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The Canadian Engineer

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BILLINGS BRIDGE OVER RIDEAU RIVER, OTTAWA

DETAILS OF DESIGN OF THIS PLATE GIRDER BRIDGE NOW UNDER CONSTRUCTION—NOTES ON SUBSTRUCTURE WORK AND ERECTION METHODS.

THE general features of the then proposed steel bridge to replace a 35-year-old wooden structure on one of the chief roads leading into the city of Ottawa, were given in *The Canadian Engineer* for January 29th, 1914. It is situated on the boundary between the city and the township of Gloucester, and is subjected to considerable traffic, chiefly conveyances of farm produce. Briefly, the superstructure is of heavy through plate girder construction, with five spans, each about 78 ft. in length and resting on piers and abutments extending 10 to 15 ft. to rock, the north abutment being of U shape and piled, and the south abutment constructed with wing walls. The bridge will carry two electric car tracks, two 15-foot roadways and two 6-foot cantilever sidewalks. Each roadway is carried on a 4½-inch reinforced concrete slab, with a 4-inch creosoted wood-block wearing surface. Sidewalks consist of a 3-inch reinforced concrete slab. The railway loadings used are those of Diagram "B" of the Dominion Government electric railway specifications. The traffic loading pro-

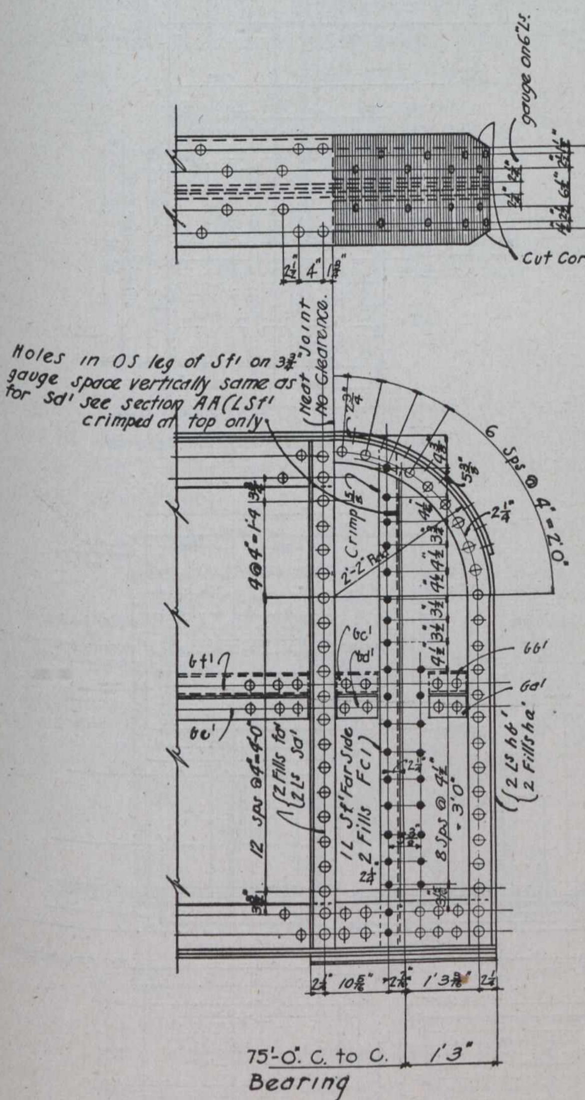


Fig. 1.

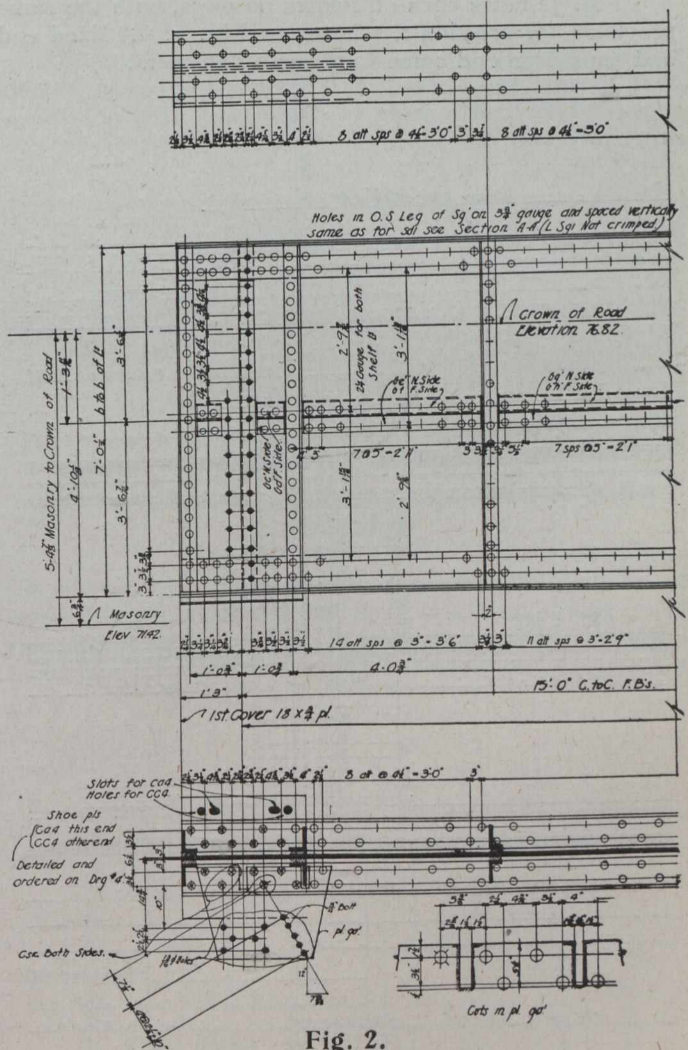
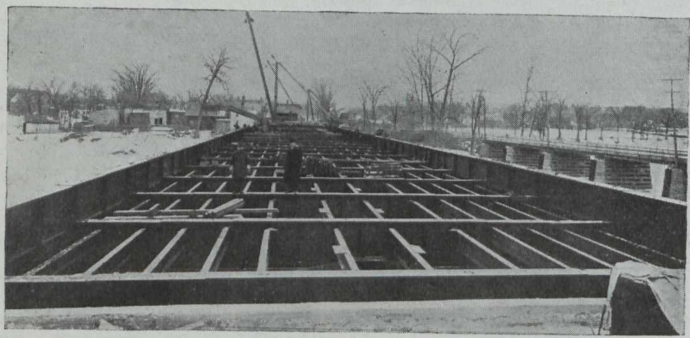


Fig. 2.

vides against the weight of a 16-ton road roller at any point.

A double system of wind bracing is employed in the steel work. Expansion is provided for by roller bearings.

The accompanying illustrations show the essential features of design.



View of Bridge Under Construction, Showing Floor Beams and Stringers.

Fig. 1 shows the curved end of the shore girders, the end stiffener being built and riveted (together with the end stiffener shop-riveted on floor beams) to facilitate erection.

Fig. 2 shows ends of girders on piers, with the same provision for erection as shown on Fig. 1. A fixed end and expansion end come together on all piers.

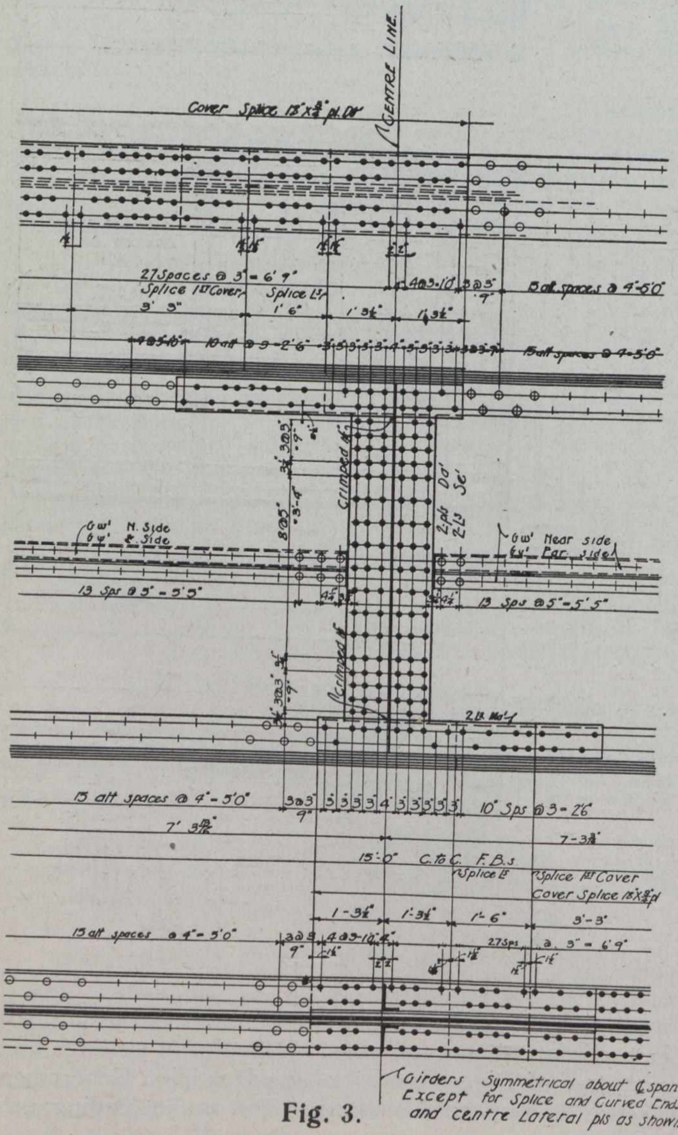


Fig. 3.

Fig. 3 shows splice at centre of main girders. This was necessary on account of difficulty in transporting the whole girder from unloading point at the bridge side. No difficulty was experienced in bringing together the two halves of the girders in the rather unwieldy splice.

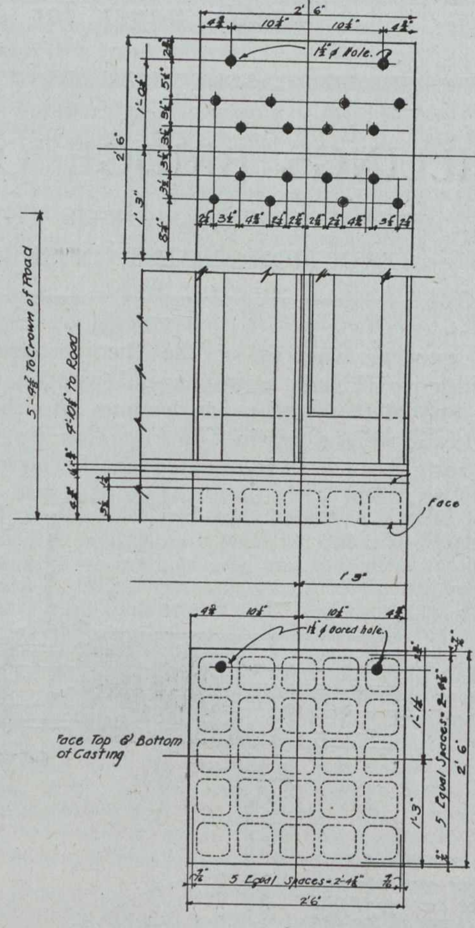


Fig. 4.

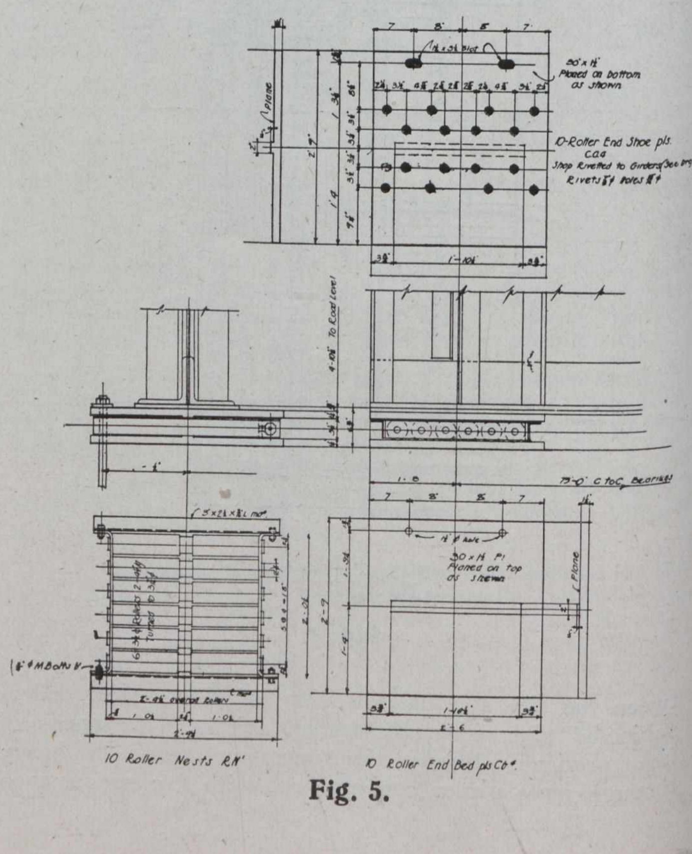


Fig. 5.

Figs. 4 and 5 show pier members and roller rests used on all spans.

Fig. 6 shows the detail of the floor beam connection at the abutment ends of the main girders. This differs

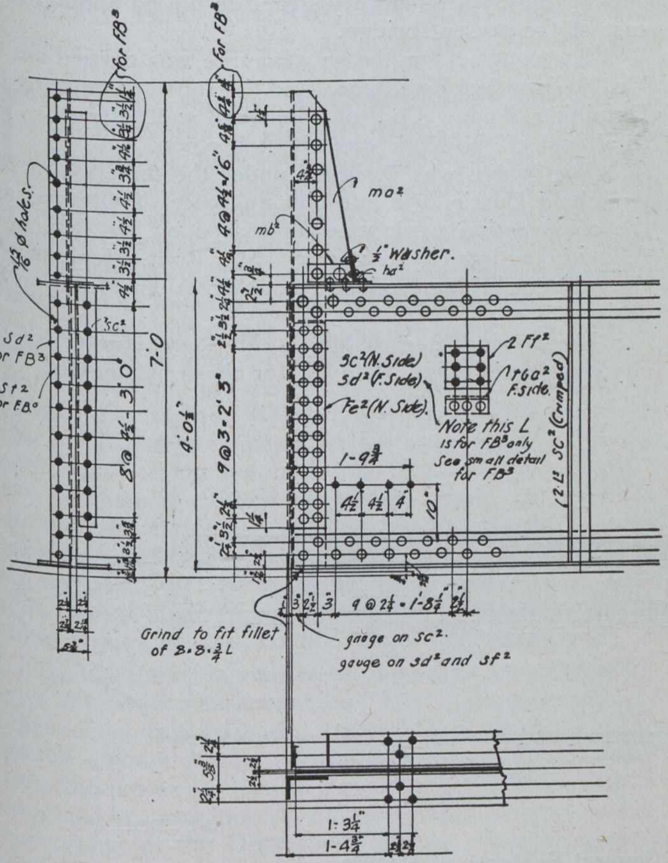
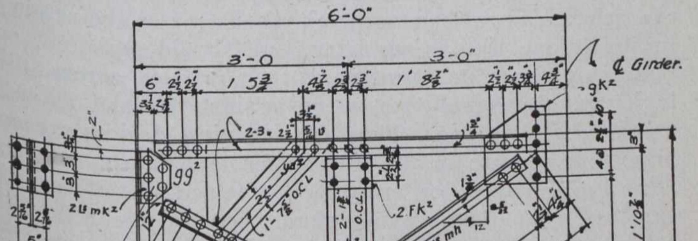


Fig. 6.

slightly from pier ends of main girders, due to the curvature of the top flange of the shore spans. The open holes in the web are for the roadway stringer, and for bottom lateral connection.



60 Sidewalk Brackets SW'

Fig. 7.

Fig. 7 shows detail of sidewalk bracket. This was made on open design to accommodate cables of power and telephone companies. Bracket is designed for a live load of 100 lbs. per sq. ft.

Fig. 8 shows detail of the piers. They are bevelled at one end and protected by a steel plate 48 in. wide by ½ in. in thickness; this will eliminate to a certain extent the catching of floating ice, which in former years used to jam in the old wooden bridge and when released in the spring, flood the surrounding district.

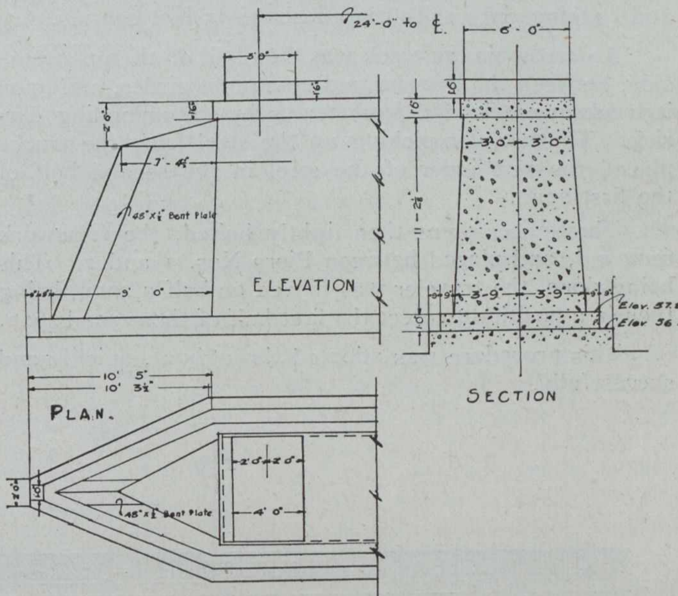


Fig. 8.

Erection was carried out by means of an unloading derrick placed at the north end of the bridge, and in such a position that it was able to place a bent of falsework mid-way between the north abutment and Pier No. 1, on

View of Abutments, Piers and Superstructure Partly Completed.

the line of each main girder. The first half section of each main girder of the first span was then picked up in turn, and each section placed with its shore end on abutment, the other end coming on to the falsework provided for it.

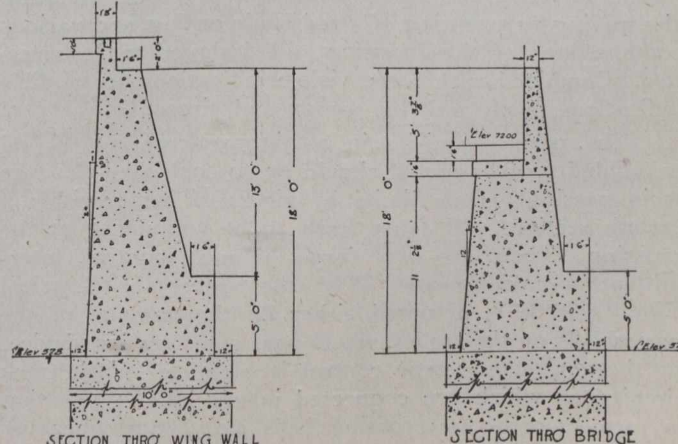


Fig. 9.

Floor beams, stringers and lateral bracing were then put into place and bolted. When the half of the first span was completed, a traveler was erected upon it. This was designed as a stiff-leg derrick supported on small trucks and running on 2 rails spaced about 35 feet centres.

A narrow-gauge track was then laid on the up-stream side, between the traveler and up-stream girder, and upon it trucks were loaded from teams by the unloading derrick. The traveler picking up the steel from the trucks placed the remainder of the steel in the second half of the first span.

The splices were then lightly bolted, the falsework removed, and placed between Piers Nos. 1 and 2. This being done, the traveler was moved on half a span, being then in a position to erect the first half of the second span.

This procedure was adopted throughout, quickly and successfully.

Riveting followed on after the first span was erected. Compressed air was used, steam being supplied to the engine by the boiler of unloading derrick.

Traffic is being maintained during the erection of the new bridge by a temporary structure placed about 100 ft. east of the present bridge.

The contract for the substructure was carried out by Mr. R. Brouder, Hull, Que., and the superstructure by the Dominion Bridge Co., of Montreal and Ottawa. The total cost of the work was about $80,000.

The bridge was designed under the direction of Mr. Archibald Currie, the late city engineer of Ottawa, and the construction work was supervised by Mr. Frank C. Askwith, acting city engineer. Mr. Robt. Henham was the resident bridge engineer, and Mr. Allan McKillop his assistant.

We are indebted to Mr. L. McLaren Hunter, of the city engineer's office, Ottawa, for these particulars.

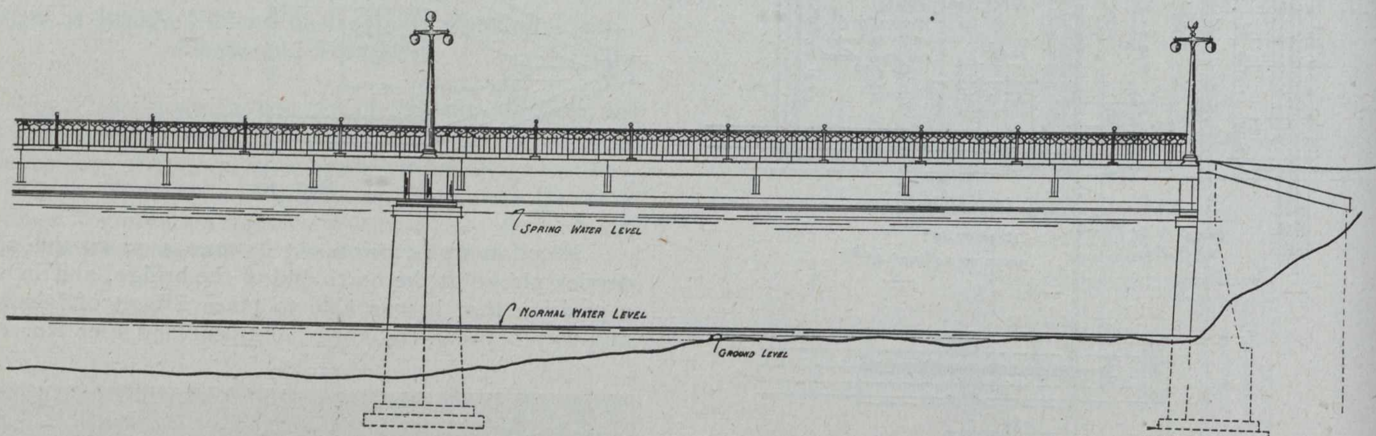


Fig. 10.—Part Elevation, Showing General Features of Design.

PUBLIC PROTECTION AT RAILWAY CROSSINGS.

THE annual meeting of the Illinois Electric Railways Association was held in Chicago in January. An interesting report on highway crossing protection was presented by one of the committees. Crossing signals are therein stated to perform two functions. They designate the location of crossings and announce the approach of trains to the crossings. Among the more common types now available for installation on electric railways are the simple illuminated crossing sign, the intermittently illuminated sign, which gives repeated flashes of light, the signal with moving parts, imitating the waving or swinging of a red blade or flag, and various combinations of these aspects, all designed to be arrestive. Combined with these visible indications are audible indications, such as bells, gongs and sirens.

The prime requisite in a highway-crossing signal is reliability. The signal should be so controlled that the train passing certain limits by virtue of being within a certain section, will cause itself to be announced at the crossing. There are two forms of such control, intermittent and continuous. With the former the electrical signal release is actuated either by the passage of the car wheels or the trolley wheel past some setting device. In the continuous type control is obtained with track circuits, in which are connected interlocking relays that in turn energize the crossing bells and lamps whenever a car is passing through or standing within the block. A second feature of importance in highway crossing protective apparatus is continuity of signalling. For example, if more than one train should enter the ringing limits at one time, and, later, one should pass out, or both stop for some time, and then proceed across the highway, the signal must warn against the last, as well as the first crossing. Thus car counting devices are an important feature in the intermittent scheme of control. It is important so to arrange the device that if several cars are near the crossing simultaneously the bell will continue ringing as long as there is one car inside the control zone.

As to signal costs, the committee found that the average cost of installing a single-track warning signal, exclusive of the cost of the signal itself, was $110, ranging from $90 to $150. One man could maintain from 15 to 50, the average being about 44. One road, having a total of 29 signals, maintained them at a monthly cost of 65 cents per bell, the data being collected over a year's operation. Another road with 64 signals reported the cost as $2.86 per signal per month, while some roads reported as high as $7 per signal per month. Of these two roads the one with the smaller up-keep cost had somewhat fewer than one-third the number of operations of the road having the maintenance cost of $2.86, showing that the maintenance cost per operation does not differ greatly. The average maintenance cost, from all the replies received, was $3.25 per bell per month, which appears to be higher than it should be.

STUDIES IN ROAD CONSTRUCTION

COUNTY ROAD ENGINEERS AND SUPERINTENDENTS IN THE PROVINCE OF ONTARIO MEET FOR INSTRUCTION AND DISCUSSION REGARDING MATERIALS AND METHODS.

THE decision of Hon. F. G. Macdairmid, Minister of Public Works for Ontario, to hold a short course of lectures on highway construction as a means of giving definite instruction on the subject to county engineers and superintendents who are in charge of roads subsidized by the Provincial Government under the Highway Improvement Act, resulted in a most successful session and an impetus to road making that will assuredly leave its mark and create throughout the province an incentive to better and more scientific work. The course was arranged by, and carried out under the direction of, Mr. W. A McLean, Chief Engineer of Highways of Ontario. It was primarily intended as a means of departmental instruction, and took the form of short papers, many of them illustrated by lantern views, followed by half-hour discussions. The lectures were given in the Parliament Buildings, Toronto, on February 23rd, 24th, 25th and 26th, Mr. McLean presiding. They were thoroughly practical in all particulars, and specially referred to local requirements of county road construction.

The chief aims in view were to provide an opportunity for an intimate discussion among the road superintendents, of their duties and methods; and to impart to them a considerable amount of direct instruction. It was thought that the convention would lead to a greater uniformity of work throughout the province, to a clearer understanding of the requirements of the Department and to an exchange of experiences by various county engineers.

The convention was opened by introductory addresses by Hon. F. G. Macdiarmid and by Mr. W. A. McLean.

The following are extracts of the papers presented at the various sessions:—

TYPES OF COUNTRY ROADS. By Robt. C. Muir, A.M.Inst.C.E., assistant engineer, Ontario Office of Public Highways. The speaker emphasized the growing demand for good roads and referred to the excellence of the old Roman highways from the permanency point of view. A brief historical sketch was given of the knowledge and practice in this respect, not only of the Romans, but of the Grecians, Carthaginians and others. The construction of the famous Roman roads was outlined as follows: (1) A trench was dug to the desired width and depth. (2) The foundation, consisting of two courses of large flat stones, was laid in lime-mortar. (3) A layer, 15 inches thick, of broken stones, brick and pottery mixed with lime-mortar was then spread on. (4) Upon this was laid the finished surface, composed of flat stones 6 inches thick set in mortar.

The speaker then passed on to roads of more recent date and outlined the Telford method of construction, which is, in brief, as follows: (1) On a prepared flat subgrade a foundation of hand-set stones ranging in depth from 4 to 7 inches is laid, the larger stones in centre and smaller at sides, all set on edge and firmly wedged with stone chips. (2) On this foundation a 6-inch layer of 2-inch broken stone is spread and allowed to be rolled into position by traffic. (3) On this is spread a layer of smaller stone and the whole thoroughly compacted.

Then the Macadam method was outlined, in which the importance of drainage was first realized, and the foundation course such as Telford's omitted. The method consists of: (1) On a prepared subgrade a layer of 2-inch broken stone. (2) On this a layer of finer stone. (3) The whole rolled and compacted.

The utility of a combination of these ideas, and the importance of a good, sound, well drained foundation, were then brought out.

Earth Roads.—An earth road with a soil composed of a mixture of sand and clay is much more satisfactory than one composed of either of these soils alone. A soil composed wholly of clay acts just the opposite from sand under different weather conditions. In dry weather the surface becomes hard, and if kept in proper shape, makes a good surface. In wet weather, the water soaks into the clay and softens it, with the result that the traffic cuts up the surface and makes the road almost impassable.

Where a suitable soil is not found ready to use, it is advisable to use a mixture of sand and clay, mixing same on the road. The idea of a sand-clay road is that the voids between the grains of sand in surface should be filled with clay.

The chief factor on an earth road, in fact all classes of roads, is proper drainage. If the surface of road is kept shaped so as to throw surface water to ditches and underdrainage used, there should be no difficulty in making this road passable at all times. A camber of about 1½ inches to the foot is usually sufficient.

The principal work in maintaining an earth road is to keep it smooth and well crowned. This is done by using the log drag, which is essential to the upkeep of earth roads. An earth road should not be dragged when dry. Should this be done, the surface crumbles up and causes a layer of loose material which quickly becomes dust and later into mud. The proper time to drag is when road is wet; the muddier it is the better. The road should be dragged at all seasons.

Gravel Roadway.—Gravel, though not as durable as crushed stone, has proved very serviceable as a road covering. The subgrade should receive careful attention and must be prepared so that it offers a firm surface. The binding quality is the chief point to be considered in selecting gravel. Bank gravel is more suitable than stream gravel, as it contains more fine material which acts as a binder. Iron oxide, found in some gravels, is an excellent binder, and roads built of this material have given good results. Gravel of this type is found in Middlesex County, where the gravel roads speak for themselves. Gravel should be screened so as to have surplus clay and loam removed; 15 per cent. of clay is all that is necessary to act as binder.

There are two methods of construction:—

Surface Method.—The subgrade having been brought to proper shape, the gravel is dumped on roadbed and smoothed out, larger stones being raked to the bottom. The surface is then rolled until firmly compacted. This is the usual method of construction and the material taken from ditches goes to form the shoulders.

Trench Method.—A trench is constructed in the subgrade of same width as gravel surfacing. Gravel is then spread on and compacted in layers. The material taken from trench is spread on sides to form shoulders, which are compacted during final rolling.

Macadam Roadway.—The modern method of construction is as follows:—

A trench is cut to desired width of macadam surface, the bottom of which is parallel to finished surface of road. Here again, the hard material taken from trench is spread on sides to form shoulders. Subgrade should be thoroughly compacted with a steam roller, and weak places filled in with hard material.

The subgrade being prepared, a layer of 3-in. stone or tailings is laid thereon as a foundation course, then the stone, graded to pass a 3-in. ring and retained by a 1½-in. ring, is spread to required depth. On this a thin coating of stone passing 1½-in. ring, except dust, is spread to fill voids, the whole then rolled by a 10-ton steam roller. The screenings, ½-in. to dust, are then applied and thoroughly soaked with water and rolled. More screenings are added as desired and sprinkling and rolling continued until the road is thoroughly consolidated. A light coat of screenings is then spread on finished surface.

In finishing a macadam road, wet the surface until a wave of mud, a puddle in other words, forms in front of roller; plenty of water is essential to build a good macadam road. Care should be taken, however, that water does not injure the roadbed. Above all, do not roll the screenings dry.

The use of brooms is strongly recommended for finishing. This practice is very seldom carried out in this country. It is an essential point in macadam road construction The intention of sweeping the surface when water is being applied is to brush the screenings into voids, thus helping the binding; also to avoid water lying along shoulders, which would otherwise soak into roadbed. Too much attention cannot be given to the spreading of stone, which really requires great care and skill as the evenness of wear of the surface greatly depends upon uniform spreading.

Telford Macadam Roadway.—The Telford foundation as constructed to-day is a great improvement on the method advocated by Telford some 90 years ago; in fact, it is more after Tresaguet's method. This class of road, though very rare in Canada, has been extensively used as a foundation for suburban roads in Britain. The stones are set on edge by hand and wedged by chippings on a prepared subgrade, parallel to finished surface of road. The stone used should not exceed 6-in. in width. The stone being laid on edge has not the same tendency to heave as when laid flat. The projecting edges of stones above surface are knocked off, the spaces between stones filled in and surface of Telford blinded. The whole is then rolled with a steam roller. The crushed stone is then laid thereon and finished as in a macadam road.

Brick Roadway.—This class of road has only quite recently come to be used in this continent, the first being laid some 25 years ago. At first, failures were numerous, these failures being due to poor foundation or the quality of the brick.

The advantages of brick pavements are: Easily cleaned and repaired; makes traction easy; good foothold for horses; little dust and no mud. The chief defects are: The lack of uniformity in the brick; noise.

There are various types of brick roadways; the type of road usually adapted for country use is one with concrete shoulders, and should be constructed in the following manner: The subgrade, having been thoroughly consolidated, should receive, if of clay, a layer of cinders or gravel, 6 in. thick. The concrete foundation is then laid 6 in. thick, this surface to be parallel to finished surface of roadway. At least 4 dry days should elapse before brick is laid thereon. A cushion of sand 1½ in. in thickness is spread on concrete to receive brick. The brick is then laid on the cushion and rolled with a 5-ton roller. The bricks having been rolled to a perfect surface, the joints are then filled with cement grout, except the two longitudinal joints at shoulders and a transverse joint every 30 feet, which are filled with pitch and called expansion joints.

Bituminous Macadam Roadway.—Penetration Method.—Before constructing a bituminous surface on a macadam road, all ruts and holes should be filled with a bituminous-coated stone to provide an even surface. All surplus dirt must be removed so as to expose the stone surface, before bitumen is applied. Should the surface not be cleaned, or any cakes of dirt be allowed to remain, the bitumen will not penetrate into macadam.

There are two methods of applying bitumen, *viz.*, gravity and pressure.

The advantages claimed for the pressure method are: More even application; ability to distribute a small quantity per square yard; economy in first cost; economy in long run; simplicity of operation and avoidance of expensive machinery, and not to mention freedom from patent infringement claims.

In applying bitumen it is essential that it should be applied as hot as possible and therefore should be heated right on the work. The quantity of bitumen required will vary according to the physical conditions of the road, but generally 1½ gallons to the square yard is ample; for surface painting thereafter, ½ gallon per square yard, and this should be carried out annually.

The method of construction is: The existing surface of macadam having been prepared and thoroughly dry, the bitumen is then applied, which is carried out by means of a pressure distributer attached to a special tank wagon capable of containing steam under pressure; said wagon is drawn by a steam roller, the boiler of which is connected with the tank wagon, furnishing the pressure on the bituminous material. An uniform layer of stone screenings is then spread on.

Mixing Method Known as "Bituminous Concrete."—This consists of mixing with the stone a sufficient amount of bitumen; the mixing is usually done at a plant some distance from the work, but if at all possible, should be done right on work. The materials are mixed in a heated state and may be done by hand or machinery for the purpose.

The treated material is then spread on and rolled, and then a flush coat of bitumen and grit, and again rolled.

The advantages claimed for this method by its advocates are: Uniformity of surface and composition of same; maximum value of surface for materials used, and economy in use of materials. This method has proved capable of producing first-class results, but there are instances of its utter failure.

The quantity of bitumen used in this method is 2½ gallons per square yard of surface.

The mixing method involves a considerable investment for machinery and, with its initial cost, has led to the development of the penetration method.

Asphaltic Concrete Roadway.—Asphaltic concrete roadway is one having a wearing surface composed of stone and a bituminous material incorporated by mixing methods; similar to "bituminous concrete," except in grading of stone. Where the traffic is exceptionally heavy, the asphaltic concrete is usually laid on a cement concrete foundation; but for ordinary traffic, a Telford or Macadam foundation is sufficient. Should a Telford or Macadam be used, then a 1-in. binder is needed.

The method of construction is as follows: The matrix, which consists of 1½-in. crushed stone, sand and asphaltic cement, having been thoroughly mixed, is applied in a heated state to the prepared surface of foundation and spread with iron rakes. This surface is rolled until properly compacted. A seal coat of heated bituminous cement is spread thereon and, if possible, while surface is still warm, spread with rubber squeegees. Very little of this seal coat is required, only sufficient to fill surface voids. The top dressing is composed of stone chips or torpedo sand which is rolled into surface. The proportions of materials should be: Stone, 55%; sand, 35%; asphaltic cement, 10%.

Concrete Roadway.—This is a class of road that is very largely in the public's eye at present and is one requiring a great deal of study. There are two methods of construction: (1) One-course; (2) two-course.

The one-course pavement is constructed in the following manner: The concrete is mixed in the proportions, usually, 1:2:4, and is laid to a compacted depth of 7 inches, on a subgrade, well compacted and well drained. Should the subgrade be of clay, a layer of cinders or gravel should be spread on same. The surface of concrete is floated over with a heavy template. Each day's work is finished at an expansion joint, such joints being constructed every 30 feet or thereby.

The two-course method is as follows: A layer of concrete 5 in. thick is laid on prepared subgrade. This having been shaped and compacted, and before it has begun to set, a wearing course 2 in. thick is laid thereon. This wearing course usually consists of a mixture of cement, sand and stone chippings in proportions 1:1:1, or may be of sand and cement.

Reinforcement is used in both methods and is placed near the bottom of concrete when sub-soil is weak.

A wearing surface of bitumen and sand is now being used extensively on concrete roads, but here again we are up against patent infringement.

The concrete surface having been thoroughly cleaned and dried, the bitumen is applied hot by means of a sprinkler and is evenly spread by using squeegees. This is then covered by a slight layer of sand. The quantity of bitumen used per square yard is usually ¼ gallon.

In conclusion, the author pointed out that one of the most important factors in successful road construction is supervision; a good foreman is essential if work is to be carried out satisfactorily and economically. Weather has the most powerful influence on the breaking up of roads. This can be minimized by effective waterproofing.

A few points that should be observed in construction of macadam roads were given as follows:

(1) The removal from roadbed of all vegetable matter.

(2) Sub-surface drainage.

(3) Use of the very best material afforded by locality, and if traffic calls for it, the importation of suitable material.

(4) Classification of stone, tailings down to ½ in.

(5) Complete exclusion of loam and clay from stones.

(6) Use of stone dust and screenings, same quality of stone used to fill crevices.

(7) Thorough consolidation of stone by using a 10-ton steam roller.

(8) Stone should be hard and tough, but hardness without toughness is of no use.

In using tar or bitumen, the following items should be kept in view:

(1) The stones must be dry and heated.

(2) Top crust never to be laid on damp foundation, and work should be carried out in dry weather.

(3) Only a sufficient quantity of binder to be used.

(4) Tar not to be overheated; if so, has tendency to cause weakness.

(5) Heating and mixing of stones and tar to be carried out on work.

ROAD LOCATION, GRADING AND ALIGNMENT. By C. R. Wheelock, county engineer of Peel.

The paper claimed that this important phase of permanent improvement of roads had been largely lost sight of during recent years, in the great attention paid to the merits and demerits of surfacing materials. While the latter must be renewed more or less frequently the road location and grade, once established, will become more fixed.

When the improvement of a road is contemplated under the provisions of the Highway Improvement Act the first duty of the county engineer or superintendent should be to make a thorough examination of the locality, and to carefully consider all the conditions in connection therewith. Probably the first matter to be considered to determine the amount of re-alignment and grading to be done in connection with the improvement, will be the amount and nature of the traffic that the road will be asked to take care of. This must not be based on present traffic census, for as soon as the road is improved the traffic increases so greatly that all former traffic data are of little or no value and the greatest foresight is required in making estimates even for five years in advance. Local points, between which the greatest amount of traffic has existed in the past, are no longer the governing factors in the value of a road. The improvement of main roads must be considered as a whole, one link in a chain of improved highways.

Having arrived at an intelligent decision as to the extent of the improvements required for the road, the next step will be the re-alignment and fixing of grade lines.

Road allowances in Ontario were laid out, in the original surveys of townships, to follow property boundary lines without regard to the suitability of these lines for the location of roads, and as a result our roads are of the most expensive description, both to build and maintain. Since then it has been learned that the first considerations in the choice of locations should be the most direct, easiest grade and minimum cost of construction and maintenance.

Upon a careful examination of the locality and conditions in making the re-alignment it may yet be found practical to remedy some of the defects. In some cases the expenditure of a small sum for land will provide for a detour around a hill which would cost much more to cut to a proper grade or around a swamp where an expensive foundation would be required to support the surfacing, or perhaps a change of location of a bridge might be desirable. In considering the benefits of such changes the matter of maintenance should be taken into consideration. This saving alone may often be sufficient reason for making a change.

Pioneer roads in Ontario, in passing along the allowances, generally followed the line of least resistance, avoiding stumps, logs, large boulders, etc. Many of these roads still follow the same old winding lines, although the obstructions may long since have disappeared. The roads now being built should be a permanent foundation for all future improvement and before grading is commenced should be carefully located in the centre of the allowance. If the boundaries or limits are not well defined by posts or fences a survey should be made by a competent engineer and the road properly located. The author quoted from the Surveys Act, providing for such alterations to concession and side roads, and from the Municipal Act, providing for the opening of roads at the jogs in the centres of double-front concessions.

Detours of the road should be made with curves as easy, and the driver's sight line as long, as circumstances will admit. With horse-drawn vehicles a fairly sharp curve is not objectionable, but the high speed of the motor vehicle makes a necessity of easy curves and long sight lines as an ordinary provision for the safety of the travelling public. Curves should have a radius of not less than 100 feet when practical and a sight line of not less than 125 feet. All sight-blocking obstructions should be removed.

After the location of the road has been established the next step will be to establish grade lines. The determination of the amount of grading to be done should depend largely upon the amount and nature of the traffic and the topographical conditions of the locality, but unfortunately the foremost consideration has too often to be the amount of funds available. It is generally agreed by engineers and roadmen that the maximum grade on main highways should not be more than 5%, but this may not always be found practicable. The maximum allowed by the regulations under the Highways Improvement Act is an 8% grade. It should, however, always be kept in view that to have our roads up to the standard adopted by both the United States and Canada the grades on main or trunk roads should not exceed 5%.

Steep grades increase the cost of transportation; no greater load can be moved over a highway than can be moved over the maximum grade. The cost of maintenance increases very rapidly with the increase of grade and is a very important consideration. It is roughly estimated that the destructive effect of heavy rains and spring freshets is four times as great on a 5% grade as on level ground and nine times as great on a 10% grade as on the level. It is not, however, on account of drainage considerations, desirable or economical to have a perfectly level road to obtain the best results. The minimum grade should be about one-half of one per cent.

On a stretch of road with a general ascending grade continuing to a higher elevation, descending grades should be avoided as much as possible, and vice versâ where the tendency is a descending grade toward a lower level.

For the purpose of establishing grade lines, a line of levels should be taken along the centre of the road at regular intervals of, say, 100 feet. All heights of land and hollows should be noted with elevation and distance of same. A profile may then be plotted from the notes and the required grade line drawn, showing cuts and fills, with a view to having sufficient material from the cuts to do the necessary filling. For making the required calculations, cross-sections of cuts and fills may be necessary.

The author pointed out that where new grade lines of any considerable distance are required the engineering should be done by an experienced man with proper instruments. He described a home-made device that might be used for taking rough levels over short distances.

When the grade lines have been established on paper they should then be located on the ground by means of stakes with the elevations marked thereon, and at heavy cuts and fills cross-sections may be laid out. All necessary culverts having been previously constructed and underdrainage provided for, the work is now in shape for grading.

Relative to the latter, the author quoted a number of paragraphs from "Principles of Roadmaking," by Mr. W. A. McLean, Provincial Engineer of Highways, clearly setting forth the best methods of grading. A number of regulations governing grading, crowning, etc., were selected from the Department's manual and dwelt upon to some length.

The author's concluding remarks dealt with a few rules suggested from his own experience:

In deep fills the material should be laid in layers of about one foot in depth commencing the full width of the cross-section of the fill, in order to insure the minimum amount of settlement. Great care should be taken to have filling thoroughly settled and rolled with a heavy roller before surface metal is laid as the least settlement or softness in the foundation is fatal to the surfacing.

All subgrades should be brought to the proper grade and cross-section and rolled. All depressions that may appear during the rolling should be filled with earth and re-rolled until firm and solid so that when metal is applied sub-soil will not be forced up into the interstices of the stone.

Side ditches on long grades where a considerable flow of water may be collected, should be located an increased distance from the centre of the road, as the probable effect of the running water will be to deepen the ditches and eat into the sides of the road.

Through hollows, where the roadway is graded high, do not unnecessarily increase the height of roadway above the sides by taking filling from the sides. High, narrow roads and deep ditches are dangerous.

DRAINAGE. By J. A. P. Marshall, B.A.Sc., assistant engineer, Ontario Office of Public Highways.

The introduction of this paper referred to the important bearing of the climatic conditions of Canada upon the question of drainage in all types of road construction. Best results cannot be obtained in road building until water, the road's natural enemy, is properly looked after. If earth roads could be made practically impervious to water, and such sub-surface water removed, the condition would produce excellent roads. But the soil absorbs water so readily that it is scarcely possible to provide a means of shedding it completely. Moreover, in climates where the road surface is subjected to periodic freezing, thawing and rainfall, the effects of water are more serious. Hence the importance of drainage.

The author stated that drainage implied that: the road be crowned to shed water to open drains and gutters; the open drains have a constant fall to a good outlet; the water rising in the road from below be carried by deep or tile drains; and the surface of the road be kept smooth, free from ruts and hollows, so that water will not remain on the surface.

Removal of water is accomplished in two ways: (1) By surface drainage. (2) By sub-surface drainage.

Surface Drainage.—The drainage of the surface of a road is very important and is provided for by making the surface crowning and keeping it smooth. It is well to remember that water upon the surface of the road cannot be carried away by the underdrains, since the water can reach them only after it has penetrated the road surface. The slope from the centre to the side ditch should be sufficient and the surface kept free from ruts.

Unless the excavations on the sides of the road have a sufficient and continual fall to outlets, they are not drains but merely elongated ponds. In this way mud is formed underneath the roadway and the surface. See that the water flows away, not soaks away.

Underdrainage.—The deep, unsightly, and in many cases useless, open drains at present in use on the public highways throughout the province, should be disposed of without delay, because they are entailing an enormous liability against the municipalities, not to speak of an existing menace to the travelling public. No farmer, however short-sighted, would think or attempt to drain his farm with open drains. The result of these open drains throughout the country is that at least 50 per cent. of our roads are receptacles or trench channels established to carry off the water from the adjoining farms.

Since the adoption of county roads in Ontario, miles of drains have been tiled. In every case results have been obtained infinitely superior to that of an equal expenditure on surface material. Side ditches are necessary to dispose of the water.

The size of tile required for any particular situation will depend on the length of the drain, the fall and the amount of water to be carried away. If smaller than 4-inch tile are used they are liable to become blocked by slight depressions and irregularity in laying.

The tile should be laid at the side of the road at a depth of 2½ to 3 feet. On hills the tile should be placed under the shoulders where the trench will not be washed out.

Soils.—It is of advantage to understand the manner in which underdrains act in different cases. With porous soils, in which the water rises under hydrostatic pressure, the water enters the tile from below. Just as the water rising in a vessel finds an outlet in the sides or flows over the top, so the underdrains supply the necessary outlet and lower the "water line."

With clay the process is different. Absorbing and holding as it does, like a sponge, a large quantity of water, drains are less effective but none the less necessary. Cracks and fissures which appear throughout the surface of a baked soil during the summer drought afford a clue to the action of underdrains upon the soil. As the clay yields up its moisture, it shrinks, and is torn apart. The fissures commencing at the drain spread in different directions and each fissure thus becomes a new drain leading to the tile. This keeps on year by year and these fissures become filled with sand, vegetable and porous material until they assume a degree of permanency and in clay soils thus underdrainage is more effective after several years than at first.

As a rule, a tile drain, laid in close clay soil, will drain six times its depth on each side. In porous soils they give good results for much more than this at times up to 15 or even 20 times the depth. With the exception of a stiff clay, a line of tile laid on one side of the road at a suitable depth will do almost as well for the roads as tiling both sides will do. The only road that will not be improved by the most perfect system of drainage that can be given it, is a road of pure sand.

Outlets and Catchbasins.—An unprotected outlet of a tile drain is very apt to be broken and obstructed by horses and cattle stepping on the tile. If the outlet is into an open ditch, or natural creek, the end of the tile should be protected by a small concrete abutment, or if the tiles are near the surface, as they often are, a very good method is to lay the tile in concrete and cover them over with, say, four inches of the same material, thus making a continuous concrete pipe of such length as the circumstances seem to require. If the outlet is to be in another covered drain, the junction should be made in a suitable catchbasin. Catchbasins are of great advantage to drain, if built in a permanent and suitable way. The best and therefore the cheapest is the one built in place, and of concrete, and should be about 16 in. x 3 ft. inside and have a concrete bottom and top, the latter to be fitted with a removable cast iron grating of sufficient weight to insure its remaining in proper place.

Some of the advantages of catchbasins are:—

(1) They admit surface water into the drain readily and insure the drain working to its full capacity even when the ground may be frozen.

(2) They are useful as inspection holes and enable one to ascertain if all parts of the drain are in working order.

(3) The pit in the bottom serves as a trap to catch all sediment that may get into the drain and

(4) They serve as a vent to let the air escape from the drain and enable it to run at its full capacity, which obviously a drain sealed at both ends will not do.

Good drainage is the basis of good roads. While road improvement in almost any form will yield big returns, it is safe to say that for the amount expended, with the one exception perhaps of the road drag, the largest dividends from any expenditure in highway improvement will come from an outlay on the perfecting of the drainage.

THE GEOLOGY OF ROAD BUILDING MATERIALS. By G. C. Parker, B.A.Sc., assistant engineer, Ontario Office of Public Highways.

In the opening paragraphs of his paper the author reviewed the causes of road wear and deterioration, and pointed out the necessity of a more intelligent selection of materials in view of the increasing severity of requirements imposed upon roads. The effects of horse-drawn and of motor traffic were outlined as under various climatic conditions, and their destructive influences analyzed.

There followed a detailed reference to the geological features of Ontario rocks and gravels suitable for road making. The varieties, three in number, *viz.*, igneous, sedimentary and metamorphic, were described as to formation, structure, color, etc. The traps, granites and felsites of the igneous rocks; the limestones, dolomites, conglomorates, sand stones and shales of the sedimentary series; and the limestone, gneiss, schist, quartzite, and slate of the lesser important metamorphic series were all described.

The suitability of rocks for road surfaces was then dealt with, the paper, in part, being as follows:

For the top course of the waterbound macadam road traps and felsites are the most suitable, particularly where traffic is heavy enough to supply sufficient binding material. They are tough and hard and the wedgelike particles into which they break assists in the compacting of the road. The natural binder from these rocks makes a strong bond with the pieces of the stone.

The harder limestones and dolomites come next in order and owing to the wide variations in qualities which are characteristic of the sedimentary rocks it would be wrong to say that all limestones make good road material. While as a class they are unsuitable for any but the lightest traffic the better varieties rival trap in excellence. The great majority of limestones are of good cementing qualities, consequently a tough, hard limestone can usually be depended on to give good service. This is especially true of flinty limestones.

The granites, like the limestones, as a class are not satisfactory. They usually lack in binding material or when this is present, owing to the granular structure, they disintegrate quickly. There are, however, some varieties that furnish first-class material and in Great Britain granite has been used with satisfaction in some limited localities.

Gneiss, which is the metamorphic form of granite, possesses much the same qualities. It is hard, has good wearing qualities, but in most cases a low binding power.

The remaining rocks of the metamorphic series need not be taken up individually as they are practically of no value except for the foundation of the road. Schist, marble, and quartzite are all suitable in some respects, but lack one or more of the necessary qualities. Slate possesses no properties that would justify its use and it is consequently valueless as road metal.

Field stone is used in some localities with success. As it contains boulders of both igneous and sedimentary rocks and may have some of the metamorphic rocks present, the author dealt with it separately, and explained that, owing to peculiar physical treatment in ages past some kinds are excellent material.

Where the boulders have lain for a long time exposed to the elements, decay sometimes penetrates them to such an extent that they are unsuitable. In using field-stone, therefore, it is advisable to separate those which have been penetrated by decay from the sound ones and confine them to the bottom of the road.

The extent to which decay has rendered the stone unsuitable may easily be determined in the field. After a little experience a person may, by the aid of a small sledge hammer, distinguish between those which are suitable and those which are not. If they ring sharply to the blow of the hammer they are sound. If, on the other hand, they pulverize under successive blows and when broken show evident traces of decay, as by iron stains penetrating the mass, they should be condemned.

Sound field stone, when crushed to commercial sizes, forms a remarkably good material and, even when of inferior value, it may be used for the bottom course and a better grade of stone applied to the top of the road.

Properties Necessary in Broken Stone.—The necessary properties that make a rock suitable for the top section of a waterbound macadam road are briefly as follows: Toughness to resist the shocks from traffic; hardness to resist the grinding action of traffic, and, good cementing properties to resist the tendency of the traffic to dislodge the stones; it should break with a clean, angular fracture in order to compact solidly in the road bed; it should be non-absorptive in order to resist the action of frost. Owing to the wide variation in the degree in which the above qualities are possessed by the rocks found throughout the province and the difference in the traffic conditions on roads within adjacent localities, care should be taken that the material selected should meet conditions. It is a waste of money to build a road of soft limestone where there is heavy traffic of both horse-drawn vehicles and motor cars and trucks simply because the material is easily procured and the original cost kept low. The amount spent on maintenance will, in a case like this, soon exceed the cost of the use of a superior material which would need a very small amount of repairs. It is, in many instances, more economical in the end to build the foundation of local stone and import a higher grade of limestone or even a good trap rock for the top section of the road. On the other hand, where light farm traffic is to be provided for, a lower grade of stone will usually give quite as satisfactory service as a better and more expensive material.

The choice of a suitable road metal is just as important. The author described the characteristic formation and source of each. He detailed its physical features, and its degree of suitability in road making. The advantages of pebbles of all sizes were shown by lantern slides. Pit gravel usually contains an excess of earthy material and can be improved by screening. River gravel is still being deposited in drifts and bars by streams and while it resembles pit gravel it has, as a rule, not as much clay, and is one of the best sources of road material. Lake gravel varies a great deal in character. It is usually free from earth and clay and contains sufficient sand to pack well, but it has a tendency to be slaty, which is undesirable.

In accepting these statements the great variation in qualities possessed by gravels even of the same class must be remembered and before deciding on a material all the available deposits should be visited and a thorough inspection made of the material in each.

A gravel that possesses suitable binding qualities will stand vertically in the pit and require considerable force, if not blasting, to remove it. If it comes from the pit face in large boulders of cemented material resembling conglomorate rock it may be said to contain suitable binding qualities.

The sizes and shapes of the pebbles as well as the materials of which they are composed has a vital effect on the service that the gravel will give. These qualities can be roughly determined by observation. Sharp, angular pebbles are preferable to round, flat, or disc-shaped ones for the reason that they will compact into a denser mass and afford greater opportunity for the binding material to hold them in place. The advantage of having pebbles of all sizes has been shown.

The determination of the materials composing the pebbles is more difficult, but by breaking some of the larger ones and identifying them as igneous or sedimentary rocks, the smaller ones can be picked out and properly classified. As trap rock is superior in hardness and toughness to the other rocks, a gravel that contains a fair percentage of trap pebbles can usually be relied upon to give good service. Hard limestone pebbles also form good gravel, but a large percentage of sandstone and shale will quickly cause the road to go to pieces.

The sizes, shape and material of the pebbles having been determined a small amount of the gravel should be weighed and screened on a ¼-inch screen, and the amount retained should be weighed. It should be from 75 to 80 per cent. of the total weight. Of the material passing through the screen about half may be considered to be clay or other binding material.

(To be continued.)

ANNUAL CHARGES FOR RAILWAY TIES.*

FACTORS governing the annual cost of maintaining any tie are: (*a*) First cost in track. (*b*) Annual interest and tax rate. (*c*) Life of tie. The first cost of the tie consists of three main charges, some of which may be still further subdivided. The three main charges are: (1) First or wood cost of tie, including foreign freight, preservatives and mechanical protection. (2) Labor and other costs of putting ties in the track. (3) Overhead supervising charge. The sum of these is the cost of the tie in track.

On the first cost of the tie there is a tax charge and an interest charge. In our calculations we assume a tax rate of 1 per cent. on value and an interest rate of 6 per cent., making a total of 7 per cent. Any other rate can be used.

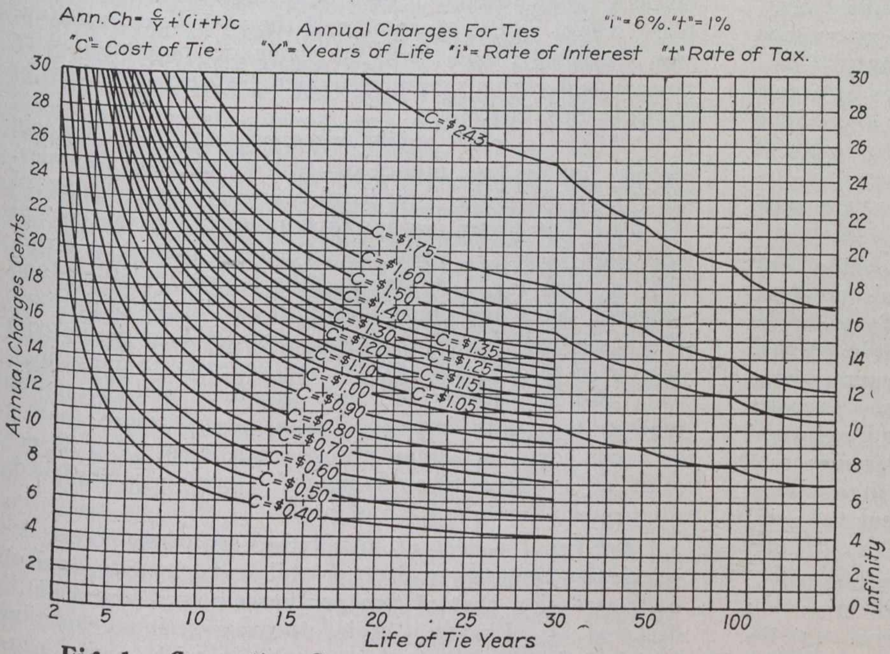


Fig. 1.—Computing Curve for Annual Charges of Railway Ties.

The annual maintenance charge for all ties is the sum of annual interest and tax on first cost of all ties in track and of the replacement cost in track of all ties removed.

Over a series of years the replacement accurately determines the average life of all ties. If one-tenth of all the ties is replaced each year the average life is running at the rate of 10 years. If one-twelfth is replaced the average life is running at the rate of 12 years. If one-eighth is replaced, the average life is running at the rate of eight years. If in 10 years as many ties have been replaced as the total in service, the average life is 10 years, irrespective of variations in different years.

The annual maintenance cost can be expressed by the formula:

$$A = \frac{C}{Y} + C\,(i + t)$$

A = Annual maintenance charge.
C = First cost of tie in track.
Y = Average years of life determined by number of removals.
i = Rate of interest on investment.
t = Tax rate on investment.

*From a paper by Harrington Emerson and T. T. Bowen, read at the annual meeting of the American Wood Preservers' Association, January 19-21, 1915.

By means of the above formula the diagram, Fig. 1, has been constructed for solving instantly as to a single tie or classes of ties, all ties for a year or series of years, the fundamental question of the relation existing between: First cost of tie; life of tie; annual cost of maintenance.

Three distinct problems may be solved with this diagram: Fixed annual cost with first cost and duration of life, both variable.

To illustrate: Take the horizontal $0.15 line of annual charge as the standard annual cost. Along this line there are numerous intersections with the curved lines of first cost and the vertical lines of duration. Therefore, if ties are kept up on an allowance of $0.15 per tie per annum, there are many solutions as follows:

First cost.	Duration, years.	Annual cost per tie.
$0.40	3.2	$0.15
0.60	5.5	0.15
0.75	7.6	0.15
1.00	12.5	0.15
1.25	20.0	0.15

But we may take another problem, namely that of first cost fixed, but annual cost and time variable.

First cost.	Duration, years.	Annual cost per tie.
$1.00	2	$0 57
1.00	3	0.403
1.00	4	0.32
1.00	5	0.27

First cost, $1.00; 2 years' duration.

Interest	$0.07
Annual cost	0.50
Total	$0.57

Finally, we can assume an average standard life, say 15 years, and determine first cost and annual costs.

First cost.	Duration, years.	Annual cost per tie.
$0.40	15	$0.0546
0.60	15	0.0820
0.75	15	0.1025
1.00	15	0.1366

The first illustration given here, that of fixed annual cost with varying duration and first cost, is by far the most valuable of the three. This solves definitely the economic question of the value of tie treatment.

Suppose a tie without treatment costs $1 in the track and lasts 10 years. How much may be spent for treatment to prolong its life to 18 years? The annual cost of $1 tie lasting 10 years is $0.17. The intersection of the $0.17 horizontal line with the 18-year vertical line falls on the $1.35 curved line of first cost. Therefore, it will pay to spend $0.35 for chemical treatment or mechanical protection, or both, on the $1 tie to prolong its life from 10 years to 18 years.

The diagram also illustrates graphically, by the steepness of the curves, the great economy in prolonging the life of ties that ordinarily last but a few years.

It is, of course, understood in this theoretical diagram and tables that tie maintenance is a continuous performance; that nothing takes place suddenly and that there are great individual variations.

The advantage of the cost formula used is its extreme simplicity. The conclusions it forces on us are, however, not invalidated by any other formula, however complex.

Annual maintenance is cheap when good ties cost little and when they last many years. This was the condition 20 years ago. White oak ties cost in certain regions as little as $0.20; the standard rails were about 60 lbs., the axle loads about 15,000, the cars with only 40,000 lbs. capacity, trains comparatively few. Ties were rarely rail-cut and lasted indefinitely. The annual cost of $0.20 tie ($0.40 in track) lasting 20 years, was $0.48 per year.

Now inferior woods cost more than best white oak formerly did, axle loads have increased, car loads have increased, trains are more frequent and heavier. It is a race between fungus and rail to see which will destroy the tie sooner. A good tie in main track costs at least $1 and, unless treated, wears out in seven years. Annual cost, $0.213. At this rate it would cost a road with 25,000,000 $4,000,000 a year more than it did 20 years ago. Creosote, at a cost of $0.25, put on heavy tie plates at a cost of $0.35 more, and the first cost rises to $1.60. Such a tie would have to last 16 years to give a yearly cost of $0.213. Will it? Assume that it lasts 10 years, the annual cost becomes $0.273. This is $5,500,000 a year more than it was about 1905.

There is at present no immediate prospect of any economical substitute. In 1904, a St. Louis patentee thought he could make a cast-iron tie for $3.50. The interest and tax charges alone on this tie would be $0.245. Assuming the tie to last 30 years and to have a scrap value of $1, the tie would cost $0.328 to maintain. There is still nothing fulfilling the purpose as cheap as a good wood tie. It is at present unreasonable to consider any substitute, even with a certain life of 20 years at a higher cost than $1.67, since $0.20 a year is sufficient to maintain best main-line ties.

Tie expense is reduced to a minimum by five rules: (1) Buy the ties carefully. (2) Spend all on protection that the gain in life justifies. (3) Use them at once. (4) Do not take them out before they are used up. (5) Assort them for proper use.

Careful buying insures a price reduction of about 10 per cent. and a quality increase of about 20 per cent.

To allow ties to lie fallow for two years shortens the life two years and adds about $0.14 first cost.

Many ties are removed from one to five years before they are really gone.

A new, rotten tie costing to lay in track $0.80 and lasting two years, costs per year $0.456, or more than twice as much as the maintenance of the best main-track tie, plated and preserved.

TEST ON NEW WINNIPEG PLANT.

Official tests were made from February 5th to 7th, on two of the three new water wheels installed by the city of Winnipeg. Mr. E. V. Caton conducted the tests after the wheels had made a 30 days continuous run. The results showed that 7,220 h.p. could be obtained by each wheel under 46 feet net head at 80 per cent. gate opening. Escher Wyss and Co., who supplied the water wheels, had guaranteed 6,800 h.p. under a net head of 45 feet. The efficiency of the wheels is calculated to be 88 per cent. at .8 gate opening.

These machines have been placed in the city's power plant at Point du Bois, Man. The tenderers were required to bid on machines which would develop the maximum possible power when using the existing wheel pits and concrete draught tubes. The pits and tubes were designed for units of 5,200 h.p., and each tenderer was at liberty to quote for wheels of the largest size he considered possible. Heavy penalties were named for failure to meet the guaranteed h.p.

STEAM VERSUS WATER POWER.

THE Ferris water-power bill, recently under the consideration of the United States Senate, was the occasion of many expert opinions from engineering experts in both hydro-electric and steam power plant construction and operation. The Senate committee held a number of hearings on the question of cost of installation and operation and the relative efficiency of both types. The differences of opinion expressed were marked, as will be shown by "Power's" résumé of the arguments.

Paul M. Lincoln, president of the American Institute of Electrical Engineers, advised that increased efficiency and lower unit cost of installation in the steam plant within recent years altered the hydro-electric situation materially, and that the value of potential water powers had perhaps been overrated because of failure to consider this fact.

"There is much public misconception," Mr Lincoln stated, "as to the profits of hydro-electric companies, which are generally considered as very large because of the idea that water power costs nothing and the cost of operation is small, while the company's income is large. On the contrary," he stated, "the interest, sinking-fund charges, taxes and depreciation on the larger initial cost of water-power installations are comparable with the cost of coal in a steam station. The invested capital in a water-power plant is so much greater than the public realizes that with interest charges at not more than 5 or 6 per cent., in a majority of cases from 70 to 80 per cent. of a water-power company's income is absorbed. This return to capital is not profit.

"When the cost of installation for water-power development amounts to $100 per kilowatt capacity against an installation cost of $50 per horse-power for steam," declared Mr. Lincoln, "it is always a serious question whether the steam plant is not likely to be more economical and profitable."

Several other electrical engineers testified along the same lines, urging the discrepancy between steam and water-power installations and the growing efficiency in steam generation of power, to such an extent that advocates of the water-power bill intimated the possibility of an organized effort on the part of the electrical engineers and water-power companies to affect the pending legislation by depreciating the potential and actual value of water powers in the minds of the committee.

In support of his argument Mr. Lincoln said that engineers have claimed it would be cheaper to install a steam plant in St. Louis to furnish light and power in that city than to transmit hydro-electric power from the Keokuk dam. An auxiliary steam plant, he claimed, could undoubtedly be installed in Buffalo to take the peak of the load for that city while the Niagara Falls Power Co. carried the main part of the load, and the combination would give Buffalo cheaper power than is now being furnished by the Niagara Falls company. In other words, the cost of the hydro-electric installation to carry a high peak is disproportionate to the return from this peak. He admitted, however, that, considering the entire load factor, the Niagara water power transmitted to Buffalo was developed cheaper than power could be generated there by steam. When questioned about Western power development and costs, he suggested that if water-power installation cost more than $150 per kilowatt capacity in Los Angeles, it would probably be found that steam power could compete with it.

Both O. C. Merrill, chief engineer of the Forest Service, and George O. Smith, director of the United States Geological Survey, attacked the statements of Mr. Lincoln and other engineers who testified along the same line. Mr. Merrill declared that Mr. Lincoln's statement that steam and hydro-electric production cost on the average about the same was startling, but wholly incorrect, and proceeded to quote figures from plants in operation. According to these figures the actual switchboard cost of power sold by the New York Edison Co. (Waterside No. 2 station) is approximately five mills per kilowatt-hour. This cost includes labor, fuel, supplies and repairs. On the basis of power generated, where 24.9 per cent. is lost in distribution, the Edison station cost is approximately four mills per kilowatt-hour. Fuel and labor costs of generation at steam plants in California were quoted as 0.336c. for Long Beach and 0.372 for Redondo, while the generation cost at the Pacific Gas and Electric Co.'s Borel hydro-electric plant was only 0.033c., or, with transmission cost added, 0.128 cent.

"On this basis," declared Mr. Merrill, "it would be as profitable to invest $380 per kilowatt capacity for installation at the Borel plant, considering the load factors in each instance, as to invest $50 per kilowatt capacity at the Long Beach steam plant; while the fact that this steam plant was being operated on a 20 per cent. load factor and the hydro-electric plant at 69 per cent. load factor, justified even a larger discrepancy in installation cost."

"In general," said Mr. Merrill, "hydro-electric installation costing eight times as much as steam, instead of three times as much, might be considered economical and profitable."

Dr. Smith attacked the water-power engineers for having made much of the increased efficiency of steam production without having mentioned the equal increase in efficiency of hydro-electric production. Quoting from a report of Samuel Insull, president of the Commonwealth Edison Co., of Chicago, he showed that within the last ten years this company, with its steam plant, had quadrupled its investment and increased its output fifteen-fold. In 1903 a one-dollar investment in the Chicago plant yielded 3 kw.-hr., while in 1913 the one-dollar investment yielded 10 kw.-hr. Chicago, all steam, now shows a per capita consumption of a little over 300 kw.-hr. and an average income of a little more than 2c. per kw.-hr., while San Francisco, part steam and part hydro-electric, shows about the same average consumption, and an average income of a little less than 2c. per kw.-hr.

As compared with the showing of the Chicago steam plant of 10 kw.-hr. per dollar of investment, the San Francisco plant had shown 6 kw.-hr. to each dollar of investment in 1911, while the ratio for the Montana Power Co. (all hydro-electric), where the average consumption was as large as 1,000 kw.-hr per capita, was 15 kw.-hr. per dollar of investment.

The hydration of Portland cement is now under investigation at the Pittsburgh laboratory of the Bureau of Standards. According to the annual report of the director of the Bureau of Standards the first series of tests, already completed, shows what the products of hydration of the constituents of Portland cement are under normal conditions, and also which of the constituents produce the early and which the later hardening. These tests were made with materials produced in an electrical furnace, and with some commercial cements, but in no case were the actual products of hydration compared with the strengths produced.

CLAY AS FOUNDATION SUPPORT.

AT a January meeting of the Institution of Civil Engineers of Great Britain, Mr. Arthur L. Bell, presented a paper dealing with the lateral pressure and resistance of clay and the supporting power of clay foundations. The author first makes reference to the difficulty to be anticipated in attempting to estimate the lateral pressures and resistances of clay, its constitution and properties being obscure. He cites Coulomb's and Rankine's theories of earth pressure as being those ordinarily used in English practice and shows that both presuppose a knowledge of the angle of repose, as well as applying, not to undisturbed clay, but to loose-granular mass. He points out that the angles of repose for clay vary, according to the testbooks from 1° to 45°, and observation of the material itself is of little value when selecting the angle to be used for calculations. Widely different results will be obtained according to the angles chosen. The results of calculations by these methods are also found to be at variance with observed facts. The lack of agreement is due not so much to error in the existing theories as to a misapprehension as to the extent of their applicability. The paper goes on to present an extension or modification of Rankine's theory which, when applied to clay would yield results more closely in accordance with fact and observation.

A short description is given of the monolith foundation work at the Rosyth dockyard, as it was in connection with this work that the investigation which forms the subject of the paper was made. As the work of founding the monoliths proceeded, Rankine's formulas were duly applied to the different cases which arose, but in view of the doubt as to the applicability of the formulas to clay, and as to the correctness of the assumed angles of repose, the results were regarded rather as aids to practical judgment than as actual and reliable solutions of the problem of stability. A search through all available records did not yield much information of value or furnish a theory of clay pressure. Practical experience with tunnels and embankments appeared to indicate that the pressures exerted by clay resembled those due to a heavy fluid. This view is supported by a quotation which is made from a previous contribution by the late Sir George H. Darwin. The search revealed a high percentage of failures in work constructed in clay.

The broad conclusions to which the investigation led were that there was no available theory of earth pressure which, when applied to clay, would command the general confidence of engineers. There were no fixed rules of practice, and there were grave differences of opinion as to what intensities of pressure could safely be placed upon clay foundations. Experiments were undertaken with a view to throwing further light upon the question. The first experiments described were made in a small testing cylinder 8 in. in diameter, fitted with gauges at the ends and sides. The results are given of a few tests with this apparatus, but the author does not regard them as having much value.

Up to this point, following established custom, it had been thought that, however difficult it might be to find the true angle of repose for clay, it might be possible by experiment, or as the result of experience, to hit upon an angle which, when introduced into the generally recognized formulas, would give correct results. Suspicions were now felt that the root of the difficulty lay deeper, and that the true reason why Rankine's and Coulomb's theories were not applicable to clay was because clay did not conform to the law of resistance to shear which forms the initial basis of both those theories. Rankine expresses the primary law upon which his theory is based in the following words: "The resistance to displacement by sliding along a given plane in a loose granular mass is equal to the normal pressure exerted between the parts of the mass on either side of that plane multiplied by a specific constant." If it could be shown that clay failed to comply with this primary condition, then it seemed clear that formulas deduced from this condition were inapplicable to clay.

To carry out the desired tests another apparatus was made, consisting essentially of a vertical cylinder 3 in. in diameter and about 10 in. high. Fitting into the upper end was a plunger which could be weighted on top, so as to compress the clay placed within the cylinder below it. Arrangements were made whereby the clay—while under pressure in a vertical direction—could be sheared through horizontally. The vertical load upon the clay and the pull required to shear through the clay being both known and capable of variation at will, it is possible with this apparatus, by making successive tests with different specimens of the same clay placed under varying degrees of compressive stress, to determine the law which governs the relation between the ultimate shearing resistances and the normal pressures on the planes of shear. Experiments made with sand gave results closely in accordance with Rankine's law as stated above, but it was found that no kind of clay complied with this law. According to Rankine's law, where there is no pressure there is no resistance to shear, but in all cases clay was found to resist shear where the pressure was zero. The rate of increase of shearing resistance with advancing pressure was found not to be so great as would be inferred from Rankine's law, adopting the angles of repose ordinarily current in practice. It was found that when plotted in diagram form —with equal horizontal and vertical scales—the results with clay could be represented, with reasonable accuracy, by straight lines. These lines did not, however, pass through the origin—as would be the case in material complying with Rankine's law. In all cases they cut the vertical axis which passes through the origin at a distance k from the origin, and with advancing pressure the resistance to shear increased in proportion to an angle α; α being the inclination of the straight line to the horizontal axis.

To make clear the state of stress and of resistance within a body subjected to external pressure, curves are shown in the paper illustrating the intensities of stress and resistance in sand and in clay. From these diagrams and by a simple mathematical proof it is shown where the plane of rupture occurs both in sand and in clay. The position of the plane of rupture ascertained in this manner is found—in the case of sand—to be identical with that deduced in a different way by Coulomb.

Having determined the position of the plane of rupture in clay, the author next proceeds, by considering the equilibrium of minute masses of clay in contact with the wall, to deduce formulas for the pressure and resistance of clay. The deduced formulas are then compared with Rankine's. These formulas, it is pointed out, suffice for the design of retaining walls in clay, the surfaces being assumed horizontal, and the paper is limited to the consideration of this case only.

It was thought desirable to supplement the theoretical work by making direct observations of pressure within a large mass of clay. The four diaphragm gauges used in the previous cylinder tests were built into the side of one of the monoliths, being arranged in two pairs. The gauges of the lower pair were fixed side by side at a height of 10 ft. above the cutting edge of the monolith shoe, while directly above them, and 12 ft. 8 in. higher up, were the two remaining gauges. By adopting this arrangement it was intended that each gauge reading should constitute a check upon the reading of that beside it; while the readings of the lower pair at any depth would be checked at a later date by those of the upper pair when the latter reached the same point.

The actual uncorrected reading of all four gauges, taken from time to time as opportunities offered during sinking, were shown in connection with the paper, together with a section of the strata through which the monolith was sunk. Unfortunately, one pair of gauges was spoiled by leakage, and owing to damage by blasting the records obtained from the other pair were insufficient to confirm completely the theoretical conclusions previously obtained. But so far as the records went they appeared to be in reasonable conformity with the theoretical position discussed in the paper.

The laying of too much stress upon the few readings obtained is deprecated, and the practicability of making effective use of the new formulas is discussed. It is pointed out that it is not easy when designs are in progress to obtain clay in its virgin state and from considerable depths below the surface for the purpose of making tests; and in certain methods of construction—the sinking of monoliths, for example—the strata are often never seen in their normal condition, even when the works are in progress. Further, the building of a new work may have, in the course of years, the effect of altering the condition of the strata which press upon the structure. What the extent of these changes will be, and whether they will be beneficial to stability or otherwise, will never be determinable by purely mathematical methods. If reasonably correct results are to be obtained, some measure of judgment must lend its aid towards the solution of the real problems of earth pressure which occur in practice, as distinguished from the simplified and somewhat unreal problems with which theorists necessarily deal.

PURCHASING AGENTS FOR MILITARY SUPPLIES.

The following is a list of purchasing agents acting for the British, French and Russian governments in the matter of contracts for the manufacture of war supplies:—British—Col. A. G. Barton and A. C. Billing, Ritz-Carlton Hotel, Montreal. French—Hudson Bay Company, 56 McGill Street, Montreal; Captain Lafoulloux, Hotel Brevort, New York; Direction de l'Intendance Ministere de la Guerre, Bordeaux, France; M. de la Chaume, 28 Broadway, Westminster, London. Russian—Messrs. S. Ruperti and Aiekieff, care Military Attache, Russian Embassy, Washington, D.C.

COPPER PRODUCTION OF WESTERN CANADA IN 1914.

Due to the activity prevailing early in the year, particularly in British Columbia, copper production for the Dominion of Canada shows very little falling off for the 12 months. Since the beginning of the war, however, the operations of the British Columbia Copper Company have been suspended and the large new Anyox smelting plant of the Granby Consolidated Mining, Power & Smelting Company, which was blown in last spring, was practically shut down. Other leading companies, including Le Roi No. 2, Limited, Britannia Mining & Smelting Company and Consolidated Mining and Smelting Company, of Canada, suspended or curtailed production. Operations are, however, gradually being resumed, and reports now being received are decidedly optimistic for the immediate future.

BITUMINOUS DEPOSITS IN NORTHERN ALBERTA.

At the recent annual meeting in Ottawa of the Commission of Conservation Dr. Eugene Haanel made some very interesting remarks in favor of the development of the bituminous sand region in the McMurray district of Northern Alberta, and stated that the non-existence of transportation facilities, upon which the utilization of the extensive deposits is dependent, will soon be overcome by the completion of the Alberta and Great Waterways Railway. This line, which will open up the region and render the deposits available, will be finished in 1916.

A preliminary examination of the deposits was undertaken by the Department of Mines, Ottawa, in 1913, and continued last year. The investigation revealed the fact that the tonnage of bituminous sands in the McMurray area is very large, and, although much of the material is low-grade and, in some cases, the overburden so heavy that mining by open-cut is impracticable, it is found that some 20 per cent. of the material representing many millions of tons, may be considered as of commercial value.

Bituminous sands have for a number of years been used in the construction of various classes of pavements. The extent to which the material has been used appears to have been largely determined by the freight rates. The greater portion of the bituminous sand used at the present time in California for paving purposes comes from the Santa Cruz quarries, and is, in many respects, similar to the Alberta material. The bitumen contained in the McMurray rock is, however, much softer. It is believed that, with proper manipulation, such as heating, and the addition of hardening flux, the penetration of the bitumen can be reduced to meet the requirements of standard specifications for its successful employment in the laying of pavements in substitution of imported asphalt.

In view of the fact that the bitumen contained in the tar sands of Alberta is softer than the bitumen of the California material, arrangements have been made by the Mines Branch for the laying of an experimental pavement in the city of Edmonton with the Alberta material, the city government having agreed to construct the concrete foundation. Upward of sixty tons of suitable material has been assembled for transportation to Edmonton, and it is expected that the pavement will be laid next summer.

The city commissioner states that: "If this work is successfully carried out it will be of greater value to the city of Edmonton and Alberta generally than the bringing in of half a dozen industries. . . . At the present time, we are absolutely suffering for the lack of cheap pavement and for the lack of good road material, whereby the farmers may haul their products to the city on well built roads. The solution of this problem will be worth millions of dollars. . . ."

At present, all asphaltic paving materials used in Canada are imported from foreign countries. In 1913-14 the value of these imports reached a total of nearly $900,000, and the consumption is rapidly increasing. The value of a cheap and satisfactory paving material in Western Canada would be very great.

The bituminous sands may also serve as a source of pure bitumen, which may be extracted either by disulphide of carbon, the lighter petroleum distillates, or by the use of hot water and steam. Among the many uses to which this extracted bitumen may be applied may be mentioned: floorings for many classes of buildings—such as mills, hospitals, schools, skating rinks—for foundations which require to absorb vibration and jars, as in electric power plants, for lining and damp courses for cellars, reservoirs, etc., for insulation of pipes, and as a source of asphaltic oils.

Attempts in this direction have been made for the past twenty years in the United States. No industry, however, has been established and no extracting plant is now in operation. The cause for the failures is not far to seek. In California extracted bitumen, at $12 per ton, cannot compete with petroleum residuum at $6.50 to $9 per ton. In Alberta, however, bitumen extracted at $12 would compete with imported refined asphalt, costing $27 to $34 per ton, delivered.

Before such an industry is attempted, however, all available information of the results of many years' serious and often costly experimentation in the United States should be consulted.

THE SECOND NARROWS BRIDGE AWARD.

The Canadian Engineer for August 20th, 1914, contained some interesting details respecting the Second Narrows Bridge controversy arising out of the conclusion on the part of the Burrard Inlet Tunnel and Bridge Company, that the first design, prepared by Sir John Wolfe-Barry, Lyster & Company, England, (a $2,500,000 proposition) was too expensive. A summary was given of three subsequent tenders for a cheaper structure, as advised by the provincial government. These tenders were those of the Dominion Bridge Company, associated with Armstrong-Morrison & Company, Vancouver; C. A. P. Turner, Minneapolis, Minn., associated with the Western Foundation Company, Vancouver; and the Canadian Bridge Company, Walkerville, Ontario. These tenders amounted to $1,916,000, $1,744,831, and $1,846,000, respectively. The Burrard Inlet Tunnel and Bridge Company did not succeed in coming to a definite conclusion when the tenders were opened. The British Columbia Manufacturers' Association, the Board of Trade and other public and influential organizations took a great interest in the proposed designs. The provincial government, although anxious that the structure be proceeded with, did not undertake the responsibility of making a recommendation. Thereupon the company called in the services of Mr. Ralph Modjeski, of Chicago, to report upon the three designs.

After a lapse of four months, Mr. Modjeski made an extensive report in which he called attention to the fact that all three designs were lacking in sufficient detail and were inconsistent in many respects. He placed them in the following order of merit, however: Canadian Bridge Company, Dominion Bridge Company, and C. A. P. Turner. He suggested that none be accepted as they stood, but that the tenderers be allowed an opportunity of revising their plans and estimates to better meet the local conditions, or better, the Board prepare a new and complete set of plans and invite new tenders thereon. In case the latter was adopted, the report suggested a more substantial substructure with pneumatic foundations; a deeper draw-span designed as a continuous structure; a long fixed span similar to the design furnished by Mr. Turner, on condition that a change in the Crown grant for portions of the bed of the Narrows might be secured; and an approach viaduct of girders supported on reinforced concrete base. Mr. Modjeski submitted an arrangement of electric railway tracks and roadway for the main bridge, that differed considerably from that in the plans of the three tenderers.

A number of members of the company were disposed to recommend that the contract be awarded to the Canadian Bridge Company. The directors decided, however, to appeal again to the provincial government, which was done. The government referred the matter back to them, however, with the additional complication that if the Board went against the Executive Council's expressed policy and awarded the contract without calling for new plans, it would not be in a position to renew its request for government assistance.

At its next meeting the Board, after considering this reply from the Premier, passed a resolution in favor of asking the city of Vancouver to increase its subscription for bridge stock from $200,000 to $550,000, as the provincial government was subsidizing the enterprise to the extent of $400,000. A good deal of discussion arose subsequently as to the advisability of persisting in making it a home industry affair, there having been all along a strong protestation against sending the work, amounting to nearly $2,000,000, out of the province. At all events it was purported to be a case of local industries of Vancouver, as represented in the bid and design of C. A. P. Turner in conjunction with the Western Foundation Company, against the Canadian Bridge Company, given first place by Mr. Modjeski. Both tenderers expressed willingness to comply with the alterations and improvements which Mr. Modjeski's report suggested.

At the first meeting for 1915 of the Burrard Inlet Tunnel and Bridge Company the design of the former was adopted and the contract awarded to C. A. P. Turner and the Western Foundation Company to erect the bridge in accordance with this design, the price being $1,744,831, the design to conform to the recommendations of Mr. Modjeski's report and the plans to be passed by the Dominion Government. The award was made on condition that the structural steel required for the whole contract be purchased from British Columbia structural steel firms, and that all materials and all labor be purchased within the province, as far as possible. At the same time, it was resolved to ask the provincial government to revote its bridge subsidy of $400,000 and it was also decided to ask the city of Vancouver to increase its subscription to the extent intimated above. It was also decided that construction work would not be proceeded with until satisfactory financial arrangements had been made. To quote a local paper the scheme "now only needs the 'quod erat demonstrandum' of the necessary finances to clinch it it home."

The following figures showing the total operating mileage in Canada, are interesting:—

Province.	Miles of rail.
Nova Scotia	1,359.97
Prince Edward Island	279.23
New Brunswick	1,544.67
Quebec	3,936.03
Ontario	8,099.76
Manitoba	3,993.28
Saskatchewan	4,650.96
Alberta	2,212.22
British Columbia	1,950.92
Yukon	101.71
In United States	224.78
	29,303.53

The mileage of track in the United States relates to lines which cross United States territory in passing from one point in Canada to another, as for example, the Canadian Pacific and the Canadian Northern. Such lines are operated wholly for the purposes of Canadian traffic.

ADDITIONAL FILTRATION FOR MONTREAL.

It has just been announced that Messrs. Hering and Fuller, of New York, consulting engineers on the Montreal filtration plant, are about to make a report relative to early extensions. The filtration plant now under construction was designed for a capacity of 50,000,000 gallons per 24 hours. It is a slow sand plant and was designed in 1910. The city's water consumption has increased more rapidly than anticipated, however, and at present, although the above plant is not yet completed, the city is using about 65,000,000 gallons per day, necessitating extensions.

The consulting engineers were in Montreal recently in connection with further construction. It is stated that they do not recommend a duplication of the present plant, but that their report will advise the installation of a system of mechanical filtration to act in conjunction with the system now being established. According to report, they have three schemes under consideration, any of which, they state, might be used advantageously in co-operation with the present filters. Their report, to be received at an early date, will make a selection.

It will be remembered that the city was authorized by the Quebec Legislature to borrow $7,000,000 for the construction of the filtration plant, the enlargement of the open aqueduct, and the establishment of a lighting plant. About $4,600,000 has been expended up to date. It is said that the suggested mechanical system of filtration, of sufficient capacity to afford adequate filtration for some years to come, could be completed for an amount well within the remaining $2,400,000.

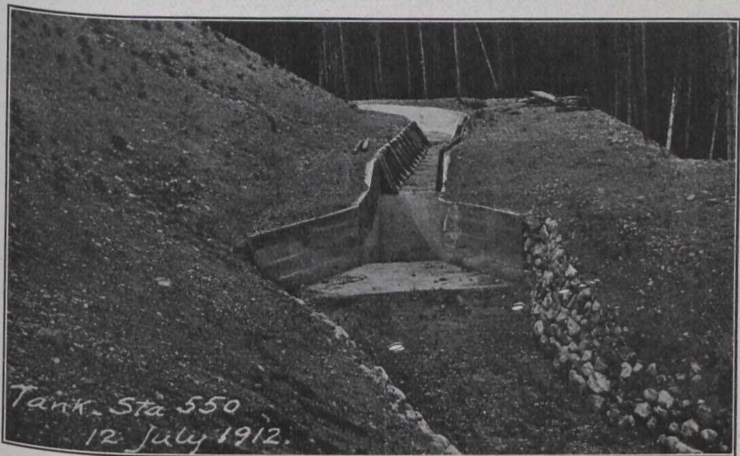
IRON AND STEEL PROTECTION AGAINST CORROSION.

Rapid progress has been made in acquiring that knowledge of the relation of pigments and finished paints to corrosion which is necessary to a better protection of iron and steel. Predictions founded on theory that a basic paint, or one containing a chromate pigment, would inhibit rusting, while one made up from lampblack or graphite would accelerate rusting, have, in the main, been found correct. The effect of the pigment upon the character of the oil film making up the paint, however, has shown itself also to be very important. Many basic pigments, such as basic lead carbonate or zinc oxide which in themselves inhibit, do not withstand the weather; lampblack and graphite, on the other hand, make a very impervious and highly resistant paint film. The logical conclusion in protecting iron is, therefore, to use a basic priming coat, a second coat of a mixture of a basic pigment and a little lampblack, and when well dried out to apply a lampblack or graphite finishing coat. Experience has shown also the importance of brushing the paint well on to the iron.

The production of petroleum throughout the world in 1913 was 381,508,916 barrels, of which the United States yielded 248,440,230 barrels, and Russia 60,935,482 barrels. Other producers were:—Mexico, 25,696,291 barrels; Roumania, 13,554,768 barrels; the Dutch Indies, 11,966,857 barrels; Galicia, 7,818,130 barrels; India, 7,500,000 barrels; Japan, 1,942,000 barrels; Peru, 1,857,255 barrels; Germany, 995,764 barrels; Canada, 228,080 barrels; Italy, 50,484 barrels; and other countries, 517,616 barrels. It will be observed that the United States produced 65.12 per cent. of the whole world's output in 1913; Russia, 15.97 per cent.; Mexico, 6.74 per cent.; Roumania, 3.53 per cent.; and the Dutch Indies, 3.14 per cent.

IRRIGATION WORKS NEAR KELOWNA, B.C.

In his paper read before a general meeting of the Canadian Society of Civil Engineers, Mr. C. A. Stoess gives a description of the Belgo-Canadian Fruit Lands Company's irrigation works, at the foot of Black Mountain in British Columbia. The company has about 9,000 acres of land, 6,000 of which are available for irrigation. A reservoir site with a capacity of 3,070 acre-feet is located at the head of the north fork of Mission Creek. There are three dams on this reservoir site. The first has a length of 445 feet with a maximum depth of 31 feet, or 24 feet above the surface of the ground. The foundation is in granitoid rock; at the west end the dip is 75° with a strike almost at right angles to the line of the dam, dipping into a water-tight hardpan below about 10 feet of



Tank at Entrance to Irrigation Ditch.

wet gravel for a distance of 95 feet, beyond which is hard gneiss for a distance of 350 feet and beyond. The dam is built of a concrete core 1½ feet wide at its top, which is 7 feet below the top of the dam, and 3 feet wide at the surface of the ground. The trench below the surface of the ground averages 6 feet wide and is filled with concrete and fillers of rock. The water surface will be 3 feet below the top of the dam, with a top width of 10 feet. On either side of the core wall there is a cushion of earth 3 feet thick that is carried up to the top of the dam, and beyond this is a heavy rock fill having slopes of 1½ to 1 on the water side, and 2 to 1 on the lower side. The water side is protected by hand-laid rip-rap. There is a concrete culvert through the dam in solid rock with a sluice gate built of three thicknesses of 2-inch plank set in heavy wooden frames anchored to the concrete, and operated from a gate house set on a heavy tower. The gate rod enters a cast iron standard, having a brass nut and ball bearings. All woodwork is coated with carbolineum and tar.

Dam No. 2 is situated about half a mile east of Dam No. 1, and is similar in construction. Its length is 255 ft. with a maximum depth of 41 ft., or 25 feet above the ground surface. The foundation is all in solid rock, except for a length of about 30 feet where the foundation was placed in hardpan at a depth of 14 feet below the ground surface. The rock fill being very heavy and large no riprapping was done. As a precaution, a 12-inch concrete pipe, set in a concrete bed, was built provided with a 12-inch gate, gate tower and house. All the rock for the dam had to be blasted and hauled to the dam, using three sets of track and cars and derricks.

Dam No. 3 is across a slight depression 250 feet long and 4 feet deep and formed of rock and earth.

At one mile below Dam No. 1, where the creek bed is in solid rock, a concrete weir is built to gauge the flow.

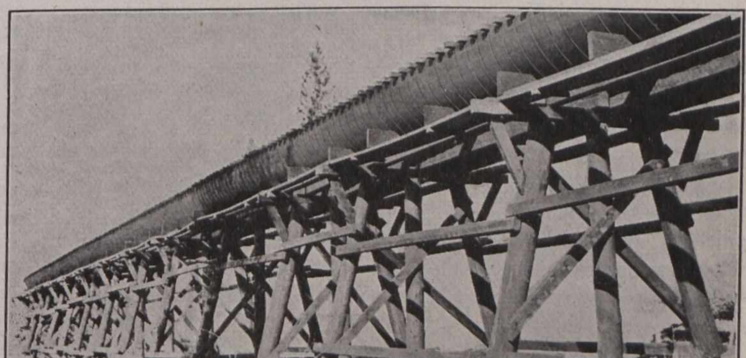
Between the reservoir and the intake several small streams add to the flow. The intake is located about 11 miles below the reservoir. A training wall of cribwork, 180 feet long, filled with rock, is built on the west side of the stream bed; the stream bed straightened and a crib abutment built on the east side and filled with rock. Between these cribs there is a bear trap dam having four leaves or traps each 5 feet wide. These leaves are worked by a winch and running tackle. In the training crib, on the west side, is an opening provided with drop logs through which the water can be diverted at low water, with the leaves raised, into a forebay or canal 10 feet wide at the bottom and 500 feet long leading to the headgate of the main ditch. Along the east side of this forebay are six spillways of concrete as a provision against the drop logs at the bear trap dam being accidentally left open.

Immediately above the headgate 4th Creek comes in, discharging about 300 c.f.s. In the spring of 1912, this creek brought down a large quantity of gravel that filled up part of the forebay 3½ feet deep, and to avoid a recurrence of this a flume has been built 10 feet wide and 2½ feet deep on a 5 per cent. grade across the forebay and the channel of the creek paved for 300 feet up above the forebay. At low water this creek can be turned into the forebay.

The headgate is built of two thicknesses of 2-inch fir with a heavy fir frame anchored to and set in the concrete, all well coated with carbolineum and tarred. The gearing is on ball bearings.

From the headgate the ditch runs through a very sandy and gravelly side hill having a natural slope of 2 to 1, requiring a concrete lining for a distance of half a mile.

On account of an adjustment of grade, and to provide a water cushion at the lower end of the concrete lining, the grade is broken and is partly 0.14 per cent., and partly 0.37 per cent.



Flume Line and Trestle.

At the lower end of the concrete lining is a concrete tank into which the water drops and stills before entering the ditch. The grade of the ditch is 0.14 per cent., or about 7½ feet per mile, the ditch being 5 feet wide at the bottom with 1½ to 1 side slopes, and calculated to run slightly less than 3 feet per second, and to carry 60 c.f.s. with a depth of 2½ feet of water. At rock excavations where steeper slopes occur, the width is 7 feet across the bottom, and at sharp bends compensation in width is allowed for.

The flumes consist of continuous wood staves set up similarly to a continuous wood stave pipe. This design

Inlet to Flume and Waste Gate.

occurred to the writer about 13 years ago, and only after very careful investigation was it adopted for this ditch. The flume is grooved and tongued, dressed to curve or radius and treated with carbolineum before erection. The rods are ⅜-inch diameter and the nuts 50 per cent. longer than the standard size to avoid stripping in tightening up especially under the strain in rounding curves. The ties across the top are of 3-in. x 4-in., set flat and one foot centre to centre. The flume is supported by wooden yokes cut to fit the flume out of 3-in. x 12-in. fir, and set to 6-foot centres. The ties and yokes were dipped in liquid asphalt.

The total length of the flume erected is 8,689 lin. ft. The diameter is 5½ feet; the weight per mile is 199 tons; the staves are 1⅝ inches thick and cut out of 2-in. x 6-in. fir. Turning curves of less than 200 feet radius was found to be difficult, and staves of less width are recommended. The continuous wood-stave flume gives even curvature, very much facilitating the flow of water. The flume was tested to a depth of 2 feet of water with very satisfactory results.

The ends of the flumes are set in concrete structures or headwalls where expansion and contraction is provided for by caulking the joint between the flume and the concrete with tarred unravelled rope or oakum.

At convenient places along the line of the ditch waste gates are provided for use in the event of a washout or accident, and these were usually placed at the entrance to flumes and sometimes in the bank of the ditch. The waste water is led away through a wooden flume to the nearest creek or gully.

At 8 miles from the headgate is Eight Mile Creek, across which the water is carried by an inverted siphon. This is a 27-inch inside diameter riveted steel pipe 1,220 feet long, with a maximum dynamic head of 200 feet, the thickness of the plate being No. 9 I.S.G., or 0.144 inches. The joints are of the Matheson type and leaded.

The grades are generally very steep (in one place 40°) and heavy anchorages of concrete with holding-down rods and shape steel were placed at each bend. The inlets and outlets are concrete tanks provided with gratings and flushing gates.

The difference in elevation between the inlet and outlet is 60 feet.

At 10½ miles below the intake a throwaway is built to keep the ditch clear of a rock slide on Black Mountain and to reduce the unnecessary elevation at this location. The throwaway is 2,000 feet long and drops 300 feet to a tank where part of the water continues northwards through a siphon across a gully to the continuation of the main ditch, that will eventually irrigate to the northern boundary of the company's property in a distance of 7 miles. The balance of the water goes through a siphon 8,879 feet long of various diameters proportional to the water conveyed, the diameters being 18, 14, 12 and 10 inches. The difference in elevation between the inlet and the outlet is 230 feet with a maximum dynamic head of 450 feet. This siphon, as well as Eight Mile Creek siphon, was tested to the full static head.

The pipe is lap-welded steel, made by Stewarts and Lloyds, with leaded joints for pressures up to 350 feet head, and with Drees bolted expansion joints for pressures over 350 feet.

The 18-inch pipe is 6 mm. thick, and the rest of the pipe 5 mm. thick.

This siphon will deliver water to a large area of land on Hepburn Hill. The main delivery from this siphon is from the low point to irrigate about 1,000 acres. In this siphon, as in Eight Mile Creek siphon, concrete anchorages were placed at the bends on the steeper ground.

The laterals are of various types and have still to be built; these will be in concrete where imbedded in the ground. Semi-circular flumes are of wood or galvanized iron or steel where trestle work is necessary, and the siphons are of continuous wood-stave pipe.

A NEW ENGINEERING FOUNDATION.

The United Engineering Society of New York has inaugurated "The Engineering Foundation," a fund to be devoted "to the advancement of engineering arts and sciences in all their branches." Eleven members constitute the Board, nine from the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers; the other two are chosen at large.

An inaugural meeting was held last January in New York, The principal speakers were: Mr. Gano Dunn, President of the United Engineering Society, Past-President of the American Institute of Electrical Engineers; Dr. Henry S. Pritchett, President of the Foundation for the Advancement of Teaching; Dr. Robert W. Hunt, Past-President of the American Institute of Mining Engineers; Dr. Alexander C. Humphreys, Past-President of the American Society of Mechanical Engineers. Standard Designs for Concrete Highway Bridges and Culverts.—C. B. McCullough, Designing Engineer, Iowa State Highway Commission, Ames, Ia. Report of Committee on Standard Specifications for Concrete Highway Bridges and Culverts.—Willis Whited, Chairman.

The growth in the rolling stock of Canada's leading railroads during recent years is shown in the following table:—

	Locomotives.	Freight Cars.	Passenger Cars.
1907	3,504	107,407	3,642
1908	3,872	115,709	4,026
1909	3,969	117,779	4,192
1910	4,079	119,713	4,320
1911	4,219	127,158	4,513
1912	4,484	140,918	4,946
1913	5,119	182,221	5,696

Editorial

THE ENGINEER IN HIGHWAY FINANCING.

In this issue space has been devoted to some of the lectures which the Ontario Office of Public Highways gave last week to its county road superintendents and engineers. One cannot speak too highly of this procedure in view of the fine incentive it creates towards better road-building and maintenance throughout the Province.

There is much to learn about roads. In this connection it is regrettable to state that the public is often disposed to lay upon engineering the blame for practically everything connected with a road scheme, if it goes wrong. It is not always engineering, however, that has been at fault. Many projects have been failures because of mismanagement of finances rather than of defective principle in construction and maintenance. Further, it is not always possible for the engineer's opinion respecting improved grades and proper drainage to prevail against public desire for speedy construction of a superficial nature and over excessive mileages. In such instances, and in others where different factors, such as the selection of materials to be used, enter, engineering is frequently charged with many things that are quite unjust.

The first cost of construction is not the total cost. At last a clearer understanding of this fact is beginning to filter through the maze of vague ideas respecting the building of roads. The tendency is now to consider the cost of highways for a period of years. This is an essential with money raised by bonds issued for a definite period. Undoubtedly the term of the bond should be restricted to the probably useful life of the original type of road under actual conditions. This caution is not always observed by municipalities, and to-day there are many worn-out roads, some of them already renewed, and others sadly in need, while the bonds covering their construction have still years to run.

The total cost of a highway for a term of years involves a study of the nature and volume of the present and increased future traffic, and a comparison of the total probable costs of the kinds of road surfaces best adapted to that traffic. Many items are still lacking for an accurate calculation and actual comparison of different surfaces. It is not generally economical to build a road of cheap first cost and high maintenance charges. This is a consideration that depends upon the local conditions. On the other hand, it is not economical to finance the construction of an expensive surface, under the impression that no provision need be made for maintenance charges during the life of the bonds.

Recent years have brought out a great deal of valuable road information and data. They cannot be too thoroughly studied by municipalities contemplating the issuance of bonds as a method of capitalizing their resources for the purpose of providing funds for road-building. The economic benefits arising from the projected road improvement are not all unmeasurable. It is true that one can hardly estimate in figures in what degree the attendance at church on Sunday mornings will be increased, to what extent business in adjacent towns will be stimulated, or what saving will be realized annually by the automobilist and the user of the motor truck, as a result of the good roads. But there are measurable economic benefits, as the owner of adjoining farm lands will speedily acknowledge. The service rendered by highways radiating from a town may be measured directly by the tonnage hauled over them. Traffic areas, traffic estimates and hauling-cost data are factors susceptible to measurement.

The place of the engineer in investigations of this nature is quite obvious. The location of the roads to be improved should not be determined by argument, but upon sound engineering and economic principles. Before an issue of bonds is decided upon the community should understand thoroughly what roads are to be improved and the approximate cost of their construction and maintenance. It should understand its needs, and should be familiar with carefully prepared maps of the proposed system of improvement. No sum should be voted until it is reasonably known what it will accomplish.

When a commission is appointed, therefore, under whose jurisdiction the bond money will be expended, the next step should be to retain the services of a highway engineer. A recent bulletin issued by the United States Department of Agriculture on the subject of highway bonds has this to say respecting this item in the financing of highways: "In all engineering construction it is customary to allow a certain percentage of the cost for engineering and supervision. There is no reason why highway building should be made an exception to this rule. At least 5 per cent. of the bond issue may well be set aside for engineering and supervision alone. Money spent to hire a competent engineer to make preliminary investigations before bonds are issued and to plan and supervise construction will be well spent. It is not uncommon to find counties that will repeatedly postpone the sale of bonds in order to obtain an increase of 1 per cent. in a bid for $100,000 or less and then proceed to construct the roads in a most haphazard and ill-planned manner."

DECREASED BORROWINGS AND ECONOMICAL MANIPULATION OF MUNICIPAL FINANCES.

The economic effect of the European war upon Canada has made itself felt, more than in anything else, in our borrowings abroad. Canada has been borrowing at the rate of from two to three hundred million dollars annually for some years past. For the six months preceding the war our loans abroad and principally in Great Britain aggregated two hundred million dollars, or over a million dollars a day. This is a subject that was aptly referred to by Hon. W. T. White, Minister of Finance, in his budget speech before the Dominion House a few weeks ago. He pointed out that these borrowings represented the sale of securities by the Federal and Provincial Governments, by municipalities and by railway, public utility, industrial and financial corporations. For the most part the purpose of loans so effected was to provide funds for the construction of public undertakings, works and services, railways and industrial and other plants and establishments. The war at once cut off this stream of borrowed money, and only recently have there been evidences of its resumption upon a greatly reduced scale. Until the war is over and for a considerable period afterwards it is not probable that monetary conditions will permit of the issue of securities, even of the highest character other than for war purposes, in any such volume as that to which we have been accustomed in the past.

"This interruption of the influx of capital has necessarily meant marked curtailment of expenditure upon undertakings, works and buildings in all parts of Canada, with consequent reaction upon the industries, trades and businesses furnishing material and supplies therefor. The result has been a material slackening of general constructional activity, considerable unemployment and attendant diminished buying power on the part of the community. Commercial houses are exercising prudence in commitments, and the public generally are practising economy, that is to say, they are buying less, both of domestic and imported produce."

TOWN PLANNING.

A summary of what municipalities can do in the interests of town planning during the present inactive stage of development is given by the Commission of Conservation as follows:—

1. Map and Survey.—Prepare map of existing conditions in city or town and environs, showing areas already built upon, and physical features.

Enquire into existing conditions as regards industrial development and location, transportation, housing, distribution of population, defects of by-law administration, local improvements, building lines, width of streets, air space, heights of buildings, etc.

2. Town Planning Scheme.—Prepare skeleton map showing main arterial roads and suggestions regarding transportation facilities, zone map of industrial and residential areas, building lines on existing and proposed streets, open spaces, sites of civic and educational centres and other general proposals—without consideration of detailed development of sub-divisions.

Prepare scheme of provisions setting out the regulations under which it is proposed to carry out the plan, the principles on which it is proposed to fix building lines, height and character of buildings, widths of streets for different purposes, proportion of areas occupied by buildings, air space in houses, etc.

Before the second step is taken enabling legislation should be secured from the Provincial Parliament on the lines proposed in the Draft Town Planning Act of the Commission of Conservation. The first step should be taken forthwith by all municipalities and the work done will be good investment apart from town planning.

SELLING TO ENGINEERS.

Engineers, large contractors and manufacturers are nearly always skilled buyers. Their training and experience have taught them to disregard the catch phrases, the best-in-the-world and the finest-ever-produced kind of claims, and to look further and more keenly into the merits of the material or machinery which they purchase.

That is why the men who have things to sell to readers of technical papers are, slowly but surely, beginning to realize the greater effectiveness of the type of advertising that reasons why,—not necessarily argumentative advertising, but "copy" that is interesting, educative, of value, well worth reading.

"Advertising is simply giving information about my business," said one of the leading American manufacturers recently, "and the more information I can give about my business to the men to whom I want to sell, the better it will be for me; because, as they appreciate more what my ideals are in this business, when they know better what the name of my house stands for in service, in up-to-date machinery and methods, and in quality of raw materials the larger my business will become."

A large number of Canadian advertisers are now using this kind of "printed salesmanship," as they call it, writing advertisements that will be found instructive, interesting and useful. Good samples of the "reason-why" type of advertising may be found in the splendid new series of advertisements of The Northern Electric Co., and in many of the advertisements of The Eugene Phillips Electrical Works, The Asphalt & Supply Co., Ideal Incinerator and Contracting Co., Canadian Ingersoll-Rand Co., Canadian H. W. Johns-Manville Co., Creosoted Block Paving Co., De Laval Steam Turbine Co., Barber Asphalt Paving Co., and scores of other leading advertisers in the technical press.

MINING IN ONTARIO IN 1913 AND 1914.

Ontario mines made a good showing in 1914. Production was not quite as large as 1913, but development work in 1915 will likely see big increases. The silver mining industry, while showing a falling off in production and profits, is in a fairly satisfactory condition. Especially noteworthy in the record of 1914 is the improved condition of the gold mining industry in Ontario.

In spite of the large output there has been, during the year, a large addition made to the known nickel ore reserves in the Sudbury district.

Gold.—In 1913, Porcupine produced 207,583 ozs., of gold, valued at $4,250,000. In 1914, the production was 270,000 ozs., valued at $5,750,000. A large production in 1915 is to be expected. War should not retard operations at the gold mines that have reached a self-sustaining position. The demand for gold is increased, not decreased, by present conditions.

Silver.—A decrease in the production of silver in Ontario during the year was expected. The output of 1913 was 29,724,931 ozs., valued at $28,350,000. The output in 1914 was less by 4,500,000 ozs., and is valued at $23,850,000. In August the market for silver practically disappeared and several mines were closed down. The 1915 output depends largely on the price of the metal. We hope for an advance.

Nickel and Copper.—The Sudbury district has made important additions to its nickel-copper ore resources. Recent prospecting and exploration work has resulted in the discovery of large bodies of ore. The matte output for the year contained 22,000 tons of nickel. In 1913 there was smeltered in the Sudbury district 823,403 tons of ore which produced 47,150 tons of matte. The nickel contents amounted to 24,388 tons valued in the matte at $5,237,477.

Dividends.—The dividends paid by Ontario gold and silver companies in 1914 and previously amounted to $52,015,475 at the end of 1913, and in 1914 to $8,349,809.

No steel reinforcement should be painted or oiled, as either treatment will lessen the adhesion of the concrete. No grease or foreign matter of any kind should ever come in contact with the steel.

THE ECONOMIES OF A MANUFACTURING PLANT.

THE profitable manufacture of articles of commerce in any locality depends on the demand, local and more distant, and the price at which the articles can be disposed of, locally and elsewhere, to meet successfully the competition of other manufacturers. It does, therefore, appear that the undertaking of any manufacture must rest upon a purely economical basis from the very inception of the undertaking, through all its stages, from the planning, location and cost of plant; its size and internal arrangement; shop and office management; management of sales and general executive management, curtailed more or less by the board of directors in their judicial and advisory capacity; and also by the stockholders, who may be compared to the legislature, as, after all is said and done, they control the purse; and what is more, furnish the sinews of war. An interesting review of how natural resources and the human element enter so deeply into successful, profitable manufacturing as to vitally affect the products of manufacture is given in the Journal of the Association of Engineering Societies, by Mr. J. S. Branne, consulting engineer, New York City. We abstract the following from his paper:—

Profitable manufacturing, depending fundamentally on the laws of economics, is thus contingent on an indefinite number of conditions requiring much knowledge and experience, and hence rest basically on the personality of the management from top to bottom, from centre to circumference.

The undertaking of any kind of manufacturing is primarily dependent on a demand, but also qualified, sometimes very much, by an evolutionary process, demanding some altered kind of article, its form based on improvement over present articles in the market, its contents at the same time not deteriorating, but often improved; as in the manufacture of more economic tools and machines, developed by thought and experience; or in food products so treated as to permit storage, long shipments or subjected to processes making the raw material yield more and better nourishment, or again called forth by new discoveries, or applying materials in ways not hitherto thought of, as shown in the extended use of reinforced concrete by combining the compressive strength of concrete with the tensile strength of steel; this stimulating the cement industry and the manufacture of certain steel products. These considerations will gradually renew old plants and create new ones where the latest and best tools and appliances can be provided, and in the right place. Profitable manufacturing then, the demand being assured, will depend on economy in raw materials, fabrication and sale.

Economy in Raw Materials.—This will involve the geographical location of the plant, taking into account the location of the raw materials, and this will naturally tend to locate factories treating all primary products of the forest, farm and mine as near as such materials as dictated by shipping facilities by land or water; the bulk and weight of raw materials greatly exceeding the finished product. Tariff regulations must be considered in connection with finished product and field of demand. Continuity of demand, together with shipping facilities, will influence the size of the plant and permanence of appliances and buildings. The climatic conditions may curtail the available supply at times and may necessitate storage at convenient distance and free from such interruptions, that the manufacture may be continuous.

Economy in Fabrication.—This will depend on the personality of the management and subordinates, this item governing in a great measure all the others, making them at times wholly subordinate. The cost or lease of land will favor the small city or rural community, where instances occur of gift of lease or even permanent property right to land, that an active industry may react an the general property of the community.

On the other hand, the rural location will involve expenditures for building roads, sewers, and providing water, the last item being of no small importance. Again, factory sites for certain industries may be wholly impracticable, either owing to space requirements or to restrictions imposed for the general welfare of a densely populated community or industries that may be somewhat of a nuisance due to noxious odors, smoke, excessive and continuous noises or general unsightliness of plant. Thus steel and iron works, coke ovens, cement plants, packing houses, saw mills are generally rural, or on the outskirts of cities. The tendency is to locate manufacturing plants which are necessarily odorous, noisy or unsightly outside the cities, that workers may get away from them after working hours. The buildings cost more in the cities, quite generally, owing to the scarcity of land which necessitates taller buildings. And, being taller, a higher grade of buildings for the safety of human life in case of fire; whereas the low building can spread out horizontally and give easy exit even with slow burning construction.

The arrangement and capacities of tools and appliances to gain the desirable end of economical manufacturing is another way of expressing the end to be kept constantly in view in the general and detailed planning of the plant. And not only the present needs but future probable needs are involved, affecting general arrangement and general appliances more, individual tools less. This foresight, so invaluable for every working day, is illustrated by the setting aside space in the yard as well as in the factories, for additional appliances for the furnishing of light, heat and power; for loading and unloading materials; providing space and even initial installation of freight elevators, travelling cranes; making the capacities of these latter greater than now required; thus also in carrying capacities of floors; headroom; for making entire ends or sides of buildings of a cheaper construction for temporary use; in buying outside light, heat and power for factories of shorter probable life or of small capacity. Economy depending on least work to obtain a good article must plan for efficient tools and least distance from receipt of raw materials to shipping platform, or storage house, or yard. A straight line arrangement is not always feasible, nor may it be desirable even if it were so, as there is a certain parallelity of operations at certain stages, subdividing one stage before the next one can be reached.

The outcome of this is a series of parallel buildings of varying length and location, with a main artery, so to speak, taking in the raw material and delivering the finished product; the parallel buildings being contiguous, or close together, and having all facilities of transportation from any one to another.

As to the buildings themselves, their kind will be predicated, first, upon the nature of the manufacturing; second, upon the geographical and community location; third, upon the temporary or permanent uses they must serve. These three conditions are co-ordinate.

The nature of the manufacturing, giving its first expression in the general planning, determines the kind of materials that may be used without suffering rapid decay; and that must have the strength to support loads imposed by raw materials, machinery, finished products, appliances for intercommunication, as travelling cranes, industrial railways; by snow and wind.

The geographical and community location further eliminates materials more expensive than others, while no more durable. The lower type of building (rural) may use wood, the city building may not economically select this material, but confine itself to steel, brick, concrete; being taller and requiring more fire protection, and larger loads on the supports. Again, the geographical location, disregarding community, will be the determinator, according to materials available, and their relative prices.

The temporary or permanent uses will determine the general qualities quite largely, of the materials, and is a highly important consideration. Sometimes a combination of the two may co-exist, as already stated under general planning and foresight. Clearly, less durable materials may be used; but even in the constructions avowedly temporary it may be well to consider whether some fundamental portion should not be of a more durable type, as many a small and tentative beginning has developed into a permanency.

Nor is the planning of the buildings complete before the economic working conditions of the human machines are considered. Looking aside from sociological conditions as ably treated by others, the engineer or architect can look after some items, wholly indispensable for economical working conditions, and comprised generally under the heads of light, heat, general hygiene and protection from fire. The light and general hygiene make for factory location in the country by a large margin. There should be plenty of windows, to admit light, and they should be movable, to afford ventilation. Windows as well as skylights should be of a material giving diffused, not direct sunlight, and have wire mesh to minimize risk from adjacent fire, or falling skylight glass.

While window ventilation will do very well for industries of a cleanly and odorless kind, the ventilation may be aided largely by some active type of ventilators on the roof, which with a slow movement of outside air help to draw the air about. But in factories employing either a great number of workers in a small space, or necessarily accompanied by noxious gases, or ill-smelling odors, a real fan blowing system should be used, in conjunction with the heating system; for no person can work well in foul air, which lowers vitality, numbs an active mind and sets at naught the intrinsic economy of the best planned shop and the finest tools.

What has been said about ventilation may include heat in this way, that whatever system is used, fresh air must be supplied in abundance. The hot air system seems to furnish both heat and fresh air, and deserves a full study in all cases.

Under hygiene may be mentioned the advisability of modern sanitary toilet and wash rooms; and in all economically planned factories of to-day this is given consideration as inculcating good habits and bodily comfort.

Protection from fire is fortunately receiving more attention from day to day. It is not always possible to eliminate inflammable materials as they may form the raw materials or the finished product. But the factory can be made fireproof, and this can be effected only by having incombustible materials of construction and ample exits, at a definite location, of easy access and stairs easy of descent. The definite location is of high importance, as the panicky fear numbs the sense of location except that it be deeply rooted in the mind.

That the exit or exits shall be ample sized comes next; that doors may open outwards; that the junctions of stairs meeting at successive floor levels may widen out and allow lower floor tenants to break into the crowd rushing down; and finally that the grade of descent may not be steep enough to cause stumbling. All narrow winding steps should be eliminated.

Based on the above conceptions two general exit types may be suggested, an inside stairs or an outside, but it must be, in either case, wholly closed by incombustible materials. There are advantages and dangers in both. The advantages of the inner stairs are worth study. The sense location which is almost wholly gone in a panic, instinctively turns to it, (the inner stairs) it is the regular building stairway; everybody knows where it is. The automatically closing door at each floor should be characteristically denoted as by a vivid coloring or inscription. This stairway, or these stairways, as the case may be, terminate in the general hallway, always fireproof—right outside is the street and safety. The disadvantage of this automatically closed (at each floor) wholly incombustible stairway, which must be easy of access, familiar of location, easy of descent, ample of proportion, safe at its base as to street exit through the familiar general entrance hall, traversed every day, is that doors at the various floors may be smashed or left open, admitting smoke, maybe flames.

If we consider the outside stairs, this must likewise be essentially the same as the inner, same case of descent, etc., etc., and will terminate at its base in a court or on the sidewalk. That it may fill with smoke or flame for the same reasons as before stated, seems evident. The advantages and safety in automatic sprinklers are so well understood that nothing needs be said but to commend them. Only we must be sure that the standpipe has water in it. Fire drills are advisable, and in tall (city) factories, absolutely necessary.

Interest and taxes are both apt to be higher in the city, from cost of land, cost of buildings, etc., thus favoring the smaller city, or rural location. Light, heat and power may cost less in the city for small plants. Some of the large companies furnishing these commodities have made lower rates recently. The country location, at some special place where water power is cheap, may be more economical, but this commodity is now quite rare, in the majority of states, at a low rate. For steam-making a soft coal may be used in the country, but hardly ever in the city, due to hygienic reasons.

The disposal of by-products in almost every industry has developed so much that it is now a distinct item of economy, and must be practiced where possible. Metal scrap is remelted; saw dust is used in lining ice houses; textile waste becomes paper; parts of animal waste tissue and soft bone becomes glue, and so on, in a most surprising way. And this is rightly becoming more and more recognized, as the natural resources of the country grow smaller and smaller, strict economy must be practiced.

Economy in Sales.—This would appear to mean getting as large a return as possible on the manufactured product. Assuming a good sales department that can dispose of articles at a fair price, it is seen that the economy in the raw materials and fabrication now enables the sales department to compete with other sellers, taking away the handicap of high cost. Of course, the articles do not sell automatically, so to speak; but the highly important human agency of sales manager, sales agents and travelling salesmen now take hold aided by economy in raw materials and fabrication and their own talents, quite well understood, together with some external agencies of sales economy.

The field of demand may be local, state, national, or world-wide, requiring adequate shipping facilities and storage at home and elsewhere. In local distribution, the evolution of horse trucking into automobile trucks, is becoming a great aid; as also for suburban and interurban shipments. In state or nation wide and even foreign shipments the freight rates, continuity of transit and tariff enter the problem. The continuity of transit will exclude the northern waterways at certain periods; a stable as well as staple article, however, will overcome this handicap; the factory can keep on running, the goods can be stored until shipment can be made; the article is a staple and finds a ready sale. However, if the article is not a staple one, sales must follow manufacture quickly, and water rates, however low, are unavailable.

Articles destined for foreign countries with a fluctuating or uncertain tariff, must be disposed of quickly. Reciprocity treaties now in force or pending will help overcome this in part. The quantities shipped at one time is an important factor in freight rates, large quantities making for economy in almost all ways.

PERSONAL.

J. D. McBEATH, assistant engineer, city of Medicine Hat, has tendered his resignation, to be effective at the end of March.

R. O. WYNNE-ROBERTS, consulting engineer to the city of Regina, has tendered his resignation, to take effect on May 31st next.

R. B. PYPER, of the engineering staff of the city of Medicine Hat, becomes acting city engineer this week, when Mr. A. K. Grimmer withdraws from office.

A. W. CHARLES, for some years chief draftsman for the Anaconda Copper Mining Co., Butte, Mont., has been appointed chief draftsman for the Canadian Copper Co. at Copper Cliff.

J. E. A. MOORE and V. G. MARANI, graduates of '91 and '93, respectively, of the School of Practical Science, Toronto, have established a consulting, civil and mechanical engineering firm in Cleveland, Ohio.

G. A. McLEOD, engineer for Foley Bros., Welch and Stewart, on the first unit of the Halifax Ocean Terminals, delivered an address on "Accounting" before the Nova Scotia Society of Engineers last week.

E. G. M. CAPE, president of E. G. M. Cape and Co., Ltd., engineers and contractors, Montreal, and a major in the 21st Battery, Montreal, is at present taking a special military course at the R.M.C., Kingston.

W. SANFORD EVANS, chairman of the Georgian Bay Canal Commission, addressed the Ottawa Branch of the Canadian Society of Civil Engineers on February 25th, his subject being "Economic Conditions Governing Transportation in Canada."

WILLIAM NEWMAN, Naval Architect for the Polson Iron Works and Shipbuilding Co., Toronto, has received a lieutenant's commission in the Twenty-third Regiment, Northern Pioneers, Owen Sound. Lieut. Newman has already held the rank of N.C.O. in the Fourteenth Prince of Wales' Own Rifles and in the Forty-eighth Highlanders.

FRANK DARLING, architect, Toronto, has been nominated by the Royal Institute of Architects as candidate to receive the King's Gold Medal, an honor granted annually to the most distinguished architect in any country by His Majesty. The presentation will likely be made in June.

W. G. MILLER, LL.D., provincial geologist of Ontario, has been awarded the gold medal of the Institution of Mining and Metallurgy, London, England. Dr. Miller is the first Canadian resident to receive this distinction and is the second geologist to receive this recognition for eminent service.

TORONTO BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

A large attendance at the meeting of the Toronto Branch on February 25th heard an interesting address by Mr. W. McNab, principal assistant engineer of the Grand Trunk Railway System, his subject being the construction of the Grand Trunk Pacific Railway.

The meeting was presided over by Mr. A. F. Stewart, of the Canadian Northern Railway, and chairman of the Branch last year, Mr. J. R. W. Ambrose, of the Toronto Terminal Co., and chairman this year, being absent from the city.

The reading of correspondence included a letter from Hon. W. J. Hanna, Provincial Secretary of Ontario, asking for the views of the Branch as to how far farm bridges should be included in the cost of drainage under the Drainage Act. A committee consisting of Messrs. Wilkie, Oliver and Barber was appointed to deal with the matter.

Mr. McNab's address was preceded by the presentation of a motion picture of the completion of track-laying on the Grand Trunk Pacific Railway. The scenes clearly illustrated the placing of ties and rails and the handling of equipment generally in the closing-in of the G.T.P. The meeting of the east and west track-laying gangs in the final spurt was very spectacular. Other views showed development work at Prince Rupert and the arrival of the first train at the Pacific terminal. The exhibition of the picture before the Toronto Branch of the Society marked its first public presentation.

In his address, which was illustrated throughout by a large number of lantern views, Mr. McNab reviewed Canada's entrance upon her great era of development. He was encouragingly optimistic in his forecast of twentieth century expansion. Substantial reasons were cited for the remarkable development in transportation facilities. The speaker mentioned in a very interesting way an instance which dates back to 1846, when it took a letter 1½ years to come from Fort McLaughlin, on the Pacific coast, to a point not fifty miles from Toronto.

Railway construction in Canada had its start between the years 1853-56 as a result of the Guarantee Act of 1849. The speaker referred with considerable pride to the evolutionary process in location, construction, maintenance and operation by which the Grand Trunk Railway worked out its own experience, sometimes even at a high price. He recalled the stage of development when steel was a very expensive material, which induced the G.T.R. to experiment with steel top rails—a head fitting over the webb of the rail. The development in steel rail manufacture from that time up to the present was traced in brief. Bridge construction was another topic concerning which the speaker made some very interesting remarks. Some of the bridge structures on the G.T.R. had been renewed three times, due entirely to the subjection of heavier loads. It was stated that the roadbed itself had been constructed so substantially at the outset as to have been found to amply answer the requirements of subsequent development in this respect.

The gauge originally adopted was 5 ft. 6 in., while for the most part United States roads were gauged 4 ft. 8½ inches. This caused considerable inconvenience at international points, and resulted in the laying of a third rail on several portions of the line. In 1872 it was decided to change the gauge of the G.T.R. This was done in three sections, and in such a way as to affect traffic but little.

During the past sixteen years it has been the policy of the system to eliminate steep grades and sharp curvatures. This work was commented upon to some extent by the speaker.

The Grand Trunk Pacific has been linked up from Moncton, N.B., to Prince Rupert, B.C., a distance of about 3,550 miles, with the exception of the Quebec bridge. Branches will extend this total to 5,000 miles. Mr. McNab referred briefly to the permanent nature of construction, to the motive power and rolling stock.

The lantern slides included views of early construction and operation, among which might be mentioned a view of the first train in Canada. This view had been taken in 1836 on the line from La Prairie, Quebec, to St. John's, Que. Others pointed out the characteristic features of earlier and modern types of locomotives. Views of elevators, trestles and bridges, including the Saskatoon, Clover Bar and Battle River bridges were given, together with many views of picturesque scenery along the line.

A hearty vote of thanks was extended to the speaker upon the motion of Mr. Speight, seconded by Mr. Loudon. The attendance at the meeting was in the neighborhood of 150.

CANADIAN SOCIETY OF CIVIL ENGINEERS.

A meeting of the general section of the Society was held in Montreal on February 18th. Mr. R. De L. French read a paper by Mr. A. C. D. Blanchard on the Lethbridge Sewage Disposal Works. The paper, which was illustrated by slides, dealt with the design, construction and maintenance of the plant. An abstract of this paper appeared in *The Canadian Engineer* for January 28th, 1914.

An informal talk, illustrated by lantern slides, was given by Col. L. R. Johnson, the subject being "Heavy Guns Used in the Field."

UNIVERSITY OF MANITOBA ENGINEERING HONOR ROLL.

The Canadian forces at the front or on the way include the following, who were students or graduates of the engineering course in the University of Manitoba: Cameron, F. C., 1912, 2nd Contingent, Engineers, 2nd Field Troop; Mitchell, C. N., 1912, 2nd Contingent, Engineers, 2nd Field Troop; Shanks, G. L., 1912, 2nd Contingent, Engineers, 2nd Field Troop; Taunton, A. J., 1912, 3rd Contingent, 100th Regiment; Urie, H. R., 1913, 1st Contingent, Engineers, 3rd Field Troop; Collins, W. S., 1914, 1st Contingent, Engineers, 3rd Field Troop; Jones, W. H., 1914, 2nd Contingent, Engineers, 2nd Field Troop; Richardson, W. H., 1914, 2nd Contingent, Engineers, 2nd Field Troop; Tait, V., 1914, 1st Contingent, Engineers, 2nd Field Troop; Hicks, E. D., 1916, 2nd Contingent, Princess Patricia Volunteers; Levinson, H., 1917, 2nd Contingent, Engineers, 2nd Field Troop; Mitchel, J. C., 1917, 2nd Contingent, 106th Regiment; Murphy, J. W., 1917, 2nd Contingent, 106th Regiment; Stevenson, R. L., 1917, 1st Contingent, Engineers, 2nd Field Troop; Wootton, F. E., 1917, 2nd Contingent, 13th Field Battery; Leathers, J. F., 1918, 2nd Contingent, 13th Field Battery.

DEGREES FOR MEN IN SERVICE.

Last week a special convocation of the University of Toronto was held for the granting of degrees to a number of its men about to leave for the front. These included the degree of B.A.Sc., granted to the following fourth year men of the Faculty of Applied Science and Engineering: F. D. Austin, Royal Canadian Engineers, now in training at Lansdowne Park, Ottawa; N. H. Daniel, Cycle Corps, now training at Exhibition Grounds, Toronto; W. E. Lockhart, Royal Canadian Engineers, Ottawa; W. B. Redman, Royal Canadian Engineers, Ottawa, and L. B. Tillson, Eaton Battery, Exhibition Grounds, Toronto.

COMING MEETINGS.

ANNUAL CONVENTION SASKATCHEWAN RURAL MUNICIPALITIES' ASSOCIATION.—To be held in Saskatoon, March 10th, 11th, and 12th. Secretary-Treasurer, E. Hingley, Regina.

CANADIAN MINING INSTITUTE.—Seventeenth annual meeting, to be held in Toronto, March 3rd, 4th and 5th. Secretary, H. Mortimer-Lamb, Ritz-Carlton Hotel, Montreal.

AMERICAN RAILWAY ENGINEERING ASSOCIATION.—Annual meeting to be held in Chicago, March 16th to 18th, 1915. Secretary, E. H. Fritch, 900 South Michigan Avenue, Chicago.

CANADIAN AND INTERNATIONAL GOOD ROADS CONGRESS.—Second Annual Convention, Toronto, March 22 to 26, 1915. Secretary, Geo. A. McNamee, Dominion Good Roads Association, Montreal.

TORONTO ELECTRICAL SHOW.—The second annual exhibition, to be held in the Arena, Toronto, April 12th to 17th. Secretary, Mr. E. M. Wilcox, 62 Temperance Street, Toronto.

AMERICAN WATERWORKS ASSOCIATION.—The 35th annual convention, to be held in Cincinnati, Ohio, May 10th to 14th, 1915. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.

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

NEW INCORPORATIONS.

Prince Albert, Sask.—The Harphill Building, Limited, $25,000.

Regina, Sask.—O. W. Smith Construction and Engineering Co., Limited, $10,000.

Montreal, Que.—The Crushed Stone Co. Limited, $20,000. C. E. Vigneault, L. Bergeron, T. Richard.

Lucknow, Ont.—The Sepoy Manufacturing Co., Limited, $20,000. F. Tait, W. G. Andrew, G. H. Smith.

Orillia, Ont.—The Orillia Hardware Company, Limited, $40,000. S. L. Mullett, W. B. Wright, D. W. Elder.

Doon, Ont.—The Dominion Fibre Company, Limited, $40,000. M. J. Huber, H. V. Huber, Viola V. Huber.

Vancouver, B.C.—Vancouver Shingle Mills, Limited, $10,000. British Columbia Shingle Co., Limited, $100,000.

Ottawa, Ont.—The Canadian Brown Scientific Tube and Accessories, Limited, $50,000. J. A. Brennan, D. E. Winter, W. J. Wallace.