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RAILWAY SWITCHES AND TRACK LAYOUTS

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In the past few years a great deal of attention has been paid to the design of railway switches and turnouts. It is not so very many years ago since railway engineers put in "any old thing" for a switch, whereas in these days of scientific refinement it is a subject which is dealt with on a proper mathematical basis. It is not the writer's intention here to deal with a number of abstruse mathematical calculations, but to give a general description of the construction of switches and their assembling in groups to give yard layouts, and the problems that railway men have to contend with in designing these layouts.

A brief description of the construction of a standard switch with the names of the various component parts is first necessary. Referring to Fig. 1, the switch is made up of two switch points "aa," a frog "b," two guard rails "cc," and the connecting or closure rails "d," the through rails "ee" are called the stock rails; "ff" are the points of the switch, "gg" the heel of the switch, "h" is the toe of the frog, and "i" is the heel. The distance from the point of switch "f" to the point of frog is called the "lead."

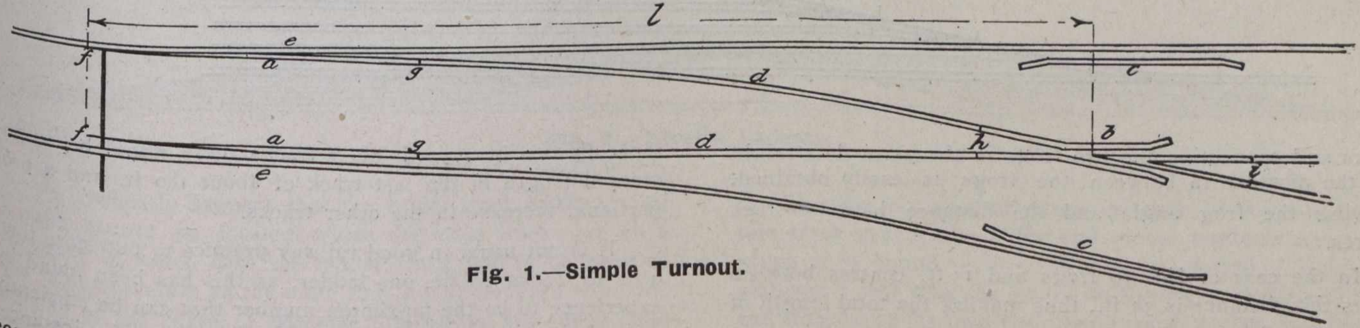

Fig. 1.—Simple Turnout.

Attached to the inside of the outer rails opposite the frog are two guard rails, varying from 8 to 12 feet long, placed there to control any side-play of the wheels passing over the frog, and so preventing the flanges mounting the rail instead of passing the point of the frog in the flangeways provided.

These guard rails are usually made from standard rail and are fastened to the running rail and the ties by special castings. The ends of the rails are splayed outwards to facilitate the passing of the wheel flanges into the flanges.

The two features which vary in different switches are the angle of the frog, and the lead. The frogs are always designated by a number, which denotes the inclination of the turnout rail to the main track, e.g., a No. 7 frog means that the two legs are inclined at an angle of 1 in 7. Now, the frogs in general use for ordinary railway work are as follows:

Frog No.	Angle.
6	8°–48 ft.
7	8°–11 ft.
8	7°–9 ft.
9	6°–22 ft.
10	5°–44 ft.

The No. 6 frog is only now being used in very exceptional cases, as it has been found to require too sharp a curvature to be able to accommodate the large equipment in general use; the No. 7 frog is also being largely discarded except on branch lines and freight tracks. The No. 8, 9 and 10 frogs are in general use, and in some cases frogs as flat as the No. 12 are used, such as for main line connections from a through main line to a local.

The switch points are usually made about 15 feet long, but a number of roads are adopting the 16-ft. 6-in. points in order to give an easier riding switch. They have a "throw" of 6 inches at the point, and at the fixed end there is a distance of 5½ inches from guage line to guage line of the two rails.

Now, after the frog and the points are selected they have to be connected with a curve on one rail and a piece of straight track on the other, or even a curve on both rails, as the case may be, but taking the case of one straight track and the curved turnout, the switch points and frog have to be spaced at such a distance apart that a curve of uniform radius will be tangential to the heel of the switch and the toe of the frog. The distance apart of the point of switch and the point of the frog (the lead) and the equivalent radius and degree of curve is given in the following table, for use with 15-ft. switch points:

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No. of frog.	Actual lead.	Equiv. radius.	Equiv. degree of curve.
7	60 ft.	410 ft.	14°– 0 ft.
8	66 ft.	573 ft.	10°– 0 ft.
9	75 ft.	702 ft.	8°–10 ft.
10	82 ft.	1,011 ft.	5°–40 ft.

This equivalent radius of 410 feet just about corresponds with the minimum radius that most standard railways are willing to adopt, even for spur tracks and sidings away from the main line, the large switching and main line engines being unable to cope with sharper curves without frequent derailments.

Whatever design for a layout of switches and tracks is considered, the three details given in the table above have to be borne in mind, i.e., the angle of the frog, the lead and the curvature.

The three commonest positions of the switch are in the simple turnout, the crossover and the "ladder." In the design of a crossover the piece of track between the two main tracks and connecting the two frogs is always made straight and the distance in between the frogs is easily obtained, knowing the frog angle and the distance between track centres.

In the case of No. 10 frogs and 13-ft. centres between tracks this distance is 34 ft., thus making the total length of crossover 198 ft.

The design of a ladder requires more consideration, and conditions such as property limits, track capacity, etc., have to be dealt with, but if there are no such limiting conditions a simple straight ladder can be laid out so that the ladder track is at the same angle with the yard tracks as the angle of the frog that is to be used in the switches, in which case the frogs are set at the intersection of the gauge lines of the two rails, as is shown in Fig. 2. If the first frog in the ladder is located it is a simple matter to find the distances between all the frogs on the ladder, e.g., if No. 8 frogs are to be used, and the tracks are 13-ft. centres, the frogs will be 8 × 13 = 104 feet apart, so that if there are going to be, say, 7 tracks connected to the ladder the last track will be about 700 feet shorter than the first. This is usually rather a serious situation as it is almost always desirable to get the longest track possible, or at any rate to get the tracks as nearly the same length as possible, but it is readily seen that in order to make the last track longer it is only necessary to increase the angle which the ladder makes with the main yard tracks, the effect of this being to reduce the distance between the frogs, which do not now point in the same direction as the yard tracks, and so have to be placed closer to the first track in order to allow room for the necessary curve between the heel of the frog and the tangent, as is shown in Fig. 3. Now, the maximum angle at which the ladder track can be placed is fixed in this way: the distance from the point of switch to the point of frog (assuming the use of No. 8 frogs) is 66 ft., the standard distance from point of frog to the heel is 9 ft., and the closest distance that the point of one switch can be placed to the heel of the frog of the preceding switch is 3 ft., to allow for the angle plates of the joint, thus we have the minimum distance between frogs is 78 ft., thus giving an angle of 1 in 5.2 for 13-ft. centres or 1 in 6.5 for 12-ft. centres. Using these figures in a yard of 7 tracks there would be an increased length in the last track of about 180 ft. and a proportional increase in the other tracks.

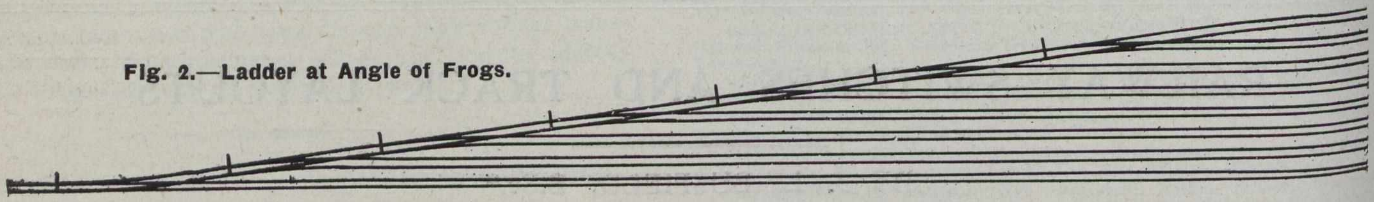

Fig. 2.—Ladder at Angle of Frogs.

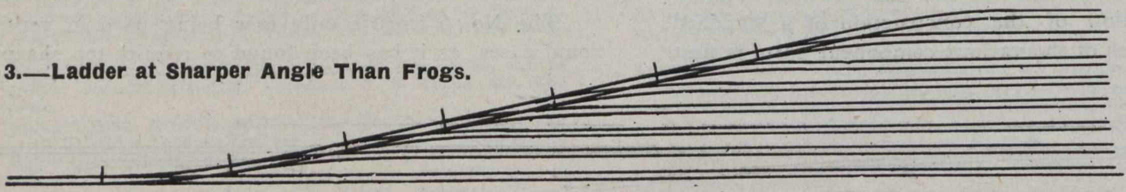

Fig. 3.—Ladder at Sharper Angle Than Frogs.

It is not usual in good railway practice to put more than 9 or 10 tracks on the one ladder, as this has been found by experience to be the maximum number that can be efficiently operated by one engine, except in special cases; for instance, where the tracks are used solely for storage purposes. Fig. 4 shows a typical arrangement of tracks with two ladders serving 18 tracks in all.

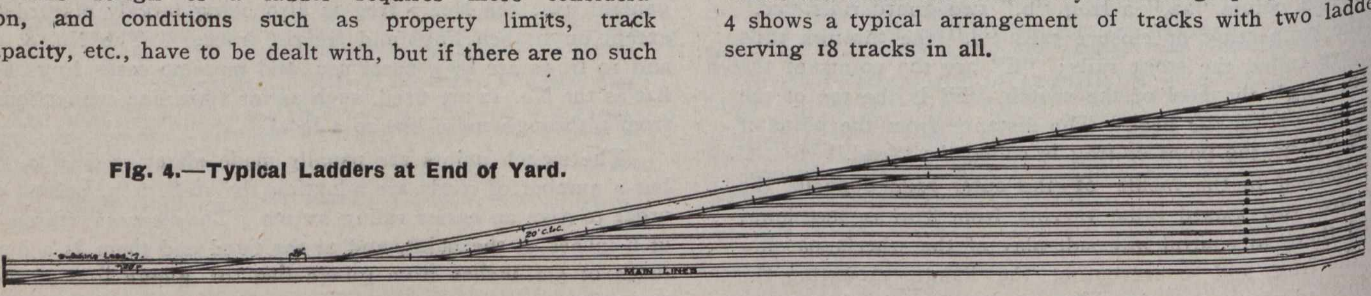

Fig. 4.—Typical Ladders at End of Yard.

It is usual to extend the first track in the opposite direction to the yard, to make a switching lead, as shown in Fig. 4; this lead allowing switching engines to make up the various trains without encroaching on the main lines.

In some instances it is desirable to put in even steeper ladders than can be done by the methods described above, especially in cities and towns where land is valuable and must be occupied to the greatest possible advantage. In cases like this a ladder can be used, as shown in Fig. 5.

This ladder, although giving the advantage of longer tracks, has the disadvantage of having the switches on opposite sides of the main track, so that the switchmen have to be continually crossing and recrossing the track in front of the switching engine and trains.

The main ladder track has to be placed at such an angle to the yard tracks that there will be enough curvature between the heels of the frogs in the ladder track, and the straight tracks to which they connect, to allow a second switch to be placed within this curve. The primary switches in the ladder track are directly connected to each alternate track, and the secondary switches pick up the remaining tracks. The typical layout in Fig. 5 shows the method better than it can be described. A certain amount of variation is possible in the angle of the ladder track, but it is limited by the lengths of the switches, the frog angles and the track centres.

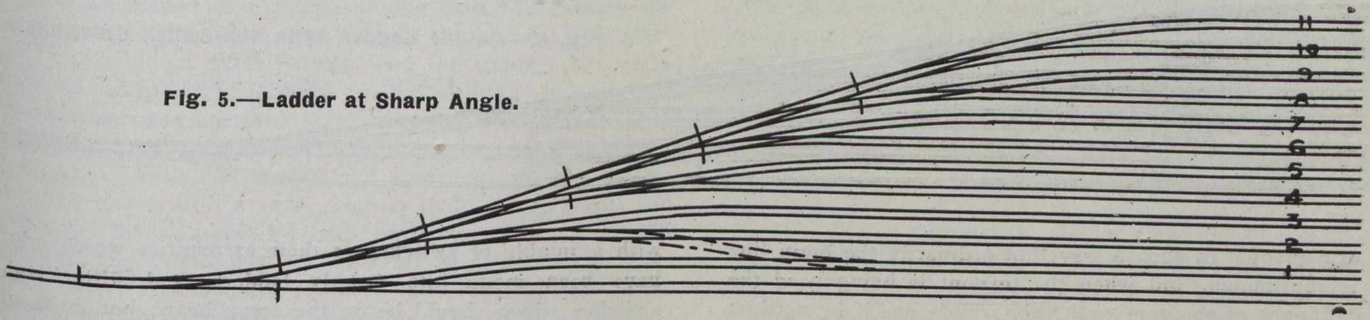

Fig. 5.—Ladder at Sharp Angle.

As will be seen from the plan of this type of layout, it is not possible to connect the first, or No. 1 track to the ladder, but this difficulty is easily overcome by running it into the main line, or else, as shown dotted, from No. 2 track.

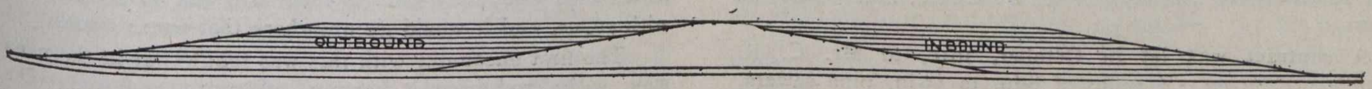

Fig. 6.—Parallel Ladders.

It frequently happens that the ladder track at the end of a yard cannot be located where the main tracks are on a tangent; in which case the ladder track has to be built to the same curvature as the main line, but if the yard is on the outside of the curve, it becomes difficult to lay down the switches without excessive curvature and the limit is reached when the curvature of the switch added to the curvature of the main line reaches the maximum permissable curvature.

Modern freight classification and storage yards are very often designed so that all the tracks forming one "set" are the same length, thus reducing the difficulties of operating the yard through having a number of tracks of greatly varying lengths. A typical layout for a yard of this nature is shown in Fig. 6, giving two main yards for the sorting of inbound and outbound freight, with a space between them for storage, caboose, and engine tracks, yard offices, etc.

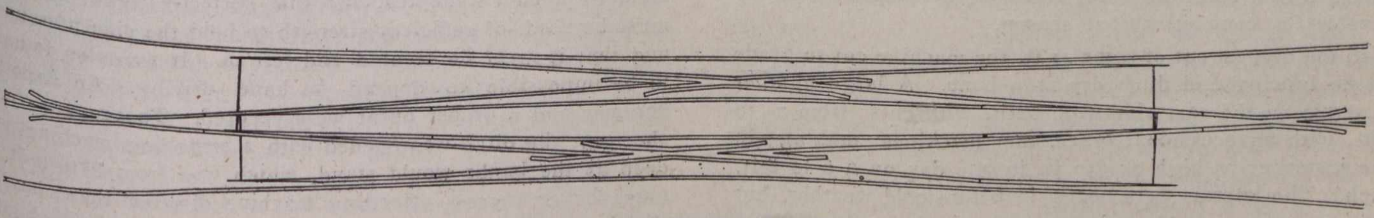

Fig. 7.—Slip-Switch Crossing.

A type of combined switch and crossover, known as a slip switch crossing, is shown in Fig. 7, and is being largely used in places where great flexibility of movement is required. As will be seen, this crossing will give two alternative routes for a train coming in any of the four directions. In construction it is a regular diamond crossing, with the sides connected with switch points and closure. It cannot be conveniently used for tracks which cross at a sharper angle than 1 in 7 because the switch points, frogs, guard rails, etc., become too crowded together to permit of their proper construction.

In a slip switch of this nature the movement of all the points is made by one lever being placed at the centre of the crossing, but the use of this crossing is not considered very advisable except in yards with interlocking apparatus, owing to the increased liability to accident through two trains coming together, either "head on" or "sideswiping."

These slip switch crossings have enabled a design to be made for track layouts which is now being used in various forms in general large passenger terminals. The general idea of this layout is shown in Fig. 8, and it will be readily seen that great flexibility of train movement can be obtained, as either an incoming or outgoing train can keep to its correct track practically to the end of the platform to or from which it is bound. For instance, an outgoing train from platform 7 will take the switch to the right at the point "b" and thus be on its own right-hand track, and be independent of trains arriving at the platforms beyond No. 7. Similarly an incoming train will keep to the right-hand track as far as possible and only cross over to its own platform track as close to it as possible. The switches marked "b" in Fig. 8 are slip switch crossovers similar to that shown in detail in Fig. 7, but those marked "a" have the connecting switch on the lower side only, so are "half slips."

This type of double ladder with slip switches is rapidly coming into use in terminals where a large number of trains are handled, as it does away with a great deal of the congestion that is liable to take place through one train having to wait outside the terminal while another one is just leaving. This leads to delays, one delay leads to another, and the working arrangements of the whole terminal are upset, whereas the double ladder permits the greatest number of movements either from one platform to another or of the main line trains, to be made without interference. A layout of this nature can only be economically used where an interlocking plant is in operation.

In main line work refinements have to be made in the switches to make them easy riding, such as the use of longer switch points, and spring frogs. The latter are made with one arm pivoted in such a way that ordinarily the main line rail is continuous, but when the turnout is being used the wheel flanges of the cars push this arm to one side, against the pressure of a strong spring.

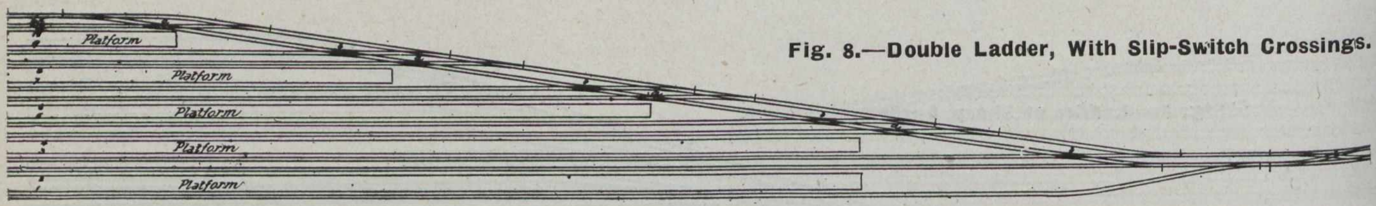

Fig. 8.—Double Ladder, With Slip-Switch Crossings.

On the railways in Great Britain even greater refinements are carried out with switches, to meet such conditions as are often obtained at junctions between stations where trains will frequently pass from the main line to the branch at as high a speed as 60 miles an hour. To meet these requirements the switch points are made very much longer and the whole switch is constructed on the principle of a spiral curve.

Great strides have been made in this subject during the past years, but even now it is quite possible to see yards with a jumble of switches at their extremities which might have been made into orderly ladders, and with "stub" switches which should be on the scrap heap; but these will all no doubt be replaced in the course of a few years with the neat and efficient layouts that are now in general use in modern track construction.

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SEWER CONSTRUCTION.

The laying of sewer pipe by contractors in treacherous ground of the quick sand type usually means pecuniary loss for the contractor if he was unaware, at the time of making his bids, of the soil of the above type he would encounter. A description of the troubles and difficulties of this kind unexpectedly run into is given in a paper presented before the Iowa Engineering Society, by C. P. Chase, and reads as follows:—

A contract was let in October, 1910, to Mr. C. R. Nichols, embracing 5½ miles of 8-in. to 15-in. pipe sewers, with manholes and flush-tanks, and a reinforced concrete septic tank with dosing chambers and sand filters.

It was expected to begin work at once, but the contractor was busy and let it go over winter. Conditions early in 1911 were ideal; but the contractor failed to begin, though constantly urged. At last, in July, 1911, work was begun on the disposal plant by a sub-contractor and the grading done and excavation made for the tank. Here the contractor, tied up by other affairs, abandoned the work.

The council gave notice to the bonding company to take up the work, and very shortly it came forward and agreed to complete the job. The contract was placed in the hands of the Lytle Construction Company, of Sioux City, which immediately began operations. The first trenching machines steamed up on Aug. 20, 1911, and conditions seemed to be favorable for completion that season.

In the deepest cut of some 21 ft. the machine cut to grade with no bracing and ditch dry as a bone. A large number of laterals on the east side were built, with cuts from 7 to 20 ft., with an occasional brace, the machines making in some instances as high as 650 ft. in one day on a 6 to 8-ft. trench. The laterals were nearly in before cold weather, but in the meantime, on the other branch of the main sewer, something had happened. As will be remembered, 1910 and 1911 to the fall of the latter year were very dry; this was especially true around West Liberty. A rain of several days came about Oct. 1, and the dry ground in 48 hours was filled with water, there to remain.

Quicksand.—In a recent English lawsuit a lawyer described a certain quicksand that had resulted disastrously to his client as "an oily, slithery, nasty mess, where men would speedily sink to their death if not rescued." There you have West Liberty. Molasses, soft glue, or crude tar come nearest. By various sewer men it was designated as quicksand, floating clay, sea mud, boiling sand, and worse. I would designate it as a silt deposit of some ancient lake bed. It varied from a fine, silty sand to a molasses-like mud, in which men frequently sank to their hips and were pulled out with ropes, and it would go anywhere that water would.

The first encounter with this was fought out in the usual way, with hand-driven sheeting afterward removed. One block about 300 ft. long, put in in this way, was clear and in good shape when finished; later the sides settled and the whole line was heaved out of line and grade and nearly every pipe crushed. The various ordinary expedients of sewer building were tried without much success.

First a small section was taken out by hand, driving the sheeting down as the excavation proceeded; when to grade short ship lap was driven about 2 ft. below grade and left 2 ft. above. Straw, cinders, stone, brickbats and other material simply floated away, the great trouble being that after the pipe was laid the bottom of the trench would raise up from pressure of the sides and break open the joints or even crush the pipe.

It was seen that although expensive, more strenuous methods must be adopted, and that perfectly tight sheeting must be used, of sufficient strength to hold the side pressure and that it must be secured and left in. It was also found to be impossible to depend on hand driving. An Arnott hammer and a proper outfit were secured. To prepare for sheeting, the ditch was opened with a trenching machine as deep as the banks would stand, which was from 6 to 9 ft., much better success attending machine digging than hand digging. Then 2 x 12-in. tight sheeting was driven about 3 ft. below the grade of the flow line of the pipe, thoroughly cross-braced and spiked. It was allowed to remain in the trench. Any attempt to remove the sheeting was attended with almost immediate disaster.

Two methods of placing and driving the sheeting were employed. In both cases the excavation was carried down 6 to 9 ft. with a trenching machine, temporary braces being set to hold the clay banks until the stringers could be placed.

In the first method a set of 4 x 6-in stringers was placed at the bottom of the machine-dug trench, 2 x 6-in. stringer being placed next to the bank and separated from the 4 x 6-in. stringer by a 2-in. block, much care being taken to have them set plumb, otherwise the sheeting would drive crooked. A similar set was placed about 3 ft. below the surface of the ground and the sheeting driven between the 2 x 6-in. and the 4 x 6-in. sets. A timber frame 16 ft. high was constructed on a platform wide enough to span the trencn, and the hammer suspended on a trolley running on a 7-in. I-beam set transversely to the trench at the top of the frame. The platform was build on skids parallel with the trench, so that it could be easily moved forward as the driving progressed. The hammer was operated between two pairs of guide rods made of galvanized iron pipe, a gasoline engine and hoist being used. With this method and equipment an average of about 60 pieces of 2 x 12-in. timber, 18 ft. long, could be driven per day at a cost for labor of 50 cents per lineal foot of trench and a total cost for sheeting of about $3.20 per lineal foot. It was hard to keep the outfit upright and steady, and this reduced considerably the driving power. Only one plank could be set on each side of the trench at a time, making it necessary to move every foot, which was impracticable and too expensive.

In the second method blocks were set between the 4 x 6-in. stringers and the 2 x 6-in. stringers omitted. The steam hammer was handled by a derrick with a 20-ft. boom, the guide rods in this case being made fast to the hammer, and sliding through iron loops fastened to the end of the boom. The derrick was erected on a platform similar to the one described above, and in such a way that the foot of the derrick was over the centre of the trench. In this way about 34 pieces of sheeting could be driven from one position. The derrick was then moved forward and the driving continued. Laborers set up the sheeting ready for the driver as soon as the stringers were in place, so that the hammer could be kept constantly at work. With this method the number of pieces driven per day was increased about 30 per cent., with a corresponding decrease in cost.

Removing Material.—The quicksand was taken out in buckets of ¼-cu. yd. capacity. To handle the buckets, two derricks made of 6 x 6-in. timbers, with 20-ft. booms, were erected on opposite ends of a platform made to span the trench. A four-post frame made of 6 x 6-in. timbers properly braced held the derricks in place. On the platform within the frame a 4-h.p. gasoline engine furnished power for the hoists, which were so arranged that one man could operate both derricks. This apparatus was employed to handle the steam hammer, and when hitched to a scraper was also used for backfilling. The blocks were so arranged that in raising a full bucket from the trench its weight pulled the boom around to the side of the trench where the bucket was to be emptied. Seven men were ordinarily sufficient to operate this device, doing more and better work than 14 formerly accomplished by hand. Without it or something similar it would have been almost impossible in the worst places to make any progress against the quicksand; for in spite of tight sheeting, carefully driven, the sand ran in through the smallest cracks and boiled up from the bottom. Occasionally after half a day's work there were no results apparent in the trench.

Preparing Bottom.—With the sheeting in place, and the trench excavated, special methods had to be devised to prepare for pipe laying. Cinders, straw, brickbats, piling and concrete were experimented with, and at last concrete was chosen—first, to keep the sheeting from pressing in and crushing or disturbing the pipe, and, second, to obtain a pipe bed. The concrete placed one day was not used to lay pipe on until the next. Half of the diameter of the pipe was buried in concrete to distribute the weight and prevent crushing.

In some places where concrete was being placed for foundation the sand boiled up through the concrete before it had time to set and rendered it useless. To overcome this, inch boards were laid lengthwise in the bottom of the trench the full width and nailed together. They were then worked down through the sand and water as far as they would go, sufficient excavating having been done to permit the boards to be worked down to a point 6 or 8 in. below grade. The sand and water were then cleaned off the boards and the concrete placed. The time saved in this way more than paid for the boards, and a much better foundation was obtained.

Of all the equipment which the contractor had on the work the steam hammer and the derrick device for handling wet excavation gave him the best returns on the investment for plant.

Occasionally there would be an oasis in this sea of antediluvian mud where a good bottom could be secured by mixing cinders with it. This seemed to work where it was sticky, with clay predominating. It would fill up and bind, but if fine sand predominated, cinders were useless.

All pipe was eventually covered with dry earth and the fill was compacted by tamping to a depth of several feet.

Railroad.—Where the 15-in. main crossed the Chicago, Rock Island and Pacific right-of-way an attempt was made to tunnel the main tracks; but the sand was so bad that it was finally found necessary to drive a temporary bridge of 15-ft. span under each of the two main tracks and make the excavation in open cut. Under the stringers of the bridges for a space of several feet horizontal sheeting was set, and below this 2 x 8-in. sheeting was driven down below grade by hand. Outside the main tracks steel sheeting was driven and later pulled, using a 6-ton Triplex block. Cast-iron pipe was used across the right-of-way, and it was not thought necessary to leave sheeting in the trench. As the sand offered no foundation for the cast-iron pipe, brickbats and concrete were placed under the joints. The excavation was carried down below grade, a wagon load of brickbats dumped at the place where the joint would come, and about one-half or three-fourths of a cubic yard of concrete dumped from large buckets on the brick. So much sand was taken out at this place that the banks settled considerably, more than 1 ft. at one point. This line of sewer, however, showed up well on final inspection.

The contract, which ordinarily would take six months, was completed in November, 1912, and much credit is due to the contractor for the gameness with which he stuck and finished the work.

ROAD GRANTS IN ENGLAND.

Considerable dissatisfaction exists among highway authorities in London, England, at the manner in which the Road Board is dispensing financial assistance for the repair of roads damaged, chiefly by heavy motor traffic. The board hinted at the outset that it was prepared to make grants and loans to the authorities in the metropolitan police area up to the amount of £250,000. But it seems that no authority can get a grant unless it is itself prepared to spend three or four times as much as the grant, and is considered that this policy is a direct incitement to local bodies to spend more money than the circumstances of the case demand. Road board grants, it is claimed, should be unconditional, and that local authorities should not be forced to spend large sums out of the rates for the special benefit of motor traffic. So strong is the resentment of the authorities on this policy that the subject is to be raised in parliament at the first favorable opportunity.

STREET PAVING IN ENGLAND.

The Metropolitan Paving Committee, of London, England, have recently issued their tenth annual report relative to paving work compiled from information furnished by the engineers to the authorities concerned. As this information is very complete in its way, it may be of interest to Canadian engineers as regards cost comparisons. It should always be remembered that our more rigorous climate and the difference of the labor wage, lessens the value of this report as far as Canadian practice is concerned. We are of the opinion that a perusal and study of its contents is nevertheless both advisable to all interested in road building.

The brief summary of the work done is taken from The Surveyor, of London, England, February 21st, 1913. The prices mentioned have been changed to the decimal system of coinage to suit our Canadian readers.

Principal Kind of Paving Laid.—The bulk of the paving laid down in the districts mentioned in the returns during the year appears to have been creosoted soft wood, although in some instances other kinds of paving predominated. Large areas of tar-macadam were laid in some districts, principally in limited traffic residential and business streets, while a large amount of tar-spraying has also been undertaken.

Foundation.—In some boroughs a foundation of Portland cement concrete 9 in. thick (in one case 12 in.) has been adopted, while in others a 6-in. foundation has been deemed sufficient. There is a decided tendency to increase the thickness of concrete foundation, owing to the detrimental effect of heavy motor traffic.

Effect of Motor Traffic.—Motor traffic is considered to be detrimental to macadam-paved roads, and the majority of the borough surveyors are of opinion that motor traffic has increased the cost of the upkeep of the roads.

Saving on Tar-sprayed Roads.—Considerable saving continues to take place in those boroughs where the tar-spraying of macadam roads is largely undertaken. From the appended information it will be seen that a very considerable saving has been effected in the boroughs of Fulham, Greenwich, Hammersmith and Wandsworth in the cost of scavenging, watering and maintenance of highways since the adoption of the system of tar-spraying macadamized roads. It is, moreover, generally agreed that a great improvement in the road results from tar-spraying.

The returns sent in during the past year have been put in tabulated form, and may be briefly summarized as follows:—

Greenwich.—Some 3,600 super. yds. of tarred macadam, 4 in. deep, were laid in this borough. The macadam was consolidated with the steam roller and laid on an old foundation, the subsoil being gravel. The cost of laying per yard super. was 79c. without foundation, the work being carried out by the local authority. The surveyor mentions that 47,227 super yds. have been tar-sprayed in the borough at a total cost of $2,258.

Hammersmith.—In Stamford Brook Road tar-macadam, composed of Trinidad Lake bitumen and granite mixed, 3 in. thick, with a sealing coat of refined Trinidad Lake bitumen, was laid on a foundation of old macadam at a cost of 90c. per yard super. In another thoroughfare, with limited traffic, tarred-slag macadam, 3 in. thick, was laid on an old foundation at a cost of 67c. per yard super. In this borough 275,164 super. yds. have been tar-sprayed at a cost of $2,931.11.

Hampstead.—Hard and soft wood, lithofalt block paving, lithomac paving and tar-macadam were laid in this borough during the past year. The 8-in. by 3-in. by 4-in. creosoted deal blocks were laid with close joints run in with a mixture of boiling pitch and creosote oil, grouted with Portland cement and top dressed with fine shingle on an old 6-in. foundation broken up and a new Portland cement foundation 9 in. thick, including 1 in. floating formed. The foundation was laid by the local authority, the paving by a contractor at a cost of from $1.36 to $1.38 per yard super. without foundation. The 4-in. Jarrah blocks which this paving replaced had been down for eleven years in these heavy traffic roads. In Heath Street, where the traffic is limited, these blocks were laid in the same manner on an existing foundation made good and refloated with Portland cement and sand, at a cost of $1.70 per yard super., including the work of remaking the foundation. The 5-in. deal blocks which this paving replaced had been down nineteen years.

In Finchley Road, a heavy traffic thoroughfare, 8-in. by 3-in. by 3¼-in. sectional Jarrah blocks were laid, the courses divided by fillets of ¾-in. in depth and 1/12 in. in thickness, the joints being filled in with a mixture of boiling bitumen. They were laid on an existing foundation made up to the proper level with Portland cement concrete, and refloated with Portland cement and sand at a cost of $3.29, including the cost of the work of remaking the foundation. The Jarrah blocks which this paving replaced had been down eleven and twelve years. The surveyor states that this sectional block paving has proved very satisfactory after an experience of seven years; the wear is smooth and even, and there is no corrugation of the paving as in ordinary hardwood paving.

Lithofalt blocks, 9 in. by 4½ in. by 1¾ in., were laid in Belsize Road, where the traffic is considerable. They were laid on wet floating, on an existing foundation, made up to suit the new paving. The blocks were supplied by a contractor, and the work was executed by the local authority, the cost per yard super. being $1.72 with foundation.

Lithomac paving, 2 in. in thickness, was laid in College Crescent, where the traffic is considerable, at a cost of $1.23 per yard super. with foundation.

Holborn.—Most of the paving laid in this borough consisted of compressed rock asphalt 2 in. thick, the Portland cement concrete foundation being, in nearly every case, 9 in. thick. The rock asphalt was compressed with heated pelons, the cost per yard super. varying from $2.47 to $3.35 with foundation, and $2.19 to $2.25 without foundation. This paving has worn well. Some Trinidad Lake asphalt macadam, 3 in. thick, was laid at a cost of $1.15 per yard super. without foundation.

In Chancery Lane, where the traffic is considerable, creosoted Swedish deal blocks, 3 in. by 9 in. by 5 in. have been laid in pitch grout finished in cement, joints 1/10 in. in thickness, on a Portland cement concrete foundation, 9 in. to 11 in. in thickness, at a cost of $3.22 per yard super. with foundation, and $1.85 without foundation, the annual cost of maintenance per yard super. being 24c.

Kensington.—The return from this borough contains particulars of a new description of paving—namely, camphor wood blocks, 9 in. by 3 in. by 4 in., grouted tar pitch and cement, and laid on a 6 in. Portland cement concrete foundation at a cost of $2.73 without foundation.

Creosoted deal blocks, 8 in. by 3 in. by 4 in. or 4½ in. or 5 in., were laid, grouted tar pitch and cement on a 6-in. Portland cement concrete foundation, at a cost of from $2.23 to $2.50 with foundation, and $1.63 to $1.80 without foundtaion. In Notting Hill Gate the wood paving which this paving replaced had been down twelve years, and in residential thoroughfares the paving replaced wood paving which had been laid from sixteen to twenty years previously.

Kensington asphalt clinker blocks were laid in residential thoroughfares by the local authority.

ELECTROLYSIS FROM STRAY ELECTRIC CURRENTS.

By A. F. Ganz, M.E.*

At a recent meeting of the New England Association of Gas Engineers, Prof. Ganz delivered the following interesting lecture on Electrolysis from Stray Electric Currents. Written in clear style and apparently free from the assumption that those reading are all highly versed in electric technology, it should be instructive and pleasant reading for all.

A Definition and Theory of Electrolysis.—Electric current may be conducted in two ways: First, by metallic conduction; and, second, by electrolytic conduction. Metallic conduction occurs when an electric current passes through a metal, and is characterized by the fact that no chemical change is produced in the conductor, the only effect being the production of heat. When electric currents, therefore, pass through metallic conductors, such as copper wires, rails, or pipes, they produce no change in these conductors except to raise their temperature. Under all ordinary conditions stray electric currents found on underground pipes are not sufficiently large to appreciably heat these pipes. Under abnormal conditions pipes may, however, carry stray currents of sufficient magnitude to produce heating at moderately high resistance joints.

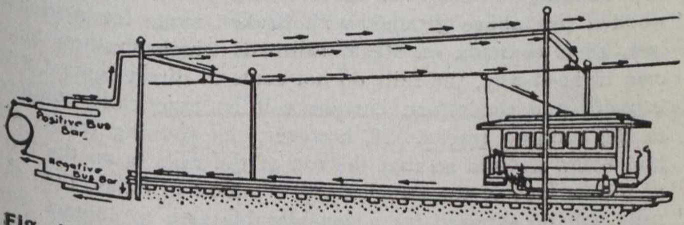

Fig. 1.—Diagram Showing Path of Current from Generator through Positive Feeders, Trolley Wire, Car and Rails.

Electrolytic conduction occurs when an electric current passes through an electrolyte, and is characterized by the fact that the electric current is transmitted by a corresponding transfer of ions in solution, with the production of chemical decomposition at the electrodes where the current enters and leaves the electrolyte. Electrolysis may, therefore, be defined as chemical decomposition produced by an electric current. Electrolysis is usefully applied in the arts for the refining of metals and for producing chemical compounds. The writer wants to discuss here the destruction of underground structures caused by electrolysis from stray electric currents which reach these structures.

Chemical compounds in solutions of water, constitute the ordinary electrolytic conductors. Pure water itself has such a high resistance that it may practically be considered a non-conductor. It is for this reason that an iron pipe full of ordinary city supply water does not have a lower resistance than the same pipe without water. Water is, however, readily made conducting by the addition of small amounts of salts, and conduction through water is, therefore, always electrolytic.

The following is a brief explanation of the theory of electrolytic conduction. When a salt is dissolved in water, some of the molecules separate or dissociate into two parts, one part having a positive electrical charge, and the other a negative electrical charge, and these parts are called ions. The metal parts (or the hydrogen) constitute the positive ions, and the acid parts the negative ions. For instance, copper sulphate, $CuSO_4$, when dissolved in water, dissociates into the positive metal ion Cu and the negative acid ion SO_4. An electric current is transmitted through an electrolyte by the transfer of these ions. The electrode by which the current enters the electrolyte is called the anode, and the one by which the current leaves is called the cathode. The metal or hydrogen (positive) ions travel in the direction of the current and carry positive electrical charges to the cathode, and these metal ions, called cations, are deposited upon or are liberated at the cathode. The acid (negative) ions travel against the current and carry negative electrical charges to the anode, and these acid ions, called anions, will corrode the anode if it is a metal which combines chemically with these anions. The cathode is not corroded. With an electrolyte of copper sulphate dissolved in water, a copper anode corrodes into copper sulphate and dissolves, while metallic copper is deposited upon the cathode. If the electrolyte is common salt dissolved in water, the anions are chlorine, and an iron anode would be corroded, the iron forming ferrous chloride; the cations are sodium, and these would decompose the water present and liberate hydrogen at the cathode. These examples furnish an illustration of the fact that the corrosive action of the current results in supplying the electrolyte with an equivalent of the amount of salt decomposed by the current, so that the electrolyte is continually replenished with salt and its electrolytic conducting power is thereby maintained. This salt will contain metal ions of the anode or hydrogen, and may be different from the original salt which started the action.

Street soils, when entirely dry, do not conduct electric currents. Under ordinary conditions, however, street soils contain considerable water with salts in solution, generally chlorines, and this makes them electrolytic conductors. When an electric current passes through soil it, therefore, does so by electrolytic conduction and by corresponding chemical decomposition at the electrodes. Where an electric current leaves an iron pipe for soil it corrodes the iron by this action of electrolysis. It has been claimed in the past that soils may conduct metallically; but this has been disproved, and it is now recognized that conduction of electric current through soil is always electrolytic.

The rate at which ions are liberated at the electrodes is proportional to the current strength. With an oxidizing anode, such as iron or lead, the mass of anode corroded by one ampere in 1 second is equal to the electro-chemical equivalent of the metal of the anode. This is 0.00029 gram for iron (ferrous). From this the mass of iron corroded by 1 ampere in 1 year is $0.00029 \times 60 \times 60 \times 24 \times 365 \times 0.002205 = 20$ pounds (approximately). The electrochemical equivalent for lead is 0.0010716 gram, and the mass of lead corroded by 1 ampere in 1 year is $0.0010716 \times 60 \times 60 \times 24 \times 365 \times 0.002205 = 74$ pounds (approximately).

The separation of the metal or hydrogen ion from the electrolyte in the cathode absorbs energy from the electric circuit and generally produces an electromotive force in the opposite direction to the current. The oxidation of the anode supplies energy to the circuit, generally producing an electromotive force in the direction of the current. If the oxidizing anode is of the same metal that is being deposited upon the cathode, and if the electrolyte is the same at the anode and cathode, then there is no resultant electromotive force due to the electrochemical actions, and the only electromotive force consumed is that due to the resistance of the electrolyte in accordance with Ohm's law, exactly as with a metallic conductor. If the metal deposited at the cathode is different from that oxidized at the anode, or if hydrogen is liberated at the cathode, or if the electrolyte at the cathode is not of the same composition or density as at the anode, then there will be a resultant electromotive force, which may be either

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in the same or in the opposite direction as the current. It has been assumed by some writers in the past that no corrosion from electrolysis can take place if the voltage between two metallic conductors in soil, such as between pipe and rails, is less than 1.5 volts, because this is the dissociation voltage of water. This, however, is entirely wrong, and it has been proven by many investigations, also by practical experience, that the amount of corrosion produced by electrolysis is independent of the voltage, except in so far as this determines the amount of current flowing, and that the smallest fraction of a volt can produce corrosion from electrolysis under suitable conditions, and this is now generally recognized by electrical engineers.

A large number of laboratory tests have been made to determine whether electrolysis is produced when an alternating current flows from a metal to an electrolyte; for example, from a pipe to surrounding soil. These experiments indicate that a slight amount of electrolysis may be produced by an alternating current, which is generally less than 1 per cent. of the amount of electrolysis produced by a corresponding direct current. It must be remembered, however, that, in the case of alternating current, electrolysis would be produced wherever there is a flow of alternating current between a metal and soil, while with direct current metallic anodes exist only at ½ the points where current flows between metal and electrolyte; namely, where current leaves the metal.

Sources of Stray Electric Currents.—Stray currents are electric currents which have leaked from grounded electrical distribution systems and flow through ground and through underground structures. Grounded telephone and telegraph lines produce electric currents through ground of such very small magnitudes that their effects upon underground piping systems can be neglected. Direct current, electric lighting systems, in which the distribution is on the Edison 3-wire plan, with the neutral conductor grounded, are in American practice provided with such large neutral conductors of copper that practically no stray currents are produced from such systems. This grounding of the neutral in Edison 3-wire systems is to serve as a safety measure, and is not for the purpose of using the ground to carry current.

The secondaries of transformers are also frequently grounded to underground pipes for the purpose of preventing a high and dangerous voltage from existing between the secondary circuit and ground. Such ground connections, however, do not produce flow of current from pipes to ground and, therefore, such grounding of transformer secondaries does not cause danger from electrolysis.

Electric railways, using the running tracks for return conductors, often produce comparatively large stray electric currents through ground, and these are the only sources of stray currents which need be considered in practice. Direct current is very generally used for such electric railways, and it is the common practice to supply current to the care from an overhead trolley wire or from a third rail, and to return this current to the power station through the running tracks, supplemented where necessary by return feeders. A single-trolley electric railway is shown diagrammatically in Fig 1, in which the path of the electric current, from the positive terminal of the generator through the circuit and back to the negative terminal, is shown. The running tracks consist of rail lengths about 30 feet long, and these are mechanically fastened together by fishplates which consist of steel plates bridging across the rail ends and bolted to both rails. Such fishplates, while mechanically fastening the rail lengths together, do not form good electrically conducting connections between the successive rail lengths. For this reason, copper wires or straps, called rail bonds, are generally used to bridge across the abutting ends of the rail lengths for the purpose of affording a good electrically conducting path between successive rail lengths. The two rails of a single-track road, or the four rails of a double-track road, are also generally connected together at frequent intervals by cross bonds so that the 2 or the 4 rails may be available for the return of current. Instead of using copper rail bonds, the rail ends are sometimes welded together, or soft steel plates are welded across each side of the abutting rail ends, thus forming both a strong mechanical and a good electrically conducting connection between the successive rail lengths. A well bonded railway track should have a conductivity not less than 80 per cent. of the equivalent conductivity of continuous rails. To give some idea of the relative conductivity of steel rails, it may be stated that a single rail, weighing 90 pounds per yard, which is a size commonly used where the traffic is heavy, has about the same conductivity as a copper wire 1 inch in diameter. Thus the 2 rails of a single-track line, or the 4 rails of a double-track line, laid with 90-pound rails and well bonded, afford a good conducting path for electric current.

In the simplest form of single-trolley railway, already shown in Fig. 1, the rails are connected to the negative terminal of the generator at the power station, and the only path for current to return to the power station is by way of the running tracks. If the running tracks are laid upon wooden ties above ground, with broken stone for road ballast, as is common on steam railroads which run on their own right-of-way, the rails do not come in direct contact with ground, and the return current will be practically confined to the running tracks. If, however, the running tracks are laid below ground so that the top of the rails is on the level of the surface of the street, as is common in cities, then the rails will be exposed for a considerable area to contact with soil. If the tracks are laid on a concrete base a considerable area of the rails will similarly be in contact with the concrete. Since both damp soil and damp concrete are under ordinary conditions conductors of electricity, part of the current returning through the rails will shunt from the rails through the surrounding soil, as is illustrated diagrammatically in Fig. 2. It will be seen that, with the usual connection of positive terminal of the generator to the trolley wire and the negative terminal to the rails near the power station, the current will leave the rails for ground at points distant from the power station, and return to the rails in the neighborhood of the power station, in its path back to the negative terminal of the generator. Since every electric circuit must be completely closed, all current escaping through ground must again leave ground to return to the dynamo so as to complete the electric circuit. When underground metallic structures, such as gas or water pipes, lie in ground in the path of these stray currents, and where these pipes have electrically conducting joints, such as lead-calked joints or screw coupling joints, current will flow from ground to such pipes and flow largely on such pipes in a direction towards the power station. In the neighborhood of the power station this current will leave the pipes to return to the negative terminal of the generator, as shown in Fig. 2.

In the negative terminal of the generator or negative bus-bar is connected to the rails, at points some distant from the power station by means of insulated negative return feeders, then, at such connection points, the rails will be rendered negative in potential to ground, and currents will tend to flow from underground pipes through ground to return to the rails in the neighborhood of these connections. Stray railway currents on pipes will, therefore, tend to leave these pipes to return to the rails in all regions where these rails are connected to return feeders.

It must be noted that, while ordinary soil is a conductor of electricity, compared with metals its electrical resistance is enormously high; for instance, the resistance between the opposite faces of a foot cube of ordinary soil may measure anywhere from 10 to 1,000 ohms, depending upon the amount of moisture and the amount of salts in the soil, while the resistance of a foot cube of iron is equal to about 0.0000004 ohms for the resistance of a foot cube of soil, it is seen that soil has no resistance which is of the order of 250,000,000 times as great as a body of iron of the same dimensions; that is to say, the conductivity of iron is 250,000,000 times as good as ordinary soil. It would seem from this that current would flow almost entirely on the good conducting rails and none through the high resistance ground. Resistance, however, varies directly as the length and inversely as the cross-section of a conductor, and with the large surface of rails exposed to the ground, the cross-section of the path of the current through ground is enormously great compared with the cross-section of the path of the current through the rails. As a matter of practice it is found that where the rails alone are used for the return of current, frequently a considerable portion of the total current actually leaks from rails through ground.

From the above considerations it will be seen that the leaking of current from the rails of electric railways, producing stray currents through ground and on underground piping, does not constitute a source of loss to the railway company; as, for instance, would be the case with leakage of gas or water. On the contrary, by allowing the current to return by ground and underground pipes as well as by way of the rails, the total conductivity of the return circuit is increased, and the voltage loss in the return of this current is decreased, so that there is an actual saving of power for the railway company.

During the last few years alternating current has also been used in a number of cases for electric railways which employ the running tracks as a return conductor. Where these rails are in contact with ground stray alternating currents through ground are undoubtedly produced. As already pointed out, such alternating currents may produce electrolysis which varies up to 1 per cent. of that which would be produced by a corresponding direct current. However, no actual case of electrolysis from alternating currents from such railways has been reported, as far as the writer is aware. This may be due to the fact that alternating current electric railways in nearly all cases operate on long distance lines and on their own right-of-way, where they are away from underground piping networks. The author, therefore, does not feel warranted in drawing any positive conclusion as to the positive danger from electrolysis caused by alternating current electric railways where they operate within city limits.

General Effects of Stray Electric Currents on Underground Piping.—The current flowing through the rails from the trolley cars back to the power station produces in these rails a drop in potential; that is to say, points in the rails away from the power station have a positive potential with reference to the rails at the power station. Since potentials are measured relatively it is convenient to consider the negative terminal of the dynamo, which is assumed connected to the rails at the power station, as at zero potential. The distribution of potentials in the rails of a simple electric railway system, and in the underground piping, is illustrated in Fig. 2, in which convenient values have been assumed. It will be noted that the stray current causes the underground pipes to be negative to the rails at points away from the power station, and positive to the rails near the power station. It is also seen that the negative potential of the pipe, plus the drop on the pipe, plus the positive potential of the pipe, equals the drop in the rails. In the case assumed a potential difference of 550 volts is maintained at the power station; of this, 10 volts is lost in the trolley wire, 520 volts is used by the motors of the cars, and 20 volts is left to bring the current back to the power station. If the negative bus-bar and the rails at the power station are considered as at zero potential, the rails at the car in the assumed case will have a potential of ÷ 20 volts. Thus, for practical purposes, the ground with its underground pipes is subjected to a potential difference of 20 volts, and the amount of stray current produced is that due to these 20 volts. If the rails are laid in the usual way—that is, in contact with ground—the 20 volts in the rails will send some shunting current through the ground and through the underground pipe as shown in the diagram. Under the assumed conditions, there is a drop of 8 volts from the rails to the pipe near the car, a drop of 4 volts in the pipe itself, and a drop of 8 volts from the pipe through ground to the rails at the power station. It is, therefore, seen that it is the potential difference or drop in grounded rails caused by the return current which is the cause of stray currents through ground. Attempts should, therefore, be made to keep the potential difference or drop in rails as low as practicable, in order to keep stray currents through ground down to a minimum.

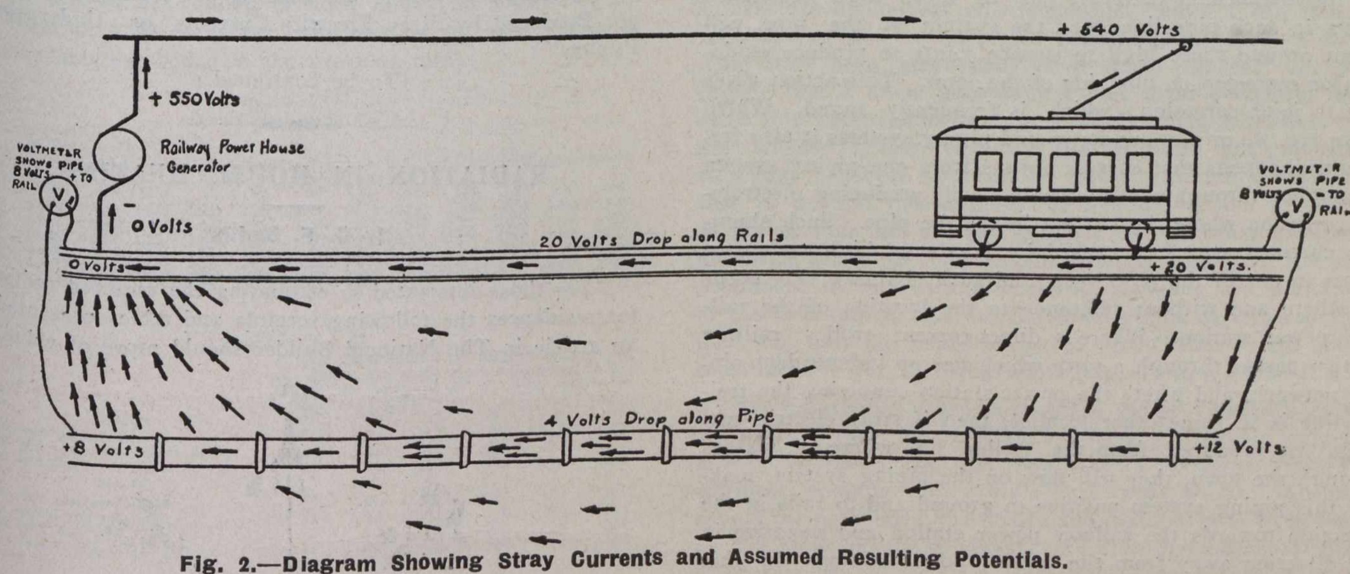


Fig. 2.—Diagram Showing Stray Currents and Assumed Resulting Potentials.

From the explanation of metallic and electrolytic conduction given in the first part of the paper, it will be understood that, where stray currents flow on underground pipes, they do no harm, except where they leave the pipes to flow to the surrounding soil. At such points corrosion of the iron from electrolysis will take place, and theoretically there will be a loss of 20 pounds of iron per year for every ampere of electric current leaving the iron. Some have assumed that, with the low densities at which current generally leaves underground pipes, little or no corrosion is produced. A number of experiments made by the writer have clearly shown, however, that, even when current leaves iron for street soil at an extremely low density, corrosion is produced which is at least equal to, and frequently greater than, the theoretical amount. This increase of the actual over the theoretical amount is undoubtedly due to secondary chemical reactions set up by the action of electrolysis.

The underground structures which are most likely to be subjected to destruction from electrolysis, caused by stray electric currents, are piping systems and lead cable systems. From what has been said above it will be seen that oxidation or corrosion of such pipes or cable sheaths will occur wherever current leaves the pipe or cable sheath for ground. In the simplest case, illustrated in Fig. 2, current flows from rails through ground to the pipes at points distant from the power station, flows along the pipes and leaves the pipes to return through ground to the rails in the neighborhood of the power station. Where the current flows from the rails to ground the rails will be corroded, and where the current flows from the pipes to ground the pipes will be corroded. If the pipe line is a uniform electrical conductor, and the relative arrangements are as shown in Fig. 2, then the pipes will be corroded only in the neighborhood of the power station. If however, the pipe line is not a uniform conductor, as, for instance, if there are one or more high resistance joints in such pipe line, then the current on the pipe will shunt around these high resistance joints to produce oxidation or corrosion on one side of the joint. This action gives rise to joint corrosion, which is frequently found. Where there are two or more underground piping systems it also frequently happens that current shunts from one piping system to another through the intervening soil, producing electrolytic corrosion where the current leaves the pipe. Such shunting currents are often caused by accidental high resistance joints in one of the pipe lines, and such shunting may occur anywhere and without reference to the location of the railway power station. Where a direct-current trolley railway system passes through a town which has an independent piping network, and where the power station supplying the trolley line is in some other locality, then if stray electric currents are produced from the trolley line where it passes through the town, they will flow on the piping system, making this piping system positive to ground and to rails in the direction towards the railway power station and negative in the direction away from the railway power station. In this case electrolysis of the piping will be produced at the ends of the piping system towards the railway power station.

Where current leaves a wrought iron or steel pipe for ground, the oxide of iron resulting from electrolysis is diffused through the soil, and streaks of iron oxide can generally be found in the surrounding soil. Electrolysis of wrought iron or steel pipes usually results in pits, which eventually go entirely through the wall of the pipe. It has frequently been found in practice in the case of gas pipes that where a service of pipe lies in clay or other tightly packed soil, it may be pitted through in many places without giving any external sign of leakage, because the soil surrounding the pipe maintains it gas tight. When cast iron is corroded by electrolysis, the oxide of iron mixed with graphite usually remain in place leaving the outside appearance of the pipe unchanged. This material resulting from electrolysis of cast iron usually has the consistency of hard graphite, and can be cut with an ordinary knife. There have been many cases in which a cast iron main was carrying gas or water without any apparent leak, where a single blow with a hammer drove a hole right through the pipe. Here the electrolytic action had corroded the iron entirely through the pipe, and the oxide of iron had remained in place, and, together with the surrounding soil, had prevented the pipe from leaking. Whether or not the mixture of iron oxide and graphite resulting from electrolysis remains in place so as to maintain a pipe gas or water tight, depends upon the surrounding soil conditions. It is, therefore, seen that an underground piping system may be suffering severely from electrolysis without having given any outward sign of the damage. A physical examination with a test hammer is required in the case of cast iron piping to establish definitely whether or not it has been damaged by electrolysis.

For a given current leaving an iron pipe, there is practically no difference in the amount of iron destroyed between cast iron, wrought iron and steel The electrical resistivity of cast iron is, however, about 10 times as great as that of wrought iron or steel, and the usual lead joints in cast iron pipes also have a resistance many times greater than the screw-coupling joints usual with wrought iron and steel pipes. For these reasons a given voltage drop through ground will cause a much smaller current to flow on a cast iron pipe than on a wrought iron or steel pipe, thus practically making cast iron pipes much less subject to electrolysis than wrought iron or steel pipes. The most frequent damage from electrolysis is found in the case of service pipes where these cross under trolley rails or other underground conductors to which they are positive. Examples of destruction of pipes by electrolysis which are often found in practice will be taken up later under the heading of "Damage and Danger Produced by Stray Electric Currents on Underground Piping."

(To be continued.)

RADIATION IN HOUSE HEATING.

By C. F. Smith.

For those interested in estimating the required radiation for residences the following formula and tables presented in an article in The National Builder should prove of value.

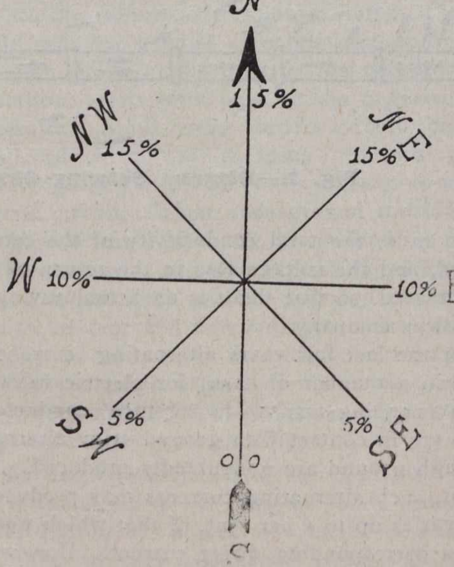


Diagram of Heat Units to be added for Different Exposures.

The formula is based on one change of air per hour in living rooms and bed rooms and three changes per hour in halls. In large living rooms or parlors, two air changes per hour, he states, should be provided for. Mr. Smith's formula is as follows:—

B.T.U. required $= W \times K + G \times L + C \times N \times T +$ a certain percentage for exposure in accordance with the following diagram.

In the formula:

W = net wall area.

K = a constant for different forms of wall construction in accordance with Table 1.

TABLE 1 (K).

Heat losses in B. T. U. through walls of brick or frame, with differences in temperature of outdoor and indoor air of

	40°F.	45	50	55	60	65	70	75	80
Brick walls, lathed and plastered inside.									
4 in. thick	12	13	14	16	17	18	20	21	22
8 in. thick	10	11	12	13	14	15	16	17	18
12 in. thick	8	9	10	11	12	13	14	15	16
16 in. thick	7.2	8.1	9	10	11	11.6	12.6	13.5	14.3
Clapboards or shingles	18	20	22	24	26	29	31	33	35
Clapboards, with paper	12	14	16	17	19	20	22	23	25
Clapboards, with sheathing	11	13	14	15	17	18	20	21	22
Clapboards, with sheathing and paper	9	10	12	13	14	15	16	17	18

All of above walls lathed and plastered inside.

TABLE 2 (L).

Heat losses in B. T. U. through windows and skylights, with differences in temperature of outdoor and indoor air of

	40°F.	45	50	55	60	65	70	75	80
Single glass	43.5	48	54.5	60	65.5	71	76	82	87
Double glass	24.7	27.8	31	34.1	37	40.2	43.4	46.5	49.6
Double window	18.4	20.7	23	25.3	27.6	29.9	32.2	34.5	36.8
Single skylight	46.5	52	58	64	70	75	81	87	93
Double skylight	19	22	24	27	29	31	34	36	39

G = glass surface (full size of window openings).

L = a constant in accordance with Table 2.

C = cubic contents of room.

N = number of air changes per hour.

T = a constant in accordance with Table 3.

If there is a cold space above or below the room, the surface area of the ceiling, or floor, should be multiplied by the constant R or S, as the case may be, as per Table 4, and the quotient added to the previous total.

TABLE 3 (T).

Specific Heat of Air, 0.2375.

Initial Temp. Deg. F.	Weight of Air per Cu. Ft. Lbs.	B.T.U. to Raise 1 Cu. Ft. of Air 1° F.	B. T. U. required to raise 1 cu. ft. of air from initial temperature (Col. 1) to final temperature of 60°F.	70	80	90	100	110	120	130	140	150
−20	0.0903	0.0214	1.716	1.931	2.145	2.36	2.575	2.789	3.004	3.218	3.432	3.647
10	0.0883	0.0209	1.468	1.677	1.887	2.096	2.305	2.516	2.725	2.935	3.144	3.354
0	0.0863	0.0205	1.23	1.435	1.64	1.845	2.05	2.255	2.46	2.665	2.87	3.075
10	0.0845	0.0200	1.003	1.204	1.405	1.605	1.806	2.006	2.207	2.408	2.608	2.809
20	0.0827	0.0196	0.786	0.982	1.179	1.375	1.572	1.768	1.964	2.161	2.357	2.554
30	0.0808	0.0192	0.576	0.768	0.960	1.152	1.344	1.536	1.727	1.919	2.111	2.302

TABLE 4 (R + S).

Heat losses in B. T. U. through ceilings and floors (the space above considered as 40° F. and below as 35° F., with differences in temperature of

Ceilings.	15°F.	20	25	30	35	40
Lathed and plastered	9.3	12.4	15.5	18.6	21.7	24.8
Lathed and plastered, double floors	2.7	3.6	4.5	5.4	6.3	7.2
Lathed and plastered, single floors	3.9	5.2	6.5	7.8	9.1	10.4
Floors.						
Single, not plastered	6.7	9	11.3	13.5	15.7	18
Single, lathed and plastered	3.9	5.2	6.5	7.8	9.1	10.4
Double, not plastered	4.7	6.2	7.8	9.3	10.9	12.4
Double, lathed and plastered	2.7	3.6	4.5	5.4	6.3	7.2

TABLE 5—ACTUAL VELOCITY OF AIR IN FLUE IN FEET PER MINUTE BY NATURAL DRAFT.

Hei't of Flue in Ft.	Temperature in Flue Above That of External Air, Deg. F. 5	10	15	20	25	30	40	50	60	70	80	90	100	110	120	130	140	150
1	24	33	42	48	54	60	67	75	81	88	95	101	108	113	118	122	127	132
5	54	75	93	108	120	135	151	168	183	198	213	228	243	254	264	275	285	299
10	78	108	133	153	171	198	216	247	266	288	308	326	342	358	374	388	404	419
15	93	132	162	189	210	231	264	297	326	354	379	393	420	438	456	474	492	513
20	108	153	189	216	243	264	306	342	376	409	435	460	483	504	525	547	569	594
25	120	171	213	243	270	297	337	384	414	444	475	507	540	564	588	613	638	663
30	132	189	234	264	297	324	372	420	460	498	533	565	594	620	647	673	700	726
35	144	204	252	285	321	351	402	453	489	525	561	597	639	669	698	726	755	783
40	153	219	267	306	342	375	429	483	532	576	616	652	684	717	750	780	809	838
45	162	231	282	324	363	399	456	513	564	610	652	690	724	759	794	829	864	887
50	171	243	297	342	383	419	482	541	595	644	688	728	765	801	837	873	908	937
60	189	264	324	373	420	461	529	594	650	703	751	795	835	876	919	958	994	1028
70	204	285	351	408	456	495	569	637	698	756	815	856	900	936	972	1008	1044	1083
80	219	306	375	435	485	530	608	687	747	809	866	918	965	1012	1060	1108	1148	1185
90	231	325	399	459	516	564	645	729	794	859	919	973	1022	1071	1116	1155	1196	1248
100	243	342	420	486	530	594	680	768	842	910	972	1029	1080	1134	1188	1233	1276	1325

* * *

EDMONTON TELEPHONES.

The city of Edmonton, Alberta, will spend in the neighborhood of $1,000,000 on extension work during 1913, the greater part of which will be cable work. It is the intention of this municipal department to build much underground conduit in both South Edmonton and North Edmonton, and there will also be considerable underground and aerial cable work. W. R. Griffith is superintendent of the department.

ENGINEERS AND GEOLOGISTS.

We take pleasure in publishing that portion of an address dealing with the general engineering profession, presented by Prof. H. E. T. Haultain, C.E., M.I.M.M., Professor of Mining, University of Toronto, before the recent annual meeting of the Canadian Mining Institute. It has caused considerable discussion, and as we mention, does not solely concern mining engineers, but applies generally. We are very sure every engineer will be glad to see Prof. Haultain taking up the gloves in an endeavor to give engineers who carry on material construction rather than interpretative theory, the credit that is due them. Quoting from this paper it states:—

There is another phase upon which I must touch, and that is the relation of the geologist to the community. Not only have the three last presidents of the Canadian Mining Institute been geologists, but the president of the American Institute of Mining Engineers is a geologist, the Dean of the Faculty of Applied Science of McGill is a geologist, the late renowned Principal of McGill was a geologist. Van Hise is president of the University of Wisconsin and Geikie is president of the Royal Society. We find geologists holding important public positions in all parts of the world, and holding them successfully and with distinction. The geologists are an ancient and honorable body. I can find no reference of slur or suspicion remaining attached to them. They have been clean and kindly men. Taking the geolgoists that I know personally I find them delightful men, agreeable companions and general favorites wherever they go. Of course, there is always the exception that proves the rule, but I believe you will all agree with me when I say that in general pleasantness the average of the geologists is higher than the average of most of the other groups of men with whom we come in daily contact. They are not only prominent in their scientific work, but they are prominent in the community, and the Canadian public at large accepts them not only as being of great importance to the State scientifically, but as being above the average good citizens.

In remarkable contrast to these public successes of the geologist, I find the condition of the engineer, not only the mining engineer, but the engineer in all branches. The engineer is doing the world's best work to-day. All that counts for prosperity and health and material growth is based on the work of the engineer. All that we are most proud of in this young nation is dependent upon the work of the engineer. The engineer exists in large numbers. Even in Ottawa there are more engineers than geologists. But we find very little public recognition of the engineer. We seldom if ever find him holding a public position of responsibility or honor outside of his immediate work. We have no engineers in Canada who are members of the Royal Society, and if we have one who has been knighted it is simply the exception that proves the rule. Why? How is it that the geologists beat the engineers to the high positions? Is it because their work is of greater importance to the State? Is it because their work is of a higher type? One would think so from the results. Is it not patent? Is it not obvious? But unfortunately the truth is not always obvious. Truth is oftener at the bottom of the well than prominent on the horizon. We must carry our analysis further. I submit that there is another and simpler reason. When we analyze the work and effort of the geologist we find it made up of two separate and distinct functions. The engineer's time and effort is devoted entirely to his engineering work. A part only of the geologist's time is devoted to the study of geology. A large part, and sometimes the larger part, is devoted to descriptions of his work, to publicity. One of their functions is that of the story-teller. From the beginnings of their existence they have been great story-tellers.

In fact, they have been the champion story-tellers of all time. Now, there is no doubt in my mind that some geologists, or near-geologists, will consider that this is another half-brick in poor disguise. But let us see what the story-teller has been to the community. When we go back to the beginning of things, that is, to the beginning of things for man, to about the time, let us say, of pithecanthropus erectus, the story-teller was beginning. He was almost the first luxury. Possibly man's first distinction was that he was a fire-using animal. Certainly about the same stage of his development he became a story-telling and a story-hearing animal, and the story-telling part was certainly more removed from mere animal than any other phase of his activities. Progress in all stages has been based largely on co-operative organization, and this came first with the fighting animal, but organization alone did not win out from the animal stage. Organization could, and does, exist without language and without man, but we departed from the animal through language and progressed through language. Language was produced by and for the story-teller. For his purpose was language developed, and without language we would have had no modern man. The neolithic scriber on bone, that "mamothistic etcher at Grenelle," was a later development of the story-teller, who told stories in pictures, and was not only the forerunner of the comic supplement, but of all that we understand in modern pictorial art. Later, he told stories in song and in mimicry, so that all our art, which represents our greatest departure from the anthropoid ape, is the work of the story-teller. He has been in the vanguard of all progress since we left the trees.

It is impossible to conceive of a geologist being eminent without this story-telling function being well developed. Unlike most story-tellers, he generally tells his own story of his own work. He is his own publicity agent; and what magnificent stories he has been able to unfold. In the second chapter of Genesis, and the second verse, we are told that God rested on the seventh day, and for a thousand years man had interrupted all his work every seventh day to signify his assent to the six-day history of the world's creation. The story-telling geologist comes along and says: "There is a mistake somewhere; it took several million years to create this earth, and I can prove it. Here are the proofs." When the world had become accustomed to the shock of this, the geologist's story went on to tell that man was not created on the sixth day, but that his creation was a gradual development occupying a period also of millions of years, the records of which in an almost unbroken chain stretching from the protozoa to modern man are preserved in the everlasting rocks. True, some links were absent, but every now and then the story is added to and the Neanderthal skull and our friend from Java help to fill in the blanks. Who couldn't attract attention and hold the stage with such stories as these? And the geologist had many such in his bag. He shows us where the moon was born. He dissects the teeth of the mammoth who wandered in our back yard before the ice was two miles thick upon it, and he counts the nervatures of the wing of the fly that plagued it.

But even the geologist's supply of stories could not keep up forever to these high-grade samples, and, as the family of geologists grew, they had to be content with less and less interesting stories. But stories they must have to maintain their eminence, and a story, to be a story, entails of necessity a hearer, a willing and an interested listener. As the quality of his stories waned he often had to expend as much pains finding the listeners as in finding the story, and this led him to the study of the listener, to the study of man, his characteristics, his wants, his needs, his foibles, and his weaknesses. He had to make the most of meagre stories, he had to study that phase of man which brought him listeners. This has been going on for generations, and the methods of the family of geologists in finding hearers is as well organized to-day as their study of geology. Are not many of them geologists in the summer and writers of their stories in the winter?

Now the story-teller is still the greatest man among us. What does Kipling get per word? and has he not had the refusal of the high honors of the realm? Theodore Roosevelt received $350,000 for seven years' work as President of the United States, but received a million dollars for the story of his African holiday. But the geologists' stock of interesting stories is running low, or rather the proportion of interesting stories to the number of geologists is becoming small, and instead of a greedily paying public he must perforce fall back on government bluebooks for publication.

And how do I interpret all this? I interpret it thuswise. The work of the geologist is in two parts. There is the study of geology to get the story and of man to get a listener. The engineer is so busy with his own work that he fails to study man. The geologist, with his knowledge of man and with his knowledge of publicity becomes useful to man in other ways.

The search for a listener has made the geologist in many ways a broader and a bigger man, and his art of story-telling brings him into the public eye.

Do I begrudge the honors to the geologist who has reached to high position through his knowledge of man? By no manner of means. I respect him, in some cases I bow down to him, but let us be honest about it and recognize that it is not the geology, but the story-telling and the man that has won to high honor.

Why, then, my half-brick of last year? It was not directed at the geologist as a geologist or as a story-teller but at men who were inclined to tell stories of no consequence to listeners provided by the reputation of the whole family of geologists, and to make capital out of these stories of no consequence. The geologist has from time immemorial been on a pedestal, and has, no doubt, taken care to be kept there. Round and about him, due to his art of story-telling, there has been a halo or an aura. His stories have not only had the important essentials of mystery and distance, but, in the main, they have been truthful and unquestioned by the general public. But there are those who would impose on this good name and on this long-earned and carefully preserved reputation.

I must confess that it is a source of some content to see the radical change that has taken place in our programme since last year, with the greatly reduced percentage of geological papers. There are many geological stories that we require, but that fact need not be abused.

This summer the geologists from all the world are coming here, and they will bring with them their best stories, and we, aided by government grants, have been diligently preparing for them, not only to hear their stories, but to provide them with new stories.

Their stories will be listened to by all manner of people, but by no one will they be more appreciated than by the mining engineer, for he will know and will preserve what he needs, and this he will use in practical work for the benefit of the community, and, going his own way, he will hold his peace and be unrecognized, and to the geologist and to the story-teller will be the glory.

◆

The Grand Trunk Railway Company reports that during February it received on outstanding orders 428 box cars from the Pressed Steel Car Company, twenty-five box cars from the Canadian Car and Foundry Company; twenty-four Pacific type locomotives from the Montreal Locomotive Works; nine switch engines from the Canadian Locomotive Company; seventeen Mikado locomotives from the American Locomotive Company, and four refrigerator cars from the Canadian Car and Foundry Company.

RAILWAYS REQUIRED THIRTEEN MILLION TIES

There were 13,683,700 cross-ties purchased in Canada in one year. This in an increase of 4,469,808, or 48.5 per cent. over previous years. The increase is due largely to railway construction, which was specially noticeable in the Western provinces on the new transcontinental lines. The replacement of ties on existing lines amounted to about 10,000,000.

There were in all eighteen kinds of wood reported for cross-ties in 1911. Red pine, Western cedar, birch, maple, beech, poplar, Southern pine, elm and black ash were reported and classified separately for the first time.

Jack pine replaced cedar at the head of the list and formed about 40 per cent. of the total. The quality of available jack pine and its wide distribution were probably responsible for its popularity. Tamarack moved up from fifth to second place and formed over 19 per cent. of the total.

Douglas fir increased from 9 per cent. in 1910 to 14 per cent. in 1911 and moved up from fourth to third on the list. Hemlock fell back and formed only 12 per cent. The new railway lines are building north of the northern range of this species. Spruce increased from 2.5 to 6.6 per cent. on account of the same activity of railway building in the northern regions of the country.

Cedar took an abrupt fall from first place on the list in 1910 to sixth in 1911. Practically all the cedar reported is Eastern cedar, as the Western species is too soft for satisfactory use for cross-ties. The supply of Eastern cedar of either tie or pole size is practically exhausted. These six species together form 97 per cent. of the total. The others in the list are used in small quantities only, and for particular uses.

The average price of ties in 1911 was 39 cents, one cent more than in 1910. Of the species used in quantity, oak ties at 81 cents were the most expensive, and spruce ties were the cheapest at 26 cents. Spruce, hemlock and cedar all show a decrease in average price while jack pine, tamarack, Douglas fir and oak all show an increase. The prices of other woods are not comparable as they are purchased in such small quantities.

About 63 per cent. of the ties purchased in 1911 were hewn. In 1910 about 70 per cent. were hewn, so the sawn tie is evidently increasing in favor, states a recent bulletin of the forestry branch compiled by Mr. R. G. Lewis, B.Sc.F. Douglas fir ties were 94 per cent. manufactured in this way. Oak chestnut and Southern pine ties were more than 50 per cent. sawn.

Jack pine, tamarack, hemlock and spruce were mostly hewn, while cedar ties were about half and half. All the poplar and red pine ties were hewn.

Sawn ties cost on the average 41 cents, or 4 cents more than hewn ties, while in 1910 the hewn ties were the more expensive by three cents.

The ties purchased by electric roads were 81 per cent. sawn as opposed to 35 per cent. in the case of steam railways.

In 1910 the electric roads used only 38.6 per cent. of their ties sawn and 61.4 hewn, so with these companies as well as with the steam railways the sawn tie increased in popularity.

Of the sawn ties Southern pine ties were the most expensive at $1.11, with oak next at 82 cents. The cheapest sawn ties were of birch, beech and maple at 23 cents. Of the hewn ties chestnut were the most expensive at 58 cents and birch, maple and beech the cheapest at 20 cents.

Steam railways in 1911 used 95 per cent. of all the ties purchased. They purchased, in 1911, 13,094,528 ties—an increase of 4,185,106, or 47 per cent. over 1910. This increase is due, as stated above, to the construction of the new transcontinental railways. They used all the ties made from Western tamarack, Larix occidentalis, Western cedar, Thuja plicata, birch, maple, beech, poplar, Southern pine, elm and black ash.

Electric railways used only 5 per cent. of the total number of ties purchased in 1911.

The electric railways' total of 589,242 is an increase of 95 per cent. over 1910. This increase is greatest with Douglas fir, the use of which has increased over sixfold. Douglas fir was not used for ties by any of the electric railways of Eastern Canada. Fir ties formed over half of the total number purchased; this species replaced cedar at the head of the list. The cost of 20 cents is below the average for all kinds of wood.

Cedar ties, which had hitherto headed the list, fell back to second place with 28 per cent., and these ties increased in price from 37 to 41 cents, a price above the general average, demonstrating the increasing scarcity of this material.

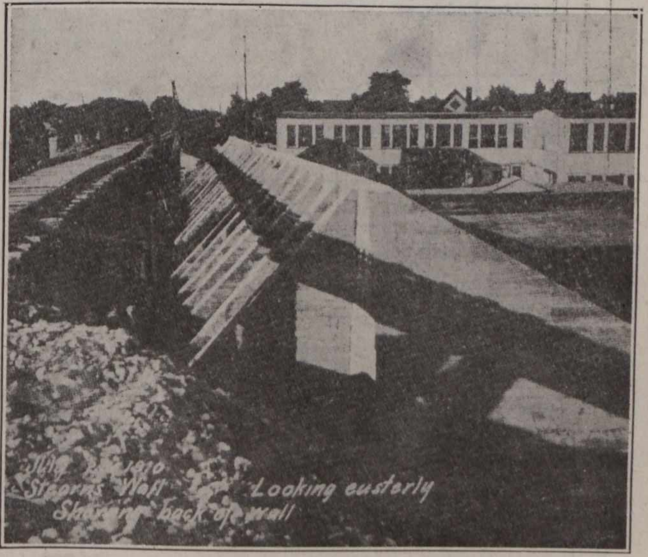
Tamarack shows an increase in number but a reduction in price. Tamarack is found in small isolated stands and its prices and quantities vary with the accessibility of the material to the railway line.

The average price of 29 cents per tie in all species used by electric railways is a reduction of 12 cents from 1910 and is due to the great reduction in the cost of Douglas fir ties, which form over half of the total. Electric railways got their ties 10 cents cheaper than steam railways. No red or white pine ties were used by electric railways in 1911.

REINFORCED CONCRETE RETAINING WALL.

An interesting article on a particular type of retaining wall appears in the last issue of The Cornell Civil Engineer. The author is engineer of grade elimination on the N.Y.C. & St. L. Railroad, and quoting from Mr. Himes' article on this subject he states:—

A wall of somewhat unusual design was constructed on the Nickel Plate in East Cleveland, in 1910. The purpose of the wall was to permit the elevation of the N.Y.C. & St. L. tracks without encroaching upon the adjacent property. The owners of that property exhibited a very unfriendly spirit towards the railroad company, and it was deemed necessary to effect the elevation of the tracks without in any way encroaching upon the property.



View Looking Eastward, Showing Back of Wall.

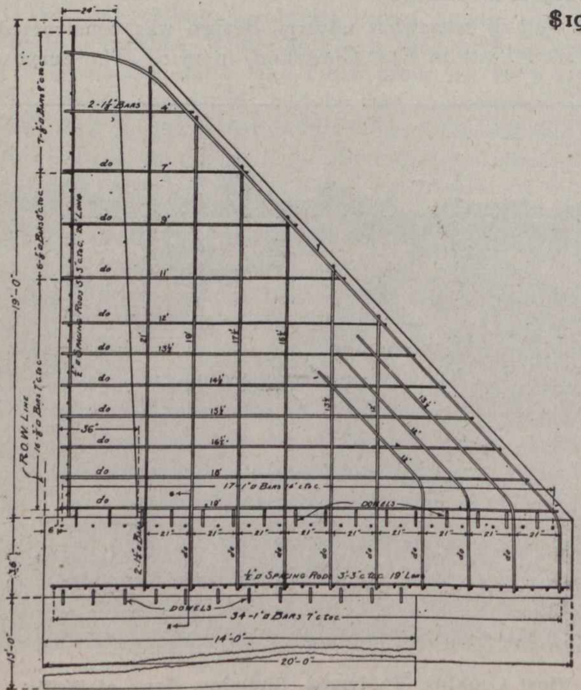
This made it necessary to carry the wall down to the rock surface, some 18 feet below the top of the ground. The centre line of the nearest railroad track was about 11 feet 6 inches from the face of the wall. The length of the wall was about 250 feet. A careful study of the problem was made and estimates prepared to show the comparative cost of a reinforced and a gravity wall.

The accompanying plans and the following tables show a full theoretical discussion of the subject and the final design, the formulæ of the American Railway Maintenance of Way Association being used.

Reinforced Counterfort Wall.

Loads per foot section.		C. of G. refer. to C tracks.	Moment.
Counterfort and main wall	30,320	5.4	183,700
Footing	9,000	2.5	22,500
Surcharge	9,600	0.0	00,000
Earth	20,790	—1.9	—39,500
Pier	30,000	5.5	165,000
Loads per foot of pier brought from intervening wall:—			
Main wall × 8/5...	6,400	11.0	70,400
Earth × 8/5.......	65,100	1.3	84,600
Footing × 8/5.....	14,400	5.5	79,200
Surcharge × 8/5 ..	15,400	0.0	00,000
	201,010		565,900

Item.	Quantity.	Unit price.	Cost.
Concrete (wall)	1,250 cu. yds.	$6.50	$ 8,125
Concrete (piers)	700 cu yds.	6.50	4,550
Excavation (wall)	40 cu. yds.	0.35	14
Excavation (piers)	1,125 cu. yds.	1.00	1,125
Steel	121,900 lbs.	0.025	3,050
Engineering & contingencies, 15%			2,530
			$19,394



Section C-D.

X = 2.81.

E = Thrust at pier;

E′ = Thrust brought to pier by intervening wall;

E = .285 × 36.5 (36.5 + 20) 120 ÷ 2 = 35,280 lbs.

E′ = .285 × 22.25 (22.25 + 20) 120 × 8/5 ÷ 2 = 25,730 lbs. per ft. of pier;

E acts at a height of $[(36.5)^2 + 3 \times 36.5 \times 10] \div [3 \times (36.5 + 20)] = 14'.26$

E′ acts at a height of $[(22.25)^2 + 3 \times 22.25 \times 10] \div [3 \times (22.25 + 20)] = 8'.84$

Taking bottom of footing at reference line,

Total horizontal thrust acts at a height of (35,280 × .01 + 25,730 × 8.84) ÷ 61,010 = 3′.75

Resultant cuts the base 4′.2 from front of footing.

Toe pressure = 2 × 201,000 ÷ (3 × 4.2) = 31,900 lbs./sq. ft. = 222 lbs./sq. in.

Resultant of forces acting on wall proper cuts the top of the pier 8′.0 from the face.

Toe pressure = $(4 \times 14 - 6 \times 8)\ 171{,}010 \div (14)^2 = 6{,}980$ lbs./sq. ft. = 49 lbs./sq. in.

Heel pressure = $(6 \times 8 - 2 \times 14)\ 171{,}010 \div (14)^2 =$ 17,450 lbs./sq. ft. = 121 lbs./sq. in.

E′ = 16,080 lbs. per foot of wall at bottom of footing.

Solid Wall.

Loads per foot section.		C. of G. refer. to C tracks.	Moment.
Main wall × 20/8.......	63,250	6.7	423,800
Footing × 20/8.......	18,500	4.25	78,600
Earth × 20/8.......	41,750	0.7	29,200
Surcharge × 20/8.......	24,000	0.0	00,000
Additional load on pier—			
Pier	39,000	3.3	128,700
Earth	12,400	—5.9	—73,100
	198,900		587,200

Item	Quantity.	Unit price.	Cost.
Concrete (wall)	2,000 cu. yds.	$6.50	$13,000
Concrete (piers)	1,000 cu. yds.	6.50	6,500
Excavation (walls)	40 cu. yds.	0.35	14
Excavation (piers)	2,020 cu. yds.	1.00	2,020
Engineering & contingencies, 15%			3,230
			$24,764

E = Same as for counterfort wall = 35,280 lbs.

E′ = 285 (22.25 × 42.25) × ½ × 120 × 12/8 = 24,120 lbs.

Total horizontal thrust acts at a height of [(35,280 × .01) + (24,120 × 8.84)] ÷ 59,400 = 3′.59

Resultant cuts the base 4′.3 from front of footing.

Toe pressure = 2 × 198,900 ÷ (3 × 4.3) = 30,837 lbs./sq. ft. = 214 lbs./sq. in.

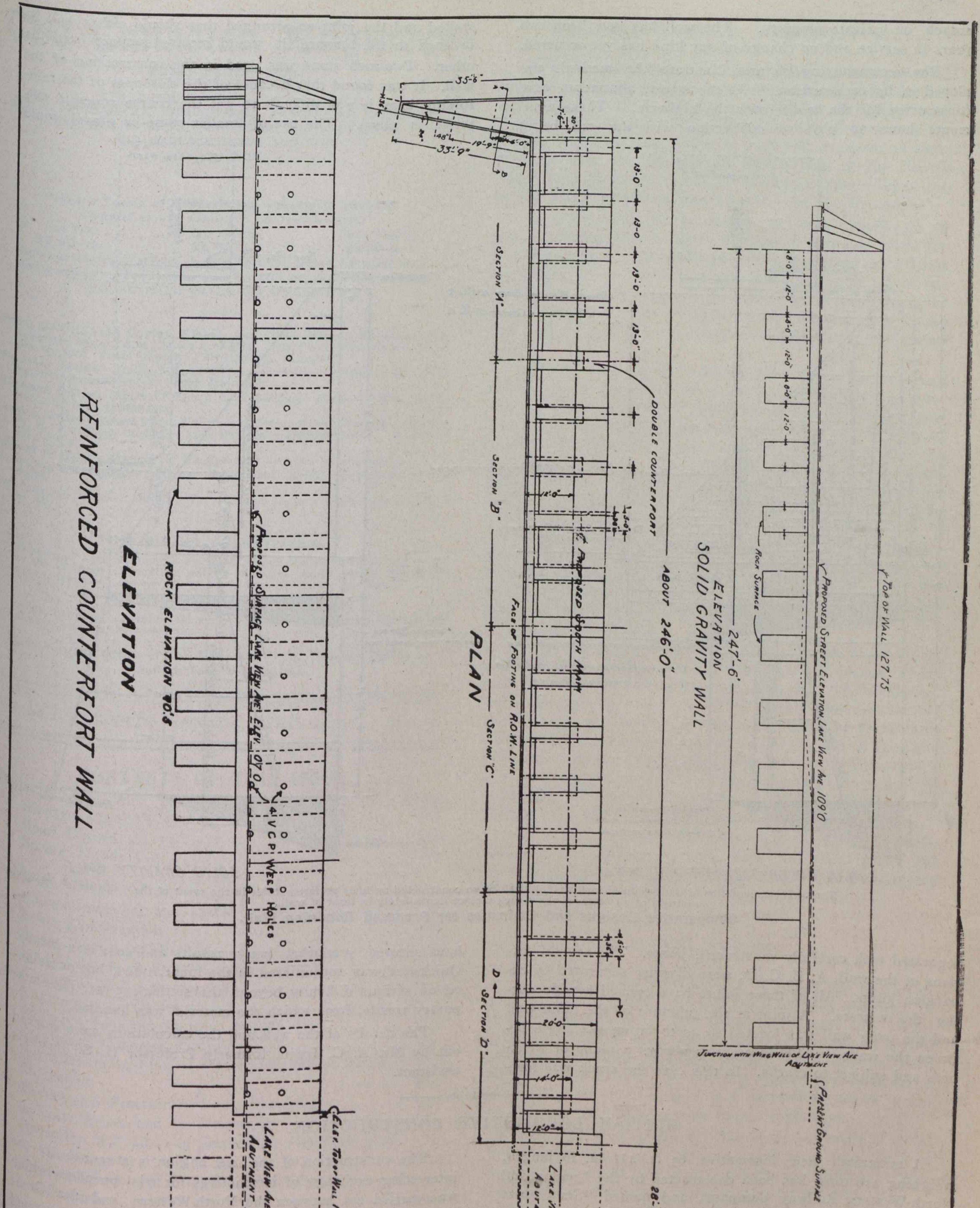
Resultant of forces acting on wall proper cuts the top of the pier 6′.5 from the face.

Toe pressure $(4 \times 16.5 - 6 \times 6.5)\ 147{,}500 \div (16.5)^2 =$ 14,628 lbs./sq. ft. = 102 lbs./sq. in.

Heel pressure $(6 \times 6.5 - 2 \times 16.5)\ 147{,}500 \div (16.5)^2 =$ 3,250 lbs./sq. ft. = 23 lbs./sq. in.

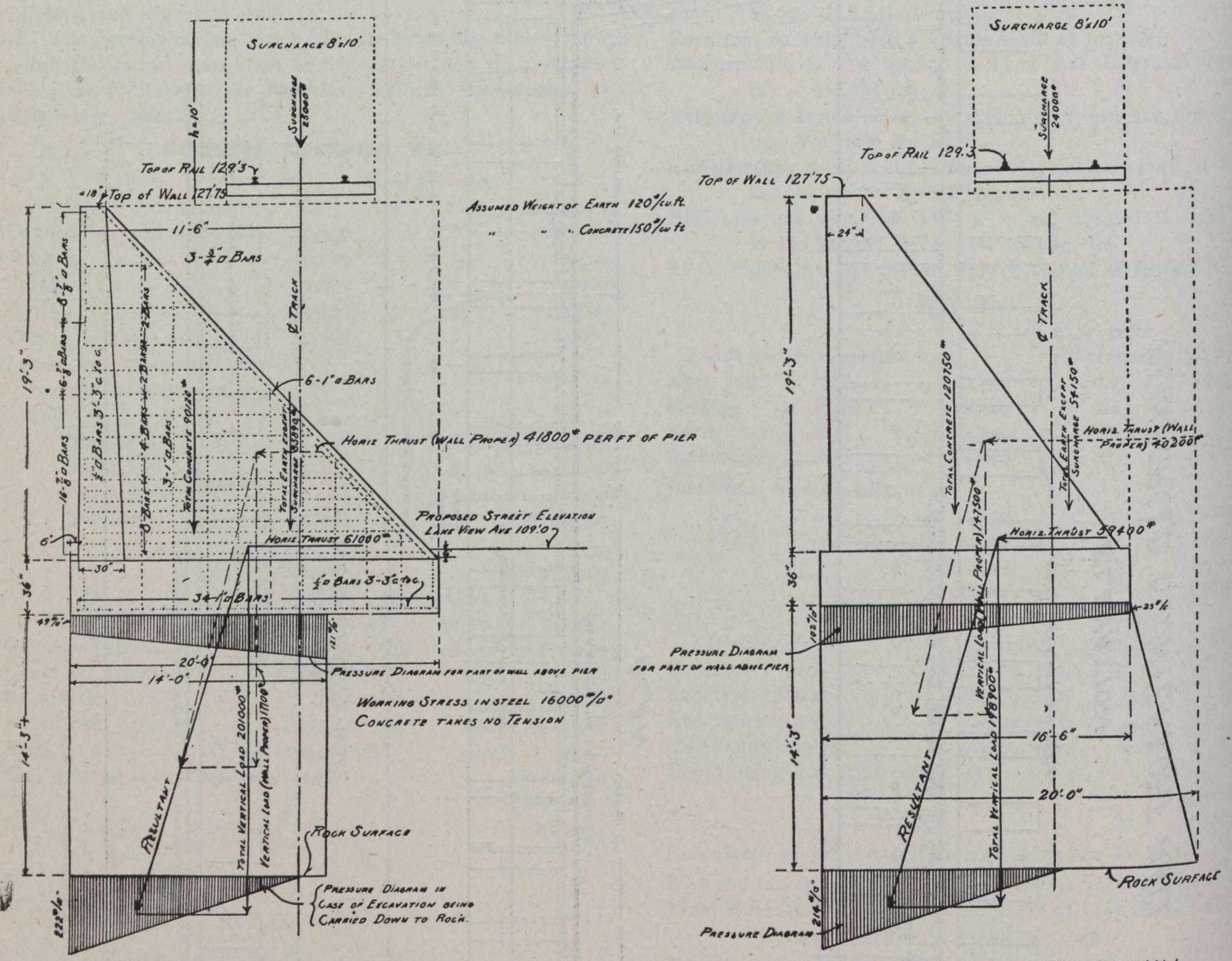
The estimated cost of the wall as finally designed was $23,570, and the actual cost after writing up the accounts was found to be $21,342.20. The estimated saving over the cost of a gravity wall was about 20%. The wall was constructed with the forces of the Grade Elimination Department, not by contract.

A feature of special interest in the wall is the manner in which the load was distributed, so as to prevent the maximum pressure from occurring at the toe of the wall on the top of the pier. Theoretically the maximum toe pressure occurs in the face of the wall at the rock surface, but since the ground surface is near the top of the piers, it is probable that the maximum toe pressure at the rock surface is somewhat less than calculated. The face of the piers was built exactly on the property line. The face of the wall was set back 6 inches, in order to insure that no part of it would by mischance en-


REINFORCED COUNTERFORT WALL
ELEVATION
ROCK ELEVATION 90.8
℄ PROPOSED SURFACE LAKE VIEW AVE ELEV. 109.0
4" V.C.P. WEEP HOLES
ELEV. TOP OF WALL 127.5
LAKE VIEW AVE ABUTMENT
PROPOSED SURFACE LAKE VIEW AVE ELEV. 109.0
PLAN
SECTION "A"
SECTION "B"
SECTION "C"
SECTION "D"
FACE OF FOOTING ON R.O.W. LINE
℄ PROPOSED SOUTH MAIN
DOUBLE COUNTERFORT
ABOUT 246'-0"
35'-6"
33'-9"
19'-9"
13'-0"
12'-0"
20'-0"
14'-0"
28'-6"
LAKE VIEW AVE ABUTMENT
ELEVATION
SOLID GRAVITY WALL
247'-6"
TOP OF WALL 127.75
PROPOSED STREET ELEVATION LAKE VIEW AVE 109.0
ROCK SURFACE
JUNCTION WITH WING WALL OF LAKE VIEW AVE ABUTMENT
PRESENT GROUND SURFACE

croach on private property. The wall has now been two years in service and no change of any kind has yet occurred.

The accompanying pictures illustrate the methods employed in its construction. At the street, abutments were constructed for the bridge over the highway. These abutments have no physical connection with the wall, being separated with carefully constructed joints. The several sections of the wall, A, B, C, D, were likewise separated by expansion joints. All of these joints have opened a trifle during the winters. A joint at the juncture of the main wall and the wing wall was located so as to bisect the angle between the walls. This location is always a plane of weakness and subject to cracks. In this case the crack was forestalled and the joint so arranged that should either wall be inclined to tilt forward it would receive support from the other. Two-inch stone was used in the construction of the wall. It was found that because of the closeness of the reinforcing bars it was difficult to get the coarse concrete material in place. The use of smaller stone or gravel would have secured somewhat better results and cost less money. Quicksand was encountered in the foundations, but occasioned no serious difficulty beyond the settlement of the temporary trestle, from which the material was handled.



REINFORCED COUNTERFORT WALL

SOLID GRAVITY WALL

NOTE.—It is a condition of the design of wall that it shall be so constructed as to be perfectly stable in the event of the removal of all material above rock surface immediately in front of wall.

Comparative Designs and Estimates for Proposed Retaining Wall.

The details of the wall and the calculations were worked out by Mr. A. C. Irwin, formerly Professor H. S. Jacoby's assistant.

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BRITISH LOCOMOTIVE CONSTRUCTION.

A mammoth new locomotive, 63 ft. 4¾ in. in length, weighing 116 tons, has been constructed by the London and North-Western Railway Company, and named "Sir Gilbert Claughton," in compliment to the chairman of the company. Having given full satisfaction on its trial, the new engine is regarded as the first of a practically new type of London and North-Western locomotives. It is a four-cylinder engine, the boiler is 5 ft. 2 in. in diameter and 14 ft. 6 in. long, and the three great coupled wheels on either side have a diameter of 6 ft. 9 in.

The construction of the new engine is a sequel to the interesting exchange of locomotives for trial purposes which was carried out between the North-Western and the Great Western two years ago. The experiments were continued for a week, and the North-Western Company came to the conclusion that the four-cylinder engine used by the Great Western was suitable to the requirements of the North-Western road. One of the first official duties of the engine will be to take the King on a visit to the London and North-Western works.

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WESTERN LIGNITE POSSIBILITIES.

Word comes from Manitoba that the experimental station of the Provincial Government at Estevan for investigating the commercial possibilities of lignite coal is now under construction. Professor Darling will be in charge of the station, and it is expected to prove as tests progress that the deposits of lignite coal of the Souris valley have potential values for power purposes important to the whole of the southern portion of the Province.

It is sincerely to be hoped that this experiment of the governments will prove all that they could wish for in the way of fuel possibilities. Water powers are neither so frequently available nor powerful when found in the comparatively level prairie provinces as in other parts of the Dominion. Any absence of a plentiful and cheap fuel supply will make industrial advancement still more difficult.

Events seem to be steadily pointing to the practical utilization in the middle west of lignite on a large scale. For several years past the United States Government has been carrying on tests of the fuel possibilities of Dakota lignites, etc., and tests showed that while the best coal produced .28 horse-power per hour under boiler, lignite when operated as a producer gas produced .30 horse-power per hour. It is difficult to make use of lignite profitably in its raw state, as the moisture amounts to about 40 per cent., and it slakes and disentegrates into small particles if allowed to weather for more than a few months. Briquetting has been tried successfully as an improvement on the raw lignite, and, while it about doubles the cost, the heating value is increased 50 per cent. and the moisture reduced to 20 per cent.

It is well known that the railways operating in that part of the middle west of the United States where coal is expensive and beds of lignite close at hand have been particularly active in investigating the commercial practicability of lignite for their use, and have apparently come to affirmative conclusions. With the aid of specially designed spark-arresters the Chicago and Northwestern in part use lignite, and the Oregon and Washington Railroad and Navigation Company have specially designed locomotives of the Mikado type using it as a fuel.

It is to be hoped from tests that the future serviceability of the deposits in the Canadian West prove encouraging and give an added stimulus to the progress of that great region.

ROAD DESIGN.

In all parts of the Dominion is heard the slogan of good roads. Counties are adopting modern methods of highway construction, and cities and towns are vieing with each other in their plans and preparations to out-do rivals by abolishing unsightly streets. Governments, both provincial and federal, are making appropriations of large sums for road construction, and everywhere there is unprecedented activity towards better highways.

It is a time to be wary. The basic principle of good road construction has not changed since the days of Macadam and Telfor, but, thanks to modern traffic requirements, there has been the evolving and trial of numerous types of road surface. Many of these have well-known advantages for particular kinds of traffic, but variety has brought us up against a varying design of road surfaces that only an accurate knowledge of traffic requirements can enable one to pass judgment upon satisfactorily.

Canadian engineers should go carefully in their design and specifications for road surface. There are large expenditures involved, and it will be cause for great regret if in the enthusiasm and haste to build good roads economical design is faulty due to a lack of proper information on traffic requirements. In the design of country roads especially, the engineer is likely to encounter difficulties, and should have an accurate traffic census for reference. Fast automobile travel, heavy truck traffic (both horse and machine), the use of narrow and wide tires, all increase the problems, and have to be considered and fullest information obtained on same, if one is going to do himself justice. Almost of no less importance must be the ability to foresee the traffic that will take place after his design has been carried into effect.

Prof. Blanchard, of Columbia, makes a definite classification of the most essential information concerning traffic; to be used in judging the suitability of a constructed road for the traffic upon it; considered as a basis for future designs, and in deciding the character of design to be adopted for a new road surface. In the latter case estimates of future changes to be made.

"(1) Differentiation between horse-drawn vehicle traffic and motor car traffic.

"(2) Division of each of these classes of traffic into pleasure and commercial traffic.

"(3) Subdivision of commercial traffic into loaded and unloaded vehicles.

"(4) Determination of the weight per linear inch of width of tire of all types of commercial traffic.

"(5) Subdivision of the two classes of horse-drawn vehicle traffic, dependent upon the number of horses.

"(6) Subdivision of pleasure motor car traffic upon the basis of weight and speed, since, in many instances, the greatest damage to certain types of roads is caused by seven-seat touring cars, limousines or landaulets, travelling at speeds of 40 to 60 miles an hour.

"(7) Extraordinary character of local traffic; for example, traction engines hauling trailers, motor bus traffic, ice wagons, milk drays, etc."

These points are further brought out by observation, as, for instance, the sharp calkes on horses' feet in winter often rapidly deteriorate what under other circumstances would be a perfectly serviceable road. They bear out the well-known truth that the amount and character of traffic are of the utmost importance to the life of the road. Accurate traffic data should be taken, both for the construction design and after building for purposes of reference and repair. It does not appear to be as thoroughly carried out as the importance warrants, and it is to be hoped the coming summer will see much useful data collected not only for present benefit but future usefulness.

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SPRING FLOODS.

The past week has witnessed the occurrence of the most disastrous floods in the history of the United States. A combination of heavy spring rains and previously swollen rivers was the cause, and there is a regrettably long list of dead as the result. Ohio and Indiana have been the chief sufferers, and Dayton City, of the former State, a city of considerable manufacturing importance, was cut off from communication for days, and in great part entirely submerged by the Miami River. Events are too fresh in the reader's mind and were too fully published in the daily press to need description here, suffice that several tributary streams meet in the Miami River just above the city, and the confluence of their swollen waters, together with a broken dam, appear to have been the cause of the destruction. Throughout the above mentioned States record flood levels have been attained by many of the streams, and the destruction wrought and the number drowned is astonishing.

Such a catastrophe is horrible to consider, and, we believe, unnecessary of occurrence. Every spring we see damaging floods in the United States to the extent of millions of dollars worth of property. Some of that money spent in preventive measures would go a considerably long way towards controlling the floods, and should certainly be used to prevent an outrageous loss of life, such as in the present occurrence. Given the opportunity and money, and engineering ability can collect data and devise means to greatly control floods. If it is beyond finance and practicability to control them, engineers can at least point out the danger zones, and people should be forbidden to reside within them.

The deforesting that has taken place in the flood area is, without doubt, in a great measure responsible for the exceptional flood conditions, and makes it very plain that the United States Government will have to do something to offset the lessening of nature's storage reservoirs.

Canadian flood problems are small in comparison with our neighbors to the south, and, thanks to provision of nature, are likely to remain so. The Great Lakes, acting as storage reservoirs, rapidly drain and make any disastrous floods in the settled portions of Ontario impossible. Further back in the Laurentian Hills, even if deforested, numerous lakes would make storage provisions, with the help of dams, comparatively easy. The prairie provinces having been always comparatively bare of forests are not likely to incur any great increase of the flood heights to which they are accustomed.

Our general topography and lake systems leave us without such gigantic flood problems to struggle with as has the United States in the Mississippi Valley and its tributaries. Nevertheless, there are valuable lessons to be learned from a study of the recent catastrophe in Dayton, and, no doubt, our government will avail itself of the opportunity.

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TELEPHONIC TRAIN CONTROL IN ENGLAND.

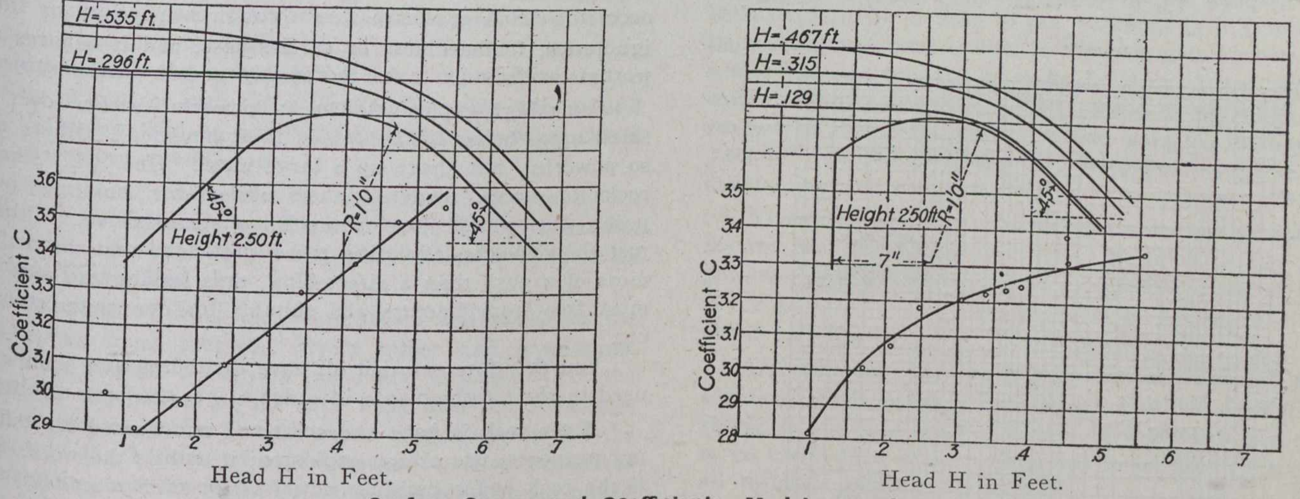
The first train-controlled system by means of the telephone in England has just been installed on one of the railways in Wales. The following description of the system recently appeared in a London journal:—

As the result of the installation of a system of telephones in all signal cabins, junctions, and stations on the line, the whole of the train working can be completely and directly controlled from the head office at Cardiff. The train controller in the general office can, by means of the telephone at the different points, know precisely the movements of all the trains, and is able to divert a train almost at a moment's notice.

It is believed that as a result of the new installation much time will be saved, and consequently that there will be quicker dispatch. It is anticipated that the new service will prove not only useful to the railway company, but also to the large number of collieries which are on the railway system and whose output forms such a large proportion of the traffic. By the telephone system as many as 45 stations may be connected to one pair of trunk wires, any one station of which may be rung up by the train controller without ringing the bell at any other station, and the controller can hear the bell ringing at the station called. On the other hand, if necessary, all of the stations on the system may be rung up at the same moment.

EXPERIMENTS ON FLOW OF WATER OVER MODEL DAMS.

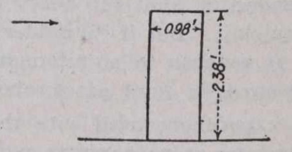
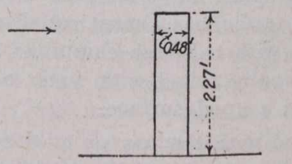
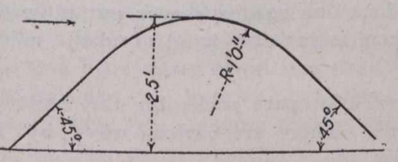
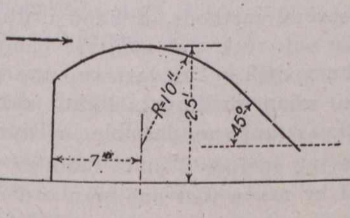
A series of experiments to determine the flow of water, under low heads, over four models of dams was undertaken at the hydraulic laboratory of Purdue University as the graduation thesis of Messrs. Lane and Kemmerer. The investigation was carried out under the general direction of Prof. R. L. Sackett, who reported the results in a paper presented before the Indiana Engineering Society on Jan. 25.



Surface Curves and Coefficients, Models 3 and 4.

The model dams were placed in a concrete channel 100 ft. long, 3 ft. wide, by 35 ft. deep. The length of crest was in each case the width of the channel. Discharges were measured with a Venturi meter; and the elevation of water surface was determined by a hook gauge.

Observed Flow Over Model Dams

Model	Discharge per ft. of crest cu. ft. per sec.	Head	Coefficient C in $Q=CLH^{\frac{3}{2}}$	Exponential Formula	Per cent Difference
	.263 .359 .503 .635 .761 .787 .937 1.090	.211 .264 .331 .385 .435 .447 .497 .548	2.71 2.64 2.64 2.66 2.65 2.63 2.68 2.69	$Q=2.67\,LH^{1.50}$	—1.5 +0.8 +1.0 +0.5 +0.7 +1.4 —0.1 —0.6
	.250 .347 .463 .613 .604 .780 .933 1.130 1.330	.212 .261 .313 .367 .368 .424 .462 .518 .568	2.56 2.60 2.65 2.76 2.71 2.82 2.97 3.03 3.10	$Q=3.42\,LH^{1.71}$	—3.0 —0.6 +1.7 +0.8 +2.6 +1.4 —2.0 —1.6 —2.3
	.0605 .112 .223 .359 .516 .656 .903 1.140 1.400	.074 .114 .177 .238 .297 .341 .415 .474 .539	3.01 2.91 2.98 3.09 3.18 3.30 3.38 3.50 3.54	$Q=3.81\,LH^{1.68}$	—1.4 —1.8 +0.9 +1.5 +1.7 +0.2 +0.2 —1.8 —0.7
	.0839 .207 .293 .388 .538 .634 .711 .785 1.016 1.007 1.390	.096 .168 .209 .246 .305 .339 .364 .388 .448 .452 .557	2.82 3.01 3.07 3.18 3.20 3.22 3.23 3.24 3.38 3.31 3.34	$Q=3.58\,LH^{1.60}$	+0.7 0.0 0.0 —2.1 —0.3 +0.2 +0.1 +0.4 —2.3 —0.1 +1.4

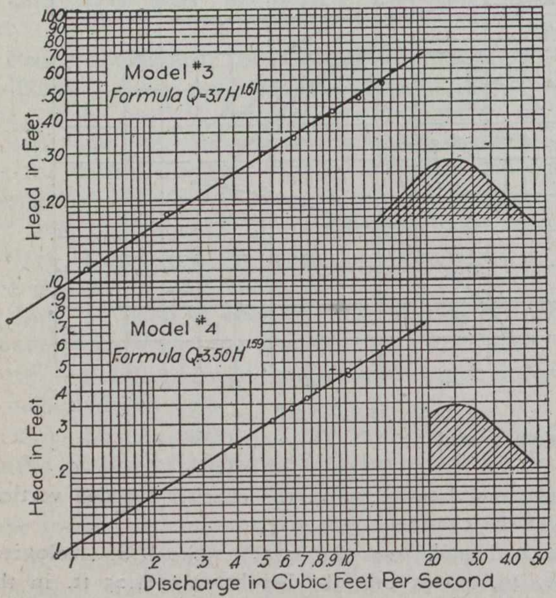
The results obtained by Bazin, the U.S. Geological Survey, as given in Bulletin 200, and by Rafter and Williams in 1899 were compared and models selected which would add to the variety of sections and heads heretofore experimented with.

The first model was a flat crested weir 0.98 ft. wide and 2.38 ft. high. This is about the width of No. 47 of the U.S. Geological Survey experiments and between models No. 2 and No. 113 of Bazin's work. Results were plotted for Bazin's dam, 1,315 ft. wide, the U.S. Geological Survey dam, 0.927 ft. wide and the Purdue model No. 1 with a crest of 0.98 ft. wide. The form of the surface curve also was plotted from data taken on the checker-boarded vertical side-walls of the channel.

The second model was the same as the U.S. Geological Survey No. 40, except that the height was 11.25 ft. in the latter and 2.27 ft. in the Purdue model. The results in both cases were plotted, and it is believed by Prof. Sackett that at low heads the data are of some value. The surface curves were plotted for three heads.

The effect of the partial vacuum formed below models 1 and 2 was very noticeable on the surface curve, but comparative data with and without the vacuum were not taken. The results are with the nappe aerated—a fact which it is necessary to consider when comparisons are made.

Model 3 is similar in section to the hollow, buttressed type of concrete dam and model 4 is the same, with the sloping approach omitted. Model 4 is a small scale reproduction of the Yakima dam, and the surface over which the water rubbed was formed of cement mortar and closely resembled the troweled finish of concrete. It is similar in form to type L, page 73, of Williams and Hazen's Hydraulic Tables.



Discharge Curves, Models 3 and 4.

The coefficients for models 3 and 4 are nearly the same for heads of 0.1 and 0.3 ft., indicating that for such low heads the upstream slope has little effect on the coefficient. As the head increases the curve is a straight line for model 3, and curved for model 4, showing the effect of the sharp corner within the limits of the heads used.

The curves show the observed head on the crest and the coefficient C in the formula, $Q = CLH^{\frac{3}{2}}$.

The table shows also the constants C_1 and n in the formula $Q = C_1LH^n$, where H is the observed head plus the velocity head.

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CONCRETE AND STEEL.

Building regulations of Greater New York require that in reinforced concrete the stresses in the concrete and steel shall not exceed the following limits:—

	Per sq. in.
Extreme fibre stress on concrete in compression	650 lbs.
Concrete in direct compression	500 lbs.
Shearing stress in concrete when all diagonal tension is resisted by steel	150 lbs.
Shearing stress in concrete when diagonal tension is not resisted by steel	40 lbs.
Bond stress between concrete and reinforcing bars	80 lbs.
Tensile stress in steel reinforcement	16,000 lbs.
Tensile stress in cold drawn steel wire used as column hooping	20,000 lbs.

In continuous beams the extreme fibre stress on concrete in compression may be increased 15 per cent. adjacent to supports.

EXPLOSIVES.

By J. K. Moore.*

In nearly all kinds of construction work carried on by engineers, blasting and the use of explosives play a more or less important part. With the arrival of spring and the start of active construction, it would not be out of place to discuss different types of explosives, their most efficient use and details of the proper handling of same. Nearly all accidents occurring from explosives are through negligence or from ignorance, foolhardiness or carelessness, and it behoves all workers with same to be thoroughly posted on the subject.

Some high explosives have a powerful action over a small area, being instantaneous in combustion. Others not so powerful, but shake up a large mass. One will smash rocks to pieces, rendering them useless for building purposes, but suitable for loading for a steam shovel. Others just the opposite, explosion being prolonged and the action more of a push than a direct blow, thus leaving the rock almost free from fracture and suitable for dimension stones, etc.

You therefore see that all have their uses and should be used in their right places in order to get the best results.

If the rock is hard and solid and not wanted for building purposes, use a high explosive; it will do the work. But if the rock is for building purposes, or even macadam, use a milder quality; you will have the better results and get your stones almost free from powder flaws. If the rock is soft or medium, you will find a high explosive is too local, so you must use the third or lower grade of dynamite, 40 per cent., or if the rock is for building purposes you must use a still milder quality, such as black powder.

Mistakes are often made in regard to producing rock for macadam. If the rock is hard and flinty a high explosive breaks it into pieces like spallings, full of flaws, and the additional fracturing, after having been broken by a stone breaking machine, renders it unfit for heavy traffic because it grinds down too quickly. But if a milder explosive is used, the fracturing is reduced to a minimum and the life of the macadam prolonged, in some cases, about four times.

I have seen this experiment tried with the two explosives, put through the same stone napping machine at different points where the traffic was almost equal, rolled in by a steam roller, dressed with half-inch chippings and sand from the same rock and finally rolled with water and well brushed, so as to produce a good surface.

The one produced with the low or mild explosive lasted just three times the one produced by the high explosive or dynamite, and as one road surveyor put it, was almost like machine broken metal and hand broken metal in comparison.

Drilling.—To prepare rocks for the explosives, drilling has to be done. There are various ways by hand, steam, compressed air, etc.

There are several methods of hand drilling, the auger or rotary drill for soft rock and coal, the hammer or jumper drill and the churn drill. The last two are more suitable for our purpose, where drilling is light, and as a rule we keep out of rock as much as possible in laying out a road.

The hammer or jumper drill is familiar to us all and it is maintained by many that one man can drill a hole to a depth of three feet cheaper than three can do, by using the hammer in one hand and turning the drill with the other. When the hole is well entered, a splasher is used on the

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*Road Superintendent, Cariboo and Lillooet Districts, B.C.

drill and water is poured in the hole. The water makes drilling easier, as it keeps the bit of the drill cool and moistens the drillings, which, when dry, cushion the blow, thereby reducing the striking force on the rock. When the drillings get pasty and stick to the drill, more water is used, and so on, until cleaning is required. Cleaning is done with a cleaner, which has a spoon button on one end and an eye on the other. The eye is used to dry out the hole by using cotton, hay or other material. Another way to clean the hole is by using a loose clack or single-hinged valve, circle pump. The clack, or hinged valve, is inside the pump on the bottom end, and as you put it down the drill hole, on coming in contact with the drillings, the valve raises and fills the pump, and as you raise it again, the valve closes and you empty it, and so on.

Up to ten or twelve feet the hammer drill does well, but after that it becomes slow, the drill being heavy to handle, etc., so that it would be better to use a churn from there up to about twenty feet.

Springing.—Having the holes drilled and ready for the charge, we must proceed. Every miner and powderman knows the benefit of having as much as possible of the charge at the bottom of the drill hole, also the advantage of springing the holes several times to make room for the charge at the bottom. The downward force of explosives is surprising and the result for those who practice springing deep holes, or chambering, is marvelous.

Springing of rock is to open up the joints at the bottom more than to make a pot hole so as to get the charge well down. I have seen holes sprung about four times in the following way:

A line of six holes were drilled about twenty feet deep, about ten feet back from the face of the quarry and about twelve feet apart. The rock was igneous, blue whinstone or granite, and about thirty feet deep, so that you will notice the holes were about two-thirds the depth of the rock. The width of the first drill was two and three-quarters and the last about two inches.

If, in drilling, the drill sticks in a joint, steel chips should be used to fill the joint. I have found this excellent in labor saving, as a troublesome hole is a nuisance.

The springing was done with black powder, glazed, because the rock was for making building stones, kerb stones and setts. The holes were sprung separately and about ten pounds used first time in each, with no tamping and fired by battery. This was more to find out how firm the joints were at the bottom. The second charge was about double that amount which opened the joints a little. This was continued until the joints were wide enough to receive the whole charge. One was a little large and was taking more powder than it should, so a little water or oil was used to make the connection good between the charge and the bore hole where the wire fuse was. This is a common custom amongst quarrymen in these building stone quarries where gunpowder is used, but should only be used if you cannot otherwise catch your powder with the fuses.

The total charge was about 350 pounds of gunpowder and the result was first class, nearly 3,000 tons being displaced. If this had been in ordinary excavation, 40 per cent. dynamite would have done to spring the holes, and 60 per cent. dynamite for the main charge.

Chambering.—I have also placed charges in chambers, but they were small, because the amount of work was light. However, there are several ways of running them, in the form of a "T" or a "Y," etc., the main tunnel being straight and the length in accordance with the work to be done. The branches are where the powder is stored. The main thing in loading these chambers is to exclude the air, build the explosive up as closely as you can, and after you have put in your primers (two at least should be used) and wires, the chambers should be built up solid with cement and stone or brick—as explosives will follow up the line of least resistance in nearly every case—then fire as any other shot. The result is fine if everything is well judged, but in rock for macadam or building purposes, unless the mine is small and the output large, it is not so good for the stone, because rock, as you will know, does not work so well after it has been exposed for a time to the weather, as it gets dry and the natural moisture, or life, in the rock gets burned out and a man can not produce as many building stones, nor a machine as much macadam. And, again, if practised near a roadway it is liable to close the road to traffic for some time. Yet, for railroad contractors, mine-owners, etc., it is very satisfactory and cheap.

The difference in explosive properties are—dynamite is instantaneous and powerful over a small area; Judson powder is progressive and not so powerful as dynamite; Black powder is slow and progressive by combustion, but about half the power of Judson powder.

Dynamite and Judson powder can not be exploded the same as Black powder, by a spark, but requires force or shock, like a blow from a sledge, so a detonator or cap has to be used. The same method has to be used for exploding all nitro-glycerine compounds.

Care must be exercised in the selection of detonators or caps. The stronger the caps the better, and the more certain of entire explosion.

Testing Dynamite.—If dynamite is hard and resists yielding to the pressure of the fingers, it is frozen. It should not feel greasy, nor should there be a trace of nitro-glycerine on the wrapping paper.

In order to find out whether dynamite leaks or not, place it on clean paper and leave it in a room to dry in about 60 degrees Fahrenheit and leave it for about eighteen hours. If, on examination, there is any oily discoloration on the paper the dynamite has leaked. The best quality of dynamite should not do this. Fusing and thawing several times tends to leakiness, therefore it should be avoided. Again, on examination, if the dynamite has a whitish crust it is no longer safe, because the whiteness means dampness, and the nitrate of soda has leaked out. If it shows greenish spots, it shows that the nitro-glycerine has started to decay and it is therefore very unsafe.

Dynamite freezes more easily than water. It is the nitroglycerine that freezes at from 42 to 46 degrees Fahrenheit, according to the character of the material in it. When frozen it is hard and can not be loaded very easily into drill holes, nor is it very easily exploded. Yet it has been proved that dynamite can be exploded when frozen, but it takes greater detonation, and some engineers say it has been proven to be more powerful when complete explosion takes place, but it is not advisable to try it and any one doing so is running a great risk.

Thawing Dynamite.—Dynamite must be thawed. In doing so a large proportion of accidents from explosives happen.

The following is a list of what should not be done to ensure safety of powderman and men working with him. Many of the following being done through ignorance, and a list of the same should be copied out and distributed, one to each foreman, and the powderman failing to follow these rules should be instantly dismissed or given other work.

1. Never allow dynamite to be placed in front of a fire to thaw.

2. Never allow dynamite to be placed on a stove or heated metal.

3. Never allow dynamite to be placed on hot stones or gravel, or sand.

4. Never allow dynamite to be placed near glass of any kind in direct sun's rays.

5. Never allow dynamite to be placed in a tin and thawed over a candle.

6. Never allow dynamite to be placed on end round a lamp or candle.

7. Never allow dynamite to be dipped in hot water to thaw it.

8. Never allow dynamite to be carried in men's pockets or breasts to thaw it.

9. Never allow dynamite to be placed in a blacksmith's hearth in the ashes.

10. Never allow dynamite to be placed on a shovel and held over a fire.

11. Never allow dynamite to be placed around or on a boiler.

12. Never allow dynamite to be placed around or on an electric globe.

13. Never allow your men to slit dynamite open with a knife when frozen.

14. Never allow dynamite to be thawed in a can or metal pot surrounded by a water jacket if the water is in any way connected with fire, nor rubbing it in the hands to hasten thawing.

No. 7.—Thawing in water is an exceptionally dangerous form, because the water becomes highly explosive from leakage and has been known to cause serious accidents.

No. 14 has caused many fatal accidents through the dynamite becoming overheated and the nitro-glycerine dropping on the hot metal.

Nos. 1, 3, 5, 6 and 7 are very common ways used for thawing dynamite amongst powdermen in this country, and even if you have been lucky enough not to have had an accident therefrom, that does not reduce the danger any.

There is only one perfectly safe way to thaw dynamite, and that is to put in a warm room at summer heat, covered up and kept as dark as possible, away from the direct sun's rays and allowed to thaw out.

There are two other comparatively safe methods. One is in fresh horse manure in a box built for the purpose, and the other, in a can or metal pot surrounded by a water jacket. In this latter case remember warning No. 14.

The very best way is to never allow it to freeze, if you can do so by placing it in a frost-proof magazine.

Familiarity breeds contempt even for dynamite, by some, and as dynamite can be alight and burn up under certain conditions, adds in a degree, to the careless handling of it.

Primers and Loading.—Warning—In loading dynamite in drill holes, etc., never use anything but wooden or copper rammers, wood is preferable. Never allow anyone to help you who is smoking, and do not smoke yourself. Never let the sticks of dynamite drop heavily down a deep drill hole, nor force it into too small a hole or aperture, nor strike hard when ramming it into place. Caps are set off by a spark from the fuses and they explode the dynamite. Never allow caps to be lying around you while loading, nor carry them in your pocket, as you are apt to drop and explode one. Also, never allow nitro-glycerine to get on the hands, as it is easily absorbed and causes bad headaches.

The best method to loan a hole or place a charge, is, slit the cartridge on two sides, let the contents slip down gently, then take your rammer and press it gently to place. Then take a second cartridge and repeat the above, and so on, until you are ready for the primer.

In making primers, use the best quality of detonators, or caps, and first quality safety fuses. Take the cap and see that there is no sawdust left on it, then take the fuses, cut off the end and see that the powder is exposed and dry, then enter it in the cap and press it up to the fulminate. Be sure this is done because shots often miss-fire through the fuse failing to set off the cap. If the fuse is larger than the cap, scrape it down to fit, only do not open the cap, then press or clamp the upper end of the cap to the fuse, being careful not to disturb the fulminate in the cap. Never clamp the cap on to the fuse with your teeth or fingers, but use nippers or pincers, a tool made for the purpose, which cuts the fuse and clamps the cap to the fuse.

If you are working in wet ground or rock, use lots of grease or soft soap around the joint you have thus made and see that your fuse is waterproof. Double or tape gutta-percha fuse is the safest in water. After the cap and fuse are ready, take a cartridge of dynamite, open one end and make a little hole with a pointed stick, then insert the cap and fuse and gather the end of the cartridge paper around the fuse and tie with a piece of cotton. If in water, grease the joint well, as previously mentioned, then place with the charge, placing one or two more cartridges on top.

Then tamp with fine clay or sand, putting in a little at a time, and at first pressing lightly. Be careful not to check the fuse or draw it away from the charge, and do not use anything but a wooden or copper tamper or rammer.

Use lots of stemming or tamping, always be on the safe side in a final charge, then cut off the part of the coil of fuse not wanted and place it on one side. Be sure you have sufficient fuse to allow everyone to get away. Accidents often happen through neglecting this point, and, after all, one foot of fuse does not cost very much.

Signals for Firing.—After everything is ready, clear away all your remaining explosives and tools to a safe place, and on return, shout "fire" or give other warning. Then when you see that every one has laid his tools safely to one side, give a second warning and split the end of your fuse, and before lighting, see that every one has gone, then light the fuse, give a third and final warning, and take shelter yourself.

Never use water for drinking purposes coming from rock or ground you have recently used dynamite in as it will cause sickness and headache. If several shots have to be set off at one time, use wind-proof fuse matches or a spitter, and, if matches, never allow one man to set off more than two or three shots. If more than that he should have a helper to light them, and remember, a flame will not light a fuse, it must be a spark.

To make a spitter, or touch, take about twelve to fifteen inches of fuse, cut into the powder every one and a half to two inches, then light, provided everything is ready and the warnings sounded, and hold it to each fuse in the shots. It will readily light, but I would not advise more than four or five shots to each man. In the smallest of shots be careful of your fuse and see that you leave sufficient length to give you time to get away. I would not recommend less than twelve or fifteen inches even if the fuse has been tested as to time.

Black Powder.—In charging holes with black powder never use an iron rammer, always use wood or copper. Never allow fire of any kind near the charge, and if loose, always use a zinc or copper can, or flask to carry it in. Use a zinc or copper filler when charging the hole, and if the hole is horizontal, or has an upward tendency and hard to load, use a copper tube made for the purpose. If the angle is too heavy, you may have to make a cartridge containing the amount of explosive required, with a fuse inserted. Upright or vertical holes are rarely used in road work.

(To be continued).

THEORY AND PRACTICE OF STADIA SURVEYING.

By J. A. MacDonald.

The credit of having first introduced this method of surveying into America belongs to Mr. John R. Mayer, a French-Swiss. It was used by him as early as 1850; and subsequently during his connection with the United States Lake Survey, he did much towards perfecting the instrument and improving the methods of work. An essay by him in the Journal Franklin Institute for January, 1865, contains a short historical sketch of the development of topographical surveying and brief discussion of the general principles of stadia measurements.

The many advantages of stadia measurements in surveying need not be dwelt upon, both because attention has been repeatedly called to them, and because they are self-vident to every engineer, so far that all instrument-makers now take especial precaution in fitting the telescopes of all good transits with carefully adjusted stadia hairs This paper will therefore dwell on the theory and practice with a view of encouraging the use of this simple, rapid and wonderfully accurate method of surveying in a larger degree than has been. Tests of correctness of stadia readings with a transit having fixed stadia hairs not properly adjusted to the unit 100, has prompted the following article.

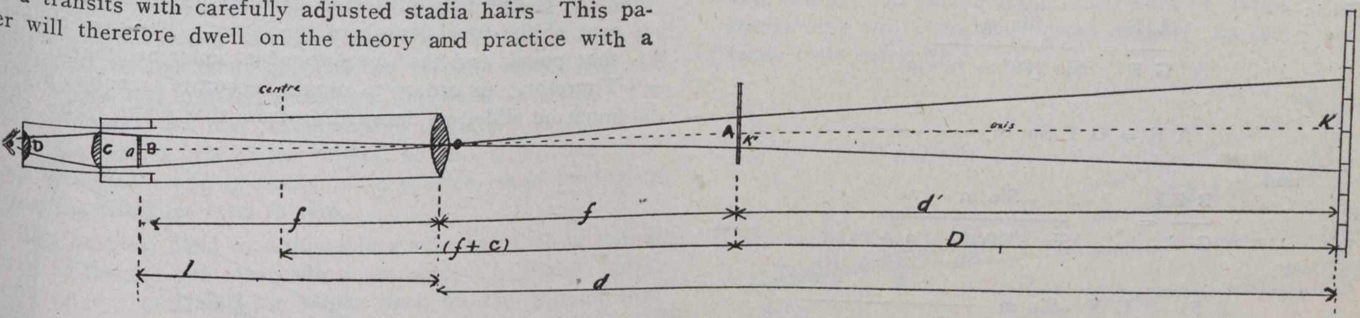

Fig. 1.

The Transit Telescope.—We find that according to the laws of optical science, an image, of any object to which the telescope may be directed, is formed within the tube, and there magnified by an eyeglass or eye pieces composed of several lenses. Any object is rendered visible by every point of it sending forth rays of light in every direction. Those rays of light coming from the object are bent in passing through the object glass. It is the law of light rays to move in a straight line when not obstructed. The best exposition of the relation of light to image is shown by the so-called pin-hole camera. There being no lens, there is no obstruction to the rays of light coming from the object photographed, and passing through the tiny pin-hole of the camera are therefore free from distortion, and are perfectly pictured on the negative, in an invented position, of course. Just as is the image passing through the object glass of a telescope, as the rays of light intercepting one foot on a rod, one hundred feet from the telescope, and passing through the object glass to the cross-hairs, are so nearly parallel, and come so near to each other that they are almost in line of colleinatem scarcely unaffected by the convexity of the object glass. For, by a principle of optics, the rays from any point of an object converge to a focus at such a position that a straight line, called a secondary axis, connecting the point with its image passes through the centre of the lens, and the point of intersection is called the optical centre. From this it follows that lines drawn from the stadia wires, through the centre of the object glass, will intersect the rod at points corresponding to those which the wires cut on the image of the rod (Fig. 1). On these underlying principles are based the law of stadia measurements.

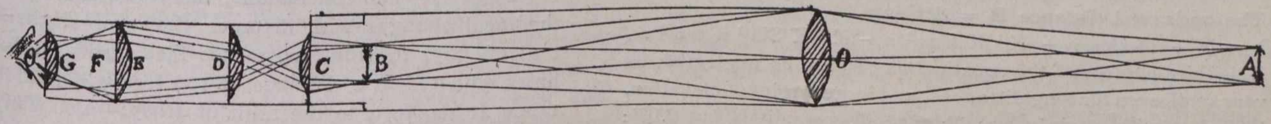

Fig. 2.

Fig. 1 represents a telescope which inserts the object. In the figure the highest and lowest points of the road are intercepted by the stadia wires, are alone considered. The upper and lower rays shown, proceeding from the rod in meeting the object glass, O, form a cone. The longitudinal section appears only in the figure (Fig. 2). It will be seen that these rays, after passing through the object glass, cross one another and thus form, at B, an inverted image of the rod. The rays forming this image continue onward and pass through the two lenses C and D, which act like one magnifying glass, so that the rays, after being reflected by them, enter the eye at such angles as to form there a magnified and inverted image of the rod K. Fig. 2 represents a telescope which shows objects erect. Its eye pieces has four lenses. It will be seen that an inverted image of the arrow A is formed at B, as before, but the rays continuing onward are so refracted in passing through the lens, C, as to again cross, and after further refraction by the lenses D and E to form, at F, an erect image which is magnified by the lens G.

That shown, Fig. 1, which shows the object inverted, is preferred for stadia work. The erecting eye pieces absorb light and lessen the distinctness of vision. A little practice accustoms the observer to seeing his rod man standing on his head, without becoming alarmed, and to motion him to the right when he wishes him to go to the left and vice versa. What makes it difficult to understand the principles of stadia measurements is that the image of the rod, or any object, is not seen at the vertical position of the cross hairs at all; for the image of the cross hairs (and the rod intercepted by them) is optically projected beyond the objective to the extent of the focal length of the latter. The image of the cross hairs, at B, Fig. 1, is optically projected at A. The rays converge at that point, and measurements must naturally be taken from there.

The Reduction of Stadia Notes.—For stadia measurements with inclined sights two methods of procedure are in use. One to hold the rod at right angles to the line of sight, the other to hold it vertical. With the first method it will be seen by referring to Fig. 3 that the distance rod is not to the foot of the rod E, but to a point F' vertically under the point F, cut by the centre wire. A curveline has therefore to be made for this. An objection to this method is the difficulty of holding the rod at the same time in a vertical plane and inclined at an angle proportionate to the angle of elevation of the telescope. The method adopted usually is the oblique view of the rod:

Oblique View of the Rod, Investigated Trignometrically.

FIG. 4 a = distance of stadia wires apart.
f = principal focus of telescope.
$\frac{f}{a} = K^1$ = constant, and generally made equal to 100.
A B = K the reading in the rod.
M F = d the inclined distance $= (f + c) + GF = (f + c) + K^1 CD$.
M P = D, the horizontal distance, d cos. n.
F P = Q = the vertical distance, D tan n.
A G B = 2 m
Vertical angle = n

Then :—

$$\frac{AF}{GF} = \frac{\text{Sin } m}{\text{Sin }\left[90^\circ + (n - m)\right]}$$

or

$$AF = GF \text{ Sin } m \frac{1}{\text{Cos }(n - m)}$$

and

$$\frac{BF}{GF} = \frac{\text{Sin } m}{\text{Sin }\left[90^\circ - (n + m)\right]}$$

or

$$BF = GF \text{ Sin } m \frac{1}{\text{Cos }(n + m)}$$

$$\therefore AF + BF = GF \text{ Sin } m \left(\frac{1}{\text{Cos }(n - m)} + \frac{1}{\text{Cos }(n + m)}\right)$$

$$AF + BF = K, \text{ and } GF = \frac{CD}{2} \frac{1}{\tan m} = \frac{CD \text{ Cos } m}{2 \text{ Sin } m}$$

By substituting, and advancing to common denominator.

$$K = \frac{CD}{2} \frac{\text{Cos } m \left[\text{Cos }(n + m) + \text{Cos }(n - m)\right]}{\text{Cos }(n + m) \text{ Cos }(n - m)}$$

Reducing this :

$$CD = K \frac{\text{Cos}^2 n \text{ Cos}^2 m - \text{Sin}^2 n \text{ Sin}^2 m}{\text{Cos } n \text{ Cos}^2 m}$$

$$\text{as } d = MF = (f + c) + K^1 CD$$

$$\therefore d = (f + c) + K^1 K \frac{\text{Cos}^2 n \text{ Cos}^2 m - \text{Sin}^2 n \text{ Sin}^2 m}{\text{Cos } n \text{ Cos}^2 m}$$

The horizontal distance D = d Cos n.

$$\therefore D = (f + c) \text{ Cos } n + K^1 K \text{ Cos}^2 n - K^2 K \text{ Sin}^2 n \tan^2 m.$$

This third number of the equation may safely be neglected, as it is very small even for long distances, and large angles of elevation. At 1500 feet with angle n equalling 45 degrees, it is but 0.07':

Therefore, $K^1 K \text{ Sin}^2 n \tan^2 m = AB \frac{\text{Sin}^2 n}{\text{Cos } n} \tan^2 m = O$ approximately and the final formula for distances with a stadia rod kept vertical and with wires equidistant from the centre wire, is the following $D = (f + c) \text{ Cos } n + K^1 K \text{ Cos}^2 n$ (1)
and the vertical distance 2 = D tan n.

$$\therefore Q = (f + c) \text{ Sin } n + K^1 K \text{ Cos } n \text{ Sin } n$$

$$= (f + c) \text{ Sin } n + K^1 K \frac{\text{Sin}^2 n}{2} \qquad (2)$$

When $K^1 = \frac{f}{a}$ focal distances, divided by distances apart of stadia hairs, and K = distance interrupted by stadia hairs in the rod.

By the above formula (1) and (2) both the horizontal and vertical distances can be immediately calculated when the reading from a vertical rod, and the angle of elevation of any sights are given. Tables, however, provide this data, saving the tedious calculations.

As regards the addition of the constant (f). Several suppositionary opinions have been advanced on the subject, each of the following having its advocates:—The common apex or point of convergency—principal focus—of the rays of light forming the two similar triangles, is:—The centre of the instrument; the stadia hairs; and the front face of the objective; none of which are really correct. The point towards which the rays of light converge when they emanate from a point at a distance from the lens vary according to that distance.

When the rays proceed from a point so distant that they may be considered parallel rays, they are refracted and converge to a point in the axis of the lens called the focus, or the principal focus, at a certain distance from the lens called the focal length of the lens, this distance depending upon the radii of curvature of the surfaces of the lens. In the figure the reason why the image is formed at distance F in front of the object glass is because the image of the cross-hairs is optically projected beyond the objective to the extent of the focal length of the latter. The rays converge at that point, and the measurement must be taken from it. Therefore, in order to obtain accurate results a constant must be added to the reading from that point. The constant is equal to the focal length of the objective plus the distance from the object to the centre of the instrument; second, when the rod is always held vertical. But owing to this oblique view of the rod, it is evident that the space intercepted by the cross-hairs on the rod varies, not only with the distance, but also with the angle of inclination of the sight. In order, therefore, to obtain the true distance from station to station and its vertical and horizontal components, a connection must be made for this oblique view of the rod.

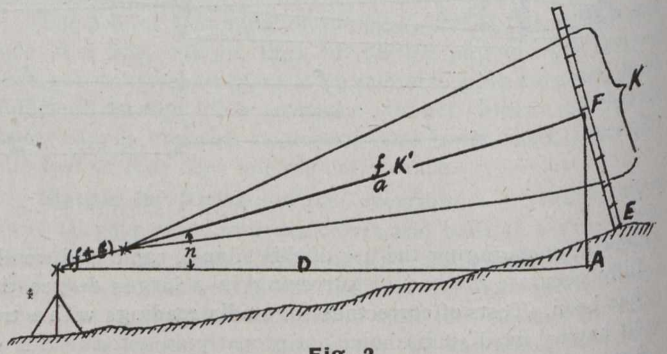

Fig. 3.

Page 17—The conclusions, therefore, are that as through the focal changes with distance (however slight) to the extent of .0052 ft. from 100 to 500 feet sights, it is plain that hairs adjusted at a distance of 100 feet will read correct distance at 500 feet, to the limit of (.0052—a). This would be somewhere like three inches. Not very much of an error, yet a needless one, and an error which may be partially if not wholly overcome by adopting a constant for each particular instrument, and not making the rule apply to an instrument by measuring. Each instrument has an individuality of its own, and must be adjusted by actual trial, and by making these adjustments, that is, adjusting the stadia hairs at a mean distance, not at 100 feet, nor yet 500 feet, but a mean distance between these, say at 300 feet, the difference of focal length is thus reduced one-half, or, for an 11-inch telescope of 30 magnifying power, the change in focal length at from 100 to 300 would be but .0027 ft., so that it will be possible to read all lengths of sights, from 100 to 500 feet to an almost perfect degree of exactness. This is refinement indeed, that, on rough ground, no chain measurement can approach, if on level ground in a series of distances. Once the instrument is thus correctly fitted with fixed hairs, this refinement may be relied on, by always observing carefully and accurately.

General Uses of the Stadia.—For taking topography in country that will not permit a plane table; for coal drop line surveys, preliminary railway locations; for land surveys.

The Transit.—The instrument best suited for stadia surveying is an accurate transit with full vertical circle rigidly attached to the axis of the telescope and graduated to minutes from 0 deg. to 90 deg. in both directions. It should be provided with two double verniers attached to the horizontal vernier arm, the zeros of the two verniers being in a horizontal plane when the instrument is levelled up.

The horizontal limb should read also to minutes, there being no advantage in a reading of 30 sec. as the reduction tables, usually, do not reduce seconds. The graduations should number from 0 deg. to 360 deg. The graduations for the needle should also be numbered from 0 deg. to 360 deg., in opposite direction to the horizontal limb, and not be divided up in quadrants. This is important because in taking topography, for example, on either side of a railway line, the magnetic reading will approximately correspond with the horizontal vernier readings, and the needle only may be read which will greatly accelerate the work in hand. For very accurate work it is recommended to have a level attached to the vernier arm of the vertical circle. It will be found very convenient and probably more precise, than having to bring the telescope level to zero.

As between fixed or adjustable stadia hairs, it is immaterial so long as the rod reading is correct. Fixed hairs, however, are preferred for stadia work on the ground that errors due to variation of the wire interval are avoided, and a better focusing of the eye-piece.

An inverting telescope is to be preferred as it gives a wider field and a more sharply defined image. The eye-piece, known as the "Ramsden" eye-piece, and is termed a positive eye-piece, consisting of two plano-convex lenses, the convex-cut faces of which are turned toward each other. It is called an "inverting" eye-piece, but is not really so, as it is the object glass that inverts the image of the object viewed, and the eye-piece picks up the image in its inverted position. To get an equal clearness of vision with an "erecting" eye-piece as with a Ramsden, or "inverting" eye-piece, a correspondingly larger object glass must be used.

Stadia Rods.—For stadia work a self-reading rod is to be preferred, though for sights of 500 to 1,000 feet a target is necessary. It is quite impossible to read a rod accurately at 1,000 feet that has no target, even with a telescope magnifying 30 to 40 diameters. With a good target rod this distance can be read, in an ordinary atmosphere, quite accurately. But as distances of one to five hundred feet are most common a self-reading rod, divided into units, is best and handiest. As good a stadia rod as any is the "flexible," or tape rods tacked on to a light board twelve feet long. These tapes are made of prepared canvass, are strong and weather proof, and are convenient to carry. They are manufactured by Keufell and Esser, New York. The rod, or board, to which they are tacked should have a hinge in the middle for convenience in carrying. A certain distinct mark, easily seen at a distance, should be made or attached to the rod at the average height of the instrument, in order to get correct elevations. While this "height of instrument," marked on the rod in this way may not correspond to all heights of the instruments, it will, however, be an average height, and these average heights will correct themselves. In case the absolute height of the ground under the instrument, the height of the telescope at each station will have to be measured by the rod, and the difference between this measurement and the average height used in sighting to the rod either added or subtracted as the case may be. The difference will ordinarily be so small, that in a great deal of stadia work no reduction will be necessary.

In sighting to the rod for the angle of depression or elevation, the centre horizontal wire must always be used. A level should be used in the rod surveys, where the value of the land is not too high—say less than $50 an acre. In fact, any place where location and elevation are required at the same time. We would not regard it as accurate enough for city lot surveying, nor convenient where it is necessary to put in stakes at regular intervals of 50 or 100 feet.

We would hesitate to use stadia in a lost boundary suit, or in any place where it would be necessary to convince a jury that the work was accurate, although we feel that more accurate work can be done in rough country with stadia than with tape line providing care is used. Owing to the great chances of error we never feel satisfied with a line until it is checked by another line having a common beginning and ending. In taking topography over a large area the transit line will necessarily cross or join, so this checking takes little extra time.

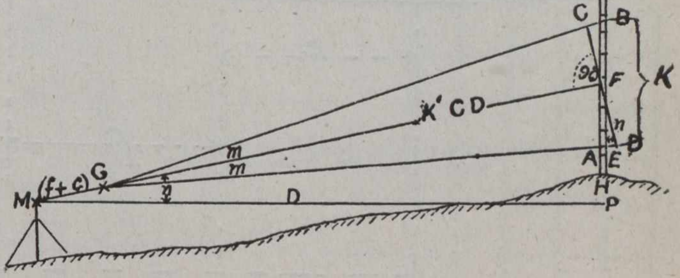

Fig. 4.

Fairchild and Gilchrist of Philadelphia, wrote the writer: "We find that errors balance; lines 10 miles long may check for elevation within a foot at the ends; and cross lines between be out as much as five feet. In the horizontal plane these errors generally do not vary so much. We consider a horizontal tie of lines between 2 and 20 miles long of 5 feet out, good; 10 feet, fair; 15 feet, questionable; and 20 feet, bad. This in a fair country. We should avoid steep sights rather than long sights, and try to get sights of average length on main transit lines. But if one can avoid a steep sight by taking a short fore-sight and long back-sight, or vice-versa, do so.

"Lengths of sights depend upon the atmosphere and the glass in the transit. Under fair conditions sights of 500 feet is good; 400 feet is a little better; 600 feet at pinch on main line; on side shots, 1,200 feet long is not uncommon.

"We add (f+c) to each rod reading, and then reduce for horizontal and vertical. The error in this is so slight that it can be disregarded. (f+c) is variable with each transit. It is important that transit be accurately adjusted, particularly plate bubbles. Only one sight is necessary. A level—a small round bubble level—is easily attached to the rod, and the rodman keeps the rod plumb by watching one bubble. Slide rods should be avoided, and a target, except for long sights, is unnecessary."

Preliminary Railway Surveys by the Stadia Method.—In making preliminary location surveys for roads or railroads, the stadia method enables the surveying party to go over the field much more rapidly, and in most cases is a cheaper method for that reason than using a level. Locating engineers, however, seem to have a decided preference for using a level for this work, chiefly because of the more accurate data obtained. It would seem to be useless refinement to go over the ground with a level taking precise but tedious readings at every station, when these levels are usually only furnishing rough data to the engineer from which the final location can be determined. In a level country or on gently undulating ground, the final location can often be determined with no preliminary observations, and the levels for grade fixed from one survey, but usually all the work of the preliminary survey must be done over once, and often many times, before the line is finally located. The stadia method is a simple and rapid way of obtaining all the necessary data with sufficient accuracy for the purpose intended since both the topography and the bearing of the tangent can be found with one setting of the instrument.

It would seem that instead of having to make two or more preliminary surveys of a railway line, that one fairly careful reconnaisance be made over the ground in the first instance, taking the data of all elevations and depressions on either side to the distance of 500 to 1,000 feet, that the preliminary line that would follow would approximately be a location line, thus saving one or more preliminaries.

In adopting the stadia method we make a compromise between reconnaisance and preliminary, and this is perhaps what is needed. Our usual reconnaisances are too limited in data, trusting to what may be obtained with hand level, compass and aneroid, while our preliminaries are necessarily of too great refinement. The stadia, then, offers a solution—a compromise between reconnaisance and preliminary, in which in a good country no preliminary may be needed but the final location made from the stadia, while in rough country a preliminary will be needed, and one approaching in refinement, a regular location.

The stations in a stadia survey need not be placed exactly one chain apart, but can be taken 200 ft., 500 ft., or even 1,000 ft. apart if the ground is level. After setting up the instrument at a station, and getting a back-sight, the telescope can be circled round in azimuth and all the topography taken on either side of the line. The rodman can be signalled to place his rod where wanted and the angles of all hills and valleys within 1,000 feet be obtained. In long sights, three observations (in rough country) on either side of the line are needed, one between 0 deg. and 90 deg., one at or about 90 deg. from the tangent, and one between 90 deg. and the fore-sight. The elevation and distance of the next station should then be taken, and finally three more observations recorded for the topography on the right of the line, one between 180 deg. and 270 deg., one at 270 deg., and one between 270 deg. and 360 deg. The deflection angle, if any, must also be read on the horizontal vernier, while the side shots need only be read by the needle, this saving a lot of time. Progressing rapidly in this way the topography of the country through which the road is to pass can be plotted with reasonable accuracy. Ordinarily a couple of side shots will be sufficient. The rodman should carry small pegs or hubs to drive at the stadia stations, and on the points taken on the tangent or main line. The axman drives stakes beside the hubs in the same way as on railway hubs.

Reducing Stadia Readings.—When working in the field with a stadia, a stadia rule, as Colby's, or a cheaper one, Keufel and Esser's, or, perhaps, what is better, graphic diagrams, should be carried for making the corrections for differences of elevation, or ½ Sin. 2θ (of observed angle), and, also, corrections for distance, Cos.^{2} θ. The constant of the instrument (f+c), may or may not be reduced to sine and cosine for small angles. The stadia rules are more convenient to handle than tables, and the graphic diagram, if made accurately, are even easier read. Any good draughtsman can easily prepare a diagram for Cos.^{2} θ, and Sin. 2 θ, from which corrections can be read direct for any observed angles and distances.

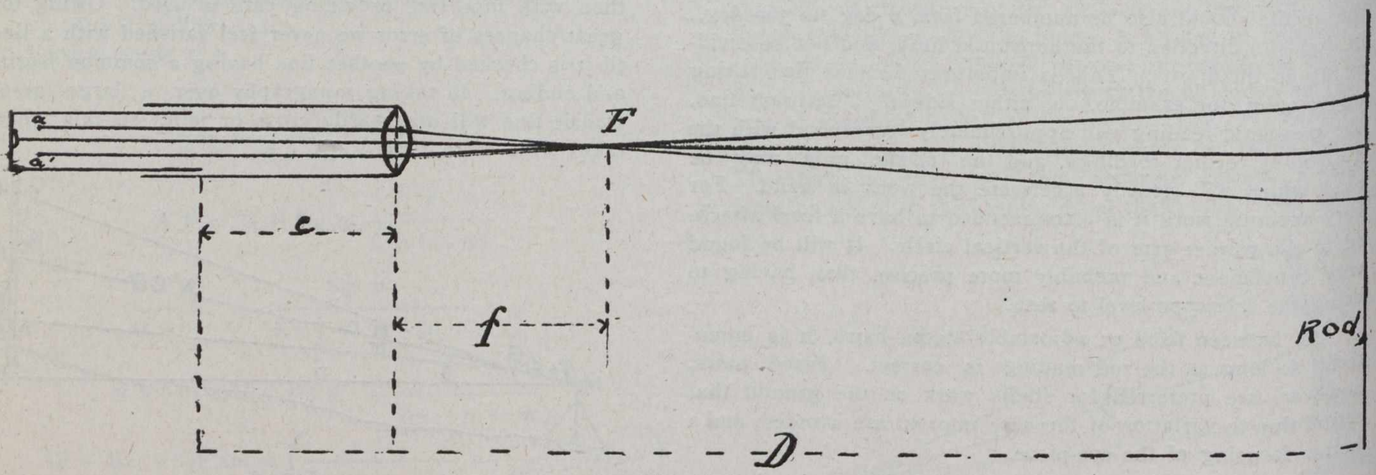

Fig. 5.

Keeping the Notes.—The most difficult part of a stadia survey is keeping notes in handy form. Books can be obtained which are ruled especially for stadia work.

Both the left hand and right hand pages are used and little room is left for the sketch on the ordinary size field books. Since the stadia reading must be corrected for differences of elevation it is perhaps better to enter the observed vertical angles and leisurely reduce with tables. The distance, however, should be reduced on the spot so as to mark on the stakes.

CONTRACTORS' WORKS IN CANADA.

Sir W. G. Armstrong, Whitworth, and Company, Messrs. Swan, Hunter and Wigham Richardson, and Messrs. Cammell, Laird and Company are negotiating for suitable sites for shipyards in Canada. Messrs. William Harkess and Sons, of Middlesborough. intend to open an establishment at Halifax, N.S., while Messrs. Denny, of Dumbarton, Messrs. John Brown and Company, the Fairfield Company, and Vickers, Limited, Barrow, are busy laying down plant at various places in the Dominion. The last-named firm also propose to build vessels at Sault Ste. Marie, an important point on the Great Lakes. So far, no decision has been arrived at by the Borden administration in regard to the request made by Canadian shipbuilders for further state assistance, but it is expected that the import duty on materials will be removed.—From Contractors' Chronicle.

EXHAUST STEAM AND ITS UTILIZATION.

By J. M. Gordon.

In the last issue of *The Canadian Engineer* we dealt with the utilization of exhaust steam in a paper by the above author which space did not permit us to publish in full. The latter portion of his paper, which deals more particularly with condensers and turbines, we take pleasure in publishing herewith.

The advent of the steam turbine has greatly influenced the design of the condenser, for in previous days any condenser giving a vacuum of 25 inches was considered all that was necessary; but nowadays the demand for high vacua has resulted in a condenser of far greater efficiency. In the use of condensers in mining plants a main difficulty is that the cooling almost invariably employed is derived from the mines. Such water is rarely below 56° F. This necessitates a large volume of water passing through the condenser; in fact, as much as can be economically allowed. Consequently, if the quantity of water is a factor of consideration, it will be essential to erect cooling towers or sprays, with settling reservoirs, as the temperature of the outlet water has such a bearing on the vacuum; in fact, some British engineers prefer expressing the vacuum from condensers by temperature, rather than by inches of mercury. Referring to Fig. 3, it will be found that each inch from 25 inches to 27 inches is equivalent to 4 per cent. consumption by the turbine; that between 27 inches and 28 inches, about 5 per cent., and from 28 inches to 29 inches, from 6 to 7 per cent.; or that approximately 3° F. difference in the temperature of the exhaust means about an increase or decrease of 1 per cent. in the consumption. This will demonstrate the importance of having the temperature of the outlet water as near as possible equal to the temperature due to the vacuum. The difference in a good modern condenser should not exceed 5° to 6° F. when condensing 12 pounds per square foot per hour. Another method of considering the efficiency of a condenser is by expressing it in B.T.U.'s transmitted per square foot of cooling surface per hour for 1° F. difference of temperature. In well-constructed surface condensers, such as Parsons, it can be as high as 1,200 B.T.U.

In the surface condenser the resistance to the heat absorbed from the steam by the water may be considered in three stages. In the first stage we have the transmission of the heat from the steam to the tubes of the condenser. This transmission is governed by the efficiency of the air-pump and by the quantity of air in the condenser. These factors can be greatly reduced by dry air-pumps or by the more recent method of the application of the Parson vacuum augmentor, which withdraws the air completely from the condenser. Air in a condenser is detrimental, since it not only vitiates the vacuum, but it also blankets the tubes and retards the transmission of heat. The second resistance is small, and hardly worthy of consideration. It is due to the metal of the tube. The third and last, but not least, resistance, is the final transmission of heat from the tube to the water. Should there be a crust of slime or carbonate on the tube the conductivity of heat drops considerably, and the efficiency drops. It is essential to keep the water in a violent state of excitement in order to prevent it having a clothing of temperatures. In recent years the application of Parson's augmentor has greatly improved the condenser. The augmentor is simply a set of steam pipes which sucks the vapor and air from the main condenser and delivers it through a small auxiliary condenser to the air pump. In practice this augmentor has been known to bring the conductivity from about 250 or 300 to between 800 and 1,000, or reduce the temperature from 26° F. to 5° F., a gain in temperature of approximately 21° F., or 7 per cent. in the total steam consumption of the turbine. This steam jet consumes 0.6 per cent. only of the amount of steam consumed by the main prime mover. In Scotland Körting Bros.' ejector condenser has been used in connection with mixed pressure turbines, and has proved eminently successful.

Discussing now the main prime mover, the turbine itself, we have a machine possessing many peculiarities and differing vastly from the old reciprocating engine. One of the chief differences is the mode of lubrication. In most types of mixed pressure turbines the bedplate is the recepticle for holding the oil, out of which it is pumped through the bearings, and thence through an oil-cooler, and again back into the bedplate. Thus the oil is used over and over again. These turbines are usually governed by centrifugal governors directly coupled to the shaft and in direct communication with the tachometer, working a trip gear, which in turn opens and closes the high-pressure nozzles according to the weight of load and supply of exhaust steam.

There are quite a number of mixed pressure turbines on the market; in fact, all compound steam turbines are adaptable for exhaust and mixed pressure use. The single stage, or De Laval turbine, is not adaptable, as the efficiency is regulated by the speed, the higher the speed the higher the efficiency of the machine, and it has been found that units of from 200 to 300 kw. is about the highest economically obtainable. These sizes run with a periferal speed of about 1,200 per second, which is about the limiting velocity, for above this, centrifugal forces become too great. Another disadvantage is that the periferal speed being so high the turbo-generator cannot be directly connected to the machine, but has to be geared down.

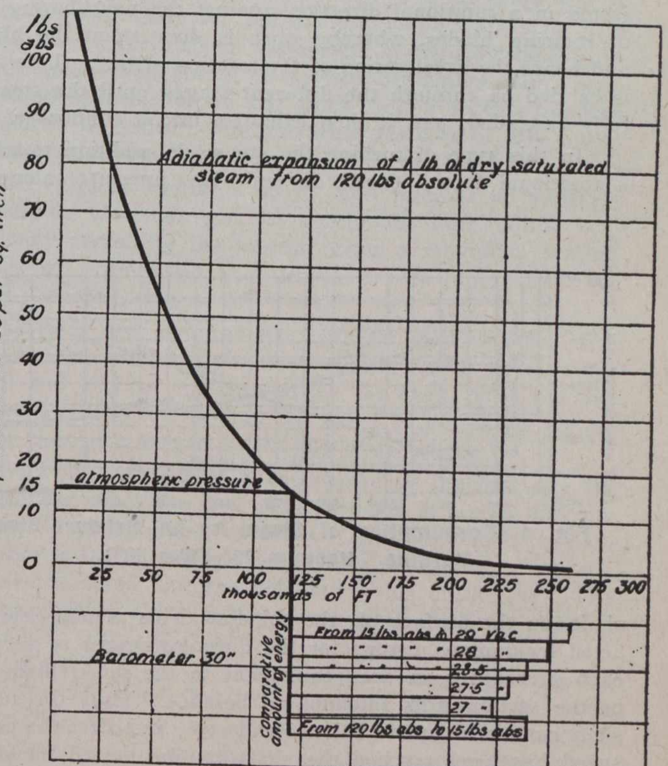

Fig. 3.

The compound-stage turbine, as already mentioned, is divided into two sub-classes, namely, the reaction and a combination of impulse and reaction. In the first sub-class we have Parsons, while in the second we have the Rateau, Zoelly, Curtis, Bergman, Riedler, Stumpf, Sulzer and Echer-Wyss. The first sub-class being the first type to be constructed had to contend with the fierce cutting action of superheated high-pressure steam on the blades; and to reduce this action as far as possible, the expansion is divided into a number of stages, thus reducing the velocity of the steam, while also reducing the high periferal speed and revolutions. Mean-while metals or alloys have been discovered to withstand this high eroding properties of superheated steam jets at great velocities; and there is now in the market a combination of the impulse and reaction turbine with very few stages.

Without discussing the details of the respective types, a short resumé of the better known turbines will not be out of place.

The Parson turbine consists of a long cylindrical drum, increasing in diameter by stages from the high to the low-pressure end. This drum is mounted on a shaft revolving in two pedestal bearings, and the whole is enclosed in a cast-iron casing. On the perifery of the rotor are placed alternate rows of fixed and rotating blades or vanes. These blades are fixed in dovetail grooves with distance pieces placed between them and cranked into position. The increase in size of the blade in the low-pressure end requires it to be stiffened by shrouding. The fixed blades project inwardly, while the revolving blades project outwardly. The steam enters in the bottom of the high-pressure end of the cylinder, leaving the top clear of steam pipes, thus much facilitates dismantling. The steam first passes through a ring of fixed or guide blades, and in so doing the pressure falls and proportionately the velocity of the steam rises, and is then projected in a rotational direction against the neighboring ring of rotating blades, whereby work is done upon the blades, and hence the acceleration of the rotation of the turbine. This is carried on through the different stages until the steam is fully expanded, and it then exhausts into a condenser.

In this type of turbine the steam, in addition to giving a rotational force, exerts an end-wise pressure along the shaft, on the surface of the blades. This is now counteracted by dummy pistons for the different stages or sections, each presenting an area equivalent to the mean blade area of the section it is intended to balance. Thus the turbine shaft runs in complete balance endways, and after the critical speed has been reached the shaft can be moved backwards and forwards with a lever with comparative ease. A claw type of flexible coupling is usually used for connecting the turbine with the generator to allow for any slight difference in alignment. A thrust block is placed at the steam end of the turbine shaft to give the proper clearances and adjustments between the fixed and moving blades. In the small sizes of Parsons turbine the shaft is usually made from a solid steel forging, but in the larger sizes hollow steel drums, which are machined both outside and inside, are fitted together and carefully shrunk and pinned. The lubrication of the bearings, thrust-block and governor gear is automatically performed by a rotary pump driven from the worm-wheel of the centrifugal governor; and, as it is placed low down, it is continually flooded; hence it is almost impossible that it would fail to perform its function. The main bearings are made of gun-metal. The bushing is held in position by a loose-fitting dowel, and is surrounded by three concentric tubes, the annular spaces being filled with oil in order to damp vibrations; this causes the bearing to be practically self-centring.

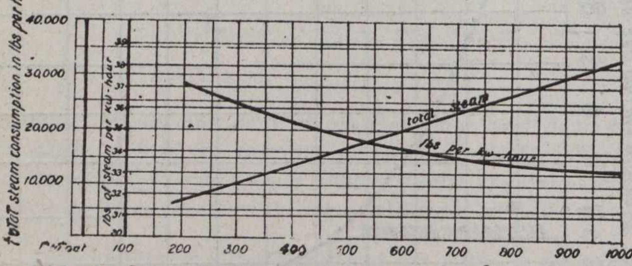

Fig. 4—Consumption of Steam by an Exhaust Steam Turbine. Vacuum 28″ (Bar 30″).

The Sulzer turbine consists of a partially injected impulse turbine for the high-pressure stage, and of a fully injected reation turbine for the low-pressure stage. The blades of the impulse wheels are made of a high-grade nickel steel, while the reaction blades are made of a special bronze. Unlike other turbines, this type does not make an oil well of its bed-plate, but has a special vessel usually kept in the basement of a power-house. This is a precautionary measure against the possibility of grains of sand finding their way into the oil. In order to obtain oil when the turbine is at rest a small steam auxiliary oil pump is provided, which is usually attached to the bed-plate. A device is provided in the turbine to make it impossible to start the turbine before the complete oil system (governor, bearings and balancing disc) is under pressure. In this type of turbine, in sizes up to 1,500 horse-power, an ordinary collar bearing is used to take up the axial thrust, but in the larger sizes a small oil-pressure balancing disc is used which is attached outside of the high-pressure bearing, and is keyed on the shaft.

The Curtis turbine, like the Parsons, is made by more than one firm in different countries. In Germany, a very excellent type of the Curtis mixed-pressure turbine is made by the Allgemaine Elektricitats-Gesellschaft, while in Great Britain the British Thomson-Houston make a unique high-pressure Curtis turbine with the generator directly above the power producer, the low and mixed-pressure type being of the horizontal construction.

In this type of mixed-pressure turbine the expansion is performed in two stages. The first expansion takes place in a row of nozzles, which brings the steam down to approximately atmospheric pressure, and its energy is then taken up by the turbine wheel, usually comprising two rows of buckets with two velocity stages. From this point the steam is exhausted into a chamber and there passes through a second series of nozzles into the low-pressure end. This second series of nozzles is divided into two sets, one set conducting the exhaust steam from the high-pressure stages, and the other set conducting the exhaust steam from the accumulator. These sets are so constructed that the exhaust steam in the accumulator gets the preference, and it is only when the load becomes too great, or the exhaust steam fails, that the turbine slows down, or rather the tendency to do so causes the governor to open the high-pressure nozzles to the amount of the deficiency; and, as soon as the exhaust steam from the generator can take the whole load, the governor once more closes the high-pressure nozzles. The governor is usually set for a speed regulation of 2 per cent. between full and no load, with a maximum monetary variation of 4 per cent. for the purpose of synchronizing and making the turbine bear a proportional share of a peak or sudden extra load. An emergency governor is also fitted to this turbine, so that at any time, should the main working governor fail, and the turbine increase to 15 per cent. above the normal speed, a trip-gear would act and cause the throttling of the valve in the main steam pipe until such a time as the normal speed was again reached.

These low-pressure and mixed-pressure steam turbines are usually directly coupled to a three-phase alternating generator. Three-phase alternating current is almost universally adopted because of the economies in the transmission lines, while also three-phase induction motors are admirably adaptable for pumping work and haulage. The great disadvantage the system once had was the sudden drop of voltage on the main alternator, when a fluctuating or a peaky load was encountered, such as occasioned by one or two haulage motors commencing operation on or about the same time. This difficulty has been overcome by automatically varying the resistances in the exciter field through solenoids actuating moving contacts.

Low-pressure turbines have also been applied to rotary air compressors, and are found economical when the demand on a reciprocating air compressor exceeds the supply. By so utilizing the exhaust steam of the reciprocating set the rotary set will supply air at 30 pounds absolute to the main compressor, and thus almost double the output of the main set with no more steam than was used previously.

The capital or initial costs of a high-pressure set and a mixed-pressure set are compared in the following table. The operating expenses for a twelvemonth at an average deep colliery where exhaust steam is plentiful are also computed. As the plant under construction is of two units, each of 1,000 horse-power, the reciprocating engine is not considered:—

Capital Costs.

Plant 2, 750 Kw. Sets.	H.P.	M.P.
Power-house and crane	$ 8,250	$ 8,250
(2) 750 kw. turbo-generators, complete	50,400	60,000
Complete installation of two condensing sets	15,000	23,000
One cooling plant	4,000	6,500
Battery of boilers with essentials.....	30,000	....
One regenerator	....	8,000
	$107,650	$105,750

Annual Cost Sheet.

Plant instld. 2,750 kw. sets. H.P. Condenser 26 kw..... M.P. Condenser 50 kw.....	High Pressure	Mixed Pressure	High Pressure $	Mixed Pres. $
Day Shift per Annum 288 Working days of 8 hours = 2304 hours at 600 kw. per hr. = 1,382,400 + condenser = 1,442,300 1,497,600	1,442,300	1,497,600		
Afternoon Shift (Same as Day)	1,442,300	1,497,600		
Night Shift 288 working days at 8 hrs... 2304 hours at 250 kw....... =576,000 + condenser....	635,900	691,200		
Grand Total of Units	3,520,500	3,686,400		
Ditto, of Useful Units	3,340,800	3,340,800		
	Heat Pres.	Mixed Pres.	Heat Pres.	Mixed Pres.
Coal consumption per annum in metric tons at the rate of 3.4 lbs. of coal per kw. hr. when mixed pressure turbine runs on 6-hr. live steam on the night shift..................	Tons 5,670	Tons 730		
Cost:				
Price of coal at $4.00 per ton			$22,680	2,920
Int. at 5% on capital outlay			5,380	5,280
Depreciation at 10%......			10,576	10,575
Boilerhouse attendance.....			2,500	600
Enginehouse attendance....			3,000	3,000
Oil waste and stores......			300	300
Total Cost per Annum			$44,625	22,675
Cost per Useful Unit			1.33 cts.	0.68 cts.

Advantage for Mixed Pressure Turbine, .65 Cents per Useful Unit.

In conclusion, an interesting instance in support of the foregoing argument may be here cited. In the power station of the Edinburgh Corporation, Scotland, were eight Willin & Beliss engines, each of 1,200 horse-power, designed to operate with a 25-inch vacuum; but because of a lack of water these engines were not operated non-condensing. Mr. P. S. Mitchell, of Glasgow, Scotland, collected the exhaust steam from four of the engines and installed two Rateau low-pressure turbines with a Brown Boveri, D.C. combination at 490 to 500 volts. Each of these turbines is capable of developing 1,250 kw. when supplied with 45,600 pounds of exhaust steam per hour. Two of the reciprocating engines have a total output of 1,550 kw. Consequently the output has been increased no less than 80 per cent. by the utilization of what was formerly waste steam. The condensers installed were the contra-flow condensers made by Richardson & Westgarth, and it is interesting to note that this Scottish engineer had the boldness to use the sewage water of the city of Edinburgh for circulating purposes.

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OPERATION OF TRAILERS IN CONNECTION WITH PEAK LOAD CITY SERVICE.

A description of the operation of trail cars in Cleveland is given by Mr. G. L. Radcliffe, general manager of the Cleveland Railway, in a recent number of the Electric Railway Journal. The article deals principally with the changes made in equipment since the trail car was last in general use.

With adequate motors and improved tracks, its operation is no longer hazardous; its application to traffic problems is definite and easy. No more a makeshift, but specially designed to meet certain conditions, it is in every way a worthy running mate for the modern motor car. The first modern trailer operated on the system of the Cleveland Railway Company was placed in service September 16th, 1912. One hundred are now on our lines, and a second hundred will shortly be added. The operating features of this equipment necessitates a brief description of the car itself.

The extreme length is 49 ft., and there is no platform or vestibule at either end. A continuous longitudinal seat completely encircling the interior gives a maximum seating capacity of seventy-two and leaves a very large area for standing passengers.

The cars are mounted on Brill No. 67-F trucks, with 22-in. wheels, bringing the floor of the trailer close to the ground and making entrance to the car easy. It is but one step from the ground into the car—15 in.—and a second step of the same height to the car floor proper.

There are two doors in the centre of the car, one for entrance, the other for exit. The fare-box is placed opposite the post which separates the doors. The conductor's position at the box is facing the rear, so that an aisle is open between the fare-box stand and the devil-strip side of the car. The stand supporting the fare-box has a small shelf for change, on which is mounted a set of push buttons to govern the doors. Each door is opened and closed by compressed air electrically controlled by the conductor through the push buttons. The opening and closing of the doors flashes signals to the motorman by an electric contact, which should make trailer operation much safer than when he is entirely dependent on the signal bell.

The trailer is pulled by a 38-ft. motor car, equipped with four 40-h.p. motors of the Westinghouse 307-F type. The train is equipped with Westinghouse semi-automatic brakes and is coupled with the Tomlinson automatic air coupler. The couplers, while not yet entirely perfect, are a great improvement over the couplers in general use on the old-type train. Cars equipped with the modern automatic air coupler can be coupled much more quickly and with much less danger to the employee than formerly, while the application of air brakes to both cars reduces very largely the danger of accidents through the heavier equipment. These two features, we believe, with the electric signal device, give the requisite safety both to employees and the public.

When these trailers were first put in operation it was decided that we should use them only during the rush hour, morning and evening, and that trains would be left coupled so that it would not be necessary to switch, couple and uncouple them several times each day. This method of operation is still pursued, and at present the motor cars are laid up during the greater part of the twenty-four hours. Upon the arrival of the next hundred trailers, however, it will be necessary for us to uncouple the trains in order to have the use of the motors during the day.

The first, and probably the greatest, advantage in operating trailers is in the cost of equipment. It will readily be seen that the elimination of motors and other electrical equipment from the car greatly reduces the cost of the equipment necessary to move rush-hour traffic, and the investment in idle equipment is smaller in proportion.

A second advantage is the carrying capacity of the trailer. In our case it is about twice that of the motor car. Seating seventy-two, while the motor seats but thirty-eight, the arrangement of seats noted earlier in this paper gives the trailer a standing area even larger in proportion than the similar area in the motor car. Thus, while the seating capacity of one of our trains is 110 passengers, we have carried over 350 passengers on a rush-hour trip, and it is not unusual to find 200 passengers on one trailer.

Another advantage is the reduction in operating costs made possible. The heavy extra loads just mentioned require the addition of only one man to a crew to handle, the trailer being in charge of one conductor and the train manned by the regular crew.

All the cars on the system of the Cleveland Railway are equipped with fare-boxes, and most of them are operated on the pay-enter plan. When the trailers were adopted it was intended to operate them also as pay-enter cars, but on account of the single-entrance and no-platform features it was found that loading took too much time and the method was changed so as to utilize the rear half of the trail car as a loading platform. Passengers boarding the trailer pay their fare as they go past the fare-box to the front end of the car, or if they go to the rear of the car, they do not pay their fare until leaving the car. In this manner about half of each load pays fare on the pay-enter plan and the other half on the pay-leave plan. This method has proved very satisfactory, and little confusion resulted from the change in method, even when first put into effect.

We did experience a great deal of trouble for a time on account of the slowness of trains in getting over the line when mixed with single cars. It developed, however, that the slowness of operation was due rather to the inexperience of the platform men than to the number of passengers carried on the trains, and, after six months' operation, we find that the amount of time necessary to operate a train over a given line is but little more than the amount required for a single car on the same line. The difference is so small in comparison to the amount of money saved in equipment and in the number of trainmen worked as to be negligible. In making up our schedules we arrange all runs so that both motormen and conductors can act as conductors on trailers during the rush hours. This, of course, requires fewer men to operate our schedules with any given number of cars than would be required if each car must be operated by two men. We find, also, that our runs can be arranged to better advantage by this method.

The train signal system between conductors and motormen is giving us some little trouble, trains being delayed for signals and slow in getting away from stops. Under our rules, even though a motorman receives his bell signal from the conductor, he should not start his car until he receives the signal light in the vestibule, indicating that all doors on the train are closed. Our present equipment being overtaxed in the rush hours, it often happens that passengers, attempting to crowd their way into cars already filled, stand in the doorways and prevent doors from closing. The conductor, busy at the fare-box, is unable to get to the door to get the passengers off the step. So it has been necessary to station inspectors at some points to clear the steps so that doors may be closed and the train properly started. We believe that this trouble would entirely disappear if we were operating sufficient cars to take care of the traffic and to prevent passengers from gathering in such large numbers.

The distribution of equipment, ever important, is especially vital to the success of trailer operation. We have not yet been able to work this out to the best advantage because of the mixing of single cars with trains, already referred to, but are hopeful that with the second hundred trailers a better adjustment can be made.

Little trouble has been given us at switches on account of operating trailers. Some motormen in their endeavor to keep their trains on time accelerate their motors too quickly when passing over switches, not waiting until the rear truck of the trailer has cleared the switch before they attain the maximum speed of their motors.

The operation of trailers in connection with peak-load city service depends entirely upon the peculiar local condition of the particular city service to which the trailer is to be adapted, and I have thought best to give you merely our experience without attempting the broad application of that experience. But I would say this much—as a personal opinion—I feel that the trail car is suitable only for peak loads, and they must be real peaks. A four-minute headway is the minimum which I consider warrants trailer operation.

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AMERICAN SOCIETY OF CIVIL ENGINEERS' CONVENTION AT OTTAWA.

Preliminary arrangements have been made for the forty-fifth annual convention of the American Society of Civil Engineers at Ottawa, Ont., June 17th to 20th, 1913. Charles H. Rust, city engineer of Victoria, B.C., is chairman of the Committee of Arrangements of the Board of Direction. Charles Warren Hunt, secretary of the American Society of Civil Engineers, and Henry W. Hodge are the other members of this committee.

The following are members of the local committee:—

Charles H. Keefer, chairman; S. J. Chapleau, C. R. F. Coutlee, A. A. Dufresne, G. H. Duggan, Sir Sandford Fleming, H. Holgate, J. A. Jamieson, Phelps Johnson, T. C. Keefer, C. H. Mitchell, W. F. Tye, G. W. Volckman.

Most of the members who expect to attend the convention will be in Ottawa by Tuesday morning, June 17th, and in the afternoon will be tendered a reception by the Ottawa city officials. In the evening there will be an informal reception, with dancing, so that members of the party can become acquainted. At ten o'clock Wednesday morning, June 18th, the president will deliver the annual address, at the termination of which the business meeting will convene.

The local committee is arranging for various meetings and excursions. It is expected that there will be two evening lantern slide lectures, descriptive of engineering work in Canada; several excursions to points of local interest; a garden party; golfing at the Royal Ottawa Golf Club links, etc. A reception will be tendered by the Canadian Society of Civil Engineers to the visiting members of the American Society.

The entire programme is subject to change, excepting the time for the president's address and the business meeting. The headquarters of the convention will be the Chateau Laurier.

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The expenditure on the harbor and railways in the South African Union for the ensuing year is estimated at £13,774,550, which is an increase of nearly £300,000 on the previous year. This is exclusive of capital expenditure in respect of the construction of new railways.

COAST TO COAST.

Ottawa, Ont.—Hon. J. D. Hazen has given notice of a government bill providing for a federal loan of $3,500,000 to the Quebec Harbor Commission to enable the commission to construct such terminal facilities as are necessary to properly equip the port of Quebec. The money is to be advanced from time to time as needed. The bill contains provisions similar to those in the act passed some years ago in regard to the Montreal Harbor Commission.

Vancouver, B.C.—At Nanaimo on March 4, at the opening session of the western branch of the Canadian Mining Institute the secretary drew attention to the better position British Columbia had reached in regard to loss of life in its coal mines. For the ten-year period, 1903-1912, the death rate was 5.08 killed per thousand employed, while for the five-year period, 1908-12, it will be found to have been 4.34 per thousand employed. Credit should be given, in justice to the provincial department of mines, the officials of which, during recent years particularly, have done their utmost to ensure the safety of coal mine employees.

Montreal, Que.—The announcement was made recently in London, England, of what is thought may prove an epoch-making invention in the steel trade. It is alleged that a process has been discovered for converting iron ore of any grade (even sands, of which hundreds of millions of tons exist ready for working) into steel of excellent quality without the aid of a blast furnace, the steel being produced direct, in a single operation. Tests have already been made of the steels so produced at an experimental plant and the results obtained are remarkable. No blast furnace is required, and no coke, which means an initial saving of capital expenditure as well as economy in production, while ores can be used which, at the present time, have no market value whatever. The ore is reduced by heat obtained from a gas, which is produced from slag. It is claimed that steel can be made at one-third of its present cost.

St. John, N.B.—Negotiations are now going on for the construction of the final 225 miles of the Canada and Gulf Terminal Railway connecting the present terminus at Matane with the Basin of Gaspe. The projected line runs through the very centre of the Gaspe Peninsula, about which very little was known up to a few years ago, yet the announcement is now made that complete surveys and locations have been made along the entire route, and that construction will probably be begun during the coming summer and continued for two or three years, as it will probably take that length of time to bring the rails down to the big government wharf now being constructed at Gaspe Basin, where there is at least forty feet of water at low tide. The federal government have subsidized this enterprise at the rate of $3,200 per mile, and this sum will be doubled if the cost of the railway reaches a certain sum. On the other hand, the Quebec government have granted a subsidy of three thousand acres per mile for the entire 225 miles.

Montreal, Que.—Montreal electrical engineers have become interested in Mr. Denys L. Selby Bigge, the English electrical expert, who is promoting direct current transmission of electric energy for long distances. Some of the advantages of his system are as follows: Long distance transmission of electricity in bulk with ground return to distances of 400 to 500 miles. The electrification of railroads, owing to the low cost of transmission, and feeders for the line, which in conjunction with a new form of high tension direct current traction motors and trolley line, would greatly reduce the construction and operative costs. The ease with which pulp mills or other industries in which direct current motors of high power are used, could be driven from the initial generating source, directly in series with the line, without any transformation either up or down—thus effecting great simplicity and efficiency in operation. The direct current system is not altogether new to Europe. The system has been in operation for four and a half years from Moutiers, in Switzerland, to Lyons. It was found possible to extend the system considerably, and has been linked up with water powers at Bredoire and Roselle.

Ottawa, Ont.—During the past few weeks the Canadian Northern Railway Company has been pressing the government to come to its assistance in a generous manner and assist the company to meet pressing financial obligations in connection with the completion of its transcontinental line. Sir William Mackenzie is now in Europe in connection with a general financial re-organization scheme, on behalf of the Mackenzie and Mann railway and allied enterprises. It is understood that the world-wide financial stringency has had a serious effect on the efforts to float new loans to keep all their gigantic and inter-related interests from suffering through the lack of ready money. The appeal for federal assistance has been pending for some time, but government action has so far been delayed by the exigencies of the naval issue. It is understood that the measure of assistance sought involves some twenty-five million dollars, partly by way of direct subsidies for the company's lines not hitherto subsidized from the federal treasury, and partly by way of a loan on the security of the company's railway lines. The details of the legislation have not yet been finally worked out, but it is understood that a general basis of agreement has been reached between the government and Sir William Mackenzie and Sir Donald Mann. The railway company claims that, in view of the magnitude of its undertaking, it is entitled to federal assistance proportionate to that given to the C.P.R. and the Grand Trunk Pacific.

PERSONAL.

MILLIS M. FERGUSON, graduate of Queen's University in '04, has resigned his position of city engineer of Guelph, Ont.

MR. HOLLAND, assistant city engineer of Guelph, Ont., has been appointed temporary city engineer in place of Millis Ferguson, resigned.

GEO. T. CLARK, B.A., graduate of Toronto University in Civil Engineering, of class '06, has resigned his position as city engineer of Saskatoon.

MR. R. H. THOMSON, late city engineer of Seattle, Wash., now engineer in charge of Strathcona Park for the province of British Columbia, and Mr. C. H. Rust, city engineer of Victoria, B.C., have been requested by the provincial government to report upon the proposed sewage scheme for greater Vancouver, which has recently been submitted to the various municipalities interested by Mr. R. S. Lea, of Montreal. The government have agreed to guarantee the interest upon bonds to the extent of five million dollars, this being the amount that Mr. Lea recommends should be expended at once. The remaining five million dollars to be spread over a period of some years.

MR. B. RAYMOND PHILBRICK has been appointed head of the buildings branch of the Department of Public Works, Saskatchewan, taking the place of Mr. W. P. Coltman, who has resigned by letter from England. Mr. Philbrick has been in the employment of this government for the past three years, and is a surveyor who commenced his career in Cape Town. He took part in the Jamieson raid, and after a term in the Matabeleland Mounted Police, resumed the practice of his profession in England. With his father Mr. Philbrick became a large contractor for several public works, prior to coming to Alberta. He has until recently been supervising the work of constructing the hospital for the insane at Battleford.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a meeting of the Vancouver Branch of the Canadian Society of Civil Engineers held recently, Mr. A. D. Creer, chief assistant to Mr. Horace Lea, the consulting engineer of the Burrard Peninsula Sewage Disposal Commission, outlined the work which it is hoped to undertake in order to efficiently dispose of the sewage of the Burrard Peninsula area. There are five drainage areas, Mr. Creer stated, namely, the Fraser River, False Creek, English Bay, Burrard Inlet and Burnaby Lake. The total area to be taken care of is 52,000 acres. Mr. Creer read passages from the report of the consulting engineer showing the way in which sewage effects the waters into which it is emptied and the plans which the commission have adopted as being able to cope with the problem.

COMING MEETINGS.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Meeting of the Toronto Section will be held at the Engineers' Club, 96 King St. West, at 8 p.m., Friday, March 28th. Secretary, H. I. Case, 709 Continental Life Bldg., Toronto.

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.

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.

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