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CALCULATIONS FOR THE STABILITY AND DISPLACEMENT OF GRAVING DOCKS

By **LEONARD GODDAY, C.E. and M.E.**

Late of the British Admiralty.

In dock construction there are several important points to be carefully taken into account and calculated in determining the section of the walls and bottom, viz., the pressure of the ground according to its composition or water, as the case may be, against the walls, and also the upward pressure of water against the bottom.

There is also the displacement of the dock itself, which is most essential to take into account when the sub-soil is saturated. This is nearly always the case when a dock is constructed at the entrance of a river, because the land is generally swampy and consequently filled up to the required level, and it follows that made-up ground has to be dealt with.

These methods of working were for a graving dock, carried out some years back in the old country, and the section had to be rather heavy on account of the soft nature of the ground to some depth.

The preliminary step is to decide upon the interior dimensions so that it will be large enough for the largest ship likely to be built in the future, such as length, breadth and depth.

Next, draw a section of the walls which are estimated with experience, to about the right section that will serve as a basis to start calculations, which will determine whether they can be lighter or heavier, as the case may be, and which is governed to a great extent by the displacement of the dock.

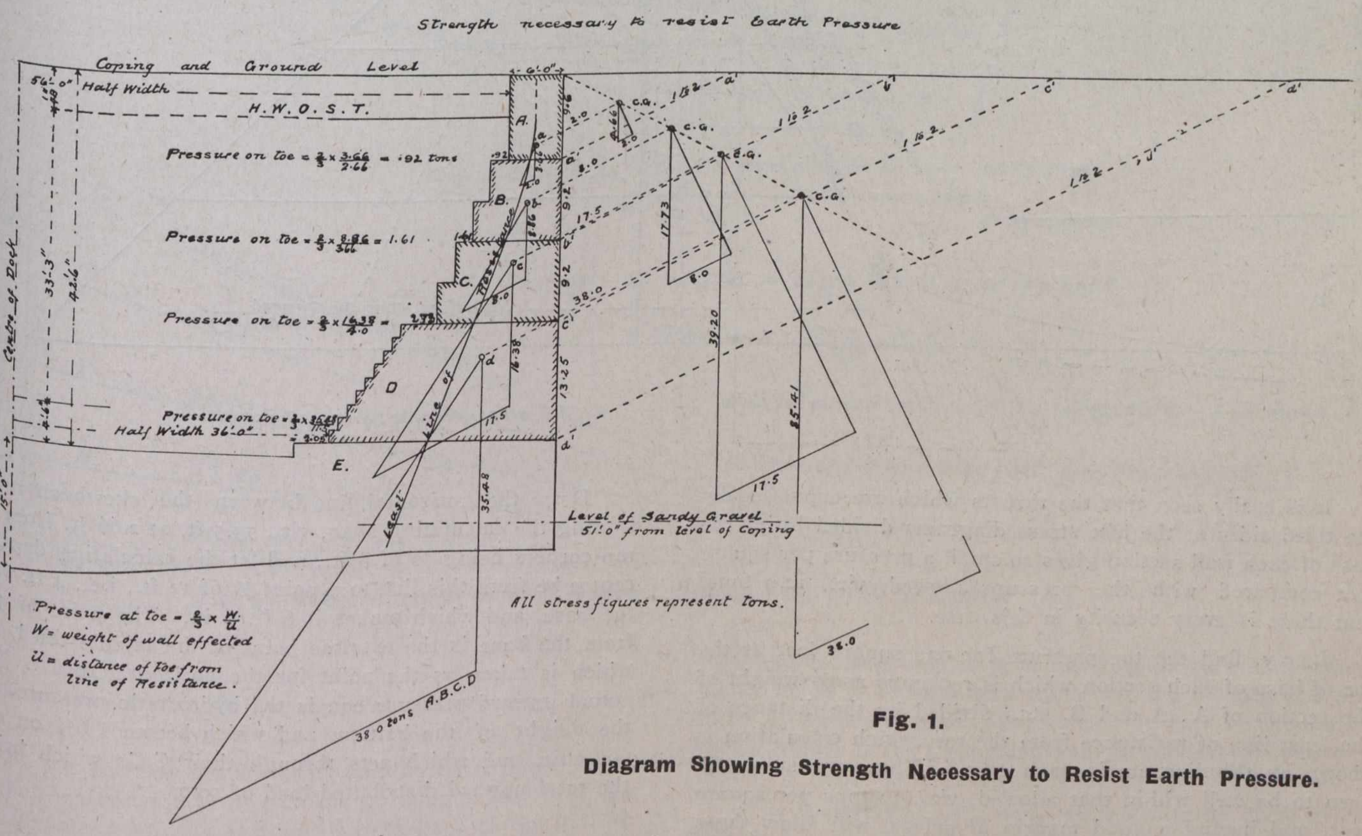

Fig. 1.

Diagram Showing Strength Necessary to Resist Earth Pressure.

Starting with the diagram (Fig. 1) for earth pressure, the wall section was divided and lettered A, B, C, D, etc., as shown. The angle of rest was taken as 2 to 1 for earth. The sections calculated are always taken as 1 ft. wide for convenience, as any length required will always be a multiple of this. The weights given are always in tons.

To begin, find the weights of A, A and B, A, B and C, and A, B, C and D, and which are 3.66; 8.86; 16.38 and

35.48 respectively. Similarly find the weights of earth prisms which are 4.66, 17.53, 39.20, and 85.41, and C.Gs of the prisms of earthwork which press against the sections of walls respectively, as mentioned, and whose angles of rest are represented by the lines a′a′, b′b′, c′c′, and d′d′. From the C.Gs of these four prisms draw the stress diagrams, as shown, having their weights as data, and from these C.Gs draw lines parallel to the angle of rest until they cut the vertical lines drawn through the C.Gs of the wall sections. From these points of intersection construct the stress diagrams, as shown with the weights of the wall sections and earth thrusts found by the first stress diagrams as data.

Through the points of intersection of the third sides of these last stress diagrams, and the base of each wall section draw in the curve which is the least line of resistance.

representing their pressures, viz., 1.3, 4.9, 11.2 and 24.0 until they cut the vertical lines drawn through the C.Gs of the wall sections, as in the last case. From these points of intersection construct the stress diagrams, as shown, with the weights of the wall and the hydrostatic pressures as data. Through the points of intersection of the third sides of these last stress diagrams, and the base of each wall section draw in the curve which is the least line of resistance. It will be seen that the pressure per square foot on the base of each wall section, as in the case for earth pressure, leaves a good margin of safety.

The next step is to make a trial calculation for the bottom, which was drawn to a thickness of 12 feet at centre in diagram in Fig. 4, and the radius of the extrados as 14 feet, the depth at the skewbacks A and B became 8 feet.

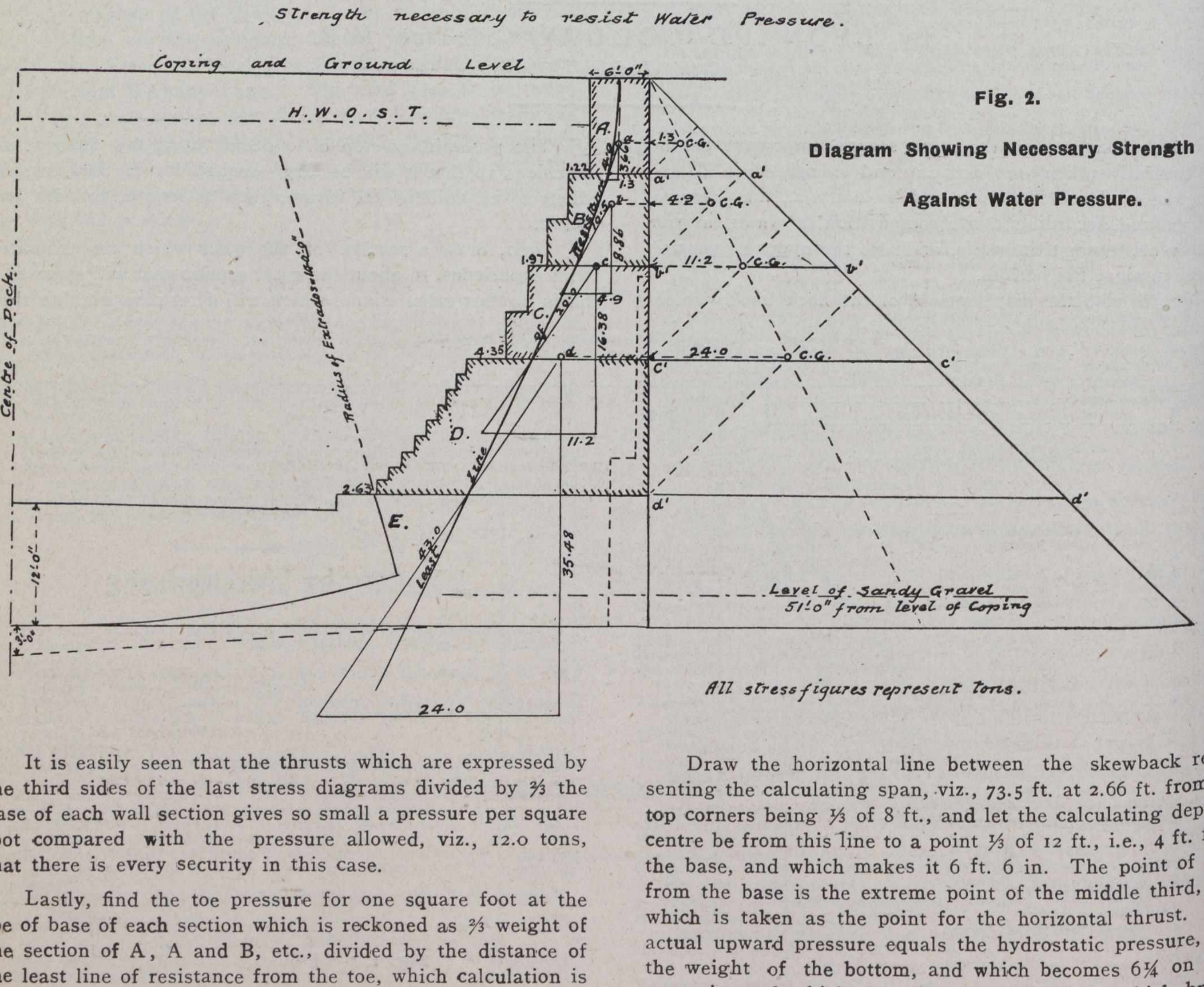

Fig. 2.

Diagram Showing Necessary Strength Against Water Pressure.

It is easily seen that the thrusts which are expressed by the third sides of the last stress diagrams divided by ⅔ the base of each wall section gives so small a pressure per square foot compared with the pressure allowed, viz., 12.0 tons, that there is every security in this case.

Lastly, find the toe pressure for one square foot at the toe of base of each section which is reckoned as ⅔ weight of the section of A, A and B, etc., divided by the distance of the least line of resistance from the toe, which calculation is shown on the diagram in each case. These pressures are seen to be well within that allowed, viz., 12 tons per square foot, and having a good margin of safety, will allow these walls to be reduced, when the calculation for displacement is being carried out.

Next draw the hydrostatic pressure for water, as in Fig. 2, as follows:—

Draw the diagram representing these pressures on the walls A, A and B, A, B and C, and A, B, C and D, as shown, their bases being a′a′, b′b′, c′c′ and d′d′ respectively, and which are subtended at loping level by an angle of $45^\circ\ 00'$ common to all; and from their C.Gs draw the horizontal lines

Draw the horizontal line between the skewback representing the calculating span, viz., 73.5 ft. at 2.66 ft. from the top corners being ⅓ of 8 ft., and let the calculating depth at centre be from this line to a point ⅓ of 12 ft., i.e., 4 ft. from the base, and which makes it 6 ft. 6 in. The point of 4 ft. from the base is the extreme point of the middle third, and which is taken as the point for the horizontal thrust. The actual upward pressure equals the hydrostatic pressure, less the weight of the bottom, and which becomes 6¼ on each voussoir, and which acts through their C.Gs which brings the total upward distributed load of 50.0.

$$\text{Now, } H = \frac{W.L.}{8.D} = \frac{50 \times 73.5}{8 \times 6.5} = 70.7 \text{ horizontal thrust}$$

at the centre. Produce this thrust by a line α until it meets the vertical line through the C.G. of voussoir F, and from this point of intersection draw a line β parallel to the line β in the stress diagram for the dock bottom until it meets the vertical line through the C.G. of voussoir G. and continue, as shown, to the skewback, which gives a thrust of 75 feet.

The thrust at centre becomes $\frac{70.7}{12} = 5.9$ per sq. ft.

The thrust at skewback becomes $\frac{75}{8} = 9.4$ per sq. ft.

Taking the calculating d as ⅔ of thickness at centre, then thrust at centre becomes $\frac{70.7}{8} = 8.84$ per sq. ft., and

This is too small as a margin of safety.

The bottom at centre was next made 3 feet deeper, or 15 feet altogether, and then a line drawn 1 in 12, as shown, on either side until they cut the horizontal line first drawn. Also, the sides were benched in 1 ft. 3 in. and 2 ft. 6 in., as on diagram, and fresh calculations made, as per Fig. 3.

The section in Fig. 3 is practically the same as per alteration given above, and as shown in Fig. 4. The method of carrying these calculations out are similar to those in Fig. 4, with far better results for the pressures per square

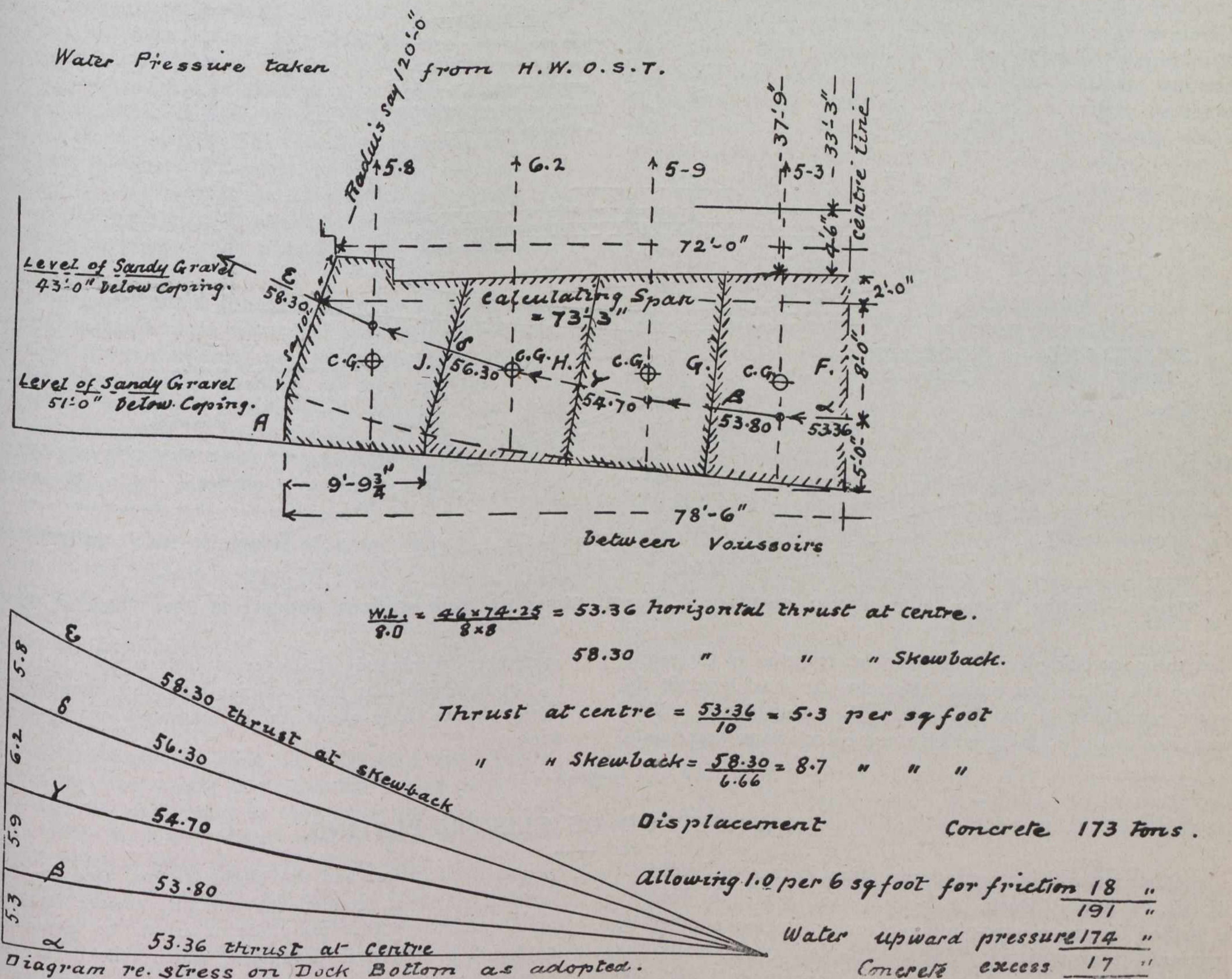

Fig. 3.—Stress Diagram of Dock Bottom; Fifteen Feet Thick at Centre.

thrust at skewback becomes $\frac{75}{5.3} = 14.0$ per sq. ft.

By the diagram for the side walls between B and C, it will be seen that the thrusts on the portions K and L of the wall become practically 75.0, and on the back of the wall 71 tons.

In respect to the upward pressure the difference between the concrete and water at section K is 0.5, and at section L is 17.5 for excess of concrete.

The total displacement is a follows:

Concrete and friction, as shown, equals	179 tons
Water, as shown, equals	174 tons
Difference equals	5 tons

foot, and in every way most satisfactory as regards displacement, which is of vital importance for the solidity and stability of the dock when completed. It may be mentioned that if a dock is too light when built in soft ground and wet, that it is liable to work upwards by hydrostatic pressure.

The construction of a dock must always be made of the very best material, and the ashlar well bonded and true in every respect, as much depends upon the workmanship.

For the purpose of affording access to the immersed parts of vessels, the ordinary graving dock, even at the present day, is the plan most commonly employed, and will continue to be preferred in places where there is a large rise and fall of tide, and where the ground is suitable for excavation.

In many parts of the world the rise and fall of the tide are sufficient to admit of a very large vessel being drawn into a dock at high water, so as to be brought over the keel blocks, on which it then settles down as the tide recedes, and at low water the dock is left dry, and the vessel exposed for repairs, the sluices being then closed exclude the water, so that the succeeding tides cause no interruption to the work. Where the tide is but small, after the tide has receded, the water remaining in the dock has to be pumped out. This was done at the dock for which these calculations were made.

Where docks are hewn out of the solid rock and "faced" there are none of the dangers to be apprehended of settlement or of blowing up the bottom that exist where the dock is built in an excavation made in the earth, which is of an extremely treacherous character at river sides.

It is hoped that these calculations and remarks will be f service to those about to be engaged on work of thi kind

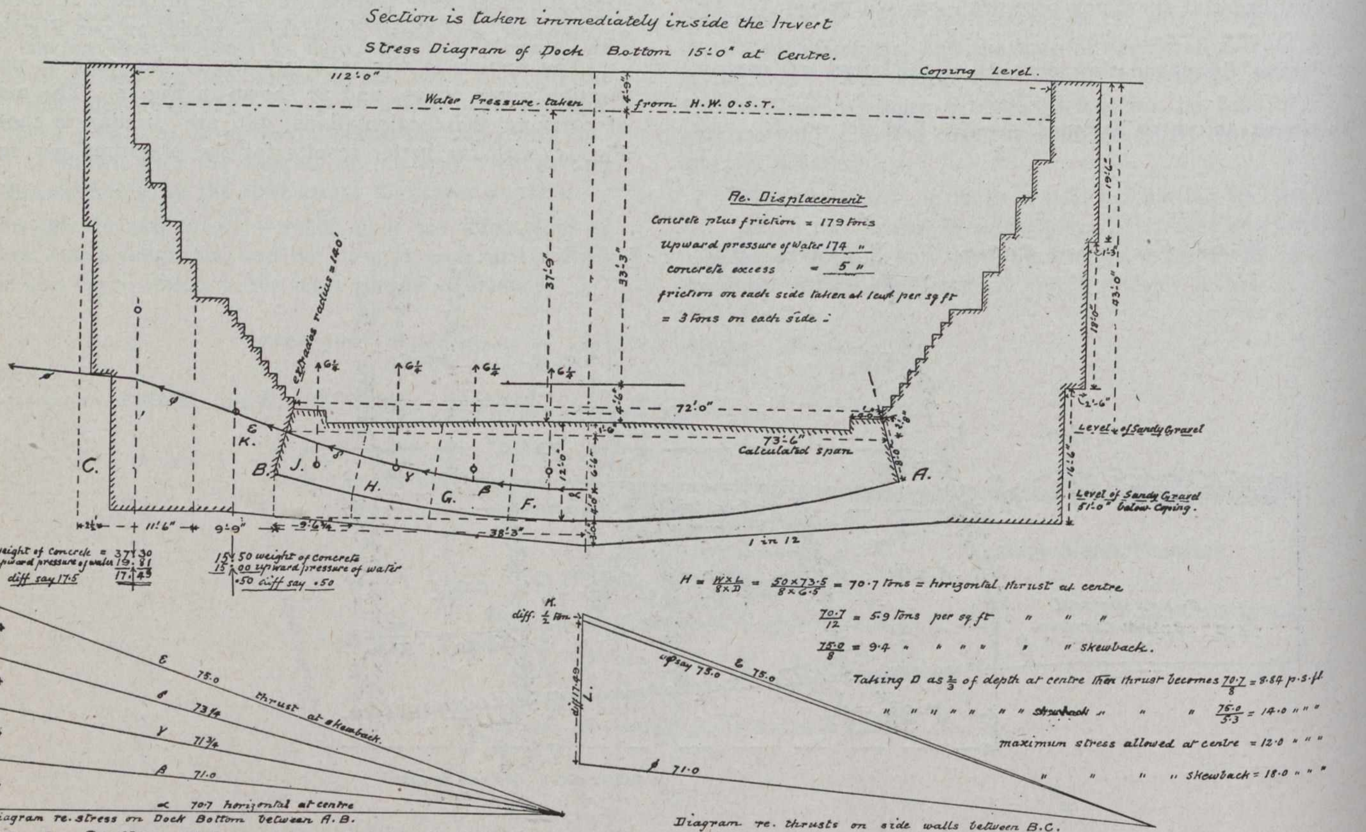

Fig. 4.—Section Taken Immediately Inside the Invert. Stress Diagram of Dock Bottom; 15 Feet Thick at Centre.

A NEW METHOD OF ELECTRO-PLATING.

A particularly interesting invention is that of "Voltite" by Mr. Arthur T. Firth, of New Zealand, which in brief is a method for the electro-plating of one metal on another by frictional precipitation. "The electro-plating of metals has grown rapidly to an industry of great importance," says Mr. Carl F. Woods, secretary of Arthur D. Little, Inc., of Boston, "but up to the present time there has been a great deal of economic waste owing to the practical difficulties in the way of replacing the electro-deposited metal which is lost by the friction of constant use. A number of attempts have been made to solve this problem and several patents have been issued, but in most instances the coating possible of application to the metal by this process is so thin as to be of little value.

A recent patent was issued for the deposition of nickel and other metals by friction which created considerable discussion in the electro-metallurgical world, but after a series of careful experiments it was found that the energy used in the process was so great in proportion to the results that the process possessed more theoretical than practical value.

The process invented by Mr. Firth is electrolytic like other electro-plating operations, but very much simplified and it is claimed for the invention that anyone of ordinary intelligence can operate the process successfully. The compound itself, water and the slight friction used in applying it form a voltaic action, the metallic powder forming the anode and the article on which it is to be deposited the cathode; hydrogen is developed, which reduces the salt to a metallic state upon the article itself. The operation is applicable to gold, silver, nickel, copper, tin and brass, and one of the most interesting applications is that of silver direct to steel. Perhaps the biggest field for its application lies in household use. The constant cleaning of silverware results in the removal of the deposited metal, whereas the use of "Voltite" is claimed to increase the thickness of the metal instead of decreasing it and at the same time to preserve the desired appearance of the article."

The coal production for 1912 is estimated at 550,000,000 tons by the United States Geological Survey. This amount compares with 496,221,168 tons for 1911, 392,722,635 tons for 1905, and smaller amounts for years before that. The production of anthracite shows a decrease on account of the suspension of operations during the wage controversy in April and May. There were, however, increases in almost all of the bituminous districts

ROAD METALS.

The rapid advance of late years towards more perfect highway requirements has resulted in road metals and their study becoming an important branch of highway engineering. W. A. McLean, Provincial Engineer of Highways for Ontario, in his report to the government for the year past dealt with the subject as follows:—

Road metal, in the construction of macadam and gravel roads, serves three important purposes. It distributes the concentrated wheel load over a greater area of sub-soil; it forms a waterproof covering to protect the sub-soil from the softening effects of moisture; it forms a hard and durable wearing surface. The depth of material used, the method of placing it on the roadway, and the quality of materials used, should be proportionate to the three main factors stated. The concentrated wheel load controls largely the depth of material to be used; the necessity of having a waterproof coat emphasizes particularly the method of placing the road metal; and the need for a hard and durable covering is met principally by the quality of stone selected.

The foregoing rule is general, and while a greater depth of material makes a more waterproof surface, and will wear longer than will a thin coat; and while certain qualities of stone have better binding qualities, are more waterproof and will distribute the load at a wider angle, yet in a broad way the three requirements are responded to in the manner stated, viz., distributing power—depth of material; waterproofing—method of applying; durability under wear—quality of material.

Distributing Power—Depth of Material.—When a wagon carries in all two tons, it is apparent that each wheel places on the roadway, along a line which is the width of the wagon tire, a load of 1,000 pounds; if the wagon and its load weigh four tons, the concentrated load on a line the width of the wagon tire is 2,000 pounds. This may be assumed to be communicated to the roadway through a single cube of stone two inches square.

Experience shows that from this cube on a well consolidated roadway, the weight is distributed at an angle of about 45 degrees; and it may be shown that the area of sub-soil over which the load is distributed, is equal to a square the side of which is twice the depth of the stone.

The supporting power of soil may be instanced by an extract from the Ontario Standard Specifications for Concrete Bridges, in which the bearing strength of soils, under foundations, is stated as follows:—

Rock in thick beds	25 tons per square foot
Strong gravel and coarse sand, dry	8 tons per square foot
Compact sand or film clay, dry	4 tons per square foot
Clay, moderately dry	2 tons per square foot
Clean, dry sand, not cemented	2 tons per square foot
Wet clay	1 ton per square foot
Quicksand and wet, yielding soils	0 to ½ ton per square foot

While the foregoing may be accepted as a safe guide for the depth of stone under heavy foundations, yet underneath a roadway, in which the protection from moisture is always insecure, safe loads under the macadam should not, with a proper factor of safety, be taken as exceeding one-half the amount stated.

From this analysis of the case, the importance of thoroughly draining the sub-soil becomes apparent; particularly with a view to securing the greatest possible strength of soil at the time of greatest danger, which is during the spring thaws and freshets. It becomes apparent also why four inches of stone placed on a strong, dry, gravel sub-soil may be as effective and durable as 12 inches of stone placed over a wet, slippery and poorly drained clay; and why a Telford or other strong foundation is at times essential over such a clay, and over a soft and marshy sub-soil. It explains why, in a given mile of road, the depth of stone and character of foundation may be varied half a dozen times to secure a roadway of uniform strength throughout the entire length.

Waterproofing—Method of Placing Stone.—A waterproof covering is one of the important features of a good macadam road, and this is largely obtained by the method of placing the stone. This requires a certain depth of material, not less than four inches on the strongest sub-soil, sufficient bonding material, which in waterbound macadam should be stone screenings; thorough consolidation by rolling, and a proper camber to shed water to the side gutters or drains

The depth of metal must in the first instance be proportioned to the strength of sub-soil and the concentrated wheel load, but a minimum depth of four inches is essential as that is the least depth that can be properly bonded by rolling.

Loose broken stone has about 50 per cent. of voids. If laid loosely on the road, without rolling and bonding, it will not shed water; but is merely a sieve through which rain and melting snow pass. The sub-soil is at once softened by moisture, and into this mud, the broken stone is forced by traffic, rutting the road and wasting the stone. To prevent this condition, sufficient fine material should be used on the road to fill the voids for some depth from the surface, and then rolled to thoroughly bond the stone, leaving a smooth water-tight surface from which rain is at once shed to the gutters.

Rolling takes an important place in making a water-tight surface. If not rolled, much damage to the road results before the metal becomes bonded by traffic, a considerable amount of the loose stone is driven into the mud and is largely wasted. Many gravel and stone roads in Ontario have had two or three feet of metal placed on them and forced into the mud in this way. With the voids filled with earth, the stone is of little use other than to strengthen the foundation in an inferior way. Economical construction requires a road crust of well-bonded stone laid in a well defined and uniform layer.

The camber of the road surface should be in keeping with the quality of the stone, and methods of construction. An average crown of one inch to the foot from side to centre is often specified, and this applies to the class of road ordinarily built in Ontario. This will provide for some settlement after construction. Except in the most expensive type of construction a new road should be given a crown that is too high, otherwise it will soon become too flat under traffic. It follows that in maintenance, the surface should be kept smooth and free from ruts and wheel-tracks in order that the flow of water from the surface will be immediate, and that none will have time to soak into the road.

Broken stone should be separated into grades according to size, the coarser stone to be placed in the bottom of the road and the finer at the top. This grading of stone is done by means of a rotary screen attached to the crusher. If the stone is placed in the road without being graded in this manner, the smaller stones wear away more rapidly than the larger and a rough surface results. Large stones at the surface, moreover, are more apt to become loose, to roll under the horses' feet or the wheels.

For common country roads using limestone, there should be placed in the roadbed:

(a) In the bottom a layer of stones such as are refused by a 2½-inch or 3-inch ring—"tailings."

(b) On this a coating of stones such as will pass through a 2½-inch or 3-inch ring.

(c) On this a sprinkling of screenings—that is, the dust and chips created by crushing, and including all that passes a 1-inch screen.

Course (c) should be only a thin covering, not more than enough to bond the stone when rolled. The main body of the road should be made of the grade (b).

Durability Under Wear—Quality of Stone.—The important properties of a good stone for roadmaking are (1) hardness, (2) toughness, (3) cementing properties, (4) and resistance to atmospheric action, including low absorptive qualities.

A stone may be very hard, and yet very brittle, so that toughness as well as hardness is necessary. A stone the dust of which will cement strongly, and re-cement when broken, makes a smoother and more waterproof road, and one which will distribute a concentrated wheel load at a wider angle. For this reason limestone, because of its cementing properties, is less inferior road metal than its softness would indicate. And some rocks, when first quarried, are hard and tough, yet through atmospheric action, decay rapidly. Rocks which absorb a large percentage of moisture are generally acted upon in this way by the combined action of moisture and frost. Low absorption is therefore desirable; and this is generally indicated by the weight of the stone, the heavier stone being more desirable in this respect.

The quality of stone is not a matter of name, as varieties of the same kind and even from the same quarry may differ greatly. Those who are familiar with limestone quarries know the great variation in hardness and toughness, between adjacent strata.

All things considered, the relative desirability of rocks available in Ontario for roadmaking may be placed in about the following order: (1) Trap; (2) Syenite; (3) Granite; (4) Limestone; (5) Schist; (6) Gneiss; (7) Quartzite; (8) Sandstone; (9) Slate; (10) Mica Schist; (11) Marble.

The name "trap," is one of very general application, and is usually applied to the black and green stones which, found in the fields, are known as "nigger-heads" and "hard-heads." For some years, this material has been quarried at Georgian Bay, and shipped to cities in the United States. In older Ontario, the most convenient point at which it occurs is near Havelock, in Peterborough County, on the C.P.R. While trap is a most durable stone, yet consideration of economy and first cost will generally dictate the use of a softer and less durable stone of the locality in which the road is being built.

Throughout Western Ontario, limestone is common, and the greater mileage of roads is now being constructed of that material, since quarries are within easy access of almost any part of the province. Limestone ranges in quality from that which is very soft and decays rapidly, to that which is very tough, with strong cementing properties. If tough and close-grained, it is an excellent material for roads on which the amount of traffic is not excessive. In some parts of Eastern Ontario, granite, gneiss and schist are being used, and are proving very suitable. Granite is a harder and tougher stone than limestone, but its cementing properties are inferior; and a good practice when granite is employed, is to use limestone screenings to surface and bond the road.

Field stones are frequently used. Picked up from the fields, they are usually found to consist of fragments of trap, granite, gneiss, limestone, sandstone, and other varieties. Owing to lack of uniformity, the serious deficiency of this material is that the softer stones wear more rapidly than the others, and in consequence a rougher surface is ultimately produced under traffic. Field stone, however, forms a good source of supply for road metal, and if obtainable in the locality, should generally be used in preference to stone shipped by rail.

Reliable tests of roadmaking material have been devised, relating to crushing strength, degree of toughness, degree of hardness, cementing properties; and absorption, indicated by weight or specific gravity. No test is so conclusive, however, as actual wear on the road, and old roads in the locality may be instructive.

Simple tests may also be applied. We may judge of the qualities of a stone by breaking with a hammer, wearing on a grindstone, crushing it in a blacksmith's vice, scratching with an iron nail, breaking small pieces with the fingers. A heavy stone is usually better than one that is light. A stone that breaks into cubical shapes is desirable, whilst one that breaks into thin, flat shapes is objectionable.

As previously suggested, the stone of the locality in which the road is being constructed should generally be used. Freight rates and additional cost of handling, will often add 50 per cent. to the cost of a road, as compared to the cost of a road made of stone obtained in the vicinity. It is usually better to accept an inferior stone, and resurface more frequently, than to pay freight rates on a more durable stone shipped in from a distance. This, however, will depend somewhat on traffic, and where travel is extremely heavy or constant, it may be in the interest of economy to pay freight rates for the more durable material. At times it is good practice to use soft material of the locality for the foundation of the road, and surface it with a tougher and more durable material, placing about 4 inches of the latter material on the surface.

SIDEWALK CONSTRUCTION POINTERS.

When it is proposed to lay a cement walk on a foundation that has been travelled over for several months, the entire surface should be loosened up, flooded, and thoroughly tamped down. This is common-sense, for, on a sub-base of this character, the foot travel generally follows one well-defined line, usually in the centre, which becomes solid and well packed and will not settle under additional weight; while the filling to either side of the centre, on being given additional weight, usually settles sufficiently to cause a crack lengthwise through the walk, unless the entire surface is first loosened and retamped to a uniform density.

A successful contractor states that in cold weather he mixes the concrete as dry as it is possible to have it, and then puts in the base in two courses, tamping each course separately—in this way obtaining a more uniform density in the concrete; and as a result he has never had to record a failure in his work. Better results will be obtained, and fewer walks with loose and cracked wearing surfaces would be seen, if workmen could be made to understand that a wearing surface will not adhere to, or form a bond with a base covered with loam or dirt which they have tracked over it either through carelessness or in order to save a few steps.

Clean-cut joints between slabs, and expansion joints adjoining the curbs at streets and alley returns and at frequent intervals in long stretches of walk, are absolutely necessary if broken curb-stones and broken slabs in the walks are to be avoided. Expansion joints at street and alley returns can be eliminated by constructing the curbing with a recess into which the sidewalk slab may be laid.

ELECTROLYSIS FROM STRAY ELECTRIC CURRENTS.

By A. F. Ganz, M.E.

(Continued from page 521 of last week's issue).

A number of investigations have been made to determine the effect of electrolysis on iron or steel embedded in concrete, and these have shown that where the iron is an anode—that is, where current passes from the iron to the concrete—this effect is to corrode the iron and form rust which occupies more space than the iron, causing expansion which finally cracks the concrete. The most recent and most complete investigation of this kind is one made at the Bureau of Standards, Washington, and described in a paper by E. B. Rosa, Burton McCollum and O. S. Peters, presented before the National Association of Cement Users in Pittsburgh, December, 1912. These recent experiments have shown that an extremely small current, flowing from an iron rod to a surrounding block of concrete, will produce enough corrosion to crack the concrete in the course of one or two years. These investigations have also shown that the presence of even a fraction of 1 per cent. of salt or of other chlorides may increase the action of electrolysis on iron embedded in concrete over 100 fold. They have also shown that, where the iron is a cathode—that is, where current passes from concrete to the iron—a softening of the concrete is produced in the immediate neighborhood of the iron which eventually destroys the bond between the concrete and the iron. The introduction in recent years, of buildings constructed entirely of reinforced concrete, has raised the question of the possible damage to such buildings from electrolysis of the reinforcing steel. Where reinforced concrete structures are located near railway power stations which have a grounded negative bus-bar, there may be a considerable potential

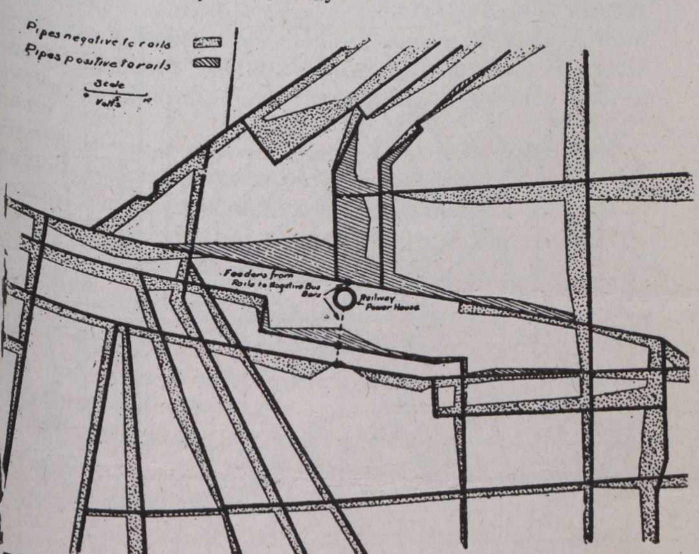

Fig. 3.—Typical Potential Survey of City, Showing Electric Railway Tracks and Potentials of Underground Pipes to Trolley Rails.

gradient through the ground upon which the concrete building stands, and in such cases it is possible that currents may flow through such a reinforced concrete building. These currents, although very small in magnitude, may cause a great deal of damage because the successive elements of steel and concrete form a series circuit, and damage will result at every point where current flows from steel to concrete or from concrete to steel. The most likely means of entrance or exit of stray electric currents, into or out of such buildings, is by underground gas or water pipes, or by foundations of concrete or of steel. In the light of these recent investigations it would, therefore, seem a wise precaution in such buildings to install insulating joints in every pipe which connects to the building from ground. In the paper above referred to it is also suggested that granite blocks might be interposed between the building footings and soil so as to prevent stray currents from flowing into and out of the building through the footings.

Electrolysis Surveys.—The diagram illustrated in Fig. 2 shows that voltage drop in the rail produces stray current through ground and through underground pipes, and pro-

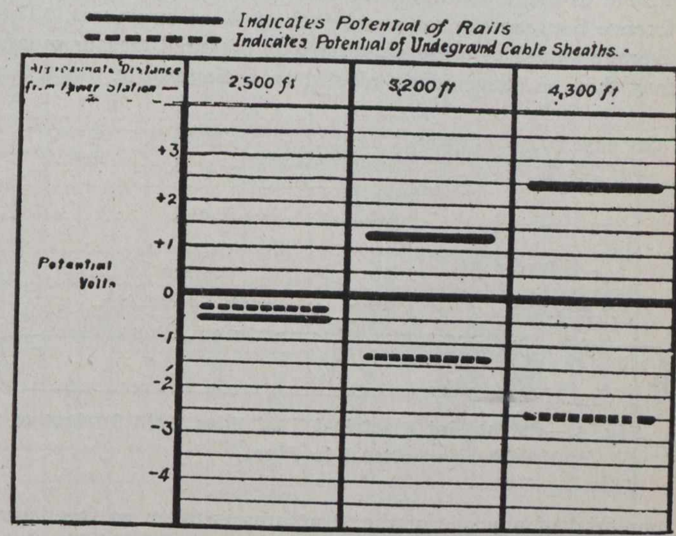

Fig. 4.—Diagram Showing Route of Potentials with Pipes Taken as the Datum or Zero Potential.

duces potential differences between pipe and rails, making the pipe appear positive in potential where current leaves the pipe, and negative in potential where current flows to the pipe. The first step in an electrolysis survey of a town is, therefore, to measure potential differences between pipes and rails, at a number of points throughout every street on which there are electric railways. Where the main itself is not exposed, connections to the pipes for these voltmeter measurements may be obtained by means of service pipe or drip connections. Such connections are generally satisfactory because the voltmeter itself has a high resistance and, therefore, takes only a very small current. Readings are taken at each point every 10 seconds for 10 or 20 minutes, depending upon the car schedules, and the maximum, minimum and average results of the readings recorded. A convenient instrument for these potential readings, which can also be used for the drop measurements described below, is a Weston, Model 1, combination millivoltmeter and voltmeter, with its zero in the centre of the scale, and having ranges of 5, 50 and 500 millivolts and of 5 and 50 volts. These instruments are made with very high resistances, so as to be particularly applicable to electrolysis testing.

After such potential measurements have been made throughout the principal streets of a town, they are then conveniently plotted on a skeleton map of the town, in which the trolley lines are shown. The potentials of the pipes referred to the rails are laid off normal to the lines representing the railway tracks to some convenient scale, usually 1 inch = 10 volts. The ends of these potential lines are then connected, and the included areas are colored red where the pipes are positive in potential to the rails, and blue where the pipes are negative in potential. In Fig. 3 is shown a typical potential survey map, in which the negative areas are shown by dots, and the positive areas by section lines, instead of by blue and red areas. It will be noted that, in the neighborhood of the railway power station, the pipes are highly positive to the rails, and at points distant from this station they are negative to the rails. The existence of potential differences between pipes and rails is, however, no conclusive evidence of stray currents on the pipes; they indicate at what points current is probably flowing from rails to pipes and from pipes to rails.

Where there are a number of underground metallic structures which may be affected by electrolysis, it is desirable to make simultaneous measurements of potential difference between the rails and each of these structures. The average values of these simultaneous potential measurements may then be conveniently plotted on a diagram in which the

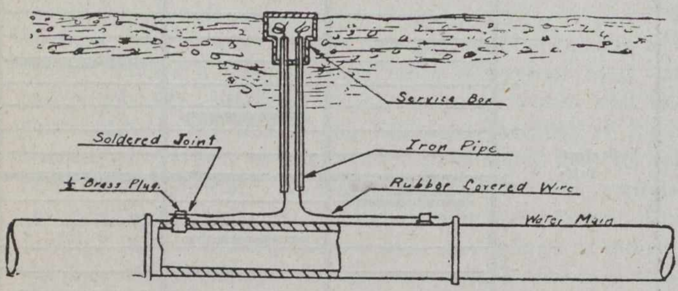

Fig. 5.—Permanent Electrical Test Wire from Surface of Street to Pipe.

potential of any one of the structures is taken as the datum or zero of potential. In Fig. 4 is shown a set of diagrams giving the relative potentials between water pipes, trolley rails and underground cable sheaths, at 3 points along a given street. In this diagram the water pipes are assumed as the datum or zero of potential, and the potentials which are positive to the pipes are laid off above the axis, while those which are negative to the pipes are laid off below the axis, to the scale indicated in the diagram. In the case shown in Fig. 4, the cable sheaths are connected to the railway return conductors near the railway power station. It will be noted that, at the point nearest the power station, the water pipes are positive both to the cable sheaths and to the rails, and that the cable sheaths are also slightly positive to the rails. At greater distances from the power station the rails become increasingly positive to the water pipes, while the cable sheaths become increasingly negative to the pipes. The potential difference between the rails and the cable sheaths increases very rapidly with increasing distance from the power station, as is seen from Fig. 4.

The next step in the survey is to measure drop between drip or service connections, which will indicate the probable existence and direction of current flow on the pipes. Such drop measurements cannot, however, be used for calculating the amount of current on the pipes. To determine the actual current flowing it is necessary to measure the drop between two points on a continuous length of pipe by means of a millivoltmeter. This drop, expressed in volts, divided by the assumed or measured resistance in ohms of the included length of pipe, gives the current expressed in amperes. A convenient table giving the current in amperes for 1 millivolt drop in 1 foot of standard wrought iron, steel and cast iron pipes is appended to this paper. To find the current flowing on a pipe corresponding to a given drop in millivolts for a measured length, multiply the amperes given in the table for 1 millivolt drop for 1 foot by the number of millivolts drop measured, and divide by the included length of pipe in feet. To measure this drop it is necessary to expose the pipe and to make good electrical contact between the millivoltmeter leads and the pipe. A satisfactory method is to use a pointed piece of steel, about the size of an ordinary lead pencil, fastened in a wooden handle, with a flexible connecting wire soldered to it inside of the latter. The pointed steel is then pressed against a bright spot or into a filled notch on the pipe. A still better contact is obtained by soldering the connecting wire directly to the pipe or to a brass plug screwed into the pipe, which is particularly advantageous when readings are to be taken over a considerable time. When such contact wires have been soldered to a continuous length of pipe it is common to use rubber covered wires, bringing them to the surface of the street, leaving the ends in drip or service boxes, which then form permanent test stations for electrical measurements. This is exceedingly convenient, for it is then possible to make current measurements on the pipe without again digging an excavation. Such permanent contact wires for electrical tests are illustrated in Fig. 5.

It should be noted that small potential differences, such as 0.1 millivolt or less, may be caused by local galvanic or thermal action. Where such small values are found in a test for drop on a pipe a careful investigation should, therefore, be made to ascertain whether the observed potential difference is actually drop due to current flow or is due to local causes. The writer has found that such local potential differences are a frequent source of error when such tests are made by persons who are not accustomed to making accurate electrical measurements.

When drop measurements between services and current measurements on pipes have been generally made on a piping system, the results are conveniently plotted on a skeleton

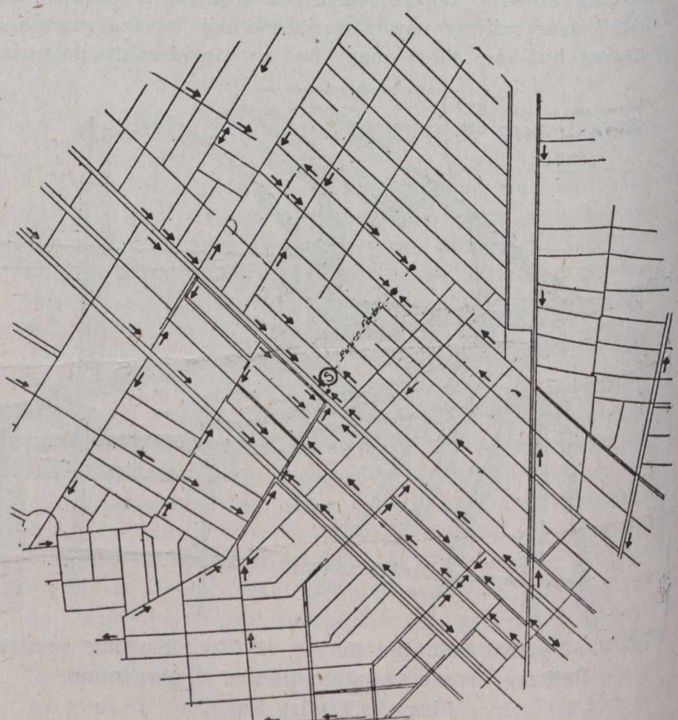

Fig. 6.—Typical Current Survey, Showing Underground Mains and Stray Currents Flowing on Mains.

map of the city in which the pipe lines are shown and the current flowing on these pipes are indicated by arrows. A typical current survey map of a portion of a city is shown in Fig. 6. It is seen that here the currents on the pipes flow in a general direction towards the railway substation.

Since current destroys the pipe only where it leaves the pipe for soil, it is important to know where the current does leave the pipe. Current measurements on pipes are, therefore, frequently made at two or more stations simultaneously in order to determine the change of current on the pipe between the stations. In Fig. 7 simultaneous current measurements made at two stations on a pipe are shown plotted where there is no change of current between the stations. In Fig. 8 simultaneous current measurements at two stations on a pipe where there is a considerable loss of current between the stations are likewise shown.

In order to determine the characteristic variations of a potential difference between pipe and rails, or of current flow on a pipe, 24-hour records of such potential difference, (or of current flow) may be obtained by means of a special Bristol, smoked-chart, recording instrument. This recorder has for its measuring system a sensitive Western millivoltmeter, and may be provided with a number of ranges. It is convenient to have the instrument provided with its zero in the centre of the scale, and with ranges of 5, 50 and 500 millivolts, and of 5 and 50 volts. Shunts of any desired ampere range can also be used in connection with the recording millivoltmeter, and the instrument used as a recording ammeter of a corresponding range. Convenient shunts for this are ordinary switchboard shunts adjusted for 50 millivolts drop, with rated capacities of 5, 50 and 500 amperes. Such potential and current records are conveniently plotted from these charts in rectangular co-ordinates. Sample 24-hour records of current on a pipe plotted in rectangular co-ordinates for one week are shown in Fig. 9, from which it will be seen that the current records for weekdays are practically alike, and show morning and early evening peaks. The record for Sunday is, however, very different and shows a very large peak throughout the whole afternoon. This is accounted for by the fact that the neighboring trolleys were carrying large crowds of excursionists on Sunday outings. By means of such 24-hour records it is often possible to positively identify the source of current flowing on a pipe as railway current from its similarity with the railway load curves. Twenty-four-hour records of current flowing on pipes may also be

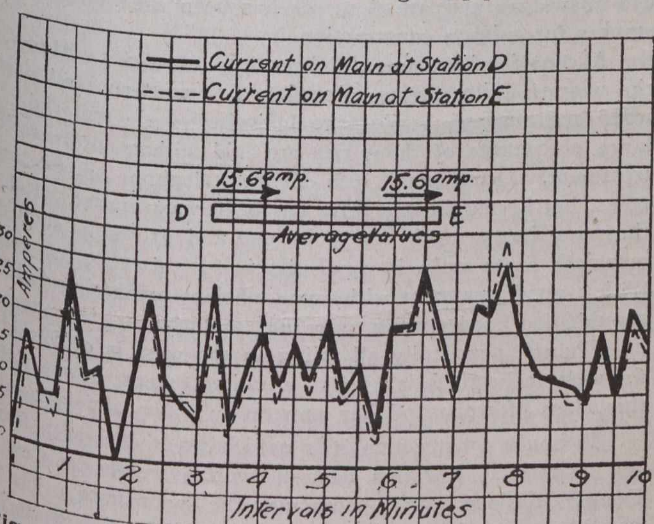

Fig. 7.—Simultaneous Current Measurements Where There is no Change in Current Between Stations.

obtained at two or more stations simultaneously, and the change of current between the stations for the 24 hours determined.

It is possible to trace the path of current flow through ground by measuring potential differences between points in the ground. Where small potential differences are measured between two points in ground and iron rods are used as electrodes, entirely incorrect results may be obtained, because of possible differences in polarization voltages at the surfaces of the electrodes. To overcome this difficulty, a "non-polarizable electrode" was devised by Prof. Haber. This consists of a glass tube, with a porous cup cemented to one end, containing a saturated solution of zinc sulphate, and of a zinc rod dipping into the solution. A wire is brought out from this zinc rod through a cork in the top of the tube. To make contact to ground with this electrode the porous cup is pressed against the part of the ground at which the potential is to be measured, thus establishing contact between the ground and the zinc sulphate solution. This establishment

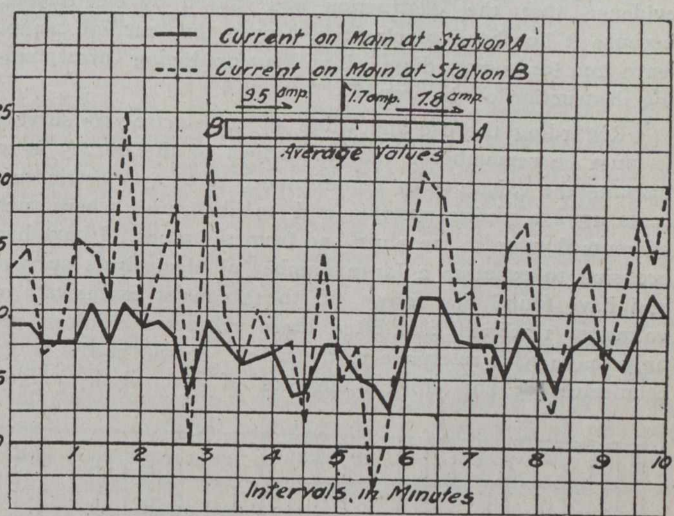

Fig. 8.—Simultaneous Current Measurements Where There is Change in Currents Between Stations.

of electrolytic contact between ground and the zinc sulphate solution eliminates polarization voltages. The polarization voltage between the zinc rod and the zinc sulphate solution, which is a definite known voltage, must be allowed for when using this electrode. It is also essential that, when this electrode is used, the potential measurements be made by means of zero methods, and not with indicating volt-meters, because of the very high contact resistance produced with this electrode.

It is often also desirable to measure directly the flow of current through ground, as between a pipe and rails, or between two pipes. This can be done by means of an earth ammeter, which was also devised by Prof. Haber. This consists of a wooden frame with two copper plates insulated from each other by a plate of mica or glass. Insulated copper wires are brought out from the two copper plates, and these wires are connected to an ammeter. To use the frame, the two copper plates are, first, coated with a paste made of copper sulphate and a 20 per cent. sulphuric acid solution. A wetted piece of parchment paper is then laid over the paste, and the remainder of the frame filled with soil from the excavation where the current flow through ground is to be measured. The frame is then buried in ground normal to the direction of the current flow to be measured, and the ammeter will indicate the current flow which is intercepted by the buried frame. The object of the copper sulphate paste on each plate is to equalize polarization potentials at the surfaces of the copper plates. This earth ammeter is also well suited for measuring current flow between pipe and ground. For this purpose the frame is buried in the ground one or two inches from and parallel to the pipe. Measurement of current flow from a pipe thus made can be used to form an estimate of the probable amount of electrolytic damage to the pipe, and in cases where corrosion has taken place, this kind of test will often serve as evidence that the corrosion has been caused at least in part by stray currents leaving the pipe. By using a recording instrument in connection with the earth ammeter, the characteristic variations of the current leaving a pipe can also be determined, and in this way the identity of the current can often be established.

From a study of the results of the survey it can be determined where current is leaving the piping. At a number of such points excavations should then be made and the exposed pipe examined with a test hammer for electrolytic corrosion. Where such corrosion and pitting are found at points where current is found leaving the pipe, it may be taken as evidence that the destruction was caused by electrolysis, because it has been conclusively proven that current cannot leave iron for surrounding soil without producing corresponding destruction of the iron.

Regarding the use and value of an electrolysis survey, it must be remembered that the object of the survey is to indicate the existence or non-existence of stray electric currents upon a piping system, and to determine where such currents flow on to the pipes and from the pipes. I have had occasion to examine a large number of electrolysis surveys and have found that many of these consist exclusively of voltmeter readings, and often these voltmeter readings are only made with reference to the rails. Such readings by themselves do not afford a measure of electrolytic danger.

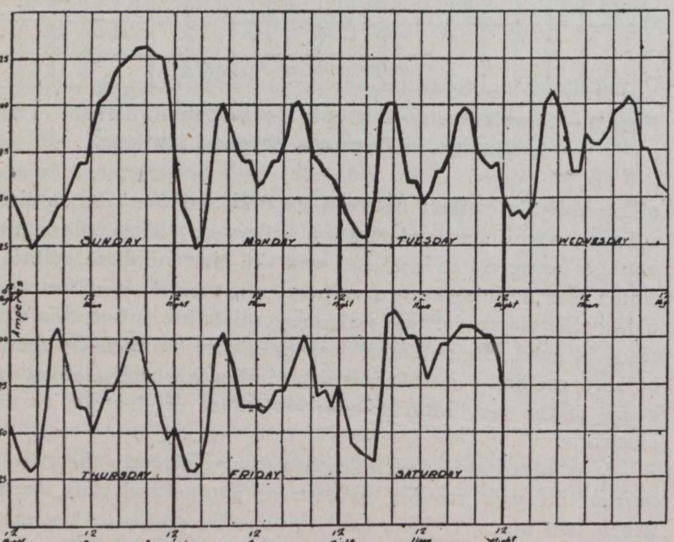

Fig. 9.—Stray Currents on Water Main Averaged from 24-Hour Record and Plotted for Week.

Potential measurements should be made to all underground structures. Measurements of current flow on pipes are also essential in an electrolysis survey because all current which flows on a pipe must leave it, and the amount of damage produced is proportional to the total current which leaves the pipe. I have seen some reports, on the other hand, where it is stated that the current on a given pipe is zero, but where the instruments and methods employed were not sufficiently sensitive to detect current as large as two or three amperes, and where, therefore, the conclusion of zero current is not warranted. From a complete and properly analyzed electrolysis survey, a great deal of good can generally be accomplished. It will not always be possible to remove all stray currents from the pipes, but measures will be indicated by which the conditions can be greatly improved, and points of greatest danger will be located. If then trouble does occur at a later time at these points, the electrolysis survey may be most valuable in affording proof of the destruction of the property from railway currents, and may be the means of compelling the railroad company not only to pay for the damage, but also to make improvements in its return system so as to avoid the recurrence of such damage. I know of a number of electric railroad companies who are regularly paying for damage caused by electrolysis to piping systems. The knowledge that a pipe-owning company is making electrolysis tests and is keeping watch on the situation, also has a strong moral effect on the electric railroads.

(To be continued).

HEMLOCK AND ITS USES.

The British Columbia Forest Service has data showing that western hemlock, which is being cut in increasing quantities on the coast, is a much more valuable timber than was heretofore thought. The sale is increasing throughout the province, some companies having placed it on the prairie market in successful competition with Douglas fir, on account of the lower freight rate and the relatively smaller danger of splitting in nailing. This latter reason makes it acceptable for joining and siding. At present the principal use of hemlock in British Columbia is in pulp manufacture, great areas in the north being cut over to supply this growing industry.

Authentic data are lacking with regard to the durability of western hemlock as compared with Douglas fir and other woods. The general impression is that Douglas fir is the more durable.

A few experiments made to determine the adaptability of western hemlock to treatment with liquid preservatives indicate that, as compared to Douglas fir, it offers about the same resistance to impregnation across the grain; but that it is easier to penetrate along the grain.

Hemlock is well suited for use in all but the heaviest construction work, as shown by results of tests which have been made, but up to the present time it has had a limited use in bridges and trestles. It has been used in some instances for caisson construction.

A considerable amount is cut into cross-ties. Many of the western railroads use Douglas fir, western larch, redwood and western hemlock exclusively for tie material. A large percentage of those ties are laid without preservative treatment. Occasionally it is cut into telephone or telegraph poles, but its use in this form has been very limited. It has the requisite strength for pole use and grows in such dimensions as to make it very suitable for this class of work. With a good treatment with some efficient preserving fluid it should give good service as a pole material.

Though practically all piling in the west is of Douglas fir, western hemlock is used to a limited extent, however, for this class of work and has apparently given satisfaction.

In house construction it is used a great deal as a framing material. For this class of work it serves as well as Douglas fir, and locally commands the same price.

When cut edge grain it makes good flooring material. It finishes smoothly on account of the uniform texture of the wood and it also wears evenly. It is not suitable for use in damp places on account of its tendency to warp under such conditions.

As a finish lumber it has the advantage of containing practically no pitch; it has a beautiful grain, works smoothly, takes stain readily, and when properly dried, will not shrink or swell materially under normal conditions. It presents a comparatively hard surface and consequently does not mar easily.

Western hemlock slabs and edgings are manufactured into lath, and as a lath material it is equally as valuable as Douglas fir or other wood. In this form there is no distinction made as to species, all pieces of a suitable form to make lath being thrown in together and used indiscriminately.

It is used to a large extent for barrels and boxes for shipping foodstuffs. For this purpose it serves admirably, since the wood is odorless and tasteless. A good development along this line may be looked for when consumers realize the value of the wood, and cease wasting it as at present.

PAINT AS AN ENGINEERING MATERIAL.*

By Dr. Maximilian Toch.

The progress that paint chemistry has made since 1905 is by far greater than the progress that has been made from its earliest invention up to that date. It is very difficult for me to imagine that my first book on "The Chemistry of Paints" stimulated others to continue the work which I had started, and if the little that I have done to enlighten the manufacturers and consumers has brought about the progressive results, I certainly have been rewarded for all the work I have ever done on the subject.

The first skyscraper ever built was the Gillender Building, corner of Wall and Nassau Streets, which was razed two years ago. Chemists knew before this building was demolished that linseed oil paint was not the best material for the protection of steel of large buildings. The question as to whether our monumental buildings are permanent has been a source of great worry to many chemists and engineers. Fortunately, if any of the steel contained in buildings like the Woolworth Building, Metropolitan Tower, the Singer Tower and dozens of others should show signs of corrosion and disintegration, the process is so slow that preventive methods could be applied, for a beam could not corrode in a masonry wall without cracking or bulging the wall. I have in mind one building in Maiden Lane where this actually occurred, and the wall of the fifteenth floor was cut away, the corroded beam exposed, thoroughly scraped, painted and reinforced, surrounded by concrete, and the brick wall replaced.

From the street level up every skyscraper in the world is safe, but from the street level to the grillage beams is the dangerous point. Of course, a small building could be "jacked up" and a grillage beam replaced. In a large building, two of which I have in mind, where the grillages were affected by leaky electrical currents, the foundation beams were uncovered, scraped clean and painted, and then a grout of almost pure neat cement injected all over the surface. Of course, it would be out of the question to "jack up" a building like the Woolworth Building or the Metropolitan Life, even though Archimides said: "Give me a fulcrum and I will move the world," but it is a source of great satisfaction to know that engineers and architects in charge of these buildings have taken sufficient precautions to prevent any danger whatever, either from electrolysis by means of stray currents, or from corrosion by means of dampness, and all the sensational talk about danger of the newer skyscrapers not lasting fifty years is utter "rot," for not one of these buildings is so constructed that should any danger result it could not be remedied in due time.

That paint is an engineering material of incalculable value is evidenced by the fact that none of our bridges would last ten years if they were not repeatedly painted and watched. The railroads are much wider awake to this condition than the municipal governments. Politics and paint do not mix very well, as is evidenced by the condition of some of our bridges. It may be very safely said, that all of our elevated railroads in New York City and all of the battleships of the United States government depend for their life on the frequency with which they are painted. My examination of the battleship "Maine" when the wreck was uncovered last year showed that not a vestige of paint remained, and it furthermore showed that wherever steel and copper, or iron and bronze were in close proximity an electric battery was formed and the iron was completely dissolved.

This, then, leads me to the general subject of the more modern type of paint containing no saponifiable oil, but made entirely of such materials as are unaffected by alkali, and such tremendous structures as the Pennsylvania Terminal, in New York City, the Metropolitan Life Tower, and Building, the Woolworth Building, and the newest and largest of all engineering structures—the New York and Connecting Railway not yet begun—are types of modern structures in which the old-time linseed oil paints have been superseded and protected by more scientific paints. Perhaps the most remarkable fact in all these instances is that fifteen years ago perhaps one concern in the United States started a campaign of education and convinced many prominent and well-known engineers that paint was an engineering material, and not one material is suitable for all purposes, with the result that the paint industry has been raised from empiricism to an exact science. Ten years ago nobody dreamed of painting cement floors or cement walls on account of the tradition that it was impossible to paint concrete. It is quite true that it is impossible to paint new concrete with a linseed oil paint owing to the resulting chemical action of the combination of the oil and the lime in the concrete, and yet when the first patent was taken out on this subject nobody infringed because it was believed that it could not be a success, but after it was demonstrated that this was a success it was the same story as "Columbus and the egg," and everybody iimitated and made a success of it.

The United States Navy, through one of its most efficient naval constructors, Mr. Henry Williams, has kept pace with the paint progress, and Mr. Henry Williams' article, a treatise on the subject of "Newer Paint Conditions in the United States Navy," read before the Eighth International Congress of Applied Chemistry, was copied not only by every paper in the United States, but was heralded throughout Europe, and to those who want to know what excellent progress has been made in this branch of the government, I would refer to his excellent treatise on the subject which is to be found in the transactions of the Eighth International Congress of Applied Chemistry.

Before closing my remarks and showing the illustrations I have taken for this lecture, I must say a few words regarding the sensational statements that have appeared lately in the press concerning the poisonous effects of white lead on workmen. It is very true that lead injected or absorbed in any form into the system produces plumbism, but the matter is not as serious as sensational newspaper writers have made it. All this talk about putty powder poisoning men in glass polishing factories is practically untrue, for putty powder happens to be tin oxide or a mixture of tin oxide and precipitated barium sulphate. The use of lead compounds in the preparation of wall papers is just as ridiculous as the arseni-

*Abstract of address before the American Chemical Society.

cal poisoning which was supposed to have injured so many operatives who used green pigments for printing wall paper designs. It turned out, of course afterwards, that the green pigments were chrome pigments, and the percentage of arsenic contained in the aniline dyes was so minute that even if they had dusted off it is a question whether they would have done any harm, for the pigments which are printed on wall paper are never released from their base.

The precautions that are taken in the white lead factories in the United States are so great that the plumbism which results is due to a large extent to the carelessness of the workmen themselves. As far as my personal experience goes, it is the hardest thing in the world for us to educate illiterate workmen that they must wash their hands before they eat, and the State is now distributing circulars printed in various languages notifying workmen that it is illegal for an employer or an employee to permit food to be consumed where these materials are manufactured. We are all well aware that the transportation of high explosives is exceedingly dangerous. There have been some frightful holocausts resulting from explosions in transit, and yet it is safe to say that any civilized country would go back untold and countless years if laws were enacted prohibiting the transportation of explosives, for coal metals and minerals would lie practically untouched in the ground; and the only safeguard is that, knowing that the materials are necessary for the excavation of the riches of the earth, due care should be taken in their transportation. Practically the same is true in the manufacture of any hazardous material, and therefore sensational and irresponsible statements pertaining to the manufacture of any chemical, whether it be lead or nitroglycerine, are to be decried.

COSTS OF CONCRETE PAVEMENT.

We publish below a table taken from the Journal of the American Society of Engineering Contractors, showing the amount, average price, and some details of concrete pavements constructed in a number of American cities:—

	Sq. yd.	Av. price per sq. yd., including grading.	Guarantee. Years.	Total thickness of pavement. Inches.	Proportions.
Portland, Me.	11,238x	$1.29	....	6	1:2½:5
Lynn, Mass.	21,402	1.70	5	6	1:2 :4
Trenton, N.J.	2,826	1.44	1	6	1:2½:5
Seymour, Ind.	1,250	.90	3	7	1:6[1]
Edwardsville, Ill.	8,950	1.40	½	7[2]	1:3 :5
Alpena, Mich.	13,000	1.30	....	8	1:6
Escanaba, Mich.	12,000	.87	0	6¾	......
Fond du Lac, Wis.	11,043x	1.25	5	6½	1:2½:5
Sheboygan, Wis.	19,860x	1.28	0	8½[5]	......
Bemidji, Minn.	19,826	.90*	2	5	1:3½
Burlington, Iowa	4,489	1.34	5	6½	1:2 :5
Cedar Rapids, Iowa	2,178	1.16*	....	7[6]	1:3 :5
Davenport, Iowa	13,208	1.23*	2	7[6]	1:3 :5
Fort Dodge, Iowa	7,900	1.60	5	7[7]	1:3 :5
Marshalltown, Iowa	14,000	1.18	0	7	1:3 :5
Mason City, Iowa	42,000	1.30	5	7[8]	1:2 :5
Sioux City, Iowa	100,000	1.20	....	5	1:3 :4½
Kansas City, Mo.	81,000	1.05	5	6	1:2½:4½
Grand Island, Neb.	3,754	1.30	....	....	......
Omaha, Neb.	4,485	....	....	....	......
South Omaha, Neb.	13,200	1.30	5	6[10]	1:2½:5
Kansas City, Kans.	....	1.09	5	6	......
Ottawa, Kans	996	1.03*	2	6	1:2 :3
Wichita, Kans.	2,137	1.00*	2	6	1:2 :4
Billings, Mont.	2,000	2.25	2	7½[11]	1:6
Boise, Idaho	23,166	1.12*	....	6	1:3 :5[12]
Grand Junction, Col.	18,000	2.20	....	7[13]	1:3 :6
Vancouver, Wash.	15,220	1.15*	....	5	......
Portland, Ore.	31,417	....	....	....	......
Salem, Ore.	85,266	1.30*	0	6	1:2 :4

* Does not include grading. x Reinforced.

[1] 1-6 mix; 1-2 surface. [2] 5 in. base, 1-3-5 mix; 2 in. top of 1 cement, 1 small gravel, 1 sand. [3] 4 in. base, 2 in. wearing surface. [4] 5 in. base, 1-2½-5; 1½ in. top, 1 cement, 1 sand, 1 gravel. [5] 6½ in. at gutter, 8½ in. at centre. [6] 5 in., 1-3-5 mix; 2 in. top 1-2. [7] 5 in base, 1-3-5; 2 in. top 1-1-1. [8] 5 in. base 1-2-5; 2 in. top 1-2. [9] 1¾ in. 2-3 grout; 5¼ in. 1-7 mix. [10] 6 in. and 8 in. [11] Laid in 6 in. gravel base; pavement; 6 in. 1-6 gravel base and 1½ in. 1-2 mortar top. [12] Also 1-3-7. [13] 5 in. base, 2 in. top. [14] 5 in. of 1-3-5 and 1¾ in. of 1-2.

The three great liners of about 50,000 tons each, which have been ordered by the Hamburg-American line, says an English exchange, are going to be fitted out with telephone exchanges of the most modern type, to which each cabin will be connected. This marks a very appreciable and further addition to the luxury of trans-oceanic travel.

THE ELECTRIFICATION OF STEAM RAILWAYS.*

By N. W. Storer.

A discussion of the subject selected for this meeting is one which almost invariably arouses the greatest interest. It is not because it is an electrical subject nor because it is about railways. It is because it is a subject that concerns every one who travels, for all such men have been subjected to the discomfort of riding behind a steam locomotive and are interested in everything that offers an improvement. Mr. Dooley says that any one may experience all the delights of riding in a sleeping car without leaving home. His advice is: "Throw a $2.00 bill out of the window, put a cinder in your eye and spend the night on the top shelf of your darkest closet." This is probably a slight exaggeration of the joys of present-day travelling, not due entirely to the steam locomotive, and although only the cinder and its attendant smoke and dirt can be eliminated from this picture by the use of the electric locomotive, most people are anxious to have the steam engine discarded even before they have seen an electric locomotive. When one has experienced the happiness of riding behind an electric on a hot day in the summer with all windows up and no smoke and cinders, he is ever after a convert to the electric.

The belief in the unbounded possibility of electricity has led to the idea that it is only a matter of a few years before all the steam locomotives will be relegated to the scrap heap. I used to share the belief, but the more I learn of the subject, the more respect I have for the steam locomotive and the work it is daily performing, and the greater the task of supplanting it with the electric appears to be; not that we are doubtful as to the ability of the electric locomotive to do the work, for we are certain that almost any railway can handle more traffic and do it better when operated by electricity than by steam. What, then, is the reason for doubting the speedv and general substitution of electricity for steam? Simply that the traffic on most railways at the present time would not pay for the large initial investment necessary for operating it by electricity.

A steam locomotive is an independent power unit requiring supplies only of fuel and water at intervals along the road. The electric locomotive is in itself powerless. It must have a power house back of it, with transmission lines to carry the power to it wherever it may be.

As the electric locomotive itself is much more expensive than the steam engine, and the power house and distribution system cost a great deal more, the investment for operating a heavy railroad by electricity must, therefore, be relatively very large, and unless the frequency of trains is high enough to maintain a good load factor on the line, substations and power house, it can scarcely pay. In other words, electric operation will pay if you can keep the apparatus working a reasonable percentage of the time, but will not pay if the percentage is small. A bank cannot pay interest on deposits when 90 per cent. of them are locked up in a safe. Similarly, a man who has a high-priced automobile that is run only 1,000 miles per annum, is paying a very high price per mile; much higher than the man whose machine covers 10,000 miles. Any apparatus must be used in order to make it pay for itself.

In comparing the cost of electric with steam locomotives, one railway official went so far as to say that the electric locomotives used to haul their trains cost not $35,000 each, which was the contract price for them, but $100,000 each, which was the cost of the entire installation, divided by the number of locomotives. This might appear to be the case, but it is not strictly correct, unless the cost of all the roundhouses, machine shops, coal handling and distributing apparatus, water tanks, etc., be included in the cost of the steam locomotives. Even that, however, would leave the cost of the latter motive power only a fraction of that of the electric. Under such a handicap, it cannot be expected that the railroads, which are laboring under great financial difficulties at the present time, will be able to electrify their lines except under conditions that absolutely require it or offer exceptional advantages.

Compulsory conditions are sometimes imposed by legislation to force a railroad to electrify to abate the danger and discomfort of operating steam locomotives through long tunnels. This was the immediate cause of the adoption of electricity as a motive power by the New York Central and the New Haven Railroads, for the entrance to New York City. This electrification cost a tremendous amount, but it has resulted in a most magnificent terminal, increased comfort and safety to the travelling public, and last but not least, in increased value of real estate owned by the railroads, which bid fair to make the electrification a paying investment. If this last proves to be really true, it will be most important, as it will make electrification much more attractive to the far-seeing railway officials and will result eventually in the electrification of the terminals in all the large cities.

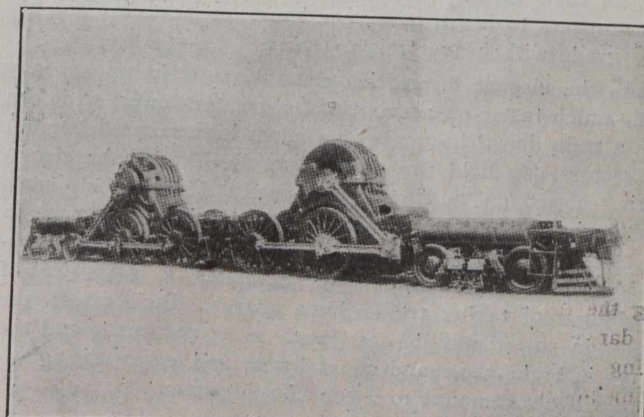

Fig. 1.—Running Gear and Motors, Pennsylvania Locomotive.

Beginning with the B. & O. R.R. at Baltimore, in 1895, a number of railroads have electrified tunnels which were a constant menace to the health and lives of the passengers and train crews. The St. Clair tunnel of the Grand Trunk Railway was electrified in 1906, and since then the Detroit River tunnel of the Michigan Central, the Cascade tunnel of the Great Northern, the Hoosac of the Boston & Maine, the Pennsylvania tunnel leading to the great terminal in New York City, have all been electrified in this country and are operating with great success, handling both passenger trains and the heaviest freight trains on both heavy grades and level track. These tunnels, in all of which, except the Pennsylvania, steam engines were originally operated, will be remembered by travellers as the places where every one was formerly nearly stifled. Now, either in the hottest summer day or the coldest of winter weather, the tunnel is welcomed as being the most comfortable part of the ride.

Another phase of the situation that is now receiving a great deal of attention is on the mountain grades where the heavy freight trains crawl up at from 5 to 10 miles per hour,

* Abstract of paper read before the Cleveland Engineering Society

and the passenger trains crawl up at from 10 to 20 miles per hour. These grades always form the "neck of the bottle," and limit the amount of traffic that can be handled by an entire road. Even if it cost a great deal more to operate such grades by electricity, it would pay large dividends on the investment by increasing the capacity of the entire road.

Some one may wish to inquire how this electrification will increase the capacity of the entire road. It is effected by increasing the speed both on the up-grade and the down-grade, and by the greater reliability of service. On electrified divisions, the heaviest freight trains of 2,000 to 3,000 tons trailing load can readily be hauled up a grade of 2 per cent. by electric locomotives at speeds of 15 to 20 miles per hour, while the speed with steam locomotives would be usually from 5 to 8 miles per hour. This is possible because the electric locomotive has the power house back of it, but does not have to haul it up the hill. At speeds of 15 to 20 miles per hour it will have all the weight on drivers, and usually only as much as is necessary for adhesion. This being the case it can haul the trains at 20 miles per hour just as efficiently as at 10 miles per hour.

The steam engine, on the other hand, must haul its entire power plant up with it, and consequently, the higher the speed at which it operates up a grade, the less load it can pull, so that the economical speed is very soon reached. This appears to be 10 miles per hour, or less, for a 2 per cent. grade with heavy freight trains.

As the electric locomotive can take a train up a heavy grade much faster on account of its greater power, so it can take a train down the grade at a much higher speed because the motors can hold the train from accelerating by regenerating power and putting it back into the line to help some other train up the grade, or by using it up in a resistance on the locomotive. This saves the brake shoes for use in stopping the train only and thereby eliminates a great deal of the danger of taking trains down grades. Incidentally, the saving in power may be as much as 25 per cent., and the saving in brake shoes and general wear and tear of the equipment will also amount to a considerable item.

We, therefore, have the greatest confidence in inviting the attention of railroad officials to the electrification of their mountain grades, for if the traffic is at all congested there, electrification is bound not only to improve the service, but to give a very substantial return on the investment. The electrification work that has already been done is enough to show that electric locomotives can handle any kind of service from the heaviest slow speed freight service to the fastest of heavy passenger work.

The next question is, when will the great lengths of line between the terminals, and connecting terminals and grades, be electrified? That is something that will depend entirely upon the territory through which the road passes and the population of the terminals. I regard it as entirely possible, if not highly probable, that within the next ten years one can travel from Boston to Washington by fast trains over the New York, New Haven & Hartford and the Pennsylvania Railroads, behind electric locomotives. The New Haven is now operating all trains between New York and Stamford by electricity and is rapidly extending its electrfication to New Haven. It is also working at the Boston end of the line between Boston and Providence, besides having its Harlem River division and its immense freight classification yards operated exclusively by electricity.

The Pennsylvania has the vast network of lines on Long Island, besides the New York terminal, operated by electricity. It is now working on the Philadelphia terminal which must be electrified in order to increase its capacity. The bad tunnel at Baltimore must be electrified and the terminal at Washington must soon follow. With these city terminals all electrified, it is a foregone conclusion that the whole distance from New York to Washington will be equipped, as it would be impractical to have any breaks in the service; aside from this consideration, however, I believe that the population is so large as to make it a paying investment anyway.

Similar results will follow in other sections of the country, but more slowly and only as it is found by the railroads to pay a good return on the investment. That is the only thing that will make general electrification possible. No matter how desirable it would be to the public the railroads cannot electrify until it can be made to pay, either at present rates for freight and passenger service or by the undesirable alternative of higher rates for the improved service.

Just a word to people who are for compelling the railroads to electrify their terminals in large cities. Don't do it. The railroads in this country are fully alive to the advantages of the electrification for such situations; or if not now, they soon will be, for they are all studying the subject with the greatest care. I believe the matter can be safely left in their hands for a few years, at least, until the necessary plans can be made and all the innumerable details connected with the adoption of the new motive power are fully worked out. Without this careful consideration, the plans will be only half baked, and vast sums of money will be wasted and the full advantages of electrification will not be secured. When the railways of any city decide to electrify the terminals, they should work out a harmonious plan that will include all of them, so that power may be furnished from a common power house, and all equipment be interchangeable.

Electrification is bound to come on a large part of the railroads sooner or later in any case, but the steam railways should not be forced into it until they have had ample time to mature their plans.

There are many, many advantages from it, some of which are only beginning to be understood and some of which have never had the correct value. When all have been shown by experience to have certain definite values, and the best way to secure the advantages has been thoroughly worked out, the railroads will need no compulsion.

Following the foregoing paper, Mr. Storer presented a number of lantern slides showing various types of electric locomotives and discussed their salient features. Prominent among the list were the locomotives of the New York, New Haven & Hartford, the Pennsylvania, the St. Clair tunnel, the Boston & Maine and several European types. In general, the types were shown to exhibit the various forms of connections between the motors and the driving wheels, and to show the disposition of the weight, and the arrangement of wheels as affecting the riding qualities of the locomotive. The different forms of transmission between motors and driving wheels were distributed as follows:

1st. Gearing motors directly to the axles as on the ordinary street car. Among the locomotives of this type shown was one experimental locomotive for the Pennsylvania Railroad, the St. Clair tunnel and the Spokane & Inland, all being suitable for service at speeds below 30 miles per hour.

Operating with this type of locomotive with heavy motors mounted directly on the axle, is confined to low speeds because of the effect upon the track on account of the dead weight on the axle and the low centre of gravity.

2nd. The locomotive having the motors mounted on a hollow shaft surrounding the axle; these hollow shafts or quills being connected to the wheels through the springs.

The early New Haven passenger locomotives were of this type and have been quite successful, although some trouble was experienced with them after a few months of operation, on account of nosing. This was overcome by the addition of pony wheels at each end of the locomotive and the use of a toothed cam centering device.

This type of locomotive is very successful as long as the track is kept in good surface, for, in spite of the low centre of gravity, the motors are entirely spring borne, so that a direct shock is very seldom given to the track.

3rd. The third type of locomotive exhibited had the motors geared to the quill surrounding the axle, which is connected to the driving wheels through long flexible springs which permit the motor and quill to move a total distance of three inches in a vertical direction with respect to the axle. It is, therefore, possible to mount the motors directly on the truck frame. This form of locomotive is made for the New York, New Haven & Hartford, with but one motor per axle and with twin motors. Where one large motor is used, it is necessary to have double gears which require very accurate alignment. Where twin motors are used only one gear is required and both of the motors drive through the same gear. The small motors are found to be less expensive for single phase work and are lighter and easier to handle. On the New Haven Railroad, the same motors are used for both locomotives and multiple unit cars, excepting, of course, the motor frames which have to be adapted for a different type of mounting. This type of locomotive gives high centre of gravity and is an exceptionally easy riding machine. All of the weight above the wheels and axles is spring borne, and there being absolutely no tendency for nosing, the machine is very easy on the track and is very comfortable to ride in.

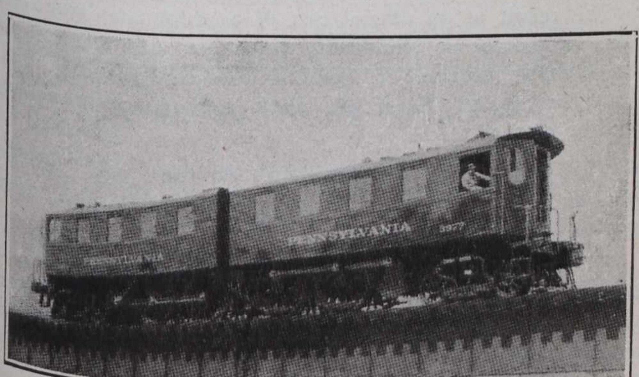

Fig. 2.—A Pennsylvania Railroad 160-ton D.C. Locomotive (600 Volts) for New York City Pennsylvania Terminal Operation.

Locomotives for both heavy freight and passenger work and for switching service with this type of drive were shown. It has been adopted as a standard by the New York, New Haven & Hartford, which has purchased over sixty locomotives of this type.

4th. Locomotives with motors mounted high in the cab and connected to the driving wheels through parallel rods from the motor to a jack shaft on the same level as the driving axles and thence to the drive-wheels by other parallel rods. The principal locomotive of this type which has been built is that of the Pennsylvania for use in the New York terminal. This is probably the most powerful electric locomotive ever built. It is used to haul trains of more than 800 tons weight up a 2 per cent. grade into the station. The locomotive weighs about 160 tons and has exerted a drawbar pull on level track of nearly 80,000 pounds. It is also able to handle the heavy passenger trains at 60 miles per hour on level track. This type of locomotive has the highest centre of gravity of any that have been built, and its operation on the track is similar to that of the best steam locomotives. A few years ago this would not have been considered very good by electrical engineers, but sad experience with machines having low centre of gravity has modified their opinions to a great extent and they are now glad to claim that such locomotives are as good as the best steam locomotives. This locomotive has established a wonderful record for reliability, there being only thirteen train minutes delay charged against the locomotives in the first year's operation. Such a record with 33 locomotives is little short of marvelous.

Another type of locomotive exhibited was that of the Italian States Railways, which connects the motors to the driving axles through a Scotch yoke. This is a form of side rod which is quite satisfactory for slow and moderate speed service. It has never been used for high speeds.

Another type is a combination of gears and side rods. This form is used for the locomotive built by the Oerlikon Company, in Switzerland, for the Loetchberg tunnel. The motors are geared to a jack shaft, instead of connecting to the latter by means of parallel rods as in the case of the Pennsylvania locomotives. This permits the use of a much higher speed motor and a considerable reduction in the weight and cost of the locomotive. It also enables the use of a single design of motor for various speeds of locomotives which may be secured by simply changing the gear reduction.

Some of the principal advantages of electric locomotives were discussed briefly and Mr. Storer expressed himself as being opposed to the extremely high wheel loads which are being used with the latest types of steam locomotives, and advocated the use of electric locomotives with wheel loads about equal to the maximum wheel loads on freight or passenger cars. It is claimed by many engineers that the destruction to the track is due almost entirely to the locomotives. These heavy wheel loads are probably necessary for the tremendous units that are now demanded, but the use of electric locomotives will permit the weight to be distributed so that no locomotive wheel need carry more weight than a car wheel in the same train. This will give the best possible results on the roadbed and will give more flexibility in locomotive units.

The matter of the arrangement of the commission appointed by the Department of Marine and Fisheries to investigate the water levels on the St. Lawrence River at and below Montreal, was brought up by Mr. Frank Carvell, at a recent session of the Commons, who stated that dredging had reduced the level in the harbor of Montreal very considerably from what it was eight or ten years ago. He suggested that the channel had something to do with the lowering of the water level in the harbor. The Honorable Mr. Hazen stated that the efforts of his department were now being directed to getting a thirty-five-foot channel. He had discussed the matter of the water level with officials of the department and had come to the conclusion that it was most desirable to obtain the best information on the point. On the recommendation of Messrs. Stewart and Forneret, of the department, he had invited Professor Haskell, dean of the Engineering School at Cornell University, to join them. Prof. Haskell had been engaged upon many river undertakings. The commission would confine its attention to the water levels between Montreal and Quebec, because the matter of navigation was urgent. A report was required without delay, whereas a commission with wider instructions would necessarily occupy a much longer period.

COSTS OF HAULING ASPHALTIC PAVING MATERIAL BY MOTOR TRUCKS AND TEAMS.

In his report on a proposed municipal asphalt plant for the District of Columbia, Mr. D. E. McComb submitted the following estimates on the cost of hauling asphaltic material in the District. The estimates are based on a haul over the streets of Washington. For hauling with a 5-ton motor truck, the following assumptions are made: Load = 6 dumps = 90 cu. ft. Cost per day, $12. Speed, 10 miles per hour = 1 mile in 6 min. Estimated time required to load, 9 mins.; unload, 7 mins.; tally, 2 mins.; total, 18 mins. For hauling with wagon and 2 horses the assumptions were: Load = 4 dumps = 60 cu. ft.; rate, $4.50 per day. Estimated time to load, 6 mins.; to unload, 6 mins.; to tally, 2 mins.; total, 14 mins. Estimated speed of team, 2½ miles per hour (1 mile in 24 mins.). The comparative cost per cubic foot of hauling asphaltic paving material for resurfacing and new work is estimated to be as follows:

	Motor truck. Per cu. ft.	Wagon. Per cu. ft.
½-mile haul	$0.0067	$0.0058
1 -mile haul	.0083	.0094
1½-mile haul	.0103	.0150
2 -mile haul	.0121	.0187
2½-mile haul	.0133	.0187
3 -mile haul	.0148	.0250
3½-mile haul	.0167	.0375
4 -mile haul	.0190	.0375
4½-mile haul	.0222	.....
5 -mile haul	.0222	.....

For hauling hot stuff on minor repair work the following estimates are given: Assumed haul by 1-horse cart for distances up to 2½ miles and by 3-ton auto trucks for distances beyond 2½ miles:

Cost of cart haul for average distance of 1¾ miles:

Estimated time required to—	Minutes.
Load	5
Unload	30
Tally	2
Total	37
To make trip and return	84
Grand total	121

Number of trips per day, 4.	Per cu. yd.
$2.50 ÷ 4 × 24 cu. ft.	$0.0260
Add 10 per cent. for delays	0.0026
Cost per cu. ft.	$0.0286

Cost of 3-ton auto truck haul for average distance of 3 miles, 12 miles per hour:

Estimated time required to—	Minutes.
Load	7
Unload	45
Tally	2
Total	54
To make trip and return	30
Grand total	84

Number of trips per day, 6.	Per cu. ft.
$10 ÷ 6 × 45 cu. ft.	$0.0370
Add 10 per cent. for delays	.0037
Cost per cu. ft.	$0.0407

The estimate for hauling asphaltic paving material for patching work is based on the following assumption: One horse cart: Load = 24 cu. ft. = 3 dumps, 8 cu. ft. each; cost per day, $2.50; estimate of speed, 2½ miles per hour; average haul = 2½ miles.

Estimated time required to—	Minutes.
Load	5
Unload (averaged)	30
Tally	2
Total	37
To make trip and return	120
Grand total	157

	Per cu. ft.
Number of trips per day, 3; cost per cu. ft. = $2.50 (÷ 3 × 24)	$0.0347
Add 10 per cent. for delays	.0035
Total cost per cu. ft.	$0.0382

REFUSE DESTRUCTION AND STEAM RAISING.

The result of an official test of a duplicate front-feed refuse destructor at Nuneaton, which was first utilized for steam-raising purposes in April of last year, appears in the report for 1912 of Mr. F. C. Cook, borough engineer and surveyor of that town.

The contractors were Messrs. Heenan and Froude, Limited, of Manchester, and the cost of the furnace, apart from buildings, was $3,902.50.

The main results show that during the eight hours of the test the furnace dealt with 61.5 lb. of refuse per square foot of grate area per hour, which is equal to nearly 50 tons per day, and that the water evaporated per lb. of refuse consumed, from and at 212 deg. Fahr., was 1.727 lb.

Very little use was made of the spare coal-fired boiler after the completion of the duplicate destructor. Altogether, the destructors worked for 302 days, and dealt with 2,711 wagon loads and 4,654 cart loads of house refuse, together with 99 loads of trade refuse, equal to a total weight of about 6,382 tons, and representing about 88 per cent. of the total house refuse collected.

The gross cost of labor in destroying the refuse was 36c. per ton, against 42c. in 1911. In 1911 the net cost (excluding capital charges, and deducting the saving in coal) worked out at $1.18 per ton; but last year there was an actual saving of $621.25 during the time the destructor was at work, as compared with what the cost of raising steam by a coal-fired boiler would have been over the same period. The result was mainly accounted for by the enhanced price of fuel—viz., 89c. per ton against 55c.—and to the very great increase in the quantity of sewage pumped, which would have led to a corresponding increase in the weight of fuel used in generating steam.

The sum of over $146 was realized by the sale of tin and galvanized-iron scrap. This is very nearly all profit, as this waste material was previously burned in the tips.

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CONTENTS OF THIS ISSUE.

GOVERNMENT SUPERVISION OF DAM CONSTRUCTION.

During the recent flood disasters in the United States at least one dam was reported as having given way, and there were many cases of panics and excitement in numerous towns over reports of the collapse of others. To what extent such panics and fears are justifiable we do not know, but there have been instances in the past in the United States of careless dam construction, disastrous to human life, which partly justifies a distrust by the people of such engineering structures. It all reflects to a certain extent on general engineering, and should be prevented. We have government supervision of buildings, etc., for the safety of the people. Why not —and more so—have it for the design and construction of dams if they endanger in their failure human habitations and life? An instance of what such supervision could have prevented was the Austin dam failure, which many of our readers will remember took place in the United States in 1911. Investigation after the accident brought out the facts that a portion of the dam which drawings showed thirty feet thick at the base was only twenty feet thick; that the existence of a cut-off wall or key, which was supposed to be four feet thick and extend four feet into bed-rock across the whole upstream face of dam could not be found.

Incompetent engineering in the above case and panics in the recent flood disasters in the United States should lead governments to adopt means of exercising skilled engineering supervision over dam construction. Ordinary static stresses in dam design are easy enough to figure, but the foundations and joints bring in elements of doubt that require to be met by liberal factors of safety in design. There should be absolutely disinterested inspection to see that improper economical risks are not taken for the sake of financial questions involved.

Such accidents and panics reflecting on the profession are not desirable, and engineers should be the first to applaud competent engineering and government supervision that would make impossible mistakes which endanger human life. Such a course serves the twofold purpose of increasing the people's confidence in their safety and preventing possible disasters which reflect on the ability and honor of the whole engineering profession. It would still further safeguard engineers in as far as when pressed for reasons of economy to lower factors of safety in design they would know it was impossible, due to government inspection.

UTILIZING THE SUN'S RAYS FOR POWER PURPOSES.

Most engineers have listened with interest at some time or other to tales of the practicability of gathering and utilizing the heat and intensity of the sun's rays in tropical countries for power purposes. Recalling the ancients and fairy tales of wonderful sun-glasses that were going to burn up ships and wreak destruction on those who ventured to oppose them, further memories come of years that have passed, with innumerable engineers longing at times to make a servant of the intense tropical heat of old "King Sol." We dwell on the fruitlessness of it all; probably recall that, while scientists in laboratories in a small way have successfully experimented, yet no practical results have ever followed, and, consequently, we are inclined to dismiss the possibilities of the scheme as hopeless.

While no startling success has yet been met with in the way of converting the energy of the sun's rays into useful work, yet it is well to remember that every perfecting of low-pressure steam engines brings the possibilities of that goal nearer. There have been advances in that line of late years, and it is of consequent interest to hear of a company which started construction in 1812 in Egypt of a 100 horse-power pumping plant to be operated by boilers obtaining fuel from the sun's rays. The history of the plant as given lately in London, England, by an official of the company is that on completion of the plant and after three days' successful running the specially designed zinc boilers, which acted satisfactorily in the United States, were unable at Cairo to stand the heat. They leaked, and had to be discarded, and the plant was at a standstill pending the delivery of cast-iron boilers ¼ inch thick. He hoped these would be fitted and the plant start running afresh on June 1st next. They had selected cast-iron boilers in order to obtain quicker delivery. In future they would use dished steel-plate boilers, for the manufacture of which it would be necessary to procure beforehand the required sets of dies. The first cost naturally was a heavy one, being probably twice that of a steam plant of equal capacity. As to operating, it might be stated that when coal was at the price of $2.50 per ton, the sun-power plant could compete with it; when coal cost more, then the sun-power plant made a profit. Starting the plant at 6 a.m., they had steam at 6.15. Starting at noon, with cold water, they had steam in three minutes. The low-pressure engine used was a special type of engine, and Prof. C. V. Boys, their consulting engineer, while feeling satisfied the boilers would substantiate in practice what had been advanced in regard to them, believed it was on the utilization of their steam that they were bound to concentrate their attention.

The report does not sound encouraging, but when we consider what the successful operation of such principles of design would mean to Egypt and other tropical countries in the way of irrigation and pumping possibilities, we cannot help wishing the enterprise all kinds of success.

Wireless and other modern inventions help one to believe that modern ingenuity will in some way find means to economically capture and convert into more useful energy the sun's heat of the tropics.

THE PACIFIC HIGHWAY.

The agitation and propaganda for good roads carried on by Highway Associations throughout the Dominion have invariably had for their primary and chief argument (and an immediately pressing argument) the mutual benefit to be derived by settlers and farmers and nearby residents in cities and towns through increased and easier trade facilities. Increased land values for farms, due to increased accessibility, have had prominence, and the importance of automobile and pleasure trips has been secondary—and rightly so—in all highway promotion. The exception to the above that might be said to prove the rule, is the case of "The Pacific Highway" in the Rocky Mountains. The proposed route of this highway is from Hazelton, in Northern British Columbia, to Yuma, Arizona, and ultimately on to Mexico. The British Columbia and California legislatures are in favor of the scheme, Washington is inclined to be favorable, and, provided the Oregon and Washington legislatures signify their willingness, the building of a splendid international highway, three thousand miles long extending from Hazelton southwards will soon be a certainty. In the meantime it is partly under construction in many parts already.

Considering the physical difficulties and expense of road building in the mountains, the slight population along great parts of the route, the certainty that fertile spots will only be found intermittently and that the major portion of the road must always run through uncultivatable mountain region, one might expect difficulties and discouragement in persuading legislatures to vote money for such a task. It is in the fact that the association which is stimulating constructions on the Pacific Highway bases in great part its arguments for the prompt construction of same on benefits to be derived from tourist travel that it differs from most highway organization. The vice-president of the association, Mr. Todd, in a recent address in British Columbia dwelt strongly on these benefits. Tourists from North America spent in Europe annually more than thirty times the amount of the expenditure of the Provincial Government for last year. Motorists from America and from England went regularly to Europe for motoring trips, and the amount which was thus spent out of the country—which might be spent in it—could be easily ascertained as an enormous sum. The Pacific Highway would tempt all these and many foreigners more to tour on the Pacific slope. In Mr. Todd's opinion 1916 will see not less than ten thousand foreign motor cars touring on British Columbia roads, and that these will do the Province a thousand times more good than any damage they may incidentally do the roads. Every one of these tourists will be a possible investor, and, presuming that these ten thousand cars average four passengers apiece and stay an average of thirty days at an expenditure of $10 a day for each person, $15,000,000 are at once in sight as a revenue which tourists must pay here for bare necessities.

Those who have ever been through the mountain districts of Europe or spent any time in the Canadian Rockies realize and will agree with him in what a tremendous asset British Columbia's scenery is, once they have accommodation and means to make travel in the remoter parts comfortable. The British Columbia legislature for years has spent more annually on trails and road-making than any other province in the Dominion. The work has been well done, and it has been rather a heart-breaking and long fight, contesting with nature as seen in British Columbia.

The people and province will reap the benefit in the end, and the present support of the Pacific Highway is only another laurel in British Columbia's crown for energetic and unswerving progress towards better means of communication throughout the Province.

The mail and passenger steamer "Lintrose," which has been constructed to the order of the Reid Newfoundland Company, of St. John's, Newfoundland, by Swan, Hunter & Wigham Richardson, Limited, at Newcastle-on Tyne, has successfully completed her trial trips, and is on the point of sailing for St. John's to take up her service of carrying passengers and mails between Newfoundland and the mainland.

The steamer is exceptionally strongly constructed for running through the ice which she will frequently find on her route, and is very finely modelled. She has accommodation for 180 first-class and 150 second-class passengers.

ALKALI-RESISTING CONCRETE.

Tests which have been carried on by the engineers of the United States Reclamation Service to develop a modified cement that would resist the action of alkalis and be cheaper than the commercial Portland cement is in the west were recently embodied in a paper read before the International Association for Testing Materials, and reads as follows:—

Sand Cement.—A good cement, comparing favorably in strength with the Portland cement used in its manufacture, can be made by regrinding Portland cement with certain proportions of inert materials (such as rock or sand, granite, basalt, sandstone, and tufa), the mixture being ground to a greater fineness than that of the original cement. The amount of diluting material may range from 30 to 50 per cent., depending on the fineness of grinding practiced.

In connection with the materials used in these tests, special interest has of late attached to the use of puzzolanic materials such as tufas, in which a portion of the silica is considered to be in "soluble" form such that it will enter into chemical combination with the uncombined lime in the Portland cement with which it is ground. That such materials can be used to good advantage in making a cement of this class has been proved by their successful use for this purpose in the construction of the new waterworks system for the city of Los Angeles in California. They are also of interest as being of possible assistance in the solution of the alkali problem. They are, however, of a lower specific gravity than most of the other materials (such as quartz sands, granites, etc.) which are generally available for making a cement of this class; and in the writer's opinion it has not yet been proved that they should be chosen in preference to these latter materials when both are available, as, on account of their lighter weight, they would tend to produce a cement of a lower strength than these heavier and harder materials.

As a result of the above investigations the use of cements of this general class has been adopted for two large masonry dams, and for the auxiliary works in connection with a large earthen dam whose construction work is about to be commenced by the Service. Grinding mills will be erected and the sand-cement manufactured at the sites of these structures, using Portland cement purchased in the usual manner, and the field materials available at these points.

With regard to the general use of cements of this class, it is evident that they are not applicable for use on small structures in scattered locations, on account of the cost of erection and operation of the grinding plant required. In the case, however, of a single structure requiring a large amount of cement, and located at a point where the cost of Portland cement is high, it would appear that they can be safely used, provided proper care is exercised in the selection of materials and in the process of manufacture, with a considerable saving in the cost of the structure as a result.

Disintegration of Concrete by Alkali Action.—Among the problems met by the engineers of the Reclamation Service, as well as by other engineers in the arid regions of the Western States, is that of the destruction of concrete by alkali action under certain conditions and in certain localities.

These arid regions contain numerous deposits of so-called "alkali," and in many places the ground waters are strongly impregnated with these salts in solution. This general term "alkali" is used to include a variety of substances, of which the salts of sodium and potassium are among the most common, although salts of calcium and magnesium are also included in the general term. As the use of cement and concrete in these regions is a comparatively recent matter, any effect that this alkaline water might have on concrete structures with which it comes into contact has until recently been a matter of conjecture if it has been considered at all.

Investigation of the subject, in the form of analysis of samples representing the alkali deposits and the ground waters where disintegration has occurred, shows that the sulphates, and especially sodium and magnesium sulphates, either singly or together, are the principal salts acting to cause this disintegration. The chemical action involved seems to be analogous to a considerable extent to the destructive action of sea water on concrete, in which magnesium sulphate is considered to be the principal salt acting to cause disintegration.

The conditions most favorable to attack appear to be where the concrete in small structures, such as culverts, etc., is subject to the action of seepage water coming through from the soil at the back, or of water which has become highly saturated and concentrated owing to light and sluggish flow in the water-courses in which the structures stand. Conditions of alternate exposure to water and air as produced by a varying flow in these water-courses are also especially favorable to the development of this action. It is hardly necessary to add that the character of the concrete also has a marked effect on the extent to which the destructive action will take place, a dense, well-made grade of concrete being, of course, more impervious and less readily attacked than concrete of a less dense, porous nature.

On a recent visit by the writer to one of the projects of the Service, where alkali conditions are prevalent, a marked contrast was noted between a tunnel lining on this project, which was in excellent condition, and another on private work in the same vicinity, which had been badly attacked by alkali action, and where the concrete work was evidently of an inferior quality. It is also probable that the character of the materials used for concrete aggregates, as well as the workmanship, may have some influence in the matter.

To refer briefly to the best method of remedying the difficulty, the main point is the production of a dense and impervious concrete, such that seepage of the alkaline waters through the concrete will be prevented. As to whether this can be best brought about by the use of a specially prepared rich and dense mixture without any other form of treatment, or whether some form of waterproofing treatment will be the best solution, is a question now under investigation.

TELEPHONES FOR FIRE PROTECTION.

According to the British Columbia report of the provincial forest branch it is their intention to construct telephone lines and pack trails where they are most needed throughout the province as a protecion from forest fires. Over the greater part of British Columbia neither of these essentials is at hand. As a means of rapid communication, the telephone is obviously the most desirable, considered from the standpoint of usefulness and cost of construction and maintenance. For woods work, a single wire (ground circuit) strung on trees has proven very satisfactory, and may be constructed at a remarkably low figure considering the protection afforded. In the national forests of the Western State, such lines have been built at a cost per mile varying from $30 to $80, depending on the accessibility of the country through which they run. Branching from trunk lines as mentioned above, there may be built cheap, temporary lines to "lookout points." A system of telephone lines is a tremendous aid in the prevention of forest fires, but should be accompanied by a system of good roads.

DESIGN OF AN AMMONIA-COMPRESSION REFRIGERATING MACHINE.

Assuming average temperatures of 70 deg. and 0 deg. F. for the ammonia in the condenser and evaporator, and allowing for losses at the regulating valve, influx of heat into the pipe connections and cold parts, and by superheating in the compressor, 450 B.t.u. per lb. of ammonia circulated may be taken as available refrigerating effect. Taking one ton of refrigeration as 322,000 B.t.u. (In the United States 288,000 B.t.u. is the recognized figure, based on a ton of 2,000 lb. and 144 B.t.u. per lb. of ice melted) per day of 24 hours, then 322,000 ÷ (450 × 24 × 60) = 0.497 = pounds of ammonia to be circulated per minute per ton. Taking the volume of 1 lb. of ammonia vapor at 0 deg. F. to be 9.1 cu. ft., volume of ammonia vapor to be circulated per min. = 0.497 × 9.1 = 4.53 cu. ft. = compressor displacement per min. per ton of refrigeration per day. This displacement is for machines of 2 tons of daily ice-making capacity; for machines of from 5 to 100 tons capacity the displacement ranges from 4.4 down to 4.1.

The maximum piston speed, because of the fact that self-acting mushroom valves are used, is about 350 ft. per min. The length of stroke of the piston should be from 2 to 2.4 times the diameter of the cylinder.

The cylinder walls, of cast iron, should be from 1 to 1⅛ in. thick to insure good working with ammonia at the pressures generally employed. With very close-grained iron, the thickness may be as little as ⅞ in. Liners may be used to advantage in cylinders over 8 in. in diameter. These should be not less than 1⅛ in. thick, and in 21-in. cylinders may well be 1½ in. thick to provide for stiffness, as they are supported only at the ends. The pores of compressor castings may be rusted up by subjecting them to a solution of sal ammoniac under a pressure of 200 lb. per sq. in.

The diameter of the suction valve may be made a little above, and the delivery valve a little below, one-third the diameter of the compressor cylinder. The piston rod should be made of steel having a tensile strength of from 78,000 to 90,000 lb. per sq. in., and an elongation of at least 21% over 6 in. The diameter of the rod should be one-quarter the diameter of the cylinder.

The mean effective pressure for an ammonia compressor working under conditions suited for ice-making may be taken as 60 lb. per sq. in.; from this the probable I.H.P. of the compressor may be computed, and that of the engine driving it will be about 25% greater. Also, I.H.P. of engine = (2 × ice-making capacity of machine in tons per 24 hours) + 10. For machines of less than 10 tons daily capacity, add 7 instead of 10.

Assuming the condensing water inlet temperature not to exceed 65 deg. F., then, for each ton of ice-melting capacity (ton of refrigeration) 60 to 70 running feet of 1¼-in. internal diameter pipe will be ample for submerged condenser pipe, and 90 ft. for pipes exposed to the air. The grids of coils for atmospheric condensers may be spaced 12 to 20 in. apart, 12 to 20 ft. long, and 8 to 12 ft. high.

Supposing that the brine is being cooled under conditions similar to those which exist when ice is being made, then for each ton of ice-melting capacity allow 125 to 150 running feet of 1¼-in. internal diameter pipe, it being understood that the greatest possible care is taken to insure an efficient circulation of the brine.—Condensed from a paper read by J. Wemyss Anderson before the Institute of Mechanical Engineers, November 22, 1912.

ARRANGEMENTS OF ROOFS FOR ENGINEERING WORKS.

A paper recently read by Mr. H. N. Allott, M.Inst.C.E., before the Manchester Association of Engineers, dealt with the construction and methods of roofing of engineering works as follows:—

Saw-tooth roofing, where possible, is usually arranged with the glazing facing north so as to prevent the direct glare of the sun through the glass. The principal advantage of the saw-tooth roof is that by its use a more evenly lighted and cooler shop is obtained. The amount of glazing to be allowed for in a roof of the ridge type should be not less than about 50 per cent. of the area of covering, and in districts with an atmosphere like that of Manchester this may be increased with advantage to 60 per cent or 70 per cent. The glass should be equally distributed on both sides of the roof, as by that means a more even illumination is obtained than when all the glass is placed on one side of the roof. Another advantage of distributing the glazing is that the direct glare of the sun and consequent heating of the shops in summer is minimized.

The roof covering in this country usually consists either of slates, asphalt felt, or corrugated iron. For slates or corrugated iron the roof generally is given a rise of not less than a quarter of the span, for if made of a flatter slope rain and snow are liable to blow in at the joints. For felted roofs the roof may be practically flat if the joints are properly made with mastic, and it is only necessary to give a fall of one or two inches to the foot to allow for drainage. Galvanized corrugated iron is usually only used in this country for buildings required for temporary purposes, and when used should be carefully painted before and after fixing, and afterwards properly maintained, as otherwise its life is only short. Slating, when used, may be laid on battens nailed to spars, or to boarding nailed to the purlins. When laid on spars the slates should be pointed on the underside with hair mortar. When laid on boarding the boarding should be covered underneath the slates with sarking felt.

An alternative to natural slates are asbestos slates, formed of a mixture of asbestos and cement, several reliable makes of which are now on the market. These are made about 16 in. square, and are best laid either with the diagonal parallel to the slope of the roof, or in what is termed "honeycomb" fashion. The point of the slate should be cut off, as it is otherwise liable to be broken by anyone walking on the roof. It is necessary in all cases to see that proper lap is given to the slates, and this is especially the case where asbestos slating is used, as owing to its smooth surface the roof is more liable to leakage, where proper attention is not given to this.

An alternative to galvanized corrugated iron sheeting has also recently been supplied by corrugated sheets of asbestos composition, which can be obtained up to 10 ft. in length and 27½ in. in width.

In the author's opinion, asphalt felt laid on thicknessed, grooved, and tongued boarding forms the best covering for engineering shops and similar buildings. Besides being cheaper than slating, it is not damaged like slating by men walking on the roof to attend to skylights, and for similar purposes. The use of felt of good quality is permitted by the building departments of most local authorities, although one or two treat it as not being sufficiently incombustible. The felt is laid in mastic and nailed to the boarding, the joints being lapped about 4 in. One thickness of stout felt will make a satisfactory job, if properly laid and if proper attention is given to maintenance, though the roof is generally covered with an extra thickness of a thinner quality of felt where a thoroughly good job is required. One advantage of the use of felt is that a considerable saving can be effected by forming the gutters in felt, instead of using cast-iron gutters; this is especially the case in roofs where large valley gutters are required. A considerable amount of lead, required for flashing at various parts of the roof, can also be saved. The only attention required to be given to felted roofs is a coat of varnish at intervals of about five years.

The comparative costs of the before-mentioned types of roof coverings are as given below, per square yard of area covered:—

20 B.W.G. galvanized corrugated sheeting	$ .79
Asbestos corrugated sheets	1.28
Slates laid on spars	1.15
Slates laid on match-boarded on underside	1.52
Slates laid on 1¼-in. boarding, including sarking felt	1.58
Asbestos slates cost about 12 cents per square yard less than natural slates.	
Asphalt felt, one layer, thick quality, laid on 1¼-in. boarding	.97
Asphalt felt, one layer thick, one layer thin quality, laid on 1¼-in. boarding	1.22

The roof glazing is best carried out with patent glazing, of which there are several satisfactory makes on the market, the alternatives to patent glazing being wood or T steel glazing bars, the glass being puttied in. The patent glazing is preferable, as with puttied bars the putty becomes defective and the glazing leaky, unless systematic attention and painting is given. The best systems of patent glazing consist of a steel bar, to which is fixed a lead flashing, which is worked down on to the glass to form a weather-tight joint. In most cases the glazing bar is sheathed all over in a lead casing, the ends of which are soldered up, thus obviating the necessity of painting. The bars should be galvanized before the sheathing is put on. Except in the case of vertical or steep-pitched glazing, as in the case of a saw-tooth roof, it is not advisable to joggle the glazing bar to form a lap in the glass. If this is done on a flat-pitched roof leakage is liable to occur, owing to capillary attraction between the two panes of glass. Where it is necessary to form a joint in the glazing on a roof of ordinary pitch, it is better to step the glazing bars. The roof glazing is best carried out with wire-wove glass, which holds together and does not drop if a pane is broken.

PANAMA PACIFIC EXPOSITION.

The Pacific Gas and Electric Company has been awarded a contract for the supply of gas, electricity and steam for the time and period of the Panama-Pacific International Exposition Company. The contract is as follows: "Contract signed between Panama-Pacific International Exposition Company and Pacific Gas and Electric Company, under which the latter will supply exclusively during the next 3½ years all electric current required for power and lighting purposes during the term of the World's Fair in San Francisco in 1915, and during the period of construction and dismantling. Present estimates are that the Exposition will require 20,000 horse-power. Gross amount of this business estimated at $500,000. Simultaneously contracts also made with Pacific Gas and Electric Company, for all gas and steam required by Exposition."

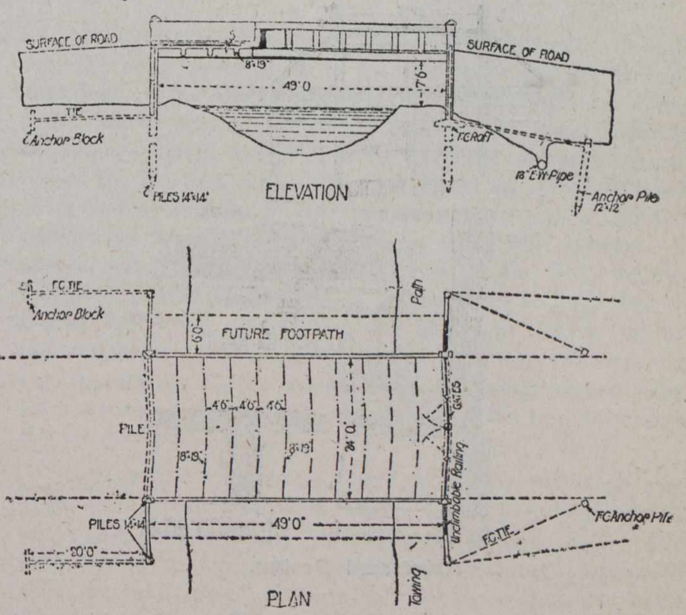
REINFORCED CONCRETE BRIDGE.

A description of a small reinforced concrete bridge with special features of design is given by Mr. D. M. Jenkins, Assoc. M. Inst. C.E., of Neath, England, in an issue of Ferro-Concrete. The following is an abstract from same.

The bridge has a span of 49 ft., a width between parapets of 24 ft., and a clear headway of 7 ft. 6 in. above the towing path of the canal.

No solid foundation being available at a moderate depth, the drawings provided for ten ferro-concrete piles, 14 in. by 14 in., which were made on the spot, to be extended upward as columns for the abutments and wings, the wing piles being tied to anchor piles, 12 in. by 12 in., by ferro-concrete ties. The accompanying drawings make clear the structural features of the bridge.

The contract length of the piles was 23 ft., which was based upon the indications of a trial shaft sunk in the marsh about 15 ft. distant from the site of the north abutment, strong gravel having been found at a depth corresponding to a length of pile of 20 ft., and provision made for entering 3 ft. into the gravel. Above this formation the whole of the excavation for the shaft was in a rather soft alluvial clay.



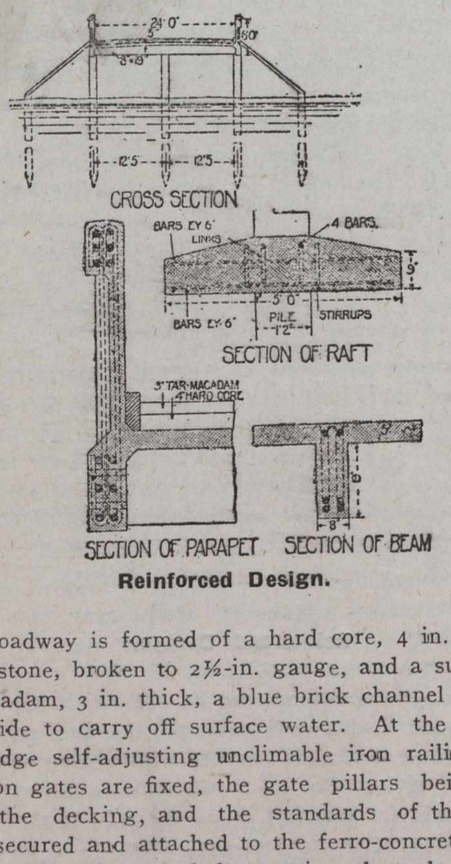
Reinforced Design.

Pile-driving was commenced on the south bank of the canal, and good results were obtained, the final set, measured for ten blows of a 2-ton monkey with a drop of 3 ft., being ⅜ in. to ¾ in. On the north bank, however, no satisfactory set was forthcoming down to and at the contract depths—nothing better in fact than from 3 in. to 6 in. for ten blows. It was then decided to drive an experimental pitch pine pile, 40 ft. long by 14 in. square, on the line of the abutment and near the central pile, but no better result was obtained. The absence thus indicated of the stratum of gravel found in the trial shaft, although it had clearly been reached below the south bank, farther away from the shaft, pointed to a deep "wash-out" of that deposit within very narrow limits; and in view of the uncertainty as to the extent of lengthening of the piles required to reach the solid, the desirability of adopting some alternative plan was considered.

Eventually it was decided, in consultation with Messrs. L. G. Mouchel and Partners, not to lengthen the piles, but to rely upon them as they were to carry a load of 10 tons each and to carry the abutment and wings on a ferro-concrete raft, 5 ft. wide, and from 9 in. to 14 in. thick, which was designed to take the remainder of the total load. The raft was formed in situ on the puddled bank of the canal, which is known to have been constructed over 100 years back, and is thoroughly consolidated and sound. The calculated maximum load on the bottom is 0.8 per ton square foot, and the estimate formed of the safe load which the bank could carry has been fully borne out by the result of the test applied (which is described later), and the subsequent traffic over the bridge.

The abutments and wings are built up of ferro-concrete columns, curtain beams and curtains, thoroughly braced together and to the ferro-concrete raft, the wings being formed with a slight batter and finished off with a rectangular coping, also of ferro-concrete.

The superstructure consists of two pilastered main beams, which form the parapets; cross beams, spaced 4 ft. 6 in. apart; and a continuous decking, 5 in. thick, with cambered upper surface—all moulded in situ so as to form a monolithic whole. Holes are left in the parapets, two to each bay, to enable ferro-concrete brackets to be bolted on to carry future footpaths.



Reinforced Design.

The roadway is formed of a hard core, 4 in. thick, of local sandstone, broken to 2½-in. gauge, and a surface coat of tar-macadam, 3 in. thick, a blue brick channel being laid on each side to carry off surface water. At the north end of the bridge self-adjusting unclimable iron railing and a pair of iron gates are fixed, the gate pillars being bolted down to the decking, and the standards of the railings similarly secured and attached to the ferro-concrete piers by means of ¾ in. diameter bolts passing through them and enclosed in lengths of galvanized iron tubing.

The approach road on the south side is carried on an embankment, with 1 to 1 batters, covered with sods obtained from the marsh; and on the north side, after the preliminary filling to counteract the outward thrust of the abutment during the process of testing, the surface was brought up to the required level by the tipping of town refuse, and a temporary sleeper road formed. Part of the "Back Cut" of the canal has been enclosed by 18-in. stoneware socket pipes, bedded on and surrounded with cement concrete, and the toes of the embankment are supported by retaining walls of rubble masonry.

In his article Mr. Jenkins points out that there were two special conditions governing the design of the bridge: (1) The superstructure had to be kept up so as to give a clear headway of 7 ft. 6 in. in accordance with the requirements of the Neath Canal Navigation, who have statutory powers, and whose consent had to be obtained in the first place for the crossing of the canal; and (2) the surface level had to be kept as low as possible so as to avoid excessive gradients on the approaches. To meet these opposite conditions, the arrangement was adopted of two main girders, carried up as parapets with cross beams spaced sufficiently close together to keep their depth within the required limits. Further, for a number of years only limited cart traffic will be required to pass over the bridge, but later on, when the marsh land has been developed, access for the general public will have to be provided. To meet this condition the bridge has been formed to the by-law width of carriageway—namely, 24 ft.—and provision made, as before mentioned, for adding when required a footpath to be carried on cantilevers outside each parapet. This is an economical arrangement, while at the same time it admitted of the distance between the road surface and the underside of the main beam being kept to a minimum—the alternative having been to space the main girders 36 ft. apart to increase their depth and strength, and incidentally the gradients of the approaches, and to incur practically the whole cost of the finished bridge long before it was necessary.

MOTOR FUELS AND THEIR FUTURE PRICE.

Mr. G. S. Sayner, in a recent lecture to the members of the Harrogate and District Automobile Club, pointed out that benzol was one of the first products of the distillation of coal tar, and was obtained in very large quantities on the Continent, and to a limited extent (now increasing largely) from the recovery plants fitted to ovens in which metallurgical coke was produced. This hydrocarbon had the formula C_6H_6, and was only a little less volatile than petrol, 1 lb. giving 4.5 cubic feet of vapor at normal temperature and pressure. Like all the volatile hydrocarbons, there was a certain amount of variation in the determinations of its calorific value—from 18,188 B.th.u., according to Thompson, to 17,780 as determined by the bomb calorimeter. The commercial washed or rectified 90 per cent. benzol was the only kind really suitable for motors, though Mr. Sayner said he had run a car on the crude 60 per cent. unwashed. There was no difficulty in driving motor carriages of any description with 90 per cent. benzol as the principal fuel. With regard to napthalene, coming from various products of the distillation of coal, it contained 93.7 per cent. of carbon, and required melting or vaporizing, and special apparatus for obtaining the explosive mixture. One advantage was its low cost—0.32d. per horse-power-hour in a recent test. Mr. Sayner added: "In looking into the future I see great possibilities for napthalene, as the source (coar tar) from which it is obtained is more likely to be equal to the demand. Those in the North of England especially are in a favored position, as the tar of the coal is full of napthalene. The quantity required for motor purposes could be easily provided."

CANADIAN PULP AND PAPER MANUFACTURERS.

The Canadian Pulp and Paper Manufacturers' Association has been formed for the "object of gathering statistics on the possibility of the world's market, the collection of rainfall data, and to co-operate with the Dominion Government in the establishing of laboratories for forest products."

EXPLOSIVES.

By J. K. Moore.

(Continued from page 534, last issue).

After the hole is loaded, or nearly so, put in your fuse and see that the powder in the fuse is exposed and dry. After placing the fuse in the powder, put in some more powder to insure ignition and tamp in the usual way, using wood or copper rammer. If the hole is deep, use double fuse, place the end in a cartridge of powder and see that it is tightly tied on.

Powder does not require a detonator or cap. It ignites from a spark. Powder will not explode if wet.

When a shot has to be set off at cross-roads, or where the traffic is heavy, men should be sent out along the different roads to stop the traffic. They should have a flag and signals should be arranged so that the powderman could be warned when everything is clear. Even with this precaution the usual calls of alarm should be given.

Electricity and Wire Fuses.—When using electricity, or a battery and wire fuse, in setting off shots, never connect up the wires to the power wires or battery until every one has gone to a safe place as there may be a leakage and a premature shot follow. Platinum electric fuses can be procured almost anywhere for black powder, and combination fuse and detonator for dynamite. Be very careful that you get the very best and be sure you keep them dry.

I am convinced that in quarry work and heavy blasting, wire fuses, cable and battery, is the safest method of exploding powder or dynamite, because immediately you disconnect the wires of the cable from the battery there is no danger from fire in the drill hole, as there would be from ordinary fuse, even in case of misfire. If you have a misfire you can go over your wires immediately after without danger. Wire fuses are placed in the charges the same as other fuse and the same care exercised when tamping so as not to cut the wire. In making your connections, see that the ends of the copper wires are clean and bare, raise every connection thus made from the ground by placing a dry piece of wood or stone under, as the damp soil may ground the current, and be sure you do not allow two connections to touch or else you will cause a short circuit.

Mis-shots.—Mis-shots are shots that have failed to explode. The causes are manifold. It may be faulty fuse, poor detonators, carelessness in pulling the fuse out from the cap or charge. Or in electricity, it may be from overcharging your battery, that is, having more shots connected up than your battery can stand. It may be the platinum in the cap, broken wires, grounding or short circuit. But whatever the cause, care should always be exercised in returning to the shot if ordinary fuse is used. Several hours should always elapse between the time of lighting and returning in such cases, as there may be smouldering, and catch the powder in the fuses again. In electric fuses, it may be better to allow a few minutes, but be sure you disconnect the battery. If you cannot find the cause and have to put down another primer or fuse in the drill hole, be very careful not to remove all the tamping, and, in the case of dynamite, it is a dangerous practice at best. In black powder, use a copper picker used for the purpose, and be sure you moisten the tamping.

It is also dangerous to drill a new hole near the misfired one, that is, within two feet, hoping that it may explode the other one, when it (the second shot) explodes, as the shock from the drilling may set it off prematurely.

Taking Out Charge.—Always follow the safest way, and that is, drill a new hole several feet away from the one that has misfired, never closer than three feet, drilling down to about the level of the charge in the other. Then load lightly and fire. Then you will be able to get a new primer down to the misfired charge in the other.

In partly exploded shots, do not try to drill the hole out to make room for another charge. Simply put in some more explosive, another primer, with no tamping, and set off. Care must be used not to put in too much dynamite to spoil the hole for further use.

There are three or four practical ways to break boulders. The first is by drilling a small hole called a plug and putting in the necessary charge. But this is slow, if it is simply to remove the boulder. The second way is by bulldosing. This is done by placing several sticks of dynamite on top of the boulder on the flattest part near the centre, and covering with fine moist clay to exclude the air. But this is very expensive as to powder. The third way is to dig a hole with a bar under the boulder, and always try to get the charge under the concave part near the centre and never on the round or bulge side. This is the cheapest and best method.

Hardpan.—In blasting hardpan drill holes horizontally into the bank about eight to ten feet apart and six to seven feet deep, with bars or spoon shovel for the purpose. These holes can be sprung by a high explosive to make room for the charge, about one stick of 60 per cent. dynamite is sufficient for the first time. This gives you an idea how it will work and what powder you may require to get a pot-hole sufficiently large enough to receive the full charge. Be careful not to reload before all chance of fire from the fuse has gone and in springing use no tamping, as confining the charge will break the wall of the bore hole. After springing and before placing the final charge, clean the hole well out, removing all loose material with the spoon shovel. Then load according to what you want done. This has been found a very successful way.

Holes can be widened in hardpan in the following way: Drive your bar-drill to above twelve to fifteen inches into the bank, then use a primer, of about one-third or half a stick of 40 per cent. dynamite, according to solidity of material, clean out and repeat, driving the bar or drill twelve inches further and charging again, and so on. Six feet is about the distance most successfully done in this manner, and the hole is anything from three to five inches wide.

This method suits best where two men are working, but in case of a whole crew with horses, etc., causes the others to lose more time than anything gained. However, a good foreman can easily regulate this. Do not use a high explosive for the final charge, as it is too quick, and therefore local. It is better to use black powder, which is slower in action, or Judson powder of low grade. Judson powder is highly recommended for that particular, because it is almost as slow as black powder and has double the power.

Blasting Stumps.—In blasting stumps, take your bar and spoon shovel and drill a hole under the stump and close to the main root. If the stump is large, you may have to spring the hole to make room for the charge. After charging, tamp well. In wet ground be careful about greasing your primer and see that you use waterproof fuse. Water makes good tamping for dynamite, but not for black powder, excluding the air, but you must see that it comes up to the surface level at the stump. If the stumps are in very soft ground, it will be deemed advisable to place a flat rock under the stump to place the charge on. If the earth is free from rocks, the hole may be drilled with an earth auger. If large stumps show signs of rottenness in the centre, place your charge under the most solid part, and in cases where they burst open, leaving parts of the stump and roots stil. in the ground, which have afterwards to be dug out, try a heavy chain fixed tightly round the upper part of the stump, about twelve inches or so from the ground. This is sometimes very successful, but depends on the powderman and the judging of his shots.

Mixing Powders.—Never use two qualities of powder in the same drill hole or charge, as it does not seem to be any great benefit. Dynamite will set off black powder, but it is so quick in its action that it may do considerable damage before the total ignition of the black powder takes place, making fractures, which allow the gases of the latter to escape, thus reducing its power. However, it is very effective in cases where a number of holes have to be tried, to load one with dynamite and the other with gunpowder or Judson powder, and so on, and firing with battery.

The magneto machine is one of the best, and be sure you get it strong enough to set off as many shots at one time as you require.

The cable used to connect up the wire fuses and the magneto machine should be strong, well insulated and pliable. A reel should be used for winding it up immediately after use.

Explosives will keep a considerable time if well stored, but one should be careful not to order more than he expects to use during the season. Explosives should not be mixed in a magazine nor should caps or detonators be stored with powder.

In handling dynamite do not throw it violently from your shoulder, nor smash the box open with an axe or hammer, or in any other violent way, particularly if the weather is hot; nor should it be packed too high one on another, in the magazine. In hot weather do not carry a box of dynamite on your head or shoulder, over rough ground, in case of stumbling. Black powder in kegs is loose, and weighs twenty-five or fifty pounds in boxes, compressed in cartridges. Do not smash a keg or box open with any iron or steel tool; wood or copper should only be used.

Magazine.—A magazine should be built much the same as a root house, frost proof, if possible, good drainage, well back from any settlement or highway or heavy timber, and according to the Explosive Regulations of this Province, chapter 80, paragraph 4, all the ironwork in the inside should be covered, or nails driven down below the surface of the boards and puttied. The hinges should be copper, also the lock and key. The floor should not be rough or rocky; it should be of earth, but better still, wood free from any iron or steel. Brick, concrete or stone is dangerous. Bitumen is one of the best. A lightning conductor should be put on outside and be well grounded away from the magazine.

TEMISKAMING AND NORTHERN ONTARIO RAILWAY.

We publish below statistics of the operation of the T. & N. O. Railway, which is managed through a commission appointed by the Ontario Government. There is a slight decrease in the total revenue for 1912, and a slight increase in the corresponding year's expenditures. The reduction in revenue from operation is due mainly to the Cobalt mining camps' increased use of mills for concentration of their ore values and a consequent great reduction in tonnage of ore shipped out. The use of electric energy for power purposes is also reducing to a great extent the transport of coal to the north country.

FROM 1905 TO 1912, INCLUSIVE.

Year.	Freight.	Passenger.	Other Revenue.	Maintenance of Way and Structures.	Maintenance of Equipment.	Traffic Expenses.	Transportation Expenses.	General Expenses.	Total Revenue.	Total Expenditure.
	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.	$ c.
1905	121.530 46	108,681 76	23,508 33	25,072 89	12,533 68	....	88,342 41	13,823 52	253,720 55	139,772 50
1906	230,552 63	254,759 33	58,706 89	77,265 87	46,382 65	....	215,256 08	23,587 98	544,018 85	362,492 58
1907	390.894 29	388,343 03	74,282 69	112,395 22	88,016 79	....	412,160 52	32,839 76	853,520 01	645,412 29
1908	471,203 41	366,504 53	135,357 67	125,563 43	119,563 01	9,789 99	405,907 58	24,863 45	973,065 61	688,397 43
1909 (10 mos.)	756,141 66	483,110 89	121,972 32	191,170 18	107,078 96	14,920 04	436,768 41	49.989 34	1,361,224 87	794,796 88
1910	852.886 46	606.967 91	131,997 65	380,314 75	137,340 46	17.705 31	556,740 45	76,045 66	1,591,852 02	1,165,361 36
1911	974,678 33	653,063 01	153,223 49	353,918 92	164,145 69	17.461 22	567,316 97	78,911 74	1,780,964 83	1,181,998 63
1912	929.464 66	599.681 73	178.303 68	346.964 01	249,683 22	12,499 96	676,963 33	93,625 91	1,707,450 07	1,384,697 69
	4.727.351 90	3.461.112 19	877.352 72	1,612,665 27	924.744 46	72,736 52	3.359,455 75	393,687 36	9,065,816 81	6,362,929 36

Temiskaming and Northern Ontario Railway Statement.

Summary.

Freight revenue	$4,727,351.90
Passenger revenue	3,461,112.19
Other revenue	877,352.72
	$9,065,816.81
Earnings—Ore Royalties, etc.	473,643.74
Balance at profit and loss	$ 338,286.03

Maintenance of ways and structures	$1,612,665.27
Maintenance of equipment	924,744.46
Transportation expenses	3,359,455.75
Traffic expenses	72,376.52
General expenses	393,687.36
Total expenditure	$6,362,929.36
Paid treasurer of Ontario	2,838,245.16

COFFERDAM CONSTRUCTION.

In a paper published by the American Society of Civil Engineers, Volume XXXIX., entitled, "Fremantle Graving Dock: Steel Dam Construction for North Wall," J. F. Ramsbotham describes the construction of a cofferdam in Australia for a submerged depth of over 50 feet. If, after excavation, a doubtful foundation was disclosed the site for the graving dock was to be changed and a quay wall built. The following is an abstract from the paper:

Steel sheet piling was used and the material in which the piles were driven consisted of a hard limestone cap, coral, clay, and sandstone, the limestone cap being particularly hard in a portion of the pumping station, where a total of 60 ft. of driving had to be done, or, in other words, each pile had to be driven 60 ft. into the ground. It is worthy of record that, in driving one of the steel piles, a 45-lbs.per-yd. steel rail was cut into two pieces, one section being found subsequently on excavating within the dam.

From a driving point of view, these piles are admirable, as the cross-sectional area, or displacement, is small compared with the covering area of the face of the pile. Although whippy, with care very few piles were damaged; and, further in shipping 1,900 piles, 60 ft. long, from the United States to Western Australia, not one was damaged, and only two were damaged in handling for driving. In handling from the steamer it was found best to have 8 x 3½-in. fish-plates of Oregon pine, 10 ft. long, with a sling chain around them, placed 20 ft. from one end. In handling, preparatory to driving, a single piece of 7 x 3-in. Oregon pine, 8 ft. long, was found best, and was slung one-third from one end.

Design of Dam.—The points that require careful watching in designing a dam are: (1) Strength of skin (which can be taken as a beam supported at several points, and to an extent this is advantageous, as benefit is derived from contraflexure); (2) strength of walings or longitudinal beams; (3) strength of shores or transverse columns; and (4) factor of safety on the dam.

Great benefit may be derived from working in water, as it is possible to calculate exactly the loads which the various members of the structure have to carry; and, needless to say, the object is to place the walings and shores so that they and also the skin will have an ample factor of safety.

In designing the dam, a maximum tide of 6 ft. 6 ins. above low-water mark was considered, and the dredged bottom was taken at 49 ft. below low-water mark, thus giving a total calculated head of 55 ft. 6 ins., which in actual work could be taken at 51 ft. Further, clay puddle was tipped to a minimum height of 9 ft. at the skin of the dam, in order to make a seal of the porous rock, and at the same time, reduce considerably the head on the dam. Assuming that the shores are placed at 10-ft. centres horizontally, the pressure on a strip of dam, 10 ft. wide is:

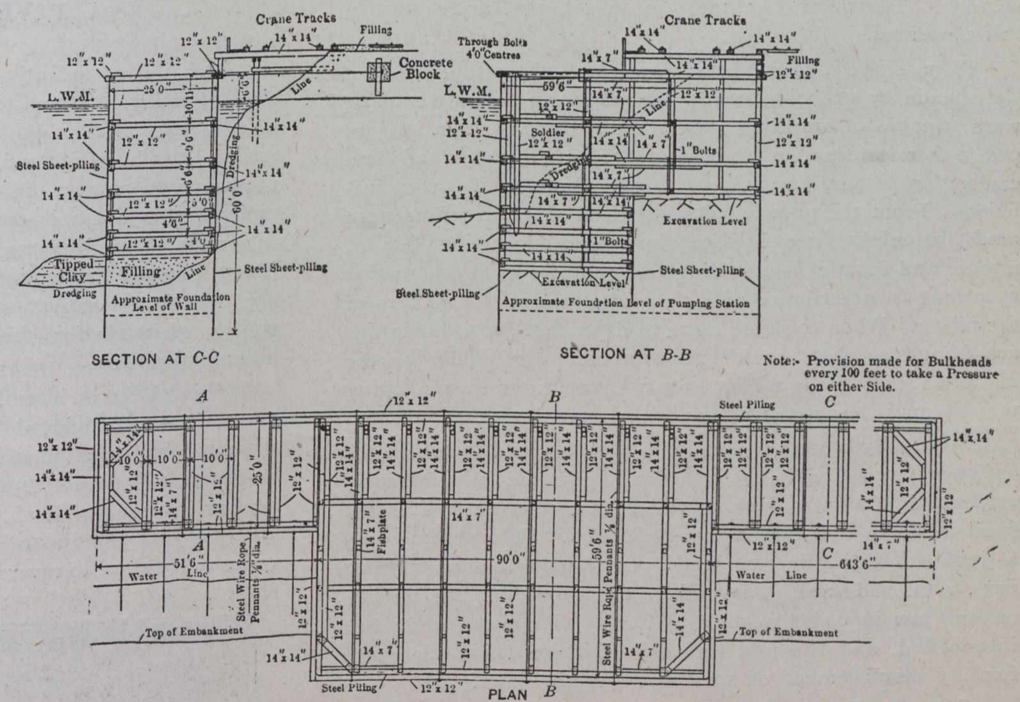
$$\frac{55 \text{ ft. } 6 \text{ ins.} \times 10 \times 55 \text{ ft. } 6 \text{ ins.} \times 64}{2 \times 2{,}240} = 440 \text{ tons.}$$

The strength of a jarrah beam. loaded uniformly and supported at each end, is given by the following formula, in which K is a constant which has been ascertained to be 13; B is the breadth, and is assumed to be 14 ins.; D is the depth, and is assumed to be 14 ins.; and L is the length which is 9 ft., or 108 ins.:

Breaking weight, in hundredweights =

$$\frac{8\,K\,B\,D^2}{L} = \frac{8 \times 13 \times 14 \times 14 \times 14}{108} = 2{,}642 \text{ cwt.} = 132 \text{ tons.}$$

Thus, using a factor of safety of 3, the safe load $= \frac{132}{3}$ = 44 tons. From this the number of walings or beams required is $\frac{440}{44} = 10$.



Plan and Section of Cofferdam.

It is worthy of note that, in calculating the strength of walings, no allowance was made for the fact that the beams were continuous over several supports, thus giving a greater margin of safety than is shown. The shores or columns were 12 ins. square and 22 ft. 8 ins. long, and were worked out by Gordon's formula in a similar manner, one end being considered rounded and the other fixed, the factor of safety being slightly less than 3.

When the driving of the piles was completed, it was found that it was impracticable to keep them absolutely vertical or in line, due to the hard nature of the ground; and, although the divers packed between all piles and the back of the walings, a certain amount of unquestionable bridging or arching took place. This was so marked that, without any further delay, additional shores were placed alongside those already in, the factor of safety of the walings thus being increased to 3¾ and the shores to almost 4½.

The skin of the dam is important, and the largest span was settled empirically from observations and was a clear span of 8 ft. 8 ins., subjected to an actual head of 17 ft. 7

ins. of water. In the dam in question, the span was 8 ft. 7 ins. between the second and third shores. Between the first and second shores the clear span is 9 ft. 11 ins., and, although allowance was made for a high tide of 6 ft. 6 ins., it is seldom if ever reached. From the writer's experience, a clear span of 8 ft. 8 ins., subjected to a mean head of 16 ft. 8 ins., is quite satisfactory, the total load on a pile being 4.88 tons, and the maximum stress about 10 tons per sq. in.

Practical Construction Details.—First, it is of the utmost importance that the female end of the pile should always be driven over the male, and not the male in the female. If the latter is done, a column of spoil will be compressed under the male in the jaws of the female which will finally end in the bursting of the structure. To enable rapid progress two piles were split down the centre and a double male pile manufactured, riveting a 6 x 3 x ½-in. T-iron on the back for stiffness. By this means two piling machines were utilized; one was built on an outrigger, with one end supported on staging and the other end on a log on the ground, the piling frame, winch, boiler, etc., being self-contained and easily moved. The other machine was on a barge, and was also self-contained.

In passing, it may be mentioned that the piling winches were made by the Lidgerwood Manufacturing Company, and were capable of working a 2-ton "tup" or hammer. A 30-cwt. tup was found to be best in practice, and a good man can get 20 blows per minute, a 5-ft. drop being quite sufficient. From the plan it will be noticed that provisions were made for subdividing the dam every 100 ft. by using T-piles, a male and female T-pile being left opposite each other; this was done in accordance with the catalogue of the makers of the piling. When the time came to drive, however, difficulties arose, and as they could be overcome very easily by the manufacturers of the piles, the writer mentions them, hoping that he may thus assist others.

First.—By having a female T-pile, it would mean, in the ordinary course, driving a male pile in it; as previously mentioned, if this is done, it will end in disaster, unless the spoil in which it is driven is a fluid mud. To overcome this, a double female pile was made, and on one side a strip of iron, 1 in. wide and ½ in. thick, was tapped on the outside on one jaw in order to make a lock. The jaws were then interlocked, and the pile was driven, there being clearance for any displacement of spoil between the jaws.

Second.—Great care must be exercised in keeping the two T-piles parallel, otherwise obvious difficulties will arise in closing. The manufacturers could overcome this by making an expanding pile with slotted holes, so as to enable the closing pile to vary its width from the top to the bottom.

Third.—Even with parallel piles, it is extremely hard to marry in with the closing pile, and it is desirable to have a few piles of different width.

Fourth.—If a male T-pile is used at each side of the dam, as should be done, a double female pile is required with which to end, and such should be supplied by the manufacturers.

Fifth.—If a male T-pile is urgently required, it can easily be made, and at small cost, by riveting an ordinary 45-lb. rail to an ordinary pile.

Sixth.—In driving the piles, the moment one seems to be hardening up and has not reached the required depth, another should be driven ahead of it, and, if necessary, this should be repeated until there are signs of having reached soft ground again. It is then possible to exert more force, but even then abuse must not be resorted to, as there is grave danger of parting the piles, but if this does happen by having driven ahead, that danger is limited in extent and is only local.

From the cross-section it will be noted that the piles toward the shore were driven on the side of a cliff, which had been left in a very irregular condition by the dredging, and added considerably to the difficulties of the piling gang; it also rather retarded the progress, as some piles had to be drawn. A fair month's work for the two machines, there being two 8-hour shifts on each machine, averaged 370 piles, representing 9,361 lin. ft. of driving.

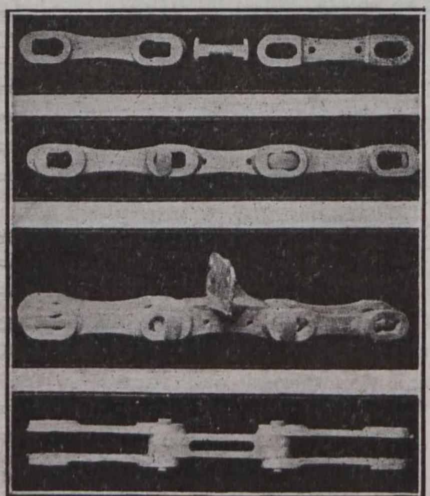
The first steel pile was driven on July 14, and pumping was started in Dam Section No. 1 on November 16, the entire dam being framed by the end of the year.

It is interesting to note that 1,872 steel piles were used, representing 47,385 lin. ft., or 9 miles of actual driving. In the first dam section there were 401 piles, which gives 24,060 lin. ft. of joint, representing very nearly 5 miles of joint.

A RIVETLESS CHAIN.

A chain was recently patented by Joseph L. Lee, general superintendent of the Cross Engineering Company, Carbondale, Pennsylvania, and manufacturing and selling arrangements have been entered into with the company, which is preparing to market the chain at an early date. The principle of this chain is entirely new, but simple, from which it derives its trade name of "Simplex." The accompanying illustrations of links, pins, attachments, and assembled parts are to a large extent self-explanatory, but the following claims are made for this new product by the inventor and manufacturers:—

This chain is interchangeable in all parts. Its parts are easily and quickly detachable, and each section can be so detached in less than a minute. The links can be released or removed by a horizontal movement of the diameter of the pin, or in the 9-in. pitch, 1⅛-in. movement, doing away with the necessity of adjustment of take-up when links or pins require renewal, or to reverse the pins for further service. It will operate over either a sprocket wheel or a traction wheel by reason of the concave shape of the links, and is also interchangeable with certain other types of rivetless chain. The chain has a wearing surface on both link and pin equivalent to standard riveted eye-bar chain, generally known as the 'Scranton' type of chain, the pins being reversible, so that after becoming worn on one side they can be reversed 180°, so presenting the unworn side for 100% additional service, and at the same time nearly restoring the chain to its original pitch.



A special feature of this chain, as well as a distinct advantage over any other type of chain, is the "lip" shown on the outside links. When the chain is in working position, and whether in the position of passing over a sprocket or traction wheel, the double-slot space back of the pins on the centre links, forming a recess or pocket, is entirely closed. This prevents dirt or gritty material from coming in contact with the wearing surfaces, and if desired the recess or pocket may be filled with any solid lubricant, such as graphite or hard grease, and so insure the longest possible life to both link and pin at the contact points of wear and friction.

The links, being solid, have a distinct advantage over the web, or open, type of link, as there is no compression at any point on either link or pin to cause the chain parts or attachments to stick or to be disconnected with difficulty, and it is not necessary to remove the attachments to disconnect the links or pins.

The two centre links form a pocket for the insertion of the several forms of attachments required, and may be reversed "back to back" and so used for attachments requiring side elevation or conveyance. Attachments for this chain will first be made of malleable iron to meet standard elevating and conveying requirements, and for extraordinary service certain attachments will later be made of a special tough steel. Attachments when bolted to links will, it is claimed, bear an equivalent strain as if cast in one piece. The links are to be drop-forged from 30 to 40-point carbon steel and broached to assemble to accurate pitch, and the pins are also to be drop-forged and machine-finished, and to be shop-assembled to links to insure the free working of chain parts.

It is the claim of the manufacturer that this chain will in a large measure displace several of the types of riveted chain now in use. The Cross Engineering Company is preparing to manufacture this chain in 4-in., 6-in. and 9-in. pitch, and it is stated that the chain will be sold at no general increase in price over the standard type of drop-forged, riveted bar chain. It is the general claim that Simplex rivetless chain is more simple to assemble and disconnect than any other type of rivetless chain now in use, and that it is as easily detached as the Ewart type of detachable chain or belting.

SHORT METHOD OF COMPUTING AREA OF CIRCULAR SEGMENT.

By J. A. Macdonald.

To find the area of a circular segment: Find the area of the sector that has the same arc as the segment; find also the area of the triangle, whose vortex is the centre, and whose base is the chord of the segment; there the area of the segment is the difference or sum of these two areas, according as the segment is less or greater than a semicircle.

The chord and height of a segment are = 24 and 6; find its area.

$$\tan \tfrac{1}{4} n = \frac{2h}{c} = \frac{12}{24} = .5 = \tan 26^\circ\ 33'\ 54'' \text{ and hence}$$

$$n = 106^\circ\ 15'\ 36'' = 106^\circ.26.$$

$$2r - h = \frac{c^2}{4h} = \frac{144}{6} = 24, \text{ and } r = 15.$$

Then sector $= .008727 \quad n r^2 = .008727 \times 106.26 \times 225 = 208.64$;

also, triangle $= \tfrac{1}{2} c P = \tfrac{1}{2} \times 24 \times 9 = 108$;

hence, segment = sector — triangle = 208.64 — 108 = 100.64.

This is the usual method of obtaining these quantities. It involves the computation of the radius, the central angle, the area of the sector, and the corresponding triangle, and the difference between the sector and the triangle equals the area of the segment.

Trautwine gives a table of areas of segments, but, when the chord and mid-ordinate alone are known, as is frequently the case, the use of this table consumes considerable time. The diameter must first of all be obtained by the formula:—

$$D = \frac{s^2}{4r} + r,$$

in which D is the diameter, s the chord, and r the mid-ordinate. The mid-ordinate must then be divided by the diameter. The table gives for this ratio a factor which must be multiplied by the square of the diameter to obtain the area of the segment.

In the handbook of the "Verein Hütte" there is a table of lengths of arcs, mid-ordinates, chord lengths and areas of segments for circles of unit radius corresponding to any central angle. In order to use this table it is, therefore, necessary to compute the radius and the central angle from the chord.

For facility of computation two tables have been prepared, one for areas of segments and the other for lengths of arcs. In one column the ratio of the mid-ordinate to the chord is given, and in the adjacent column the corresponding value of c. To obtain the area of the segment, the product of the mid-ordinate and the chord is to be multiplied by c, obtained from the table. More time is saved by the use of the table of areas of segments, and this table is, therefore, given.

Areas of segments of circles:—

Span or chord = s.
Rise or mid-ordinate = r.
Area = c r s.

r/s.	c.	r/s.	c.	r/s.	c.
0.01	0.6667	0.18	0.6836	0.35	0.7280
.02	.6669	.19	.6855	.36	.7313
.03	.6671	.20	.6875	.37	.7347
.04	.6675	.21	.6896	.38	.7382
.05	.6680	.22	.6918	.39	.7418
.06	.6686	.23	.6941	.40	.7455
.07	.6693	.24	.6965	.41	.7493
.08	.6701	.25	.6989	.42	.7531
.09	.6710	.26	.7014	.43	.7569
.10	.6720	.27	.7040	.44	.7608
.11	.6731	.28	.7067	.45	.7648
.12	.6743	.29	.7095	.46	.7688
.13	.6756	.30	.7124	.47	.7729
.14	.6770	.31	.7154	.48	.7770
.15	.6785	.32	.7185	.49	.7812
.16	.6801	.33	.7216	.50	.7854
.17	.6818	.34	.7248		

As an illustration of its use the area of the segment being a chord of 3.9634 feet and a mid-ordinate of 1.5 ft. is computed.

s = 3.963 ft.	r = 1.5 ft.
r/s = 0.37[illegible]5	log. = 9.578023
r = 1.5	log. = 0.176091
s = 3.9634	log. = 0.598068
c = 0.7377	log. = 9.867880
Area = 4.386 sq. ft.	log. = 0.642039

The Canadian Contracting and Construction Company have opened offices at the McKinnon Building, Toronto, and at Brandon, Manitoba. The managing director is C. G. Gillespie, of Toronto.

COMPARISONS OF COST OF WOOD AND STEEL FENCE POSTS FOR RAILWAYS.*

Wood Posts.—The life of wood posts of various kinds actually in use is as follows:—

Life of Posts.

	Years.
Red Cedar	7 to 25
Cedar	10 to 30
White Cedar	12 to 17
Chestnut	10 to 15
Locust	7 to 20
Yellow Locust	15 to 30
Black Locust	10 to 25
White Oak	7 to 15

Doubtless some give little heed to the particular species of the timber that they use, and assume that any species of that genius has about the same life. This is manifestly incorrect as is demonstrated by the oak family. The inferior grades of oak have a life only of from 2 to 4 years, while a good white oak has a life in our northern climates of from 10 to 12 years at least. Certain classes of oak last much longer in their native regions than in other localities to which they are transported for use. This principle applies with equal force to every other class of timber.

In reviewing the replies of the various roads we find that the consensus of opinion, based upon experience of the users, is that the different classes of timber have an average life as indicated below:—

	Years.
Red Cedar	18
White Cedar	15
Chestnut	12
Yellow Locust	20
Black Locust	20
White Oak	10

Climatic influences have an important bearing upon this phase of the case, and may lengthen or shorten the life of a particular kind of wood, dependent upon locality in which used.

From information received, the cost of the various kinds of wood posts is:—

	Range.	Average.
Red Cedar	15c. to 25c.	22c.
Cedar	7c. to 20c.	14c.
White Cedar	12c. to 15c.	14c.
Chestnut	10c. to 27c.	20c.
Locust	15c. to 40c.	25c.
Yellow Locust	20c. to 38c.	30c.
Black Locust	15c. to 25c.	20c.
White Oak	11c. to 40c.	20c.

It was of interest to know to what extent wooden posts were subject to destruction by fire. Replies received indicated that this varied by from 1 per cent. to 5 per cent., with the exception of one road which reported a loss of 30 per cent. from this cause. We think it fair to assume that the average loss by fire is around 3 per cent.

Steel Posts.—Only two roads so far as we can learn make mention of having used any metal posts, and then but to a limited extent. In the one case bar iron ¼ x 2 inches was used and in the other old boiler tubes. We have reason to believe, however, that quite a number of roads, not replying to our circular, are trying out a proprietary metal post.

Several styles of steel right-of-way fence posts are on the market. Their exploitation has just begun in the last year or two, and any statement as to their efficiency and economy could be but vague and from the manufacturers' standpoint alone. Greater experience may demonstrate their utility, but thus far we have no data upon them, and can only give some computations from one of the manufacturers, which might be of interest for study from the viewpoint of railroad economy. These figures, while prepared for a certain style of post only, if reliable, will no doubt be equally accurate for any other style of metal post, built along similar lines, and others are generally so designed.

Steel posts cost	23.03 cents
Cost of setting	1.30 cents
Total	24.33 cents
Estimated life	30 years

Based upon above figures, steel posts set one rod apart cost 81 cents per year.

The cost of setting wood posts is estimated at 5.8 cents each. The following table is based on wood posts costing from nothing up to 20 cents each, and is intended to show what the life of wood posts must be at different first costs to be as cheap as the steel posts:—

Cost of post. Cents.	Cost of setting. Cents.	Total cost. Cents.	Years it must last to be as cheap as steel. Years.
0	5.8	5.8	7.1
5	5.8	10.8	13.3
8	5.8	13.8	17.
10	5.8	15.8	19.5
12	5.8	17.8	21.9
15	5.8	20.8	25.6
17	5.8	22.8	28.1
18.53	5.8	24.33	30.
20	5.8	25.8	31.8

The above figures would indicate that wood posts costing 15 cents would have to have a life of 25.6 years and those costing 20 cents a life of 31.8 years to be as cheap as steel.

The first steel posts are said to have been manufactured about 15 years ago at Bloomfield, Ind. Others, doubtless, of different design unknown to the committee were manufactured as long ago and perhaps longer, but only during the past twelve years have they been given any serious study with a view to placing them on the market for ordinary right-of-way fencing. Hundreds were taken up and examined to discover signs of rust and deterioration at ground line or elsewhere. They have been in use at Spencer, Worthington, Bloomfield, Ind., and elsewhere in all kinds of soil and under all conditions. The investigations have resulted in placing them on the market during the past year or so.

To be of economic worth for right-of-way protection, a fence post must possess the following qualities: Durability, practicability, efficiency and the price must be right. Inquiry develops that one man can set in a day from 15 to 35 wooden line posts. To be conservative, 30 posts per day per man is assumed as the unit of work. Estimating wages at $1.75 per day places the cost of setting a wood post at 5.8 cents. The cost of post is estimated at 12 cents, resulting in an entire outlay of 17.8 cents. Experience is to have demonstrated that three men can readily set from 390 to 640 steel posts per day, or 130 to 213 per man—130 posts per man is taken as the basis of calculation with wages at $1.75 per day. This places the cost for setting a steel post at 1.3 cents. Cost of steel post 23.03 cents, plus cost of setting 1.3 cents, resulting in entire outlay, 24.33 cents.

* Abstract of report of a committee of the American Railway Engineering Association.

Comparative Cost of Steel and Wood.

Entire cost of steel post, 24.33 cts., estimated life	30 years
Money worth 6 per cent.	
Entire cost of wood post, 17.80 cts.; estimated life	12 years
Expenditure for steel posts	24.33 cents
Expenditure for wood posts	17.80 cents
Difference	6.26 cents

Compound interest on 6.26 cents for 12 years amounts to 13.06 cents. At the expiration of 12 years wood posts have failed and need renewal. 13.06 cents has been saved over cost of steel posts. This is equivalent to purchasing 8.8 years more protection with wood. In other words, 24.33 cents expended for steel gives 30 years of protection, while same amount expended for wood gives 12 years original life, plus 8.8 years' interest on investment, or 20.8 years, a balance in favor of steel of 9.2 years. Viewing the matter from another angle, assuming that posts are set one rod apart, track protection costs per year as follows:—

Steel Posts—	
Per rod	$ .0081
Per mile	2.59
Per 100 miles	259.00
Wood Posts—	
Per rod	$ .0117
Per mile	3.74
Per 100 miles	374.00
Balance in favor of steel posts of—	
$ .0036	per rod per year.
1.15	per mile per year.
115.00	per 100 miles per year.

Other advantages claimed are no staples used; right-of-way may be burned over from time to time without injury to posts. No loss from accidental fires and no renewal on that account. Special end, corner and gate posts must be used in connection with the steel line posts. No means are provided for bracing them so as to use them as end or corner posts. There is not enough steel in them to stand the strain of stretching a heavy wire fence. The minimum amount of steel is used necessary to meet requirements of a right-of-way fence. The line and end posts are treated as distinct problems. In this they are not unlike posts made of other materials. The demands on the end and corner posts are entirely different from those on the line posts. The line post should possess a certain degree of flexibility, while end and corner posts must be absolutely rigid. The following is the comparative cost of steel and wood end and corner posts:—

Cost of end post	$1.62
Cost of corner post	2.30

Assuming it fair to say that twice as many end posts will be needed as corner posts, it places the average of the stretching post at $1.84 each. If $1.84, the cost of the steel corner post, bears the same relation to the cost of a good wooden corner post that the price of the steel line post bears to the price of the wooden post, then the economy is demonstrated. In order to determine whether or not this relation maintains, we resort to the following equation:—

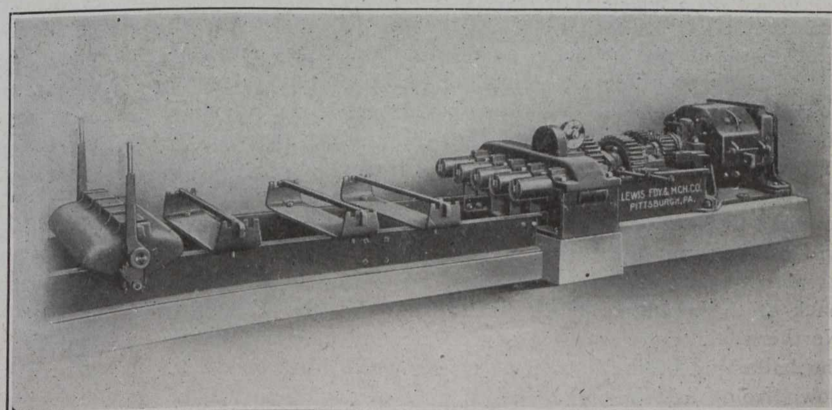
$$\frac{\text{12c. (cost of wood line post)}}{\text{23.03c. (cost of steel line post)}} = \frac{x \text{ (cost of wood corner post)}}{\text{\$1.84 (cost of steel corner post)}}$$

We find x = 96 cents, cost of wooden corner post, which appears to be a conservative estimate of the cost of a good wooden corner post. From a mathematical and perspective point of view, the manufacturer of the steel fence post appears to have made out a case that is worthy of continued and further close investigation. Time alone, under practical service conditions, can demonstrate if the figures are based upon substantial premises.

The steel fence post has not yet proved its merit in practice and at this time concrete with suitable reinforcement seems to offer the only solution to the problem.

MOTOR-OPERATED BAR-TWISTER.

In concrete work the steel bar gives the tensile and the concrete the compression strength. In order to produce a bar having a high elastic limit and homogeneous texture, it is essential that continuous and uniform running be attained on the machine used in twisting these steel sections. A great deal of trouble is experienced with belt-driven machines on account of belt slippage causing unnecessary strain during the twisting process, which usually results in an inferior product due to the elastic limit of the bar being exceeded. With a motor gear-connected to the machine, as shown in the accompanying illustration, an occurrence of this kind is practically impossible, since this method of motor connection insures constant torque being applied during the time the bars are being twisted.



The type of machine here shown, manufactured by Lewis Foundry and Machine Company, which is used for twisting Ransom bars, is arranged for two speeds. A 75-h.p. Westinghouse mill motor is used on five 1¼-inch bars, and a 60-h.p. motor on five 1⅛-inch bars. The twisting heads are steel castings arranged to receive tool steel dies for bars ⅜-inch to 1¼-inch, advancing by eighths of an inch. Bearings are brass bushed, and the shafts turned and hammered open-hearth steel. The bed is made of 10-inch channels of sufficient length to accommodate 60-foot bars. The tail stock is so arranged that is may be locked on bed at any distance from head stock. An index is provided to register the number of turns made by the bar-twisting head. The dial is re-set by hand, and can be moved back to zero when the load is released. The twisting speed of the head is about 60 r.p.m. for 1¼-inch bars, taking about one minute. The time consumed in loading and unloading is about two minutes; consequently, a complete cycle occurs every three minutes. One complete standard twist will occur on 1¼-inch bars in 12½ inches, and on 1-inch bars in 10 inches.

COAST TO COAST.

Vancouver, B.C.—Mr. H. M. Davy, engineer in charge of test borings for the public works department, Ottawa, has completed his work here of securing full data of Victoria and Vancouver harbors. Test borings were made along the south and north shores of Burrard Inlet with the object of locating sites for the proposed government wharves, and for other wharves and docks which may be erected here later on by the Dominion Government. Borings were made in False Creek in order to secure data for the amount of dredging which would be required, and to learn the class of materials which will have to be removed. The contract for this work has already been awarded to the Pacific Dredging Company, Limited. In Victoria a great many borings were made to secure information necessary for the proposed improvements to the inner harbor, and also for the proposed wharves for the outer harbor. The work in Victoria was frequently delayed by rough weather, but no delay was caused here, owing to the harbor being practically landlocked.

Montreal, Que.—An extensive programme of harbor improvements for the coming season, mapped out by the harbor commissioners, marks a new era in the history of the port of Montreal. The guard pier will be completed, and the south side described on the maps as the east wall quay embankment, will be continued to effect the backing up of the great volume of water below Victoria pier, across the channel in the direction of Moffat's Island, thus diminishing the velocity of the St. Lawrence current. The estimated cost of these improvements exceeds $2,000,000. A great portion of the material to be used in the erection of breakwaters, piers, etc., will be procured from the Mount Royal tunnel. Already great quantities of the solid rock are being shipped from back of the mountain to the water-front by the Canadian Northern Railway. Another improvement to be completed is the ballasting of the high level tracks which have been laid down from Victoria pier to the Racine pier. These will be trimmed and made permanent.

Victoria, B.C.—A deputation consisting of members of the Board of Trade and City Council will go to Ottawa to interview the Dominion Government upon the necessity of making immediate and adequate provision for the handling of large vessels at the outer wharf. In a recent letter to the City Council Mr. E. J. M. Nash, the special representative of the Royal Mail Steam Packet Company, which concern has four 20,000-ton vessels on order at Belfast to be ready to break into the service of this coast immediately the Panama Canal is completed, pointed out that the present facilities at Victoria, both as regards handling the traffic of such vessels, and as regards having them repaired in the event of an injury, were utterly inadequate; and that if Victoria desired to take her proper place as an ocean port it was up to her not only to extend her wharf accommodation in a greater ratio than has even been contemplated so far, but to at once make a start upon the construction of a large drydock.

Toronto, Ont.—A unique collection of model roadways in miniature is now on exhibition in the Parliament Buildings for the education of the general public in the secrets of highway construction in the province. Stretched upon a frame along with others dating from time immemorial and composed of bits of the stone and material of the actual construction, is a replica of the old Appian way as it came from the hands of the ancient Roman builders. There is also the model of an old French road constructed previous to the year 1775, following upon the Roman style of stone laying. It is composed of two layers, the foundation being formed of broad flat stones cleverly jointed by hand and the interstices filled with carefully ground pebbles. The next design in the evolution of the modern highway advocated the laying of the stones on the edges and in this way the wearing capacity was hugely increased and the drainage made more simple. The English Telford road followed, with a stone base laid entirely by hand and a curved surface. The old macadamized road which proved the most efficient of all for increasing road traffic is shown subject to the improvements which the highways department of Ontario has instituted in the substitution of three layers for one to withstand the wear and tear of heavy automobile driving. An exhibit of peculiar interest is that of a bituminous asphalt or tar highway comprising in all six layers of a most durable nature, and intended especially for pleasure drives where power machines are in constant use. This road the Ontario Government will experiment with to some extent during the year, and it is hoped will prove it so successful that actual construction will be undertaken. The display is under the care of Provincial Engineer of Highways W. A. McLean, and has been obtained from the public roads department of the United States Government.

Kingston, Ont.—The first step towards the cleaning up of the waterways of the province in accord with the recommendations of the recent convention of the International Waterways Commission has been taken, under the direction of the provincial board of health here. Owing to certain local conditions which are considered to be especially suited for experimentation by the board, F. A. Dallyn, provincial sanitary engineer, with a staff of assistants, has begun operations in the line of water investigation. A laboratory has been opened in Clarence Chambers and a launch has been chartered. Tests will be made from here down through the islands and for a space around the city. The investigation is made under the co-operative management of the Ontario and United States authorities, Dr. McLaughlin, an American expert, working jointly with F. A. Dallyn, provincial sanitary engineer. The working staff employed in that direction, it is understood, will be supplemented by a number of advanced science students now studying at Toronto University.

New Westminster, B.C.—In addition to the three million dollars which the Canadian Northern Railway will spend in improvements at Port Mann, an equal amount will be expended in New Westminster. According to recent despatches, Sir William Mackenzie and Col. Davidson, who are at present in London, are finding no difficulty in obtaining money for the project. Definite appropriations have been made for extending the railway through the city to the North Arm Bridge, and for the Port Mann improvements. This sum will be expended on elevated tracks, terminal yards on the Royal Mill site, trackage on the Trapp ranch and on the North Arm bridge, to connect with the Lulu Island line to Steveston. It is planned to start the Port Mann construction prior to the commencement of the local improvements, and it is stated that the contractors will have the work at the former place under way within a month. This work consists of filling in, the construction and equipment of machine and repair shops, boiler works, roundhouses and other terminal buildings. About twenty miles of storage and sorting tracks will be provided as a first unit.

Ottawa, Ont.—Mr. L. J. Burpee, secretary of the Canadian section of the International Waterways Commission, in a recent interview, said in regard to certain reports from Washington as to the abolition of the organization, they were evidently based on a misconception of the status of the international joint commission. "Neither Congress nor the

Imperial or Dominion Parliament," he said, "has any power to abolish the commission that constitutes that tribunal. Three were appointed by the President of the United States and three by the King on the recommendation of the Governor-in-Council of Canada—that is, practically on the recommendation of the Canadian Government. They were appointed under terms of the Waterways Treaty, which was signed in 1909 and ratified in 1910, and one of its provisions is that the treaty shall remain in force for five years from the exchange of ratifications and thereafter until terminated by twelve months' notice by one or other of the high contracting parties. The treaty, therefore, remains in force at least until the year 1916, and the commission, which is an essential development of the treaty, also remains in existence until that year at least. The personnel of the commission, the individual members, may, of course, be changed at any time by the National authorities by whom they were appointed; but the commission itself rests upon the foundation of a solemn treaty entered into by the two countries and cannot be put out of existence until the treaty itself comes to an end."

Toronto, Ont.—A deputation from the district between St. Thomas and Windsor, representing all the cities and the municipalities, waited on Hon. Adam Beck and the Hydro-Electric Commission at the Parliament Buildings recently and advocated the southern route as near to the lake as possible as the most advantageous one for the route of the proposed transmission line that is to convey between 25,000 and 30,000 horse-power to the various municipalities between these two points. It is proposed to build an electric railway along the right of way. Hon. Adam Beck explained that three or four routes had been suggested, and that the most advantageous one would be selected.

Ottawa, Ont.—In view of the new loan and subsidy, which the Canadian Northern interests are now busy negotiating, and which the government is proposing to grant, the question was asked by A. K. Maclean, of Halifax, as to what amounts have been paid since August 28, 1912, by the minister of finance and the receiver-general to the Canadian Northern Company from the proceeds of the authorized loans. In answer to the question it was stated that from the date mentioned until March 20, the Canadian Northern had received from the Dominion treasury $6,901,991.25 from the proceeds of loans authorized in connection with their line from Montreal to Port Arthur. The maximum amount payable is $35,000 per mile for 1,050 miles.

Winnipeg, Man.—The Canadian Domestic Engineering Company, Limited, announces the opening of a branch at Winnipeg, in the Alfred Building. The western manager is Frank W. Walker, M.E., of Winnipeg. Mr. Walker is a McGill graduate, and was formerly with Babcock & Wilcox Company, and more recently with the Transcona Shops.

PERSONAL.

DR. HARRIS LOGAN has been appointed medical health officer of Niagara Falls, Ont.

MR. ANGUS SMITH has resigned his position as city engineer of North Vancouver. His resignation will take effect at the end of April.

MR. HENRY JUNGERMAN, formerly with the Motive Power and Inspection Department of the Harriman Lines, has been appointed railway representative of the Tate-Jones & Company, Inc., of Pittsburg, Pa.

J. C. DUFRESNE, M.Can.Soc.C.E., M.Can.Mi.Inst., formerly of Penticton, B.C., is now associated with the consulting firm of Cummins & Agnew, Vernon, B.C. Cummins & Agnew make a specialty of municipal and irrigation work.

ARTHUR H. BLANCHARD, M.Can.Soc.C.E., professor of Highway Engineering in Columbia University, on March 31st delivered an illustrated lecture on "Highway Engineering in Europe and America," before the Brooklyn Institute of Arts and Sciences.

MR. JOHN A. BENSEL, M.Am.Soc.C.E., New York State Engineer, Albany, N.Y., on March 20th delivered an illustrated lecture on "Inter-relationship of Highways, Waterways and Railways" before the graduate students in Highway Engineering at Columbia University.

JAMES COWIN, manager at Winnipeg for the C. A. P. Turner mushroom system of construction, has left Canada to take charge of Mr. Turner's affairs in Texas. A. W. Fosness and S. J. Sieverson, both of Mr. Turner's head office at Minneapolis, have taken charge of the Winnipeg office.

MR. H. R. PARSONS, C.E., graduate of the University of Michigan, has been appointed city engineer of Peterborough, Ont. Mr. Parsons was for six years employed as assistant city engineer of Ottawa, being in charge of the construction of pavements, sewers and waterworks systems in that city.

W. J. WELLER, provincial bridge builder for Manitoba, has been appointed superintendent of construction of bridges on the main line of the C.N.R. at the coast, and has left to commence operations. Mr. Weller has been with the G.T.P. for some time and for many years was connected with Mackenzie and Mann interests.

W. H. BREITHAUPT, C.E., is continuing the engineering office in which he was formerly associated with the late E. H. Keating. Chas. B. Kingsley, C.E., will be associated with Mr. Breithaupt. Mr. Breithaupt is a member of the Canadian Society of Civil Engineers, American Society of Civil Engineers and also of the Institute of Civil Engineers of Great Britain.

VIRGIL BOGUE arrived in Victoria, B.C., recently for a consultation with the minister of railways, Hon. Thos. Taylor, respecting work for which he is the consulting engineer in British Columbia. Mr. Bogue, whose headquarters are in San Francisco, recently reported upon the projected dock improvements for the Grand Trunk Pacific Railway Company at Prince Rupert. Recently the Canadian Pacific Railway Company engaged Mr. Bogue to report upon the projected Rogers' Pass tunnel, for the construction of which tenders are now being called.

OBITUARY.

ALBERT G. MACFARLANE, district engineer of the National Transcontinental Railway, dropped dead in his room at the Russell House on April 4. He was a native of Almonte, Ont., and had been at various periods in the employ of the Parry Sound, Midland, Algoma, and Canadian Northern Railways. He was 52 years old.

GEORGE P. BROPHY, C.E., superintending engineer of the Ottawa River works for 36 years, one of the founders of the Ottawa Electric Street Railway and Lighting Companies, and a figure in the local financial world, died at Ottawa on April 4th. He was 65 years of age. As superintending engineer Mr. Brophy was actively identified with important government projects all over the Dominion. Besides being a director of the Ottawa Electric Company and the Ottawa Electric Railway Company, the deceased held extensive interests in British Columbia and other provinces, as well as locally. He assisted in forming the Ontario Graphite Company, the Dominion Carbide Company, Ahearn Electric Heating and Manufacturing Company, Locomotive and Machine Company of Montreal, the Thousand Islands Land Company, the Ontario Smelting, Milling and Refining Company, and other similar organizations. He was a director of the Ottawa Gas Company and a vice-president of the Ottawa Trust and Deposit Company.

SOCIETY MEETINGS.

A joint meeting of the Electrical and Mechanical Sections of the Canadian Society of Civil Engineers was held on Thursday, April 3rd, at 8.15 p.m. A paper on "Electrification of a Reversing Mill at the Algoma Steel Company," by B. T. McCormick, A.M.Can.Soc.C.E., was read by the author.

Dr. John W. S. McCullogh, chief health officer of Ontario, will deliver an address on Friday, April 11th, 1913, at 8 p.m. on "The Evolution of Public Health," at the Engineers' Club, Toronto. The library committee announces that a series of interesting lectures have been arranged for.

COMING MEETINGS.

CANADIAN ELECTRICAL ASSOCIATION.—Annual Convention will be held in Fort William, June 23, 24 and 25. Secretary, T. S. Young, 220 King Street W., Toronto.

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

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

ENGINEERING SOCIETIES.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—413 Dorchester Street West, Montreal. President, Phelps Johnson; Secretary, Professor C. H. McLeod.

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

MANITOBA BRANCH.—Chairman, J. A. Hesketh; Secretary, E. E. Brydone-Jack, 83 Canada Life Building, Winnipeg. Regular meetings on first Thursday of every month from November to April.

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

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

TORONTO BRANCH—96 King Street West, Toronto. Chairman, E. A. James; Secretary-Treasurer, A. Garrow. Meets last Thursday of the month at Engineers' Club.

CALGARY BRANCH—Chairman, H. B. Mucklestone; Secretary-Treasurer, P. M. Sauder.

VANCOUVER BRANCH—Chairman, G. E. G. Conway; Secretary-Treasurer, F. Pardo Wilson, Address: 422 Pacific Building, Vancouver, B.C.

VICTORIA BRANCH—Chairman, F. C. Gamble; Secretary, R. W. MacIntyre; Address P.O. Box 1290. Meets 2nd Thursday in each month at Club Rooms, 584 Broughton Street.

MUNICIPAL ASSOCIATIONS

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

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

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

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

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

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

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

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

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

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

CANADIAN TECHNICAL SOCIETIES

ALBERTA ASSOCIATION OF ARCHITECTS.—President, R. W. Lines, Edmonton; Hon. Secretary, W. D. Cromarty, Edmonton, Alta.

ALBERTA ASSOCIATION OF LAND SURVEYORS.—President, L. C. Charlesworth, Edmonton; Secretary and Registrar, R. W. Cautley, Edmonton.

ASSOCIATION OF SASKATCHEWAN LAND SURVEYORS.—President, A. C. Garner, Regina; Secretary-Treasurer, H. G. Phillips, Regina.

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

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

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

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

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

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

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

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

CANADIAN FORESTRY ASSOCIATION.—President, Hon. W. A. Charlton, M.P., Toronto; Secretary, James Lawler, Canadian Building, Ottawa.

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

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

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

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

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

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

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

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

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

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

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

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

ENGINEERING SOCIETY, TORONTO UNIVERSITY.—President, F. C. Mechin; Corresponding Secretary, A. W. Sime.

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

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

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

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

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

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

MANITOBA LAND SURVEYORS.—President, J. L. Doupe; Secretary-Treasurer, W. B. Young, Winnipeg, Man.

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

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

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

ONTARIO PROVINCIAL GOOD ROADS ASSOCIATION.—President, N. Vermilyea, Belleville; Hon. Secretary-Treasurer, J. E. Farewell, Whitby; Secretary-Treasurer, G. S. Henry, Oriole.

ONTARIO LAND SURVEYORS' ASSOCIATION.—President, J. S. Dobie, Thessalon; Secretary, L. V. Rorke, Toronto.

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

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

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

QUEEN'S UNIVERSITY ENGINEERING SOCIETY.—Kingston, Ont. President, W. Dalziel; Secretary, J. C. Cameron.

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

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

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

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

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

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

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