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SLOPE PROTECTION—NEW WELLAND SHIP CANAL

DESCRIPTION OF WASH WALL IN CUTS AND ON WATERTIGHT EMBANKMENTS OF CANAL—ITS CONSTRUCTION ALONG WATER LINE AND SODDING OF UPPER SLOPES.

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TO avoid sliding or damage that might arise from the corroding action of waves and currents, the slopes of the new Welland Ship Canal are being protected throughout by a concrete slab or wash-wall at water level, and in cuts by sodding the slopes above.

The canal prism, both where watertight banks are necessary and in cuttings, is to be 200 feet wide at the bottom, with a 2 : 1 slope to five feet below water level, which is 25 feet above grade. This slope is unprotected, and is followed by a horizontal five-foot berm, the back of which forms the footing for the slab which extends up 14½ feet on a 1¼ : 1 slope, thus bringing the slab from five feet below to four feet above the water. On the east side the 2 : 1 slope continues above the slab where cuts occur, and the slab is here extended to five feet above water level. This slope is sodded as soon as possible after trimming, the sod being held in place by pegs driven through it. In Fig. 2, which shows a small slope on the construction railway, a man may be seen placing the pegs.

On the west side the tow path, on which a macadamized roadway 16 feet in width is to be built, intervenes between the top of the slab and the slope. This slope is also 2 : 1, and is up or down depending on whether the tow path is on the top of a watertight bank or in a cut. In either case the slope is sodded. It might be interesting to note also that the slopes of all drainage ditches as well as the canal slopes proper are being sodded.

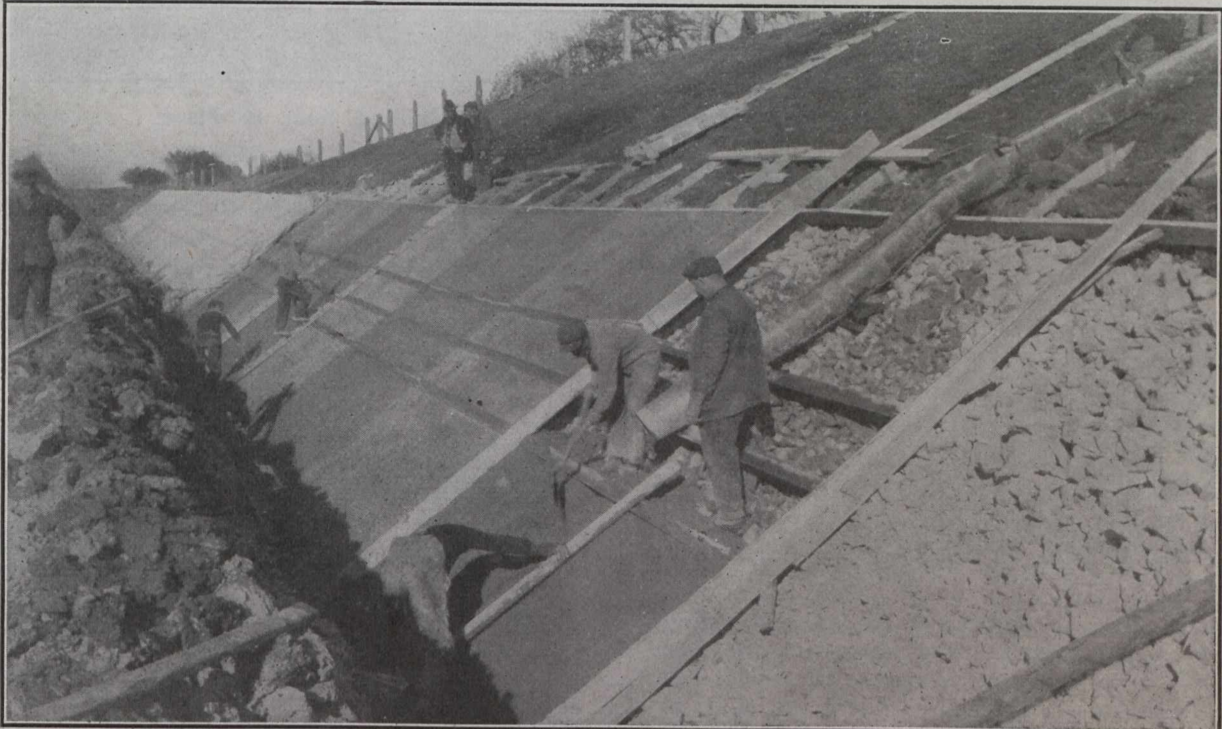


Fig. 1.—Concrete Slab Construction Showing Crushed Stone Foundation and Sodded Slope Above.

The slab itself is six inches thick and is placed on a 12-inch layer of 4-inch crushed stone. Its construction on the slopes of the watertight banks has not yet been attempted owing to the necessity of leaving the banks already built a considerable time to attain as nearly as possible final settlement.

Construction in cuts has begun on the east slope of the 70-foot cut at the Queenston Road, near Homer, and also adjoining the waste weir of Lock No. 2. In taking out the cuts with steam shovel or dragline excavator, excavation is being carried to what will be the face of the slab. This necessitates the removal of an additional 18 inches when slab construction is begun. This is done in order to obtain an even surface on which to place the stone, and also to preserve the slope above, which would not be possible if the interval between the excavation and the placing of the slab became at all extended.

The material for the part now under construction is being shot down from the top of the slope to the required position. The placing of the stone backing is finished off by hand, and the concrete shovelled into position. This is shown in Fig. 1, which also shows the sodded slope above and, on the left, the excavation for the slab piled on the berm, which material will be removed later with the next shovel cut. A stiff 1 : 2 : 4 mix is being used, making it possible to dispense with all forms except two ¼-in. x 6-in. steel plates as side forms and a board at the top and bottom, the edges of which are placed flush with the surface of the slab.

Two laborers at the bottom of the chute distribute the concrete to two screeders who work from the berm level and from three steps placed one at the water level and one a little above and below. These are made by placing three 4-in. x 4-in. x ¼-in. angles in notches in the two plates already mentioned as side forms. The steps are not only useful for the purpose for which they are made, *i.e.*, providing a means of exit for a person in the water, but also form three additional edges to work to, as well as facilitating the screeders' movements. Fig. 1 shows a straight edge from the board at the bottom to the first step.

No trouble has as yet been experienced in making the concrete stand on the 1¼ : 1 slope, and fair progress has been made with the placing. A gang of seven men are able to lay about 200 feet of stone a day with the stone on top of the slope and by chuting it down, as shown in Fig. 3. The average progress on the slab, pouring directly from the mixer into the work, is four 16-foot panels, or about 107 square yards, with a maximum of five panels. This can be done with a force of twelve men and a ½-yard rotary mixer.

Fig. 1 shows part of the cut at the Queenston Road, which at present has been carried to berm elevation. From ten feet above the slab to canal grade the material

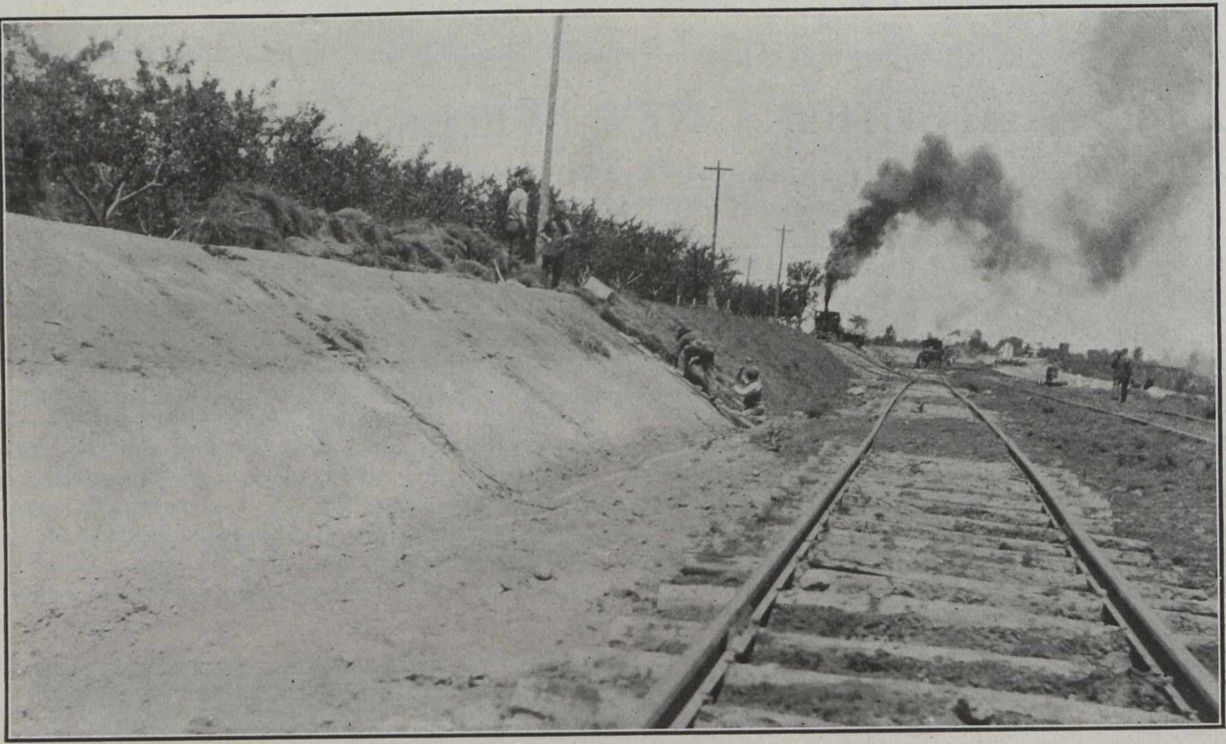


Fig. 2.—Sodding Railway Slope, Using Pegs for Holding Sods in Place.

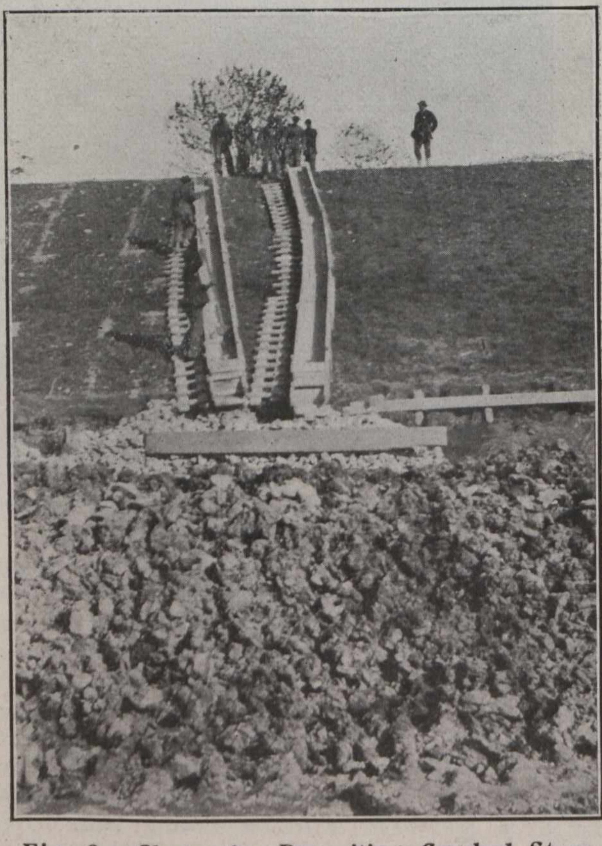


Fig. 3.—Chutes for Depositing Crushed Stone Foundation Layer.

is a gummy blue clay. To ensure that the slope and the slab will not slide, when the prism excavation is continued to grade, 30-foot piles at 6-foot centres are to be driven along the toe of the slab on the berm. In this connection it is interesting to note that piles were driven in the banks of the present canal to grade to prevent the banks sloughing off when any particular reach is unwatered for repairs, and that they have met with marked success.

The slab construction is at present confined to the two places mentioned, where the work is being carried out by Messrs. Bennett and Kellet, sub-contractors, under Messrs. Baldry, Yerburgh and Hutchinson, general contractors for Section No. 2 of the canal. Mr. J. L. Weller, C.E., is engineer-in-charge for the Department of Railways and Canals, Ottawa.

PRELIMINARY INVESTIGATIONS FOR MASONRY AND FOUNDATION DESIGN.

THE importance of thorough preliminary explorations before designing any foundation or substructure is urged by Henry S. Jacoby, Professor of Bridge Engineering, Cornell University. He made this the subject of a paper presented in February at a good roads congress held at the Cornell College of Civil Engineering and appearing in the April issue of the Cornell Civil Engineer. The following notes on preliminary work, taken from Prof. Jacoby's paper, will be found of considerable value:—

In the first place, test pits may be used for relatively shallow foundations. The advantage of digging a test pit is that the material is found in exactly the condition in which it is naturally placed; its compactness and composition can be learned and therefore a decision made as to the proper stratum upon which to rest the foundation. Also, the bottom of the pit can be tested by proper loading, and a good estimate of its character consequently formed.

A device sometimes used is a sounding rod; this is a bar 1 to 1½ inches in diameter, sometimes driven down with a maul but more properly provided with a cross bar or handle upon which a number of men put their weight to force the rod into the ground. All that can be determined with a sounding rod is that the resistance increases or decreases, that it is slight or considerable; any obstruction, of course, stops the operation and then the problem is, what is that obstruction? Because it is so often misleading, this method is the most unsatisfactory one for making investigations of the soil. For example, at one site eight men on the handle bar could force the rod only 7 feet into the earth, but no trouble was experienced in driving piles to a 70-foot penetration. Another condition often arising is the striking of a thin layer of hard gravel with the sounding rod, while underneath it there may be soft material for a considerable depth. There is no means of knowing the exact conditions unless some other investigation is made.

A much more satisfactory method is by the use of a wood auger, say 2 inches in diameter. It can be attached to a short pipe which is coupled to a number of sections of pipe 6 to 12 feet long. A handle is needed, while a block and fall are also required to operate the device properly if the boring must be carried to a considerable depth. If the hole clogs so that it is impossible to work through the material, it may be necessary to use a one-inch auger for the rest of the boring. Often in working through sand by pouring water into it the sand can be made to retain the form of the hole when it would not otherwise do so. Where the form of the hole cannot be retained a three-inch casing may have to be driven in four or five-foot lengths. This method can be used for depths up to 100 feet, and that covers the great majority of cases. It cannot be used to advantage in fine running sand unless the stratum is very thin. The loose material can be removed by a sand pump, consisting of a long narrow cylinder with a cutting edge at the bottom and above it a flap valve opening upward. It is partly filled by rapidly raising and dropping alternately.

An earth or clay auger has two cutters directed inwards and downwards so as to pull the auger into the material, and to support the excavated material when the auger is withdrawn. This method can be used in frozen earth or in hardpan quite successfully. It is a curious thing that sometimes a larger hole will retain its form where a small one will not. For example, if a 2 or 3-inch hole will not retain its form, many times an 8-inch hole will. Even a post hole digger can be used to a depth of 16 feet with considerable success.

The next standard method is the wash boring. This has been very extensively employed, but not nearly so much as it should be. To-day those who have charge of foundation work certainly ought to have proper equipment of this kind. A standard outfit includes a light tripod casing, hollow drill rods, and a hand force pump. The casing is usually about 2½ inches in diameter inside and the drill rods ⅞ inch outside. The rods are connected by special couplings. The bottom rod has a chopping bit at the end with an X-shaped form, and four holes through which the water jet operates. The force pump should be double acting, with a single handle, and an inch-and-a-half suction. By having a hoisting water swivel at the top the drill rods can be turned without twisting the hose. The material at the bottom is eroded and the jet operated by turning the drill rods. The water passes down through the hollow drill rods and out through the openings at the bottom, erodes the material and brings it up between the two pipes. Samples can be taken from the settlings and the composition of the material determined. The casing, of course, is rotated in the meantime, or, in some cases, driven. By using a double block and a jarring weight the casing can be driven without taking out the drill rods; without that arrangement more time is required. The samples taken from the boring are properly tabled and bottled so that they can be placed in order and examined afterwards. Occasionally boulders or other obstructions are struck. By withdrawing the casing a short distance dynamite may be used to shatter the boulder, thus allowing the process to continue. In this way, borings can be made through sand and gravel, clay of varying hardness, indurated clay, and hardpan. All depends on the care with which the work is done. For small work in light, sandy material a less expensive outfit may be used.

We, of course, do not learn the exact form and condition in which the material rests in its natural location, because it is separated by the water, or the finer material may be brought up and in some cases the coarser pushed aside, so that there is a difference in estimating its character as compared with a test pit. This difficulty can be surmounted by taking out the drill rods at intervals, unscrewing the lower end and putting on a short piece of brass pipe, pushing that down into the material and bringing it up, thus obtaining a piece of the material in just the condition in which it occurs. It is also an excellent thing in hard clay to take out some dry cores by using a drill rod at the end that has a serrated edge. Special attention is called to this because at times, if it is not done, we may work our way through a layer of clay adapted for a foundation, and perhaps be obliged to go 10 or 20 feet deeper before finding something else that is suitable. By operating with the wash drill process, the clay, of course, is reduced to a condition which does not indicate its real character. A core in the dry has to be taken in order to determine its supporting power. There have been many illustrations of this sort. In one case 30 feet depth was saved in a foundation by taking out occasional dry borings through hard clay. An important thing in wash borings over a site is to notice whether layers of corresponding material are uniform over the area or "peter out", from one side to the other; whether further tests should be made can thus be determined.

The next appliance to be considered is the shot drill. It is not intended to discuss the diamond drill, because the use, as a rule, is at least twice as expensive as that of the shot drill, and further, it generally applies to unusually deep foundations requiring extensive investigations. The shot drill is a more modern development due to the fact that diamond drilling has run up the price of the carbon quite materially. In the shot drill chilled steel shot is rotated underneath a soft steel rotating bit and thus mills away the rock. It is rotated at fairly high speed and under pressure. The amount of shot to be fed and the pressure to be applied requires some degree of experience and observation. One side of the cylinder, which is the bit, has a V-shaped inclined notch to allow the water that passes down the interior of the drill rods and comes up in the casing to escape without carrying away all the shot. It also enables the shot to be fed in through the water in the interior. There is usually a calyx or sludge received just above the lower section in which the material as it comes up enters a large chamber where the velocity of the water is reduced so that it drops the sediment. Hence we get a record in inverse order in which the material is milled, and at intervals it is taken out and examined. The diameters of the core range from 1½ up to 20 inches and in some cases even larger.

The Davis cutter works in a somewhat different manner. It has a series of long, sharp teeth with an angle that varies from 30 to 35 degrees. These teeth cut like chisel and hammer instead of milling. As each tooth takes hold of the rock it bends and then jumps. It has a rapid chipping action and operates in the same way as the ordinary shot drill except that it has a chipping instead of a grinding action.

It is a fundamental proposition that one cannot be sure of making economical designs of substructures with their foundations without adequate preliminary exploration. Many a time the expenditure of a little money—just a small percentage of the cost of the substructure—for exploration will save many times what would otherwise be expended in extra construction. It is often omitted because of time and labor, but the time as well as extra cost is paid for afterwards. Frequently it costs less than merely to make changes in the drawings, to say nothing of the changes in the structure itself. I know engineers who have built long culverts and arch bridges under high embankments where the loads were tremendous, in which, by making adequate preliminary explorations, they did not need to make a single change in the substructure, not a single modification in the number of piles required nor the distribution of these piles. Then, too, it frequently means a saving in cost of maintenance as well as in first cost of construction.

Another reason for adequate exploration is that the owner should assume the full responsibility for local conditions; the contractor should not be obliged to gamble on uncertainties relating thereto. It is a case of straightforward honesty to begin with, and certainly of economy. In the first place, we should make the exploration in order to determine the conditions, and if, in spite of that, there may be variations subsequently determined, the owner gets the benefit and should pay for the difference. All that is necessary is to make the contract in such a way that fair allowance will be given the contractor for either increased or decreased cost.

The next point to consider is the test for bearing capacity of the material on which it is expected to found. Ordinarily the best arrangement is to use a single vertical post of known area of rectangular or round section and supporting a balanced platform. It is not desirable to use four posts with a platform across them all because the same amount of care to prevent unequal settlement of the four posts will keep a single post from tipping over; also a smaller load is required and it usually takes less time. For large work we should use more than a 12-in. x 12-in. to give the best results, but for small work it is sufficient to use a 12-in. x 12-in. or even slightly smaller. The bearing should be tested at the bottom of the proposed excavation and it is necessary to explore a little distance below to be sure that it is not a thin stratum underlaid by poor bearing material. The wash boring should go considerably below the foundation bed. The load can be applied rapidly to the test post until it reaches ⅔ of the amount considered to be the safe bearing power; then adding smaller increments and allowing certain time interval between increments in order to determine whether the settlement is continuous. We proceed in this manner until we determine the heaviest load the foundation will carry without continuous settlement. More time is required in test loading in clay than for other soil, because clay in many cases has a habit of yielding; if it is plastic, the resistance may be very high under a quick test but yield continually under a slow, steady load.

Both timber and concrete pile foundations are very extensively used—more extensively than any other kind. In my judgment, the greatest sin of commission in regard to timber piles is over-driving. There are so many who think that a little extra driving is so much the better, and who say, "Just give a few extra taps for good measure." It may be the "few extra taps" that cause the damage.

In regard to the construction of ordinary light structures the problem is a difficult one on account of the way in which the work is done, and since it is frequently expensive to get the kind of equipment to do the best work. That is one of the arguments for doing things on a somewhat larger scale and in a co-operative way, so that pile drivers with steam hammers may be used instead of drop hammers. When one considers how long ago the steam hammer was invented, it is discreditable to engineers that it has not been more extensively used.

The greatest sin of omission in pile driving is the failure to use the water jet. Many a time piles can be driven without a hammer. If piles are driven through quicksand or through ordinary sand, the best way to drive them is by means of the water jet. Using this method, the pile is not injured, it generally costs less, and it can be done effectively. The water jet is well worthy of study and should be employed more extensively. Its use will do more to eliminate over-driving than any other one thing. The water jet is also valuable as a help to learn the exact length of the test pile before driving, since it can be used to bore a hole in a given position before driving the pile. The ideal material in which to use the water jet is pure sand. Some claim it cannot be used in any sort of hard material, but men of equal or larger experience can always be found who have successfully done it. Now, a few points regarding the water jet. The jet pipe is 2 to 2.5 inches in diameter, the pump discharge 4 inches and suction 6 inches. The diameter of nozzle ranges from ¾ to ½ inch, or the nozzle may be flattened to an opening of ¼ inch. The pressure ranges from 65 to 200 pounds per square inch; the volume of water from 50 to 250 gallons per minute. Many troubles have arisen from insufficient capacity of pumps or insufficient volume of water. There should be pressure enough to do the excavating at the bottom, and volume enough so the water will come up alongside the pile. The kind of material in which the water jet cannot be used is so pervious that it allows the water to spread out and not come up along the pile.

REINFORCED CONCRETE T-BEAMS.

FOLLOWING the publication of his article on the design of reinforced concrete T-beams in our issue of April 15th, 1915, Mr. E. G. W. Montgomery, of the bridges branch, Department of Highways, Province of Saskatchewan, makes the following suggestion to more readily convey to the reader a clear understanding of a feature of the method of design which the article describes.

Instead of the paragraph reading "When the centre of compression . . . only for small beams," the following is suggested:—

When the centre of compression is at $\frac{t}{3}$, t is equal to x, and the ratio $\frac{b^1}{b} = 1$. The beam is thus a simple beam and must be designed accordingly.

When $x < t$, i.e., when the neutral axis falls within the slab, the case is still that of a simple beam, with $\frac{b^1}{b} = 1$.

But these cases have little practical value and need not be considered, being very extravagant of steel. But if at any time such a section is deemed essential, it is to be remembered that the width of the stem is no longer the b of our equations, and does not govern the width of flange to be taken as acting in compression. All that now governs the width of flange are the dictates of good practice, which are based upon considerations of span and spacing.

Mr. Montgomery suggests the above addition to the article as the result of an enquiry from an engineer who was using the described method to test the design of some heavily loaded beams. He is of the opinion that the further elucidation may be of service to others who might entertain similar uncertainty as to what relation, if any, existed between the width of flange and stem in a T-beam in which the neutral axis fell within the flange.

DETERMINATION OF BEST STATIC PRESSURE IN A WATER SUPPLY SYSTEM.

AFTER the engineer who has set about to design a water distribution system for a municipality has gone into the necessary investigation of population, consumption, metering, distribution, fluctuations, fire services, etc., the question of pressures presents itself. The pressure under which the water should be delivered is subject to several important influences. If there were no draft of water from the mains, the pressure throughout the system would be that ordinarily termed static pressure, or the pressure resulting from the elevation of the water in the reservoir. A draft of water from the mains, however, immediately sets in motion the mass of water therein contained, causing friction which is proportional to the draft, and which must be overcome. The dynamic or service pressures at various points on the system may be greater or less than the corresponding static pressure. When the supply is from a reservoir, the service pressure at any point on the distribution system will be less than the corresponding static pressure by the amount of the friction loss between the reservoir and the point considered. When water in excess of the immediate requirements is flowing from a pumping station into a storage or distributing reservoir, the dynamic pressure at all points between the pumping station and the reservoir will be greater than the corresponding static pressure from the reservoir. Fire service at different pressures, differences in ground elevation, etç., add to the attractiveness of the subject, as well as to its importance, for the waterworks engineer.

In the Journal, for March, of the American Waterworks Association, Mr. Nicholas S. Hill, Jr., has presented a paper covering fully the subject of pipe distribution systems. The following remarks relating to static pressure are abstracted from it:—

Having decided upon the service pressures required at various critical points of a system, and the number of service pressure districts into which the city will be divided, the next step is to determine the size of mains required to convey the estimated quantities of water at the required pressures from the immediate source to the various points of use. This source may be a pumping station, distributing reservoir, or the point at which a conduit or supply main delivers to the distribution system.

The problem presented may involve fixed pressures at the immediate source, as, for example, where one has to deal with existing pumping plants, distributing reservoirs, or conduit lines, the elevation of or pressure from which is fixed. Under these circumstances, the sizes of the distributing mains must be figured so that the losses in friction between the immediate source and the points of use shall not exceed the difference in pressures at the two points.

The problem presented may be one in which the initial pressures are not fixed, and where the designer may, at his discretion, determine upon the most economical pressures to be carried at the immediate source. He is then at liberty to adjust pressures and pipe sizes in the distribution system so as to increase or diminish the friction losses therethrough in such ways as economic considerations may suggest.

The problem presented is really the determination of the static pressures required to produce most economically the desired service pressures, or the determination of the most practical static pressure to be used. The most advantageous static pressure will be that at which the total annual cost of supplying satisfactory service is a minimum.

Below are listed the principal elements in the construction or operation of a waterworks plant which will increase or decrease with an increase in pressure carried. The effect of these several elements upon the total annual cost of supplying water must be appraised by the designer and carefully weighed and compared under the various static heads considered, preparatory to a final decision.

Elements in the design or operation which will increase with an increase in static pressure—other things being equal:—

1. Cost of pipes composing the distribution system, excluding feeder mains.

2. Weight and strength of house service connections and plumbing fixtures.

3. Cost of service pumping engines.

4. Cost of boilers, stacks, and pumping station auxiliaries.

5. Cost of fuel per million gallons pumped.

6. Cost of repairs to mains in distribution system.

7. Cost of repairs to house service connections and plumbing.

8. Cost of water wasted through leaks in distribution system.

9. Cost of water wasted through house service connections and leaky plumbing fixtures.

10. Quantity of water used per consumer.

Elements in the design or operation which will decrease with an increase in static pressure—other things being equal:—

11. Cost of pipes composing the feeder mains.

12. Diameter of house service connections.

13. Number and capacity of booster plants required to increase pressures in restricted high areas.

Some of the elements listed above appear at first sight to exert an appreciable influence on the cost of the plant. Analysis, however, will show that a number of them may be discarded from serious consideration.

Generally, the experienced engineer will be able to weigh the relative effect upon the cost of the several considerations affecting the selection of the most advantageous static head, without elaborate calculations of the relative economy of several schemes.

In addition to the effect exerted upon the cost by the elements mentioned above, the cost may be affected by external considerations, characteristic of the particular community considered, such as the greater land values of the reservoir sites at low elevations, or vice versâ, topographical considerations which would make the cost of a reservoir at one elevation more costly than one at some other level, or the existence of expensive structures which it would be commercially inexpedient to discard.

The function of a pipe distribution system is the conveyance of water from the point at which the water is delivered to a community to the point at which it is to be used. This delivery must be accomplished in such a manner that an uninterrupted and adequate supply of water under satisfactory pressure will be available at every point on the system under all conditions of demand. The supply must be sufficient in respect of pressure and volume not only to meet the present and future demands of ordinary domestic and public consumption, but to supply the needs of large industrial consumers and for the extinguishment of fires. It must be able to meet not only the average present and future demands of these several classes of consumers, but such of their maxima as are likely to occur simultaneously. The pipes should be of a size sufficient to supply these maxima after proper allowance has been made for deterioration in the carrying capacity of the mains as a result of tuberculation and from other causes.

The delivery of water must be accomplished at a cost as low as is consistent with a wise provision for the future growth of the community to be served. By low cost is meant not necessarily the first cost, but the total annual cost including fixed charges, depreciation, replacements, maintenance and incidental costs chargeable to poor construction, such as losses of water through leakage, etc.

IMPACT CO-EFFICIENTS FOR RAILWAY GIRDERS.

THE proper allowance to be made for the impact of moving loads is one of the subjects treated in a paper read on April 13 before a meeting of the Institution of Civil Engineers (Great Britain) by Mr. C. W. Anderson, member. The author had had the privilege of making use of much data collected in the shape of deflection and extensometer results by the Indian Government, whose Rules are under considerable discussion in England and elsewhere.

The following remarks refer to impact coefficients:—

Standard Moving Loads.—The Indian Rules lay down a standard uniform moving load to which all new or strengthened girders are to be designed. These loads are to be considered as static, and the allowance for impact is provided by a separate rule, in contradistinction to the Board of Trade Rule, which leaves to the designer what proportion of the safe working stress he shall assign to the effect of impact.

In order to dissociate the consideration of the static and dynamic effects, the author gives diagrams of the equivalent distributed loads for the engines and trains in actual or probable use on Indian railways, and arrives at the conclusion that in this respect the Indian Rules are not excessive in their demands.

The Safe Working Stress.—The correctness of any rule for the coefficient for impact cannot be discussed without first coming to a conclusion with regard to the safe working stress which is used in conjunction with it.

If it be accepted as axiomatic that the elastic limit of the material should never be passed, what has the margin of 8 tons per sq. in. to cover?

It has to provide for: (*a*) Accidental defects in the material; (*b*) initial stresses in the material due to rolling; (*c*) stresses due to variation in temperature; (*d*) loss of section by corrosion; (*e*) faulty workmanship; (*f*) secondary stresses due to eccentric loading.

Taking all these probable causes of increase of actual as compared with calculated stresses into consideration, it does not appear that the normal unit stress of 8 tons per sq. in. could be increased with advantage.

Impact Formulæ.—All impact formulæ are derived from Wöhler's experiments, followed by Bauschinger, Baker, and others. Laundhardt and Weyrauch deduced formulæ from these. Mr. E. H. Stone has proposed a formula which expresses the ultimate effect of the moving load, building up his theory from the ratio which that load bears to the total load.

The Pencoyd formula, as used by the Government of India, depends more upon span than upon range of stress, thus differing from Stone's range rule.

The effects of the use of the various formulæ are shown in diagrams.

The Evidence of the Immediate Effect of Moving Loads.—One of the principal causes of increased stress, especially on small spans, is the periodical shifting of the weight due to the lurching of the engine. Variation of pressure is caused by centrifugal force, set up by unbalanced parts or by excess vertical action of balance-weights. An engine in use on the Bengal-Nagpur Railway is chosen for illustration, and increase of stress for spans of 5 ft. to 308 ft. is calculated for bending moments, shears, and cross-girders.

In addition, the causes of increased stress are: (1) The effect of the velocity with which the load is applied. (2) The effect of shocks caused by flat wheels, etc. (3) The side pressure of the wheel-flanges against the rails. (4) Wind pressure on one rail. (5) Coincidence of period of vibration. (6) Curved trajectory of the moving load.

Extensometer results of Messrs. La Touche and Sales, and Professor Turneaure, and deflection observations of the Government inspectors are plotted and examined in comparison with each other and with the Indian Government Rules.

The Evidence of the Cumulative Effect of Moving Loads.—The condition of 350 wrought-iron girders on the North-Western Railway is shown in appendices detailing the result of tests of the material, and also in a drawing of a girder tested to destruction. After thirty years' use the girders had lost camber and showed loose rivets, and tests of the material indicated extreme brittleness.

The Lansdowne Bridge, on the North-Western Railway, after twenty-four years' use, has a large number of loose rivets. The stresses and typical joints are given in illustrations. Corroborative evidence is given in a typical girder on the Bengal-Nagpur Railway.

General Conclusions.—Considering the sources of stress dealt with, and the evidences of the immediate effect of the moving load, the author concludes that the minimum increment which should be allowed to the moving load is that which may be calculated by the formula:—

$$I = \frac{50}{50 + L} S$$ as against the Government rule

$$I = \frac{300}{300 + L} S.$$

This formula is suggested as a basis for discussion, as a suitable rule for use in connection with existing girders. For cross-girders and rail-bearers even the Government rule is, if anything, too small.

For new girders intended to last indefinitely, it is doubtful whether the suggested formula is sufficient when taken in conjunction with the working stress of 8 tons per sq. in.

GERMANY'S STEEL PRODUCTION.

The following table shows the German production per month for the last six months of 1914 of pig and steel:—

	Pig. Tons.	Steel. Tons.
July	1,561,944	1,627,345
August	587,661	566,822
September	580,087	663,223
October	729,841	900,201
November	788,956	900,026
December	853,881	941,399

The aggregate production of pig-iron in Germany during 1914 amounted to 14,389,517 tons, against 19,309,172 tons for the previous year; and of steel, 14,973,106 tons, against 18,958,819 tons for the preceding year.

RESULTS OF HYDRO OPERATION IN ONTARIO.

According to the 7th annual report of the Hydro Electric Power Commission of Ontario the operation of the various municipalities (now 69 in number) to which hydro power is distributed shows the following results:—

	Dec. 31st, 1912.	Dec. 31st, 1913.	Dec. 31st, 1914.
Number of municipalities included in report...	28	45	69
Operating and maintenance expense	$1,086,135	$1,516,613	$2,012,754
Debenture charges and interest	291,033	525,054	661,949
Total annual expense..	$1,377,168	$2,041,667	$2,674,703
Total revenue	1,617,674	2,617,439	3,433,936
Surplus for year	$240,506	$575,771	$759,232
Depreciation charge	124,992	262,675	357,883
Surplus less depreciation charge	$159,219	$313,096	$401,349
Total assets	$6,349,711	$11,977,175	$15,249,203
Net debenture balance and other debt	5,822,156	10,468,351	12,702,689
Percentage of net debt to total assets	92.5%	87.2%	83.0%
Total plant value	....	$9,196,483	$12,901,125
Accumulated surplus invested in plant extension	$ 284,211	$ 859,983	$1,601,167
Accumulated depreciation reserve	240,229	502,904	850,618
Surplus from operation.	$ 43,982	$ 357,078	$ 750,549
Estimated saving to light users only during year	....	1,576,500	1,694,300
Number of consumers, light	33,568	63,157	93,179
Number of consumers, power	1,399	2,532	3,565
Total number of consumers	34,967	65,689	96,744

	Domestic light.	Commercial light.
Highest cost per kw-hr. in 1914.......	10.9	9.4
Lowest " " "	3.7	1.8
Average " " "	4.8	3.9
" " " prior to Hydro .	9.4	9.5

The outstanding features, states the report, are that while the municipalities have invested in distributing plants to the extent of $15,249,203.36, carrying annual fixed charges for interest and sinking fund of $661,949.23, the surplus from operation in 63 municipalities for periods of from one month to three years amount to $1,601,167.42 in addition to the reduction in debenture debt due to sinking fund and principal payments.

Deducting from this profit a depreciation charge to provide for deferred maintenance due to general decay and obsolescence amounting to $850,618.07 there is still a surplus of $750,549.35, or over ten per cent. of the total revenue of the three years. In other words, the total revenue has been over ten per cent. greater than the cost of the service, including depreciation, although the selling rates in most municipalities have been reduced from time to time.

These statements show not only the status of the utility in each municipality, but of all the municipalities in the Niagara, Severn, Wasdell's Falls, St. Lawrence, Ottawa and Port Arthur systems consolidated into one unit. The result is of particular interest and value, as it is the final answer of the municipalities to their experiment in the co-operative transmission and municipal distribution of hydro power.

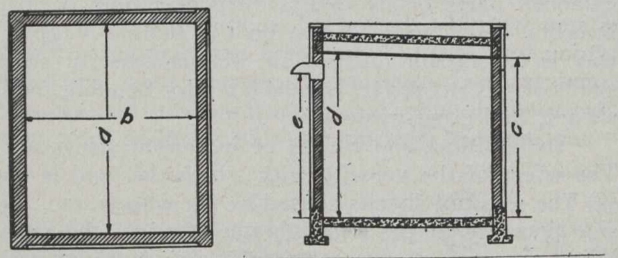
STANDARDIZATION OF DISTRIBUTING STATIONS IN ONTARIO.

MANY of the distributing stations of the Hydro-Electric Power Commission of Ontario are required to meet similar demands, and are, therefore, almost identical in arrangement. With the idea of standardizing these stations the Commission has prepared building drawings and electrical drawings for several standard layouts, and each type of station is represented by a letter, as shown in the accompanying drawings and table:—

Types "E," "F" and "H" have no inside high-tension oil switch or lightning arrester but are provided instead with a horn pipe, air brake disconnecting switch mounted on a pole outside the station, and a choke coil and disconnecting switch fuses inside the station. Type "E1" differs from "E" in that the building has a concrete roof, whereas "E" has a corrugated iron roof. "G1" building is the reverse of "G," that is, the entrances are on the opposite side with respect to the door. The "G1" electrical layout is also reversed. Such differences as those between "G" and "G1" are necessary because of local conditions, which in this particular case required that the lines come in on the site in a certain way with respect to the entrance to the building.

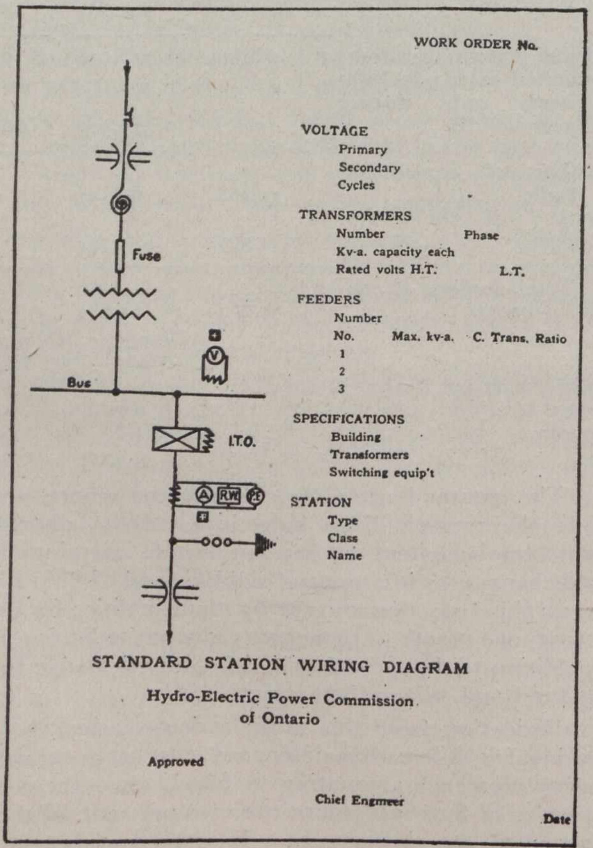
A building standard specification and an equipment standard specification covers each of these stations. The accompanying illustrations represent two of the standard wiring diagrams that were prepared.

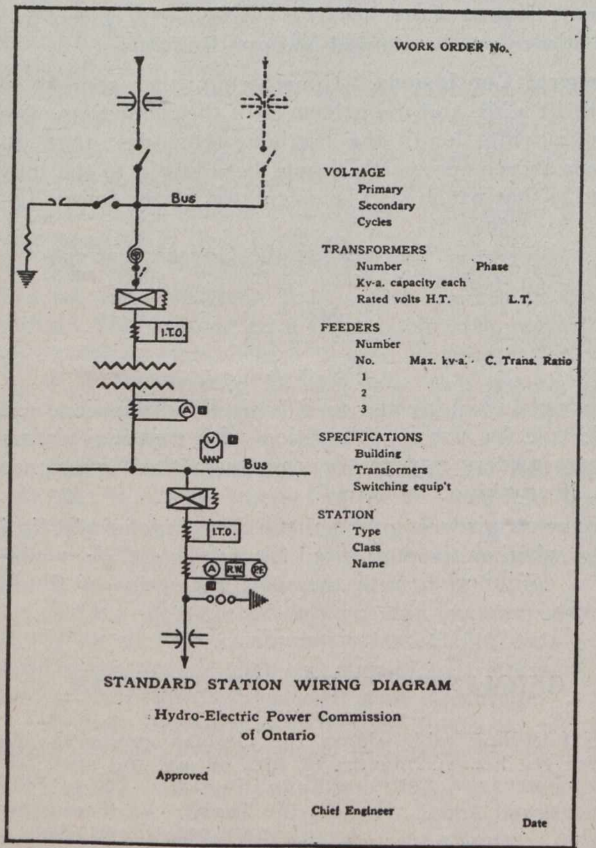
A set of the electrical layout drawings and a copy of the electrical specifications are forwarded to each of the manufacturers. These are kept on file for reference. When tenders are requested, a copy of the wiring diagram with the blanks filled in, is sent with a letter to the manufacturer. This is sufficient to give him the necessary information for submitting his tender.



Type	a	b	c	d	e	Volts H.T.	Volts L.T.	Trans Kv-a.	H.T. Entr.	L.T. Entr.	Building Drawing	Electrical Layout
A	ft. in. 11-0	ft. in. 11-0	ft. in. 9-9	ft. in. 12-6	ft. in. 11-2	13,200	2200	3-25	3	6	3-S -14031	4-S -14032
B	18-0	13-0	12-6	13-0	12-5	13,200	4000Y / 2200Δ	3-50	3	9	4-S -14028	4-S -14033
C	20-0	15-0	13-6	14-0	13-6	13,200	4000Y / 2200Δ	3-75	3	9	4-S -14026	4-S -14027
D D1	20-0	15-0	13-9	14-3	13-6	13,200	4000Y / 2200Δ	3-150	6	9	4-S -14067	4-S -14062 ....
E E1	15-0	12-0	12-9¼	14-5½	12-5	13,200	4000Y / 2200Δ	3-150	3	6	4-S -14111 4-S -14137	3-S -14106 3-S -14106
F F1	15-0	12-0	12-9¼	14-5½	12-5	22,000	2200Δ	3-150	3	6	4-S -14111 4-S -14137	3-S -14110 3-S -14110
G G1	23-0	18-0	14-7	15-2	14-5	26,400	4000Y / 2200Δ	3-150	6	9	4-S -14150 4-S -14151	4-S -14142 4-S -14117
H H1	15-8	13-0	15-1¾	15-3⅜	13-8	26,400	4000Y / 2200Δ	3-150	3	9	4-S -14140	4-S -14134 ....

Table of Dimensions and Capacities of Various Types of H.E.P.C. Distributing Stations in Ontario.





Standard Station Wiring Diagrams.

USE OF SCREW SPIKES IN RAILWAY WORK.

THE results of five years' use of screw spikes in both construction and maintenance, by the Delaware, Lackawanna and Western Railway are the subject of a paper by G. J. Ray, chief engineer, in a recent issue of the Bulletin of the American Railway Engineering Association. The consideration of screw spikes is becoming a live subject through the realization of the necessity of designing some method of rail fastening which will protect against the mechanical destruction of ties, by cut spikes, rail base and tie plates. It is only natural that the screw spike should receive due consideration long in advance of what may later develop to be the final outcome with wood ties—*i.e.*, a heavy plate or chair bolted firmly to the tie. When the first cost of the wooden tie will warrant the construction of heavy fastenings bolted to it its total cost may be so great that steel or composition ties may, disregarding questions other than cost, prove more economical.

According to Mr. Ray, the general use of screw spikes in both new construction and maintenance on the Lackawanna was started with the beginning of 1910, and during the past five seasons there have been placed in new tracks and maintenance of old tracks 5,120,000 flat-bottom tie plates and approximately 12,272,000 screw spikes.

As would be expected, some mistakes were at first made, and no doubt later developments will change some of the present practice. As a whole, however, the screw spike installation has proved satisfactory, and no conditions have developed such as to cause any doubt about its ultimate success.

In cases of derailment, the screw spikes have almost invariably stood up better than cut spikes. Certain cases of spreading on sharp curves where some screw spikes were used seem attributable rather to the class of wood in the ties than to the spikes. In many cases where the track could no longer be held to safe gauge with cut spikes, screw spikes with flat-bottom tie-plates were installed and not only rendered the track safe but also prolonged the life of the ties, and of the bridge and switch timbers. In re-laying rail, more time will be consumed with screw spikes, but in other respects, conditions are the same as with cut spikes.

The effect of the weight of equipment is important; through-passenger trains are handled by Pacific type locomotives, weighing 227 tons, and fast freights by the same type weighing 228 tons; standard heavy freight engines are of the Mikado type, weighing 238 tons. The Pacific locomotives have an axle-load per driver of from 62,000 to 63,000 pounds; the Mikado, 59,500 pounds.

For several years it was the practice to use flanged tie plates. Some years' experience showed much damage done to the ties. It was, therefore, concluded that their use should not be further considered.

A good flange plate, or something equivalent thereto in actual holding power, is absolutely necessary to held gauge on many of the sharp curves. After a careful investigation of all available data on screw spikes, it was concluded to adopt them as a means of holding track to gauge, and thus permit the use of a flat-bottom tie plate which would not destroy the fibres of the tie.

It is necessary to have a tie plate of sufficient size to provide a safe bearing area for the weakest kind of wood used. As the main-track ties are 7 in. by 9 in. by 8 ft. 6 in., it was considered not advisable to make the tie plates wider than 7 in. Often the best pole ties have a face at the rail seat of 7 in. or less, and, therefore, any excess in width of tie plate over 7 in. would be a waste of material. Evidently, the tie plate must be of good length in order to provide a safe bearing area for all classes of wood.

The first plates were 7 by 10¼ by 12 in., with raised lugs to support the heads of two screw spikes and with an intermediate shoulder on the outside of the rail. The plates were smooth on the bottom, and did not have a shoulder or raised lug for the screw-spike head on the inside of the rail. The following season the plates were lengthened to 10⅝ in. and made ⅝ in. thick, with lugs for the inside screw spikes. Two holes were also punched for lag screws, one at each end. There was doubt at first whether it would be possible to keep the flat-bottom plates from rattling and causing unnecessary noise in service. Furthermore, it would seem reasonable that the least possible wear between the tie plate and the tie would be the ideal condition. This can best be obtained by securely fastening the tie plate to the tie. If the raised lug for supporting the head of the screw spike is sufficiently high and of proper shape to hold the head of the spike firmly, the tie plate will be held firmly to the tie, and most of the wear will take place between the rail and the tie plate, rather than between the tie plate and the tie. There was difficulty at first in getting the lugs rolled sufficiently high to allow for play between the head of the spike and the rail base, and for this reason it was considered that the additional lag screws might be necessary in order to hold the tie plate more securely. These lag screws have not been used, excepting in certain cases for experimental purposes. It has been found that, with few exceptions, tie plates do not rattle or cause any unnecessary noise, and plates with a good support for the screw-spike head can now be rolled. So long a plate must have considerable thickness to avoid buckling. This thickness has now been increased to ¾ in.

The first change made from the standard cut-spike fastening occurred in February, 1909, when a new double-track tunnel through Bergen Hill, Jersey City, was put in operation. This tunnel has a concrete roadbed, with short, creosoted, yellow pine ties. Flat tie plates, 6 by 9 by ½ in., were used, and the rail was fastened with a lag screw and clip. New rail has now been laid on the tracks in question and the old fastenings have been replaced with heavy plates and screw spikes.

On the screw spikes now in use, care has been taken never to vary the thread, in order to avoid destroying the threads formed in the wood, in case a new screw spike was inserted in an old hole.

The heads of the screw spikes have been somewhat increased from those first used, on account of the great deterioration from rust caused by brine dripping at certain points on the line. This difficulty has not been experienced generally. The worst places were those in the immediate vicinity of icing stations. This is a difficulty which could and should be entirely eliminated by using containers under refrigerator cars, and thus avoid this unnecessary damage, not only to track fastenings, but to bridge structures, interlocking, etc.

The first year that screw spikes were used an Ajax hand machine was used for boring all ties in the field, with a template to spot the holes. Creosote oil was poured into all the holes as soon as bored. In 1911 a boring and adzing machine, manufactured by Greenlee Brothers, of Rockford, Ill., was installed at the creosoting plant. This machine operated more or less successfully, but was not of sufficient capacity nor heavy enough in construction to handle successfully heavy hardwood ties.

Accordingly, two new and larger machines, manufactured by the same company, were installed during the fore part of 1913. These machines have operated successfully, and have, without difficulty, adzed and bored 5,000 ties per day.

The cost per tie for adzing and boring, including the interest on the investment, depreciation, operation, running repairs, electrical current for operating the machines and trams, while the latter are taking ties to and from the machine, does not exceed 1½ cents per tie.

Some service tests are being made with different kinds of linings. One of these, the Thiollier helical lining, is a steel screw of the same pitch as the threads of the screw spike, and the inside diameter the same as the core of the spike. A special tool is first used in the hole, after which the lining is inserted. As would be expected, the device provides good holding power, but to date there has been difficulty in applying the device.

There has also been tried a malleable lining with inner threads to correspond to the pitch of the screw spike and outer threads to form a new contact with the fibres of the wood. The lower end of this lining is cut in three parts and spreads as the screw spike is forced into place. This device is not hard to apply. The old hole has to be enlarged and the lining inserted. All of the devices so far tested have been placed in new timber; as yet there has been no occasion to make such applications in old ties where the screws have become loose.

The following labor costs apply to a distance of about 60 miles of main track:—

	Per mile.
Boring by hand in the field 2,880 ties at $0.035..	$ 100.80
Applying 11,520 screw spikes at $0.019	218.88
Laying track, less boring and placing spikes at $0.085 per foot	448.80
Surfacing at $0.17 per foot	897.60
Total	$1,666.08

The figures include the entire labor cost for putting the track in finished condition but not for distribution of materials. It should be noted that machine boring was 2 cents cheaper per tie.

To sum up, as regards tie plates, they should be used on all ties where screw spikes are used. They should project well beyond the base of the rail on the outside and less on the inside to counteract the tendency of rail to roll out. Their required thickness will depend upon their projection beyond the base of the rail, and on the traffic. Four holes should be provided for screw spikes, so that two extra holes will be available if needed. All holes should be punched from the top down and be as neat a fit for screw spikes as consistent, so as to make all screw spikes act together in resisting lateral pressure.

Regarding the screw spikes, themselves, the size and the design of the thread should be carefully considered before adoption and thereafter no changes should be made. Where salt brine drippings are excessive, heads must be made sufficiently large; otherwise there may be difficulty in the future in removing the spikes from the track, due to corrosion. During nearly five years' service no screw spikes have been found rusted within the tie, and there was no rust to speak of below the head, although some heads were rusted so badly that they could not be removed with the standard tool. The head should have tapering sides to prevent turning in the wrench socket after the size of the head has been diminished by rust. Any mechanical device for setting down the spikes must automatically release when the screw spike is seated; otherwise the spike is apt to be damaged in hardwood or the wood fibres destroyed in soft wood. Little trouble is experienced by heads breaking off, either on account of track movement or of derailed equipment. The heads are, at times, damaged by derailments, but as a rule the spikes are not broken, nor is their holding power affected. Where spikes are broken off, a device for extracting the broken portion without injury to the wood threads would be valuable. When spikes are fully seated, no further strain should be put on them, as this will tend to destroy the threads in the wood or injure the spikes.

As for the holes, all ties should be bored at the treating plant before treatment. This can be done while the ties are being adzed, and not only insures that the holes are bored sufficiently deep, but provides for good treatment of all wood adjacent to the spike holes. Where the ties are bored before treatment, the track must be to proper gauge before the ties can be placed. The holes should be of proper dimensions for the class of wood used. Holes should be bored somewhat deeper than the length of the spike. There is no serious objection to boring them clear through the ties.

As regards maintenance of gauge, with oak, birch, hard maple, gum or longleaf yellow pine ties, gauge can be maintained with a flat-bottom plate, using two screw spikes on straight line and two or three on curves. Not only is the lateral and vertical resistance of a screw spike greater than that of a cut spike when both are first applied, but the lateral and vertical resistance of a loose screw spike is considerably greater than the lateral and vertical resistance of a loose cut spike. When the threads in the tie are entirely destroyed, a screw lining may be used with good results.

In general, the following points may be noted: All boring and adzing should be done before treatment to insure good gauge and perfect bearing for the plates. Screw spikes should be driven by hammer, only enough to make the threads take hold. The holding power of screw spikes in hardwood ties shows no material reduction after four years' service. No screw spikes have ever been found so loose that they could be pulled easily from the holes and few that could be extracted as easily as a newly driven cut spike; only in loblolly pine have the threads in the wood been found to be weakened. In maintenance work rails of standard pattern are more economical when screw spikes are used, as not requiring the regauging of the track. Slight irregularities of track when frozen are likely to throw excessive strain on screw spikes when only a few are mixed with the cut spikes; the best results follow their use for new construction or where they predominate over the cut spikes.

A cut spike when driven into a screw-spike hole spoils it for screw spikes thereafter. Low ties should not be drawn up with screw spikes where the roadbed or ballast is frozen. Screw spikes do not have to be set down continually, as do cut spikes, but should be gone over and set down properly after the plates are seated in the tie.

Buffalo, N.Y., will likely be the first city to profit by the efforts of the International Waterways Commission's investigation into the pollution of boundary waters. A sedimentation plant of some description will be necessary there, and the decision as to its nature will be reached before long. It is unlikely that construction will begin this year. Detroit will be treated second and consideration to Canadian cities will follow. The commission will reach definite decisions shortly.

EXTENSIVE DEVELOPMENT IN NEWFOUNDLAND.

THE government of Newfoundland has under consideration a contract with the Newfoundland Products Corporation, Limited, for extensive development of natural resources. Sir Edward Morris, speaking in the Legislature on April 22nd, outlined the main features of the agreement, which involves an expenditure comprising the following items:—

Water power	$ 6,440,300
General work	2,564,000
Industrial plant	3,745,000
Phosphoric acid plant	900,000
Ammonia plant	450,000
Working capital	2,000,000
Railway revision	250,000
Grand total	$16,349,300

The company proposes to establish at Bay of Islands at a cost of about $18,000,000 an industry for the manufacture of ammonium phosphate, ammonia, cement, wood pulp and lumber. The details are set forth as follows as regards construction and equipment:—

Coke and gas works	$ 799,000
Lime quarry	75,000
Lime kilns for 250 tons production per day	142,000
Calcium carbide works	462,800
Carbide crushing works	71,400
Electrode carbon works	25,000
Saw mills	211,800
Sulphite pulp mills, electrolytic bleaching plants and wood preparations	1,568,300
Machine shops, iron and brass foundries, boiler and structural shops, forges, pattern shops, and storage rooms	161,400
Engineering and supervision of foregoing items	228,300
	$3,745,000

In Sir Edward Morris' speech, the main features of the agreement were given as follows:—

(1) The Government leases for a term of ninety-nine years, in so far as they have any power or property in the same, the water power or powers in and upon the Humber River, and in or upon Junction Brook, with the right to divert and dam the same or any lake or water powers within the drainage area of the Humber River; and also, should the company at any time within twenty-one years become the owners of any additional water powers within a distance of forty miles of the company's factories at Bay of Islands, within an area laid down by a map and defined in this agreement, the Government propose to allow the provisions of this agreement, with the exception of clause 10, to apply to any water powers so acquired and developed within the said area for the purposes of the same business.

(2) If the company fails to develop the water powers so acquired, then the advantages of the agreement shall not apply.

(3) The company agrees within two years to survey the Hamilton and Northwest rivers in Labrador, and finish the surveys within five years, and furnish the Government with all plans of the survey, and the Government agree that if the company, within ten years from this date, in addition to an expenditure of $5,000,000 at Bay of Islands, expend an additional sum of $5,000,000 in Newfoundland in connection with the extension of its business in Newfoundland, it will grant the company a water power on the Hamilton River from the head of Lake Winocapau to the sea or an equivalent water power on the Northwest River, Labrador, but the condition of the grant of the said water power is that the company shall within five years expend in the development of the said water power, and its plant in Labrador, the further sum of $10,000,000. In the event of failure to so spend, the grant shall be void, and the water power on the Hamilton or Northwest river shall revert to the Crown.

(4) The company agrees to furnish up to 50,000 horsepower in Labrador to all persons or companies operating within one hundred miles of their power houses.

(5) The Government grants to the company a block of limestone near the Humber River, about five miles from Bay of Islands, for the purpose of making lime.

(6) The company's property shall be free from municipal taxation. The stocks of the company are also free from taxation. Construction material and machinery will be admitted duty free. Ten thousand acres of Crown land are granted the company by the Government at 30 cents an acre for wharves, piers, docks, factories and warehouses. Property required not in possession of the Crown to be taken and paid for by arbitration.

(7) The company has the right to build telephones between the factories and piers and workshops.

(8) Phosphate rock, pyrites, electrodes, soda and bags for packages are admitted free of duty into the colony.

(9) Coal for use in connection with the company's work in Labrador is admitted duty free.

(10) The company agrees to sell at its works at wholesale prices, and deliver the same at all railway stations in Newfoundland, and at ports of call where the Reid-Newfoundland Company's steamers now call, its fertilizer, freight free.

(11) All damages to Crown land to be paid for and settled by arbitration.

(12) Renewal of lease if not determined by 99 years.

(13) The company undertakes to begin actual construction operations within two years of the date of the agreement, and expend the sum of $5,000,000 within the island of Newfoundland within five years. Failure to begin or expend renders the agreement null and void.

(14) Dams to be constructed with proper log sluices for the passage of salmon and fish. Use of the waters by the public continues as heretofore.

(15) The company will provide cranes for lifting boats over dams.

In its dealings with the Government, the Newfoundland Products Corporation, Limited, is represented by Mr. Thomas L. Willson, of Woodstock, Ont., and with him is associated the Reid-Newfoundland Company.

Capitalization of railways per mile in Canada amounts to $60,000; in the United States, $57,976; and in Great Britain, $275,040.

During the last four years the export of power from Canada to the United States by three of the companies engaged in this business, has increased from 318,000,000 to 424,000,000 k.w.h. The amount of power supplied by the same three companies to be used in Canada actually shows a decrease for the same period.

HIGHWAY ARCH BRIDGE, ST. JOHN, N.B.

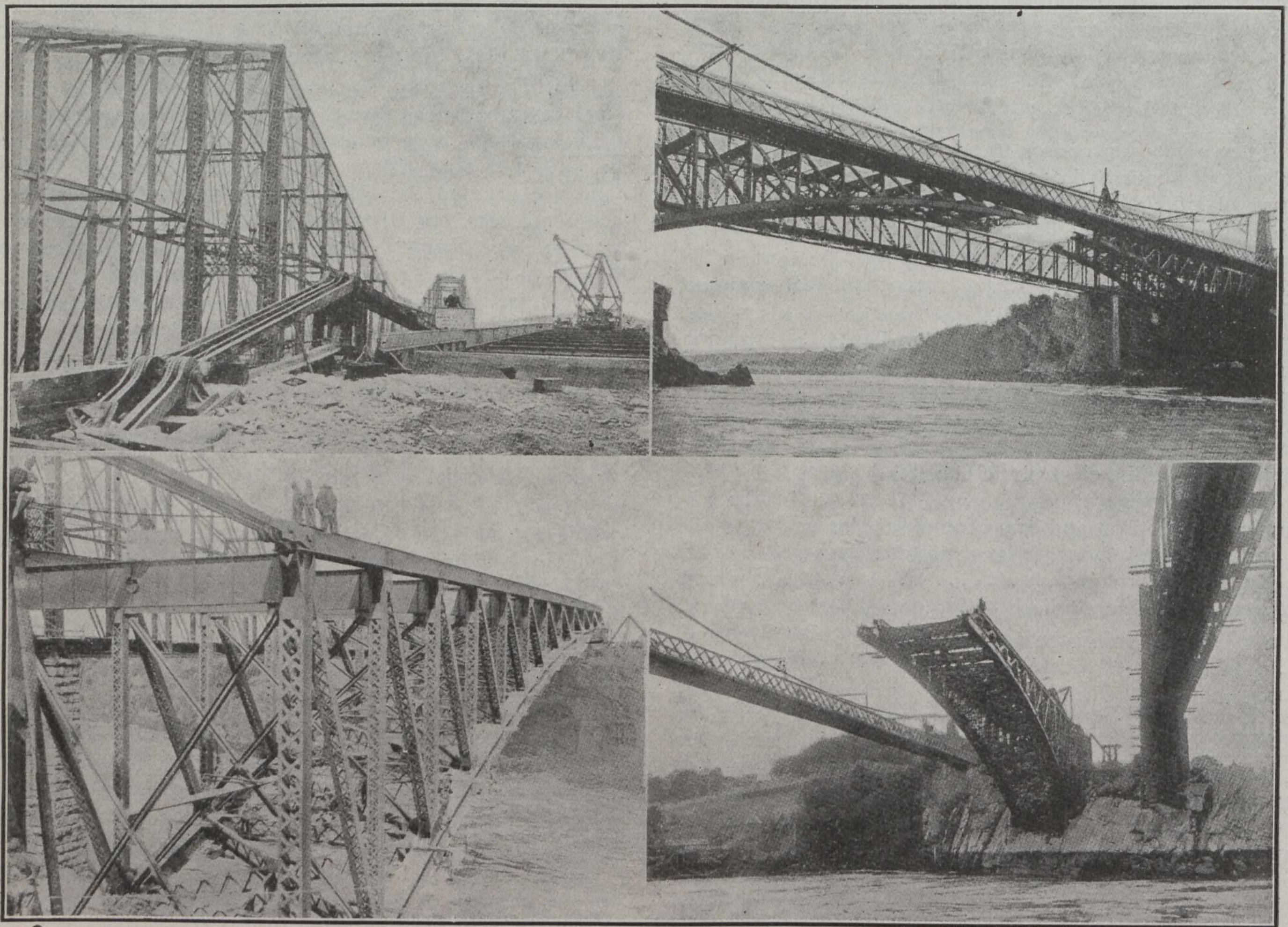
THE highway arch bridge recently erected over the gorge of the St. John River, New Brunswick, ranks among the heaviest and shallowest structures of this type. It is designed to carry the regular city highway traffic, including two lines of street railway, and will eventually replace the old suspension span built in 1852, and shown along the new structure in several of the illustrations. The floor of the new bridge is of reinforced concrete with a creosoted wood block surface, and with concrete slabs for the sidewalks. The latter are 7 feet wide and are partially cantilevered on brackets from the tops chord. Between curbs the roadway measures 36 feet, the trolley poles for the electric railway being placed on the centre line while the lamp posts are incorporated in the railings at either side.

The arch spans across the Reversible Falls and lies between the suspension bridge and the railway cantilever. River traffic being considerable at slack tides, clearance was demanded as nearly as possible equal to that previously existing, consistent with good design and pleasing appearance; and this feature led to the adoption of the flat parabolic spandrel braced arch. The distance between centres of skew back pins is 565 feet, the height between skew back pins and the centre pin in the bottom chord being 61 feet 3 inches. The depth of the trusses is 60 feet at the end posts and 8 feet 6 inches at the centre, and they are spaced 41 feet apart centre to centre.

At each end of the arch there is an approach span of plate girder construction, equal in length to two panels of the main bridge, the total length between abutments thus being 654 feet.

The steel in the structure, including railings and skew back castings, amounts to 2,181 tons.

The span was erected as a cantilever from both ends, and upon the junction being made at the centre, the condition of a three-hinged arch was secured. By the insertion of the centre portion of top chord, accurately fitted and under no stress, all further dead load, such as flooring and minor steel work, as well as live load was carried by the truss as a two-hinged arch. The anchorage during erection was accomplished by connecting a chain of eyebar members to the upper chord and guiding them by inclined shoes at pin points into anchor pits. The pits were excavated to a sufficient depth to secure ample reaction against uplift, chambers were hollowed out at the bottom, and cross-beams and girders served to engage the concrete with which the pits were then filled. By this means the weight and strength of the natural rock were used as anchorage factors, the total uplift in each pit being calculated at about 1,075 tons. Adjustment of the position of the cantilevered truss was made possible by the provision of a toggle arrangement, consisting simply



West End Anchor Bars.
West Arm Cantilevered.

Erection of East Arm.
West Arm from East Bank (showing suspension and railway bridges).

of powerful hydraulic jacks, reacting against the abutment, and capable of lifting that pin point in each eyebar chain which was situated some fifty feet from the arch end post. Two 190-ton jacks for each truss were sufficient for all purposes, including the final adjustments necessary for the insertion of centre pin and centre top chord.

The photographs illustrate the erection progress as carried out last fall and serve also to indicate the character of the site. The uniqueness of the situation is realized when a suspension, a cantilever and an arch bridge are seen side by side.

The new span was built for the province of New Brunswick, the general design being prepared by Mr. C. C. Schneider, of Philadelphia. The Dominion Bridge Company, of Montreal, were the contractors for the supply and erection of steel work, concrete flooring and the wood block pavement. To their recently issued booklet, descriptive of many similar bridges and steel structures, we are indebted for the foregoing information.

OPERATION OF N.T.R.

On May 1st the Government took over the operation of the National Transcontinental Railway from Winnipeg to Moncton, and also the Lake Superior Division of the Grand Trunk Pacific from Superior Junction to Fort William, including the terminals at the latter place. These will be operated under the jurisdiction of the Canadian Government Railways, F. P. Gutelius, general manager.

This procedure is the result of a refusal on the part of the Grand Trunk Pacific to carry out its contract to lease from the Government the line of the N.T.R. By the terms of the contract this was to have been done by the G.T.P. when the line reached completion. It was to have the road for seven years without rental, afterwards paying 3% on the total cost. It is stated that it is this element of cost, which exceeded the original estimate, that has caused the Grand Trunk Pacific to refuse to carry out the contract.

The Grand Trunk Pacific employees on the line between Fort William and Winnipeg will be absorbed into the Government railway's staff, which has under an arrangement with the Department of Railways and Canals, been operating it for the contractors east and west of Cochrane for a distance of about three hundred miles.

The Transcontinental Railway was begun in 1904. The estimated cost was $60,000,000. The last estimate of actual cost is $173,000,000.

St. John Arch Highway Bridge, During Erection, to Replace the Old Suspension Span.

LACKING GOVERNMENT AUTHORIZATION.

Information was received a few days ago to the effect that the Alberta Hydro-Electric Power Co. would shortly proceed with the construction of a series of six dams and power houses at a cost of $2,000,000.

We are advised, however, by the Department of the Interior, Water Power Branch, that the Dominion Government has not authorized any power project in the province of Alberta which will conform in any way to the statement set out above.

The Gatun spillway, Panama Canal, was put to use April 3rd, owing to a heavy rainfall on the Chagres River watershed. Five gates were open part of the time, effecting a maximum discharge of 64,015 sec.-ft.

ALLOYED STEEL RAILS AND JOINT PLATES.

Tests of alloyed steel rails and point plates were recently conducted in the Case School of Applied Science for the Cleveland Railway Company. This company has been using a treated rail for several years, which its maintenance-of-way engineer, Mr. Chas. H. Clark, considers has given satisfactory results, a conclusion which seems to be substantiated by the results of the tests, which are described in a recent issue of "Electric Traction."

Tests were first made to determine the strength of two rails and the joints by bending, each sample, about 6 ft. in length, having a riveted joint. The rails were of different sections and compositions, one being a 95-lb. Lorain Steel Company rail, section No. 400, of 75-90 point carbon, treated with titanium, and the other a 100-lb. A.R.A. Series A open-hearth steel rail, of 65-80 point carbon. The joint plates were of a special section, heat treated, high carbon stock, titanium treated, and the rivets of an alloy steel made by the Lorain Steel Company, known as "Mayari" rivets. All tests were made with a span of about 3 ft., joint in centre of span and load also in centre of span, directly over the joint.

As the form of test piece and method of test put the principal burden on the joint plates and rivets, no attempt was made to verify the rail sections until the later tests were made. Careful measurements were made, however, of the cross-sections of the joint plates, and their area and section modulus were computed.

The two specimens were tested to destruction, the centre loads and deflections being observed and recorded at intervals of about 10,000 lb. Stresses were afterward computed and the elastic limit was determined by plotting, in the usual manner, with the following results:—

Joint Plates	L. S. 95-400 Rail	O. H. 100-lb. A. R. A.
Breaking load	175,590 lb.	180,480 lb.
Maximum stress	121,400 lb. per sq. in.	167,860 lb. per sq. in.
Elastic limit	86,200 lb. per sq. in.	67,860 lb. per sq. in.
Deflection in 3 ft. for load of ½ elastic limit	.05 in.	.075 in.
Loading causing above deflection	51,980 lb.	39,370 lb.
Failure	One plate broke at 139,950 lb., then the other carried 175,500 lb. alone.	Both plates broke simultaneously by tension on bottom.

This indicates that the joint plate of the 95-400 rail, under similar conditions, would be about 12% stronger than that of the 100-lb. section, based upon the elastic limits, and about 30% stiffer under working loads.

Similar tests were later made of two samples of rail of the same sections and compositions as those used in the tests previously described, except that they were without joint.

The results of the last two tests are as follow:

	L. S. 95-400 Rail	O. H. 100-lb. A. R. A. Rail
Breaking load, held	200,000 lb., maximum capacity of testing machine.	
Maximum stress	95,200 lb. per sq. in.	110,900 lb. per sq. in.
Elastic limit	78,000 lb. per sq. in.	68,000 lb. per sq. in.
Deflection in 3 ft. for load of ½ elastic limit	.068 in.	.058 in.
Load causing above deflection	80,730 lb.	59,700 lb.

These figures indicate that under similar conditions the 95-400 rail would be about 11½% stronger than the 100-lb. A.R.A. section, based upon their elastic limits, and that the two rails have about the same stiffness, based on deflections for equal loads.

Abrasion tests of the rail heads were then made. These required considerable special preparation, as this test is an unusual one. The method adopted was to mount a 2-in. long section of the head or wearing surface of the rail in a frame, which held the specimen rigidly, and to slide back and forth over it a carborundum stone of standard hardness and coarseness, the standard adopted being known as a No. 212 rub stone, 40 grit, hardness No. G-6. The stone was loaded with a fixed weight, and was given a fixed length of stroke and speed, 8-in. stroke and 85 r.p.m., so that all variable elements except those inherent in the rails were controlled.

The small pieces of rail were weighed, before and after 1,000 strokes of the stone, and the amount of metal removed was determined to the nearest 50 milligrams. It was found that under this treatment the 95-400 L. S. high carbon titanium treated rail lost 8.10 grams, and the 100-lb. A.R.A. low carbon rail lost 9.80 grams, indicating that under similar conditions the titanium treated high carbon rail is about 12% more resistant to abrasion than is the low carbon rail. This, however, assumes equal sections exposed to wear; but the L.S.-400 rail head is 3 in. wide, while the 100-lb. A.R.A. rail head is only 2¾ in. wide, so that for an equal wearing depth the advantage would be still more in favor of the high carbon rail.

As a check on the information obtained from this test of abrasive hardness, or endurance of wear, it is interesting to note that in cutting off a section of the high carbon rail for the abrasion test 17 hacksaw blades, used in a power hacksaw machine, were worn out, while only four blades were required to remove a section from the low carbon rail. Although the sections are somewhat different, the amount of metal sawed through is nearly the same, the ratio of areas being in the proportions of the weights, 95 to 100; so that from this data it would seem that the high carbon rail is about four times as difficult to abrade as is the low carbon section. This latter information, however, is probably not as reliable as that from the test where all the conditions were controlled.

SAND AND WATER FLOW.

For the purpose of ascertaining the proper ratio of water to sand in discharging mixtures through spigot openings Messrs. B. Dudley and R. H. Richards undertook a series of experiments which they describe in the Transactions for January, 1915, of the American Institute of Mining Engineers. According to the results obtained the apparent viscosity is increased, *i.e.*, the volume rate of flow is diminished by the friction of the sand particles with each other. Three factors govern the rate of discharge, *viz.*, head of water (h), area of opening (a), and viscosity (f). These factors are related by the equation:

$$a = \frac{fq}{c\sqrt{2gh}}$$

where q is the rate of discharge by volume, and c the coefficient of discharge. A table of values for f for different mixtures of sand and water was constructed by experiment, based on the different volume rates of discharge as compared with pure water. The value of c depends on the shape of the orifice, and was taken as 0.88 for a short tube with a conical mouth.

The Canadian Mining Institute is contemplating the organization of an Iron and Steel Section.

A.R.E.A. ACTIVITIES DURING 1915.

THE board of direction of the American Railway Engineering Association has selected its committees for the year. In addition to making critical examination of the subject-matter in the Association's Manual and submitting definite recommendations for changes in it, the respective committees have been assigned the following subjects for investigation and report:—

Committee I.: Roadway.—Continue the study of unit pressures allowable on road-bed of different materials; report on the prevention and cure of water pockets in road-bed.

Committee II.: Ballast.—Report on the economical and efficient depth of ballast; on methods and costs of applying ballast (*a*) by contract, (*b*) mechanical camping and shoulder formings; and on efficiency of various stone and gravel ballasts.

Committee III.: Ties.—Report on the effect of tie plates and track spikes on life of cross-tie; specifications for cross and switch ties; metal, composite and concrete ties.

Committee IV.: Rail.—Report on rail failures, statistics and conclusions; on effect on rail of defective equipment and improper maintenance; continue special investigation of rails; report on track bolts and nut-locks.

Committee V.: Track.—Continue the study of economics of track labor; study the relation between worn flanges and worn switch points, with a view to correcting the causes and decreasing the number of derailments due to the combination of worn switch points and worn flanges on wheels; present specifications and designs for cut and screw-spikes; and, report on guard rails and flangeways and effect of increase of ⅛-inch thickness of wheel flanges.

Committee VI.: Buildings.—Report on coaling stations; on freight house scales; and on ash pits.

Committee VII.: Wooden Bridges and Trestles.—Continue study of design of docks and wharves; report on comparative merits of ballast deck and reinforced concrete trestles; continue study of the use of lag screws in trestle construction.

Committee VIII.: Masonry.—Report on cost and method of constructing concrete piles; on cost, appearance and wearing qualities of surface finish of concrete; on design of foundations for piers, abutments, retaining walls and arches in various soils and depths of water (not including pneumatic foundation).

Committee IX.: Signs, Fences and Crossings.—Report on principles governing the use of railway signs; continue study of concrete fence posts.

Committee X.: Signs and Interlocking.—Continue study of economics of labor in signal maintenance; report on signal installations on single-track roads; present, for approval, specifications adopted by the Railway Signal Association, which, in the judgment of the committee, warrant consideration; requisites for switch indicators, conveying information on condition of the block to conductors and enginemen.

Committee XI.: Records and Accounts.—Report on the use of small forms on cardboard or other suitable material for use of fieldmen in making daily reports, to the end that supervision may be facilitated and efficiency encouraged; continue the study of feasible and useful subdivisions of Interstate Commerce Commission classification accounts 202 and 220, with a view to securing uniformity of labor costs, separating the items in accordance with such forms as are promulgated by the I.C.C. during the year; investigation of methods for reproducing maps and profiles on drawing linen for permanent record.

Committee XII.: Rules and Organization.—Report on clearance for maintenance of way structures under assignment from the Committee on Maintenance of the American Railway Association, conferring with other committees; continue the formulation of rules for the guidance of field parties; continue the study of science of organization.

Committee XIII.: Water Service.—Report on cost of pumping water by various methods; and on protection for water stations against freezing.

Committee XIV.: Yards and Terminals.—Report on handling of freight in double-deck freight houses and cost of operation; continue study of typical situation plans of passenger stations and approaches, and methods of operating same; and continue study of classification yards.

Committee XV.: Iron and Steel Structures.—Continue the study of methods of protection of iron and steel structures against corrosion; of the relative economy of various types of movable bridges; of secondary stresses and impact; and of column tests.

Committee XVI.: Economics of Railway Location.—Establish a rational basis for determining the relative efficiency of various locations; report on effect of curvature on cost of maintenance of way and equipment; on train resistance at speeds exceeding 35 miles per hour; and on fuel consumption per horse-power hour.

Committee XVII.: Wood Preservation.—Continue the study of the effect of water in creosote; the study of the relation of amount of preservative and depth of penetration to the resistance of materials against decay, and also the penetration of preservatives; the compilation of service test records; and report on drying process of wood preservation.

Committee XVIII.: Electricity.—Continue the study of the subject of clearances of third rail and overhead structures, conferring with other committees, and of electrolysis and insulation and its effect upon reinforced concrete structures; report on water power for electrical railway operation; and continue the study of maintenance organization with relation to track structures.

Committee XIX.: Conservation of Natural Resources.—Continue the study of tree planting and general reforestation; present specifications for southern yellow pine, conferring with other committees and associations; continue the study of resources of iron ore, coal, fuel-oil and timber; report on water power for railway electrical operation.

Special Committee: Uniform General Contract Forms.—Report on siding agreements; and on agreement forms for interlocking and railway crossings.

Special Committee: Grading of Lumber.—Report on grading rules for white and Norway pines; specifications for southern yellow pines; and for timber to be treated in co-operation with the committee on wood preservation.

The following names of Canadian railway engineers appear in the personnel of the various committees:—

I.—Roadway: J. R. W. Ambrose, G.T.R., and S. P. Brown, C.N.R.

II.—Ballast: L. W. Baldwin, I.C.R.; I. M. Egan, I.C.R.; Wm. McNab, G.T.R., and D. W. Thrower, I.C.R.

III.—Ties: L. A. Downs (chairman).

IV.—Rail: A. S. Baldwin, I.C.R.; L. C. Fritch, C.N.R., and Howard G. Kelley, G.T.P.

V.—Track: J. M. R. Fairbank, C.P.R.; T. T. Irving, G.T.P.; A. C. Mackenzie, C.P.R.; F. B. Oren, I.C.R., and H. R. Safford, G.T.P.

VII.—Wooden Bridges and Trestles: H. C. Brown, Jr., I.C.R.

VIII.—Masonry: F. L. Thompson (vice-chairman), I.C.R.

IX.—Signs, Fences and Crossings: Arthur Crumpton, G.T.R.; Maro Johnson, I.C.R., and Thomas Quigley, I.C.R.

X.—Signals and Interlocking: W. M. Vandersluis, I.C.R.

XI.—Records and Accounts: J. W. Orrock, C.P.R., and Frank Taylor, C.P.R.

XIV.—Yards and Terminals: W. G. Arn, I.C.R.

XV.—Iron and Steel Structures.—Charles Chandler, I.C.R.; J. M. Johnson, I.C.R.; P. B. Motley, C.P.R., and H. B. Stuart, G.T.P.

XVI.—Economics of Railway Location: John G. Sullivan (chairman), C.P.R.; A. S. Going, G.T.P., and C. W. P. Ramsey, C.P.R.

XVII.—Wood Preservation: E. H. Bowser (vice-chairman), I.C.R.

XVIII.—Electricity: D. J. Brumley, I.C.R.

XIX.—Conservation of Natural Resources: William McNab, G.T.P.; F. F. Busteed, C.P.R., and A. L. Davis, I.C.R.

Stresses in Track: A. S. Baldwin, I.C.R., and William McNab, G.T.P.

H. E. P. C.'s DUPLICATE CONDUIT SYSTEM AT NIAGARA STATION.

IN connection with the Niagara transformer station of the Hydro-Electric Power Commission of Ontario, until last year all the 12,000-volt feeders were placed in one conduit system, and the Commission's report for 1913 referred to the early construction of a duplicate system. During 1914, a private right-of-way was purchased, running in a straight line between the Commission's transformer station and the Ontario Power Co.'s distributing station. The G. M. Gest Co., of Montreal, secured the contract for the construction of the duct line. It is about 1,828 feet long and provided with eight manholes, the longest distance between manholes being 307 feet. The line consists of 12 ducts, two wide and six high, purchased by the Commission from the Clay Products Co., of Brazil, Indiana. These ducts have a minimum square bore of 3⅝ in. with a ¾-in. wall, and after they were laid a 3⅜-in. square steel mandrel 20 in. long was drawn through each duct and a No. 10 B.W.G. iron wire was left in the ducts to be used as a fishing wire when the cables were installed. The ducts were laid closely together and surrounded by 3 in. of concrete on the sides and top and a 4-in. concrete base.

The manholes were constructed of concrete with 7-ft. headroom. The tops consist of 6-in. reinforced concrete slabs, which support the cast-iron manhole frames and covers. This light manhole top construction is made possible by the location of the manholes, which are on private property, where there is no heavy traffic. Each manhole has five 1½-in. by 9-in. shelves on each side for supporting the cables. The spacing between the shelves is 8 in. In some cases 3-in. deep recesses were left in the manhole walls, and the concrete slabs grouted into the recesses after the form work for the walls had been removed, while in other cases the slabs were poured with the walls. This construction assures exceptionally neat appearing manholes. About 12 ft. from manholes the ducts commence to change from the close centre to centre spacing of 5½-in. to a spacing of 9½ in. where they enter the manhole. This allows the cable to leave the duct at the level of and in line with the manhole shelves.

Ten of the twelve ducts are to be used for five power feeders of two cables each, while the other two ducts are to be employed for other small cables that may be required, such as, for instance, telephone, lighting, etc.

The system is drained by means of two 4-in. agricultural tile pipes, laid at each side of the duct run and entering each manhole on a level with a 3-in. gutter in the floor, so that they also drain the manholes. No. 1 and No. 8 manholes are connected to separate drainage systems. In this way the whole system of eight manholes is drained with only two sewer connections.

BRIDGE COMPLETED OVER ST. JOHN RIVER.

ON May 1st a new line of railway 1.36 miles long was opened for traffic in the vicinity of St. Leonard, N.B. It is an interesting piece of construction in that its purpose is to connect three railroads, one of which is a United States line and the other two Canadian. At the same time, it crosses a fourth, a branch line of the Canadian Pacific Railway. The connection is known as the Van Buren Bridge route and starts at a junction at Van Buren with the Bangor and Aroostook Railroad. Of its length 1.19 miles is the property of the bridge company and extends from the United States bank of the St. John River to a connection with the Transcontinental. The new line affords the only connection between Northern Maine and the National Transcontinental Railway.

An article descriptive of the foundation work in connection with the structure appeared in our issue of January 28th, 1915. The river is crossed by a bridge of five single-track, steel riveted, lattice through spans of 160 ft. each, the base of rail being 97 ft. above high water, and 133 ft. above low-water level. The rapidity with which the bridge was constructed is a notable feature. Excavation and substructure work began in September last and was completed during the winter months. To cope with cold weather conditions, the piers were housed and heated with steam piping. In January, steel erection was commenced on the Canadian side of the river, while the last pier of the substructure on the American side was finished early in April, the steel work following immediately upon the piers as they were completed. The cantilever method of erection was used throughout. The principal contractors for the work were: The Cyr Bros. Company, of Walkerville, Me., for the substructure; the Dominion Bridge Co., Montreal, for the superstructure; Hill and Hammond, Woodstock, N.B., for grading and track work, and the General Railway Signal Co. of Canada, Lachine, for the interlocking plant. Mr. Percy R. Todd is president of the Van Buren Bridge Co., and is also president of the Bangor and Aroostook Railway. Mr. W. J. Wilgus, of New York, was consulting engineer on the work.

There are 46 cities and towns in Canada using natural gas, and the average price per 1,000 cubic feet is 33⅓ cents. Edmonton is at present considering an offer of 27 cents per 1,000 cubic feet. Medicine Hat and Redcliffe, Alberta, are the only two cities where natural gas is cheaper than 27 cents.

DRAINAGE OF EARTH ROADS.

DRAINAGE is the key to success in making earth roads, and constant watchfulness is the sure means of keeping them up after they are once well made.

Water is destructive to any road, especially to a dirt road; therefore, drainage that will at once carry away rainfall or melting snow is absolutely necessary. Again, little breaks in the road made by rain or by a heavy load at any time, if not repaired immediately, will grow into mud holes, especially in the fall and spring, and these mud holes easily and rapidly develop into an almost impassable mire. But frequent inspection and a little work will keep the road in good condition, and with less cost than under ordinary methods. With good drainage established in building the road, and frequent inspection to keep the drainage efficient, and to mend promptly small injuries to the surface, earth roads may be maintained in a fairly high state of usefulness, and at a very moderate cost.

The principles to be followed in a successful campaign against the destructive agency of water in earth road maintenance are well defined by Hiram Donkin, road commissioner and provincial engineer of Nova Scotia, in a recently issued bulletin on the subject of earth roads. It is pointed out that earth is more susceptible to the action of water, and more easily softened and moved by it than any other road material, and for this reason too much attention can hardly be given to the drainage of roads. Drainage alone will often change a bad road into a good one, while on the other hand the best road may quickly go to ruin for lack of drainage.

Most country roads are too flat on top to shed water; indeed, in a great many of them the crowns are inverted. The sides of the roads are often square shoulders which obstruct the water on its passage to the side drains, and as a result the water lies on the surface until it is absorbed by the material or evaporated by the sun. It is often allowed to stand in the travelled way until the material softens and yields to the impact of the horses' feet and the action of the wheels of wagons; holes and ruts rapidly increase in number and size; and wagon after wagon sinks deeper and deeper, until the road becomes utterly bad.

On open or pervious soils, surface draining in connection with heavy rolling, is usually quite satisfactory, provided the slope is good and the traffic is not too heavy; but for the close, impervious, alluvial, and clayey soils, subdrainage is sometimes necessary. With heavy traffic, narrow tires, long-continued rains, frosts and thaws, the surface of any dirt road is liable to be completely destroyed in one season, and in this case the remedy is a consolidated mass or crust of gravel or broken stone, forming a roof to keep out and carry off the water.

Surface Drainage.—On ground with good natural under-drainage, as on hillsides, surface ditches are sufficient to carry off surface water from rain or snow. In order to prevent washouts on steep slopes, however, it sometimes becomes necessary to construct water breaks; that is, broad shallow ditches, so arranged as to catch the surface water and carry it each way into the side ditches.

Where a road is constructed and on a hill, the slope from the centre to the sides should be slightly steeper than on the level. The reason for this is that every wheel track on an inclined roadway becomes a channel for carrying down the water, and unless the curvature is sufficient these tracks are quickly deepened into water-courses, which cut into and sometimes destroy the best surface. The slope must be sufficient to lead the water quickly into the side ditches instead of allowing it to flow down the middle of the road. The cross-section, consisting of two plane surfaces sloping uniformly from the centre to the sides, is perhaps a little better for a steep grade than the circular form because of the danger of overturning, which would necessarily be increased if the circular or elliptical cross-section were used. Water should never be permitted to flow long distances or to collect in puddles by the roadside, for it soon sinks into the adjacent soil and softens the foundation of the road. Open drains should not be allowed to become deep and dangerous from neglect of proper outlets. Careful attention should be given to the regularity of the grade and fall of the side ditches. Where the road is built on a steep grade some provision

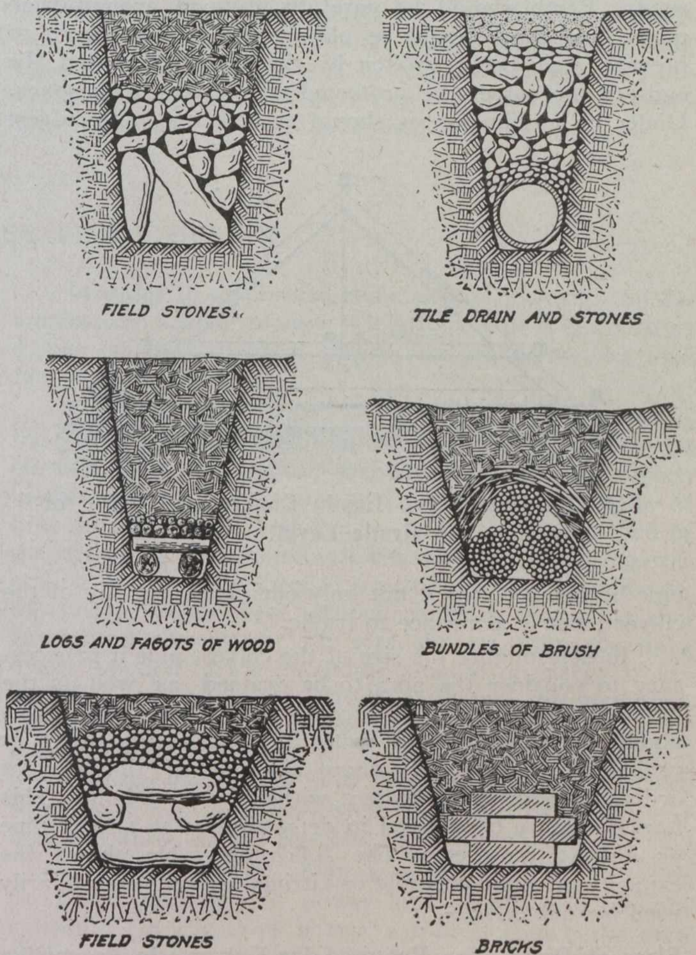


Fig. 1.—Various Types of Subdrains for Earth Roads.

should be made to prevent the washing of the gutters into deep gullies. This can be done by paving the bottoms and sides of the gutters with field stones. In order to make the flow as small as possible in side ditches, it is often advisable to construct frequent outlets into the adjacent fields or streams.

All side ditches should have a gradual fall of at least half a foot in every 100 feet. Their sides, particularly those sloping toward the roadway, should be broad and flaring, so as to prevent accidents as well as the caving in of their banks. Their bottoms should be wide enough to carry the largest amount of water that is likely to flow through them at any one time. Sometimes the only ditches necessary to carry off surface water are those made with the road machine. The blade of the machine may be set at any desired angle, and when drawn along by horses or by a traction engine, it cuts into the surface and spreads the earth uniformly over the travelled way.

Cross Drains.—To drain a road surface properly, water should be gotten rid of before it gains force or headway, or has time to damage the road. It is just as economical, and far more practicable, for the road builder to put in four or five 12-inch culverts at such points as may be found necessary in a mile of roadway, as it is to carry the water along the higher side of the road a mile or more and be compelled to deliver it in a 24-inch culvert.

In the laying of culvert pipes or box drains the upper end or intake should be kept sufficiently high to insure a proper flow of water. The excavation for culvert pipes should be straight and of uniform grade, so as to provide a regular even fall from the upper to the lower side of the road. Earth should be carefully tamped around such pipes, and they should be placed at sufficient depth to prevent their being broken by the traffic, and that the ends of the culvert be protected with concrete masonry. Under no circumstances should a ridge over the culvert

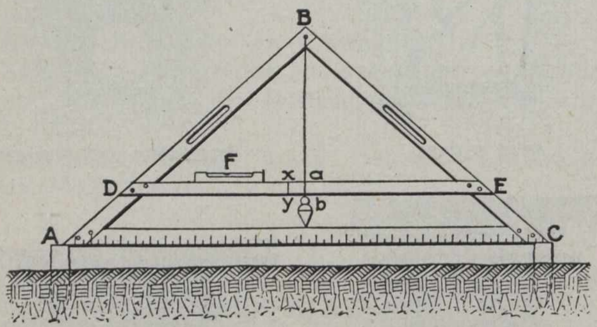


Fig. 2.—Useful and Easily Constructed Form of Grade Level.

pipe be allowed, for it not only endangers the life of the culvert, but is a menace to traffic.

In determining the size of the culvert pipe it is necessary to consider the area to be drained as well as the maximum rainfall. One inch of rainfall per hour gives about 22,600 gallons of water for each acre, and it is probably true that only about one-half of this amount ordinarily reaches the culvert within the same hour. This fact should be considered in determining the size of pipe or culvert required. The following table shows the capacity of round concrete or vitrified clay pipes ordinarily used for culverts:—

Sizes of Drain Pipe Required for Culverts in Proportion to Capacity and Fall.

Diameter, in inches.	3-in. fall per 100 ft. Gal. per min.	6-in. fall per 100 ft. Gal. per min.	9-in. fall per 100 ft. Gal. per min.
6	129	183	224
8	265	375	460
9	355	503	617
10	463	655	803
12	730	1,033	1,273
15	1,282	1,818	2,224
18	2,022	2,860	3,508
24	4,152	6,851	7,202

It will be seen from the above table that as the fall increases the capacity of the pipe is increased in proportion. Observing this principle, it is often possible to decrease the size of the pipe, and by so doing decrease the cost of culverts. For instance, a 24-inch culvert pipe with a fall of only 1 inch in 100 feet has a capacity of about 2,300 gallons per minute, while a pipe of only half that size, when given a fall of 3 feet to the 100, has a capacity of about 2,500 gallons per minute. Fall is therefore a very important factor in disposing of water, but in this connection it should not be overlooked that the greater the inclination of the culvert or pipe the better must be the work of constructing the same, and more precautions against failure of the structure are necessary than in flatter ones.

Concrete Drains and Culverts.—Culvert or bridge construction forms a very important branch of highway improvement. Large sums are often appropriated for this purpose, and frequently these appropriations exceed those made for the actual improvement of the road. Wooden bridges and culverts wear, warp and decay so rapidly under the action of rain, sunshine, frost and traffic that their usefulness is very short, and their maintenance consequently very expensive. Wherever the expenditure will justify, and the materials can be obtained within a short distance, it is much more economical in the long run to use sewer pipe, home-made or manufactured concrete pipe, or stone, brick, or concrete arches to carry the water under the road. These materials are much more durable than timber, and if protected from frost and traffic they can be considered permanent.

Sub-Drainage.—Where a road runs through low, wet lands, or over retentive or clayey soils, drainage is not all that is required. In winter, if water is allowed to remain in the substructure and form a deep frozen crust, the surface is heaved up by frost and destroyed by the wheels of carriages on thawing. If the sub-soil be kept dry, frost has nothing to act upon, and to this end subdrainage is essential. It is undoubtedly true that many of our worst roads could be improved by sub-drains. Subdraining earth roads is neither expensive nor difficult, but, like all other kinds of road work, it takes good judgment. Surface water from side ditches should not be allowed to run into these sub-drains, especially where the grade is flat. Mud and sand will soon be carried in by storm water and stop them up.

Obviously the preventative against damage from frost is to get rid of the water in the foundation of the road, and get rid of it before it has time to soften the substructure, or freeze. For this purpose it is advisable to construct horizontal drains under the roadway, which should empty into the open drains or the natural water courses at frequent intervals. If the road surface is composed of retentive soils, such as fine clay, there should be two or three drains; but if the soil is open or pervious, and if two drains are considered too expensive, one drain along the road three feet from the ditch nearest the higher ground will often be found to suffice.

Depth and Fall of Sub-drains.—The depth to which drains should be laid will depend upon the character of the soil as well as the depth of the frost line. These drains can be placed parallel with the surface of the road in rolling countries, provided they have a fall of not less than three-tenths of a foot to each 100 feet. Outlets into side ditches, or preferably into the adjacent fields or streams, should be provided as often as practicable. The size of the drains will depend upon the distance between outlets as well as the grade of the ditch. Ordinarily if the distance is 500 feet or less, 3-inch pipe will answer. If the distance is greater than that, the size of the tile should be increased about 1 inch in diameter for 400 feet in length. Where roads are practically level, it is sometimes advisable to construct blind ditches of vitrified clay tiles, into which the contents of the sub-drains above mentioned can be discharged. Water can be carried a long distance in well-laid pipes with but little fall. Six or 8-inch pipes can be placed alongside the road, with a fall of 1 inch to the hundred feet, if carefully laid, with the discharge in a river or stream. Such drains can be run several miles with the fall mentioned, and their size increased, if necessary, as they approach the place of discharge.

The greatest care should be exercised in the laying of sub-drains. They should be carefully graded and should have a continuous and even fall throughout their entire length. Great care should be taken not to allow sand and soft earth to be carried in from the surface by storm water as it would soon fill them up.

An intelligent road-master with a home-made level can do the work sufficiently well. If drains are not laid with great care low points are liable to form where the mud and sand will collect and reduce the flow, and finally choke the drains altogether. In some places after the drains have been carefully laid, inch boards should be laid under tile and the ditch should then be half filled with rough, broken stones, or if no stones are available, with broken gravel, cinders, or some other imperishable material. A little hay, sod, or brush packed around the tile to prevent silt from washing in and clogging the drains will be useful. The ditch can then be tamped full of firm earth. Care should be exercised in keeping the drains open and unobstructed at outlets. Under-drains are useless unless outlets are provided; for if the outlet is obstructed the water is kept standing in the drains until it soaks in and softens the foundation.

A grade level of light planed boards may easily be made, as shown in Fig. 2. To establish a 5% grade, for example, bring the instrument to a level along the line of the drain by use of spirit level F; mark centre a b; then raise the up-drain end through a distance one-twentieth of the length of the base line A C. The plumb line will cross the board D E in some line away from the centre a b. Mark this crossing as x y. The same grade can then be found at any point in the drain by levelling till plumb line crosses at a b, and then raising the up-drain end till the plumb line crosses again at x y. A uniform grade can thus be maintained.

HYDRO-ELECTRIC POWER PLANT DESIGN.

The general hydraulic problems relating to the design of hydro-electric power plants from the standpoint of the engineer in charge of the complete undertaking is the subject of a paper to be delivered on May 19th, at a meeting of the American Society of Civil Engineers, by Mr. J. D. Galloway. The author deals with (1) the conditions affecting the design of plants, (2) the conduit, (3) the penstock pipes, and (4) the station design. The following notes respecting the first consideration, *i.e.*, general conditions, are reproduced herewith. It is to be pointed out that the paper does not refer to the development of water supply or storage, to the details of design of water wheels, nor to the electrical features of the proposed installation. Further hydro-electric developments cover ranges in head of water from 10 up to 3,000 ft. or more. Although there are many differences of detail, the essential features are the same in all cases. Some of the problems of high-head plants are absent from those of low heads, and for this reason the author dwells more at length on the subject of high-head design.

The first general condition considered by Mr. Galloway is the load factor. By this term is meant the ratio between the average power demand and the maximum or peak demand during any period in which a cycle of events is gone through, generally a day. A lighting load factor may be from 15 to 25%, that of a street car system 50%, and that of a mill or a mine, running night and day, 80 to 90%. A large power system has a factor which is the composite of all its separate load factors. Such factors vary considerably, as shown by Table I.

Table I.—Load Factors.

Niagara Falls Power Company	81.0%
Commonwealth Edison Company, Chicago	40.0%
New York Edison Company	34.7%
Philadelphia Electric Company	34.4%
Boston Edison Company	32.5%
Pacific Gas and Electric Company, California	59.0%
Great Western Power Company, California	70.0%
Sierra and San Francisco Power Co., California	50.0%
Pacific Light and Power Company, California	47.8%
Los Angeles Gas and Electric Co., California	40.0%

In order to emphasize some points of design by examples, the author chooses a load factor of 50% and uses a load curve of a street car system producing this load factor for illustration.

The load factor affects all parts of the design, and is the governing condition in many cases. The water at an elevation contains a certain amount of energy, static when in the reservoir. This energy is carried by the water at first through canals and flumes, or by the natural bed of the stream, is transmuted into electric energy at the power station, and in this form is transmitted to a distance by the lines. In all these various conduits containing and conducting the energy, the size and resulting cost is a direct function of the maximum amount of energy transmitted at any one time. Hence it is that the maximum demand fixes the size and cost of the conductors. As the average flow of energy is a measure of the resulting revenue, the load factor is of vital importance in the design, as it may be shown that a projected development may be unprofitable if the load factor is too low.

The possibility of using a reserve steam station to carry the peak of the power load should also be considered. On Fig. 1 is shown a typical load curve of a street car system, the changes in the curve being taken by hours. The load factor of the curve is 50% and the power developed at any one time is shown as a percentage of the peak load. If the peak load is carried by the hydro-electric station, the entire equipment must be designed with reference to the maximum output. If, on the other hand, a reserve steam station is installed for emergencies, then use can be made of this station to reduce the peak on the hydro-electric station, or, in other words, to raise its load factor.

By allowing the steam station to take 40% of the system peak, the hydro-electric station must carry 60% of the peak. In this case the steam station generates some of the energy, and if a given quantity of water is available for the hydro-electric station, the total energy delivered by the two plants is increased over that of the hydro-electric station by the small amount generated at the steam station during peak load. On the curve in question, the hydro-electric station, by carrying 60% of the system peak, gains a load factor of 75% and at the same time generates 90.6% of the total energy. The steam station carries 40% of the peak, has a daily load factor of 11.75%, and generates 9.4% of the total energy.

In such a system as this, if the hydro-electric plant has an average capacity of 15,000 kw., the peak load on a load factor of 75% is 20,000 kw.; but if the load factor is reduced to 50%, as given for the entire system, the peak load becomes 30,000 kw. This would require, in the latter case, an addition of 10,000 kw. of installation more than that necessary for a load factor of 75%. As this addition of installation affects the design and size of pipe lines, water-wheels, generators, transformers, and transmission lines, a large difference in cost is represented by the difference of 10,000 kw. At $100 per kw., this would amount to a difference of $1,000,000, which would build, under modern conditions, a steam plant of 20,000 kw., or as large as would be necessary in such an installation, as an emergency plant. The additional cost of operation, over the standby charges, would be slight, and is represented practically by the fuel. For this there is compensation in the sale of the steam-generated energy.

These statements would be varied by every different kind of load curve, but in general they remain true. Depending on the form of the curve, and with present fuel prices, it can be shown that when a hydro-electric plant, with an ordinary length of transmission line requires (for continued operation) to be supplemented by a steam plant, it is the best practice to operate the steam plant over the peak and raise the load factor on the hydro-electric plant up to the neighborhood of from 60 to 75%.

A further requirement for raising the load factor at the hydro-electric plant is derived from the operation of the transmission line. The energy transmitted varies directly as the current, and the electrical losses vary as the square of the current. On a load factor of 50%, the energy transmitted at peak load is twice that at average load, at which time the losses would be approximately four times that of average load. On a 75% load factor, the losses at peak would be less than twice those at the average.

This entire subject becomes one where the conditions surrounding each particular case must govern. It is mentioned here as a major point affecting the design of hydro-electric plants.

The Rules of Economy.—The first rule of economy is that, in any given installation, the design should be governed by the consideration that the amount of the investment should be the least possible within the limits of good construction, other things being equal. In some cases where there is an abundance of water, it is not necessary to strive for the highest efficiency of the various parts, as the losses are not vital. This statement is true during a large part of the year in most plants, but, as a general rule, the power developed is measured by the minimum flow of water, and hence the economy of design holds true.

The second rule of economical design can be stated as follows: Any conduit carrying energy satisfies the requirement of minimum cost when the sum of the annual cost of conduit plus the value of the energy annually lost is a minimum. This rule governs all the conduits of the energy: ditches, flumes, tunnels, pipes, and transmission lines. Considerable latitude is possible in any design, without departing far from the rule, and here the governing factor is to reduce the cost of the investment to a minimum.

The Value of Power.—In applying the rule of economy, the value is not that for which it is sold. It is the cost alone that measures the value as far as design of parts is concerned. If the design is made on this basis, it will be properly proportioned to the actual sale value of the energy.

The value of the energy at any place is a variable, depending on the position it then occupies in the course of its transmission from the source to the place of use. Judged by cost, the energy in water as it falls has no value. At the intake of the conduit it has a value depending on the value of water rights, cost of storage dams, and the diverting dam. At the end of the conduit the value of the contained energy has been increased by the cost of the conduit and regulating reservoir. At the high-tension bus-bars the value has been further increased by the cost of penstocks and power-station equipment, and, at the delivery end, there has been added the cost of the transmission line and the sub-station. A corollary of this proposition is: If money is to be spent to save energy by reducing losses, it should be apportioned, not along the

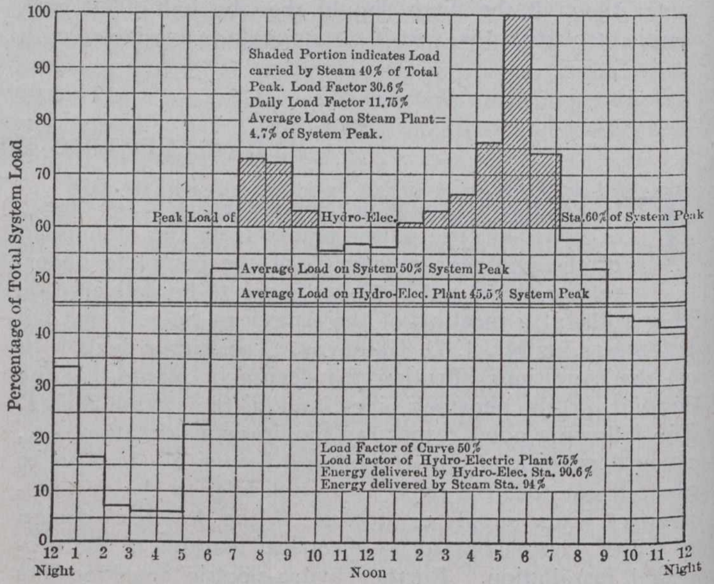


Fig. 1.—Load Curve Illustrating Load Factors and Influence of the Operation of an Auxiliary Steam Plant.

course, but near the receiving end. If a given sum of money will save a given amount of energy otherwise lost, it is much better to apply it at the receiving end. If applied near the origin, say, on the conduit, the energy saved must be transmitted through all the other parts of the system along the entire course. It must also be borne in mind that the amount of energy conveyed grows constantly less by losses, and is decreased to about 60% of the original amount at the receiving end.

In practice it is impossible to know the cost before the design is prepared, and assumptions must be made. If the cost of an installation is such that the resulting cost of energy amounts to 0.5 cent per kw.-hour, the values may be apportioned at 0.2 cent for the conduit calculations, 0.3 cent for the penstocks, and 0.4 cent for the transmission line. Such values will give results of sufficient accuracy.

FAIR WAGE CLAUSE IN ONTARIO GOVERNMENT CONTRACTS.

The Minister of Public Works of the Province of Ontario has announced that the government will in future place the fair wage clause in all contracts arranged under that department.

Editorial

ACTIVITIES IN CALGARY OIL FIELDS.

It is just a year ago since oil was struck about 40 miles southeast of Calgary, and the surrounding country in the following summer experienced unprecedented excitement in the shape of an oil boom which received its quietus only through the outbreak of hostilities in Europe. In three months following the discovery of oil about 450 oil companies were organized with a nominal capitalization of half a billion dollars. Out of the 450 organized companies about 45 have actually carried on boring operations, and five of these have shown genuine and valuable discoveries of oil. This represents the work that has been done in the Calgary field during the past year. It is not yet on a producing basis.

INDUSTRIAL RESEARCH A MIGHTY FACTOR.

Samuel Butler said that life is the art of drawing sufficient conclusions from insufficient premises.

The thin veneer of German civilization and its absolute subservience to militarism as evidenced by the baseness of its belligerent methods and its disregard for lives and property of non-combatants, of neutrality and of treaties, have astounded us and the rest of the world; yet we cannot forget or entertain disrespect for German industrial development.

Among the various causes contributing to the latter a thorough and widely diffused technical education must be given an important place. The branches of industry in which Germany has acquired a dominant position are those in which advanced applications of science are most necessary. The German government clearly recognized the interdependence of science and industry and the duty of the state to assist industry in matters beyond private initiative. Large amounts were spent by the government in providing the highest type of technical instruction and elaborately equipped state research laboratories. A single but significant example of German confidence in scientific principles may be borrowed, for illustration, from the chemical industries, which generally involve a good deal of mechanical engineering. Baeyer discovered synthetic indigo in 1880, but nearly 20 years and nearly $5,000,000 were spent in research before commercial synthetic indigo was placed on the market. What the discovery did to the natural indigo industry is an old story.

This was an instance immensely creditable to German faith in science. Our electrical engineers can tell us of the extensive degree to which Germany met the world's demand for porcelain insulators, before the war began. Germany's practical monopoly of the treatment of the complex ores of the baser metals is well known to our metallurgists. There are many other similar cases in which Germany had no natural advantages over other nations, but only a greater scientific intelligence and greater confidence of financiers in supporting scientific advisers.

While we loathe German militarism and national dishonor, German research and industry have provided a lesson which Canada should take seriously to heart.

FUTURE STEEL RAIL DEVELOPMENT.

The present status of the steel railway problem may be stated to consist of making all rails of a lot uniformly satisfactory. For the present, at least, the problem is not so much to improve the average quality, but to effectively eliminate the defective rails. Most of the defective rails, from the standpoint of rail failures, may be divided into three classes: (1) Those with excessive segregation of carbon and phosphorus; (2) those with seams in the base; (3) those with internal fissures.

Excessive segregation is to be avoided by using steel, well deoxidized with suitable amounts of silicon, titanium or aluminum. Such steel, however, pipes deeply, and the full advantage of such steel requires the commercial development for rails of some "liquid-top" or "sink-head" process of casting the ingot. The avoidance of seams requires a close study of ingot casting to avoid surface cracks and a close study of the details of rolling the bloom, or of removing seams before the final finishing pass. The manufacturers have already done much in the last few years to eliminate these two types of defect, and the future promises much further improvement if well followed up. The third type of failure, internal fissures, is still a big conundrum, but the outlines of the problem are slowly becoming more distinct, and much may confidently be hoped for under suitable investigation.

In the development and improvement of steel rails during the last few years, the work of the Rail Committee of the American Railway Engineering Association has played an important part. The purpose has been to present reliable fundamental information that would serve as a secure foundation and safe guide for work of improvement and invention by the mills and railroads, and in this way avoid making mistakes on a large and expensive scale, as has sometimes been done in the past. At the present time about 1¼ per cent. of the rails made are removed from track as failed rails (although probably only a small part of these cause disaster to trains), but with the continued activity of all agencies we may well hope to reduce the number of rail failures to a small part of what they now are. After this has been done, attention should then be given to the matter of increasing the resistance of the rail to wear.

REPORT ON POWER CONSUMPTION IN CANADA.

The Commission of Conservation is busy compiling data respecting the power used in Canada. The importance to power users and manufacturers of such an inventory should be readily recognized. The more complete it is, the more valuable the report will be to them and to Canada as a part of the British Empire.

The requested information regarding plant operation and power consumption should be carefully and accurately set forth on the forms provided by the Commission, and returned, without delay, to Ottawa. A second blank has just been sent to those who overlooked the first one. The report is now in preparation.

CANADIAN PEAT RESOURCES AND THEIR POSSIBILITIES.

Sulphate of ammonia, the chief by-product of European peat plants, is a valuable fertilizer worth about $60 per ton. The world's production last year is estimated at 1,365,000 tons, worth about $80,000,000. The chief importing countries are, according to the Journal of the Canadian Peat Society, as follows, the figures representing excess of consumption over production:—

	Tons.	Value.
United States and Canada ...	58,000	$ 3,500,000
Japan	115,000	7,000,000
Java	57,000	3,500,000
France	15,000	900,000
Spain and Portugal	42,000	2,500,000
Italy	15,000	900,000
	302,000	$18,300,000

Of these amounts the portion supplied by Germany and Austria was:—

	Tons.	Value.
Germany	90,000	$5,400,000
Austria	30,000	1,800,000
	120,000	$7,200,000

These figures show the existence of extensive markets which might be supplied, in part at least, by Canada, and of an opportunity to capture some share of the trade of Germany and Austria in this product.

The extent and rapid growth of the domestic market for artificial fertilizers is shown by the following statement of Canadian imports for 1902 and 1903 and the past six years:—

Year.	Value.	Year.	Value.
1902	$ 84,996	1910	$548,493
1903	112,256	1911	586,453
1908	403,171	1912	620,147
1909	529,660	1913	737,656

Many Canadian peat bogs are rich in nitrogen, and therefore suitable for this industry, and enquiries have already been made by British capitalists with a view to establishing chemical works in Canada, provided that a sufficient supply of peat can be guaranteed.

OPACITY OF BACTERIAL SUSPENSIONS.

In an article appearing in the January, 1915, issue of The Indian Journal of Medical Research, Major H. C. Brown and Capt. E. W. O'G. Kerwan deal with the standardization of bacterial suspensions by opacity. The following aspects of the subject are dwelt upon: (1) The relation of opacity to the weight of dried organisms contained in a known volume of bacterial suspension; (2) the variability of different organisms in this respect; (3) the relation of the opacity of a bacterial suspension to the number of organisms contained therein. The authors endeavored in the first place to prepare some chemical emulsion, the opacity of which would remain constant. This was a 1 per cent. suspension of barium sulphate in a 1 per cent. aqueous sodium citrate solution, diluted as required to form a standard opacity tube. It was found that the size of the organisms has some effect on the opacity of a given weight. A numerical equivalent was made by direct count of Staphylococcus aureus, which was proved to give concordant figures.

BACTERIOLOGICAL STANDARD FOR DRINKING WATER.

THE following are the maximum limits of permissible bacteriological impurity in drinking water, as adopted by the U.S. Treasury Department, in connection with the supply to the public by common carriers engaged in interstate traffic:—

1. The total number of bacteria developing on standard agar plates, incubated 24 hours at 37 degrees C., shall not exceed 100 per cubic centimeter. Provided, that the estimate shall be made from not less than two plates, showing such numbers and distribution of colonies as to indicate that the estimate is reliable and accurate.

2. Not more than one out of five 10 cc. portions of any sample examined shall show the presence of organisms of the bacillus coli group when tested as follows:

(*a*) Five 10 cc. portions of each sample tested shall be planted, each in a fermentation tube containing not less than 30 cc. of lactose peptone broth. These shall be incubated 48 hours at 37 degrees C. and observed to note gas formation.

(*b*) From each tube showing gas, more than 5 per cent. of the closed arm of fermentation tube, plates shall be made after 48 hours' incubation, upon lactose litmus agar or Endo's medium.

(*c*) When plate colonies resembling B. coli develop upon either of these plate media within 24 hours, a well-isolated characteristic colony shall be fished and transplanted into a lactose-broth fermentation tube, which shall be incubated at 37 degrees C. for 48 hours.

For the purposes of enforcing any regulations which may be based upon these recommendations the following may be considered sufficient evidence of the presence of organisms of the Bacillus coli group.

Formation of gas in fermentation tube containing original sample of water (*a*).

Development of acid-forming colonies on lactose litmus agar plates or bright red colonies on Endo's medium plates, when plates are prepared as directed above under (*b*).

The formation of gas, occupying 10 per cent. or more of closed arm of fermentation tube, in lactose peptone broth fermentation tube inoculated with colony fished from 24-hour lactose litmus agar or Endo's medium plate.

These steps are selected with reference to demonstrating the presence on the samples examined of aerobic lactose-fermenting organisms.

3. It is recommended, as a routine procedure, that in addition to five 10 cc. portions, one 1 cc. portion, and one 0.1 cc. portion of each sample examined be planted in a lactose peptone broth fermentation tube, in order to demonstrate more fully the extent of pollution in grossly polluted samples.

4. It is recommended that in the above-designated tests the culture media and methods used shall be in accordance with the specifications of the committee on standard methods of water analysis of the American Public Health Association.

It is pointed out, in connection with the above recommendations, that such supplies constitute a special case because of the following reasons:—

(1) The supplies come from widely diversified and mixed sources.

(2) Samples taken from common carriers represent waters stored for various lengths of time under varying conditions.

(3) In view of the impossibility of accurately ascertaining the source and history of each supply examined reliance must be placed upon results of laboratory examination to a greater extent than is necessary or justified in estimating the quality of a supply from a known source with a known history.

CANADIAN TELEPHONE STATISTICS.

THE Deputy Minister of the Department of Railways and Canals, A. W. Campbell, Esq., C.E., has recently issued his report on the telephone interests of Canada for the year ended June 30, 1914. The report shows a steady growth, and also a distinctly noticeable movement, when compared with reports of previous years, toward the consolidation and centralization of telephone interests in populous communities, particularly in the province of Ontario.

A total of 1,136 telephone organizations made returns for 1914, as compared with 1,075 organizations in the previous year.

The number of miles of telephone wire in use in 1914 was 1,343,090.07—an increase of 250,503.30 as compared with 1913. This wire mileage for 1914 was divided as follows: Urban, 962,947.49; rural, 380,142.58. There was 1 mile of telephone wire in use for every 6.0 of the population, as against 6.8 in the preceding year. (The population of Canada on March 31, 1914, was estimated by the Census Office to be 8,075,000.)

The number of telephones in use was 521,144, representing a gain of 57,473 over 1913. There was one telephone in use for every 15.5 of the population, which places Canada in a foremost position among the nations with respect to telephone service. Only one other country, the United States, is known to have as large a number of telephones in use on the basis of population.

The wire mileage for 1913 and 1914 was divided into classes as follows:—

1913.

Classes of wire.	Urban. Miles.	Rural. Miles.	Total. Miles.
Galvanized	40,296.02	282,906.76	323,202.78
Copper	12,837.02	50,140.41	62,977.43
Cable: overhead ..	274,136.03	3,811.25	277,947.28
underground	425,138.45	92.00	425,230.45
submarine..	3,180.00	48.83	3,228.83
Total	755,587.52	336,999.25	1,092,586.77

1914.

Classes of wire.	Urban. Miles.	Rural. Miles.	Total. Miles.
Galvanized	43,550.61	322,225.17	365,775.78
Copper	14,330.41	48,629.23	62,959.64
Cable: overhead ..	340,388.08	8,148.29	348,536.37
underground	563,431.84	251.00	563,682.84
submarine..	1,246.55	888.89	2,135.44
Total	962,947.49	380,142.58	1,343,090.07

In addition to the internal elevators now in operation at Saskatoon (3,500,000 bu.) and Moose Jaw (3,500,000 bu.) the Calgary elevator (2 500,000 bu.) will be ready for next crop, according to a recent announcement by Sir George Foster.

COAST TO COAST

Moose Jaw, Sask.—The construction of storm sewers, costing $26,440, has just been completed by the city.

Berlin, Ont.—The new incinerating plant, described recently in *The Canadian Engineer*, has been placed in operation and is giving good satisfaction.

Edmonton, Alta.—The Canadian Northern Railway has nearly a thousand men engaged on ballasting the main line west of this city. A number of small steel bridges will also be erected shortly.

Sarnia, Ont.—It is stated that at present the new waterworks system at Point Edward is supplying only about one-fourth of the demand. Steps are now being taken to effect a better flow of water into the infiltration basins.

Vancouver, B.C.—Two sections of the recently completed Connaught bridge over False Creek were damaged by fire on April 29th, effecting enormous inconvenience to traffic. The damage to the structure was estimated at $50,000.

St. Thomas, Ont.—It is reported that a meeting of municipal representatives in Essex County is to be held with a view to organizing under the name of The Essex County Hydro-Radial Association. There is in view a project to purchase the Pere Marquette Railway between Windsor and London and to electrify it.

Brantford, Ont.—Work on the Lake Erie & Northern Railway south of Brantford, on the line to Port Dover, is being rushed. Track-laying started on May 6th at Simcoe and Mount Pleasant, while a steam shovel has been started on the grading at Simcoe. It is expected that the ballasting of these sections of the line will be started within thirty days.

Toronto, Ont.—On the Don section of the Bloor Street Viaduct some 225 men are at present employed by Messrs. Quinlan and Robertson, the contractors. One abutment has been finished. Work is well advanced on another and several others are under way. It is expected that the substructure will be completed this summer, so that steel construction may advance during cold weather.

Victoria, B.C.—It is intended to have a formal opening of the Sooke Lake Water Supply System during the convention of the Union of Canadian Municipalities, to have been held in Victoria during July. The convention has been cancelled, however, and the ceremonies relating to the waterworks system will necessarily require alteration. It it expected that the work will be completed next month.

Brockville, Ont.—The town has been advised by Dr. J. W. S. McCullough, chief officer of the Provincial Board of Health, that the proposed intake pipe will not meet with the approval of the Board unless a filtration plant is simultaneously proceeded with, and measures also taken to divert sewage from above the pumping station. Tenders have been called for the construction of the mechanical filtration plant and close on May 17th.

Brantford, Ont.—The electrification of the Lake Erie and Northern Railway between Brantford and Lake Erie has been the subject of controversy between the city and the C.P.R. A proposal was made by which the city should hand over the Grand Valley Railway between Paris and Galt, in return for the electrification. It is reported that the city refused, however, and further negotiations are being carried on concerning the purchase of that section of the city's municipal road by the C.P.R.

PERSONAL

WM. O'HALLORAN succeeds Mr. John Morris as engineer of the waterworks and electric light system of the town of Newmarket, Ont.

WILLIAM C. SEALEY, of Toronto, has been appointed master mechanic of Ontario Lines of the Grand Trunk Railway System, succeeding Mr. James Markey, deceased.

T. I. CLARSON, industrial engineer of the light and power department of the city of Winnipeg, severed his connection with the city recently to join the flying corps of the British army.

R. S. RICHARDSON, assistant superintendent of the Intercolonial Railway at Moncton, N.B., has been transferred by the Canadian Government Railways System to the Winnipeg section of the National Transcontinental Railway.

CLAUDE A. BULKELEY has accepted the position of chief consulting engineer with the Canadian Domestic Engineering Company, Limited, Montreal. Until recently Mr. Bulkeley practised consulting mechanical and electrical engineering in New York City.

F. M. RUTTER has been appointed assistant superintendent of the Intercolonial Railway with headquarters Railway. He has been in the employ of the C.P.R. since 1902, and has been engaged on both construction and maintenance work at Woodstock, N.B.; Montreal and Toronto.

F. P. BRADY, who has been general superintendent of the I.C.R. at Moncton for the past eight or ten years, has been appointed general superintendent of the National Transcontinental Railway, between Quebec and Winnipeg, and the Lake Superior branch of the Grand Trunk Pacific Railway between Fort William and Superior Junction, with headquarters at Cochrane, Ont.

J. K. McNILLIE, of Montreal, has been appointed general superintendent of the I.C.R., the Prince Edward Island Railway, and the National Transcontinental Railway east of Quebec, with headquarters at Moncton, N.B., succeeding Mr. F. P. Brady. Mr. McNillie started his railway career with the Grand Trunk and in 1896 went with the C.P.R. for District No. 3, of which he has been superintendent for several years.

Dr. J. A. L. WADDELL, a graduate of McGill University, and for many years a prominent consulting engineer with offices at Kansas City, Mo., has received the degree of Hakushi from the Department of Education of Japan. This is the highest scholastic honor in the gift of the Department, and denotes "Doctor of Engineering." Dr. Waddell, who is a Canadian, holds similar honorary degrees from a number of universities.

OBITUARY.

The death occurred last week of Mr. T. Harry Mace, who, for a number of years, had a consulting engineering practice in Toronto. Some little time ago Mr. Mace became associated with the patent office of the Dominion Government at Ottawa. Deceased was a member of the 3rd Field Company, Canadian Engineers.

Among the Canadian passengers on the "Lusitania" was Mr. James Barr, a mechanical engineer of the Works Department, city of Toronto. Mr. and Mrs. Barr were proceeding on a visit to relatives in England. As no word of their safety has been received up to time of writing it is gravely feared that they are among the lost.

ENGINEERS ON HUDSON BAY RAILWAY.

The following is a list of engineers on the six divisions of the Hudson Bay Railway:—

The Pas—J. P. Gordon, assistant chief engineer; T. B. Campbell, division engineer; W. T. Jamieson, resident engineer.

Division 2, Goose Lake, Mile 137—W. J. D. Reed-Lewis, division engineer; A. M. Hanson, resident engineer; A. McNaughton, resident engineer; W. W. Christopherson, resident engineer.

Division 3, Landing River, Mile 280—F. P. Moffat, division engineer; F. L. Lloyd, resident engineer; S. Hett, resident engineer; L. Johnson, resident engineer.

Division 4, Landing River, Mile 280—A. Timbrell, division engineer; J. Scott, resident engineer; W. A. McCarthy, resident engineer; G. C. P. Montizambert, resident engineer; R. L. Fairbanks, resident engineer; J. Strachan, Jr., resident engineer.

Division 5, Kettle Rapids, Mile 332—L. F. Silcox, division engineer; W. A. Hillman, resident engineer; J. L. Charles, resident engineer; J. S. Fraser, resident engineer; B. Henderson, resident engineer; F. E. Mathews, resident engineer.

Division 6, Kismagistakum, Mile 393—G. H. Parker, division engineer; H. McNeil, resident engineer; L. Easton, resident engineer.

COMING MEETINGS.

NATIONAL CONFERENCE ON CITY PLANNING.—June 7-9. This year's Conference to be held in Detroit, Mich. Secretary, Flavel Shurtleff, 19 Congress Street, Boston, Mass.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.—Annual meeting to be held at the Iowa State College, Ames, Iowa, June 22nd to 25th, 1915. Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Annual meeting to be held in Atlantic City, N.J., June 22nd to 26th. Secretary, Prof. E. Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—Annual convention to be held in San Francisco, Cal., September 16th to 18th, 1915. Secretary, Charles Warren Hunt, 220 West 57th Street, New York.

INTERNATIONAL ENGINEERING CONGRESS.—To be held in San Francisco, Cal., September 20th to 25th, 1915. Secretary, W. A. Catell, Foxcroft Building, San Francisco, Cal.

AMERICAN FORESTRY ASSOCIATION.—Special meeting to be held on October 20th at the Panama-Pacific International Exposition, San Francisco, Cal. Secretary, P. S. Ridsdale, Washington, D.C.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.—Annual convention to be held in San Francisco, Cal., October 4th to 8th, 1915. Secretary, E. B. Burritt, 29 West 39th Street, New York.