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MISSING

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

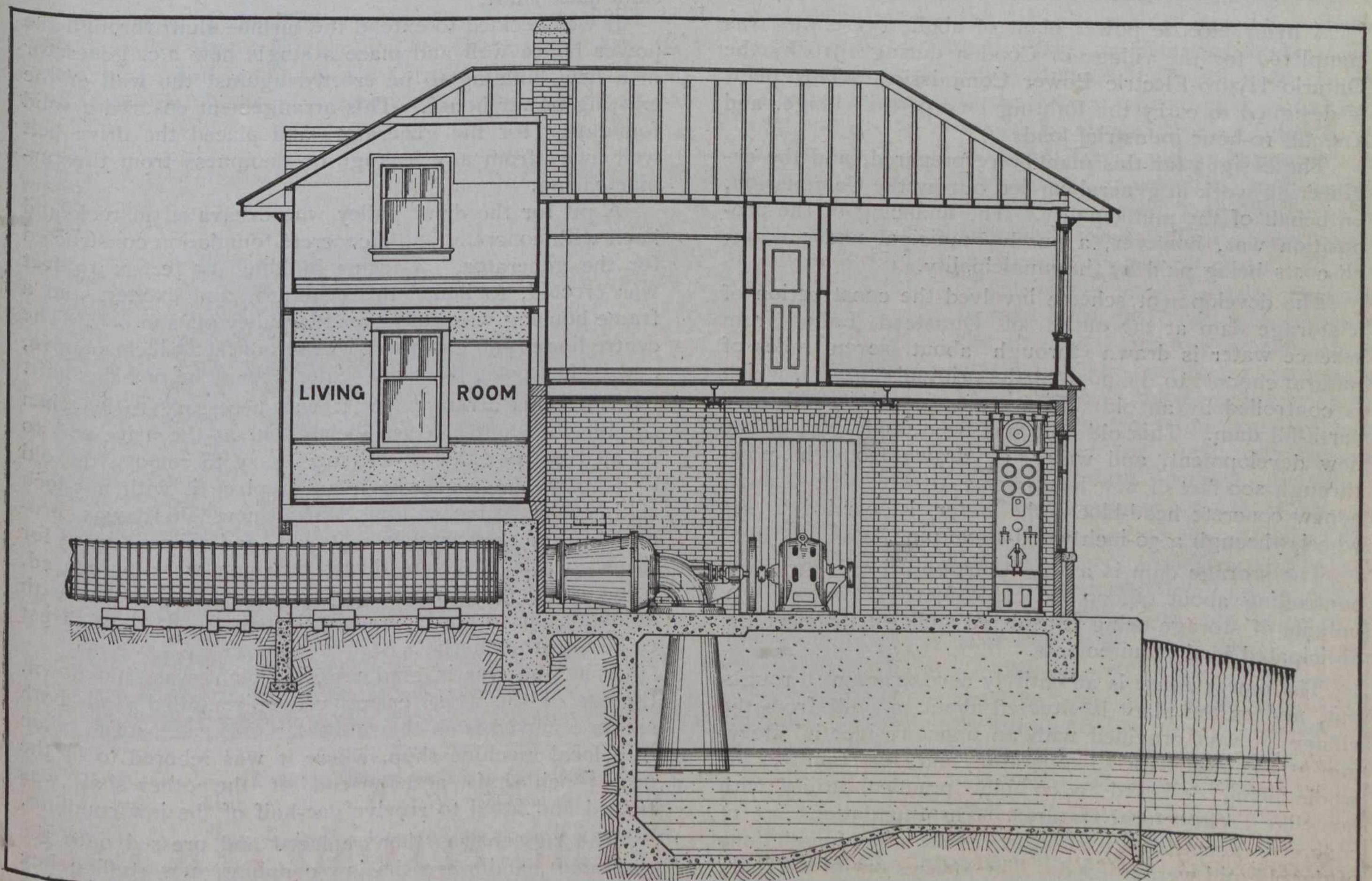
South Falls and Cobden Hydro-Electric Plants

Ontario Hydro-Electric Power Commission Combine Power House and Operator's Residence at Cobden—Typical Small Plants at South Falls and Almonte Taken Over and Greatly Improved by the Commission—Stream Flow Data Collected for Area of Forty-Seven Thousand Square Miles

THE South Falls plant of the Ontario Hydro-Electric Power Commission is located on the south branch of the Muskoka River. After this plant had been acquired from the town of Gravenhurst, the Commission decided to effect the changes and additions which had been contemplated. The work of extending the plant was commenced during September, 1915. A permanent road to the power house, and the subgrade for the wood-stave pipe were completed during the next six weeks. Cofferdams were put in for unwatering the head-works and tail race, the discharge water from old unit was diverted, and good progress made in the enlarging of tail race cut.

The excavation for the tail race and power house foundations was completed on January 10th, 1916. The first concrete in the power house was poured on January 11th, 1916, and the substructure was completed on March 27th, 1916. All of the above work was done by day labor, under the supervision of the Commission's engineers. The power house superstructure was built under contract by Witchall & Son, of Toronto. Work was started on March 13th, and completed on May 27th, 1916.

The steel penstock, supplied by the Wm. Hamilton Company, of Peterborough, was delivered to the site in December, 1915, and the erection was completed on January 31st, 1916. The material for the wood-stave pipe, with the exception of sills and chocks, was supplied by the Pacific Coast Pipe Company; the erection being done by the Commission's working staff. The work of erection was started on April 4th, 1916, but owing to delays in delivery of sills, etc., was not finally completed until the end of June. Some alterations had also to be made on the head works to accommodate the second pipe, this work being completed by April 4th, 1916.



Sectional Elevation of Combined Power House and Residence at Cobden, Ont.

The turbine, flywheel, butterfly valve, etc., supplied by the Wm. Hamilton Company, were delivered at South Falls on June 28th, and the governor and relief valve on July 15th. These were erected in place and grouted in by July 24th, and the new unit was put on commercial load on August 25th, 1916. The old unit was then shut down and the steel penstock emptied. Concrete saddles were built under it, earth and debris removed, and the pipe painted.

The wood-stave pipe is 946 feet long and 60 inches inside diameter, and is connected to the head works by means of a steel thimble 5 feet in diameter. The penstock at the lower end of the pipe is 64 feet long and 5 feet in diameter. It is provided with a 48-inch diameter "T" connection for a future surge tank, and a 42-inch diameter cross-over connection to the old steel penstock in order that the capacity of the same may be increased when required.

The turbine is a 23-inch single runner horizontal Samson wheel in a cone-cylinder case, and is provided with a 3-ton, 60-inch diameter flywheel. The rated capacity is 1,060 mechanical horse-power at the generator coupling when operating at 102-foot head and 720 r.p.m. The unit is controlled by a Ludlow oil-pressure governor, and a governor-operated relief valve.

The turbine is direct connected to a 750 k.v.a., 60-cycle, three-phase, 6,600-volt generator installed by the Canadian Westinghouse Company, of Hamilton, Ont.

The capacity now installed in this plant, including the old unit, is about 1,500 electrical horse-power, and is now in continuous operation, supplying light and power to the municipalities of Gravenhurst and Huntsville.

Cobden Plant

A hydro-electric power plant of about 135 e.h.p. was completed for the village of Cobden during 1916 by the Ontario Hydro-Electric Power Commission. This plant is designed to carry the lighting load of the village, and a small 10-hour industrial load.

The designs for this plant were prepared, and the engineering work in general carried out by the Commission, on behalf of the municipality. The financing of the proposition was, however, a purely municipal undertaking, all costs being paid by the municipality.

The development scheme involved the construction of a storage dam at the outlet of Olmstead Lake, from whence water is drawn through about seven miles of natural channel to the pond at the original mill site, which is controlled by an old, but still serviceable stone and earth-fill dam. This old dam has been made part of the new development, and water is drawn from the pond through 200 feet of new head-race. After passing through a new concrete head-block, the water is carried to the wheels through a 30-inch wood-stave pipe.

The storage dam is a small earth-filled crib structure controlling about 96,000,000 cubic feet of water, this volume of storage being considered sufficient to meet the anticipated load requirements.

The power house is an entirely new structure throughout, and as the plant is situated about a mile from the village, it was provided with an upper residential story, and a rear annex for the operator and his family, the whole being designed to combine practical utility with homelike architectural features. The foundations are of concrete, except for a portion where the stone foundations of the old mill were utilized. The lower story of the main building is pressed brick, and the upper story and annex is of wood with stained shingle trim and roof. The building contains eight residential rooms in addition to the machine room, which opens directly into the living-room.

The machine installation consists of one Boving globe casing single runner turbine, of 160 h.p. capacity, running at 720 r.p.m., and provided with a flywheel coupling. Direct connected to the turbine is a Canadian General Electric Company generator, 3-phase, 60-cycle, 2,300 volts, and 100 k.v.a. capacity, with a belt-driven exciter. The unit is controlled by a type "C" Woodward mechanical governor.

This plant was tested out and put in commercial operation on November 24th, 1916, and has been operating satisfactorily and continuously since that date. The plant as originally designed did not include the operator's residence, but apart from the increase in cost, which this change involved, the work was completed within the original estimates.

Almonte Plant

In the spring of 1916, the town of Almonte asked the Ontario Hydro-Electric Power Commission to investigate the possibilities of changing over their generating station and distribution system from direct to alternating current. The station is located on the Mississippi River, and operates under a 24-foot head.

The old equipment consisted of a pair of 42-inch diameter Barber turbines, set horizontally, belt connected to a countershaft driving three-belted direct current generators of 130 k.w. total capacity.

The two wheels were originally coupled together with a flange coupling, but this coupling broke due to vibration in the setting, so that at the time of inspection the wheels were working independently, though belted to the same jack shaft.

It was decided to extend the turbine shaft through the power house wall and place a single new a.c. generator in a new building to be erected against the wall of the existing power house. This arrangement ensured a solid foundation for the generator, and placed the drive belt well away from any leakage or dampness from the turbine casing.

A pit for the drive pulley was excavated in rock and lined with concrete, and a concrete foundation constructed for the generator. A frame building 15 feet x 19 feet was erected, to house the generator and exciter, and a frame housing was built over the pulley pit and belt. The centre line of the generator was set 18 feet 5 inches above, and 19 feet over, from the center line of the turbine shaft.

With this arrangement it was necessary to lengthen the turbine shaft 6 feet 4 inches, but as the drive was to be all from one end it was necessary to remove the old shaft from the near wheel, and replace it with a 5-inch shaft 19 feet 6 inches long. This new shaft was procured, the necessary key seats cut, and collars turned for thrust bearings. New thrust bearings were purchased, being standard bearings 4 15/16 inches x 15 inches with adjustable base plates, and babbitted to fit the thrust collars on the shaft.

When all was in readiness, the plant was shut down, the top of the wheel casing was dismantled and both shafts removed from the runners. One runner was taken to a local machine shop, where it was rebored to fit the new 5-inch shaft, and the end of the other shaft was turned and fitted to receive one-half of the jaw coupling.

The runner was then replaced and pressed onto the new shaft, and when the jaw coupling, new stuffing box and dome bushings had been placed, the shafts were lined up and the thrust bearings grouted.

New lignum vitæ bearings were placed inside the casing, one on either side of the jaw coupling. These bearings were bolted to cast-iron supports, resting on each side of the wooden wheel casing, and as the wet wood had proved to be far from rigid, new cast-iron struts were placed so as to form knee braces from the bearings to the iron floor of the casing.

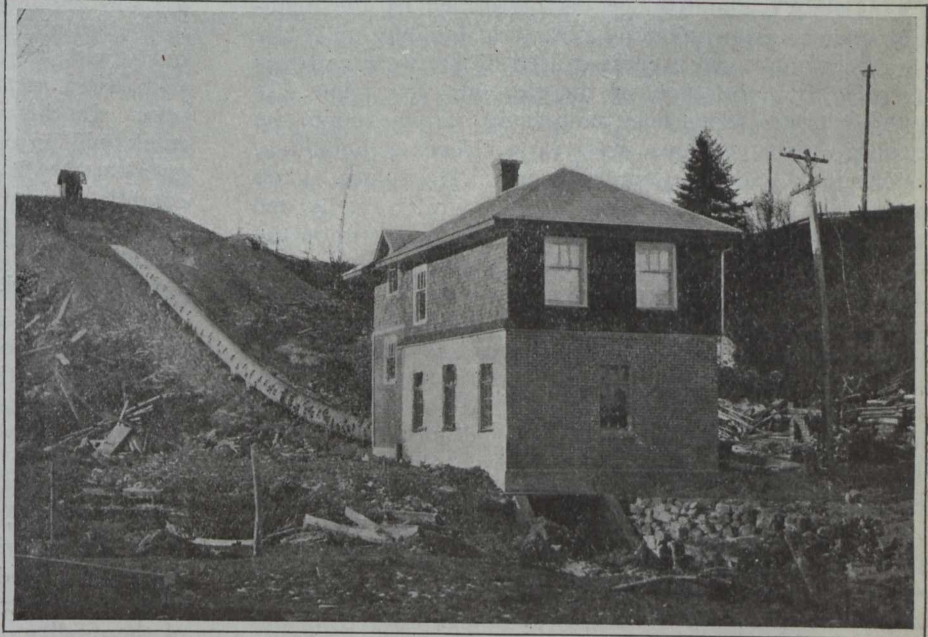
Owing to the bearings not being rigid, during the period of previous operation, the perimeter of the runners had become badly worn, causing considerable leakage. To remedy this a ¾-inch x 1½-inch bar bent to the radius of the runner, was riveted to the inside of the cowl close up to the runner to ensure a more efficient water seal.

The thrust bearings were located near the outer edge of the new shaft, one on either side of the 58-inch drive pulley. This pulley, as also the 46-inch pulley on the generator shaft, is an iron centre wood rim split pulley with a 20-inch face. The belt is 3-ply leather 20-inch x 69 feet 3 inches, and drives the new 250-k.w., 60-cycle, 2,200-volt, 3-phase Westinghouse generator.

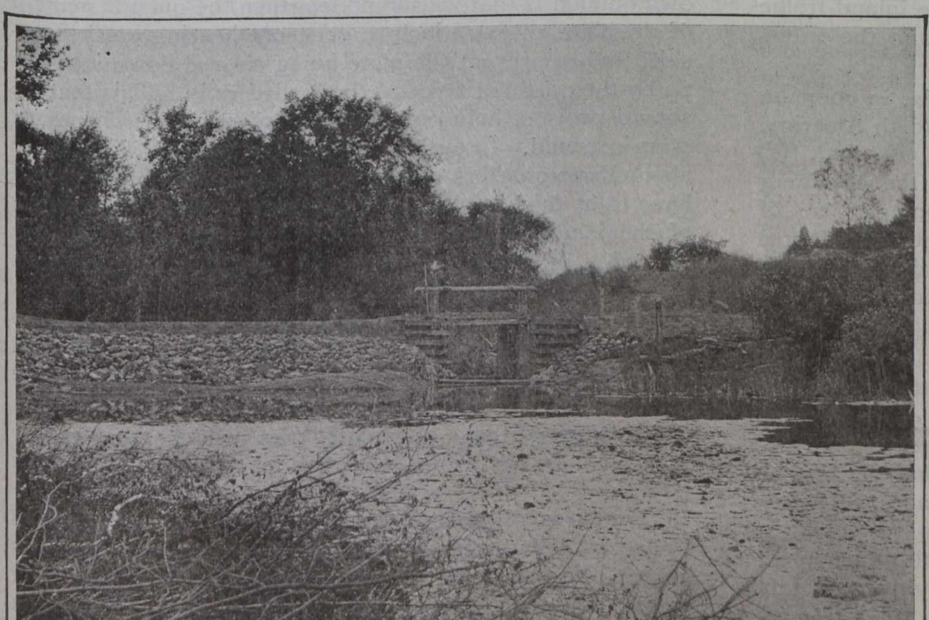
The plant has been operating quite satisfactorily since the change has been made.

Power and Storage Surveys

The third (hydraulic) volume of the annual report of the Ontario Hydro-Electric Power Commission for the past year (ninth annual report), from which the above plant descriptions were secured, also contains a report on power and storage surveys, Crown leases and measurement of stream flow; also about 220 pages of stream-flow data. The report on power and storage surveys is as follows:—



Combined Power House and Residence at Cobden, Ont.



Cobden Storage Dam at Olmstead Lake

During 1916, surveys were carried on continuously in connection with the gathering of the detailed information necessary for the design of the Chippawa-Queenston power plant.

These surveys have necessitated the use of a comparatively large field force of engineers, and have included the securing of the necessary topographical information, core drill explorations of the rock surface, and hydrometric data of the Welland and Niagara Rivers. The hydrometric information covered the continuous reading of water levels along the Niagara River at essential locations, the measurements of flow in the Welland River, and at its mouth, and the study of velocities and surface filaments in the Niagara River at Chippawa, and at the power house location at Smeaton's curve.

The office staff has been increased to transcribe the above information to the drawings, and to proceed with the design of the necessary structures. Good progress has been made on the studies of the best methods of construction for the work, and the preliminary designs are well advanced.

The Nipissing Power Company, which was part of the assets of the Electric Power Company, taken over by the Provincial Government in May, 1916, is located on the South River near Powassan.

The natural flow of the stream must be augmented in the near future, by storage on its head waters. Studies were made during 1916 by the Commission on the possibilities of securing this storage at Cox's Chute, and designs of the necessary dams have been prepared.

Under the terms of water-power leases issued by the Department of Lands, Forests and Mines of the Ontario

(Concluded on page 316)

SOME PRESENT-DAY PROBLEMS IN RAILWAY MAINTENANCE WORK*

By F. B. Tapley

Assistant Engineer of Maintenance, Canadian Government Railways, Moncton, N.B.

RAILWAY maintenance, as performed by the maintenance department, is a constant building-up of the breaking-down process caused by the wear and tear of traffic, and the effect of the elements and time. It covers a pretty broad field, embracing in its scope the roadbed, track, bridges, waterways, fences, buildings, water supply and other kindred work. The subject is too extensive to be covered, even in a general way, by one paper, so this paper will be confined to a few notes on the track structure itself, and the present-day problems pertaining thereto. The track structure, as it is called, embraces the roadbed as well as the rail and ties. The roadbed and track of a railway is one of the most important parts of the complete railway structure, and may, on account of its importance, be called the backbone of the system. To keep it in good condition, the railway must provide a certain sum of money each year, have a stock of material, and a trained organization of men.

The present-day tendency in Canadian railway practice is toward the large car and the long train, and, as Canada is a country of long distances, this tendency will grow. Large cars and long trains require big locomotives to haul them, and big locomotives mean more wear and tear on the track. This condition is manifesting itself at a time when material is high in price and hard to get hold of; when labor is scarce and independent in attitude; when operating costs are growing in volume; while rates, both freight and passenger, remain almost stationary. Yet the Canadian railways must have and maintain good tracks if passengers and freight are to be carried safely and expeditiously. Canada's long winter climate and short season for the carriage of water-borne inland traffic places the railways in the premier position in the transportation field.

The railway maintenance men of Canada, in common with those of the rest of the continent of North America, are to-day facing three important problems, *viz.*, (1) Stronger and more permanent track; (2) the obtaining and holding of labor; (3) the more economic use of material and labor. The first may be obtained in a degree by better drainage, both of the surface and under type; ballast of a better grade and more of it; heavier tie plates of the shoulder type, and the more extensive use of treated ties.

Should you ask a maintenance man what he thinks of the importance of track drainage, he will concede right off that it is one of the most important matters there is, and nine times out of ten he will tell you that the farther you keep the water away from the subgrade the better the track will be. He generally recognizes water as an enemy to be feared and guarded against, all as a matter of theory. As a matter of practice, track drainage gets secondary consideration. There are many good reasons for this. When the extra forces are put on in the spring there is great anxiety to get the ties in, the new rail laid, and the track surfaced, because the men higher up know about these things, and take a natural interest in their completion. The side ditches and other drainage work, instead of receiving first attention in the spring, are left until the last. We go into the winter with nice clean side ditches, when there is little or no water running, and through the spring and summer with dirty ditches, when it rains the greater part of the time. All this time the drains are working the moisture down into the subgrade, and storing up trouble and extra expense for cold weather. My own opinion is that we should start in the first thing in the spring and carry on the ditching work, simultaneously with the tie renewals, surfacing and other work, with extra section men specially taken on for this purpose. In this way all the work in connection with the track will be carried on in an orderly manner, and the greatest benefit derived. There are many locations where conditions must be met with drainage works of a special character, but for ordinary conditions, and ordinary conditions predominate, a good ditch well maintained is all that is required.

Ballast pits in the past have, in the majority of cases, been chosen more with a view to short haul and low cost in handling rather than to the desirability of the ballast. The result has been that a lot of fine dusty ballast has been put out, which has given us dusty track, and the money put into the venture has not proved a good investment. In the future we shall have to make a closer study of these things, and when it is not possible to obtain bank gravel of the right quality, resort to the use of broken stone or washed gravel. Ballast of this kind is bound to be high in cost, so that we shall have to be more critical of the quality of the material chosen, pay more attention to our handling methods, and see to it that the dead ballast is stripped off the roadbed so that the new ballast will not become mixed with the old.

Shoulder tie plates have proved money-savers in lessening labor in holding track to gauge; and those with the canted rail seat have helped to prolong the life of the rails by adjusting the wearing surface of the railhead to conform more closely with the coning of the wheels. My own opinion is that we should lengthen the outside margin of the plate an extra inch to get more bearing on the outside, and to prevent the plate being shoved down into the tie by the crushing force of the loaded rails. This feature should prove a help on the inside of curves. The extra margin would, of course, increase the weight of the plate about three-quarters of a pound, and, no doubt, it would have to be thickened slightly to make it stiffer, on account of the increased length, making the increase in weight around a full pound. The extra cost at ordinary prices would amount to about 2c. each, and at present prices about 4c. each. Personally, I would favor a tie plate with shallow, blunt ribs, or a smooth bottom, rather than those with deep, sharp ribs, as there is less danger of the wood fibre being cut into and destroyed by rot. With a more extensive use of treated ties, which must surely take place in the future, this feature will require close attention.

Time was when the cedar tie occupied the first place in Canadian railway tracks. It was chosen because it was low in price, easy to manufacture, and resisted rot for a longer time than other woods. Under heavy loads it has not lived up to the first impression it gave, and has given out in other ways. Experience has shown that it is not so good as the harder woods for curved track, and without tie plate equipment it is very easily cut by the rail bases. This led the railways to cast around for a harder tie, and the result has been that you will see the harder woods, such as jack pine, tamarack and hemlock favored to-day, although the life in some respects is shorter. Oak

*Abstracted from paper read before the Canadian Railway Club.

ties are nearly out of the question in Canada, as the supply of native timber is too small, and the cost of importing too high. With the treated tie we can increase the lifetime to about 12 years, and bring into use varieties of wood which to-day cannot be used in the untreated state. The argument has been set forth that the treated tie showed such a small margin in saving over the untreated article that a drop of a cent or two in the price of a tie would wipe the saving out. This argument carries a good deal of weight with the powers that hand over the money, but my prediction is that the prospective future supply of ties will alter this viewpoint.

The second problem which is staring us in the face is the obtaining of labor; and the retention of it after it has been obtained is becoming a still more serious matter. It is the opinion in some quarters that wages may remain high after the war, and that there will be a scarcity of good labor. This is a reasonable view and the prophets may be right. Be that as it may, we are sure to face a labor shortage for the next three or four years. The solution of the problem would, at the first glance, appear to be to go into the market and bid up to the price the other employers of labor are offering, and take our chance of getting men. However, there are some sceptical people who will tell you that you cannot make bricks without straw, that men are scarce, and that the few who are available are offered more attractive living conditions by other branches of industry. It is true that the manufacturer and the contractor have offered higher wages and more attractive living quarters to the men than the railways have, but we can overcome this in a degree by providing better living accommodation.

I read the other day of the experience of a prominent American railway in doing some track elevation work in a large city. It hired 2,874 laborers in six months to keep a working force of 400 men filled up. In other words, they hired the men over seven times, and the average working time of each laborer amounted to a trifle over 21 days. In the same article the experience of a firm of contractors doing public work adjacent to another large city, by force account, is given. The work consisted of ordinary hand work in a lock, which is about as hard and unattractive as you could make it, yet very few changes in the working force took place, in spite of the fact that the rate of wages paid was on the whole considerably below the scale obtaining in the vicinity, and that labor agents from munitions plants endeavored to entice the workmen away by the promise of higher wages. The reasons for the successful holding of the men on the job were quite simple. The contractor saw to it at the start that comfortable buildings were provided in which to house the men, and that a supply of good food, cooked and served in the way the different nationalities desired it, was on hand. These two influences were the main things which kept the men satisfied and on the job for a year, in spite of the efforts to get them away. Keeping the men on the job has the big advantage of a larger output of work per man, and a more efficient working gang. It is obvious to anyone familiar with the various features of maintenance work that the longer a gang works together and the fewer the changes made, the more the work goes with a better swing, and a higher class of work and more of it will be turned out in the working day.

So much has been said about the vast amount of money to be saved by the care, rehabilitation and the re-use of old material, that one is prone to approach the subject with fear and trembling. We can, however, by a freer use of the rail saw, treat our released rails to advantage and prolong their life in branch line service. My idea would be to do the sawing work in the winter when the work is slack, maintaining a small gang for this purpose, or the work might be carried on throughout the entire year, if there were enough of it to justify it.

A process for rerolling worn rails into rails of slightly lighter section, with heads of an altered shape, both symmetrical and unsymmetrical, for use on branch lines, has been patented in the United States, and several of the prominent railways over there have had some of their rails treated in this manner. In the majority of cases the alteration to the rail is so slight that the old fastenings can be used. Briefly, the process consists of a reshaping of the worn head. This process is worth looking into.

We can make better use of our locomotive cinders than we have in the past, by spreading them on the sides of new cuts and banks, where vegetation is slow to start, and the material slides. Cinders will prevent sliding to a considerable extent, and are useful in keeping down the dust. They make good ballast in rock cuts, and in other places where rails batter because of a hard, unyielding subgrade.

There is an extensive field for the introduction of motor-driven section cars to convey section crews to and from their work. The time saved in pumping a hand car will, under the right kind of foreman, be used to the railway's advantage in increasing the day's output of work. Having employed the man, it is essential that he be kept working profitably and effectively during the hours of work.

I think it can be safely estimated that the use of motor-driven section cars will save one hour a day per man employed on the tract section. This saving under present schedule hours will amount to about 10 per cent. of the day's work, and this time, if properly and efficiently employed, would add just so much more work to the upkeep of the track. In other words, the gain of one extra day in every ten would be made, or say three days each month. Apart from the gain in time, I believe the motor section car would help to attract men to, and hold them on the job.

In concluding, I wish to make an appeal to the maintenance engineers of Canada for closer co-operation in the detailing of track material. The conditions on each of the various railways do not differ so widely that we cannot get together and adopt a standard to which we can all work. With one type of material in each class or weight, better deliveries and slightly lower prices from the manufacturers will be obtained, as they will be under a lighter investment expense and providing fewer machines than they are to date. With one type of bolt, spike, or angle bar, they would carry larger stocks, as they would feel more certain of a ready sale for their product, than if they waited to see which railway was going to come into the market and buy. About the only thing in railway track material which is interchangeable today is the track spike; our angle bars, bolts, and rail-drilling are pretty much all different, not in any important feature, but in the little unimportant details. Yet these small differences prevent the material from interchanging.

In Perth, Western Australia, a large and influential committee has been appointed to formulate a scheme for holding a post-war exhibition to celebrate the opening of the East-West transcontinental railway. Only 36 miles of the railway remain to be completed, and it is expected that it will be opened by the end of October.

STANDARD METHODS OF WATER ANALYSIS

At the meeting of the Canadian Public Health Association held in Ottawa on Friday, September 28th, the committee on Standard Methods of Water Analysis reported progress. Report was adopted and the committee continued. A meeting of the committee was held the following evening and a report, a draft of which is here given, was agreed upon. This was presented at a special meeting of the Canadian section of the Society of Chemical Industry, held the following day, and a motion for its adoption was carried. Mr. Jos. Race, city bacteriologist of Ottawa, in presenting the report, briefly outlined the history of the movement and referred to the association's inception and early progress.

Draft Report of the Committee on Standard Methods of Water Analysis

That the physical, chemical and microscopical methods of analysis as published in the 1917 edition of "Standard Methods of Water Analysis" by the American Public Health Association be adopted with the following amendments:—

(*a*) All determinations of hardness by the soap method are to be made at a standard temperature of 20° C.

(*b*) That the Winkler method of estimating dissolved oxygen be tentatively adopted and that a study should be made of the method of Lancaster and Bonham, as developed in the laboratories of the Ontario Provincial Board of Health, and also that of Miller (Jour. Soc. Chem. Ind., February 28th, 1914). These methods appear to give sufficiently accurate results at a smaller expenditure of time and the Miller method also appears to be very suitable for field work.

(*c*) That the ortho tolidine method of estimating free chlorine be eliminated.

Bacteriological. — Regarding the bacteriological methods, the committee was unable to agree with many sections of the report of the American Public Health Association.

Media.—A recommendation is made that all solid media should be clarified by the addition of egg albumen in the proportion of 5 grams per litre.

Bacterial Counts.—Either agar or gelatine with incubation at 20° C. for 48 hours may be used. The committee recognizes the fact that gelatine may give a higher count than agar but is of the opinion that this advantage is generally offset by other factors that make agar more suitable for general use. Counts are also to be made on agar after 24 hours incubation at 37° C.

B. Coli.—The question of the most suitable enrichment media for the B. coli presumptive test was postponed for further consideration. In view of the absence of precise information as to the significance of the quantity of gas formed during enrichment, no final recommendation is made, but as a working basis it was agreed that all tubes showing less than 10 per cent. of gas after 48 hours should be regarded if, on shaking the tube, there is no visible evidence that gas formation is still proceeding.

Whenever practicable, all positive presumptive B. coli tests are to be plated out as soon as possible after gas formation becomes evident and the medium to be used may be litmus lactose agar, Endo's medium, or neutral red bile salt agar; the presence of typical red colonies is to be regarded as partial confirmation of the presence of some member of the B. coli group. The nature of the final confirmatory tests is postponed with a recommendation that a study should be made of the Voges and Proskauer reaction, gas production in saccharose broth, and indol formation in peptone water.

A request is also made for the investigation of plate methods for the estimation of the B. coli group.

Expression of Results.—When frequent samples are taken from the same source, only one tube of each dilution is necessary if the average number of B. coli is to be estimated by the method of Phelps (Amer. Pub. Health Assn. Rep., 33, 9) but it should be remembered that the accuracy of this method depends upon the number of variants from which the average is calculated. For individual samples several tubes of each dilution should be used and the actual results stated in the report. The most probable number of B. coli present can be calculated by the method of McCrady (Jour. Inf. Dis., 1915, 17, 183) which has recently been somewhat simplified by Wolman and Weaver (Jour. Inf. Dis., 1917, 21, 287).

ALIGNMENT DIAGRAMS FOR DETERMINING THE BENDING MOMENTS OF REINFORCED CONCRETE BEAMS*

By F. P. Watson and G. L. Wingfield

THE diagrams reproduced herewith are graphical representations of the formulæ for reinforced concrete beams given in the London County Council Regulations.

The upper diagram shows the relation between the bending moments and the working stresses of rectangular beams, and the lower, which is really a pair of separate diagrams, supplies the same information for T-beams.

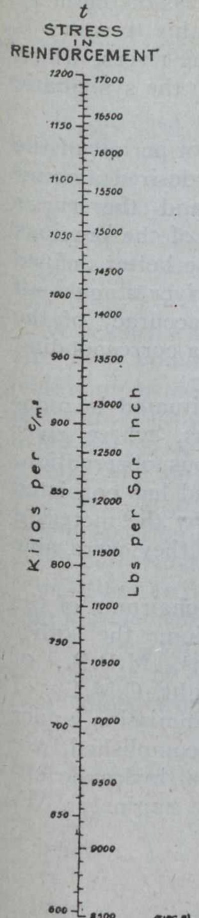
In the upper diagram the three straight-line scales are drawn on the ordinary principles of a logarithmic alignment diagram, the interesting feature being the curved scale for values of $B \div b\,a^2$. This scale is an approximation, but the error involved is in no case more than 1 per cent. for any reading which can be taken between the left and right-hand scales.

The method of using the diagram is extremely simple. In all calculations for the designing or checking of rectangular reinforced concrete beams the values t, c, $B \div b\,d^2$ and r occur, two of these values being known or assumed, and the other two required. A straight line drawn through the known values on any two of the scales will intersect the other two scales at points corresponding to the two required values.

Thus if it be intended to design a beam in which the steel is stressed to 16,000 lbs. per square inch and the concrete to 600 lbs. per square inch, a straight line is drawn through these values on the t and c scales and produced through $B \div b\,d^2$ and the r scales. It will then be found that the percentage reinforcement is 0.675 and that $B \div b\,d^2$ is 95. Similarly, if the load on a given beam is such that $B \div b\,d^2 = 110$, and if $r \times 100 = 0.82$, the readings on the t and c scales will be 15,400 and 650 respectively.

The values of the lever arm, $1 - \frac{n}{3}$, are shown on the reverse side of the percentage reinforcement scale,

*"Engineering," London.



BENDING MOMENT DIAGRAM FOR RECTANGULAR REINFORCED CONCRETE BEAMS

FORMULAE L. C. C. Notation

$$m = \frac{Es}{Ec} = 15$$

$$n_1 = \sqrt{(m^2 r^2 + 2mr)} - mr$$

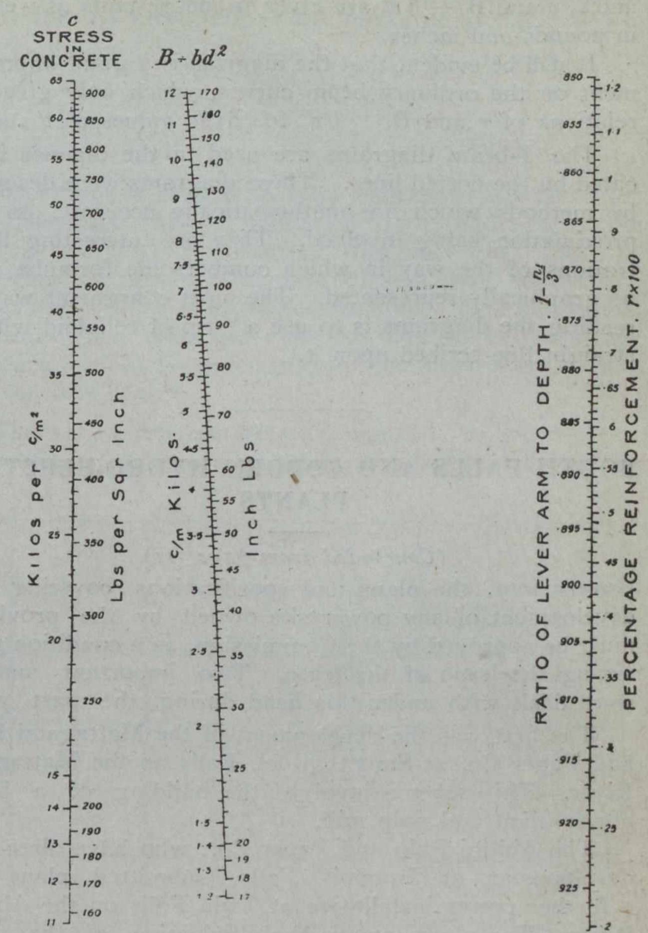
$$B \div bd^2 = tr\left(1 - \frac{n_1}{3}\right)$$

$$B \div bd^2 = \frac{c}{2}\, n_1 \left(1 - \frac{n_1}{3}\right)$$

ROUND BARS

Diameter		Area		Perimeter		Weight	
Inches	cm.	Inches	cm.	Inches	cm	Lbs. per Ft.	Kgs. per M.
$\frac{1}{4}$	0·635	0 0491	0·3168	0 785	1 994	0·167	0·249
$\frac{5}{16}$	0·794	0·0767	0·4948	0 982	2 494	0 261	0 388
$\frac{3}{8}$	0 952	0·1104	0·7122	1 178	2 992	0 376	0 560
$\frac{7}{16}$	1·111	0·1503	0·9696	1 374	3 490	0 511	0 760
$\frac{1}{2}$	1·270	0 1963	1·2664	1·571	3·990	0 668	0 994
$\frac{9}{16}$	1·429	0 2485	1 6032	1 767	4·488	0·845	1 258
$\frac{5}{8}$	1·587	0·3068	1·9793	1 963	4·986	1·043	1 552
$\frac{11}{16}$	1·746	0·3712	2·3947	2·160	5 486	1·262	1 878
$\frac{3}{4}$	1·905	0·4418	2·8502	2·356	5·984	1 502	2 235
$\frac{13}{16}$	2·064	0·5185	3·3450	2 553	6·484	1 763	2 624
$\frac{7}{8}$	2·222	0·6013	3 8792	2·749	6·982	2 044	3 042
$\frac{15}{16}$	2 381	0·6903	4·4534	2·945	7·480	2·347	3·493
1	2·540	0·7854	5·0669	3 142	7·981	2·670	3·973
$1\frac{1}{8}$	2·857	0·9940	6·4127	3 534	8·976	3·380	5 030
$1\frac{1}{4}$	3·175	1·2272	7·9171	3 927	9 974	4 172	6 209

(S.M.C.B.) Reproduced by the Survey Department Egypt, 1916 (100)



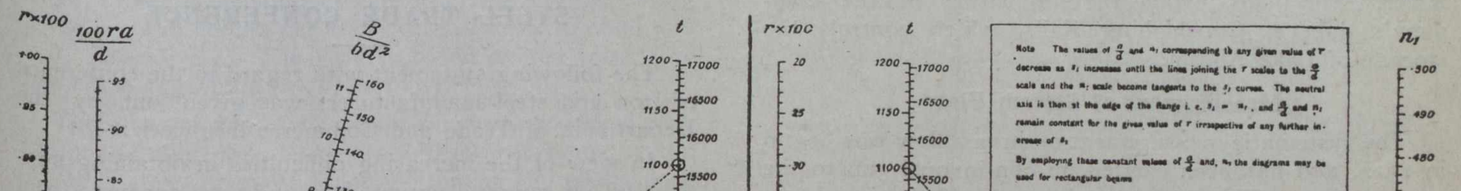


Diagram of the Bending Moments of Reinforced Concrete Beams.

(For description see opposite page)

and t, c and $B \div b d^2$ are given in metric units as well as in pounds and inches.

It will be evident that the diagram is a great improvement on the ordinary beam curves, which only give the relations of r and $B \div b d^2$ for fixed values of t and c.

The T-beam diagrams are used in the manner indicated by the dotted lines. These diagrams were designed by methods which are mathematically accurate, no approximation being involved. They are interesting illustrations of the way in which cumbersome formulæ may be graphically represented. The most convenient way of reading the diagrams is to use a strip of celluloid with a straight line scribed upon it.

SOUTH FALLS AND COBDEN HYDRO-ELECTRIC PLANTS

(Concluded from page 311)

Government, the plans and specifications covering the development of any power site owned by the province, must be approved by the Commission, as a condition governing the issue of the lease. Two important matters were dealt with under this head during the past year.

The first was the development of the Mattagami Pulp and Paper Co. at Smooth Rock Falls on the Mattagami River. This scheme involved the building of a large power plant and pulp mill.

The Abitibi Pulp and Paper Co., who have already a development at Iroquois Falls, submitted plans for a further power installation at Twin Falls on the Abitibi River. The plans involve the elimination of the company's dam at Couchiching Falls, which controls the storage of Lake Abitibi.

Measurement of Stream Flow

The systematic measurement of stream flow was begun in 1912, and has been carried on continuously up to the present time. This hydrometric study of the important rivers of the province, though so far extending over a period of time too short to be really comprehensive, has nevertheless resulted in the accumulation of an appreciable amount of valuable data, and has provided an absolutely necessary basis of computation for the proper study of hydraulic development, river improvement, and flood prevention.

It is only by means of some governmental agency that information on stream flow can be adequately secured. The value of the data being directly proportional to the period of time over which it has been taken, the process is essentially continuous. No individual or private enterprise, therefore, possibly can carry on a work the utility of which is dependent solely upon the consistent accumulation and compilation of data over a continuous and long period of years.

The run-off from 47,000 square miles of watershed is now under continuous observation, but this is only about 12 per cent. of the total area of the basins within the boundaries of the province, and the great number of enquiries received with reference to the flow of the rivers of Ontario, indicates not only that the Hydro-Electric Power Commission is becoming recognized as the source for dependable data of this kind, but also the necessity of increasing the scope of the work to cover a much greater territory within the province than it does at present. In this connection it is especially necessary that the rivers flowing into James Bay and in the Lake Superior district be brought under observation, as the success of the large number of mining and pulp industries in this territory is absolutely dependent upon the power of the rivers, which cannot be gauged by any means other than the systematic study and recording of their flow.

During the year 1916, conditions did not permit of the addition of new stations, or even of the desired amount of work on those already established, and the rivers covered are practically the same as those of the previous year. The discharge curves, however, are better defined as a result of measurements secured at river stages not reached during previous years, and the accuracy of the daily flow estimates has been increased to a corresponding extent.

Many very valuable power sites are situated in uninhabited country often difficult of access, where river stages cannot be brought under continuous observation. In such cases the only information secured has consisted of intermittent flow measurements taken by the metering parties on the occasion of such visits as they were able to make.

Col. Sir Adam Beck, K.B., LL.D., is chairman of the Ontario Hydro-Electric Power Commission, the other commissioners being Hon. I. B. Lucas, M.P.P., of Markdale, Ont., and Col. W. K. McNaught, C.M.G., of London, Ont. The officers of the Commission under whom the above hydraulic work was accomplished, are F. A. Gaby, chief engineer; H. G. Acres, hydraulic engineer; T. H. Hogg, assistant hydraulic engineer; W. W. Pope, secretary.

STEEL TRADE CONFERENCE

The following statement with regard to the conference of iron and steel manufacturers was given out by the Department of Trade and Commerce last week:—

In view of the increasing difficulties in obtaining supplies of pig iron and various iron and steel products from the United States, a largely attended meeting which was hurriedly summoned, of representative iron and steel manufacturers was held in Ottawa yesterday. In view of the urgency of the matter a number of distant firms of importance could not be included. The meeting, however, canvassed the situation generally and decided to appoint representatives of the various industries. Those representatives are as follows:—

Government departments, F. C. T. O'Hara; shipbuilding, P. L. Miller, Canadian Vickers Co.; bridge and structural building, R. M. Davy, Dominion Bridge Co.; locomotives, D. W. Fraser, Montreal Locomotive Co.; farm machinery, R. Harmer, Sawyer-Massey Co., Hamilton; merchants handling plate for general trade, T. McC. Hutchison, Drummond McCall Co.; high carbon and alloy steel, F. R. Humpage, Wilkes Twist Drill Co., Walkerville; boilers, tanks, pulp and general machinery, C. A. Watrous, Watrous Engine Co.

Additional representatives will be appointed representing the car-builders, railways and foundrymen.

It is the intention of the various chairmen to circularize those in the respective industries and ascertain from them their immediate requirements in those iron and steel products which are prohibited from being exported from the United States, showing in detail the commodity and quantity required and the specific purpose for which the same is required. Firms interested may, if they so desire, communicate with any of the above noted.

ECONOMICAL PROPORTIONS FOR PORTLAND CEMENT MORTARS AND CONCRETES

(Concluded from last week's issue.)

In the case where concrete is made from the bank run of gravel, or a concrete mix, and cement, it would be reasonable to expect the same general principles to apply as previously stated for mortars. Where mortar is added to a coarse aggregate, such as rock, it is reasonable to assume that an important function of the mortar is to fill the voids in the rock.

A scientific test to determine the laws of concrete mixtures would be, first, to determine the mortar of maximum density and the yield of mortar; second, to make progressive proportions of the mortar with the rock, using values of the ratio of the volume of mortar to the volume of voids in rock equal to 0.50, 0.75, 0.90, 1.00, 1.10, 1.25, 1.50, 2.00 and 3.00, with a view of determining that proportion giving maximum efficiency; and, finally, to make additional progressive proportions, maintaining the ratio of fine to coarse aggregate of the "efficient" proportion just determined, but increasing the amount of cement to 1.1, 1.2, 1.3, 1.4, 1.5, 2.0 and 3.0 times that used in the mortar of maximum density. The most economical proportions would be determined by the following equation:—

$$\text{Economy Factor} = \frac{\text{Compressive Strength (lbs. per sq. in.)}}{\text{Cost of Mortar (dollars per cu. yd.)}}$$

$$= \frac{\text{Compressive Strength} \times \text{Yield}}{C_r + \frac{P_s \times C_s}{P_r} + \frac{P_c \times C_c}{P_r}} \quad (8)$$

P_c, P_s, P_r being the volumetric proportions and C_c, C_s and C_r the costs in dollars per cubic yard of cement, sand and rock, respectively. The yield is based on the volume of the coarse aggregate (rock) as unity.

There are no test data extant on the economical proportions of concrete. Some tests have been made by the United States Bureau of Standards, using the void theory of proportioning in a limited way. The results of these tests will be analyzed in the following discussion and may throw some light on the subject:

The economy of any mixture depends largely upon the local cost of materials. If the cost of cement is twelve to fifteen times that of the aggregates, the economy of leaner mixtures will be more apparent. In Table VI., the economy factor for several 1:2:4 mixtures is compared with that of several void-theory mixtures, the factors having been computed by the writer from the results shown in Tables VIII. and XII. of the Bureau of Standards paper (Technologic Paper No. 58, U.S. Bureau of Standards). The void-theory mixtures may be expressed by Equations 9 and 10, the void-filled ratio (1 to 1.5) being 1.1 in every case both for the mortar and for the rock. The cost of the aggregates was assumed at $1.20 per cubic yard and the cost of cement at $12 per cubic yard. The yield of the various mixtures is necessarily assumed as unity, as it is not possible to closely approximate the yield by calculation.

It would appear from a study of this table that the void-theory mixtures compare quite favorably with 1:2:4 mixtures, considering efficiency. The two combinations of granite show the 1:2:4 mixtures as the most efficient. However, there are too few combinations to be conclusive.

In Table VII. the economy factor is shown for various combinations of aggregates in three mixtures, 1:2:4, 1:3:6 and a void-theory mixture. In 33 comparisons the ratios for the most economical mixtures are as follow:

Theoretical	1:2:4	1:3:5
18	15	
30		3
	30	3

The ratio of cement to total aggregate is 1:8.12 for the theoretical mixture, compared to 1:6 and 1:9 for the 1:2:4 and 1:3:6 mixtures. The fact that the 1:9 arbitrary mixture is much less efficient than an average 1:8.12 theoretical mixture and that the 1:8.12 theoretical mixture is somewhat more efficient than the 1:6 arbitrary mixture would appear to indicate that there is some basis for the void theory.

The 1:2:4 mixture generally appears to be a very efficient one, and the explanation may be the efficiency of

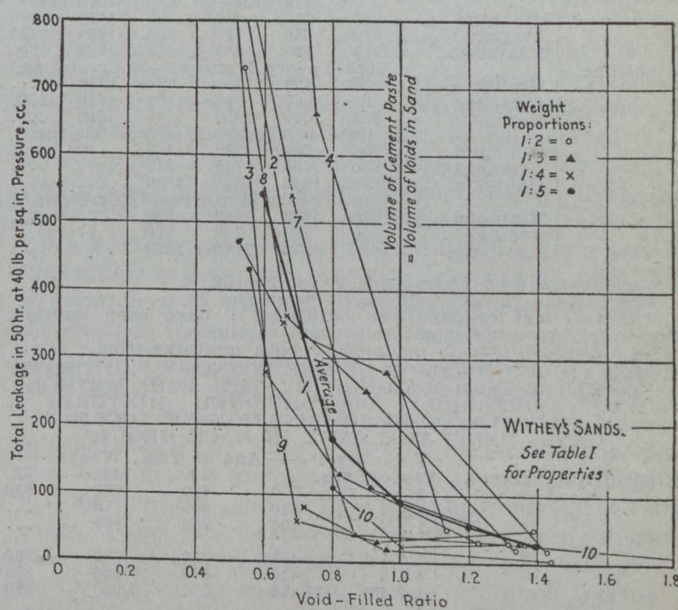


Fig. 4.—Variation in Leakage of Mortars in Proportion to Void-Filled Ratio

the mortar. As the voids in sands are seldom below 33 per cent. or above 50 per cent., the ratio of cement paste to voids for the 1:2 mortar varies from 1 to 1.5, which corresponds to the limits previously determined for efficient mortars. Rock seldom shows less than 35 per cent. or more than 50 per cent. of voids, so that in a 1:2:4 mixture the volume of mortar will vary from 1 to 1.5 times the volume of voids in the rock. A 1:3:6 mixture is seldom an efficient one because a 1:3 mortar is seldom efficient, few sands showing less than 33 per cent. voids.

Conclusions Regarding Concretes

1. An important function of a mortar in concrete is to fill the voids in the coarse aggregate.

2. The efficiency of a concrete mixture depends largely upon the efficiency of the mortar.

3. For economical proportions the volume of cement should be equal or greater than the volume of voids in the sand but not to exceed a multiple of 1.5, and the volume of mortar should be equal or greater than the volume of voids in the coarse aggregate but not to exceed a multiple of 1.5.

4. The equations for economical mixtures may be stated as follows:

$$\frac{\text{Volume of Sand}}{\text{Unit Volume of Cement}} = \frac{1}{(1 \text{ to } 1.5) \times \text{Proportion of Voids in Sand}} \quad (9)$$

$$\frac{\text{Volume of Rock}}{\text{Unit Vol. of Cement}} = \frac{\dfrac{\text{Vol. of Sand} \times \text{Yield of Mortar}}{\text{Unit Volume of Cement}}}{(1 \text{ to } 1.5) \times \text{Proportion of Voids in Rock}} \quad (10)$$

5. The economy factor expresses the relative efficiencies of concrete mixtures and may be determined by Equation 8.

TABLE VI.—ECONOMY FACTORS COMPARING 1:2:4 MIXTURES WITH VOID-THEORY MIXTURES.

Kind of Aggregate.		Age at Test, Weeks. 4	13	26	52	78	104
Granite	1:2:4 Mixtures—2 Combinations.[1,4]						
	Minimum	490	630	700	990	....	....
	Average	510	720	710	1010	....	....
	Maximum	540	820	720	1040	....	....
	Void-Theory Mixtures—2 Combt'ns.[2,4]						
	Minimum	410	510	590	880	....	....
	Average	440	620	670	900	....	....
	Maximum	470	730	750	920	....	....
Limestone	1:2:4 Mixtures—20 Combinations.[1]						
	Minimum	260	360	450	780	1140	1280
	Average	570	680	750	990	1260	1410
	Maximum	820	820	940	1360	1520	1500
	Void-Theory Mixtures—20 Comb't'ns.[3]						
	Minimum	300	390	410	470	1210	....
	Average	600	760	800	890	1330	1710
	Maximum	890	1020	1050	1440	1590	....
Gravel	1:2:4 Mixtures—10 Combinations.[1]						
	Minimum	200	300	390	440	....	....
	Average	550	600	740	810	....	....
	Maximum	870	1040	1090	1190	....	....
	Void-Theory Mixtures—8 Comb't'ns.[2,3]						
	Minimum	280	420	460	530	....	....
	Average	560	680	740	820	....	....
	Maximum	1080	930	1110	1220	....	....

[1]From Table 8 of Technologic Paper No. 58.
[2]From Table 12 of Technologic Paper No. 58.
[3]The two last combinations of Table 12 have been omitted, since they were not common to both mixtures.
[4]Two combinations in common to both mixtures used.

TABLE VII.—COMPARISON OF THE ECONOMY FACTORS OF CONCRETES PROPORTIONED BY THE VOID METHOD AND ARBITRARILY PROPORTIONED MIXTURES 1:2:4 AND 1:3:6, THE COMBINATION OF AGGREGATES BEING THE SAME IN EACH GROUP.[1]

Kind of Aggregate.	Volumetric Proportions.	Age at Test, Weeks. 4	13	26	52
Limestone	1:2.4:4.47	570	720	900	930
	1:3:6	620	690	750	...
	1:2:4	700	750	960	...
	1:2.4:4.45	470	570	680	860
	1:3:6	410	520	600	800
	1:2:4	450	590	660	880
	1:2.4:5.46	800	1000	1050	900
	1:3:6	790	810	1010	1030
	1:2:4	600	820	...	1040
	1:2.6:6.8	640	760	840	1000
	1:3:6	570	750	820	860
	1:2:4	830	...	830	1240
	1:2.4:5.81	670	900	930	710
	1:3:6	490	730	840	970
	1:2:4	540	820	810	970
Granite	1:2.4:4.92	470	720	750	920
	1:3:6	380	440	520	580
	1:2:4	540	820	720	980
Gravel	1:2.4:7.0	640	820	790	...
	1:3:6	410	540	610	...
	1:2:4	700	...	920	...
	1:2.4:6.2	940	930	1110	1220
	1:3:6	440	590	680	860
	1:2:4	860	1030	1090	1190
	1:2.3:6.4	750	930	990	...
	1:3:6	410	550	650	...
	1:2:4	700	...	970	...
Average	Void Theory	661	817	893	934
	1:3:6	502	624	719	850
	1:2:4	658	805	875	1050

[1]See Table 13, Technologic Paper No. 58.

In Denmark a new section has just been formed within the Union of Danish Engineers with a view to securing the co-operation of engineers for the advancement of Danish industry and of the commercial undertakings which it entails. This section will embrace all technical branches, but it will differ from the other sections by also comprising general industrial and mercantile aspects, in close touch with the doings of the day. The scheme is being backed by a number of eminent engineers.

ELECTROLYSIS IN UNDERGROUND WATER PIPES*

By Jos. W. Ivy,
Manager, Kansas City, Mo., Branch of American Cast-Iron Pipe Company

VERY soon after electrically operated tramways were introduced into this country underground piping systems began to show damage from electrolysis. Prior to that time little or no trouble had been experienced. With the multiplication of electric-car lines the situation has become more serious, and to-day the problem is receiving much attention at the hands of the Government Bureau of Standards, various engineering societies, and other interested organizations. It will be the purpose of this paper to deal only with electrolysis as affecting underground piping in water systems. However, before going into a discussion of this matter, it is desirable to set forth briefly the general principles involved and to define a few technical terms that will be used.

Terms and Definitions

Certain solutions or chemical compounds are capable of conducting an electric current. Such solutions or compounds are called "electrolytes," and the transmitting of an electric current under these conditions is called "electrolytic conduction." This differs from ordinary metallic conduction—such as the passage of a current through a copper wire—in that electrolytic conduction is independent of any heating effect and produces chemical decomposition, whereas metallic conduction produces heat in the metal, but does not otherwise affect it. This chemical change of decomposition produced by the passage of the electric current is called "electrolysis." A common example of this action and one of the forms in which it is usefully employed is the process known as electro-plating. The operation consists merely in passing an electric current through a solution of copper salt (or salt of whatever metal is desired), the conducting terminals—or electrodes—being of copper plate; copper is removed from one terminal and carried into solution, and an equal quantity of copper is deposited on the other terminal. The terminal through which the current enters the solution is called the "anode," and the terminal at which the current leaves the solution is called the "cathode."

Electrolysis from Stray Currents (Anodic Corrosion)

In this age of electricity there is abundant opportunity for electric current to leak into the soil from numerous grounded distribution systems. These are called "stray currents." For our purposes we need consider only stray currents that have leaked from the return conductors of ordinary street tramway systems, the currents due to grounded telephone, telegraph and lighting system apparatus being negligently small and not of sufficient strength to cause any serious trouble in pipe lines.

Most electric tramways in this country employ direct current, the power being supplied to the cars through an overhead trolley wire and the return circuit to the power-house being completed through the running rails. It is common practice to lay these rails with the tops flush with the street surface. Under such conditions the major portion of the rail area is in direct contact with the street

*Abstract of paper read at the South-Western Waterworks Association Convention at Topeka, Kan.

soil, or where concrete has been used as a base, in contact with this. The water found in such soils (or concrete) usually contains salts, acids, etc., sufficient to make it capable of electrolytic conduction; hence either the wet concrete or wet soil is capable under ordinary conditions of conducting electric currents. Current from the return rails that flows or leaks into the soil or concrete must find its way back to the power-house through some underground path. In doing so the current obeys the law of divided circuits, flowing through all possible paths in parallel, the strength in each being inversely proportional to its resistance. Underground water piping systems readily offered themselves as convenient conductors of these stray currents, especially where the rails cross, or parallel in close proximity the pipe. In general, these currents flow along the pipe until they reach the neighborhood of the power house, and at the nearest point to this leave the pipe, return through the soil to the rails, and thus back to the negative terminal of the generator. Where the current leaves the pipe and flows back to the rails the pipe serves as the anode, the soil as the electrolyte, and the rails as the cathode. These currents do no harm to the pipe except where they leave it, and at such points the pipe is corroded or eaten away. The extent of corrosion, or amount of metal destroyed is in keeping with Faraday's law, which holds that chemical decomposition occurring at the electrodes is directly proportional to the current flowing, the duration of flow and the chemical equivalent weights of the substances. The destruction of the metal is independent of voltage, except the determining effect of this on current flowing.

In addition to the damage occurring in the locality of the power house—which is by far the greater and more serious source of trouble—the pipe is also affected at other points where for certain reasons currents leave the pipe, either to shunt around some high resistance section or to return to the rails because of favorable soil conditions and possible close proximity of the tracks. Particularly in the case of cast iron, where there is a more frequent possibility of some lengths of pipe being of unusual high resistance, or the lead joints are so made that the pipes themselves are not in direct contact, the current flowing sometimes shunts around such high resistance pipes or joints. However, this is really an advantage rather than a disadvantage, because it exerts a strong tendency to keep the total current low, causing, as it does from time to time, a portion of what would be final accumulated current to leave the pipe and seek some other path, such as the rails, back to the power house. Obviously, in general, under these conditions the total current leaving the pipes at the power house is small—much smaller than the accumulated current would have been had there been no loss or leakage as here described. Wherever the pipe lines parallel the rails and pass through unusually wet soil there is more danger of serious trouble, such conditions lending themselves readily to the passage of current to or from the pipe or rails.

Under similar conditions with currents of equal strength flowing through iron pipes, the amount of metal destroyed is the same, whether the pipe is steel, wrought or cast iron. However, due to its inherent qualities and peculiar metallic structure, the resistance offered to the flow of electricity by cast iron is, roughly, ten times as great as steel or wrought iron, and the ordinary lead joints employed with cast iron increase this resistance materially, thus reducing proportionately the current flowing, which makes the possibility of electrolysis in the case of cast iron approximately one-twelfth what it would be for the other two kinds of pipe mentioned. It should also be borne in mind that in practice cast-iron pipe has a metal thickness about four times that of wrought iron or steel, which proportionately delays the ultimate total destruction in the case of this class of pipe.

If pipe is of steel or wrought iron, results of electrolysis are seen in pits, these finally extending through the plate. Where the current leaves such pipe the metal is converted into iron oxide, which is frequently noticeable in surrounding soil. If the pipe be of cast iron, the oxides formed often are still held in position by the graphite, and the external appearance of the pipe remains unaffected. When the pipe has been entirely eaten through the mass is about the hardness of pencil lead and collapses under an ordinary hammer stroke, yet a pipe in this condition, if the soil is rather tightly packed about it, may remain without leaking for a considerable period. It is frequently necessary to make a direct physical examination of a pipe and subject it to a hammer test to determine if it has been attacked by electrolysis. So far, we have dealt only with trouble in the mains and distribution system proper. However, while less serious, probably the greater percentage of damage actually occurs in the service pipes, because these frequently pass under the car lines close to the rails, and the pipes, being relatively thin, are quickly pierced. Investigation made in about fifty cities brought out the fact that, roughly, 75 per cent. of the trouble experienced occurred in the service pipes, lead, wrought iron or steel, all being readily affected. Besides the damage to the service pipes themselves, stray electric currents flowing on these may occasionally reach the steel structure of buildings, causing electrolysis to attack the steel, but seldom to any serious extent. Under certain unusual conditions, current flowing on these service pipes may be sufficient to raise them to a temperature approximating red-heat, and in this way cause fires. In some cases of gas pipes explosions have been brought about. However, such occurrences are undoubtedly very rare at the present time, and there seems no good reason to anticipate any increase in this hazard.

Electrolysis from Local Action (Self-Corrosion)

In the preceding section it has been the intention to deal only with the effects of electrolysis due to stray currents, or what is usually spoken of as "anodic corrosion"—that is, action when the pipe serves as the anode, corrosion taking place only where current flows from the pipe to other conductors. Now, in addition to this form of electrolysis, we have what is termed "self-corrosion"—that is, electrolysis by local galvanic action. This is termed "self-corrosion," for the reason that the current originates on the metal itself, and is due in the case of pipe to the impurities of the metal or the presence of carbon or coke in the surrounding earth, or both. Salts and acids in moist soil increase this action. Small pieces of coke or carbon in wet soil in contact with the pipe, even if no physical differences between adjacent parts of the metal exists, will bring about local action, because a difference of potential will exist between the carbon and the iron, which will cause a current to flow from the pipe to the carbon. The potential difference existing under such conditions is approximately one-half a volt—causing a sufficient flow of current to bring about rapid deterioration.

An instance of this kind came to the writer's attention where a large coated steel pipe passing through a cinder bed tailed completely in a short time, the metal structure of the pipe becoming a mere honey-comb of rust. Self-corrosion is undoubtedly accelerated where anodic corrosion exists, galvanic action following as a secondary reaction. The primary action due to the stray currents produces iron oxide which is precipitated on the pipe exterior. This oxide acts just as a piece of coke in the case previously cited, bringing about a current flow due to the potential difference existing. The general effect of self-corrosion on iron pipes differs very little, if any, from the effects of corrosion by stray currents; the pipe being pitted and gradually eaten away, oxides form and behavior of these are the same. It is often very difficult to distinguish between the two actions. This has led to some disputes in an attempt to place the responsibility for electrolysis troubles, it being the practice in many cities to force the electric tramways to pay for all the damage caused by electrolysis.

However, it should be stated that, in the case of cast iron at least, except where this is laid in excessively damp cinder beds or like materials, the local action is very seldom, if ever, sufficiently severe to cause the entire destruction of the pipe within the period of years usually ascribed to the life or usefulness of the ordinary pipe line. In other words, since practically all of the mains and distribution systems in the great majority of our cities consist of cast iron, there is not much trouble to be expected, except under unusual local conditions, from electrolysis other than that caused by stray currents that have leaked from electric railway systems. Owing to the present growth of the interurban lines, even many small towns and cities that have no street tramway systems of their own are no longer free of possible trouble from electrolysis. Hence this is a subject that demands attention from both towns and cities.

Mitigation of Electrolysis

While it is not the writer's purpose, nor is it possible in the limited time and space assigned, to cover in detail the broad subject of electrolysis mitigation, this paper would be incomplete without a brief discussion of this and a mention in general of a few of the methods—good and bad—that have been tried to date. First of all, a more careful attention to proper bonding of rails would materially lessen the trouble by reducing in this way the leakage of current from the rails. Such a practice has been employed in European countries, particularly England and Germany. Many patented devices or so-called "mitigation systems" have been brought out, and in some instances these have seemed to work out very satisfactorily. In other cases results have not been so good. Local conditions differ so widely that a system which might answer in one city would do very little good in another. The writer considers these systems still in the experimental stage. In this country many cities have attempted to lessen the evil by bonding at frequent intervals the pipe to the rails, employing some good conductor like copper wire in this operation. In most cases this method has been attended with only indifferent success, and in the writer's opinion is more likely to prove a detriment than a help, because it is liable to increase rather than decrease the current leaving the pipe at points not in the neighborhood of the power house, as the bonding would have a tendency to cause a larger current flow than would otherwise be the case.

From time to time in recent years a great many paints, dips, tar and fabric coatings and various so-called "insulating coverings" have been on the market and claims made of their worth, but so far, after extensive experiments and practical tests, it is yet to be proven that paints, coverings, fabric and otherwise (except possibly asphaltum of one or two inches in thickness), are of much, if any, value. Tests made have only served to emphasize the fact that many of these coverings, such as pitch and burlap wrappings, increase rather than decrease the action of electrolysis.

Certain rather satisfactory results have been obtained by introducing insulating joints in pipe lines at proper intervals. Further developments along this line promise good results, provided experiments prove that the insulating joints can be inserted economically. Some cities have spent quite a little time and money in drainage experiments, their purpose, of course, being to remove as much as possible of the water from the soil and thus reduce the likelihood of electrolytic conduction. So far these experiments have not been productive of very good results, and the opinion seems to be growing that the cost is excessive in comparison with results obtained. To sum up, so far the only method yet developed of securing absolute immunity from electrolysis is to perfectly insulate the return circuit. Several cities, notably Havana (Cuba) and Cincinnati (Ohio), have accomplished this by providing an overhead return wire. Others have their return circuit through insulated underground conduits. At present a committee composed of leading men from engineering societies and kindred associations, organized into what is known as the "American Committee on Electrolysis," are giving the subject of electrolysis mitigation very close study, and it is to be hoped that their findings, when made public, will go far towards settling this rather distressing problem.

Conclusions

From the foregoing statements, and investigations made by the writer in the preparation of this paper, the following conclusions are drawn:—

1. The possibility of electrolysis trouble increases as electric tramways become more numerous and the loading becomes heavier.

2. Stray currents are the principal and most troublesome source of damage. This damage is confined entirely to points where currents leave pipes.

3. Anodic corrosion in underground pipe lines is directly traceable to currents that have leaked from imperfectly insulated return circuits of electric tramways.

4. The really serious damage to supply lines and distribution systems proper is confined in the main to the neighborhood of the power house, except under certain peculiar local conditions, such as unusually wet soil, cinder beds, etc.

5. Service pipes furnish the greater number of failures in a short period of time, and for this reason are generally regarded as the seat of probably 75 per cent. of the total trouble, lead, steel or wrought iron all being readily attacked.

6. The higher electrical resistivity of cast iron and the extra thickness of metal presented greatly reduces the possibility of ultimate destruction in this class of material as compared with ordinary steel or wrought-iron pipes.

7. Self-corrosion, except under extremely trying conditions, is seldom, if ever, sufficiently serious to cause complete failure of cast iron, though it might destroy iron of thinner structure.

8. Paints, dips, fabric coatings, etc., are of little or no value in mitigating electrolysis, fabric coatings especially rather tending to increase than decrease the damage.

9. Better bonding of rails, introduction of insulating joints and like remedial measures have so far proven the most helpful in electrolysis mitigation.

10. Only perfectly insulated return circuits offer absolute immunity from stray current damage.

ECONOMICS OF BRIDGE DESIGN*

IT has been found by experience that, for trusses with polygonal top chords, the economic depths, as far as weight of metal is concerned, are generally much greater than certain important conditions will permit to be used. For instance, especially in single-track, pin-connected bridges, after a certain truss depth is exceeded, the overturning effect of the wind-pressure is so great as to reduce the dead-load tension on the windward bottom chord to such an extent that the compression from the wind load carried by the lower lateral system causes reversion of stress, and such reversion eye-bars are not adapted to withstand. A very deep truss requires an expensive traveler, and decreasing the theoretically economic depth increases the weight but slightly; hence it is really economical to reduce the depth of both truss and traveler. Again, the total cost of a structure does not vary directly as the total weight of metal, for the reason that an increase in the section area of a piece adds nothing to the cost of its manufacture, and but little to the cost of erection; consequently it is only for raw material and freight that the expense is really augmented. Hence it is generally best to use truss depths considerably less than those which would require the minimum amount of metal. For parallel chords, the theoretically economic truss depths vary from one-fifth of the span for spans of 100 ft. to about one-sixth of the span for spans of 200 ft.; but for modern single-track railway through-bridges the least allowable truss depth is about 30 ft., unless suspended floor-beams be used, a detail which very properly has gone out of fashion.

In designing plate-girders, if one will adopt such a depth as will make the total weight of the web with its splice-plates and stiffening angles about equal to the weight of the flanges, he will obtain an economically designed girder, and a deep and stiff one. For long spans, however, this arrangement would make the girders so deep as to become clumsy and expensive to handle; consequently, when a span exceeds about 40 ft., the amount of metal in the flanges should be a little greater than that in the web; and the more the span exceeds 40 ft. the greater should be the relative amount of metal in the flanges.

A rather lengthy mathematical investigation for plate-girders, based upon fairly accurate assumptions, proves that the theoretical maximum of economy exists when the gross areas of flanges and of web at mid-span are equal—a condition readily remembered. Although this is the theoretically correct criterion for economy, if it be applied to any particular case, it will generally be found that the resulting web depth is so excessive as to cause one or more of the following modifications in construction, as compared with the depth which would make the total weight of the flanges equal to the total weight of the web with all its details:

(*a*) An additional splice or two in the web, or else a slightly increased pound price for the large plates. (*b*) Larger outstanding legs for all stiffening angles. (*c*) Reduction in the number of cover plates. (*d*) Narrowing of flange angles and necessitating thereby either an additional bracing frame or an increase in sectional area of the compression flange, in order to compensate for the greater ratio of unsupported length to width. (*e*) Possibly thickening of web because of its greater depth. (*f*) Possible encroachment on under-clearance in deck spans, or raising of grade to avoid the same. (*g*) Possible difficulty in fabrication or shipment in case of long or heavy girders because of excessive depth.

Any of these changes would be likely so to upset the economics of the case as to cause a material decrease in the theoretically best depth, hence it is generally advisable to adhere to the rule previously given; but there are occasionally cases where a saving of metal may be effected by making the web depth somewhat smaller, when by so doing a web-splice may be avoided or lighter stiffening angles may be adopted. It should be borne in mind that there is quite a range in web-depths over which the theoretic minimum weight is about constant, unless the thickness of the shallower web must be increased on account of shear; hence one may often vary the dimensions of a plate-girder materially without affecting greatly the matter of economics.

Concerning economic panel lengths, it is safe to make the following statement: Within the limit set by good judgment and one's inherent sense of fitness, the longer the panel the greater the economy of material in the superstructure. Of course, when one goes such an extent as to use a 30-ft. panel in an ordinary single-track railway bridge he exceeds the limits referred to, because the lateral diagonals become too long, and their inclination to the chords becomes too flat for rigidity. Again, an extremely long panel might sometimes cause the truss diagonals to have an unsightly appearance because of their small inclination to the horizontal.

There is another mathematical investigation which is of practical value. It relates to the economic lengths of spans. The principle is that "for any crossing the greatest economy will be attained when the cost per lineal foot of the substructure is equal to the cost per lineal foot of the trusses and lateral systems." The old practice was to make for economy the cost of a pier equal to the cost of the span that it supports, or, more properly, equal to one-half of the cost of the two spans that it helps to support. Is not the difference between these two methods perfectly plain? In one the cost of the pier is made equal to the cost of the trusses and laterals, and in the other it is made equal to the cost of the trusses, laterals and floor system. When one considers that the cost of the floor system is sometimes almost as great as one-half of the total cost of the superstructure, he will recognize how faulty the old method was.

The demonstration proves that in any layout of spans, with the conditions assumed, the greatest economy will be attained when the cost of the substructure per lineal foot of bridge is equal to the cost per lineal foot of the trusses and lateral systems. Of course, no such condition as a bridge of indefinite extent ever exists, nor is the bed-rock often level over the whole crossing; nevertheless, the principle can be applied to each pier and the two spans that it helps to support by making the cost of the pier equal to one-half of the total cost of the trusses and laterals of the said two spans.

*From a lecture by Dr. J. A. L. Waddell at the School of Engineering of the University of Kansas.

The principle will apply also to trestles and elevated roads; for in the latter, when there is no longitudinal bracing, if we make the cost of the stringers or longitudinal girders of one span equal to the cost of the bent at one end of same, including its pedestals, we shall obtain the most economic layout. In an ordinary railroad trestle consisting of alternating spans and towers, it will be necessary for greatest economy to have the cost of all the girders in two spans (one span being over the tower) plus the cost of the longitudinal bracing of one tower equal to the cost of the two bents of said tower, including their pedestals.

The economics of reinforced concrete bridges have not received much attention from technical writers. In general, it may be said that the unit costs are lower for those structures which have the simplest form-work; and a reduction will also be effected by decreasing the area of form-surface per cubic yard of concrete. For instance, in the case of a wall or slab the form-cost per cubic yard will vary practically inversely as the thickness of the said wall or slab. Evidently, therefore, it is desirable to concentrate the concrete into a few large members, rather than to employ a great number of small ones.

It should be noted that reinforcing bars less than ¾ in. in diameter command higher pound prices than do the larger bars.

Taking up, first, girder bridges carried on columns, the following points must be considered: First, the panel length, when cross-girders are employed; second, the number and spacing of the longitudinal girders; third, the number of columns per bent; fourth, the span length; fifth, the use of reinforced concrete piles to carry the footings.

The panel length adopted is usually not of great importance from the standpoint of economy. Lengths of from 8 to 10 ft. are generally employed; but a considerable variation from these values will cause little change in the combined cost of the slabs and cross-girders. A reduction in concrete quantities can frequently be effected by using long panels, and by carrying the slabs on short stringers supported by the floor-beams; but the extra form-work required will generally overbalance this saving in volume.

The number and spacing of the longitudinal girders will depend upon the width and the height of the structure, the span-length, and the load to be carried. For a high structure in which the economic span-length is fairly long, it will nearly always be found best to employ two lines of girders, the spacing thereof being equal to about five-eighths of the total width of the structure; but for bridges much over 60 ft. wide, the use of three or even four lines may be preferable. The slab in such structures is carried on cross-girders and cantilever-beams. For a low bridge in which the economic span-length is short, it will generally be the cheapest to omit the cross-girders, except at the bents, and to employ several lines of longitudinal girders. The wider the structure, the more likely will this arrangement prove to be economical; and very heavy loads also favor its adoption. For a structure in which the span-length is from one-half to two-thirds of the width, it will usually make little difference which of the two types is adopted, unless the height is rather large; and even in extreme cases the variation between the two is not likely to exceed 10 per cent. Ordinarily, it will be found more desirable to use two lines of girders, with cross-girders and cantilevers about 8 or 10 ft. centres.

The proper number of columns per bent depends on the number of longitudinal girders. When there are only two lines, two columns will, of course, be employed. When there are several lines of girders, there should generally be one column per girder in low structures, and two columns per bent in higher ones. In this latter case a heavy cross-girder will be required at each bent to carry the longitudinal girders.

The economic span-length is affected by the height and the load, being larger for greater heights and smaller for heavier loads. An approximate value thereof is given by the formula

$$l = h\left(0.3 + \frac{2{,}000}{w + 1{,}000}\right)$$

in which l = economic span length, centre to centre of supports,

w = load per lineal foot of girders (excluding its own weight), and

h = fixed height of structure.

The quantity h represents in any given case the height which is fixed, such as the height from grade to top of footing, height from grade to bottom of footing, height from underside of girder to top of footing, as the case may be. There is always a considerable range of lengths for which the quantities remain nearly constant. The formula gives values a trifle greater than those for which the quantities are a minimum, since the use of heavier sections will reduce slightly the unit costs of the concrete.

Reinforced-concrete piles should be used under footings when a suitable foundation is to be found only at a considerable depth, or when a very large footing area would be required in order to reduce the pressure to a proper amount. A comparison must be made for each case as it arises, allowing properly for the cost of the column shaft, the footing, the piles, and the excavation. This latter item must not be overlooked.

In arches the problem is much more complicated than in girder spans. The factors that affect the economic lengths are the cost of the arch ribs and that of the piers and abutments, the dividing lines between them being the verticals through the springing points. For any fixed span-length the greater the rise, up to a limit of nearly one-half of the opening, the smaller will be the costs of both the arch and the piers or abutments which sustain it; but in most cases the distance from grade to ground is too small to permit the adoption of such a large rise; hence the problem generally resolves itself into a determination of the question, "How long can the span be made economically for a certain limit of rise?" This will be influenced by several important considerations, among which may be mentioned the following:

(*a*) The live load used. (*b*) The amount of earth fill, if any, over the arches. (*c*) The depth of the foundations for the piers and abutments below the springing points. (*d*) The cost per cubic yard for putting the bases of piers and abutments down to a satisfactory foundation. (*e*) The necessity for a heavy or substantial appearance of the piers and abutments. (*f*) The height to which the large pier shafts must be carried. (*g*) The condition of the arch barrel—whether solid or ribbed. (*h*) The necessity, or otherwise, of adopting certain span-lengths to meet existing conditions.

Here are too many variables for a technically correct economic investigation, hence the surest and most satisfactory way to proceed is to make by judgment the best possible layout consistent with the conditions, then two others, one involving a span-length a certain number of feet greater and the other a span-length the same number of feet less, and figure the costs of arches and piers (or abutments) for all three cases. Instead, though, of increasing and decreasing the span by a certain number of feet, it may be necessary to reduce and augment the number of spans by unity. After the costs of the arches and piers or abutments are found and properly combined, the cost of these two portions of the construction per lineal foot of span for each of the three layouts can be computed and compared. The one which gives a minimum will indicate approximately the best span-length to adopt.

In some cases it will prove to be economic to make the middle span of the bridge a certain length and reduce gradually the lengths of the spans at each side. If the configuration of the crossing will permit of a symmetrical layout on this basis, the effect will prove to be pleasing to the eye and generally economic of first cost, especially if a constant ratio of rise to span be maintained; because, as far as cost of substructure is concerned, the overturning moments from live load on a single span only and from inequality of dead load thrusts are kept low, owing to the fact that the lighter thrusts in the smaller span act with a greater lever arm than do the heavier thrusts of the longer span, on account of higher location of the points of springing. In adopting this expedient, though, care has to be exercised to prevent the principles of esthetics from being violated.

Comparing rolled I-beam and plate-girder deck spans for modern heavy live loads, the weights of metal are about equal for spans of 15 ft.; but the former are cheaper per pound than the latter by about 0.4 ct., consequently the costs per lineal foot erected are equal to a span of about 20 ft.

Comparing deck plate-girders and through, riveted truss-spans, for which there is usually a difference of about ½ ct. per pound erected in favor of the former, the weights of metal per lineal foot are the same for spans of 115 ft., which is about the extreme limit of length for plate-girder spans shipped in one piece; hence it may be concluded that for all practicable lengths, deck plate-girder spans are more economic than through, riveted truss-spans. Besides, the use of such deck spans effects a great economy in the substructure by reducing the length of each pier from 6 to 10 ft., the longer the span, of course, the less the reduction. It generally reduces also the heights of the piers.

Comparing half-through, plate-girder spans and through, riveted truss-spans, for which there is a difference of about 0.2 ct. per pound erected in favor of the former, the weights of metal per lineal foot are the same for spans of 70 ft., but the costs per foot are about equal for spans of 75 ft. However, as plate-girder spans are in many respects more satisfactory than short, through, riveted spans, the dividing point is generally placed at about 100 ft.

Comparing Pratt and Petit truss-spans, for which there is no difference worth mentioning in the pound prices of the metal, the weights per foot (and therefore the costs) are alike for single-track spans of 300 ft., and for double-track spans of 350 ft.; but both constructive and esthetic reasons necessitate limiting the lengths of Pratt trusses to about 325 ft.

The economics of column spacing for bents when cantilever brackets are employed is an interesting little problem, but the final determination must be in accordance with good judgment as well as economy; for if the spacing be too small, rigidity is likely to be sacrificed. Upon certain assumptions of approximate correctness, the mathematical solution of this problem is a possibility; but the equations involved would be so complicated that it is much better for any particular case to assume two or three spacings, compute the total weight of metal in the bent for each, and find the one which will give approximately the least weight of metal. If the columns are placed at the quarter points of the beam, the dead load bending moment at the middle will be approximately zero; and if the effect of stress reversion is ignored, the direct and reverse bending moments for the central portion of the beam will be equal, and this arrangement would be about the most economical possible. But if the reversion is considered, the sectional area of the middle portion of the beam must be greater than that of the outside portions, hence for economy its length should be somewhat less than one-half of the total, and the columns would then be spaced somewhat closer than when they are located at the quarter points. The fact that the brackets are usually lighter near the outer ends than at the inner ones would, for economy, tend to draw the columns together; but on the other hand this would increase the weight of the splices and connecting details. The proper column spacing to adopt will depend upon the length of the columns; for it is easily conceivable that the structure could be so high and so narrow that the quarter-point spacing would be too close for proper resistance to wind pressure. Again, in such a case the wind load might be so great as to necessitate an increase in column section above that required to care for the live and dead load stresses only; and thus the effect of wind pressure would enter the economic study. It will be found in most cases that it is inadvisable to space the columns much less than one-half of the total length of the beam.

The economic functions of swing spans are somewhat difficult to formulate. The minimum perpendicular distance between central planes of trusses for first-class construction should be the same as for simple-truss spans—*viz.*, one-twentieth of the span length. It is evident, of course, that the narrower the bridge the less it will weigh and cost. The truss depth at ends of through swing bridges are generally determined by the clearance requirements; but in long spans it is sometimes advisable, for the sake of vertical stiffness and to avoid the raising of span-end from a load on the other arm, to make the said depths still greater. As a rule, this increase is not of an uneconomic nature. For long spans, or those exceeding, say, 400 ft., the truss depth at outer hips should be about 1/14th or 1/15th of the total span length. The truss depth at the inner hips should generally be from 1/9th to 1/10th of the total span length; and when towers are used, their height should generally be from 1/6th to 1/7th of the span. Of course the esthetic features of the design should govern greatly the determination of all these depths; and, fortunately, any moderate change in them does not affect materially their economics.

In swing spans it is evident that, as far as is consistent with safety, the diameter of the drum for economy should be made as small as possible, not only because this effects a saving of metal, but also because it reduces the diameter, and therefore the cost, of the pivot pier. For spans of moderate length and width there is generally a small economy in centre-bearing swing-spans over rim-bearing ones, especially as the former sometimes permit of smaller pivot piers, but the difference is often inconsiderable. There is a limit to the size of centre-bearing swing-spans due to the objectionable feature of concentrating great loads upon small areas and to the necessity in the case of very wide spans for excessively heavy cross-girders. The question of economics between the two styles of swings is one that has to be determined for each special case as it arises by preparing actual estimates and not by a priori reasoning.

In respect to the economics of cantilever bridges the following may be stated:

The economic length of the suspended span is about three-eighths of the length of the main opening, but a considerable increase or decrease of this proportion does not greatly change the total weight of the metal.

The most economic length of anchor arms, where the total length between centres of anchorages is given, and when the main piers can be placed wherever desired, is one-fifth of the said total length. By keeping the anchor arms short, the top chords may be built of eye-bars, provided that, with the usual allowance for impact, there is no reversion of chord stress; and this effects quite an economy of metal. But it is conceivable that cases might arise where, from danger of washout of falsework, eye-bar top chords would be objectionable; hence this method of economizing must be used with caution.

In respect to the economic length of anchor-span in a succession of cantilever spans, it may be stated that within reasonable limits the shorter such anchor-spans are the greater will be the economy involved; but, generally, navigation interests will prevent their being built as short as might be desired. If permissible, they may be made so short that, as in the case of anchor-arms, eye-bars may be used for the top chords, thus effecting a decided economy of metal, although shortening the anchor-span increases proportionately the stresses on the web members and the weights thereof.

The question of what is the economic limit of length of simple-truss spans as compared with cantilevers is still a mooted one. Professors Merriman and Jacoby place it in the neighborhood of 600 ft., but the speaker has had occasion to compare simple-truss spans of 700 and 800 ft. with the corresponding cantilever structures, and has found the former more economic. The continuity of cantilever spans in resisting wind loads lowers the requirements for minimum width from one-twentieth to about one twenty-fifth of the greatest span-length, and hence, because of substructure considerations, gives an advantage to the cantilever type that in certain extreme cases will more than offset its disadvantages of greater weight of truss metal.

CONSULTING ENGINEERS RECOMMEND CONCRETE FOR WINNIPEG AQUEDUCT PIPE LINE

The board of consulting engineers to the Greater Winnipeg Water District, comprising Messrs. Rudolph Hering, Frederic P. Stearns and James H. Fuertes, have recommended the use of reinforced concrete in place of cast iron for the pipe line between the Red River and McPhillips Street. The water board at the meeting last week received the report and deferred decision in regard to it till the next regular board meeting.

At a previous meeting of the water board a recommendation had been received from James H. Fuertes, consulting engineer, and W. G. Chace, engineer of works, to the effect that reinforced concrete should be used chiefly on the ground that it would be $175,000 cheaper. The purchase price of cast-iron pipe and the cost of laying it was estimated at $575,000, whereas the cost of material and the laying of the reinforced concrete was estimated at $400,000. The board, acting on this recommendation, asked a report on the recommended change from the three consulting engineers.

Part of the consulting board's report is as follows:—

"At the time we made our original report on August 20th, 1913, we recommended cast-iron pipe west of the Red River in connection with steel pipe from the Deacon reservoir to the Red River, having in view the future establishment of a pumping station near the Deacon reservoir to force the water to the district through these pipes under the full head required for supplying the inhabitants directly from the street mains.

"A subsequent report by Messrs. Hering and Stearns, dated January 25th, 1916, endorsing the change proposed by Messrs. Fuertes and Chace, by which a 5-foot 6-inch reinforced concrete pipe was substituted for the 5-foot steel pipe from the Deacon reservoir to the Red River, made a fundamental change in the plan under which water is to be supplied to the district from Deacon. This change of plan precluded the location of a future main pumping station near the Deacon reservoir, increased the capacity of the pipe, from Deacon to Red River, and indicated the desirability of locating a booster pump (and probably a future high-pressure pumping station) in the neighborhood of the Red River, all of these matters being fully dealt with in the last mentioned report. The change also provided for an increased capacity of the 48-inch pipe leading to the McPhillips Street reservoir, by gravity, and a still greater increase by the use of a booster pump; and made it of comparatively little importance for the 48-inch pipe to be able to withstand more than the moderate pressure needed for discharging the water freely into the reservoir.

"Under the original plan it was essential that the pipe should be of cast iron, or some other material capable of withstanding a high pressure, but under the plans as changed in 1916, under which the work is now being constructed, there is no longer a necessity that the 48-inch pipe should withstand high pumping heads, and this makes it feasible to substitute reinforced concrete for the cast iron.

"The report of Messrs. Fuertes and Chace, dated August 10th, 1917, shows that the saving based on the substitution of the reinforced concrete for cast iron would amount to $175,000.

"We understand that on September 6th, 1917, an informal offer was made to the administration of the Greater Winnipeg Water District by the Canadian Iron Foundries, Limited, to furnish cast-iron pipe and specials for this line for a sum which, if a contract were made at the price named, would reduce the saving due to the change to $130,000.

"In our judgment a well-designed and constructed reinforced concrete pipe will be in line with good practice, efficient and safe under the comparatively low pressures which will occur with water discharging freely into the McPhillips Street reservoir; and furthermore, with the plans as modified in 1916 there is no other use to which this pipe may be put to warrant the additional expenditure of $130,000 or any large fraction thereof."

The Alaskan Railway, now being built by the United States Government, is to be hurried forward, as its completion will hasten the development of its vast resources; will encourage the production of foodstuffs, thus reducing Alaska's dependence upon the United States for supplies; will furnish coal in unlimited quantity for the navy, obviating the necessity for the shipment of coal across the American continent to the Pacific, and, at the same time, release thousands of cars for the transportation of war materials and foodstuffs.

THE IRON AND STEEL INDUSTRY OF CANADA; NOTES ON ITS PRESENT AND FUTURE POSITION*

By D. H. McDougall,
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IN reviewing the iron and steel industry in Canada, a clear distinction must be drawn between the position during war time, and the position that may be forecasted after the war.

The present condition of the steel and iron industry is one of artificial stimulation, brought about by the action of numerous temporary factors, prominent among which are: Extraordinary demand for munitions steel; increased cost of transportation, accompanied by congested railroads, and shortage of shipping; an unparalleled coal shortage; and a severe and increasing shortage of labor.

These factors, all abnormal and arising out of war conditions, have rendered temporarily obsolete all hitherto accepted standards of economics, and they have been accompanied by an increased cost of living, large increases in wages, and increases in the selling prices of steel and steel products. No one can say how far these extraordinary conditions will extend, or how long they will last, but some day the world will resume its normal course, and the laws that govern normal times will again operate.

Therefore, in considering the after-war situation of the Canadian steel industry, we should see what the permanent essentials of a successful steel industry are, apart from present unusual and evanescent conditions.

Factors that favor success and permanence in steel and iron manufacture are:—

Geographical location, giving cheap access to world markets, and opportunities for the cheap assemblage of raw materials.

Close proximity of metallurgical coal, iron ore of good grade, and limestone deposits of suitable quality. All these raw materials should be accessible in large quantities, and so placed as to render mining costs and transportation reasonably cheap.

General conditions favoring the manufacture of steel in large tonnage.

A review of the iron ore and coal deposits of Canada will show that such a combination is to be found in very few places in Canada, and that already large steel and iron works exist at the localities where the manufacture of iron and steel is permitted by natural conditions to rest upon a permanent and commercial foundation.

The location of iron and steel plants in all parts of the world has been primarily determined by the proximity of coal, and it does not seem probable that any steel plant can exist and pay profits in normal times which has not to hand a plentiful and inexpensive supply of metallurgical coal. It is perhaps hardly an exaggeration to say that the steel industry is always an outgrowth of a coal mining industry.

Present conditions favor the commencement of small war industries. For example, the time is opportune for the opening up of small and easily accessible coal areas, the operation of which in normal times was not profitable; and in the same way, small smelting plants and small works for making munitions have been commenced and successfully worked because of the unbalanced state of demand and supply. These passing conditions, on the other hand, act to the disadvantage of large and long-established concerns, or at the most they offer merely an opportunity to get rid of the load of debt that is the legacy of the depression that preceded the war and persisted for some time after hostilities commenced.

After-war conditions will eliminate most of these small ventures, and in the days of financial stress that are surely coming the mainstay of industry and the hope of the country will be the large and long-established companies, who, if they are wise will have stored financial reserves and expended profits on rehabilitation of plant, as a safeguard against the future.

Applying these general principles to specific cases, it would seem advisable that the energies of the country should be concentrated on ensuring the future of the large steel works on Sydney Harbor and on the Great Lakes, and that these existing works should be looked to for the production of steel and iron in large quantities, because in these places only is there available a sufficient quantity of coal, iron-ore and limestone.

For the treatment of steel in small quantities to produce tool-steels, crucible-steel and special alloyed steels, the electric furnace has a future, and industries of this kind will probably increase in the populous parts of Quebec and Ontario.

It is also advisable that any increase in the rolling and forging capacity of Canadian steel works should take place at the large and established plants referred to. These plants have hitherto regarded the manufacture of rails as their chief activity, but in the future, and with a view to after-war conditions, it seems probable that the rolling of ship-plates and other commercial shapes will become necessary. It is self-evident that the manufacture of finished steel products can nowhere be so satisfactorily and economically carried on as at the existing plants.

Considering particularly the question in what way it may be possible to obtain some considerable increase in the production of iron and steel in the future, that is, after the war, the first point to be determined is: Allowing for the rolling in Canada of steel shapes and forgings now finished outside of Canada, for all the export business obtainable, and for all Canada's own requirements in iron and steel, what tonnage of iron and steel over and above the existing capacity of Canadian works will be required?

Summarizing, and applying these principles, it would appear that the Canadian steel industry should be guided towards two main ends, namely:—

That the present abnormal demand for steel should be supplied as far as possible by the extension of existing plants.

That these existing plants should prepare to enlarge the variety of their finished products.

That should it then appear there was a necessity for greater production of iron and steel such as to require new plants, these plants should comply with the factors that have already been named as requisite to commercial permanence, and as giving ability to compete in world markets.

By following along these general lines, the existing plants will be extended, rehabilitated and modernized, and given an opportunity to accumulate financial reserves to carry them successfully through the troubled days ahead, and they will be placed in a position enabling them to enter world markets, and to compete with other countries, particularly the United States.

*Canadian Mining Institute's October Bulletin.

GROWTH OF GOOD ROADS IN ONTARIO

According to a report recently prepared by W. A. McLean, Deputy Minister of Highways, thirty-three of the counties in older Ontario have now established county road systems. This leaves but six counties that are still without county systems and it is expected that these will soon fall in line.

The counties which have adopted county road systems are: Wentworth, Lanark, Simcoe, Wellington, Lincoln, Oxford, Hastings, Peel, Middlesex, Lennox and Addington, Prince Edward, Halton, Perth, Frontenac, Waterloo, Carleton, Leeds and Grenville, York, Haldimand, Welland, Essex, Prescott and Russell, Dundas, Stormont and Glengarry, Brant, Victoria, Elgin, Kent, Huron, Bruce, Norfolk and Ontario. Gray and Renfrew have passed preliminary by-laws and are therefore committed to early adoption of the county roads system.

According to this report "Southern Ontario has 55,000 miles of road in the open country, of which 40 per cent. has been surfaced with gravel, broken stone or other more permanent material. It is a conservative estimate that, in the past ten years, $28,000,000 has been spent on rural roads, of which less than one-quarter remains as bonded debt. This is a record very creditable to municipal governments of the province; and the construction of leading highways to join up the systems of improved local and county roads would place Ontario in a very enviable position with respect to good roads."

Cost of Road-building

Interesting figures showing the average cost per mile of county roads in 1915 are given as follows:—

County.	Average cost per mile completed, exclusive of bridges.	Total expenditure on bridges.
Wentworth	$2,315.45	$ 19,917.09
Lanark	1,329.41	33,120.32
Simcoe	1,128.30	127,573.86
Wellington	3,266.66	106,514.83
Lincoln	3,487.04	12,027.52
Oxford	2,560.15	78,668.84
Hastings	798.67	232,201.78
Peel	3,715.84	48,917.36
Middlesex	1,856.22	175,986.54
Lennox and Addington	1,092.48	22,806.91
Prince Edward	2,613.88	10,780.04
Halton	3,024.03	96,432.86
Perth	2,247.34	57,132.97
Frontenac	1,514.05	35,778.19
Waterloo	1,565.79	52,419.94
Carleton	2,403.99	28,306.60
Leeds and Grenville	1,998.92	24,576.40
York	7,245.38	20,520.26
Haldimand	5,865.86	4,508.60
Welland	4,890.82	7,597.43

In connection with the matter of cost it is only proper to state that this cost varies with local conditions, and the cost of each mile of road should be estimated on its own merits. Some counties have an abundance of local stone; in other counties, stone must be imported by rail, with attendant freight charges, and additional cost of handling from the cars. Some counties have large deposits of gravel, and build gravel roads. Some roads already have had a coating of stone or gravel, which serves as a foundation and requiring only resurfacing; other roads have had little or no previous attention.

INTERNATIONAL JOINT COMMISSION'S ANNUAL MEETING IN OTTAWA

At the annual meeting of the International Joint Commission, held in Ottawa, October 2nd, 3rd and 4th, the Commission gave very full consideration to the question of its final report to the Canadian and United States governments in the pollution of boundary waters investigation, having before it as a basis for discussion, a tentative draft prepared by the Commission's committee which had special charge of this matter.

The order of approval was adopted and signed for transmission to the two governments in the case of the application of the International Lumber Co. for approval of their plans for booms and sorting gaps in the Rainy River at International Falls. In approving the plans, the Commission stipulated that in the event of booms or other similar structures being found necessary on the Canadian side of the river opposite the booms of the International Lumber Co., the company should be required to remove their booms south of the international boundary to such a distance as the Commission might think necessary.

Another question that has been before the Commission for some time is that of the measurement and apportionment for irrigation purposes of the waters of the St. Mary and Milk Rivers in Montana, Alberta and Saskatchewan. Certain legal questions in connection with this matter were argued before the Commission at its Detroit meeting in May last by counsel for the United States and Canadian governments, the Canadian Pacific Railway and the State of Montana. On the request of counsel for the United States, the Commission at that time granted to the attorney-general of the United States, the right to submit an oral argument, if desired, at a future meeting of the Commission. At last week's meeting, M. M. Wyvell, on behalf of the U.S. attorney-general, explained that owing to the extraordinary pressure of work arising out of the war, the attorney-general had not yet had time to consider the matter. It was therefore decided that the Commission would hold another meeting in New York on November 12th, at which both the St. Mary and Milk Rivers matter and the pollution report would be further considered.

CORRECTION

In our July 26th issue, page 81, in a review of the new book, "Water Purification," by Jos. W. Ellms, it was stated that this book was published by John Wiley & Sons, Inc., of New York. This was an error, as the book was published by the McGraw-Hill Book Co., New York. Copies of this or any other technical book in print can be secured through *The Canadian Engineer* Book Department, 62 Church Street, Toronto.

During 1916 the value of the New South Wales mineral output was £10,975,742, a total which is the third highest in the history of the State. It exceeds that of 1915 by £911,-173. The high prices ruling for the industrial metals, notably copper, are mainly responsible for this result. The increase is general, the only branches of the industry which show decreases to any extent being gold, coal and zinc. It is estimated that 31,304 persons were employed in and about the mines during the year, or a decrease of 107 when compared with the preceding year. The aggregate value of all minerals won in New South Wales to the end of 1916 was £273,154,084.

Editorials

UNION GOVERNMENT

Half a loaf being better than no loaf, the professional and business men of Canada will welcome Premier Borden's Union Government which is just emerging from the political oven. We do not mean to insinuate that the Union Government is half baked; to the contrary, it is undoubtedly a well-mixed, nicely risen and richly browned political effort. Both sides of the House, apparently, are well represented; the currants, or plums, or whatever flavors the staff of political life, seem to be well distributed.

But the engineers, at least, are weary of the diet. They would prefer a different style of loaf—a whole-wheat bread, we might say, with the "bark" left on the component grains, not polished by years of rubbing against red tape, nor whitened by the acid atmosphere of Ottawa. They would prefer a government of business men, a national government of efficiency, with a cabinet selected purely for their fitness for the work in hand, the whole being freed entirely from the taint of party politics.

In war times, how can we afford to play at government? Why should Dr. Somebody—a medico by profession, let us assume—be transferred from the Customs Department, concerning which he probably never knew very much, to—let us say—the Department of Railways & Canals, of which he knows less than nothing, in order to permit Sir Lawyer, a distinguished Liberal, to have a seat in the government as Minister of Customs? The Customs Department should now be managed by the most expert tariff man in the country; the Department of Railways & Canals by the ablest transportation expert available; the Trade Department by an outstanding man of practical commercial knowledge; and so forth, all chosen for their ability,—not for their politics or for the voting precinct in which they reside. Such a government could be under the direction of Sir Robert Borden, Sir Wilfrid Laurier or any other Prime Minister; it wouldn't matter much about that, because a government thus composed wouldn't be a one-man government and the Prime Minister would be pretty much of a figurehead anyway.

This may be Utopian; but, paradoxically, it is the only eminently practical and sensible plan, and nothing short of it will satisfy the business interests of this country, if the war continues. England is coming to it rapidly and so will Canada.

The Public Works Ministry is the only appointment yet made in the new government in which *The Canadian Engineer* is much interested as an engineering paper. Public works are largely engineering works, and that appointment, to fit in with our Utopian scheme, should go to some engineer of national standing. Mr. Ballantyne is not an engineer. However, he is a most capable executive and a fine type of modern business man, and Sir Robert could have chosen far less wisely.

Mr. Ballantyne will no doubt make one of the best public works ministers Canada has had in a long time. He has a big reputation for honesty, capacity for work, initiative and enterprise. It is refreshing to see a man of his type selected for the public works office. Had he been selected purely for his ability to run that department, however, and without any consideration for his previous political affiliations or place of residence, his appointment would have been even more warmly welcomed. But despite the politics of the appointment, *The Canadian Engineer* congratulates Hon. C. C. Ballantyne upon his new office, which he will fill with credit, and congratulates Sir Robert Borden upon having been able to induce Mr. Ballantyne to accept the job.

TORONTO'S STREETS NOT YET CLEANED

The strike of the street cleaners and garbage collectors in Toronto still continues, and there is apparently a deadlock between the strikers and the aldermen. The strikers want a board of conciliation to settle their grievances, and the aldermen have agreed to that, but the men most unreasonably demand that Commissioner Wilson be removed before the Board meets. That is equivalent to demanding that Mr. Wilson be sentenced before his trial, so to speak. It is not British fair play. There is no reason why Mr. Wilson should not administer his department until he is proven unworthy of office, and the sort of piffle that the men have brought up about him proves nothing. Up to a few days ago, the only charge made by the men was that Mr. Wilson had insulted the flag by removing it from a manure wagon. Nobody took that charge seriously—not even the men themselves. The public waited patiently for the men to come out into the open with definite grievances. They have not done so, and the Toronto public are now convinced that they have no real grievances, but merely a grouch because the Commissioner has been requiring them to work steadily and politely. This grouch has no doubt been aided and abetted by a few interfering political bosses.

The strikers having proven obdurate, the city must get along without them. To begin with, the Board of Control should wash their hands of the whole matter if the men cannot submit proof of any real grievances, and

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permit the Commissioner to deal with the situation as he thinks best. The purchase by the Commission of a number of powerful flushing machines would enable the city to get along indefinitely without the strikers, and would soon break the strike. Garbage can be burned in any furnace; ashes can pile up without any injury to health; but the streets must be cleaned. If the men refuse to clean them, Commissioner Wilson should get machines that will. In Ottawa power flushers cut down the number of white wings employed by the city from ninety to fifty, and those fifty are not indispensable. Many United States cities have bought a battery of flushers just to avoid such labor troubles as Toronto is now experiencing, and have also found that the machines mean a large monetary saving compared with other methods. Various cities have estimated the saving at from $60 to $90 per day per machine, and the cleaning is better done.

Toronto must take some action or the doctors and undertakers will reap a harvest. For many years past, street dust has been the subject of much study by eminent bacteriologists, with the result that the causative connection between street dust and an appalling number of diseases is now clearly established. B. coli comm., B. tuberculosis, the bacterium pneumococcus, staphylococcus and streptococcus, pyogeneus, diphtheria, anthrax, tetanus, have been recognized as permanent inhabitants of street dust. Out of forty-six inoculations of animals with bacteria from city dusts,—an experiment tried by a prominent doctor some years ago,—thirty-two caused infectious diseases.

Another well-known authority states that among the diseases that lurk in the dust on the streets are tonsilitis, quinsy, laryngitis, pneumonia, rhinitis, influenza, tuberculosis, poliomeylitis, asthma, rheumatism, diarrhoea, skin disease, conjunctivitis, trauma of the cornea, nasal catarrh, frontal sinus and middle ear disease. And physicians all say that dust may, by predisposing an irritated condition of the respiratory organs, so lower the vitality of the mucosa that the development of any germ deposited thereon will be favored. In fact, suspicion now points strongly toward street dust as one of the worst etiological mischief makers with which we are afflicted.

PERSONALS

J. B. Mussellman, secretary of the Saskatchewan Grain Growers, has been appointed fuel controller for that province.

M. F. Cochrane, A.M.Can.Soc.C.E., of the International Boundary Survey, has joined the Dominion Water Power Branch, Ottawa.

Jas. J. MacKay, of the firm of MacKay, MacKay & Webster, of Hamilton, Ont., has been appointed engineer of the township of Barton, Ont.

R. C. Manning has been appointed assistant to Mr. W. D. Robb, vice-president of the Grand Trunk Railway, in charge of motive power, car equipment and machinery.

H. A. Harrington, secretary of the coal section of the Retail Merchants' Association, Toronto, has been appointed assistant fuel controller for the province of Ontario.

A. C. Boyce, K.C., M.P. for West Algoma, has been appointed a commissioner on the Dominion Railway Board in succession to Dr. Mills, who retired over a year ago.

J. A. Blakney, of Brantford, Ont., has been appointed superintendent of the new hydro-electric system of Brantford township, with instructions to commence the installation of the lines at once.

Frank Sheppard, M.P., of Nanaimo, has been appointed inspector of dredging for British Columbia, by the Dominion Government. Mr. Sheppard was formerly inspector of mines for British Columbia.

L. V. Rorke has been appointed director of surveys, province of Ontario, to succeed the late George B. Kirkpatrick, who filled that position since 1878. Mr. Rorke has been acting for the past two years on account of the illness of the late director.

Col. Charles Colquhoun Ballantyne, who has accepted the portfolio of Minister of Public Works, was born at Colquhoun, Ontario. He commenced his business career in Montreal, and while still a young man, became managing director of the Sherwin-Williams Paint Company. In 1911 he participated in the purchase of the entire concern, and since then he has been vice-president as well as general manager of the company. In 1903 he was president of the Montreal branch of the Canadian Manufacturers' Association, and in 1905-6 of the general association. He was appointed to the Montreal Harbor Commission in 1907.

Gerald Brabazon, M.P. for Pontiac, P.Q., has been appointed superintendent of the storage dams system on the Upper Ottawa.

B. J. McCormick, of Welland, has been appointed general sales manager of the Canada Foundries and Forgings, Limited, of Welland and Brockville.

E. M. Whitling, road superintendent of the city of Hamilton, Ont., will spend two weeks in New York City to study in the laboratory of Dow & Smith, consulting engineers, and also to inspect asphalt paving as laid in New York.

OBITUARIES

George Morgan, mayor of Blenheim, Ont., died recently at his home in that city, at the age of 78. Mr. Morgan was a well-known contractor and carried out a considerable quantity of construction work in western Ontario.

William Murdoch, city engineer of St. John, N.B., died suddenly on October 8th of apoplexy. Mr. Murdoch was born in Paisley, Scotland, 69 years ago. He became a member of the Canadian Society of Civil Engineers on April 25th, 1901. On August 15th Lieut. Douglas Roy Murdoch, son of the late Mr. Murdoch, died of wounds received in action.

Coast to Coast

Brandon, Man.—The sale has been completed of the properties of the Brandon Electric Light Co., Ltd., and the Brandon Gas and Power Co., Ltd., to the Canada Gas and Electric Corporation, a company composed of financial interests in the city of Cleveland. G. A. Paterson, who, for the last 25 years has been managing director of the Brandon Electric Light Co., Ltd., has been appointed general manager of the new corporation's properties in Brandon.

Chatham, Ont.—The city is now using 800 horse power of hydro power, and it is expected this will be increased to 1,000 h.p. by the end of the year.

Cooksville, Ont.—The Hydro-Electric Power Commission of Ontario has recently purchased a 1,000 horse-power frequency changer set, which was originally the property of the Interurban Electric Company, and it is proposed to install this set in the Cooksville high-tension station. Both ends of this unit are designed to operate at 13,200 volts, and it is proposed to use the set to convert the power supplied by the Erindale Power Company from 60 to 25 cycles to operate so as to supply power to the Niagara System during peak load hours. This unit will also be operated for power factor correction.

Edmonton, Alta.—Work is proceeding favorably on the Peace River bridge, Mr. J. D. McArthur, of the Edmonton, Dunvegan and British Columbia Railway Co., reports, and he expects to have a gang begin laying the steel work in November. About 75 per cent. of the pier construction is already completed, and this part of the contract will be pushed on to make ready for the superstructure. The steel is now about to leave the mills at Walkerville, Ont., and will be shipped west during the next few weeks. Mr. McArthur says the bridge will be completed, if present expectations carry out, by next May, as the work will continue through the winter.

Galt, Ont.—During September City Engineer Fairchild issued building permits with a total value of $15,410. The increase for the month was $1,505.

Hamilton, Ont.—Capacity tests of the city's water mains were made recently by City Engineer E. R. Gray and were eminently satisfactory, showing that, with 22 hydrants and four "blow-offs" open, the capacity of the pumps for one-half hour was equal to 34 million gallons per 24 hours. Hamilton's water needs average about 17,000,000 gallons per 24 hours. At a certain period of the day when the demand is greatest, the pumps work at the ratio of about 27,000,000 gallons per 24 hours. This lasts only about one hour, however. The test was made in that section lying west of Bay St., so that all the water pumped really had to traverse the entire system.

London, Ont.—During September there were 74 building permits issued for a total of $59,395. For the same period last year, there were 69 permits issued for a total of $39,710. The balance of the year will show up well, as some large buildings will be constructed. Building Inspector Piper expects the total for the year will be over $800,000.

Montreal, Que.—It is reported that several Canadian corporations which have been engaged in the manufacture of munitions have received offers for the purchase of their plants by manufacturers in the United States, but only the preliminary stages of the negotiations have been reached yet.

Montreal, Que.—One hundred and twenty-eight building permits were granted during the month just closed as against 146 last year. The value this year is $250,958 as against $205,456 last year. January 1 to September 30 last year 1,498 permits were granted totalling in value $3,787,919. This year the permits numbered 1,300, while their value was $3,852,665

Mount Dennis, Ont.—The main service pipes by which Mount Dennis will be supplied with water by the York Township Council have made their appearance on Weston Rd., and the work of laying has been completed from Northlands to Eglinton Ave.

Niagara Falls, Ont.—A report on the Gorge Railroad has been presented to the City Council by H. W. Middlemist, engineer of the Ontario Railway Board.

Niagara Falls, Ont.—Stamford Township Council has agreed to pay the city $1,200 for the mains of the city in Stamford Township.

Nipissing Tp., Ont.—Work is progressing favorably on the erection of a new steel surge tank at the power house. This tank will replace an old wooden one which has outlived its useful life, and it is expected that considerable improvement in the speed regulation of the plant will be effected thereby.

Omemee, Ont.—A hydro-electric power distributing system for this town is being erected at the present time, and it is expected that this work will be completed in the course of a few weeks. A 44,000-volt outdoor substation is being erected at this point, in order to serve the village.

Peterboro, Ont.—Work is progressing on the new plant of the Quaker Oats Co. The 18 new silo tanks for storing grain are about complete, also the concrete structure south of the tanks, which is the elevator proper. On top of the entire structure will be placed a huge water tank that will extend as high as the present wooden tower for elevating concrete. This will supply water for the various services throughout the building, including the sprinkler system, and will supplement the city water supply.

Regina, Sask.—Fifty per cent. more pavement, concrete sidewalk, and curb and gutter, is being repaired this year than in any previous year in the city's history, according to a statement recently made by officials. In addition to repairs which are being made by the city itself, contractors, in the final year of their guarantee, are working on $700,000 worth of paving, sidewalks, and curb and gutters.

Sarnia, Ont.—Work has started on the construction of a new market building for the city.

Sorel, P.Q.—The Sorel shipyard, one of the oldest shipbuilding plants in Canada, has been acquired by the Federal Government. It has been under lease to the latter for several years.

St. Boniface, Man.—Buildings to the value of $21,500 are now being constructed in this city.

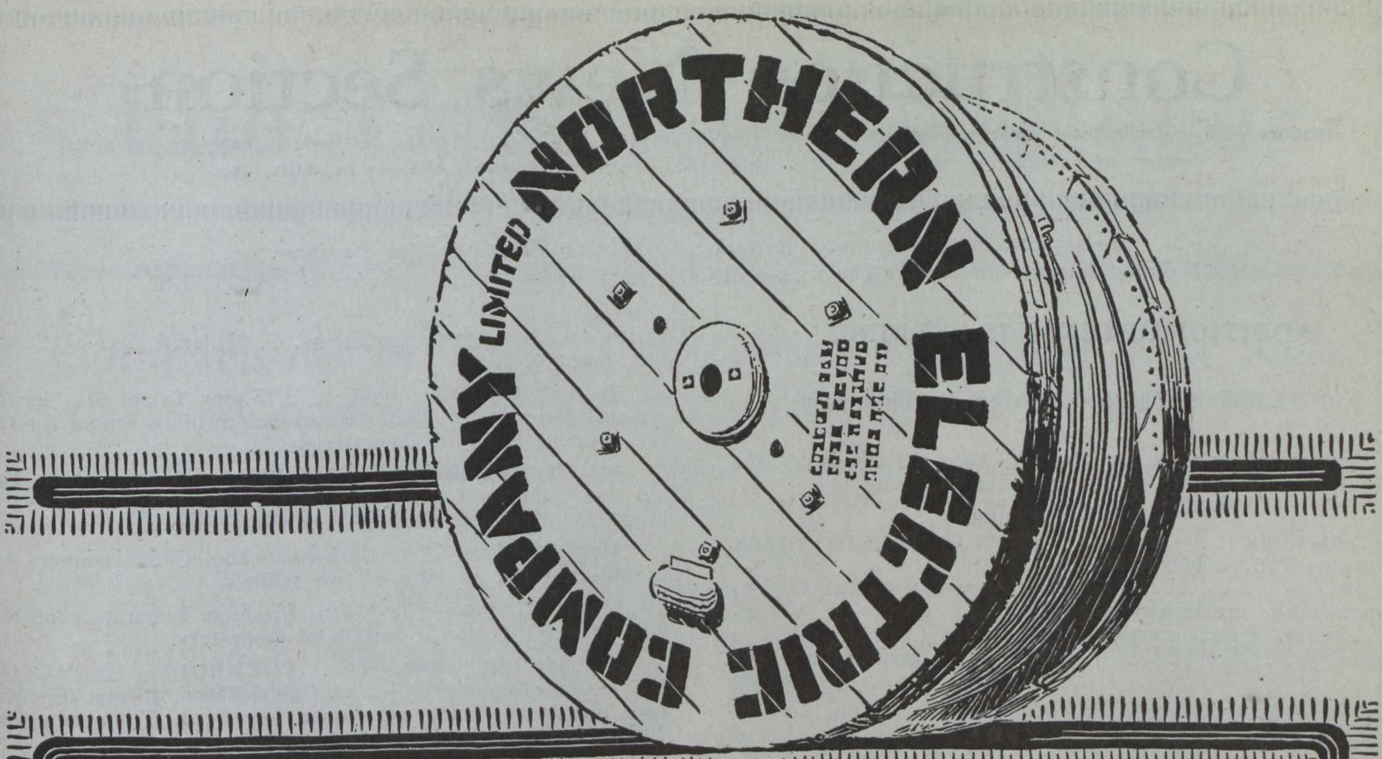
St. John, N.B.—The building permits issued during the month of September number 7, and the work was estimated to cost $30,200. During the same month in 1916 the number of permits was eight and the value of work proposed was $21,250. For the nine months of the present year the estimated cost of building operations in St. John was placed at $515,150. From January to September, in 1916, the figures were $364,250.

Stamford Twp., Ont.—The Township Council is at present arranging for the sale of its Hydro debentures and will take over the system in the township which was recently purchased from the Ontario Distributing Company, and is now being operated by the Hydro-Electric Power Commission of Ontario for the township.

Stratford, Ont.—The statistics for the building department show quite an increase for the month of September, 1917, over the same month last year. The building permits issued during the month were 30, with a value of $37,993, while for the corresponding month of 1916, 24 permits were issued for work valued at $15,963.

Sydney, N.S.—Board of Works has recommended the erection of a gasoline storage tank for the City and Suburban Bus Company.

Toronto, Ont.—An agreement between the counties of York and Peel and the Toronto-Hamilton Highways Commission, regarding the apportionment of the cost of new bridges on the highway, will be reached shortly as a result of the recent hearing before the Ontario Railway and Municipal Board. Under the special act, the counties are made liable for that proportion of the cost of new bridges which would represent the expenditure they would have had to make on an ordinary county bridge. Evidence was taken by the board to establish the cost of a bridge suitable for ordinary traffic. Chief Engineer Hogarth, of the Provincial Highways Department, stated that a bridge of the type approved by the department would cost about $15,000. The bridges constructed by the commission at Mimico Creek, Etobicoke and Port Credit represent an expenditure of about $25,000, so that the counties will have to pay approximately $10,000 on each bridge.


NORTHERN ELECTRIC COMPANY
LIMITED

Construction News Section

Readers will confer a great favor by sending in news items from time to time. We are particularly eager to get notes regarding engineering work in hand or projected, contracts awarded, changes in staffs, etc.

▲—Denotes an item regarding work advertised in *The Canadian Engineer.*
+—Denotes contract awarded. The names of successful contractors are printed in CAPITALS.

ADDITIONAL TENDERS PENDING

Not Including Those Reported in This Issue

Further information may be had from the issues of *The Canadian Engineer* to which reference is made.

PLACE OF WORK	TENDERS CLOSE	ISSUE OF	PAGE
Cornwall, Ont., construction of roads	Oct. 17.	Oct. 4.	56
Leaman, Alta., erection of school	Oct. 11.	Oct. 4.	46
Maisonneuve, Que., erection of factory	Oct. 15.	Sept. 13.	50

FACTORIES AND LARGE BUILDINGS

Alliance, Alta.—The ratepayers passed a by-law to borrow $10,000 to construct a solid brick school building.

Aylmer, Ont.—E. Millard contemplates erection of a vulcanizing plant.

Brandon, Man.—Elevator owned by the Western Canada Flour Mills Company, Ltd., destroyed by fire.

+—Brantford, Ont.—Schultz Bros. & Co., Ltd., 35-47 Albion St., have the general contract for $10,000, two-story, brick warehouse for the Massey-Harris Co., Ltd., South Market Street.

Brantford, Ont.—Tenders are being received by the architect, Gordon Hutton, Bank of Hamilton, Hamilton, for various trades in connection with alterations and addition costing $5,000, to bank for the Bank of Hamilton, head office, Hamilton.

+—Cardston, Alta.—MR. WHITE has the general contract for telephone building for the Department of Public Works, Province of Alberta, Parliament Buildings, Edmonton.

Chatham, Ont.—The Sargeant Co. plan to enlarge or rebuild their ice house on Adelaide St. W.

Dartmouth, N.S.—The School Board is being urged to erect a new school.

+—Ford, Ont.—The DICKIE CONSTRUCTION CO., Ryrie Bldg., Toronto, has the general contract and will sublet smaller trades for the erection of a two-story, stone and brick bank for the Canadian Bank of Commerce, 23 King W., Toronto.

Fredericton, N.B.—City may erect an Isolation Hospital.

Galt, Ont.—The erection of a new Isolation Hospital is being considered by the Board of Health.

+—Hamilton, Ont.—Board of Control let contract to H. R. COOPER, for the erection of a new city scales building on Barton Street East.

+—Hamilton, Ont.—W. H. YATES, 24 Leeming St., has the general contract and masonry, and the HAMILTON BRIDGE WORKS CO., LTD., Bay N., the steel contract for $100,000 factory addition for the Canada Screw Co., 334 Wellington N.

Langley Prairie, B.C.—Fire destroyed the local warehouse of the Vancouver Milling and Grain Co.

Lindsay, Ont.—Plans are being prepared for alterations costing $8,000 to hotel for the McDonald Estate. Proprietors, Burns and Lenorgan. Architects, G. Miller & Co., 93 Yonge St., Toronto.

+—London, Ont.—SAM WILLIS, 765 Talbot St., has the general contract for $7,000 vocational training school for the Government Hospital Commission.

+—Montreal, Que.—J. GILLETZ, 1206 St. Urbain St., has the general contract for $3,500, two-story, brick warehouse for Martin & Stewart, 177 Duke Street.

Montreal, Que.—The Catholic School Commissioners are considering the erection of two schools.

Montreal, Que.—The Forest Products Laboratory of McGill University, plan extension of laboratory.

+—Montreal, Que.—The TURNBULL ELEVATOR MFG. CO., 10 Victoria St., has the elevator contract for $30,000, four-story, brick warehouse for Fred. Thompson Co., Ltd., 326 Craig St. W.

+—New Glasgow, N.S.—A. A. McDONALD, Pickford & Black's Wharf, Halifax, has the general contract, and W. K. McDONALD, Stellarton, the carpentry for $40,000 two-story brick telephone office for the Maritime Telephone and Telegraph Co., Ltd., head office, Halifax.

New Glasgow, N.S.—The Trustees of Aberdeen Hospital are receiving tenders for the erection of a nurses' home. Separate contracts will be let for plumbing, heating and electrical work.

+—Ottawa, Ont.—Contract let to O'LEARY'S, LTD., Bank National Bldg., Ottawa, for pavement costing $8,000 for the Canadian Pacific Railway, Broad St. Station, head office, Montreal.

+—Ottawa, Ont.—DARTNELL, LIMITED, 374 Beaver Hall Square, Montreal, have been awarded the contract for white enamelled brick for the Parliament Buildings.

+—Ottawa, Ont.—JOHN SUTHERLAND, 216 Cooper St., has the general contract for $4,000 boiler house and chimney for the Ottawa Car Co., Albert St.

Perth, Ont.—In connection with the erection of a $50,000 factory for Henry K. Wampole & Co., Herriott St., boilers, engine and generator are required. Address, Stewart & Adams, care of company.

+—Perth, Ont.—MILFORD RABB, Wilson St., has the general contract for remodelling business block for Col. J. M. Balderson, Gore St.

+—Perth, Ont.—W. J. RABB, Wilson St., has the general contract for $10,000 factory for Henry K. Wampole & Co., Herriott St.

Petewawa, Ont.—L. E. Dowling, 167 Yonge St., Toronto, has the general contract for $14,000 Y.M.C.A. building. Frame construction.

Quebec, Que.—The Godbout building was damaged by fire to the extent of $4,000.

+—St. Hyacinthe, Que.—PAQUETTE & GODBOUT, 21 William St., have been awarded the contract for $25,000, two-story, brick office building for the Bell Telephone Co., head office, Montreal.

St. Thomas, Ont.—Fire damaged the lumber and manufacturing establishment of D. L. Schafer and Co., Ltd., Curtis St., to the extent of $7,000.

Ste. Anne de Bellevue, Que.—Tenders will be called about October 11th for the erection of a $200,000, limestone and plastic brick hospital for the Military Hospitals Commission, Drummond Bldg., Montreal.