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The Canadian Engineer

An Engineering Weekly

WATER-POWER FROM THE MISSISSIPPI.

The Large Hydro-Electric Development in the Centre of the United States.

BY G. DONALD DELL

The notable things in the water-power development in the Mississippi River are three: the location; the size of the plant, and the solution of some engineering problems involved.

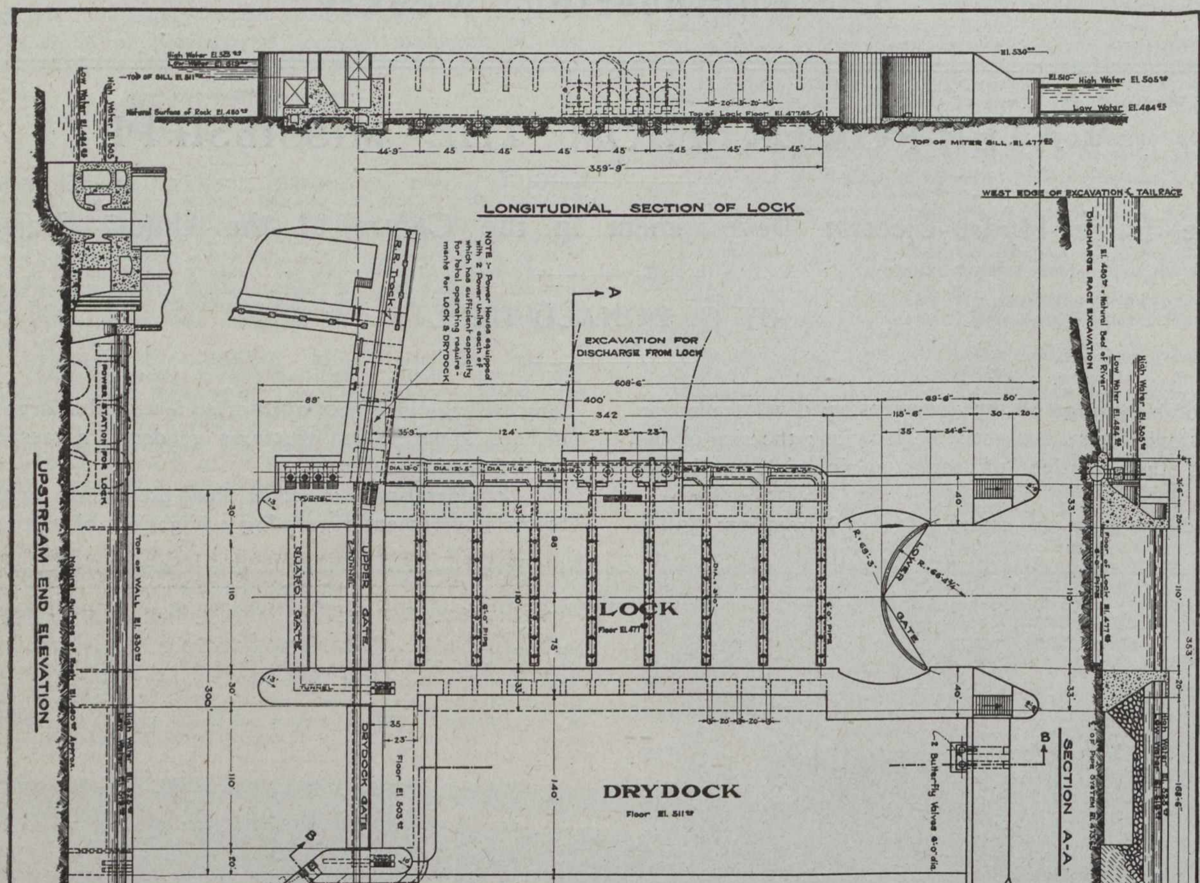
The location is in the centre of the Mississippi Valley with its large supply of raw materials for factories and its large consumption of manufactured products—and there are no other large water-power sites near this one.

Part of Forebay Side of Power House, Showing Arch in Front of Each Unit. Behind the Arches are the Pilasters Carrying the Strainers and Separating the Four Intakes to each Turbine.

The development at the foot of the Des Moines Rapids in the Mississippi yields over 300,000 horse-power on the turbine shafts. It consists of a dam 4,649 feet long, including the abutments at either end, a power house 1,718 feet long, a large lock with a lift of 40 feet, and a large dry dock, besides appurtenant structures rendered necessary by the conditions found there.

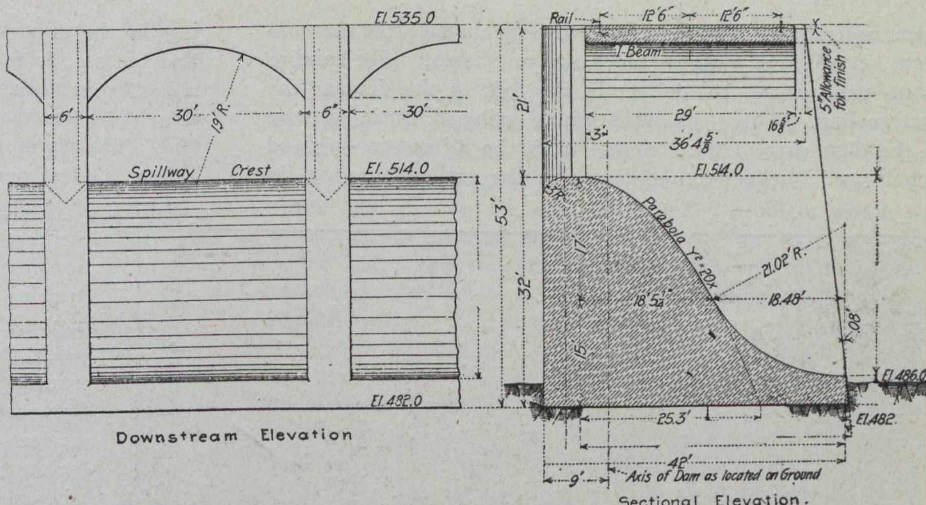
Considerations of river flow prescribed by the United States government regulating navigation, of storage, and of constant head, determined the plan of the dam. It consists of 119 arched spans with 30-foot spaces between 6-foot piers; in each span is a spillway topped by a steel gate. The dam is gravity section, massive concrete with each one of the 119 sections capable of withstanding all stresses upon it without reference to any other part of the structure. At first glance, the dam strongly suggests a bridge, and reduced to its lowest mechanical terms it is a bridge with spillways between the piers. The spillway portion is 4,278 feet long; the east abutment is 290 feet long, and the west abutment 81 feet long, the latter being integral with the substructure of the power house. The dam structure is 29 feet wide on top and 42 feet wide at the bottom, which is set several feet into the hard limestone bed of the river; the height of the structure is 53 feet and the spillways are 32 feet high.

Each spillway has a vertical up-stream face; the down-stream face of the spillways is an ogee curve. The steel gate on top of each spillway is 32 feet long, working in slots in the piers, and is 11 feet high, reaching to the springing line of the arch of the span. They are trusses faced with ⅜ inch steel plates and will be operated with a traveling crane running on the top of the dam. The down-stream bearing surface of each slot is faced with an iron plate. When the final installation is completed the surface of the pool will be a little below the tops of the 119 gates, and conditions of



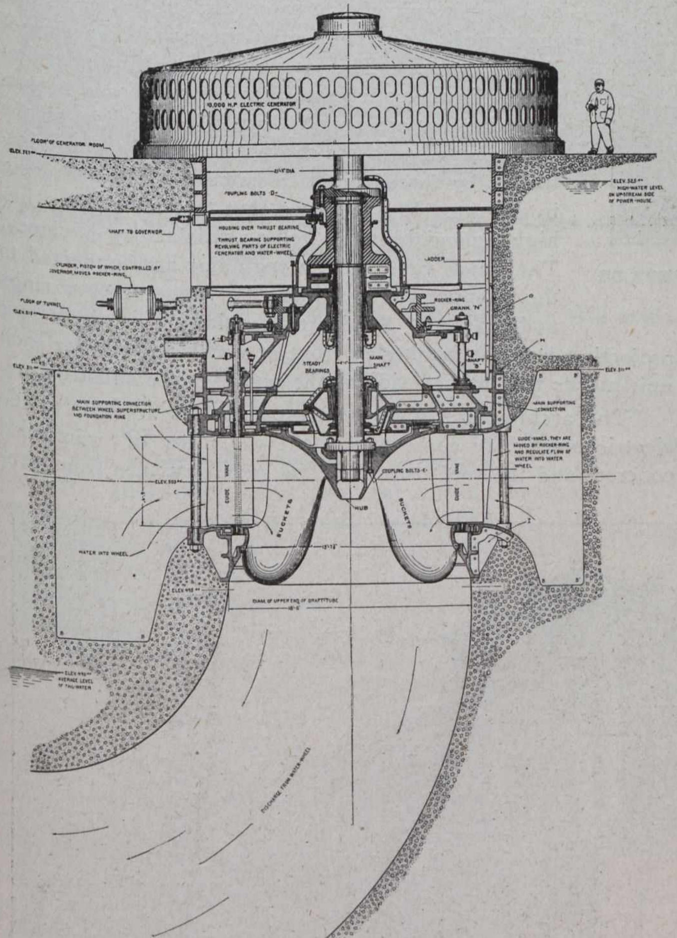
river stages and flow will govern the number of gates open at any one time.

In building the dam, a thorough examination was made of its foundation. The river bottom at the side is blue limestone of rather remarkable homogeneity considering the distance involved. The bottom was unwatered by a cofferdam



Details of Main or Spillway Dam Across the Mississippi River.

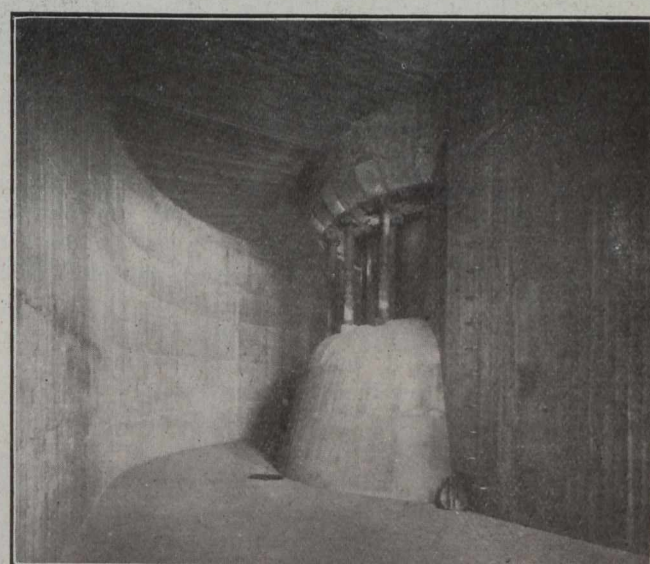
several hundred feet long built ahead of the progress of the concrete dam itself, section by section as the work advanced. In this cofferdam section was made the excavation to key the dam into the bed-rock. Holes 4 inches in diameter and 30 feet deep were drilled to test for seams and pockets of softer material. Tests of these drill holes were made in three ways: They were dried and carefully inspected later for any moisture; they were put under air pressure after being sealed at the top and the attached gauge examined for any loss of air; the penetration of the drill as an ordinate to time was carefully platted and a regular curve required. The failure of the test hole to withstand these severe tests was



Centre Section of Main Turbine on Transverse Axis of Power House.

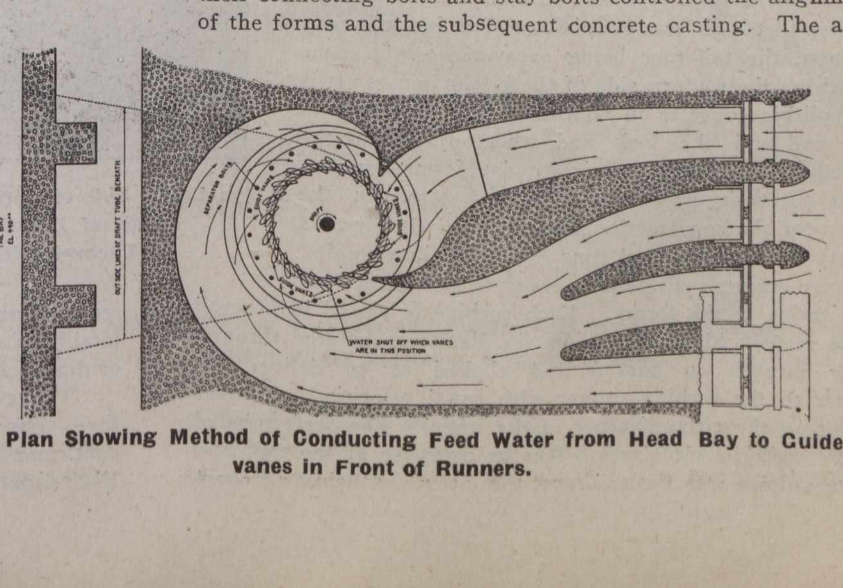
cause for special excavation and investigation, although this was practically not necessary in the entire length of the dam.

Steel forms were used in casting the dam, eight being in use at one time and the rear-most being constantly moved to the front, so that there was no delay on account of the concrete workmen waiting on the form riggers. The parts of each form were made interchangeable with the others. In the bottom member of each pier-form were two holes to fit over two dowel pins projecting from castings set in small concrete piers. There was a main frame for each up-stream and for each down-stream leg of the forms of each pier, and it was in the bottoms of these that



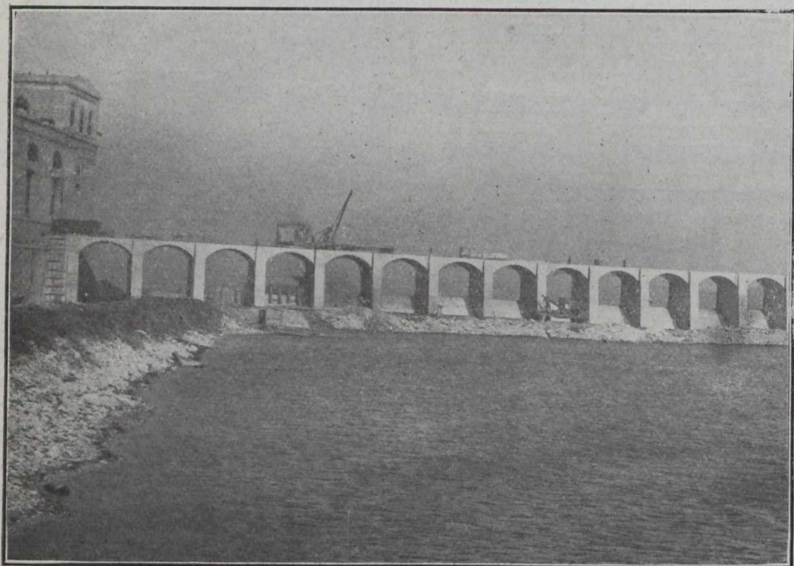
Part of Scroll Case with Turbine Installed, Surrounded by Guide-vanes.

the sockets fit the dowels in the base plates. By careful instrument work, these base plates were accurately located in alignment. After that, the members of the forms and their connecting bolts and stay bolts controlled the alignment of the forms and the subsequent concrete casting. The arch



Plan Showing Method of Conducting Feed Water from Head Bay to Guide-vanes in Front of Runners.

forms were hinged and arranged to be removed after the concrete set without wedges, blocking, or shores. The mixing plant was placed to deliver in the axis of the dam at the eastern end. Three standard gauge railroad tracks on top of the dam carried the concrete from the mixers in one and a half-yard buckets to the forms at the end of the dam in



Junction of the Dam and the Power House, Showing Some Spillways on Top of which go the Steel Gates.

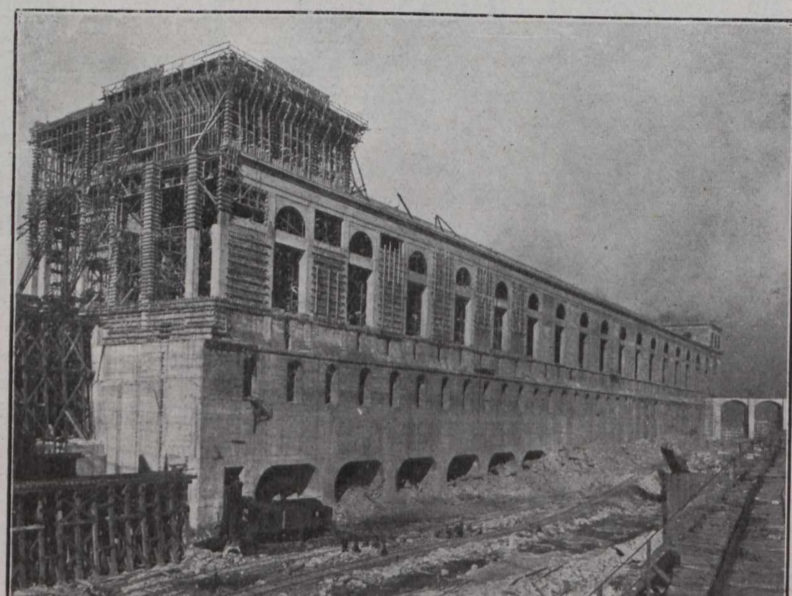
process of construction. There was a cantilever traveler with its cantilever arm 150 feet long extending out over the forms, which picked up the buckets from the cars and dumped them in place. This cantilever traveling crane had a main frame 25 feet by 90 feet, mounted on six heavy steel wheels which ran on a track of 25-foot gauge and 100-pound rails, spanning the three tracks used for hauling the concrete. This cantilever traveler, after its work on this dam was done, was sold to a Canadian company for use on the St. Lawrence.

The spillways were built with side dump cars pouring the concrete into conveyers which carried to the forms below, after the main structure of the dam was completed. Temperature variation of volume inducing cracking was provided against by strips of tar paper inserted in every pier and arch.

The power house is set near the Iowa shore almost parallel with the river, with the forebay between it and the Iowa bank, a curve in the river increasing the width of the upper end of the forebay. The substructure, 132 feet 10 inches by 1,718 feet and 70 feet high, was set about 25 feet into the river bottom, the tail race being excavated to the same depth on the eastern side of the power house. It is monolithic concrete in continuation of the dam at one end and the lock and other adjuncts at the other end. It was cast in wooden forms, an area of about thirty-five acres being unwatered in the river for the construction plant there. It contains thirty power units and four exciter-auxiliary units. Gantry cranes were used as concrete conveyers from the trains to the forms. Each turbine is placed in a scroll case 22 feet high and 39 feet in diameter, entered through four intakes so curved and choked as to deliver the water to the turbine runner with equal velocities at every point on the circumference of the wheel. The draft tube of each unit is circular, 18 feet in diameter at the top, and curves down into the tail-race, the lower end being an opening in the superstructure, two semicircles with tangent top and bottom, 22 feet 8 inches in vertical diameter and 40 feet 2 inches in horizontal width. The bottom of the draft tube is at the bottom of the tail race about 25 feet below the river bed. The water velocity at the upper end of the draft tube will be 14 feet per second, and at the exit 4 feet per second.

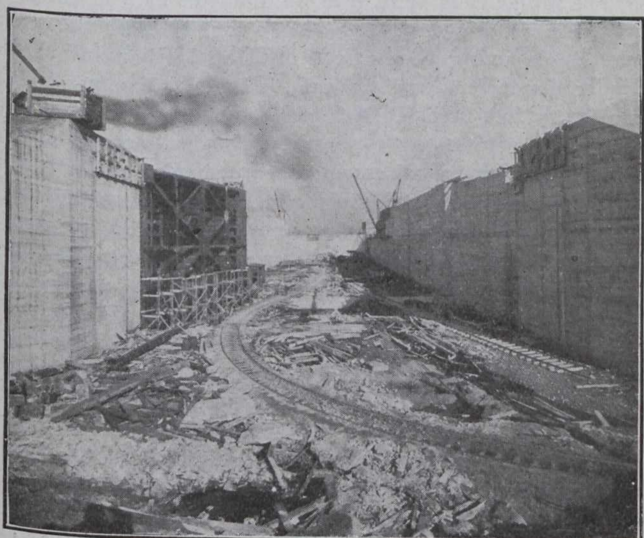
The turbine here presented the problem of a head of 32 feet with large volume of water and low rotation. As finally worked out, the answer is a turbine of original design, Francis type, of 57.7 r.p.m., efficiency of 86 per cent. by Holyoke test, and a little over 10,000 h.p. on the shaft. The runner has twenty buckets and weighs about 130,000 pounds, is 16 feet 6 inches in diameter and 11 feet 3 inches high. The shaft, with the turbine below and the revolving field of the generator above, is 25 inches in diameter. The weight is supported on one thrust bearing set high in the turbine pit, out of the water, and easily accessible, the top of a cone resting on the foundation ring of the pit liner. The latter is a steel cylinder imbedded in the concrete with rings at top and bottom weighing 100,000 pounds each. The weight on the thrust bearing is 550,000 pounds, and the lubrication is by forced oil with immersed roller bearing in reserve. It is believed that this installation has high dependability as well as satisfactory efficiency. The guide vanes of the regulator are connected to the compression cylinder by levers, rocker rings and cranks. Strainers are placed on buttresses projecting between intakes in front of which an arch for each unit marks the forebay side of the power house substructure.

The architecture of the superstructure is adapted to the electric machinery content, and the walls are of reinforced concrete and the roof trussed. The superstructure from generator floor to roof pinnacle is 107 feet 6 inches, making the total height of the power house 177 feet 6 inches from bottom of draft tubes to pinnacle.



The Lower Side of Part of the Power House, Showing Parts of Lower Ends of Draft Tubes with Exits into the Tail Race Excavated into the Bottom of the Mississippi.

The generators are rated at 9,000 k.v.a., 11,000 volts, three-phase, 25-cycle, with a full load efficiency of 96.3 per cent. and a regulation of 13 per cent. at unity power factor. Each armature is 30 feet 9 inches in diameter, and each generator weighs 614,000 pounds. Alternators, driven by turbines, supply current of 25 cycles at 460 volts to three-phase busses running the length of the power house generator room, and from these busses is tapped off a 100 kw. generator set for each generator to excite the latter at 250 volts. The



The Keokuk Lock in the Mississippi During Erection of First Leaf of Lower Gates.

wiring of the electrical installation is worked out with some interesting novelties.

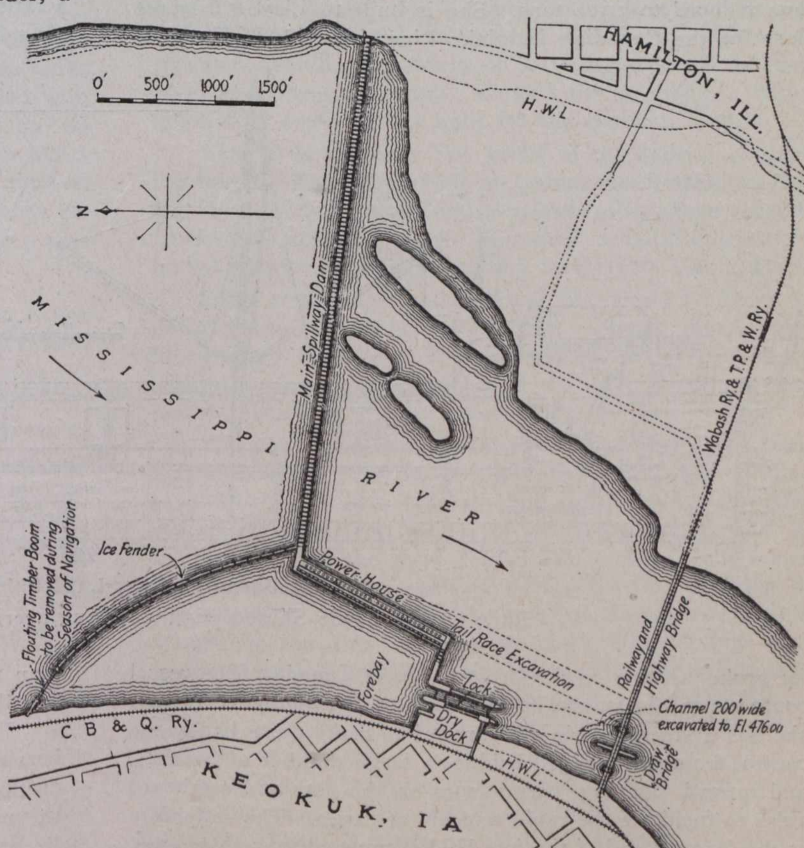
Swinging in a long curve from the western end of the dam across the entrance to the forebay is the ice fender, a concrete bridge with 10-foot piers and 60-foot spans, 8 feet wide at top and 16 feet wide at bottom, with its top 5 feet above high-water and the top of the span openings 4 feet below low-water. At the shore end is a floating boom of timber to permit steamboats to pass.

The shore side of the forebay is a sea-wall 1,100 feet long and 45 feet to 53 feet high, which protects the railway tracks elevated above the new water level above the dam. Fourteen miles of railroad had to be elevated and relocated along the pool.

The lock is at the lower end of the forebay, beside the dry dock, and is connected to the lower end of the power house substructure by a wall in which is placed the small turbines generating power to operate lock and dry dock through compressed air engines. The basin of the lock is 110 feet by 400 feet, and the lift is 40 feet with 8 feet over the sill of the upper gate. The conduit system comprises a main stem 13 feet in diameter under the east wall, with eight cross conduits 6 feet in diameter under the lock floor. In each cross-conduit are seven apertures, making a total of fifty-six openings for filling and emptying the lock chamber. Cylinder valves control the culvert system.

The lower gates are curved to R. 66 feet 4¾ inches inside and of 69 feet 3 inches outside. The versine is 10 feet 8½ inches. Their height is about 50 feet. Buoyancy chambers in the bottom are 12 feet by 31 feet 8 inches in dimensions. Each leaf has thirteen horizontal arched ribs 4 feet apart, connected by heavy girders and nine lines of intermediate framing. The railroad bridge steel, of which it is built, is tested to 65,000 to 70,000 per square inch. The pintles are of nickel-steel with bushings of bronze, and are hemispheres 18 inches in diameter. The mechanism by which these gates will be moved is the same as that at the Gatun locks on the isthmus of Panama, and it will be operated by a 40 h.p. compressed air engine.

The lock is 8 feet over the sill, in harmony with the 6-foot depth of channel being worked out by the government engineers between St. Paul and St. Louis, by order of Congress, with a factor-future of one-third added here. The upper gate of 110-foot span presented a problem which was solved with a gate of unique design. The lock gate and guard are raised to closed position and latched there by a buoyancy chamber, into which compressed air is pumped to replace water. To open the gate, water is allowed to enter the buoyancy chamber. The gate sinks beside the sill and the boat passes over it. Valves control the water and air inlets to the buoyancy chamber, and are themselves operated by compressed air. A rod running the length of the gate has a pinion on each end engaging a vertical rack, this device preventing jamming. Simplicity characterizes the design, and care was taken to make these upper gates "fool-proof," that is, dependable when operated by ordinary laborers. On top of the lock gate will be a standard railroad track, affording entrance to the power house from the railroad systems of the country, and the heaviest loaded freight cars may pass over the gate into the power house to be unloaded there by traveling cranes of 150-ton capacity installed there. Besides the lock gate and the guard gate, there is another gate to the adjoining dry dock chamber, and all three are built interchangeable. Should any gate need repairs, it will be floated, buoyant, into the dry dock, and if necessary, the guard gate may be temporarily used as either the lock gate or the dry dock basin gate. Each gate is easily and quickly removed by disconnecting it at both ends and floating it in the axis of the lock outside of its normal position, where the walls are re-



General Plan of the Dam and Power Plant of the Mississippi River Power Company, at Keokuk, Iowa.

cessed in a curve on each side, permitting the gate to be turned on its own centre and towed away. The dry dock basin is 140 feet wide and 463 feet long on the bottom, and has a culvert system for filling and emptying it by gravity. It has sloping sides, and the dimensions at the top are 168 feet 6 inches by 468 feet over all. The grounds for machine shops, store house and other government buildings are extensive. This work, which is just beginning with the advent of 1913, requires a fill of 200,000 cubic yards.

The chief engineer of the work, all of which is done by administration, is Hugh L. Cooper, M. Am. Soc. C.E., who organized the Mississippi River Power Company, the proprietor of the water-power development there in which considerable British capital is invested. Mr. Cooper was attracted to the possibilities of the Mississippi development after finishing his labors on the plant of the Electrical Development Company at Niagara Falls, Ontario. He has a large and carefully planned organization on this Mississippi River work, which has progressed with remarkable speed and economy.

A NEW CANADIAN OIL-ENGINED SHIP.

An oil-engined vessel, the "Fordonian," has just been finished and has received her initial trials. The ship was built by the Clyde Shipbuilding and Engineering Company, Limited, of Port Glasgow, Scotland, and is the first vessel built on the Clyde propelled by two-stroke cycle Diesel oil-engines.

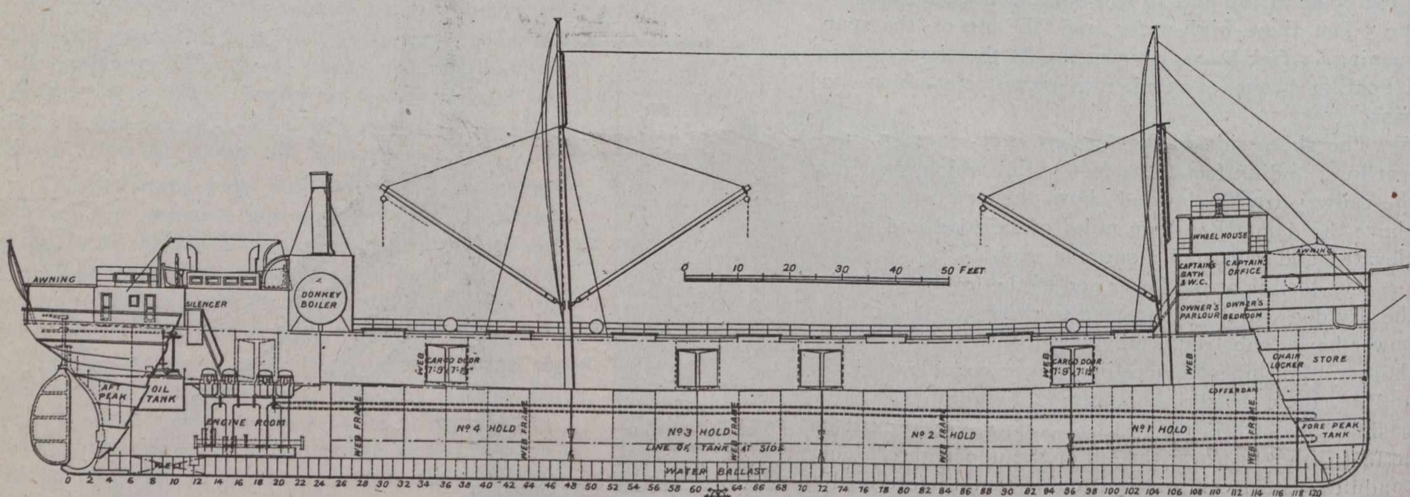
The leading dimensions of the ship are 250 ft. long, 42 ft. 6 in. beam, 16 ft. 10 in. moulded depth to the main deck, and 26 ft. 6 in. to the awning deck. The "Fordonian" has a 2-ft. frame pitch, and a dead-weight cargo-carrying capacity of 3,300 tons on 16 ft. 6 in. draught. The draught on service is restricted to 14 ft., and the dead-weight capacity is thus reduced to 2,200 tons. She is built to Lloyd's highest class for the Canadian Interlake Line, Limited, of Toronto, for grain-carrying on the Great Lakes of Canada. The vessel conforms to the standards of Canadian Lake practice in that she has a steering-pole out forward to make quite handy the control from the forward bridge, a large number of hatches, and inward opening cargo-doors on the port and starboard sides to facilitate the rapid removal of cargo. The cofferdam at the forward end of the fore hold is unusual in such vessels, and is intended to preserve the cargo from damage should the ship spring a leak as a result of coming in contact with any one of the many locks through which she passes in her regular trading. There are two independent controls from the bridge to the engine-room telegraph, and the steam steering-engine is operated by rods from the bridge.

As with sister-ships, there are two masts with derricks on each, and the chart-house and navigating bridge are situated right forward. The rudder is balanced and is of large area. In the trials the vessel turned almost in her own length, and when the helm was put hard over she almost came to a dead stop.

The propeller is 11 ft. 9 in. in diameter by 9 ft. pitch.

The main propelling engine is a four-cylinder two-stroke cycle single-acting Carels type of Diesel oil-engine. The cylinder dimensions are 460 mm. (18.1 in.) diameter by 820 mm. (32.25 in.) stroke, and the engine runs normally at about 100 revolutions per minute. The bed-plate is of cast iron and is of the usual marine design, having a flat bottom and being supported in the centre as well as at the sides. This design contrasts with that evolved by many Continental makers, who prefer the bed-plate supported at the sides only, with the cross-members of deep box section carrying the main bearings, which have forced lubrication. The columns of the engine are of the usual box section, bolted rigidly together at the top, and are very thick, to withstand the tension stresses consequent upon the high pressures of the Diesel cycle. These tend to give great rigidity; the engine ran entirely free from vibration. With this design of support the bed-plate must be strong to take the bending stresses between the column feet and the main bearings.

The arrangement of the engine into two units of two cylinders each permits of a two-piece crank-shaft in interchangeable halves, of the vertical spiral drive for the valve gear being taken from the centre of the engine, and also of the scavenging-pumps being driven from the two centre crossheads by links, as with the air-pump of steam-engines. The dimensions of the double-acting scavenging air-pumps are 27¾ in. in diameter with a 23½-in. stroke, and give thus a ratio of free air compressed for scavenging to combustion air taken into the main cylinders of 1.65, which is higher than the usual practice. The pressure of the scavenging air is 3 lb. per sq. in.



The Canadian Inter-Lake Ship "Fordonian."
Built by the Clyde Shipbuilding and Engineering Company, Limited, Port Glasgow.

The system of lubrication is interesting. For the main bearings solidified oil is used, for the crank-pin bearings the ordinary drip-feed suffices, and the bearing pressures for the main and crank-pin bearings are respectively about 300 lb. and 650 lb. per sq. in. For the lubrication of the cross-head bearing, a small lubricating-oil forcing-pump is attached to each crosshead, and worked by the swing of each connecting-rod, as shown. This system of lubrication permits of an open crank-case, and the bottom end bearings can always be easily felt by the engineer on watch. There are two guides for each, such being Messrs. Carels' practice for oil-engines.

The piston is lubricated by four Mollerup lubricators, which force the oil between the piston and the cylinder; there are four inlets to the cylinder, and they are arranged to enter on the fore-and-aft and athwartship centre lines.

The control of the engine is by means of one wheel and two levers on the starting-platform; one lever controls the compressed-air engine, which gives the cam-shaft its angular displacement by raising or lowering the vertical driving-shaft, and also gives the manœuvring-shaft its fore-and-aft movement. The other lever controls the fuel. The wheel operated by hand, gives the manœuvring-shaft its rotary motion. The cams upon the manœuvring-shaft act upon the suction-valves of the fuel-oil pump. Hand control is also provided by the handle on the column, which actuates a shaft running fore and aft on the engine, and so sets all the fuel-pump suction-valves. Although compressed air is used for actuating the vertical shaft, causing the angular rotation of the cam-shaft and the rotation and displacement of the manœuvring-shaft, hand-gear in emergency may be used.

Air storage for starting purposes is provided by four welded steel bottles, of 23⅝ in. diameter by 8 ft. long, and that for fuel injection by one bottle, 1 ft. in diameter by 3 ft. long. The pressure of the fuel injection air and the starting air is 850 lb. per sq. in., and for slow-running engines, such as this, this pressure is quite usual practice. The time taken by the auxiliary compressor to fill up the air storage provided is about one hour. The remainder of the auxiliaries are normal steam practice, and call for no special mention.

The weight of the main engine alone is about 100 tons, and if the auxiliaries are included, all ready for work, 150 tons is the weight of machinery abroad.

There is fuel storage in two oil-tanks placed on both sides of the oil-fired donkey boiler, and two ready-use tanks are placed aft of the engine-room, and are provided with steam heating coils, whilst the oil is filtered, on its way to the fuel-pumps of the main engines, through 15-gallon filters in the engine-room. In all 105 tons of oil fuel is carried, whereas with the sister steamships 250 tons of coal is required. The consumption per day for all purposes is 5 tons of oil fuel, against 14 tons of coal.

The fuel consumption of this engine is 0.47 lb. per brake horse-power per hour, and this is good practice for two-stroke cycle engines with the scavenging-pump and air-compressor driven off the main engine. The pressure of compression is 490 lb. per sq. in. The indicated horse-power at 102 revolutions per minute and 90 lb. per sq. in. is 970; 10 knots were achieved with the engines doing 128 revolutions per minute. The maximum revolutions were 140, the normal about 102, and the minimum 46. The results will undoubtedly be improved upon when the engines are finally tuned up, as prior to the trial trip they had only been run in dock trials for twelve hours in all. This is exactly the same treatment as is given to steam-engines.

The crank-shaft is in two interchangeable pieces, and there are two scavenging-pumps of large capacity. The auxiliary air-compressor is of half the capacity of the main compressor, and since the vertical shaft drive for the valve-gear is in the centre of the engine, should the compressor give out, one scavenging-pump fail, or even the crank-shaft break, the main engine will still develop more than half its normal power. This type of engine seems very suited to the propulsion of cargo boats, and the saving in space consequent upon the adoption of the Diesel engine for this ship is five frame spaces, aggregating 10 ft., some 33 per cent. of the machinery space.

A NATIONAL BOARD OF ENGINEERING CONTROL.

By Evolu.

[Some months ago Mr. T. Chase Casgrain, chairman of the International Joint Commission, offered two prizes for the best essays on the Formation of a National Engineering Service. The competition was held under the auspices of the Royal Military College Club and the Canadian Society of Civil Engineers. Through the kindness of Mr. Casgrain, we are enabled to publish the essays which obtained first and second prizes. The following essay, by Evolu, obtained first prize, and that by Observer the second prize.—Editor.]

Emerging from the Central Station in the city of Ottawa to proceed in the direction of Parliament Buildings it is necessary to cross a wide highway bridge spanning the Rideau Canal. The canal and the site of the bridge are enduring monuments to a corps of men whose work may be encountered in every quarter of the globe. Men whose motto is "Ubique": as Kipling says, "The men who do something all 'round' . . . the Corps of Royal Engineers."

The canal, built almost a century ago for purposes of defence, is still in the year 1912 a commercial asset to Canada.

To build the new highway bridge at Ottawa, known as the Plaza, it was found necessary to pull down the arch of the existing Sapper's Bridge, built under the direction of Colonel By in 1828. Before the old bridge could be torn down much labor and dynamite had to be employed. After the arch had been materially weakened a boulder weighing almost a ton, hoisted and dropped from a height of fifty feet, failed to complete the process of demolition. Only after repeated assaults and hours of battering did fall the works of these pioneer engineers; works built to endure, without thought of profit, works built for the common weal.

Thus it is wherever the works of the earliest engineers are found. The Great Wall of China, the Roman roads of Europe . . . how many engineers remember those schoolboy (sometimes painful) efforts to render a faithful translation of the chapter on bridge building in Cæsar's Gallic wars?

Some of the most enduring of the world's historic records are the works of the engineer, almost invariably of the military engineer. It would almost appear that engineering originated as a branch of the art of war, cultivated and developed as a department of state.

The passing of the feudal system witnessed the limitation of military government. But while war has declined, engineering has advanced into vast new fields: evolved from the art of war to the science of industrial civilization. And though some of the most remarkable modern achievements of the engineer, the appalling "Dreadnought" fighting machines and to some extent the Panama Canal, owe their existence to the new military method of preserving peace, nevertheless the civil engineer has outgrown his military parent. So that in modern states, such as the Dominion of Canada, even the military colleges are concerned in educating civil engineers.

Although an offspring may outgrow a parent it does not follow that the larger body necessarily must be the more efficient. There is much to be learned from the past. It would be well if every civil engineer could make a pilgrimage to Ottawa and read, mark, learn and inwardly digest the moral to be learned from those century-old works of the Royal Engineers and Colonel By.

Under the industrial system the stress of competition must be held responsible for tremendous waste and lack of combined effort. Work and study have suffered through undue haste. Efficiency has been subordinated to expediency. But the error has been recognized. There would appear to be a growing movement in favor of engineering service organized by the state. Such a service may be found in France known as the Societé de Ponts et Chaussées; in India and Egypt where vast engineering projects are carried out by the Civil Service. In the United States the Army Engineers are responsible for the design and construction of federal works—harbors, waterways and canals; the engineering staff at the Panama Canal has proven such an efficient body it is suggested that the entire organization be retained and employed upon a great national undertaking in the Mississippi Valley.

In Canada the various public service departments have each a staff of engineers, but each departments works entirely independent of the others. Practically no steps are taken towards co-operation or systematic organization of the state engineers. In such a magnificent domain, awaiting development, with great engineering problems to be faced and solved, the day has arrived when some move ought to be made in the direction of the scientific handling of national projects. There is great need for a Supreme Court of Engineering.

Amongst the eight million inhabitants of Canada there is ample material for the formation of such a body. The great works of construction already in existence is good evidence of the nation's ability to accomplish any undertaking. National development could be reduced to an exact science by the organized efforts of experienced, far-seeing men, acting in co-operation, acquiring and recording information systematically.

It would not be proposed to make a revolutionary sweep of the present intricate system of departmental engineering, rather to form a nucleus around which the twentieth century organization could be gradually built up. Studying the history of industrial civilization all roads seem to lead to the principle of combination, evolution from distinct units to corporate organizations. The world's captains of industry appear to have worked out an unassailable method of assuring economic efficiency. Without aiming to effect a corner in technical experts—nationalization of the engineering profession is not yet above the horizon of possibility—it would be possible to draw together and form into, let it be termed, a Board of Engineering Control, a number of engineers with experience and ability sufficient to pronounce with authority upon any engineering project. It would be essential that such a board would be entirely non-political, as the Supreme Court of Justice is intended to be. In the engineering profession there is an abundance of public-spirited men doing faithful service in Canada and actuated entirely by love of their work.

In personnel the suggested National Board of Control could consist of five directors, equivalent to president and vice-presidents of a corporation. In the first formation directors might be appointed by a Royal Commission after due investigation of all conditions relating to the engineering expansion of Canada. The Board should have power to fill all vacancies in future, either by promotion or appointment; also power to select from amongst themselves a permanent chairman of the Board. The appointment of director should be for an unlimited period with retiring pension after a specified period of service.

As with the present system of Auditor General, the Board of Engineering Control should be responsible to parliament alone. The Board should have power to dismiss or appoint any subordinate and have authority to suspend or approve any public engineering contract.

Recall of any director could be enacted only by parliament. Each director upon entering office to be required to tender a formal resignation to the Governor-General in Council: the resignation being signed but undated. Should a reason arise making it necessary to recall any particular director a vote could be taken in the House of Commons. With the approval of the members the resignation of the director could be accepted. The date when resignation should take effect could be specified by parliament and filled in by the Governor-General in Council, thus effecting drastic control of any director by the nation through the national house of representatives.

Following upon the successful establishment of a board of directors the process of gradually building up a staff of expert engineers would commence. It would not be proposed to interfere with the regular working system of government departments, other than to consider and to report upon national projects, until the success of the Board, as an instrument for promoting economic efficiency, had been thoroughly established. But the ultimate aim would be transference of the purely technical work from the various independent units and staffs to the central authority of the National Board of Engineering Control.

Momentous questions are looming up regarding the policy of canal construction in Canada. To deal adequately with the great problem of freight transportation by water it would need a completely organized staff of canal experts. The logical proceeding would be to appoint a Chief Engineer of Canals and Water Service responsible to the Board of Control, with the necessary assistant engineers, draughtsmen and technical clerks. Departmental engineers with the necessary experience could be transferred to form the staff. In the process of time similar staffs could be built up, all directly under the Board of Control, to deal with railways, marine service, harbors, and the rest, until the majority of engineers at present scattered through the various departments would have assembled entirely under the direction of the Board. Where necessary a consulting engineer could remain on the staff of an administrative department. So that should questions arise regarding, for instance, the lease of a water power, it would be the consulting engineer's duty to see that the questions were submitted in their proper form with regard to the technical matter. Just as at present the law clerk or auditor of a department might be required to attend to questions coming under the jurisdiction of the Department of Justice or Auditor General.

The staff of engineers responsible to the Board of Control would be men widely experienced in particular branches; the Chief Engineer of Railways an expert in railway engineering; Chief Engineer of Marine Service, a qualified engineer in marine work; the Chief Engineer of Canals and Water Service should include on his staff expert hydro-electric engineers and irrigation engineers; Chief of Surveys be responsible for all state surveying and conservation; and Chief Engineer of Harbors include a designer of grain elevators. Each chief engineer would have an estimating assistant who should be especially trained to deal with the economic branch of engineering: economics and finance being the most important features in civil engineering under the present day industrial system. It would be the estimating assistant engineer's duty to have reports prepared and estimates made dealing with the economic aspect of any proposed undertaking. Other assistants, electrical, mechanical, hydraulic, would be included on the staff where necessary. Bridge engineers under the Chief of Railways, ship designers under the Chief of Marine, draughtsmen, inspectors and technical clerks as the work demanded.

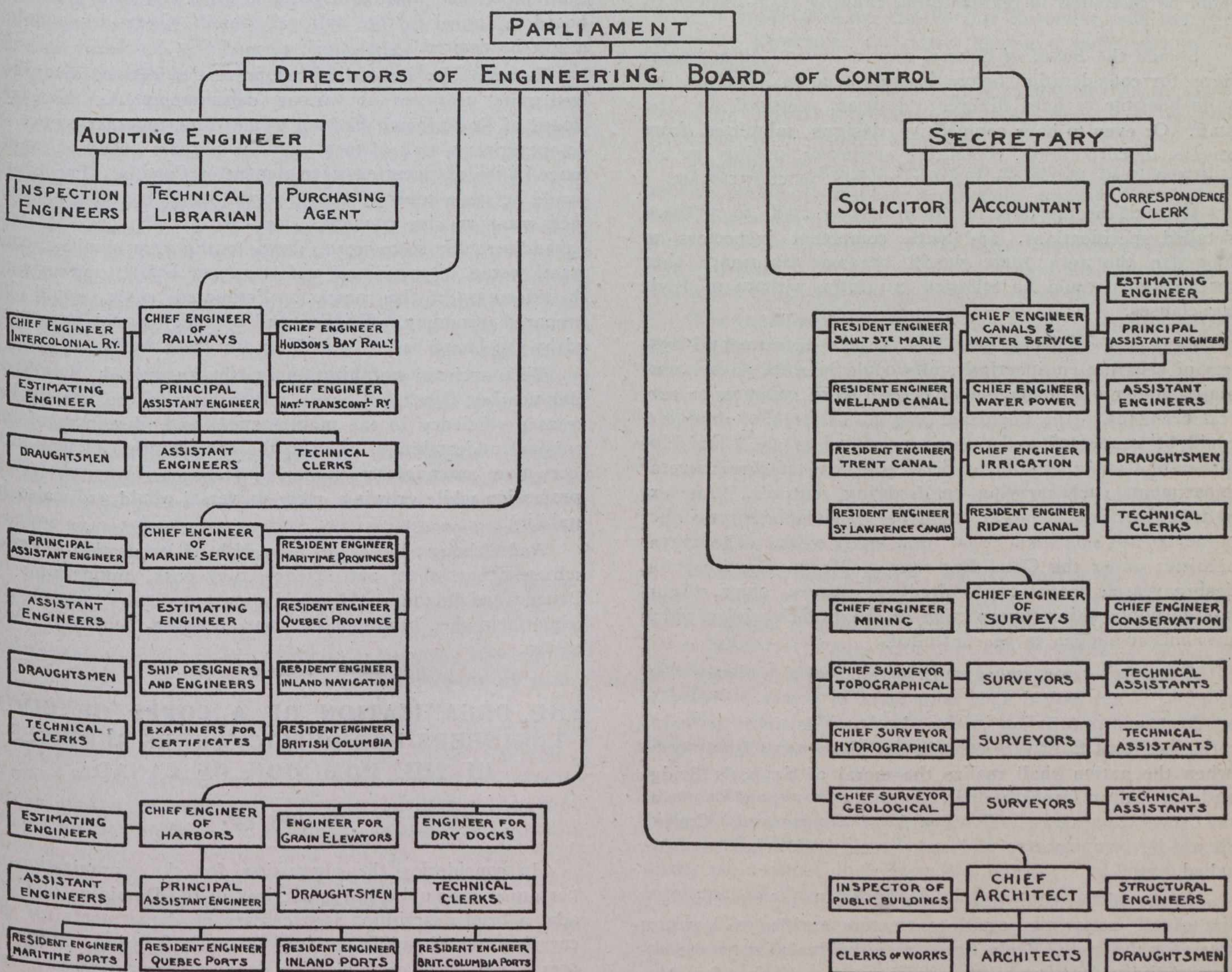
An auditing engineer would be responsible to the Board for fair and just expenditure upon such as inspection, surveying, equipment, tools. The inspection and analytical staff, the technical librarian and the purchasing agent for Board of Control supplies also coming under the auditing engineer.

The secretary to the board to deal with correspondence and the direction of affairs through the proper channels, to be responsible through the solicitor for the legal drafting of contracts and specifications, through the accountant for the payment of salaries and accounts, also for advertising of public contracts, and other clerical work.

Thus, to use the diagramatic form of illustration, the proposed Board of Engineering Control might be organized on lines similar to the appendant plan:

The work of the board could be divided under a number of heads, namely, appraising, approving, estimating, surveying, designing, construction, maintenance. Perhaps the most important would be the work of collecting and tabulating information. There has been published at one time and another a tremendous amount of valuable information for the guidance of engineers and those who are concerned in the development of the country. But owing to the lack of cohesion amongst the various departments, and owing to overlapping, lack of responsibility, lack of system, much of the information has been neglected and practically lost. It would be the duty of the Board to place on record all information available regarding the cost of production and distribution of commodities. A technical librarian would be necessary to classify the information, such as reports, blue books, treatises, scientific publications, catalogues, price lists and other literature, and to arrange it in a system easy of access. The librarian could also be responsible for the filing of all maps, charts, plans and drawings, and for the making of blue prints and photographs.

Designing would necessarily occupy an important place in the work of an effective Board of Control. It has been the practice of state departments upon calling for tenders for some particular contract to allow each tendering firm to prepare and submit their own design with the tender. Such a process would not appear to be the most economic nor the most efficient. The system of varying the design according to the schemes of the various tendering firms is the cause of much wasted effort. It being possible to accept only one tender it generally follows that the unsuccessful designs produce nothing. But each design, whether used or wasted, has to be paid for, if not directly then indirectly by the community. Designs have to be prepared by experts. Therefore included in the bid of each tendering firm is a certain percentage to pay for the services of the expert designers. The percentage is usually sufficient to pay out of the profits of one successful contract, the expense (and a little more) of all tenders, whether the design be used or wasted.



For instance, supposing tenders are invited for the construction of an elevator at some point on the grain route, or for a ship, or a bridge, or a post-office—any public utility. Say five companies are invited to tender and submit their own designs. The average price bid may be one million dollars. Possibly five per cent. ($50,000) of the price may be included to cover cost of preparing design. The actual cost of designing may have amounted to only $5,000: the extra $45,000 goes to pay for unaccepted designs in other unsuccessful tenders.

To the national exchequer a great saving in contracts could be effected by the Board of Control preparing its own designs.

Each contractor bidding upon a different design entirely nullifies the system of awarding contracts to the lowest bidder. The design of the lowest bidder may be, and usually is, far inferior to those of the higher bidders. Thus efficiency may be sacrificed to false economy.

By having one approved design only, each firm would be bidding upon an equal basis. The Board of Control could have sufficient copies of the approved design forwarded to the particular firms invited to tender, and the resultant bids could be compared in regular order ranging from highest to lowest.

Should the Board of Control require several different designs for consideration before inviting tenders, it would be quite possible to have different designs prepared by the staff. Or even to have competitive designs submitted from private, or corporation, consulting engineers, paying for accepted designs before calling for tenders on construction.

It would be the duty of the designing staff to prepare detailed specifications, and with competent inspectors to supervise the work, there would be some assurance that specifications would be followed faithfully, without misleading clauses.

Increased efficiency over the present departmental system of separate engineering staffs could be effected by combining under one management certain work common to several branches. The important and costly work of dredging could be conducted under the supervision of the Chief Engineer of Canals and Water Service instead of three several departments each carrying on dredging contracts. An experienced bridge engineer could be responsible for the accuracy of all important structural steel work. The naval architect under the Chief Engineer of Marine Service could design vessels, canal tugs, dredges, survey ships, lighthouse supply ships, irrespective of the branch under which they might happen to be controlled.

Contracting, or actual construction work, by state employees, is not looked upon with favor at present. There is an erroneous impression in Canada that it is more profitable to let out work to private contractors. But the day may come when the nation shall realize the moral of Sapper's Bridge and the Rideau Canal built by those state servants known as the Royal Engineers. The Board of Engineering Control should be competent to undertake such work when occasion called.

It should be within the power of the Board to compile a list of all corporations and contractors entitled to perform work for the state. Only firms, or individuals, upon the approved list to be afforded the privilege of tendering for state work. The Board to reserve the right to add to, or expunge from, the list any undesirable or defaulting contractor. Such a list is effectively used to maintain a high standard of efficiency in British Admiralty work, where the annual expenditure amounts to £45,000,000 (over two hundred million dollars per annum).

Outside engineering staffs, those of the national railways, canals, lighthouse engineering and the rest, would pass automatically under the control of the Board.

There would be practically no change in the routine work of the various departments outside of the technical staff. But by relieving the deputy ministers of the responsibility of attending to technical work there would be a great relief of pressure upon the several executive heads. A desirable state of affairs which one may be sure would be welcomed by the ministers of the Crown.

Qualification for an appointment under the Board of Control would be based strictly upon experience and ability as an engineer. Any attempt to introduce irrelevant influence, appeals to members of parliament or commissioners, or any other than the mode of application specified by the Board should be deemed sufficient to cancel an application.

With the successful establishment of the Board of Engineering Control responsible to the Federal Parliament it might be possible to expand the principle to the various provinces and towns, provincial and city, or local engineering boards being founded upon similar lines. Provincial Boards to stand in relation to the national board on a basis similar to the standing of the Provincial Courts of Justice and the Supreme Court, making it possible for a city or a provincial board to appeal to the national board where its opinion might be desired.

To sum up: Instead of the present system of disorganized units scattered in various departments the National Board of Engineering Control would draw together to act in co-operation a staff of men with the highest grade of experience in the engineering development of Canada. The board would act as a court of appeal to the many engineering projects vital to the country's well-being. All designs and expenditure for state work, down to the very smallest contract, would be examined and approved before authorizing the execution of the contract. Estimated costs would be prepared, economy, efficiency and accuracy would be ensured by the board before launching any state work.

With such an organization as the suggested Board of Engineering Control, Canada might hope to see greatly increased efficiency in the maintenance and development of national undertakings. And in the consideration of new projects more exact information and foresight. The engineering profession while growing more universal would grow also in stability.

And although the era of war, with its inspiration to great achievements in art and science, may pass, engineering in Canada and in the world would progress from triumph to triumph in the never-ending war between humanity and nature.

THE ORGANIZATION OF A CORPS OF CIVIL ENGINEERS FOR PUBLIC WORKS SERVICES IN THE DOMINION OF CANADA

By Observer.

In considering the suggestion for the organization of personnel for public works services in the Dominion of Canada, a brief description is necessary of departments for the carrying out of public services of an engineering nature in some other parts of the world; only two countries have been selected.

IN THE BRITISH EMPIRE.

(1) India.
(2) Colonial Possessions.
(3) The United Kingdom.

where the long record of successful engineering works carried out by engineers of our own race is one worthy of careful consideration.

IN THE UNITED STATES.

Where, to a certain extent, natural features and climatic conditions have presented engineering problems similar to those of the Dominion which have been handled by engineers with educational qualifications of a similar nature to those acquired at Canadian engineering institutions.

An outlined scheme for the development of a public works service in Canada will then be put forward for consideration.

The British Empire.—In newly acquired territories it has been the usual procedure that, during the process of development, the government has turned to military engineers to carry out the pioneer work of the country. As the public works increase in importance and magnitude and the country settles down, the formation of a civil engineering department has been undertaken, recruited partly from the military engineer corps and partly from civil engineering institutions.

The difficulty in the organization of these departments has been in the adjustment of the conditions of service for the personnel recruited from the two sources, so that they shall work together harmoniously, the strong points of the one class supporting the weak points of the other.

The military engineer brings to the public service a good general education, the power of organization, and a ground work of engineering knowledge on many subjects coupled with the habits of obedience and discipline acquired from his military training.

The civil engineer brings a higher standard of engineering knowledge from a specialized course at an engineering college; he is, as a rule, a specialist in one particular line, in which he excels over his military confrére; but he is not so adaptable as his rival, who usually has a better grounding in general education on which to build technical knowledge during his career. Moreover, the attractions of an independent engineering career in civil life, with its higher rewards for success, draw away the best class of engineers from the public service, which appeals more to the engineering graduate of lower attainments and less ambition, who is drawn by the fixed salary on a graduate scale, and the prospect of a pension in later years.

The selection of candidates for the public service in Great Britain, India and the Colonies, is made under certain conditions by competitive examination tests conducted by a public examining body termed civil service commissioners, who are appointed "at pleasure" by orders-in-council.

The civil service commissioners in the Uniter Kingdom, who examine candidates for entry into the public service in all its many departments under conditions laid down by these departments, consist of two commissioners only, who hold office practically for life, so as to ensure continuity of policy and procedure.

These commissioners select examiners and critics for the preparation and marking of examination papers, exercise a general control over the papers set, and conduct the detailed arrangements for examination, namely, publishing announcements of examinations and syllabi, collecting entries of candidates, supervising written and practical examinations of candidates, checking, collating and recording marks, and preparing and publishing lists of results.

INDIA.

The Railway Department deals directly only with railway systems that are the property of government; the department is sub-divided into two main branches: (1) Construction, and (2) Traffic. **Construction** includes the survey and construction of new lines and the maintenance of existing lines. From this branch are selected the consulting railway engineers to government, whose duties cover the inspection of lines owned or worked by companies.

The Traffic branch handles passenger and freight traffic on open lines; from this branch the managers of both state-owned and company lines are usually selected.

Locomotive and audit branches, with personnel recruited from other sources, are usually separate from the other two.

The Public Works Department is divided into two branches.

(1) Buildings and Roads.
(2) Irrigation.

The Building and Roads Branch deals with the construction and maintenance of all government buildings and main roads, outside military cantonments. The country is divided into areas corresponding to the civil administrative districts, with public works department officials on the staff of the civil administration.

The Irrigation Branch controls the construction of new canals and reservoirs, the maintenance of existing irrigation works, and the distribution of water for agricultural and other purposes. Irrigation is carried out either by diverting the supply from the main rivers by means of canals (Punjab and Ganges Canal System) or by damming large catchment areas to retain the periodical rainfall either by one large tank or a series of smaller ones, (Mysore Tank System). The largest projects undertaken are the Periyar Reservoir, and the Mari Kunaway Reservoir, the latter having a water area of 120 square miles.

The engineers in the higher grades are drawn partly from the Royal Engineers and partly from civil engineer graduates in the United Kingdom.

The Royal Engineers remain on the active list of the corps, receive periodical military promotion, qualify for military pensions, and are liable to recall to military duty when required; they receive pay at civil rates, department promotion and periodical furloughs (on military pay) similar to the civil engineers of the railway and public works departments.

The commissioned ranks of the Royal Engineers are recruited by competitive examination amongst the cadets of the Royal Military Academy, Woolwich, after a two-year course of study; about thirty commissions are offered annually (one commission annually is offered at the Royal Military College, Kingston). After receiving a commission in the Royal Engineers, and before proceeding to India, a two-year course is followed at the School of Military Engineering, Chatham, including occasionally a six months course of instruction on a British railway.

Engineers of the public works department are lent to native states in India for local public works departments; Lieut.-Colonel Joly de Lothbiniere, R.E., a graduate from the Royal Military College, Kingston, has served in the states of Mysore and Kashmir, being at present chief engineer in the latter state.

The civil engineers used to be recruited from the Royal Indian Engineering College at Cooper's Hill, England, after a three years course of study. This college was abandoned some years ago, and now civil engineers are obtained by competitive examination from graduates at engineering colleges in the United Kingdom. The supply, however, hardly meets the demand, and there is a tendency to increase the proportion of Royal Engineer officers in the higher grades.

The various grades in the railway and public works departments with approximate rates of pay for each year's service are as shown below; these rates of pay are not so high as are given in the army administrative departments in India, (i.e., supply and transport, ordnance and accounts); it has also to be remembered that Royal Engineer officers have to keep up military uniforms, equipment and field kit, pay regimental subscriptions, meet extra expenditure involved by active military service, and receive less favorable pay while on furlough than the civilian engineers in the Indian public works department.

Approximate Rates of Pay in Public Works Department, India, by Length of Service.

Years of Service	Military Rank in R.E.	Grade in P.W.D.	Rate of pay per mensem	Equivalent in Dollars per Annum
32	Colonel	Chief Engineer, 3rd grade	2127 Rs.	$8,508

There are two higher grades of chief engineer.

Approximate Rates of Pay in Public Works Department, India, by Length of Service.

Years of Service	Military Rank in R.E.	Grade in P.W.D.	Rate of pay per mensem	Equivalent in Dollars per Annum
31, 30	Lieut.-Col.	Superintending Engineer, 1st grade	1915 Rs.	$7,660
29, 28	"	Superintending Engineer, 2nd grade	1861 Rs.	$7,244
27	"	Superintending Engineer, 3rd grade	1692 Rs.	$6,768
26	Major		1540 Rs.	$6,160
25, 24, 23	"	Executive Engineer, 1st grade	1445 Rs.	$5,780
22, 21, 20	"	Executive Engineer, 2nd grade	1149 Rs.	$4,596
19, 18, 17	Captain	Executive Engineer, 3rd Grade	939 Rs,	$3,756
16, 15, 14, 13	"	Assistant Engineer, 1st grade	780 Rs.	$3,120
12, 11, 10, 9	Lieutenant	Assistant Engineer, 2nd grade	548 Rs.	$2,192
8, 7, 6, 5	"	Assistant Engineer, 3rd grade	496 Rs.	$1,984
4, 3	2nd Lieutenant	"	439 Rs.	$1 756

The following Indian military pensions may be earned by Royal Engineer officers, who have served all their time in India (except three years at the School of Military Engineering and with the Royal Engineer units in England under 15 years' service):

After 20 years' service, 250 pounds per annum.
After 24 years' service, 365 pounds per annum.
After 26 years' service, 432 pounds per annum.
After 28 years' service, 500 pounds per annum.
After 30 years' service, 600 pounds per annum.
After 32 years' service, 700 pounds per annum.

Survey of India.—Besides the railway and public works departments there is another public department in India which is entirely manned by military officers, the survey of India.

This department is divided into three branches: Trigonometrical, Topographical and Revenue.

For those gifted with a talent for higher mathematics, a liking for delicate instruments, and an interest in geodesy and astronomy, the trigonometrical branch affords full scope. The framework of all mapping is based on the work of this branch.

The topographical branch carries out any original topographical work (nearly all the country within the British frontier has now been surveyed) and periodical revisions of existing maps; about six or eight months are spent under canvas every year.

The revenue branch prepares cadastral plans for revenue purposes in settled districts.

Besides these branches some officers are employed on tidal and magnetic surveys, and in the instrument and map producing offices at Calcutta.

The rates of pay are slightly higher than in the public works department; the officers belong to the Royal Engineers, with a few specially selected officers from the Indian army.

Indian Telegraph Department.—This department used to draw on Royal Engineer officers to fill the higher grades, but as a succession of Royal Engineer officers filled the post of director-general for some years, it was decided that the employment of military officers was not in the interests of the civilians in the department.

Except for a few junior Royal Engineer officers under instruction for two years, none have been employed in recent years. This department has recently been amalgamated with the post office department, following the post and telegraph organizations in the United Kingdom. No private telegraph or telephone companies are allowed in India; these services being reserved for government revenue purposes.

The personnel of this department used to be recruited principally from the Royal Indian Engineering College, Cooper's Hill, but in recent years candidates have been selected by open competitive examination held by the Civil Service Commission, followed by a course of instruction at a University in the United Kingdom.

Railway Construction by Military Labor.—It is very customary for sapper and miner companies, under their own officers, to be employed on railway construction work by contract, in unsettled districts, or in districts where civil labor is difficult to obtain.

The Khushalgarh-Kohat-Thol Railway on the northwest frontier, and parts of the Southern Punjab Railway, amongst many others, have been entirely constructed by military labor under military contract.

The sapper and miner companies draw their ordinary regimental pay from army funds; while, instead of engineer pay, a contract is agreed upon between the railway department officials and the commanding officers concerned.

The number of Royal Engineer officers at present employed in the government departments in India is as follows:

Railway Department.

Managers and assistant managers	5
Engineering department (including government consulting engineers)	37
Traffic department	5

Public Works Department.

Road and buildings	23
Irrigation	5
Miscellaneous civil appointments	13

Survey of India.

....	40

EGYPT AND THE SOUDAN.

When Egypt was first taken over for administrative purposes after the downfall of Arabi Pasha, in 1882, the country was administered entirely by military officers.

Gradually, as the country settled down, the military administrators and engineers were replaced by civilians, and the military officers concentrated for constructing the military railway, which eventually carried the British flag back to Khartoum.

Since the overflow of the power of the Khalifa the government of the Soudan has been carried out under military administration.

The governors of provinces are infantry officers, seconded from their regiments, while the postal and telegraph department, survey department, public works department, are entirely controlled by engineer officers.

The Soudan Railway, from Port Soudan on the Red sea to Khartoum, with its branches, is also entirely controlled by engineer officers.

The following number of Royal Engineer officers are at present employed:—

Soudan Railway	6
Posts and telegraphs	2
Public works department	3
Survey	1

besides six officers on the railway, telegraph and survey departments in Egypt proper.

COLONIAL POSSESSIONS IN AFRICA.

Besides the military governors and administrators in the various Crown colonies and dependencies in Africa (excluding United South Africa) the surveys of the British African possessions are being carried out by some twelve Royal Engineer officers, besides four employed on railway and road work.

The Baro-Kano Railway in Nigeria and the Uganda Railway have furnished employment for many engineer officers.

THE UNITED KINGDOM.

Telegraphs.—The general post office in Ireland furnishes permanent employment for officers, non-commissioned officers and men of "K" Telegraph Company of the Royal Engineers, seven officers and about 150 other ranks. The officers are selected from those who have served in the field telegraph units, while the men are specially recruited from telegraph employees of the general post office. The men undergo a short course of military training and then return to their civil duties under the general post office (on civil rates of pay), but retain liability to recall to the colors when required for active service and periodical training. Practically all the telegraphs in the South of Ireland are worked by "K" Company Royal Engineers.

Special Reserve of Officers for General Service in the Royal Engineers.—In addition to the regular officers of the Royal Engineers, a reserve of junior officers for employment on active service was started in 1909.

Before appointment a candidate must have qualified by examination as an Associate Member of the Institute of Civil Engineers.

After appointment the special reserve officer carries out a short course of military training at the School of Military Engineering, Chatham, and is expected to do a short annual training with a regular engineer unit on field training and manœuvres.

No promotions are made above the rank of captain, nor will any officer be retained in the reserve above the age of 45 years.

There are at present 91 officers on the reserve list, but of these the following are shown as "on leave":

In India	18
In Africa	11
In Canada	4
Elsewhere abroad	6
	39

It will be seen, therefore, that no restriction is placed on young engineers leaving the United Kingdom, but they remain liable to recall to military duty when required.

An annual retaining fee is paid, with military pay and allowances while under instruction or training.

The Ordnance Survey in the United Kingdom is manned principally by engineer officers and men in the Survey Companies of the Royal Engineers. The control is entirely in the hands of engineer officers.

The department originally started under the master general of the ordnance (hence its designation), as the necessity of systematic mapping work was, and always has been, first recognized by the army. After subsequent reorganizations, it has now been placed under the home office, by which part of the pay and allowances of the personnel are provided.

The existing topographical maps on various scales are revised periodically, and cadastral plans prepared as required; the production of maps and distribution on payment to the public are also entrusted to this department, in which twenty Royal Engineer officers are employed.

Other Government Departments provide employment for engineer officers on the retired list as follows:—

Board of Inland Revenue	1
Board of Education	1
Board of Trade, London traffic	2
Government railway inspectors	4
Local Government Board	2
Admiralty (Works Department)	1
Light Railways Commission	1
Prisons Commission	2
Crown agents for colonies	2
Office of Works	3
General post office	2
Total	21

From the above brief description of the duties and employment of the commissioned ranks of the Corps of Royal Engineers, it will be seen that their duties are many and varied, and that the government has not hesitated to employ military engineers to a great extent on duties unconnected with the military profession. It is no doubt a system which is full of anomalies and capable of improvement, but it is the the result of many years' slow development, and it is worth taking into consideration when formulating proposals to suit Canadian conditions.

THE UNITED STATES.

The corps of engineers in the United States army was first organized on a small scale under a Federal Act in 1802. Between 1808 and 1863 a separate Bureau of Topography and a corps of topographical engineers was established under the War Department, being finally merged in the latter year into the corps of engineers.

The corps of engineers was first employed on public works service in 1824, when the President was authorized "to procure the necessary surveys, plans and estimates upon the subject of roads and canals." This work was to be carried out "by two or more civil engineers and such officers of the corps of engineers, or who may be detailed to do duty with that corps, as the President might think proper."

From the year 1832 both the corps of engineers and topographical engineers have been constantly employed in public works under the federal government; in fact, until recent years these have been the only government officials who have been available to carry out technical duties of this nature.

Amongst the works carried out may be cited:—

Construction of roads and canals.

Survey of the coast of the United States.

Light-house service.

Bridges.

Harbors.

Reclamation of land.

Railway surveys, including that from the Mississippi to the Pacific Coast in 1853

All public works in the District of Columbia.

And last, but not least, the construction of the Panama Canal.

The successful execution of this latter work being largely due to the co-operation of the military medical department in sanitary work.

As has been the experience in the British Empire during the process of developing the country the civil engineering work has largely been carried out by military engineers. As the country has developed the work has been taken out of the hands of the military engineers, and has been entrusted to civil engineers employed permanently or temporarily by the federal government.

Public works under the control of the various States have, however, been carried out by civil engineers, as no military engineers have been available for States duties.

The same procedure has been adopted in Cuba and the Phillipines on their acquisition by the United States; all administrative legal and technical work of government has has been carried out by soldiers, as has been the case in British possessions.

It has not been custom ary to a ward any higher rates of pay to engineer officers employed on public works than are allotted to officers employed on ordinary military duty. These rates, however, are considerably higher than are paid to officers of the Canadian permanent force or Royal Engineer officers employed on regimental duty.

CANADA.

In Canada the main sources of supply for engineers are:

(a) The Canadian universities, which are in close touch with the principal employers of labor in the country, and which have adopted courses of study particularly suited to local conditions.

(b) The Royal Military College of Canada, where a course of study embracing both civil and military subjects, has been adopted, and whence a large proportion of graduates adopt a civil career, either directly after they leave the college or after a subsequent course at a Canadian university.

(c) The lower grades of the engineering profession in which practical experience is gained by work commencing often at an early age, in the elementary and unskilled stages; finally, after a long apprenticeship, personal ability, skill, and engineering knowledge acquired by years of practical work, have enabled many of the foremost Canadian engineers of the present day to rise to the top of their profession.

The system of selection to fill engineering appointments in private as well as in government service has, however, been somewhat haphazard. Personal influence, as well as political considerations, have often been the determining factors in selecting candidates for appointments. In the absence of any obligatory theoretical engineering qualifications particular attention has usually been paid to practical, as opposed to theoretical, qualifications.

Four years of practical experience in the unskilled branches of the profession are often held of more account than a four-year course of study at a university.

The three government departments in which officials with technical engineering knowledge are required, are:—

Department of Railways and Canals.
Department of Public Works.
Department of the Interior (for topographical surveyors).

Outlined Scheme for Canadian Public Works Service.— It is suggested that a public works service be formed in Canada, consisting of two main divisions.

The first division to consist of higher officials with the grades of:—

Assistant engineer.
Executive engineer.
Superintending engineer.
Chief engineer.

The second division to consist of subordinate officials with the grades of:—

Foremen of works, and other lower grades, with at least six different classes.

Appointments to the second division to be made by selection from those who have served an apprenticeship in practical work. Opportunities would be given to selected men of this division to transfer to the first division, by reserving a proportion of the appointments therein annually for nominations amongst especially qualified foremen of works.

Direct appointments to the first division to be made by open competition, held by a permanent examining board appointed by orders-in-council, among graduates in certain specified branches of engineering at Canadian universities.

Graduates from the Royal Military College, Kingston, would be eligible to compete, but only after they had completed their three-year course at Kingston by a fourth year at a Canadian university. The course of instruction in engineering subjects at the Royal Military College, Kingston, would require revision so as to bring it into line with those arranged for the first three years course of study for an engineering degree at Canadian universities. As many subjects, other than civil engineering, are studied at the Royal Military College, Kingston, the standard required from Royal Military College graduates at the end of their fourth year at a university would necessarily be lower than that required from other graduates.

On appointment to the first division of the public works service candidates would be graded as assistant engineers and encouraged to specialize in one particular branch of engineering.

A further course of instruction at a university in special branches of engineering might be arranged during the winter months for assistant engineers with at least four years practical experience in departmental work.

The rates of pay in the grade would be based on (a) length of service; (b) actual appointment held.

An annual rate of pay on a graduated scale according to length of service, with additional "grade" pay as assistant, executive, etc., engineer, would be the most satisfactory solution. Graduated pensions, after 20 years government service, would induce good men to remain in government service late in life.

Appointments to the various grades would be made by selection according to the importance of the duties to be carried out and to the capability of the engineer. There should be no restriction to a junior engineer holding an important appointment (with "grade" pay accordingly) if he were professionally capable to hold the position. The less gifted members would receive annual increments of pay in the lower grades for the length of service.

In order to bring the engineers of the public works service into closer touch with those employed by private firms, the former should be permitted to accept appointments in private firms, if offered to them; but after the conclusion of a fixed term of years (seven or ten) with a private firm, they should be required to retire from the public works service or to return to government duty. While employed by a private firm a contribution towards pension would be required, so long as the public works department engineer remained eligible for a government pension.

In each government department the senior public works official would be the head of the service in his particular department. All appointments, promotions, and transfers of public works officials would be made by the responsible minister on the recommendation of the head of the public works service in his department, who would always be a permanent government employee, unaffected by a change of government.

A society of the public works service, composed of public works officials in all departments, with an elected president and council, would ensure stability to the service, and would be a connecting link for the furtherance of the interests of the members in general.

The creation of a scientific public works service in Canada, organized on the above lines, would provide a strong body of men, possessed of experience in technical matters, sufficiently permanent in government employ to ensure continuity of policy, and capable of placing at the disposal of Canada's representatives in parliament technical advice on economics, as well as engineering, questions, which would go far towards the expenditure of public funds to the best advantage of the Dominion

The Canadian Engineer

ESTABLISHED 1893.

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JAMES J. SALMOND, MANAGING DIRECTOR

T. H. HOGG, B.A.Sc. MANAGING EDITOR — A. E. JENNINGS, ADVERTISING MANAGER — P. G. CHERRY, B.A.Sc. CIRCULATION MANAGER

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CONTENTS OF THIS ISSUE.

A NATIONAL ENGINEERING SERVICE.

Any engineer who has stopped to consider the question of civil engineering as handled with regard to Government service in Canada, must be struck with the general lack of efficiency and the overlapping of departments in the Canadian Government service.

Mr. T. Chase Casgrain, chairman of the International Joint Commission, a few months ago offered two prizes for the best essays on the "Formation of a National Engineering Service." In this issue will be found the two essays which secured first and second prize. These articles will repay careful reading, for they show very clearly some of the difficulties of the present conditions at Ottawa.

As conditions now exist, a number of departments of the Government service carry on work in which the engineering profession are vitally interested, and for which members of that profession are responsible, both in design and execution. A lack of efficiency is conspicuous throughout a great deal of this work. Several departments are carrying on work of the same character which, logically, should be under one head. As a result, there is a duplication of staff and equipment. Petty jealousies arise between the different departments, and there is little incentive to consistent and loyal work on the part of the individual members.

Evolu, in his article on "A National Board of Engineering Control," suggests the appointment of a board of control directly responsible to Parliament. All work of the same nature would logically come under one department and under one man. Increased efficiency would, no doubt, result, and the present lack of cohesion among the various departments, due to the overlapping, lack of responsibility and lack of system, would be obviated. The combining under one management of the work common to several branches would result in the work being done far more cheaply and economically than under the present system.

Probably one of the greatest improvements which would come as a result of the appointment of such a board of control would be the removal of all appointments from the sphere of politics. Appointments would be based strictly upon experience and ability.

There is no logical reason why the work of the government should not be carried on as economically and efficiently as that of a private organization. Until some such method is used, however, as is outlined in these articles, the present state of affairs will continue. It is to be hoped that this move on the part of Mr. Casgrain will be instrumental in drawing the attention of the public to the present state of affairs.

A PROSPECTIVE COURSE OF CERAMICS IN UNIVERSITY OF TORONTO.

The Canadian Clayworkers' Association, meeting in Toronto Tuesday, Wednesday and Thursday of last week, have revived with renewed vigor a movement to establish in the Faculty of Applied Science and Engineering, University of Toronto, a course in Ceramics.

This movement on the part of the executive is the result of a deeply-felt need experienced by the manufacturers of clay products for technical knowledge of the properties of the raw materials, and for more scientific methods in the process of manufacture.

No sooner had it been decided to take steps in this direction than a United States brick machine company came forward with an offer to furnish any Canadian university disposed to inaugurate such a course with a fairly complete laboratory equipment consisting of a brick machine, grinding-pans, automatic cutter dies, and other necessities.

The president and the Board of Governors of the University of Toronto have expressed their sympathy with the desire of the Canadian Clayworkers' Association for the founding of a course in Ceramics. President Falconer, as the representative of the Board, stated that it was entirely a question of funds, and he impressed upon the deputation which waited upon him the necessity of bringing the matter before the Provincial Government in order that funds might be provided for such a course.

It is vitally important to the clayworkers' industries of the Province of Ontario, and, in fact, of the Dominion of Canada, that a department of Ceramics should be founded in the immediate future. The Provincial Government must not withhold the requisite aid for technical instruction in one of the most important industries of the Province.

TORONTO'S WATER SUPPLY.

Our criticisms of the report of the Board of Water Commissioners are not based on the question of the possibility of water not being able to run down hill or, as put by Mr. Randolph, on the question of the suspension of the law of gravitation, but on the question of hydraulic design, and economical construction, maintenance and operation.

Since our last issue appeared, one of the Commissioners, Mr. T. Aird Murray, has written to the Board of Control to state that his opinions regarding the feasibility and desirability of the Scarboro scheme had changed since he signed the report. He stated that he had serious doubts from the first, and he now withdraws from responsibility for the report. If Mr. Murray devoted so little time and attention when the report was being compiled that he did not fully appreciate what he was recommending, and if his attitude is typical of the other members of the Commission, certainly very little reliance can be attached to the report. His belated objections to their recommendations are based on facts of which, he says, he was cognizant during the compilation of the report; therefore, his conclusions as now presented to the Board of Control are diametrically opposite to those for which he received his fee.

It is only fair to *The Canadian Engineer* to state that the criticisms of the Scarboro water scheme which appeared some two weeks before Mr. Murray's letter to the Board of Control are not those on which Mr. Murray bases his objections to the report.

Our objections to the location may be summarized in very few words: The quality of the water is no better than that of Centre Island, and must be continuously filtered. There will be a greater first cost of construction; greater continuous cost of operation; greater cost of maintenance; and the lack of flexibility of the gravity scheme as compared with direct pumping.

For the benefit of the daily press in Toronto, which appear to feel that the question at issue is whether the water will flow down hill from Scarboro or not, we would like to call attention to an article which appeared in the January 9th issue of *The Canadian Engineer*, describing the Los Angeles Aqueduct. The length of this aqueduct, which supplies water for the city of Los Angeles, a municipality of 400,000 population, is 234 miles, and the fall is 1,500 feet. There are many other gravity systems in successful operation, but this particular Scarboro scheme is criticized in connection with the local conditions.

Our objections to the report are based on the fact that we do not believe that the Board of Water Commissioners have presented a practical plan.

Commissioner Harris has stated that the by-law to provide the requisite funds for the construction of a duplicate water supply was intentionally worded in such a way as to leave the choice of location and the details of design open. We have every confidence that Commissioner Harris, before he proceeds with the construction, will thoroughly investigate the whole situation and base his decision on the principles of engineering economics and design. To make his decision, he does not need the arguments of certain of the commissioners in favor of the Scarboro location (arguments which should have been presented with their report) or the repudiation of the recommendations in the report (a repudiation which should have been presented as a minority report) by the Commissioner who has changed his mind.

EDITORIAL COMMENT.

Do not forget the Annual Meeting of the Canadian Society of Civil Engineers in Montreal next week.

* * * *

The description of the plant of the Mississippi River Power Company in this issue will, we are sure, be of interest to all our readers.

OZONE TREATMENT OF WATER.

In some of the larger European cities the water supplies are sterilized by ozone treatment used as the sole means of purification or in conjunction with filters. The largest installations in which ozone is employed are the following:—

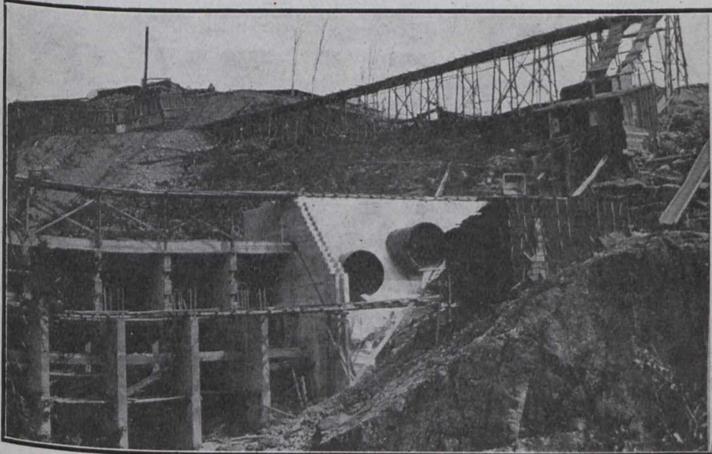
Locality.	Capacity, gallons per day.
St. Maur, Paris	13,000,000
St. Petersburg	11,000,000
Nice	10,000,000
Wiborgen	2,640,000
Florence	1,100,000
Wiesbaden	660,000
Hermannstadt	880,000
Chartres	325,000

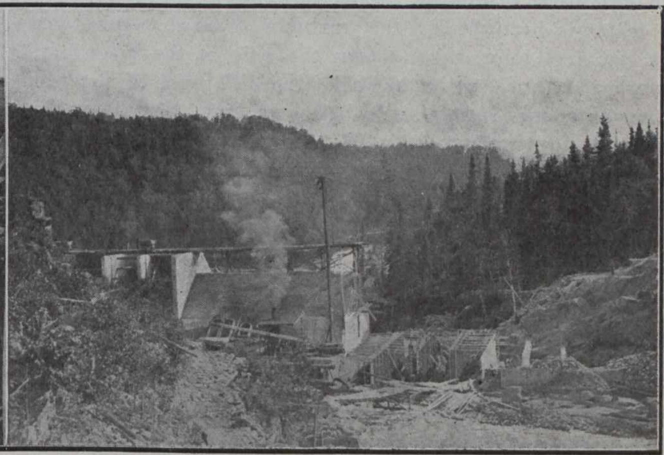
There are also two new plants supplying the city of Paris which will have a total capacity of 12,000,000 gallons per day.

In America little progress has been made in the use of ozone owing primarily to its excessive cost. In the European plants the average cost of treatment is $10 per million gallons. The hypochlorite treatment in this country offers opportunity for efficient sterilization without an excessive outlay. Recently, however, a small plant at Great Falls, S.C., with a capacity of 80,000 gallons per day, has been installed, and it is claimed that the cost of treatment does not exceed $5.00 per million gallons. The principal objection to the ozone treatment has been its excessive cost and if this objection can be met it may be expected that the use of ozone will greatly increase.

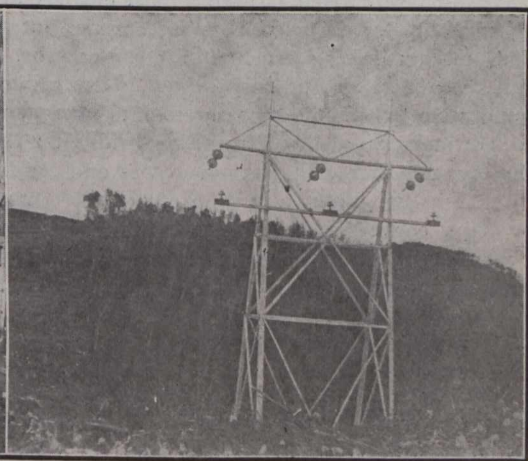
HYDRO-ELECTRIC DEVELOPMENT ON THE MAGPIE RIVER.

About fifteen miles north of Michipicoten, in the province of Ontario, a dam has been constructed on the Magpie River, just above the falls known as Steep Hill Falls; the object being to develop electric energy for the use of the iron mines belonging to the Algoma Steel Corporation, of Sault Ste. Marie. The distance from the Helen mine is about five miles, and from the Magpie mine, twelve miles. A wood-pole transmission line, designed for an ultimate pressure of 22,000 volts carries the three-phase aluminum conductors from the power station to the mines. The pressure, in the first instance, will be 11,000 volts, and generators wound for this voltage will be connected directly to the line. If it is desired to step-up to the higher pressure at a later date, transformers with a ratio of one to two will be installed. The step-down transformers at the mines are suitable for either 11,000 or 22,000 volts on the primaries, with a secondary pressure of 600 volts.


Down-Stream View of Dam, Showing Position of Steel Penstock.


View Looking Down-Stream During Construction.


Eight-foot Steel Penstock from Power House Site.


Steel Tower Supporting 1,000-ft. Span Over Ravine.

The dam, which is now completed, is of the Ambursen type, built of reinforced concrete with buttresses spaced twelve feet apart, supporting deck slabs tapering in thickness from 30 inches at the bottom near the cut-off wall, to 17 inches at the top. The height of the spillway above river bed is 45 feet and the total length of spillway is 145 feet; the overall length of the dam being 230 feet. There are 2,800 cubic yards of concrete in the dam, the mixture being 1 part cement, 2 parts sand, and 4 parts crushed rock in the cut-off walls, decks and spillway; while a 1:3:6 mixture is used in the buttresses and the solid work at both ends of the dam. About 65,000 lbs. of reinforcing steel, mostly in the form of 7/8 in. square bars, are imbedded in the concrete of the dam.

The dam is so constructed as to allow of the height being raised another 12 feet at a future date. With the spillway at its present elevation, the reservoir created on the upstream side of the dam is of negligible capacity, and is practically useless for storage purposes, the power available for a continuous supply of energy being determined by the quantity of water available at times of minimum flow.

Much of the concrete work on the dam was put in during the winter months in the early part of 1912, and as the winter temperatures in this district north of Lake Superior are very low, great care had to be exercised to prevent the too rapid cooling of newly placed concrete. During the months of January and February the thermometer very frequently stands at 40 degrees below zero, and temperatures between 50 and 60 degrees below zero were actually recorded. The water, sand and rock were steam heated, and after the concrete was placed, it was covered with canvas and every possible means employed to maintain it above freezing point until it had set. Under such conditions the forms have to be left in position considerably longer than when the concrete is placed under ordinary conditions. It is, however, a notable fact that the concrete put in during the cold weather was generally satisfactory.

The total head available for driving the turbines is in the neighborhood of 60 feet. The power house, now nearing completion, is situated at the foot of the falls. It is being equipped with two turbines of the horizontal type, supplied by Messrs. Hamilton and Company, Peterborough. These will develop 1,000 h.p. each and will be direct coupled to three-phase generators supplied by the Crocker-Wheeler Company, of Ampere, N.J., and designed to develop 900 k.v.a. at 11,000 volts, when running at 400 revolutions per minute. The continuous current for the generator fields is provided by a separately driven exciter, direct coupled to a water turbine supplied by the Rodney Hunt Company. The switchboard is supplied by Ferranti, Limited, of Manchester, England, and it provides for the hand operation of oil type switches on generators and feeders, through a simple system of levers.

The elevation of turbine shaft above low-water level in the pool at the foot of the falls, is 21 feet; but in seasons of flood, the water in the lower pool may rise as much as 8 feet. The water is brought to the turbines through a steel penstock 240 feet long, taken down the side of the river bank through a channel cut in the rock; the difference of elevation between top and bottom ends being 43 feet. Provision has been made for two penstocks, but one only is necessary for the operation of the 2,000 h.p. plant at present being installed.

The intake is closed by racks consisting of bars ¼ in. thick, spaced 1 9/16 in. apart, the total area of rack being 230 square feet.

The penstock, where it is built into the dam, is 8 feet in diameter, made up of ¼ in. steel plates which are increased to ⅜ in. at the bottom near power house. Just outside the power house, the pipe divides into two 6 ft. branches leading to the turbines. A surge tank is also provided at this point. It measures 12 ft. diameter, and has a total height of 80 feet, which brings the top of the tank 26 ft. above the level of the present spillway. The surge tank is built up of riveted steel plates 7/16 in. thick at the bottom, reduced to ¼ in thick at the top.

Two separate three-phase circuits leave the generating station. These are carried together on one set of poles for a distance of about 1¼ miles, where they branch off; one line going south to the Helen mine, and the other going north to the Magpie mine.

Three-phase current is used almost entirely at the Helen mine, not only for the main hoisting engine, but also for the various motors driving crusher, air compressor, conveyers, pumps, etc., both on the surface and below ground. At the Magpie mine, where the most up-to-date machinery is being installed, including a large travelling bridge for the handling of the ore, together with gas generators and complete calcining and roasting plant, a portion of the three-phase current, after being converted to 600 volts pressure, is used for driving a motor generator to provide continuous current for the motors on the ore bridge and other purposes.

The address of Dr. Allen J. McLaughlin, assistant surgeon of the United States Public Health Service, Washington, D.C., last month before the annual meeting of the Association of Life Insurance Presidents, on "The Effect of Safe Water Supplies on the Typhoid Fever Rate," was illustrated by a series of ten charts. Dr. McLaughlin presented an interesting comparative table showing the contrast between the typhoid mortality of fifteen of the largest American cities and fifteen of the largest cities of Europe. The lowest typhoid death rate abroad was 1.3 per 100,000 of population in Edinburgh, and the highest 5.6, in Paris. The lowest death rate from typhoid in American cities was 8.8 per 100,000 of population in Cincinnati, and the highest, 58.7, in Minneapolis. The Philadelphia mortality is 17.5 per 100,000, and that of Pittsburgh, 27.8.

STREET CLEANING IN PORT ARTHUR.

By W. S. Bowden, Street Commissioner.

The proper cleaning of paved streets has become a necessity. Vast sums of money are being spent every year by almost every town and city in Canada in the construction of high-class pavements designed to improve their principal streets, and business centres. And no municipality that has undertaken to improve and beautify their city this way, for the convenience and benefit of their citizens and the public generally, can possibly afford to overlook the great importance of this work. In fact it is frequently the case that a town or city gets its reputation from the condition of their streets; for beauty and cleanliness are qualities which catch the eye of every visitor, call forth admiration of every tourist, and not infrequently make a lasting impression upon the minds of business men.

The cleaning of paved streets is necessary for the following reasons: The preservation of the public health; the physical comfort and convenience of the people, and due regard for decent cleanliness and good appearance. Sanitary authorities have for some time held that dirty streets are a prolific cause of disease, and therefore a menace to the public health.

And in the light of recent investigations the conclusions reached by the most eminent scientist in regard to the germ theory of the spread of disease, that nearly all infections or contageous diseases are caused directly or indirectly by specific organisms or their germs, which, being incorporated into or attached to some solid or fluid matter, are carried thereby into the body and to the blood, where they propogate and multiply, causing destruction and death. These conclusions have a very important bearing upon the theory and practice of street cleaning.

When the question of adopting a system of pavements for a municipality is first brought up for consideration it often happens that so much time and energy is devoted to preliminary investigations before a decision is made, that any arrangements for cleaning are neglected until after much construction work has been done. They are then often forced to make a hurried selection of equipment which may later prove to be a failure But, the expenditure having been made, they hesitate to throw it aside. This is one of the reasons why many places are not using the system best suited to do the work effectively. From the sanitary point of view, street dirt may be divided into two physical classes or forms: First, the comparatively fresh, coarse and recently deposited material that reaches the street; and second, the finely comminuted matter, which, when dry, is called street dust.

The views here outlined indicate the importance which is, or should be, attached to the selection of the equipment best suited to secure a frequent and speedy removal of the coarse material before it becomes pulverized and dry, and also to provide some satisfactory method of removing the fine dust that cannot be prevented. In order to do this work effectively one of the best methods that has so far been developed is the use of the hand cleaning patrol system, whereby the men with their carts and brooms are able to pass over their beat several times a day, and promptly, and frequently remove the coarse material, and by this method, if the work is done properly, from ninety to ninety-five per cent. of all the refuse matter and rubbish that finds its way to the street will be removed.

We now come to consider the removal of the fine dust which cannot be prevented, and this is most important. Assuming that this street dust is infected with disease germs, and that if allowed to remain upon the street it will, by the action of the sun and wind and the pulverizing action of travel, be reduced to a condition of powder so fine and light that it will readily float in the air and be carried by the wind and breezes to a considerable distance, and while thus suspended it may be breathed into the lungs, or deposited upon the bodies of those in the vicinity. It is therefore most dangerous to public health.

For this part of the work the practice of flushing the streets with water under pressure using the street flushing machine is very successful. This is especially true where the proper system of catch basins have been provided to prevent the dirt being carried into the sewers. This is the system and method of doing the work that are in successful operation in the city of Port Arthur.

In the early summer of 1910 the city began the construction of high-class pavements, and by the end of June, 1912, there was laid and open for traffic 81,869 square yards. These pavements consist of five different kinds, viz., sheet asphalt, asphalt block, bitulithic, asphaltic concrete, granatoid or concrete. They are laid on eleven streets and total 3,165 miles. On one of these, which is about a mile in length and paved with asphalt block, there is operated a double track street railway. In cleaning these pavements we find that one man with a Menzie street cleaning cart, using an 18-inch broom, covers an average of 11,695 square yards per day. He wears the ordinary street suit and cap, and has two cans in connection with his cart, when one becomes filled he leaves it at the curb and proceeds to fill the other until the wagon comes to collect it. One man with team and dump wagon collects an average of 8 cubic yards per day, which has to be carted an average distance of one mile.

The sanitary automatic street flushing machine which is used to remove the fine dust, is operated by one man with team. The water for this purpose is taken from stated hydrants.

About thirty minutes are required to fill the tank of the flushing machine and discharge the contents upon the pavements. Each load contains about 480 Imperial gallons and flushes an average area of 2,000 square yards. In the most central part of the city the flushisg is done three times a week, and the remaining portion of the pavements are flushed one and one-half times each week. No cleaning or flushing is done on holidays or Sundays, and the complete system of catch basins is cleaned five or six times during the summer season. Some extra work is done on Saturday night and on evenings before holidays. In this way the pavements are kept almost spotlessly clean.

The first cost of the equipment which we have in use was as follows:—

One automatic street flushing machine	$1,341.00
One dump wagon	180.00
Seven Menzie street cleaning carts (each with one extra can)	115.50
Seven 18-inch street brooms	7.30
Two street suits for each of seven men	49.00
Total	$1,692.80

The average daily cost for labor to do the work of hand cleaning with brooms and carts, flushing, removing the refuse and cleaning the system of catch basins in connection with the 81,869 square yards of pavement referred to, amounts to $26.00. This shows that under the local conditions as I have stated, and with the equipment referred to, the cost of cleaning one square yard of pavement is .003176 cents per day. Assuming that the streets are free from snow and require to be cleaned in the usual way for 240 days, the cost for the summer season would amount to 7.62 cents per square yard.

It might, however, be said that if the traffic was much heavier, as in very large cities, the cost would be considerably higher, but at present, with the limited area of pavements which we now have, there are 40 earth roads leading to them at various points. These roads, during the wet weather, are a source from which large quantities of mud are carried in upon the pavements by the traffic, and when it is considered that this is most difficult kind of dirt to remove, and that as the area of pavements is increased this source of trouble will become proportionately less, I see no reason to assume that the cost should be materially increased, even with heavier traffic.

KING EDWARD VII. HIGHWAY.

By H. S. Van Scoyoc,*

Unquestionable proof of the interest which is being taken in permanent road construction throughout the Dominion is shown by the fact that on the Western coast many miles of the Canadian portion of the Pacific Coast Highway, which will eventually join Mexico with the Yukon, have already been built. In addition, the Western and the Prairie Provinces have completed a number of sections that will form portions of the proposed Across Canada Highway. In Ontario, the completion of the Toronto to Hamilton Road is only a question of time, the portion leading from Toronto through York County having already been built. Quebec has maintained a foremost position in the Good Roads movement, and possibly its most interesting project has been the building of the Canadian portion of the International Highway which will join the city of Quebec on the north with Miami, Florida, on the south. Tenders have recently been requested on that portion of the road which will connect Quebec with Montreal, and it is planned to do as much as is possible of the actual work during the coming season.

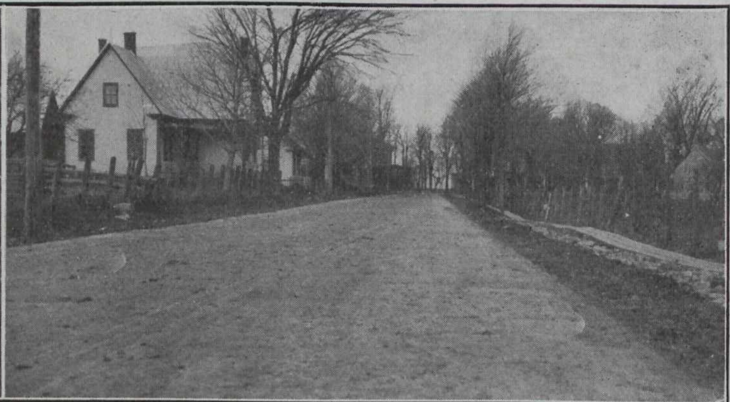
That portion of the International Highway which extends from Montreal, Que., to Rouses Point, N.Y., is known as the King Edward VII. Highway, and it had been hoped that this road would be completed during 1912. The very bad season made this impossible, however, and when work was discontinued last fall, approximately one-half of the work remained unfinished. The original plan called for macadam construction, but it was modified to the extent that the portion passing through Napierville was built of concrete. It is the purpose of this article to take up in detail the methods used in the construction of the concrete portion.

The soil in this vicinity is a clay with occasional stretches of sandy loam. Drainage was provided by the construction of open ditches, the bottoms of which were about two feet below the sub-grade. In the village proper, the ditches were filled with large stone, and the stone covered to provide space for sidewalks. In general the grade of the finished roadway follows the surface of the old road so that the amount of either cut or fill was practically negligible. The concrete portion of the road is 16 feet wide, and the excavation was of this width and of such a depth that after thorough rolling with a ten ton roller the sub-grade was parallel to the surface of the finished road, and seven inches below it.

*Inspecting Engineer, Canada Cement Company, Limited. Associate Member American Society of Civil Engineers.

On the sub-grade, prepared in the manner described above, 2 x 7 inch planks were placed on edge 16 feet apart, inside to inside, and held in position by iron pins driven into the sub-grade on either side of the planks. Concrete the proportion of one part cement, two parts sand and four parts broken stone, mixed in a batch mixer and of a rather wet consistency was then placed to a thickness of seven inches and brought to grade and given the proper shape by means of a strike-board or template. The template was cut to give the road a crown of 2 inches in 16 feet and was made from 2 inch planks. The curved edge was protected by a steel plate and the finished template rested on the side around the plate and the whole kept in position as before, but when the concrete had been deposited about three feet beyond the joint, the plate was withdrawn and the concrete tamped against both sides of the tarred paper, closing the space left by the withdrawal of the steel plate. In this way a very narrow joint was made with less trouble and expense, for the filling with asphaltum was avoided, and the steel plate was withdrawn much more readily than when the concrete set up in contact with it. Whenever it was found necessary to discontinue work for any reason, a vertical joint was made. Whenever possible work was stopped at one of the regular contraction joints.

Crowning Road with Template, Napierville, Quebec.



The Road Completed.

planks as shown in the accompanying photographs. To properly shape the concrete, two men, one at either end, slowly moved the template towards and away from each other, and at the same time, slowly moved it forward. In some cases an up and down motion was used to bed the larger stone in the motar. The template was kept approximately at right angles to the centre line of the road.

After the road had been brought to shape no one was allowed to walk on the concrete or disturb it in any manner, and all subsequent work was done from a bridge which was clear of the road and rested upon the side forms. The finishing was done by two cement workers with wooden floats, who worked from the bridge. Great care was used to prevent any depressions in the surface, as it was realized that wear on the surface would be reduced to a minimum if this was accomplished.

Each day's work was covered at night with a tarpaulin and when the concrete was hard enough, the tarpaulins were removed and a covering of two inches of dirt from the sides of the road was placed on the concrete to prevent its drying out too rapidly. It was allowed to remain for two weeks before being removed. The intention had been to sprinkle the dirt each day to keep it damp, but there was so much rain that this was found unnecessary. The rainy weather also kept the sub-grade moist so that it was not sprinkled before the concrete was placed.

Transverse contraction joints were made every twenty-five feet at the time the concrete was placed. The earlier joints were made by means of steel plates ⅜" thick at the top and ¼" at the bottom. The plates were held in position by iron pins driven on either side. When concrete had been placed on both sides of the plates, the pins were withdrawn. After the concrete had set sufficiently the plates were removed and the edges of the joints were rounded to a radius of a quarter of an inch and were tooled down hard and smooth; these joints were afterwards filled with asphaltum.

In the later construction the joint was made in a different manner. A piece of tarred roofing paper was folded

After the concrete had thoroughly hardened, macadam shoulders, four feet in width, were built on either side of the concrete, making the finished roadway twenty-four feet over all. Traffic was not permitted on the road until the concrete had been down for at least three weeks.

DRY DOCK FOR MIDLAND.

A floating drydock and building berth will be constructed by the Midland Drydock Company, Limited, at Midland, Ontario. Among those interested in the enterprise are Mr. James Playfair, Mr. D. L. White, Mr. D. S. Pratt and other residents of Midland. The town has granted a bonus of $25,000 to the company, as it is anticipated that the undertaking will cause the expenditure of large sums of money in the town, give employment to a considerable amount of labor and tend to assist and encourage the marine trade in the port of Midland. The town will issue debentures for the purpose. It has made an agreement with the drydock company and with the Canadian Dredging Company, Limited, by which the plant will be erected for the construction and repair of steel and wooden vessels.

The dock will be built in separate units, the first unit having a length of 150 feet by a beam measurement of 72 feet, and having a lifting capacity of 1,200 tons. The first unit is to be constructed and ready for operation before September 1, 1913, and the second unit by May 1st, 1915. The company will operate their machinery by electric power, purchasing the power from the town, which has agreed to place a fixed assessment on the company's property. Mr. H. Calderwood has prepared the plans for the drydock and building berth.

Midland is in Simcoe County, on Mundy's Bay, an arm of the Georgian Bay, and on the Grand Trunk Railway, 32 miles north-west of Orillia, and 120 miles north of Port Hope. The population of the town is about 4,600.

GREATEST PIER REACTIONS DUE TO LIVE LOADS.

By S. J. Glaser.

In figuring the bearing on foundations of bridge piers, it is necessary, among other things, to find the maximum reaction due to live loads acting on the two adjacent spans.

The accompanying table gives the values of the maximum reactions for any combination of two adjacent spans, varying from 50 to 130 feet in length at five-foot intervals. These spans are most usual for plate girder bridges. The values above the heavy zig-zag line running through the table are for class I., and below for class heavy loading, Dominion Government specifications.

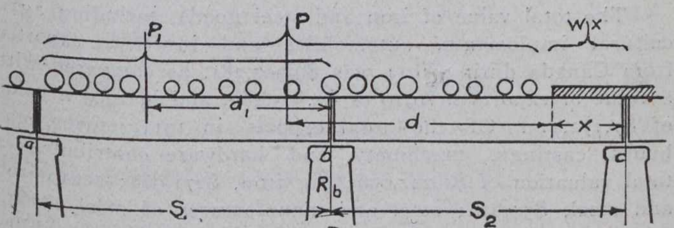


Fig. 1.

To obtain the value of the maximum reaction for any two spans, the larger span should be looked for in the first or last vertical column, depending respectively on whether class I. or class heavy loading is used.

A series of curves can be platted from the values found in the table and the greatest pier reactions for intermediate spans can be obtained. It will also be found that the lower part of the curves are straight lines, and when these lines are produced values sufficiently correct for spans less than 50 feet can be mechanically obtained. Such span lengths are frequently used for steel viaduct bridges.

The values in the table may be enterpolated for intermediate spans in a horizontal direction for the variations are proportional.

The method of obtaining the greatest pier reactions due to live load is as follows: The load on any pier is the sum of the reactions at the end of the adjoining spans. In Fig. 1 the reaction of pier B, due to live load, is equal to the sum of the right reaction of span ab and left reaction of span bc.

The criterion of loading giving the greatest value of this sum is similar and is derived in the same way as that for maximum floor beam loading.

Letting P, (Fig. 1) be the load on the span ab, d, the distance of its centre of gravity to the right end of the span, and letting P be the sum of the concentrated loads of the typical consolidation locomotives on both spans ab and bc, and d the distance of its centre of gravity to the head of the train, whose weight is w pounds per linear unit. The total live load on the span is $P + wx = W$. Let Rb be the combined reactions of the two adjoining spans, of lengths S_1 and S_2. An expression for Rb can be obtained. Placing the dirivative of this expression equal to zero, also substituting for $P + wx = W$ we get

$$\frac{W}{P_1} = \frac{S_1 + S_2}{S_1} \qquad (1)$$

or the loads should be proportional to the lengths of the spans is the criterion to make the value of Rb a maximum.

When $S_1 = S_2$ the criterion becomes $W = 2 P_1$ (2)

Care must be used in applying these criterions. Since the concentrated loads are not uniform the loading to give a maximum should be so apportioned that a heavy driver is at b and as large a load brought on the two adjoining spans as possible.

In figuring the reactions from a moment diagram it may be arranged more conveniently as follows: Let Mc equal the moment of the loads in both spans about c and Mb equal the moment of the loads in span S_1 about b, then

$$Rb = \frac{M_1 S_1 - Mb\ (S_1 + S_2)}{S_1 \times S_2} \qquad (3)$$

Table Showing Maximum Pier Reactions Due to Live Load for One Rail for Class I. and Class Heavy Loading, Dominion Government Specifications, Values Given in Kips.

Class Heavy — Larger Span	Maximum Pier Reaction — Class I — Dominion Government Specifications: 130	125	120	115	110	105	100	95	90	85	80	75	70	65	60	55	50	Class I — Larger Span
	341.0	335.4	329.7	324.1	318.5	313.9	307.3	301.6	296.0	290.3	284.8	279.2	273.6	267.9	262.3	256.7	251.1	130
50	159.1	331.1	325.5	319.8	314.2	308.6	302.9	297.3	291.6	286.1	280.4	274.8	269.1	260.5	257.8	252.3	246.7	125
55	170.8	177.0	321.2	315.5	309.9	304.3	298.6	293.0	287.4	281.7	276.1	270.4	264.8	259.2	253.5	247.8	242.2	120
60	180.3	187.2	193.9	311.7	306.0	300.5	294.6	289.0	283.3	277.6	271.9	266.2	260.5	254.8	249.1	243.3	237.5	115
65	189.0	195.8	202.5	209.1	301.9	296.2	290.6	284.9	279.2	273.5	267.8	262.1	256.4	250.7	244.9	239.2	233.4	110
70	197.4	204.0	210.6	217.2	223.7	291.8	286.1	280.4	274.7	269.0	263.3	257.6	251.9	246.2	240.5	234.7	228.9	105
75	205.5	212.0	218.4	224.8	231.0	237.3	281.7	276.0	270.3	264.6	258.8	253.1	247.3	241.5	235.6	229.8	223.9	100
80	212.5	219.0	225.5	231.8	238.1	244.3	250.5	271.2	265.5	259.7	254.0	248.2	242.5	236.7	230.1	224.9	219.0	95
85	219.2	225.4	231.7	238.0	244.3	250.7	256.7	262.9	260.1	254.4	248.7	242.9	237.1	231.3	225.5	219.6	213.7	90
90	225.5	231.8	238.0	244.2	250.3	256.4	262.5	268.5	274.6	249.1	243.2	237.4	231.4	225.5	219.5	213.6	207.7	85
95	231.2	237.4	243.7	249.8	255.9	262.0	268.1	274.2	280.2	286.3	237.3	231.5	225.6	219.6	213.6	207.5	201.3	80
100	236.4	242.5	248.7	254.8	261.0	267.1	273.2	279.3	285.3	291.3	297.4	224.8	218.9	212.9	206.9	200.8	194.7	75
105	241.6	247.7	253.8	259.9	266.0	271.9	278.0	284.0	290.0	296.0	302.0	308.0	211.9	205.7	199.5	193.2	187.1	70
110	246.4	252.5	258.5	264.6	270.7	276.7	282.7	288.7	294.7	300.7	306.7	312.7	318.7	198.1	191.8	185.5	179.1	65
115	250.7	256.8	262.9	269.0	275.0	281.0	287.1	293.1	299.0	305.1	311.0	317.2	323.0	328.9	183.7	177.3	170.8	60
120	255.6	261.6	267.6	273.5	279.5	285.5	291.4	297.4	303.3	309.3	315.2	321.3	327.1	333.1	339.0	167.7	161.8	55
125	260.4	266.3	272.1	278.2	284.1	290.0	296.0	301.9	307.9	313.8	319.8	325.7	331.7	337.6	343.6	349.5	150.7	50
130	265.1	271.0	276.9	282.8	288.8	294.7	300.6	306.5	312.5	318.4	324.3	330.3	336.2	342.1	348.1	354.0	359.9	Larger Span
	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	
	Maximum Pier Reactions — Class Heavy — Dominion Government Specifications																	

This becomes

$$Rb = \frac{Mc - 2\ Mb}{S} \qquad (4)$$

for two equal spans of length S.

For two unequal spans with train running in either direction there will be two maximum reactions. It can easily be shown from (3) that the greater maximum value of Rb will be obtained when S_2 is the smaller span and train running in direction shown in Fig. 1.

CANADA'S STEEL INDUSTRY

The production of steel ingots and castings in 1911 was 882,396 tons, as compared with 822,284 tons in 1910 and 754,719 tons in 1909. In 1911 the production of open-hearth ingots was reported as 651,676 tons; Bessemer ingots, 209,817 tons; direct open-hearth castings, 20,163 tons, and other steels, 740 tons. The total increase in production over 1910 was 60,112, or a little over 7 per cent. The production during the five years, 1907-1911, follows:—

	1907. Tons.	1908. Tons.	1909. Tons.	1910. Tons.	1911. Tons.
Ingots — Open-hearth (basic)	459,240	443,442	535,988	580,932	651,676
Bessemer (acid) ...	225,989	135,557	203,715	222,668	209,817
Castings—Open-hearth	20,602	9,051	14,013	18,085	20,163
Other steels	1,151	713	1,003	599	740
Total ...	706,982	588,763	754,719	822,284	882,396

Statistics showing the quantities of the principal materials used in steel furnaces were obtained for the first time for the year 1910, and it may be of interest to refer to these here. The total quantity of pig iron used in steel furnaces during 1911 was 700,679 tons, of which 640,636 tons were produced by firms reporting, and 60,043 tons purchased. The quantity of ferro-alloys used was 21,359 tons purchased. Scrap, etc., was used to the extent of 278,797 tons, being 198,482 tons produced by the firms reporting, and 80,315 tons purchased. Ores used included 829 tons of manganese ore and 42,892 tons of iron ore, while 130,270 tons of limestone or dolomite flux were used and 8,067 tons of fluorspar. In Ontario a little over 662 million cubic feet of natural gas were used, while in Nova Scotia coke oven gas was used at Sydney, of which a record of quantity is not obtained.

In 1910 the total quantity of pig iron used in steel furnaces was 690,913 tons, of which 601,219 tons were produced by firms reporting, and 89,694 tons purchased. The quantity of ferro-alloys used was 8,143 tons purchased. Scrap, etc., was used to the extent of 211,453 tons, being 140,913 tons produced by the firms reporting and 70,540 tons purchased. Ores used included 1,317 tons of manganese ore and 39,332 tons of iron ore, while 144,110 tons of limestone or dolomite flux were used and 7,461 tons of fluorspar. In Ontario a little over 600 million cubic feet of natural gas were used.

Statistics of the production of steel ingots and castings since 1900 are given in the following table:—

Calendar year.	Short tons.	Calendar year.	Short tons.
1900...........	26,406	1906...............	639,396
1901...............	29,214	1907...............	706,982
1902	203,881	1908...............	588,763
1903...............	203,296	1909...............	754,719
1904...............	166,381	1910...............	822,284
1905...............	451,863	1911...............	882,396

Mr. J. McLeish, chief of the division of mineral resources and statistics, shows that while complete statistics of the production of rolled products and of manufactured steel were not available, returns from seven of the largest producers showed a production of blooms, billets, slabs, etc., of 737,261 tons, of which 719,514 tons were used by the producer for further manufacture, and 17,747 tons sold to other rolling mills.

The production of rails was 399,760 tons; of rods, 85,811 tons; of bars, 199,623 tons, and of other rolled products, 65,076 tons. The production of steel rails in 1910 was returned as 399,762 tons, and in 1909, 377,642 tons.

The production of finished rolled iron and steel in Canada from 1909 to 1911, as ascertained and published by the American Iron and Steel Association, was as follows, in long tons:—

	1909.	1910.	1911.
Rails	344,830	366,465	360,547
Structural shapes and wire rods	74,136	80,993	76,617
Plates and sheets	36,241	26,642	14,833
Nail plate, merchant bars, and all other finished rolled forms	207,534	265,711	323,427
Total	622,741	739,811	775,424

Since 1896 a total of $16,785,827 has been paid by the government of Canada in bounties for the production of iron and steel.

The total value of iron and steel goods, including agricultural implements, automobiles and bicycles, exported from Canada during 1911 was $9,907,281, as compared with a value of exports in 1910 of $7,895,489, and in 1909 a value of $7,172,413. Of the total exports in 1911, stoves, gas buoys, castings, machinery, and hardware contributed a total valuation of $1,242,006; pig iron, $271,968; scrap iron and steel, $54,618; steel and manufactures of steel, $769,-692; agricultural implements, $6,281,929, and automobiles and bicycles, $1,287,068. Particularly large increases are noted in the exports of agricultural implements and of automobiles and bicycles.

The total value of the imports during the fiscal year ending March, 1911, was $85,319,541, as compared with the valuation of imports in 1910 of $59,952,197, and $40,393,431 during the fiscal year 1909. These imports include all classes of iron and steel goods manufactured, as well as those of a crude form. In many cases the imports of manufactured goods are given only in dollars, so that the total tonnage of imports cannot be estimated. In the case of most of the cruder materials, however, the quantities are given, and a compilation of these shows a minimum importation of iron and steel during the fiscal year ending March, 1911, of 1,284,401 tons, as compared with 915,425 tons in 1910 and 565,734 tons in 1909.

The record shows an importation in 1911 of ingots, blooms, billets, puddled bars, etc., of 48,395 tons; scrap iron and scrap steel, 53,824 tons; plates and sheets, 205,690 tons; bars, rods, hoops, bands, etc., 183,865 tons; structural iron and steel, 345,350 tons; rails and connections, 36,690 tons; pipe and fittings, 28,831 tons; nails and spikes, 3,099 tons; wire, 64,850 tons; forgings, castings, and manufactures, 24,523 tons.

The total value of the 1,284,401 tons imported was $33,766,865, or an average value per ton of $26.29. Other iron and steel goods of which the weights are not recorded were imported to the value of $51,552,679, making up the total value of $85,319,541.

A very large proportion of these imports is derived from the United States, and it may be of interest here to quote from the records published in the "Commerce and Navigation of the United States," showing the exports of iron and steel goods from that country to Canada.

According to this authority there was exported to Canada from the United States during the twelve months ending June 30th, 1911, 821,526 tons of iron and steel goods, valued at $25,544,421, together with other iron and steel goods of which the weight is not given, valued at $38,738,-575, or a total value of $64,282,996.

During the twelve months ending June 30th, 1910, the corresponding exports to Canada were 574,807 tons, valued at $19,673,740, together with other iron and steel goods to the value of $28,153,628, or a total value of $47,827,368. Iron ores are not included in either case.

The imports of some iron and steel products of which the weights are available follow:—

Material.	Twelve months ending March. 1910. Tons.	1911. Tons.
Pig iron	159,506	270,102
Ferro-products and chrome steel	15,153	19,182
Ingots, blooms, billets, puddled bars, etc.	36,819	48,395
Scrap iron and scrap steel	28,797	53,824
Plates and sheets	200,575	205,690
Bars, rods, hoops, bands, etc.	117,159	183,865
Structural iron and steel	195,748	345,350
Rails and connections	55,183	36,690
Pipes and fittings	16,705	28,831
Nails and spikes	3,476	3,099
Wire	68,211	64,850
Forgings, castings and manufactures	18,093	24,523
Total	915,425	1,284,401

ENGINEERING AND THE BEAUTIFUL.*

It is an idle platitude to state that the present is an age of specialization, for no man can say as Lord Bacon did: "I will take all knowledge to be my province." Even the most versatile engineer can attempt to master but one branch of his profession, although collectively the engineers' achievements have changed the whole aspect of modern civilization. If we cast our minds back to-night to, say, the new year 1813, what a fascinating kaleidoscope it makes, especially to us on the Pacific slope, when we try to realize what has been accomplished in that country of progress, and then contrast the material progress that had been accomplished up to that time from the days when the architects Ictinus and Callicrates collaborated with Phidias, to produce the beautiful Parthenon, one only of many beautiful structures which the Greeks so magnificently created more than two thousand years ago.

The engineer of the past century has been a powerful and beneficial revolutionist, and his successful revolutions have instituted many reforms that have accomplished more for the well-being of the human race than most of the boasted achievements of contemporary wars and political agitations.

But, with all our progress, proud though ye may be, is it not well to remember that because the work of the engineer forms a vital and integral part of the life of any community, we should all pay some regard to the creation of beauty and the influence of engineering upon the minds of the people.

Ruskin's well-known aphorism on architecture might have some meaning for us as engineers; he defined it, you may remember, as "the art which so disposes and adorns the edifices raised by man, for whatsoever uses, that the sight of them may contribute to his mental health, power and pleasure."

Engineers are usually regarded as estimable utilitarians who, by their works, enable continents to be crossed in comfortable cars, who control rivers, build harbors and docks, develop water powers by converting the rain and snow of the upper mountains into electrical energy, do much toward conquering time and space and invent wonderful machines for the general advancement of the people, but who are not primarily concerned with beauty or the creation of beautiful objects.

*An address delivered at the year end dinner of the Pacific North-West Engineering Society, Seattle, January 4th, 1913, by G. R. G. Conway, M.Inst.C.E., M.Am.Soc.C.E., M.Can.Soc.C.E.

In olden days engineering and architecture were practised by the same individuals. The old Roman engineers, designers of the Pont-du-gard and the Claudian aqueduct, produced great engineering works that are among the finest architectural remains of that great race. In the rennaissance period were not the great artists Michael Angelo, Leonardo-da-Vinci and Palladio great both in architecture and engineering? Modern engineering, though, with all its mighty achievements, is still in the early pioneer stage, while the traditions of architecture are hoary with the experience of ages.

Engineering structures in steel have been accused of being purely utilitarian, and even William Morris denounced the famous and, as many of us think, beautiful Forth Bridge as "that supreme specimen of all ugliness." But Morris did not understand as the designers did, that their "object had been to arrange the leading lines of the structure so as to convey an idea of strength and stability," and that object they had considered the highest art. On the other hand, a famous artist—Alfred Waterhouse—writing to Sir John Fowler after the bridge was completed said:

"The simple directness of purpose with which it does its work is splendid, and invests your vast monument with a kind of beauty of its own, differing though it certainly does from all other beautiful things I have ever seen."

We cannot yet expect that a well-designed steel structure will be properly appreciated as stone structures have been. Let us remember that the Parthenon was built during Pericles time, when Greek art and literature reached its proudest zenith, but that great period was preceded by centuries of strenuous effort and experience; while steel structures belong but to yesterday, and many new and more perfect types remain to be evolved in the future. It is therefore unfair to apply the same standards of criticism to a modern steel structure as would be applied to one of wood, brick or stone.

The evolutionary process that is apparent in the design of modern steel structures, to use Herbert Spencer's line of progress in organic evolution is from "simplicity to complexity of structure, and from obscure complexity to a defined simplicity of function," and this "simplicity of function" should be the prevailing note in all well-designed structures to-day. Michael Angelo maintained that an architect should have a knowledge of anatomy; cannot we also boldly assert that to those who examine iron and steel structures from an aesthetic point of view, that a knowledge of their anatomy and of the functions of their various parts is essential?

What I really want to urge is that it is essential to-day that there should be greater co-operation between engineers and architects. Engineers have no right to load their structures with architectural decoration that they do not understand. "I love a sufficient man," said Emerson, "he meets my needs," but we cannot to-day, in the infinite variety of duties an engineer is called upon to perform, produce the "one sufficient man" for a great engineering structure. It takes the engineer the greater part of a busy life to master even one branch of the profession, and it takes the whole of an architect's life to understand his art. I am, therefore, advocating the co-operation of engineers and architects in the design of engineering works; these works are primarily for the use of the community, and in many cases, such as in the building of great masonry dams which may last for many centuries, we have no right to inflict ugliness upon the present and coming generations, especially as a beautiful design generally costs no more to construct than an ugly one, and not infrequently costs less.

One almost hesitates to suggest, in these days when the young engineering student's college curriculum is so crowded, that a part of his training should be to acquire some knowledge of classic architecture. To appreciate the proportions of an old Greek temple is part of a liberal education, and in after life it might prevent the engineer from placing meaningless ornament upon his designs, and lead him in all humility to seek advice from the members of his brother profession.

That versatile and eminent English engineer, the late Sir Benjamin Baker, used to tell a story of how, when he was very young he thought he could do without architects, and how he had carried out what he thought was some very pretty work. There had been scrolls and columns and arches in iron work, and John Ruskin said when he had seen it that he wished that he had been born a blind fish in a Kentucky cave!

To-day, I think, we can point to many fine works that have been constructed on the American continent and in Europe, where engineering works have a magnificent and beautiful appearance. There is great scope in the building of masonry and concrete dams, and this has been well carried out in the Croton Dam for the water supply of New York, and in the dams for the supply of water to the cities of Liverpool and Birmingham. We see the co-operation of engineers, sculptors and architects in such beautiful bridges as the Pont Alexandre, in Paris, and in the great terminal railway stations of the Pennsylvania Railroad, the New York Central, the terminal at Washington, and the Orleans station at Paris; in power houses, Niagara and elsewhere, and in the general progress of town planning; and I might also further point out, the possibility of beautiful designs in reinforced concrete structures is being thoroughly appreciated.

In many cases, an engineer, be he the servant of a government, municipal or private corporation, must of necessity attain results by economy in design. In our new and developing towns on the Pacific Coast, it is not possible to do what is being done in older established communities. None of us believe that cedar poles with dozens of power wires strung on them along a public street are beautiful objects—unless seen in an etching by Whistler—but the public must always remember they belong to a transitional epoch when money is needed for necessary development, and distant shareholders have a right to the modest dividends they obtain from electric railway and power undertakings. The future, though, with the great growth of business, will make it necessary for all interests to place such wires underground, and then we have what is right from an engineering point of view, assisting in promoting the beauty of our towns.

Why should not even the humblest railway station be a beautiful object? We no longer believe in Ruskin's fierce denunciation of architectural railway stations, and in these days of constant travel, the comfort and beauty of a railway terminal is a delight to travelling man. Why cannot we have beautiful designs for the buildings and chimneys of a steam power plant, for a water tower, for all our bridges, for service reservoirs and valve houses? We should, though, in every case let these structures express by their design their meaning, stating plainly without pretension what they represent. We do not want a railway terminal to look like a temple for the worship of Minerva, or a steam plant chimney to resemble Cleopatra's needle.

Engineering touches every phase of our life, and it is clearly our duty to do all we can, not only to assist the material prosperity of our country, our state or province, but to contribute to all those things that elevate man outside of the strenuous every-day struggle for existence into a sphere that will enable him to appreciate the higher arts, and in that work the engineer can do his share in proving that the useful can also be the beautiful.

CANADIAN POTTERY

The pottery made from Canadian clays has been, hitherto, chiefly of the common grades, such as flower pots, jardinieres, crocks, jars, churns, etc. A number of potters make a higher grade product of stoneware, but the majority of these use imported clays. Sanitary ware is made at St. Johns, Que., and other points; but the raw material including clays and feldspar, is nearly all imported.

The total value of the production of pottery and clay sanitary ware in 1911, according to returns received, was $439,264, of which it is estimated that a value of $336,771 is attributable to imported clays. The value of the production reported in 1910 was $250,924, and in 1909, $285,285.

The total imports in 1911 were valued at $2,516,536, as compared with a value of $2,283,116 in 1910. These imports are subdivided into eight classes, and in 1911 include: brown or colored earthenware, etc., $52,100; C.C. or cream colored ware, decorated, printed or sponged, etc., $184,291; demijohns, churns, or crocks, $4,933; tableware of china, porcelain, white granite, etc., $1,718,582; china and porcelain ware, N.O.P.. $62,025; tiles or blocks of earthenware or stone prepared for mosaic flooring, $123,203; earthenware tiles, N.O.P., $154,351; manufactures of earthenware, N.O.P., $217,051.

Great Britain is the principal source of the imports of this class of products, but quite large supplies are also obtained from the United States, Germany, France, Austria-Hungary, Japan, Belgium, and other countries.

Although there has as yet been no actual commercial production of china-clay or kaolin in Canada, the development of kaolin deposits in the township of Amherst, Ottawa county, and the construction of a washing or refining plant at St. Remi d'Amherst, are worthy of note.

The present operators are the Canadian China Clay Company, with a capital of $250,000. Mr. John C. Broderick, St. Remi d'Amherst, is mine manager, and Mr. Jas. G. Ross, B.Sc., consulting engineer.

The plant for refining the clay is situated two miles from St. Remi d'Amherst and seven miles from Huberdeau station, the terminus of the Canadian Northern Quebec Railway, 94 miles north-west of Montreal.

Development work was begun by the present operators in June, 1911, and the washing plant completed in April of 1912.

The clay is mined by digging, no drilling or blasting being necessary, trammed 600 feet to the plant, washed free from grit and allowed to settle. After the filter presses have extracted the surplus moisture, it is dried in the open air in stacks.

Dry kilns are being built for drying in the winter and wet seasons. After drying it will be pulverized and bagged for shipment. It is expected that an immediate market will be found in the demand of the Canadian paper mills.

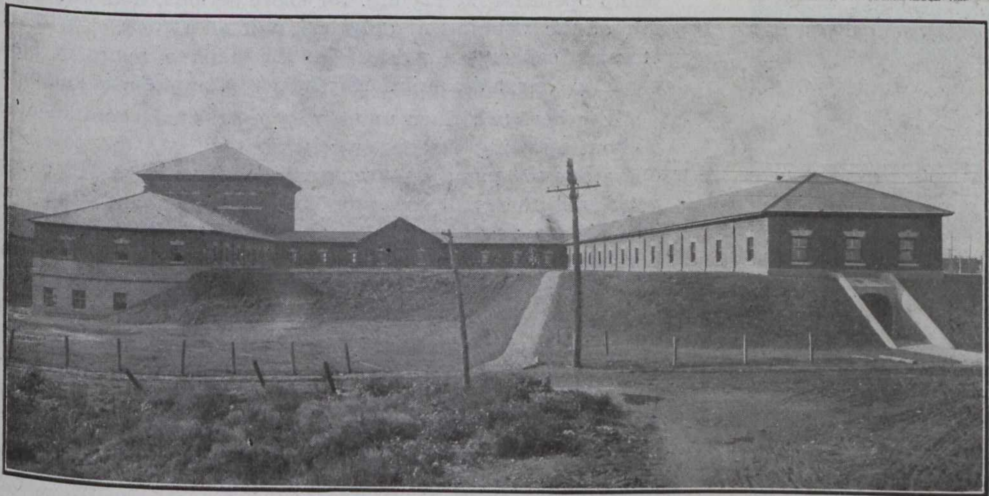
The imports of china-clay, ground and unground, into Canada during the twelve months ending December 31st, 1911, were valued at $125,768, as against a value of $142,125 in 1910, and $100,066 in 1909, thus indicating to some extent at least the present actual demand for this product. The imports of earthenware and chinaware, however, valued at $2,516,436 in 1911, and composed chiefly of tableware of china, porcelain, etc., show the possibilities in the development of industries utilizing china-clays, suggests Mr. J. McLeish, chief of the division of mineral resources and statistics, in a recent report.

Kaolin or china-clay is also in considerable demand in the United States, the imports into that country in 1910 being valued at $1,593,472.

THE FILTRATION PLANT OF THE MONTREAL WATER AND POWER COMPANY AT MONTREAL, QUEBEC.

The Montreal Water and Power Company furnishes water to the outlying wards of the city of Montreal and to the cities of Westmount and Maisonneuve, and the town of Outremont, comprising in all, a population of about 250,000.

The water supplied consists of a mixture of St. Lawrence and Ottawa River water and is subject to marked seasonal changes in character. Normally, it is quite clear and free from turbidity or color. The alkalinity averages about 95 parts per million and the permanent hardness for incrustants about 20 parts per million. For a short period in the spring and autumn it becomes turbid and considerably colored. The bacterial content is never high, in fact it is abnormally low for water from a river of this character. A sterilizing plant has been in operation for over two years, and the water supplied has been satisfactory from a bacteriological standpoint to the Provincial Board of Health.



The Building of the Filtration Plant, Montreal Water and Power Company.

However, owing to an ever-increasing demand for filtered and colorless water, the company decided to install the present plant.

The filtration plant, which is of the so-called rapid mechanical gravity type, is situated near the main pumping station on the banks of the St. Lawrence River, at the southwestern city limit. It comprises low lift pumps, settling and coagulating basins, filter beds, clear water basin, wash water pumps, blowers, a storage tank for air and wash water, chemical mixing tanks and complete apparatus for handling sulphate of alumina and hypochlorite, a completely equipped chemical and bacteriological laboratory and a large chemical storage room.

All pumps, blowers, agitators and other machinery in the plant are operated by electricity and are all provided in duplicate.

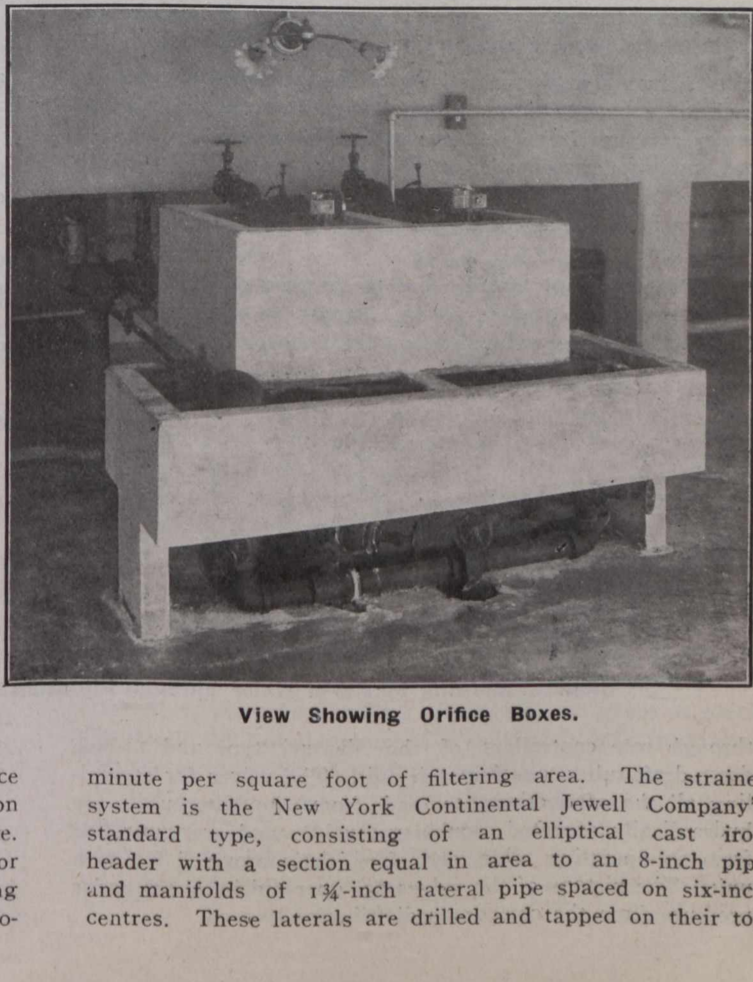
The capacity of the plant is 25 millions of Imperial gallons per day, but provision has been made throughout for the extension when required to a capacity of 42 millions per day.

The river water flows by gravity into a suction well thirty feet in diameter and is pumped from this into the coagulating basin, from which it flows by gravity to the filters, through the filters to the clear water basin, and thence to the high lift pumps, which deliver it to the distribution system. This is shown in the diagram on the following page.

The raw water pumps are electrically driven turbine or centrifugal pumps operating against a total head, including suction and friction, of thirty feet, and discharge into a 60-inch steel main connecting to a concrete flume leading to the sedimentation and coagulating basins. At the inlet end of the basin is a float chamber, where the flow of water is automatically regulated by floats which operate throttle valves on each of the pumps. This is accomplished by means of hydraulic valves, the floats merely opening or closing small pressure valves which control the hydraulic valves.

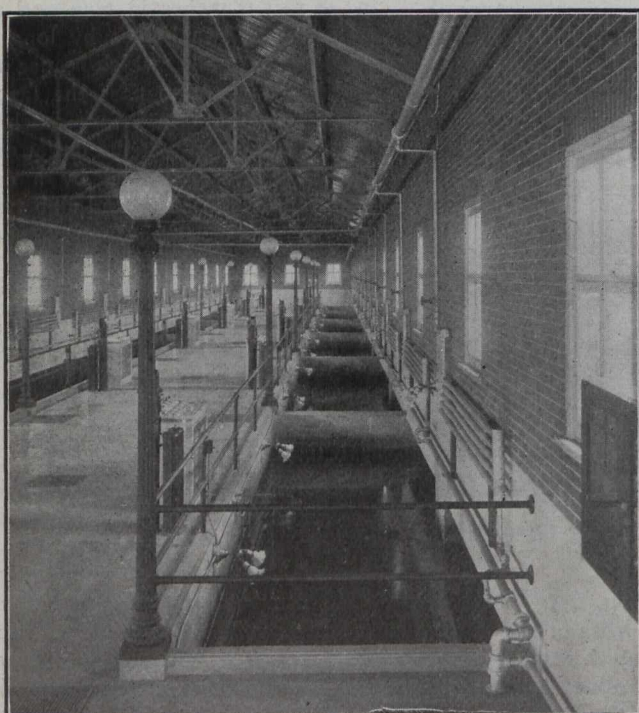
Settling Basins.—These are in duplicate, each holding about 500,000 Imperial gallons. They each measure 110 feet by 48 feet 6 inches in plan and are divided into two halves by longitudinal baffle walls which cause the coagulated water to pass the length of each basin twice before reaching the skimming weir at the outlet end. The basins are covered by a concrete roof of the beam and slab type, carrying about three feet of earth for protection from frost.

The Filters.—Coagulated and settled water is conveyed into the filted house by a concrete flume with connections to each of the 15 units. The top of this flume forms the floor of the operating gallery, and below it is the pipe gallery. Each filter unit has an area of 696 square feet, and is divided into two equal parts by a central gutter of concrete to which are connected eight lateral gutters of cast iron, four on each side. The filtering material consists of 9 inches of gravel graded in size from ⅛ inch to ¾ inch, upon which rests 27 inches of sand having an effective size between 0.4 mm. and 0.65 mm. and a uniformity coefficient ranging from 1.5 to 1.8. The rate of filtration at which the plant is operating and for which it was designed is 1.67 gallons per minute per square foot of filtering area. The strainer system is the New York Continental Jewell Company's standard type, consisting of an elliptical cast iron header with a section equal in area to an 8-inch pipe and manifolds of 1¾-inch lateral pipe spaced on six-inch centres. These laterals are drilled and tapped on their top



View Showing Orifice Boxes.

sides at intervals of six inches to receive the strainers. The elliptical header pipes are also drilled and tapped for a double row of strainers. This arrangement provides four strainers for each square foot of filtering area. The strainer heads are mounted on ⅜ inch tubes extending into the lateral pipe to form a water seal and effect a proper distribution of air while washing. Each strainer contains thirty-three one-sixteenth-inch holes. The system, when assembled in place,



View of Filter Gallery of the Filtration Plant.

is embedded in concrete so as to leave only the upper portions of the headers and strainer caps exposed.

The wash water main is 30 inches in diameter with 16-inch branch connections to each filter. The water is supplied under pressure from the storage tank, passing up through the bottom of each header of the strainer system, out through the laterals and up into the filtering material. The main air line is 12 inches in diameter with 8-inch connections to each filter.

The piping is carried above the wash water gutters and is connected at two points in each header by a 4-inch vertical pipe. The filtered effluent passes into the clear water basin

Telescopic Storage Tank.—The distinctive feature of this plant is the large telescopic storage tank for the supply of wash water and air under pressure for washing the filter beds. This tank is built in two sections; the upper one telescoping into the lower one after the manner of a gas holder.

For washing one filter unit, water must be delivered at the rate of 5,000 gallons per minute for about three minutes, and pumping capacity to this extent would be necessary if no storage were provided. This would require a motor-driven pump operating at 125 h.p. for short periods, and would permit of the washing of only one unit at a time. With the storage capacity provided in the tank a pump of small capacity operated continuously by a 15 h.p. motor is sufficient.

Further, two filter units may be washed simultaneously without affecting the power consumption. As the power for operating the plant is purchased at a flat rate based on the peak load, the great economy of this arrangement is abvious. The conditions governing the supply of air for agitating the beds are precisely the same, a 5 h.p. motor and blower being sufficient as against 60 h.p. required without the intervention of storage. There is the further advantage that the air and water are supplied under more nearly uniform conditions than would be possible by direct supply from pumps or blowers. In order to compensate for varying levels of water in the tank, an automatic pressure regulator is provided at the outlet. The air is maintained at a constant pressure by the loading of the top of the inverted tank with a slab of concrete about three feet in thickness.

The small pumps and blowers supplying the tank are automatically controlled by floats and require practically no attention from the operators.

Chemicals.—The chemical storage room and the appliances for mixing and preparing the sulphate of alumina and hypochlorite solutions are situated on the floor above the machinery room and the prepared solutions delivered by gravity to their points of application. The alum is dissolved in rectangular tanks with perforated bottoms open to the storage tanks below. The solution thus prepared is conducted through lead pipes to the suctions of the low lift pumps, an arrangement which ensures a thorough mixing of the alum with the raw water.

The hypochlorite is fed to the mixing tanks through grinders which deliver the material in a finely divided state, ensuring a thorough mix.

Both alum and hypochlorite are provided with motor driven agitators to maintain a uniform density of the solution.

The flow of these solutions is regulated by means of orifice boxes, in which a constant level is maintained and

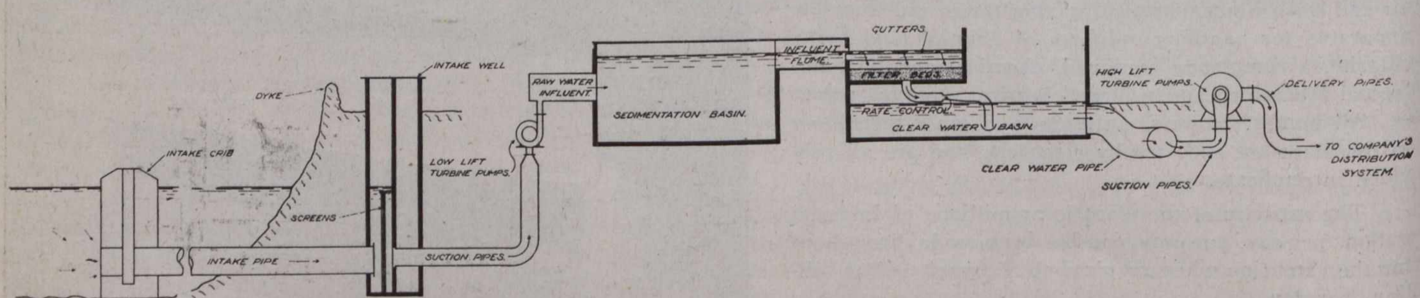


Diagram Showing Course of Water Through Filtration Plant, Montreal Water and Power Company.

through rate controllers of the Venturi type and 14-inch down-draft tubes, one for each unit. The valves for controlling all the connections to and from the filter units are hydraulically operated, double gatevalves and are controlled from an operating table, one of which is provided for each unit. The pistons of the valves are operated by water under pressure from the company's distribution system.

from which the solution is fed through graduated orifices of hard rubber.

The plant has now been in successful operation for about six months and is delivering clear, colorless and practically sterile water.

The plant was designed and constructed for the Montreal Water and Power Company, under the supervision of Mr. F.

H. Pitcher, general manager and chief engineer, and Mr. Wm. H. Sutherland, assistant engineer of the company.

The contractors were Messrs. Laurin and Leitch, of Montreal, and the entire mechanical equipment, detailed plans, etc., were furnished by the New York Continental Jewell Filtration Company, as sub-contractors.

The mechanical operation of the plant is in charge of Mr. W. G. Dryden, superintendent, and the sanitary engineer is Mr. J. O. Meadows, formerly sanitary engineer of the Provincial Board of Health, Quebec.

STEAM BOILER EXPLOSIONS.*

By William H. Boehm.

Every year there occur in the United States between 1,300 and 1,400 serious boiler accidents, of which 300 to 400 are violent explosions. These accidents kill between 400 and 500 persons, injure 700 to 800 more, and destroy more than a half million dollars worth of property. These disasters have but scant respect for boiler types—for they occur with water-tube boilers, although with them violent explosions occur less frequently than with fire-tube boilers. They also occur with low-pressure boilers.

It is of the utmost importance that boilers be carefully designed, that the stresses to which they are subjected be accurately computed, that suitable material be specified, that the material be critically examined for flaws or defects, that specimens of the material be tested to determine its strength, that no abuse of the material be allowed in the process of constructing the boiler, and that the completed boiler be subjected to a thorough inspection and a hydrostatic test before being put into service.

The stress in the girth seams of a boiler may be obtained by the formula

$$S = \frac{rp}{2t}$$

in which

S = Stress per square inch to which the material is subjected;
r = Radius of the boiler;
p = Steam pressure carried;
t = Thickness of the shell.

The formula means that if we multiply the shell radius by the steam pressure, and divide the product by twice the shell thickness, the result will be the stress in pounds per square inch to which the material in the girth seams is subjected.

The stress in a side seam of a boiler may be obtained by the formula

$$S = \frac{rp}{t}$$

which means that if we multiply the shell radius by the steam pressure and then divide the product by the shell thickness, the result will be the stress in pounds per square inch to which the material in a side seam is subjected.

An inspection of these formulas show that the stress in a side seam is just twice as great as the stress in a girth seam. It is for this reason that the side seams are usually double riveted when the girth seams are only single riveted.

The pressure required to rupture the shell of a cylindrical boiler is given by the formula

$$P = \frac{st}{r} e$$

in which

P = Bursting pressure in pounds per square inch;
s = Tensile strength of the material in the boiler;
r = Radius of the shell;
e = Efficiency of the riveted side seam.

Stated in words the formula means that if we multiply together the tensile strength of the material, the thickness of the shell, and the efficiency of the riveted side seams, and then divide the product so obtained by the radius of the shell the result will be the steam pressure at which explosion will occur.

If it so happens that the efficiency of the girth seam is too low by reason of improper design, then the girth seam may fail instead of the side seam, in which case the bursting pressure is given by the formula

$$P = \frac{2ts}{r} e'$$

which means that if we multiply together twice the thickness of the shell, the tensile strength of the material, and the efficiency (e') of the girth seam, the result will be the steam pressure at which explosion will occur. The girth seam is not likely to fail before the side seam, because to do so the efficiency of the girth seam would have to be less than half that of the side seam—a weakness that should not exist in a boiler of proper design and construction.

The formulas expressed herein give the pressure at which the boiler will explode and not the pressure at which it may be safely operated. It is usual in boiler practice to fix the allowable working pressure for a new boiler at one-fifth the computed bursting pressure and to decrease the pressure allowance as the age of the boiler increases.

This is equivalent to saying that the factor of safety applied to a new boiler is usually not less than five. The term "factor of safety," is often misunderstood and a better name would be "factor of ignorance," as it is as much a factor of ignorance as it is a factor of safety.

Take, for example, the case of a new boiler operated with the safety valve set at 100 lb. If the computed bursting pressure be 500 lb., then the assumed factor of safety is five. The assumption, however, is based upon the tensile strength stamped in the plate by the maker and this strength is only true of that particular part of the plate from which the test specimen was cut and not necessarily of any other part.

As a matter of fact it is current practice to cut the test specimen from the outer edge of the plate and the strength there is almost invariably greater than the strength at the centre of the plate. The reason is that after liquid steel is poured into a mold its solidification in forming an ingot proceeds in much the same manner as does the solidification of water in forming a block of ice. That is to say, the impurities and gases are driven toward the centre.

Boiler plates made by the rolling of such an ingot will, therefore, have more impurities and less strength at the centre of the plate than at the outer edges, and this variation in strength is very considerable. Then, too, the stress at which the elastic limit of the material is reached is little more than half the stress at which rupture occurs.

Besides our ignorance of the dependable strength in all parts of the plate, there is also our ignorance of the character of the workmanship in the boiler. We cannot be certain that all rivet holes come fair, or that incipient cracks

* Abstract of a lecture delivered at Cornell University before the state branch of the American Society of Mechanical Engineers.

have not been set up by an abuse of the material during the process of construction. It is seen, therefore, that factors of safety are really made up of two parts—one part a true factor of safety, the other a pure factor of ignorance.

Boiler explosions may be attributed to improper installation, or incompetent or careless operation.

Improper construction may consist: of unsuitable or inferior material; poor workmanship; abuse of material, as when unmatched rivet holes are drift-pinned to place, or uncylindrical shells are sledged to form; of employing the more dangerous lap joint for the side seams instead of the more safe and more sensible butt joint, etc.

The lap joint is dangerous because this form of construction promotes the formation of incipient cracks in the upper surface of the lower lap where they may be impossible of detection. These cracks extend from rivet hole to rivet hole and gradually deepen with the continued raising and lowering of the steam pressure until the metal, no longer capable of resistance, gives way and causes a violent explosion.

The lap joint is given the preference over the butt joint solely, because, it appears at first thought to be cheaper. But there is no excuse for its existence, and its employment in the construction of new boilers should be prohibited by law in all states, as it now is in some.

Improper installation may consist of so supporting the boiler and its piping as to allow temperature changes to set up dangerous stresses in the material, of improperly attaching the usual appurtenances such as safety valves, steam and water gauges, check, blowoff, stop valves, etc.

Incompetent or careless operation may consist in allowing the steam gauge to get out of order, in allowing the water-gauge connections to become so clogged as to indicate ample water when there is none in the boiler, in allowing the safety valve to become so stuck to its seat as to fail to blow at the pressure for which it was set, in allowing grease to enter or scale to accumulate in the boiler, in allowing large quantities of cold water to be impinged against hot plates, in allowing the water to be driven from the heated surfaces by forced firing, in allowing a large valve to be opened too suddenly, in allowing two boilers to be cut in on the same steam main when their pressures are unequal, and in allowing minor repairs to be neglected until they endanger the whole structure.

It is significant that many violent boiler explosions occur either just prior to the starting of the engines in the morning or while they are idle at the noon hour, or shortly after they have been shut down for the day. One reason is that when steam is not being drawn from the boiler it accumulates rapidly; and if the safety valve fails to relieve the pressure, explosion soon follows.

The rapidity with which the bursting pressure is reached may be shown as follows:

Let

T = Time in minutes required to reach the bursting pressure;

W = Weight of water in the boiler;

t = Temperature of the steam at bursting pressure;

t' = Temperature of the steam at normal working pressure;

U = Number of heat units per minute supplied by the furnace and absorbed by the water.

The heat balance is then represented by the equation:

$$UT = W\,(t - t')$$

$$T = \frac{W}{U}\,(t - t')$$

which means that if we multiply the difference between the temperature of the steam at bursting pressure and at normal pressure by the weight of the water in the boiler, and then divide the product by the number of heat units supplied per minute by the furnace, the result will be the number of minutes that will elapse from the time the openings are all closed until explosion follows.

Take, for example, a 100-h.p. boiler containing at normal level 5,000 lb. of water and suppose it uses 50,000 heat units per minute when evaporating 50 lb. of water per minute. Then if the normal gauge pressure be 85 lb., the corresponding temperature of the steam is 327 deg., and if the bursting gauge pressure be 485 lb., the corresponding temperature of the steam is 467 deg.; and the time required to reach the bursting pressure with all steam openings closed and the safety valve stuck is:

$$T = \frac{5{,}000}{50{,}000}\,(467 - 327) = 14 \text{ min.}$$

That is, with a stuck safety valve, only 14 minutes would elapse from the time the engines were shut down until the explosion followed.

The temperature of the water in a boiler is approximately the same as the temperature of the steam with which it is in contact. If the fire be drawn when the openings are closed, ebullition ceases. If a valve be opened, ebullition starts again, even though there still be no fire under the boiler.

It is plain, therefore, that with the openings closed it is the pressure on the surface of the water that prevents further generation of steam. It is also plain that if a small rupture below the water line a violent explosion may not ensue. But it ought to be evident that if a large outlet above the water line be suddenly opened, as, for example, when a steam pipe fails, then the sudden liberation of the pressure on the surface of the high-temperature water will allow it to flash suddenly into steam and cause a violent explosion and water-hammer that will disrupt the strongest possible construction.

Grease does not dissolve or decompose in water, nor does it remain on the surface. Heat in the water and its violent ebullition causes the grease to form in sticky drops which adhere to and varnish the metal surfaces of the boiler. This varnish by preventing the water from coming into intimate contact with the metal, prevents the water from absorbing the heat, and this causes a blistering or burning of the plate that often results in a serious rupture, or a violent explosion.

If scale is allowed to accumulate to any considerable thickness in a boiler, a bag or rupture of the shell is inevitable, unless the scale happens to be of a spongy formation, which is not often the case. Just why this is so, is shown by the following simple experiment.

Take an ordinary granite iron or tinned iron stewpan and firmly glue to its underside a postage stamp. Pour water into the pan and place it on a gas stove so that the postage stamp will be in direct contact with the flame. Leave the pan on the stove until the water has boiled violently and then examine the stamp. The stamp will not even be charred, much less burned, notwithstanding that it was on the underside of the pan and in direct contact with the hottest part of the flame.

Now put into the pan a mixture of water and Portland cement half an inch thick. This, when set, will be the equivalent of half an inch of scale. Repeat the experiment made before and it will be found that the stamp will burn up very quickly.

The reason that the postage stamp is not charred by the flame when no scale is present is that the water, being in immediate contact with the thin bottom of the vessel, absorbs the heat as fast as it is put into the vessel by the flame. The result is that, no matter how hot the flame may be, the bottom of the vessel remains at practically the same temperature as the boiling water with which it is in contact. In an open vessel the temperature of boiling water is 212 deg. and this is not sufficiently high to char paper. When scale is present, the water cannot absorb the heat as fast as it is put into the vessel by the flame, and as a result the temperature becomes greater than 212 deg. and burns the postage stamp.

It is the same with steam boilers. If the water comes in direct contact with the thin plates, the heat is absorbed, the temperature of the plates remains practically the same as the water, and no harm is done. If there be a considerable thickness of impervious scale in the boiler, the water cannot absorb the heat as fast as it is put into the plates by the furnace, and so the plates become overheated, get red, become plastic, and finally give way to the force of steam pressure, causing a bag, or a rupture, or a violent explosion of the boiler.

Scale endangers the safety of boilers in other ways. It clogs the feed pipes, preventing the feed water from freely entering the boiler. It clogs the connections to the water gauge, causing it to indicate ample water when it is at a low level in the boiler. Pieces get under valves and prevent their closure.

Scale in boilers is a serious matter, and in order to prevent its accumulation, it is good practice to eliminate the scale-forming matter from the feed water before allowing it to enter the boiler. This can be accomplished either mechanically by means of separators, or chemically by treating the water in vats especially arranged for the purpose. If preferred, compound may be fed with the water into the boiler, but in such case the water should be analyzed, and the proper compound prescribed by a chemist making a specialty of such matters. Kerosene fed into the boiler has proved beneficial in many instances.

It is an almost universal custom for boiler owners to have their boilers insured and inspected. The insurance serves as a guarantee that the inspections will be intelligently and carefully made and the inspections lessen the chance of accident.

When boiler insurance is carried, an inspector visits the plant at regular intervals and critically examines the boilers, both internally and externally. During the past 10 years the company represented by Mr. Boehm made 1,101,140 examinations and reported 140,989 defects, many of which consisted of dangerous fractures in or near the riveted seams, and that one boiler out of every eight examined, contained defects serious enough to warrant their being reported.

CLEANING THE WATER MAINS.

It is of interest to note that during the past five years the water department of Cincinnati had been been almost constantly employed in removing deposits from the water mains of that city. Previous to 1907 the muddy Ohio River water, having a turbidity varying from 7 parts per million to over 300 parts per million, was pumped directly into the distribution system. In 1907 the purification plant was installed and placed in operation. The deposits in the mains so decreased their capacity as to make it necessary to remove them, and although the work has been in progress for five years a large part of the system still remains to be cleaned. The enormity of the expense of cleaning will be recognized from the cost figures which vary from 10 cents to 26 cents per foot of pipe cleaned. The carrying capacity of the distribution system is greatly increased after the deposits are removed and an increased pressure results at all points on the distribution system.

DRIVING THE LARAMIE-POUDRE TUNNEL.

General methods and records of progress in driving the Laramie-Poudre Tunnel were described in our issue of April 10, 1912. The bonus system used in paying the men and descriptions of the method of loading the holes is of special interest and are further described in a paper by David W. Brunton, published in a recent Bulletin of the American Institute of Mining Engineers. We abstract from this paper as follows:

European tunneling methods were copied as closely as the American wage scale and differences of conditions would permit. A workman once assigned to a position in the tunnel remained there, not being allowed to change even from one side to the other. He was not allowed to drop his tools at shift-change, but was obliged to hand them to his successor, and, in case of his successor's non-arrival, was expected to work another shift, care being taken, of course, that either a substitute was found, or meals were sent in to the man working a double turn.

To give each man a personal interest in the work a bonus system was maintained. At first the bonus paid to each underground workman was 25 cents per day for each 25 ft. in excess of 400 ft. for the month.

After a few months this schedule was discontinued, as it was found to be both cumbersome and excessively high, considering the rate of progress made possible by the superior equipment; and the following bonus rate was adopted:

When the rate of driving for any calendar month exceeded 400 ft. and was less than 500 ft., each underground employee was paid $10 extra; between 500 and 600 ft., the bonus was $15; and between 600 and 700 ft., $20.

This bonus should have been paid to the men in currency, so as to distinguish it from the earnings under the wage schedule, but, as this was impracticable, money earned under the bonus was paid with a separate check, thus giving the men a better opportunity to realize what speed meant to them as well as to the contractor.

The list of employees and their rate of wages is as follows:

1	Superintendent	$	10.00 per day
3	Foremen	each	5.00 per day
9	Drillers	each	4.50 per day
6	Helpers	each	4.00 per day
18	Muckers	each	3.50 per day
6	Drivers	each	4.50 per day
3	Dumpers	each	3.50 per day
1	Track and pipeman		3.50 per day
1	Master mechanic		6.00 per day
1	Stable boss and janitor		3.00 per day
2	Power engineers	each	110.00 per mo.
1	Car greaser		3.00 per day
1	Man at odd jobs		3.00 per day
1	Timberman		4.00 per day
1	Timberman's helper		3.50 per day
2	Blacksmiths	each	5.00 per day
2	Blacksmith's helpers	each	3.50 per day
1	Book and timekeeper		110.00 per mo.

In the operations of setting up the machines, drilling, firing and mucking, the utmost regularity and system were observed; and, while the time consumed in these different operations varied somewhat from day to day, there was a remarkable degree of uniformity in the amount of work performed by the different shifts.

Picking down the roof and squaring up places on the sides for the drill-bar rarely occupied more than 10 minutes. The adjustable end of the cross-bar was always placed on the right-hand side of the tunnel, the lifter on this corner having been exploded last for the purpose of clearing away the muck and leaving plenty of room for the men to operate jack-bars. The drillers and the foreman attended to this work while the helpers were busy bringing forward the hose, air-pipe, water-pipe and steel. Even with the tremendously heavy charges fired, most of the broken rock lay within 30 ft. of the face and rarely exceeded 5 ft. in depth at any point, making it easy to bring the bar and drills over the muck pile.

The fuses were always ignited and the charges fired in rotation.

The usual practice of tamping the holes over the explosive was soon discontinued, as it was found that with such heavy charges the powder formed its own tamping, with the further advantage that when the holes were loaded to the collar the rock was more thoroughly pulverized and consequently much easier shoveled into the cars than when lighter charges were used.

Holes will occasionally miss fire, even when loaded with the greatest care; and when no tamping is employed they can be afterwards fired by simply pushing a primer down tightly upon the unexploded charge, without taking the risk of performing that most dangerous of all operations, picking the tamping out of a "missed" hole.

At first, each pair of fuses was lighted about ten seconds before the next—which, on 40-second fuse, gave 3-in. steps on the receding line of fire. This interval, however, being repeated on 10 pairs of holes, occupied considerable time, and the smoke became so intolerable that some method of expediting the rate of fuse-lighting had to be adopted. The one which proved most satisfactory was exceedingly simple. The foreman cut 22 ins. from the ends of the fuse protruding from the short cut holes; 20 ins. off the fuse from the upper cut holes; 18 ins. off the fuse in the lower cut holes, and so on. This automatically provided a difference of 2 ins. in the distance the fire had to travel, and, even when the fuse-ends were lighted as rapidly as possible, at least another inch was represented by the time between the lightings, so that the two shot-firers could secure the necessary interval between the explosions, and yet get away from the face before the smoke from the burning fuse became too dense.

The following tabular recapitulation of the drilling-operations shows that the men could not only complete a round in an 8-hour shift, but had sufficient extra time to provide for shooting missed holes or taking care of any of the minor difficulties which often arise in tunnel work.

Time Occupied in Various Operations.

Exhausting smoke from face	10 to	12 min.
Picking down roof and sides	5 to	10 min.
Jacking cross bar in place	6 to	8 min.
Attaching drills, making hose and water connections	5 to	15 min.
Drilling from top set-up	3 hr. to 4 hr.	15 min.
Dropping horizontal bar to lower position	15 to	20 min.
Drilling on lower set-up	1 hr. to 1 hr.	15 min.
Removing drills, cross bar, hose, etc.	15 to	20 min.
Blowing out holes, loading and firing	20 to	25 min.
Ignition to explosion of last hole	8 to	8 min.
Total time required to complete cycle of operations	5 hr. 24 min. to	7 hr. 28 min.

During March, April and May, 1911, the record months for driving, the following data were gathered, showing the amounts of work done:

	March.	April.	May.
Ft. of tunnel driven	653	583	635
Number of holes drilled	1,965	1,759	1,985
Linear ft. of holes	14,330	12,510	15,263
Ave. lin. ft. of holes daily	154	139	164
Sticks of powder used	14,808	16,171	18,311
Cars (16 cu. ft.) of muck sent out	4,983	4,765	5,156

Considering the hardness of the rock, the speed attained in drilling, as shown by the figures above, was exceptionally good; but even these averages fall considerably below what was possible with the equipment used. For instance, a number of the best drill-runners were able to average over 60 ft. of holes per shift, one of them making a monthly shift average of 61.68 ft.; another of 61.75 ft.; and a third of 61.86 ft.

While this work shows a great advance over current American practice, it still falls behind the records obtained in the best examples of European tunnel driving. A direct comparison, however, is not quite fair to the United States, since the Alpine tunnels are very much longer than anything yet attempted in this country. At first sight, it would seem that additional length would tend to retard instead of accelerate the rate of progress; but this is not the case. It has been clearly shown that the increased length of transportation and difficulty of ventilation are much more than offset by the improved conditions and the perfection of organization effected by time and experience. As a rule, the greater the magnitude of the undertaking the more thorough the preparation; and the time and labor expended in studying conditions and designing plants for the different Alpine tunnels have been more than justified by the results obtained. European tunnel engineers have also the advantage of being able to select their employees from an almost unlimited supply of highly-skilled workmen from the Tyrol, Switzerland and Piedmont, which gives them an incomparably better selection than can be drawn from our heterogeneous labor supply.

ILLINOIS WATER SUPPLY ASSOCIATION.

The fifth annual meeting of the association will be held at the University of Illinois, Champaign-Urbana, Illinois, March 11 and 12, 1913.

Titles of papers to be presented at the meeting should be sent to the secretary before February 20, 1913. A number of good papers have been promised, but we have room on the programme for more. Prepare a short paper, 1,000 to 1,500 words, on some topic that has been interesting you and that may help someone else. Send to the secretary items that are troubling you. The programme committee can arrange to have a discussion on the subject.

Associates intending to exhibit, please notify Mr. G. C. Habermeyer, Engineering Hall, University of Illinois. The usual arrangements have been made for the exhibits. If the exhibits are sent in care of Mr. Habermeyer they will be delivered at the University.

In the hydraulic laboratory there will be an exhibit of apparatus illustrating the principles of washing filters. In the water survey laboratory there will be an exhibit of water softening by permutit and water sterilization by ultraviolet light.

The University band will give an informal concert for the association. A subscription dinner will be held Tuesday evening, March 11. In order that suitable arrangements may be made, sign and return the enclosed card to the secretary at once. Programmes showing railway lines and hotel accommodations will be mailed February 24 to members and to others who return the card. Edward Bartow, secretary.

COAST TO COAST.

Steveston, B.C.—The cost of engineering ventures, road and sidewalk extension, during 1912 was $70,000, and is divided up into the wards as follows: Ward I., $7,595.23; Ward II., $7,605; Ward III., $10,705; Ward IV., $11,962.50; Ward V., $23,193.65.

Fort William, Ont.—The first two car loads of structural steel to be used in the construction of the plant of the Canada Car and Foundry Company, arrived in this city recently, consigned to the Dominion Bridge Company. There will be 3,000 tons of metal in the buildings of the Car Company's plant here.

Prince Albert, Sask.—The new council of this city decided to erect a market building, appoint a parks board to take charge of the Prince Albert annual exhibition, to push forward as quickly as possible the erection of an isolation hospital, and to take immediate steps towards the erection of an incinerator.

Regina, Sask.—A material reduction in the cost of power to the citizens of Regina has been recommended owing to the large surplus of $70,000 having been obtained by the power plant last year. It is the intention of the officials to charge a rate that will only be sufficient to pay the cost of producing power and provide a slight surplus each year.

Halifax, N.S.—The plans providing terminal facilities that will make Halifax the best equipped port on the continent, while it will enjoy the advantage of being the nearest of all the ports to Europe, were discussed by Senator Wm. Dennis, who is on his way to Ottawa. It is understood that the development and equipment that is to provide for Halifax's present needs and its wants in the immediate future will involve an expenditure of at least $20,000,000.

Moose Jaw, Sask.—Evincing the progressive tendencies of Western Canadian municipalities, Leonard W. Rundlett, former St. Paul city engineer, now city commissioner of Moose Jaw, cites the fact that this city is installing a high pressure system of fire protection. The method is used in but few cities of the United States. Winnipeg, Toronto and Moose Jaw are the only Canadian cities with high pressure systems. As a starter for the work $600,000 has been appropriated.

AMERICAN INSTITUTE OF CONSULTING ENGINEERS.

The annual meeting of the American Institute of Consulting Engineers was held January 14, 1913, at the Engineers' Club, New York City.

Mr. Henry Holgate, of Montreal, Canada; Mr. Daniel E. Moran, of New York City, and Mr. Charles Sooysmith, of New York City, were elected members of council to serve three years, and Mr. F. A. Molitor, of New York City, was elected a member of council to serve one year.

After the routine business of the meeting was transacted, Prof. George F. Swain, of Harvard, addressed the meeting on the question of "Education," which was very ably discussed by Mr. Rudolph Hering, General T. A. Bingham, Prof. Gardner S. Williams, of Ann Arbor, Michigan, and Mr. Frank J. Sprague. Mr. Eugene W. Stern is the secretary.

Mr. Noulan Cauchon, A.M.Can.Soc.C.E., addressed the members of the Ottawa Branch of the Canadian Society of Civil Engineers and their friends on Thursday, December 16th. He chose as his subject "Town Planning and Beautification," illustrating his various statements with lantern projections depicting work of this nature in Europe.

TORONTO UNIVERSITY ENGINEERING SOCIETY MEETING.

On Tuesday, January 21st, Mr. Frederick W. Taylor addressed the Engineering Society of the Faculty of Applied Science and Engineering of the University of Toronto on "Scientific Management." The meeting was held in Convocation Hall, about 700 being present.

"Any scheme that makes for increased efficiency cannot be stopped. History shows this time and again," was the keynote of Mr. Taylor's address. Mr. Taylor illustrated this by referring to the many futile strikes that have taken place on the introduction of means to increase efficiency. The attitude of the workman in "soldiering" was a result of a mistaken attitude of financial men in not paying sufficiently for increased output. "The workman is no fool. He soon learns how little he can do for the money," he said. It was the overcoming of this attitude in employer and employee that was the main problem in introducing scientific management.

PERSONAL.

J. McD. PATTON, superintendent of waterworks, of Regina, Sask., has tendered his resignation to the city commissioners.

CLIFFORD RICHARDSON, M.Am.Soc.C.E., consulting engineer, New York City, on January 17th delivered a lecture on "The Economics of Highway Construction," before the graduate students in Highway Engineering at Columbia University.

C. L. FELLOWES has resigned his position of deputy city engineer of Toronto, which he has held since 1898. Mr. Fellowes, in all probability, will remain with the Works Department and will take charge of the plans for the new mains and services in the Waterworks Department.

F. A. CREIGHTON, of Prince Albert, Sask., who recently resigned his position in that place as city engineer, has been offered the position of manager of construction of La Colle Falls civic electric development project. He will also be retained as consulting engineer in any engineering problem that may arise.

GEORGE POWELL, B.A.Sc., has succeeded Mr. C. L. Fellowes as deputy engineer of the city of Toronto. The former post held by Mr. Powell of principal assistant engineer is abolished. Mr. Powell is a graduate of the School of Practical Science in Civil Engineering. During 1903-4 he was employed with the Canadian Niagara Power Company at Niagara Falls, Ont., on the work incidental to the installation of their new plant. In the fall of 1904 he came to Toronto to act as engineer for a firm of contractors. Mr. Powell entered the service of the city in 1906, and has been with them continuously to date.

ANTHONY D. MacTIER, who was appointed as general manager of the Eastern lines of the Canadian Pacific, with headquarters at Montreal, Que., recently, was born on December 27, 1867, at Blairgowrie House, Scotland, and was educated at Sedbergh school, Yorkshire, England. He began railway work in May, 1887, in the general baggage agent's office of the Canadian Pacific, and was later in the general superintendent's department. He was then in the department of the superintendent of sleeping, dining and parlor car stores, and later in the car service department. In April, 1896, he was appointed general baggage agent, and in November, 1899, became general fuel agent. He was appointed assistant to the vice-president of the Canadian Pacific in June, 1907, and now becomes general manager of the Eastern lines of the same road.

ANNUAL MEETING OF ONTARIO GOOD ROADS ASSOCIATION.

The annual meeting of the Ontario Good Roads Association has been announced for February 26th, 27th and 28th, and the programme now in course of preparation will be issued shortly. Road construction and maintenance, concrete and steel bridges, and the building of town streets, will be discussed. Honorable J. O. Reaume, Minister of Public Works, will deliver an address. L. W. Page, Director of the United States Office of Public Roads at Washington, will attend and address the convention on "Road Maintenance." The city engineer of Toronto, Mr. G. G. Powell, will contribute a paper on "Town and City Streets." Other addresses will be delivered by the mayor of Toronto, the president of the Toronto Board of Trade, and Mr. W. A. McLean, chief engineer of highways for Ontario, who will discuss county road organization and construction.

COMING MEETINGS.

ILLINOIS WATER SUPPLY ASSOCIATION.—The Fifth Annual Meeting of the Association will be held at the University of Illinois, Campaign-Urbana, Ill., March 11th and 12th, 1913. Secretary, Edward Bartow.

AMERICAN WOOD PRESERVERS' ASSOCIATION.—Ninth Annual Convention will be held at Chicago. Jan. 21-23, 1913. Secy-Treasurer, F. J. Angier, Mount Royal Station, B. & O. R. R., Baltimore, Md.

ENGINEERS' CLUB OF TORONTO.—Meeting of the Members will be held on Friday evening, January 24th, at 8 p.m., in the Lecture Room, 96 King Street West, Toronto. Secretary, R. B. Wolsey.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—Annual Meeting will be held on Jan. 28th, 29th, and 30th, 1913, at the Society's new headquarters, 176 Mansfield St., Montreal. Secretary, C. H. McLeod.

THE CLAY PRODUCTS EXPOSITION.—To be held in the Coliseum, Chicago, Feb. 26th to Mar. 8th.

THE INTERNATIONAL ROADS CONGRESS.—The Third International Roads Congress will be held in London, England, in June, 1913. Secretary, W. Rees Jeffreys, Queen Anne's Chambers, Broadway, Westminster, London, S.W.

THE INTERNATIONAL GEOLOGICAL CONGRESS.—Twelfth Annual Meeting to be held in Canada during the summer of 1913. Secretary, W. S. Lecky, Victoria Memoriam Museum, Ottawa

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, W. F. TYE: Secretary, Professor C. H. McLeod.

KINGSTON BRANCH—Chairman, A. K. Kirkpatrick; Secretary, L. W Gill; Headquarters: School of Mines, Kingston.

OTTAWA BRANCH—
177 Sparks St. Ottawa. Chairman, R. F. Uniacke, Ottawa; Secretary, H. Victor Brayley, N.T. Ry., Cory Bldg. Meetings at which papers are read, 1st and 3rd Wednesdays of fall and winter months; on other Wednesday nights in month there are informal or business meetings.

QUEBEC BRANCH—Chairman, W. D. Baillairge; Secretary, A. Amos; meetings held twice a month at room 40, City Hall.

TORONTO BRANCH—96 King Street West, Toronto. Chairman, T. C. Irving: Secretary, T. R. Loudon, University of Toronto. Meets last Thursday of the month at Engineers' Club.

VANCOUVER BRANCH—Chairman, C. E. Cartwright Secretary, Mr. Hugh B. Fergusson, 911 Rogers Building, Vancouver, B.C. Headquarters: McGill University College, Vancouver.

VICTORIA BRANCH—Chairman, F. C. Gamble; Secretary, R. W. MacIntyre: Address P.O. Box 1290.

WINNIPEG BRANCH—Chairman, J. A. Hesketh; Secretary, E. E. Brydone-Jack; Meets every first and third Friday of each month, October to April, in University of Manitoba, Winnipeg.

MUNICIPAL ASSOCIATIONS

ONTARIO MUNICIPAL ASSOCIATION—President, Mayor Lees, Hamilton. Secretary-Treasurer, Mr. K. W. McKay, County Clerk, St. Thomas, Ontario.

SASKATCHEWAN ASSOCIATION OF RURAL MUNICIPALITIES.—President, George Thompson, Indian Head, Sask.; Secy-Treasurer, E. Hingley, Radisson, Sask.

THE ALBERTA L. I. D. ASSOCIATION.—President, Wm. Mason, Bon Accord, Alta. Secy-Treasurer, James McNicol, Blackfalds, Alta.

THE UNION OF CANADIAN MUNICIPALTIES.—President, Chase. Hopewell, Mayor of Ottawa; Hon. Secretary-Treasurer, W. D. Lighthall, K.C. Ex-Mayor of Westmount.

THE UNION OF NEW BRUNSWICK MUNICIPALITIES.—President, Councillor Siddall, Port Elgin; Hon. Secretary-Treasurer J. W. McCready, City Clerk, Fredericton.

UNION OF NOVA SCOTIA MUNICIPALITIES.—President, Mr. A. S. MacMillan, Warden, Antigonish, N.S.; Secretary, A. Roberts, Bridgewater, N.S.

UNION OF SASKATCHEWAN MUNICIPALITIES.—President, Mayor Bee, Lemberg; Secy-Treasurer, W. F. Heal, Moose Jaw.

UNION OF BRITISH COLUMBIA MUNICIPALITIES.—President, Mayor Planta, Nanaimo, B.C.; Hon. Secretary-Treasurer, Mr. H. Bose, Surrey Centre, B.C.

UNION OF ALBERTA MUNICIPALITIES.—President, F. P. Layton, Mayor of Camrose; Secretary-Treasurer, G. J. Kinnaird, Edmonton, Alta.

UNION OF MANITOBA MUNICIPALITIES.—President, Reeve Forke, Pipestone, Man.; Secy-Treasurer, Reeve Cardale, Oak River, Man.

CANADIAN TECHNICAL SOCIETIES

ALBERTA ASSOCIATION OF ARCHITECTS.—President, G. M. Lang Secretary, L. M. Gotch, Calgary, Alta.

ASSOCIATION OF SASKATCHEWAN LAND SURVEYORS.—President, J. L. R. Parsons, Regina; Secretary-Treasurer, M. B. Weeks, Regina.

ASTRONOMICAL SOCIETY OF SASKATCHEWAN.—President, N. McMurchy; Secretary, Mr. McClung, Regina.

BRITISH COLUMBIA LAND SURVEYORS' ASSOCIATION.—President, W. S. Drewry, Nelson, B.C.; Secretary-Treasurer, S. A. Roberts, Victoria, B.C.

BRITISH COLUMBIA SOCIETY OF ARCHITECTS.—President, Hoult Horton; Secretary, John Wilson, Victoria, B.C.

BUILDERS' CANADIAN NATIONAL ASSOCIATION.—President, E. T. Nesbitt; Secretary-Treasurer, J. H. Lauer, Montreal, Que.

CANADIAN ASSOCIATION OF STATIONARY ENGINEERS.—President, Wm. Norris, Chatham, Ont.; Secretary, W. A. Crockett, Mount Hamilton, Ont.

CANADIAN CEMENT AND CONCRETE ASSOCIATION.—President, Peter Gillespie, Toronto, Ont.; Secretary-Treasurer, Wm. Snaith, 57 Adelaide Street, Toronto, Ont.

CANADIAN CLAY PRODUCTS' MANUFACTURERS' ASSOCIATION.—President, W. McCredie; Secretary-Treasurer, D. O. McKinnon, Toronto

CANADIAN ELECTRICAL ASSOCIATION.—President, A. A. Dion, Ottawa; Secretary, T. S. Young, 220 King Street W., Toronto.

CANADIAN FORESTRY ASSOCIATION.—President, John Hendry, Vancouver. Secretary, James Lawler Canadian Building, Ottawa.

CANADIAN GAS ASSOCIATION.—President, Arthur Hewitt, General Manager Consumers' Gas Company, Toronto; John Kelilor, Secretary-Treasurer, Hamilton, Ont.

CANADIAN INDEPENDENT TELEPHONE ASSOCIATION.—President, W. Doan, M.D., Harrietsville, Ont.; Secretary-Treasurer, Francis Dagger, 21 Richmond Street West, Toronto.

THE CANADIAN INSTITUTE.—198 College Street, Toronto. President J. B. Tyrrell; Secretary, Mr. J. Patterson.

CANADIAN MINING INSTITUTE.—Windsor Hotel, Montreal. President, Dr. A. E. Barlow, Montreal; Secretary, H. Mortimer Lamb, Windsor Hotel, Montreal.

CANADIAN PEAT SOCIETY.—President, J. McWilliam, M.D., London, Ont.; Secretary-Treasurer, Arthur J. Forward, B.A., 22 Castle Building, Ottawa, Ont.

THE CANADIAN PUBLIC HEALTH ASSOCIATION.—President, Dr. Charles A. Hodgetts, Ottawa; General Secretary, Major Lorne Drum, Ottawa.

CANADIAN RAILWAY CLUB.—President, A. A. Goodchild; Secretary, James Powell, P.O. Box 7, St. Lambert, near Montreal, P.Q.

CANADIAN STREET RAILWAY ASSOCIATION.—President, Patrick Dubee, Montreal; Secretary, Acton Burrows, 70 Bond Street, Toronto.

CANADIAN SOCIETY OF FOREST ENGINEERS.—President, Dr. Fernow, Toronto.; Secretary, F. W. H. Jacombe, Department of the Interior, Ottawa.

CENTRAL RAILWAY AND ENGINEERING CLUB.—Toronto, President, G. Baldwin; Secretary, C. L. Worth, 409 Union Station. Meets third Tuesday each month except June, July and August.

DOMINION LAND SURVEYORS.—President, Mr. R. A. Belanger, Ottawa Secretary-Treasurer, E. M. Dennis, Dept. of the Interior, Ottawa.

EDMONTON ENGINEERING SOCIETY.—President, J. Chalmers; Secretary, B. F. Mitchell, City Engineer's Office, Edmonton, Alberta.

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, J. E. Ritchie; Corresponding Secretary, C. C. Rous.

ENGINEERS' CLUB OF MONTREAL.—Secretary, C. M. Strange, 9 Beaver Hall Square, Montreal.

ENGINEERS' CLUB OF TORONTO.—96 King Street West. President, Willis Chipman; Secretary, R. B. Wolsey. Meeting every Thursday evening during the fall and winter months.

INSTITUTION OF ELECTRICAL ENGINEERS.—President, Dr. G. Kapp; Secretary, P. F. Rowell, Victoria Embankment, London, W.C.; Hon. Secretary-Treasurer for Canada, Lawford Grant, Power Building, Montreal, Que.

INSTITUTION OF MINING AND METALLURGY.—President, Edgar Taylor; Secretary, C. McDermid, London, England. Canadian members of Council:—Prof. F. D. Adams, J. B. Porter, H. E. T. Haultain and W. H. Miller and Messrs W. H. Trewartha-James and J. B. Tyrrell.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.—Secretary R. C. Harris, City Hall, Toronto.

MANITOBA ASSOCIATION OF ARCHITECTS.—President, W. Fingland, Winnipeg; Secretary, R. G. Hanford.

MANITOBA LAND SURVEYORS.—President, George McPhillips; Secretary-Treasurer, C. G. Chataway, Winnipeg, Man.

NOVA SCOTIA MINING SOCIETY.—President, T. J. Brown, Sydney Mines, C. B.; Secretary, A. A. Hayward.

NOVA SCOTIA SOCIETY OF ENGINEERS, HALIFAX.—President, J. N. MacKenzie; Secretary, A. R. McCleave, Assistant Road Commissioner's Office, Halifax, N.S.

ONTARIO ASSOCIATION OF ARCHITECTS.—President, C. P. Meredith, Ottawa; Secretary, H. E. Moore, 195 Bloor St. E., Toronto.

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, Major. T. L. Kennedy; Hon. Secretary-Treasurer, J. E. Farewell, Whitby; Secretary-Treasurer, G. S. Henry, Oriole.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, T. B. Speight, Toronto; Secretary, L. V. Rorke, Toronto.

TECHNICAL SOCIETY OF PETERBORO.—Bank of Commerce Building, Peterboro. General Secretary, N. C. Mills, P.O. Box 995, Peterboro, Ont.

THE PEAT ASSOCIATION OF CANADA.—Secretary, Wm. J. W. Booth, New Drawer, 2263, Main P.O., Montreal.

PROVINCE OF QUEBEC ASSOCIATION OF ARCHITECTS.—Secretary, J. E. Ganier, No. 5. Beaver Hall Square, Montreal.

REGINA ENGINEERING SOCIETY.—President, A. J. McPherson, Regina; Secretary, J. A. Gibson, 2429 Victoria Avenue, Regina.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—President, H. C. Russell, Winnipeg, Man.; Hon. Secretary, Alcide Chausse, No. 5. Beaver Hall Square, Montreal, Que.

ROYAL ASTRONOMICAL SOCIETY.—President, Prof. Louis B. Stewart, Toronto; Secretary, J. R. Collins, Toronto.

SOCIETY OF CHEMICAL INDUSTRY.—Wallace P. Cohoe, Chairman, Alfred Burton, Toronto, Secretary.

UNDERGRADUATE SOCIETY OF APPLIED SCIENCE, McGILL UNIVERSITY.—President, W. G. Mitchell; Secretary, H. F. Cole.

WESTERN CANADA IRRIGATION ASSOCIATION.—President, Duncan Marshall, Edmonton, Alta. Permanent Secretary, Norman S. Rankin, P.O. Box 1317, Calgary, Alta.

WESTERN CANADA RAILWAY CLUB.—President, R. R. Nield; Secretary, W H. Rosevear, P.O. Box 1707, Winnipeg, Man. Second Monday, except June, July and August at Winnipeg.