith $4.50.
Maximum progress in any calendar month: 170 feet, August, 1904.
Average monthly progress: 150 feet (last 10 months).

Cost of Driving.

	Feet.	Cost per foot of tunnel.
1901	12	$23.88
1901-2	490	22.98
1902-3	377	27.94
1903-4	702	21.69
1904-5	1,077	21.19
1905	292	30.37
Average for	2,950	$23.38

These costs include all labor, supplies, repairs, powder, fuse, caps, candles, tools, lubricants, and general expenses, and the total value of the electric-drill plant with which the tunnel was started, and the total value of the air-drill plant which succeeded it, together with tunnel buildings, pipe, rails, and the ventilator, with no credit for salvage on any of this permanent equipment.

The fiscal year dated from September 30.

The tunnel was driven in 1901-3 with electric drills, and the high cost for:

1905	292	$30.37

Strawberry Tunnel.

Location: Utah and Wasatch Counties, Utah.
Purpose: Irrigation and reclamation.
Cross-section: Straight bottom and walls, with arched roof.
Size: 8 feet wide by 9½ feet high.
Length: 19,100 feet.
Character of rock penetrated: Limestone with interbedded sandstone, and sandstone with interbedded shale.
Type of power: Electric power generated in a hydraulic plant operated in connection with the tunnel. Dis-

tance of transmission from west portal to power house approximately 23 miles.

Ventilator: Pressure blower.

Size of ventilating pipe: 14 inches.

Drills: Piston pneumatic, usually 2 in the heading.

Mounting of drills: Vertical columns.

Number of holes per round: 16 to 18.

Number of drillers and helpers per shift: 2 drillers and 2 helpers.

Number of drill shifts per day: 3.

Explosive: 40 per cent. gelatine dynamite.

Number of muckers per shift: 6.

Number of mucking shifts per day: 3.

Type of haulage: Electric after first 2,000 feet.

Wages: Drillers $3.50, helpers $3.25, muckers $2.75, motormen $3.25, brakemen $2.75, blacksmiths $4, helpers $2.75.

Maximum progress in any calendar month: 500 feet, November, 1910.

Average monthly progress: 320 feet per heading.

Cost of Driving.

	Feet.	Cost per foot of tunnel.
West heading:		
Previous to 1909	1,613	$60.05
During 1909	3,892	33.58
During 1910	5,021	30.56
During 1911	3,491	41.52
January to July, 1912	2,382	36.79
East heading:		
October, 1911, to July, 1912	2,682	33.04
Average for	19,081	$36.78

Detailed Cost of Driving the West Heading for the Year 1909, 3,892 Feet.

	Cost per foot of tunnel.	
Labor:		
Engineering	$0.49	
Superintendence	.73	
Shift bosses	1.22	
Timekeepers	.36	
Drillmen and helpers	3.15	
Miners (for handwork, trimming, etc.)	.23	
Muckers	2.96	
Track and dumpmen	.74	
Mule drivers	.39	
Motormen and brakemen	.44	
Electricians and blower men	.07	
Disabled employees	.19	
Timbermen	.22	
Miscellaneous	.40	
		$11.59
Materials:		
Powder, fuse, caps, etc.	3.08	
Lumber	.29	
Oils, candles, etc.	.22	
Ventilating pipe	.64	
Track, including ties	.68	
Pressure air pipe	.40	
Drill repair parts (including hose)	.18	
Miscellaneous	.19	
		5.68
Repairs:		
Machine-shop expense (including labor and supplies)	.93	
Blacksmith-shop expense (including labor and supplies)	1.22	
		2.15
Power (all purposes)		7.65
Depreciation:		
Haulage equipment	.09	
General equipment	1.00	
		1.09
General expense	3.96	
Camp expense	1.21	
Corral expense	.25	
		5.42
Total		$33.58

"General expense" includes a proportionate charge for the expenses of the Provo office, such as salaries, stationery, telephone, and supplies; also a proportionate charge for the expenses of the Washington, the Chicago, and the supervising engineer's offices. The Provo office covers approximately 68 per cent. of this charge, the Washington office 23 per cent., the Chicago office 2 per cent., and the supervising engineer's office 7 per cent.

GUNNISON TUNNEL.

Location: Montrose, Colo.

Purpose: Irrigation and reclamation.

Shape of cross-section: Horseshoe.

Size: 10 feet wide at the bottom, 10 feet 6 inches wide at the spring line, 10 feet high at the spring line, 12 feet 4 inches high at the centre of the arch.

Length: 30,645 feet.

Character of rock penetrated: Chiefly metamorphosed granite with some water-bearing clay and gravel, some hard black shale, and a zone of faulted and broken rock.

Type of power: Steam.

Ventilator: Pressure blower.

Size of ventilating pipe: 17 inches.

Drills: At first, pneumatic hammer, 4 drills in the heading; afterwards, pneumatic piston, 4 drills in the heading.

Mounting of drills: Horizontal bar for the hammer drills, vertical columns for the piston drills.

Number of holes per round: 20 to 24 in the heading (approximately one-half of the tunnel).

Average depth of round: 6 to 7 feet.

Number of drillers and helpers per shift: 4 drillers and 2 helpers.

Number of drill shifts per day: 3.

Explosive: 60 per cent. gelatine dynamite, with some 40 per cent.

Number of muckers per shift: 5 to 8.

Number of mucking shifts per day: 3.

Type of haulage: Electric.

Wages: Drillers $3.50 and $4, helpers $3 and $3.50, muckers $2.50 and $3, blacksmiths $3.50 and $4, motormen $3, brakemen $2.50 and $3, power engineers $4.

Maximum progress in any calendar month: 449 feet.

Average monthly progress: 250 feet, approximately.

Cost of Driving.

	Cost per foot of tunnel.
10,019 feet driven by undercut heading and subsequent enlargement	$87.23
20,626 feet driven by top heading and bench	62.18
Average cost of excavation of entire tunnel	70.66

These costs include all labor, all materials, all repairs, all power, depreciation figured as 100 per cent. on all equipment, with a proportionate charge for general (supervisory) and miscellaneous expenses of the entire reclamation project.

LARAMIE-POUDRE TUNNEL.

Location: Home, Colo.

Purpose: Irrigation.

Cross-section: Rectangular.

Size: 9½ feet wide by 7½ feet high.

Length: 11,306 feet.

Character of rock penetrated: Close-grained red and gray granite.

Type of power: Hydraulic at the east end, electric at the west.

Ventilator: Pressure blower.

Size of ventilating pipe: 14 and 15 inches.

Drills: 3 pneumatic hammer.

Mounting of drills: Horizontal bar.

Number of holes per round: 21 to 23.

Average depth of round: 10 feet at first, 7 to 8 feet later.

Number of drillers and helpers per shift: 3 drillers, 2 helpers.

Number of drill shifts per day: 3.

Explosive: 60 per cent. gelatine dynamite, with some 100 per cent. in the cut holes.

Number of muckers per shift: 6.

Number of mucking shifts per day: 3.

Type of haulage: Mules.

Wages: Drillers $4.50, helpers $4, muckers $3.50, blacksmiths $5, drivers $4.50, dumpmen $3.50.

Maximum progress in any calendar month: 653 feet, March, 1911.

Average monthly progress: 509 feet (for the 16 months when complete plant operated).

Special feature: Inaccessibility; the tunnel was located about 60 miles from the nearest railroad siding, and the roads were mountainous and very steep in places.

Cost of Driving 11,306 Feet.

	Cost per foot of tunnel.
Superintendents and foremen	$ 1.50
Drilling	4.47
Mucking and loading	4.92
Tramming and dumping	4.63
Track and pipe	.47
Power house	.35
Blacksmithing	.84
Repairs	.47
Bonus to workmen	1.75
Maintenance of camps, buildings and fuel	.62
Machinery repairs	.12
Air drills and parts	1.33
Picks, shovels and steel	.84
Explosives	4.50
Lamps and candles	.42
Oil and waste	.38
Blacksmith supplies	.53
Liability insurance	.81
Office supplies, telephone and bookkeeping	.86
	$29.81
Permanent equipment (less approximately 10 per cent. salvage)	9.73
	$39.54

The permanent equipment included power plant, camp buildings and furnishings, pipes, rails, etc.

PRESERVATIVE TREATMENT OF POLES FOR LINE WIRES.

THE normal yearly production of poles in the United States is about 2,750,000, and to-day there are, approximately, over 50,000,000 poles supporting wires, either telephone, telegraph, light, or power. It is only of recent years that the pole user could be induced to take the precaution of preserving his timber.

In the last few years, prompted by their increased price, there is hardly a pole set without the owner's having some idea of preserving it. He begins to compare what he or his predecessor formerly paid for a pole with the present price, hence he begins to figure how to stop the expense of replacing rotten poles.

Since the records obtained in the past years show what ingredients remain in treated timbers the greatest period of time, it is natural to conclude that a good preservative should contain as great an amount of these ingredients as it is possible to obtain. The impregnating process, while one of the oldest methods known, is yet in its infancy. The records referred to, however, are based on timbers which had been treated with a tar oil under pressure. This method, if properly used, is frequently so expensive that the additional cost makes its use prohibitory.

It is the high boiling oils of coal tar which preserve timber, because that is what was obtained by subjecting the preserved timbers to dry distillation. The records do not show whether or not these high boiling oils originally contained any neutral, such as paraffin or similar oils, which have not as yet been proven germicidal.

The average tar oil obtainable, which is forced into timber under pressure, contains from 15 to 35 per cent. oil distilling above 300 degrees centigrade. Hence, if an oil that contained 35 per cent. distilling above 300 degrees centigrade, at most, which had been injected into the timber showed such excellent results, it is reasonable to suppose that a lesser amount of oil containing proportionally a greater per cent. of distillate above 300 degrees centigrade will bring good results when properly applied.

It is important for the one who supposes petroleum to be a preservative to exercise much care in the selection of the petroleum because it may prove an unwise form of economy, as it has repeatedly.

In 1900 the C-A-Wood-Preserver Company began directing attention to the value of high boiling tar oils as against the offered "secret" or "patented" process in connection with preservatives. Since scientific investigations by the government and others have substantiated these theories and arguments, some are attempting to use preservatives which are the high boiling portions of crude petroleum. These mislead the chemist unless he make the sulphonation test. The company mentioned, in 1886, sold one of the first barrels of coal tar distillate that came to America. This product, which was intended for the superficial method, distilled only 75 per cent. above 300 degrees centigrade. Eleven years afterward this was increased to 85 per cent. and during the summer of 1909 to 92 per cent. This was the highest mark reached so far and it required special machinery to produce it.

It is practically impossible to produce a successful oil distilling more than 92 per cent. above 300 degrees centigrade according to the United States Forest Service method of analysis, as it would solidify at normal temperature if it were free from petroleum residues or similar oils. Some tars will distill much more than 92 per cent.

above 300 degrees centigrade, but they are not free from the paraffin oils which have a high boiling point though they are nongermicidal.

While it has been less than a year since a strictly coal tar distillate containing as much as 92 per cent. liquid residue (oil) above 300 degrees centigrade (United States Forest Service method) has been manufactured and put on the market, it may be interesting to note a few records and illustrations of the methods of application and results derived from the use of that heretofore produced, or from the oil distilling 85 per cent. above 300 degrees centigrade.

After determining the quality of preservative, the pole user is interested in the method of application. The brush method is the simplest and most universally used. Next is the pouring system, which is done in two ways. One consists of a portable tank, while the other is stationary, the poles being conveyed to the treating tank.

Poles which are already erected and which have begun to show decay can be saved by a very simple method. By digging away the earth to a depth of about two feet around the pole, applying two coats of a good preservative with a brush and then replacing the earth, the pole is saved. Rot is caused by a germ and the preservative being a germicide or antiseptic kills those present when applied to the decaying parts and its presence in the wood prevents future decay as well. The manager of the Memphis (Tenn.) Telephone Company, in 1904, made this experiment on cypress poles and he reports them in perfect condition to-day with every evidence of lasting many years longer. The Austin (Texas) Electric Railway Company has likewise found this a most successful experiment on cedar poles.

Cross arms can be treated by the brush method, however, the complete dipping or immersion is the more favorable. The cost of treating a pole depends upon its size, character, condition, price of the preservative and the amount used—whether it be treated at the ground line only or the entire butt end. There is a variation from four cents to perhaps a dollar per pole and each user of poles knows best what he can afford to pay for the protection of his timber.

Last, but not the least important, it should be noted that under no circumstances should unseasoned or green timber be treated, regardless of the preservative used; it must be at least partly seasoned to allow penetration.—*Municipal Engineering.*

MILEAGE ON THE N.T.R.

The accompanying chart, denoting the mileage between principal points on the Eastern Division, (Moncton to Winnipeg), of the National Transcontinental Railway is self-explanatory. Special attention is called to it, however, in connection with the concise review of the construction of the N.T.R. appearing in *The Canadian Engineer* for September 17th, 1914. As stated there, the whole line is expected to be ready to cope with its share of the western wheat crop in the course of a few weeks, at which time ballasting, and erection of buildings, etc., will have been completed.

NATIONAL TRANSCONTINENTAL RAILWAY

EASTERN DIVISION

MILEAGE BETWEEN PRINCIPAL POINTS

	Moncton	Halifax	Sydney	St. John	McGivneys Jct.	Napadogan	Edmundston	N.B. Boundary	Monk	Quebec Bridge N. Abut.	Bridge	Quebec via N.T.Ry.	Hervey Jct.	Fitzpatrick	Parent	Doucet	O'Brien	Que. & Ont. Bound	Cochrane	Hearst	Grant	Armstrong	Superior Jct.	Fort William	Graham	Redditt	Manitoba Bound	Transcona
Moncton																												
Halifax (I.C.Ry.)	185.9																											
Sydney (I.C.Ry.)	337.6	276.4																										
St. John (I.C.Ry.)	89.4	275.2	427.5																									
McGivneys Jct.	96.3	282.2	433.9	185.7																								
Napadogan	117.4	303.3	455.0	206.8	21.1																							
Edmundston	230.5	416.4	568.1	319.9	134.2	113.1																						
N.B. Boundary	256.3	442.2	593.9	345.7	160.0	138.9	25.8																					
Monk	354.4	540.3	692.0	443.8	258.1	237.0	123.9	98.1																				
Quebec Bridge N. Abut.	460.2	646.1	797.8	549.6	363.9	342.8	229.7	203.9	105.8																			
Bridge	460.6	646.5	798.2	550.0	364.3	343.2	230.1	204.3	106.2	0.4																		
Quebec via N.T.Ry. (Champlain Market)	466.7	652.6	804.3	556.1	370.4	349.3	236.2	210.4	112.3	6.5	6.1																	
Hervey Jct.	532.9	718.8	870.5	622.3	436.6	415.5	302.4	276.6	178.5	72.7	72.3	78.4																
Fitzpatrick	586.6	772.5	924.2	676.0	490.3	469.2	356.1	330.3	232.2	126.4	126.0	132.1	53.7															
Parent	705.5	891.4	1043.1	794.9	609.2	588.1	475.0	449.2	351.1	245.3	244.9	251.0	172.6	118.9														
Doucet	808.5	994.4	1146.1	897.9	712.2	691.1	578.0	552.2	454.1	348.3	347.9	354.0	275.6	221.9	103.0													
O'Brien	915.3	1101.2	1252.9	1004.7	819.0	797.9	684.8	659.0	560.9	455.1	454.7	460.8	382.4	328.7	209.8	106.8												
Que. & Ont. Bound	956.2	1142.1	1293.8	1045.6	859.9	838.8	725.7	699.9	601.8	496.0	495.6	501.7	423.3	369.6	250.7	147.7	40.9											
Cochrane	1027.9	1213.8	1365.5	1117.3	931.6	910.5	797.4	771.6	673.5	567.7	567.3	573.4	495.0	441.3	322.4	219.4	112.6	71.7										
Hearst	1156.9	1342.8	1494.5	1246.3	1060.6	1039.5	926.4	900.6	802.5	696.7	696.3	702.4	624.0	570.3	451.4	348.4	241.6	200.7	129.0									
Grant	1282.1	1468.0	1619.7	1371.5	1185.8	1164.7	1051.6	1025.8	927.7	821.9	821.5	827.6	749.2	695.5	576.6	473.6	366.8	325.9	254.2	125.2								
Armstrong	1413.5	1599.4	1751.1	1502.9	1317.2	1296.1	1183.0	1157.2	1059.1	953.3	952.9	959.0	880.6	826.9	708.0	605.0	498.2	457.3	385.6	256.6	131.4							
Superior Jct.	1546.1	1732.0	1883.7	1635.5	1449.8	1428.7	1315.6	1289.8	1191.7	1085.9	1085.5	1091.6	1013.2	959.5	840.6	737.6	630.8	589.9	518.2	389.2	264.0	132.6						
Fort William (G.T.P. Branch)	1738.1	1924.0	2075.7	1827.5	1641.8	1620.7	1507.6	1481.8	1383.7	1277.9	1277.5	1283.6	1205.2	1151.5	1032.6	929.6	822.8	781.9	710.2	581.2	456.0	324.6	192.0					
Graham	1552.5	1738.4	1890.1	1641.9	1456.2	1435.1	1322.0	1296.2	1198.1	1092.3	1091.9	1098.0	1019.6	965.9	847.0	744.0	637.2	596.3	524.6	395.6	270.4	139.0	6.4	198.4				
Redditt	1675.7	1861.6	2013.3	1765.1	1579.4	1558.3	1445.2	1419.4	1321.3	1215.5	1215.1	1221.2	1142.8	1089.1	970.2	867.2	760.4	719.5	647.8	518.8	393.6	262.2	129.6	321.6	123.2			
Manitoba Boundy.	1712.0	1897.9	2049.6	1801.4	1615.7	1594.6	1481.5	1455.7	1357.6	1251.8	1251.4	1257.5	1179.1	1125.4	1006.5	903.5	796.7	755.8	684.1	555.1	429.9	298.5	165.9	357.9	159.5	36.3		
Transcona	1799.2	1985.1	2136.8	1888.6	1702.9	1681.8	1568.7	1543.9	1444.8	1339.0	1338.6	1344.7	1266.3	1212.6	1093.7	990.7	883.9	843.0	771.3	642.3	517.1	385.7	253.1	445.1	246.7	123.5	87.2	
Winnipeg (Water Street)	1804.5	1990.4	2142.1	1893.9	1708.2	1687.1	1574.0	1549.2	1450.1	1344.3	1343.9	1350.0	1271.6	1217.9	1099.0	996.0	889.2	848.3	776.6	647.6	522.4	391.0	258.4	450.4	252.0	128.8	92.7	5.3

A. S. Cook
Asst. to Chief Engineer.

— REVISED —
OTTAWA, ONT.
SEPT. 15th. 1914.

Editorial

A NEW PHASE OF WAR ENGINEERING.

The part played by engineering in the present European conflict is something for the details of which we may be obliged to wait a considerable length of time. The continual shifting of positions by the contending armies, however, impress us as sufficient to require a most remarkable manipulation of guns and supplies over rough country whose transportation routes have already been blocked and destroyed. This work falls naturally to the military engineers.

An outstanding feature of the methods of transportation and communication is the extensive use of the motor truck. It has brought about a revolution in transportation methods and has made possible the manoeuvring of millions of men and the required equipment of various classes of guns, ammunition, provisions, etc. These trucks are, for the most part, of ordinary type. This we know from the knowledge that Germany, France and England have systematically subsidized motor trucks during recent years on condition that they be available for governmental use in case of need. In Germany the subsidy amounted to $2,000, one-half of which was applied to the purchase price, and $250 of which was applied on upkeep yearly for four years. These trucks were to have a capacity of 6½ tons, to run 10 miles an hour with full load, to climb a 10% grade, and to haul one, or, if necessary, two trailers. At the beginning of 1912 over 800 trucks had been subsidized and the number has very greatly increased since that time, the government having power to requisition every motor vehicle in the German Empire.

In France a subsidy of $600 toward purchase, and $200 a year for three years toward upkeep, could be obtained from the government by owners of trucks of capacity of over three tons.

Great Britain allows a subsidy varying from $40 to $60 per vehicle and $75 a year for upkeep. Austria also subsidizes motor trucks and has a right to take possession in times of need.

The result is that motor trucks are brought into commission in almost every conceivable way for the rapid transportation of men and supplies. Artillery is, to a considerable extent, hauled by motors. This applies particularly to big motors such as constitute the heavy siege artillery. Many of these guns are known to weigh from 8 to 20 tons, while it is stated that there are larger pieces weighing 40 tons each, and at least as much more for the gun carriage. The projectile which such a gun uses weighs approximately a ton. It is evident that the transportation of these pieces of artillery, together with their ammunition supply, over stretches of country where there are no railroad facilities and whose bridges, etc., have been previously destroyed, is an engineering task that requires utmost skill, as the manipulation has to be prompt and absolutely reliable, since there may be depending upon the service armies of hundreds of thousands of men.

It is interesting to note that the Canadian expeditionary force at present on its way to Great Britain possesses an extensive motor equipment, including motors for mechanical transport, armoured cars with machine-guns, motor-drawn trucks, motor ambulances, touring cars for the officers and an armoured motor machine shop. This shop is very complete in itself with a full equipment of tools and lathes.

The problem of transportation is sufficiently gigantic of itself to evidence the dependence of military manoeuvres upon the engineering corps. There are other problems, such as those of entrenchments and fortifications, of water purification and sanitation—problems that are of an impromptu nature requiring immediate solution, thereby differing from the engineering that has already made itself evident in the design and construction of artillery pieces, ammunition, etc., while the world was yet at peace.

OPPORTUNITY FOR CANADIAN ELECTRICAL MANUFACTURERS.

Canadian exports of electrical apparatus amounted last year to $215,546. Imports, on the other hand, amounted to $9,098,736. At the present time there is a scarcity in England of electrical apparatus. It is only a few days ago that a newly established foreign trade commission in Pittsburgh, Pa., had a communication from a large engineering equipment house in London, England, stating that owing to the war its orders could not be filled and asking to be put in touch with Pittsburgh firms supplying all kinds of electrical equipment and machinery.

In view of the above figures of Canadian foreign trade in electrical apparatus, it is somewhat improbable for Canada to hope to export largely to Great Britain unless her productive capacity is materially increased. That Britain, whose supplies from Germany in this line amounted last year to £721,078 will have to look elsewhere should be an inducement of no small magnitude to Canadian manufacturers of electrical machinery and apparatus. The portion of the demand that might be supplied in this country is small, perhaps, in proportion to that which the United States is prepared to look after. Last year Great Britain's imports of these supplies from the United States attained a value of £437,906. Canadian manufacturers, however, should give the problem their very careful consideration at the present time. There is undoubtedly a market and that market is a country with which we are more closely associated than any other.

TRANSFER OF LOCOMOTIVE CONTRACTS.

Owing to the European war and the immediate cessation of trade relations with Germany the supply of railway locomotives and rolling stock, for which Germany has long been a keen contender, is rapidly undergoing a change in its source of manufacture. Before war broke out the leading German companies had in hand some enormous orders from British and overseas railways. One of the most important contracts comprises a large number of passenger carriages for the new electrified services around Buenos Ayres of the Central Argentine Railway Company. This contract was originally placed with a Hanover firm, but has now been awarded to the

Metropolitan Amalgamated Railway Carriage Company, of Birmingham.

South Africa and New Zealand had large orders for locomotives with the Maffic Company, of Munich. The Hanover company were also building thirty-four passenger carriages for the Union of South Africa railways.

Kersckel of Casel had orders for eighteen heavy main line engines for South Indian and some Argentine railways.

The Hanover Machine factory was building locomotives for the Bengal railway and Taff Vale railway, and the Hohenzollern works at Dusseldorff were building six powerful shunting locomotives for the Port of London authorities.

All these contracts now have been cancelled and shortly will be divided amongst British and American engineers.

AMERICAN ROAD BUILDERS' CONVENTION, CHICAGO.

The programme committee of the American Road Builders' Association reports that plans for the 11th Annual Convention to be held in Chicago, Dec. 14-18, are near completion. The general features of the programme have been decided upon, practically all of the subjects have been chosen and the assignment of speakers is now being made.

Registration will be carried on throughout Monday afternoon and evening. The forenoon of Tuesday, Dec. 15, will be devoted to the reception of delegates and visitors and to committee meetings, other preliminary business and the inspection of exhibits. At 2.30 p.m. the Congress will be formally called to order by President W. A. McLean, Provincial Highway Engineer of Ontario, and addresses of welcome will be given by officials of the city of Chicago, the state of Illinois, the Illinois Highway Commission, the University of Illinois, the Illinois Society of Civil Engineers and Surveyors, and the Illinois Highway Improvement Association.

The technical sessions will commence on Wednesday, and will be held each morning and afternoon until the close of the convention. On Wednesday evening, the Association will hold its annual dinner.

Essentially the same plan for the programme as that adopted at recent conventions of the Association will be followed. The various subjects to be treated have been so chosen as to cover the important phases of the three general divisions of the subject of highway work: Organization, Construction and Maintenance. Each topic will be introduced by a short paper presented by an authority especially selected for his knowledge of the subject on which he will speak. The discussion on that topic will then be opened by an especially selected speaker, who will be followed by other speakers, also selected because of their familiarity with the subject. The discussion will then be open for anyone who chooses to take part.

Among the topics to be treated are the following:—"Road and Pavement Dimensions—Widths, Depths and Crown;" "Road Foundations—Concrete, Telford, Gravel, etc.;" "Organization;" "Traffic—Present Tendencies, Probable Development and Regulation;" "Machinery for Construction and Maintenance;" "Brick Roads and Streets;" "Surface or Floors for Bridges;" "Bituminous Construction and Maintenance—Recent Practice;" "Concrete Roads;" "Recent Practice in the Construction of Wood and Granite Block Pavements;" "Earth and Gravel Road Construction;" "Street Paving in Small Cities;" "Convict Labor in Road Construction," and "Dust Prevention and Street Cleaning."

STEEL PRODUCTION IN CANADA, 1913.

Production of all kinds of steel ingots and castings in Canada in 1913 amounted to 1,042,503 gross tons, an increase of 189,472 tons above 1912, according to the report issued by the American Iron and Steel Institute. Of the 1913 production, 1,006,149 tons were ingots and 36,354 tons were direct steel castings, being respective increases above 1912 of 185,357 and 4,115 tons.

The total productions of steel ingots and castings has increased rapidly in recent years, and the 1913 output was by far the largest in the history of Canada.

A table covering the production by both classes in gross tons, during the last ten years, follows:

Years.	Ingots.	Castings.
1913	1,006,149	36,354
1912	820,792	32,239
1911	768,559	22,312
1910	723,002	18,922
1909	664,789	13,962
1908	500,300	9,657
1907	629,026	17,728
1906	555,913	14,976
1905	394,055	9,394
1904	142,279	6,505

Plants Involved.—In 1913 there were sixteen steel works engaged in the manufacture of ingots or castings, compared with fourteen in 1912. There were four idle works in 1913, compared with three in 1912. In regard to processes, the production of Bessemer steel ingots and castings in 1913 was 273,391 tons, an increase of 65,822 above 1912. The output of open-hearth steel ingots and castings in 1913 amounted to 768,663 tons, which was 123,601 above 1912. Nearly all Bessemer steel made in the last two years was in the form of ingots. Of the 1913 open-hearth production, 736,562 tons was in ingots and 32,101 in castings.

The production of all kinds of finished rolled iron and steel in 1913 amounted to 967,097 tons, an increase of 105,873 tons, and also was the largest in the Dominion's history. Of last year's output about 95,881 tons were iron and 871,216 steel.

Finished Iron and Steel.—The production of all kinds of finished rolled iron and steel, in gross tons, by provinces, during a two-year period, follows:

Provinces.	1913.	1912.
Nova Scotia	380,488	337,466
Quebec	72,439	88,172
Ontario	504,900	418,346
New Brunswick, Alberta, Manitoba	9,270	17,240
Total	967,097	861,224

In 1913 there were twenty-one works engaged in rolling finished forms of iron and steel, and also the same number in the previous year. There were five idle rolling mills and steel works in 1913, compared with four in 1912. Three new steel plants were built in 1913, all equipped to make steel castings but not rolled iron or steel products. At the close of 1913 three additional similar plants were in course of being constructed.

Assurance comes from New York city that Tramways, Limited, the company which proposes to build the interurban line in the Edmonton district, announces that it is prepared to proceed with the project as soon as arrangements can be finally completed by the Edmonton city council for that construction.

Coast to Coast

Montreal, Que.—The taking over of the Montreal Water and Power Company is still a live question in the city of Montreal.

Sarnia, Ont.—Water from the new Sarnia waterworks plant on the lake shore is now flowing through the new mains into the city.

Peterborough, Ont.—On September 24, the distributing system of the Peterborough Light and Power Company passed into the possession of the city of Peterborough.

Fort William, Ont.—The net earnings of the Kaministiquia Power Company for the first 8 months of 1914 are announced as $185,295, with a surplus for the same period of $126,479.

Kingston, Ont.—What is said to be the most modern sewerage system in America has just been installed at the Rockwood Asylum for the Insane, Kingston. It was formally opened on September 19th by Dr. A. Amyot and J. A. Dallyn of the provincial department of public health.

Winnipeg, Man.—Though the contracts amounting to approximately $6,000,000 have just been awarded in connection with the Shoal Lake water supply project for Winnipeg, the work on the five various contracts totalling the stated amount will not be commenced until next May.

Selkirk, Man.—The public works under construction by the Dominion Government, which are being continued in spite of war conditions, are the new $100,000 drydock to accommodate the shipping on the Red river, and a $150,000 steel boat to serve as a fishing patrol on Lake Winnipeg, which is to be completed by June, 1915.

Winnipeg, Man.—The report of works completed thus far this year in the city of Winnipeg shows a long list of large paving works in asphalt No. 1, asphalt No.2, concrete, and other pavements, sewers, walks, and various local works. The report further details important works yet under construction in sewers and pavements, as well as an extensive list of smaller works of all kinds throughout the city, either finished or now in the final stage of completion.

West Kildonan, Man.—Extensive public improvements have been conducted this year in West Kildonan. These include a 6-foot granolithic sidewalk on Main street from the city limits of Winnipeg to Kildonan Park; the laying of a portion of the two miles of 12-foot trunk sewer, which is to be completed from the river along Jefferson avenue by 1917; paving on North Main street for a distance of about 1½ miles; and a sewer to drain this 24-foot paved street which will be laid as soon as the paving is completed.

Prince Rupert, B.C.—It is expected that by the beginning of 1915 six of the great pontoons which are to be used in the construction of the G.T.P. floating dock at Prince Rupert, will have been completed. The first of these was launched about two weeks ago at the northern terminal. To build this 300,000 feet of lumber were used, besides tons of iron bars, bolts, nails and other fixtures required; and it is 130 feet in length. There will be 12 pontoons in all in this great dock, which will require 3,600,000 feet of lumber, not to speak of the many thousand extra feet will be necessary for the sides of the floating shipyard. The capacity of the new dock will be 20,000 tons, which means that it will be able to lift the largest warships or mercantile ships which ply the Pacific Ocean. The dock is so arranged that it can be used as three separate units or in any combination that is desired. The dock will probably be completed some time next year. Most of the piers in connection with the plant have been erected, and the buildings are now almost completed.

Toronto, Ont.—The work of dredging sewer outlets in Toronto harbor for the Toronto harbor commissioners, the contract for which was awarded to Mr. John E. Russell, has been about three-quarters completed. The work consists of dredging material which has been deposited in the slips along the waterfront through the sewers, and of conveying the matter dredged into the lake a distance of 10 miles and of dumping it there. The other work in connection with the harbor improvements being carried out this year by the commissioners, is making very substantial progress under the contractors, The Canadian Stewart Company. Both the ship channel, which is to serve the industrial district being created in the old Ashbridge's Bay, and the dock structures along the west face of this district, are well under way. Also work is being carried on rapidly from both the east and west ends and working towards the centre in the placing of cribs as a foundation for the seawall which is to protect the shore from the foot of Bathurst street west to the Humber river. Approximately $1,500,000 will be spent on this work during the year 1914.

Winnipeg, Man.—According to the recent progress report furnished to the meeting of the board of the Greater Winnipeg Water District, the field staff at work on the Shoal Lake water supply scheme was engaged in laying out and measuring up railway grade, track-laying, ballasting and drainage work. Up to August 31st, delivery had been taken of 266,879 railway ties, or 97 per cent. of the total order; telephone lines had been strung along a distance of 82.89 miles, leaving a balance of 11.89 miles to complete; 8,415½ long ton steel rails had been delivered, or 84 per cent. of the total tonnage required; 1,004,176 lbs. of splice bars had been delivered, completing the order pending an adjustment of the quantities shipped; 52 per cent. of the estimated total of necessary railway construction was under excavation; track-laying had been completed on 29.196 miles or on 29 per cent. of the estimated total; 12½ miles of the right-of-way had been fenced; 2,536 acres of the right-of-way had been cleared; division engineers' residences were practically completed; and 115,664 cubic yards of material were placed in the Falcon river dike, or 47 per cent. of the total required.

Winnipeg, Man.— An official announcement by the Greater Winnipeg Water District administration states that half of the Falcon river dyke at the Shoal Lake end of the water supply aqueduct, being constructed by Tomlinson and Flemming at a cost of $120,700, has been completed. This undertaking requires an embankment 5,070 feet long; and a channel 3,300 feet long, 35 feet wide, and 7 feet deep. For the former 170,000 cubic yards of sand and gravel, 12,000 cubic yards of riprap, and 5,000 feet of trestle will be used. For the latter 30,000 cubic yards of earth is to be removed. These operations are carried out to avoid the dark-colored water discharged by the river and to cut off the shallow flowage at the extreme westerly end of Indian Bay. The dyke is being built across the end of the bay, and a canal constructed therefrom to Snowshoe bay. It will be curved a mile long, and be a substantial embankment of sandy and gravelly material, raised 4 feet above the high-water level of the lake and protected on the exposed side with a heavy facing of riprap. A gate and screen chamber on the shore will be built; and to protect the intake from material drifting along the shore, piers will be constructed 150 feet out into the lake at each end of the receiving hole. A submerged conduit is also planned to bring the water from a point at least 150 feet from the shore. The gate and screens have been designed with liberal areas for sluice-gate openings and for screens, so as to cause as little fall of the water from the bay to the aqueduct as possible. There will be at least two sluice-gates, not less than 5 feet wide, and 6 feet high; and the screens will have a total length of not less than 50 feet, and a height extending from the bottom of the aqueduct to the surface of the water. At the Falcon river crossing, a pile foundation for 600 feet is to be constructed; and for 150 feet of this length it will be necessary to depress the aqueduct, so that its top will be low enough to permit the passage of water of the river and light-draft boats. The depressed portion will be reinforced with steel, and the concrete will be much thicker than under usual circumstances.

PERSONAL.

Hon. Dr. J. O. REAUME, Minister of Public Works in the Ontario Cabinet, has resigned.

Hon. FINLAY G. MACDIARMID has succeeded Hon. Dr. Reaume as Minister of Public Works for the Province of Ontario.

R. O. WYNNE-ROBERTS, consulting engineer, Regina, Sask., is on a trip east, visiting Toronto, Ottawa, Montreal and New York.

Hon. W. H. HEARST, Minister of Lands Forests and Mines for the Province, has been chosen to succeed the late Sir James Whitney as Premier of Ontario.

E. L. HORWOOD, Ottawa, has been appointed chief architect of the Department of Public Works. Mr. David Ewart, who for about forty years has been acting in that capacity, will be consulting architect.

H. C. GROUT, St. John, N.B., has been appointed general superintendent of the Atlantic Division of the C.P.R., succeeding Mr. Wm. Downie, resigned. Mr. Grout has been in the company's service since 1898.

Hon. Sir ADAM BECK, chairman of the Hydro-Electric Power Commission of Ontario, has retired from the Ontario Cabinet. It is understood that his desire is to devote as much time as possible to the affairs of the Commission.

H. A. WOODS, of Montreal, is acting as chief engineer of the Grand Trunk Pacific Railway Co., at Winnipeg, since the resignation of Mr. B. B. Kelliher. (See *The Canadian Engineer*, Sept. 10th, 1914.) The directors have decided not to appoint a successor at present.

Hon. I. B. LUCAS, Provincial Treasurer of Ontario, has been appointed a member of the Hydro-Electric Power Commission of Ontario, to succeed Lieut.-Col. Hon. J. S. Hendrie, whose appointment to the Lieutenant-Governorship of the Province left a vacancy on the Hydro Board.

Dr. T. KENNARD THOMSON, consulting engineer, New York City, has been appointed by Gov. Glynn, of New York State, a member of the Atlantic Deeper Waterways Commission. This commission, of which Hon. J. Hampton Moore is President, has under investigation a system of canals to extend from Florida to Maine, with a total length of between seven and eight hundred miles and at a probable cost of $35,000,000.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

The Council of the Canadian Society of Civil Engineers have announced that their fees for the year will be remitted to all members of the Society who have volunteered for service with the allied armies.

At its meeting on Sept. 9th the Council also resolved to establish a fund to be applied in aid of dependent members of families of Society members who have volunteered for active service in the army.

Premier McBride says that public works in the province will not be stopped, that construction will proceed on the railways in different sections, and that every effort will be made to sustain that confidence which has generally marked the people of British Columbia.

IRRIGATION PUMPS FOR EGYPT.

Some particulars have been recently made public regarding the pumps which are being supplied from England in connection with the irrigation work now being carried out in the Behira district.

The pumps are of the Humphrey pattern, similar to those at the Metropolitan Water Board's reservoir at Chingford, but incorporating some novel ideas. The valves, for example, are of a unique design, which permits them to shut fairly close even when a large obstruction fouls the seating. The pumps will be eight in number, with a total capacity of 792,000,000 gallons per 24 hours, and the lift to be provided for is from 19 ft. to 20 ft. The maximum internal diameter of the combustion chamber will be 8 ft. 8 in., and it will be about 14 ft. in height. The water valve box, which will be 7 ft. in height, will be 8 ft. 8 in. in diameter.

The gas for the pumps will be produced by an anthracite Mond plant, gasifying 44 tons per day, the plant consisting of nine producers, one of which is a spare. The plant is being supplied under a guaranteed consumption of 1.15 lb. of coal per water horsepower.

COMING MEETINGS.

MOTOR TRUCK CLUB OF AMERICA.—Annual Convention, Detroit, Mich., October 7th to 9th. President, George H. Duck, New York City.

GULF AND INTEROCEAN NATIONAL HIGHWAY ASSOCIATION.—October 8th, 9th, 10th; conference to be held at New Orleans, La. Secretary, Jno. B. Kent, Lake Charles, La.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—Annual Convention, Grunewald Hotel, New Orleans, La. October 20th to 23rd. Secretary, Mr. McFall, Roanoke, Va.

ALABAMA GOOD ROADS ASSOCIATION. — Nineteenth Annual Convention will be held from October 21st to 23rd at Montgomery, Ala. Secretary, J. A. Rountree, 1021 Brown Marx Building, Birmingham, Ala.

NORTHWESTERN ROAD CONGRESS.—Annual Convention, to be held at Milwaukee, Wis., October 28th to 31st. Secretary, J. P. Keenan, Milwaukee.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—Charles Carroll Brown, Secretary, Indianapolis, Ind. Meets at Somerset Hotel, Boston, Mass., October 21st, 22nd and 23rd.

AMERICAN HIGHWAYS ASSOCIATION.—Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.

WASHINGTON STATE GOOD ROADS ASSOCIATION.—Convention to be held at Spokane, Wash., November 18th, 19th, and 20th. Secretary, M. D. Lechey, Alaska Building, Seattle, Wash.

ANNUAL MEETING, AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The annual meeting of the American Society of Mechanical Engineers will be held in New York, December 1st to 4th, 1914. Secretary, Calvin W. Rice, 29 West 39th Street, New York.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Eleventh Annual Convention; fifth American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.