PAGES

MISSING

Volume 30. Toronto, March 30, 1916. Contents of this issue on page 5.

The Canadian Engineer

A weekly paper for Canadian civil engineers and contractors

STRACHAN AVENUE BRIDGE, TORONTO

DESCRIPTION OF A BRIDGE IN WHICH THE DESIGN OF THE FLOOR SYSTEM PRESENTS SOME NEW FEATURES.

By E. M. PROCTOR, B.A.Sc.,
Structural Designer, Railway and Bridge Section, Department of Works, City of Toronto.

THE Strachan Avenue bridge is over the Grand Trunk Railway, Toronto-Hamilton line, at the foot of Strachan Avenue, Toronto. This bridge replaces an old timber truss bridge which was completely worn out. There are several points in the design of the structure which may be of interest.

The bridge is a through plate girder type with a reinforced concrete floor and has all members below the floor encased in concrete. The abutments are 92 ft. 4½ ins. face to face of back walls and the bridge is 57 ft. 6 ins. centre to centre of handrails. There are two roadways 18 ft. 3 ins. curb to curb, and two 6-ft. (in the clear) sidewalks. The girders are 21 ft. 9 ins. centre to centre. The loading specifications (Fig. 2) are the Standard City of Toronto Class A. Provision was made in the steelwork for future possible street railway traffic, but no rails were laid.

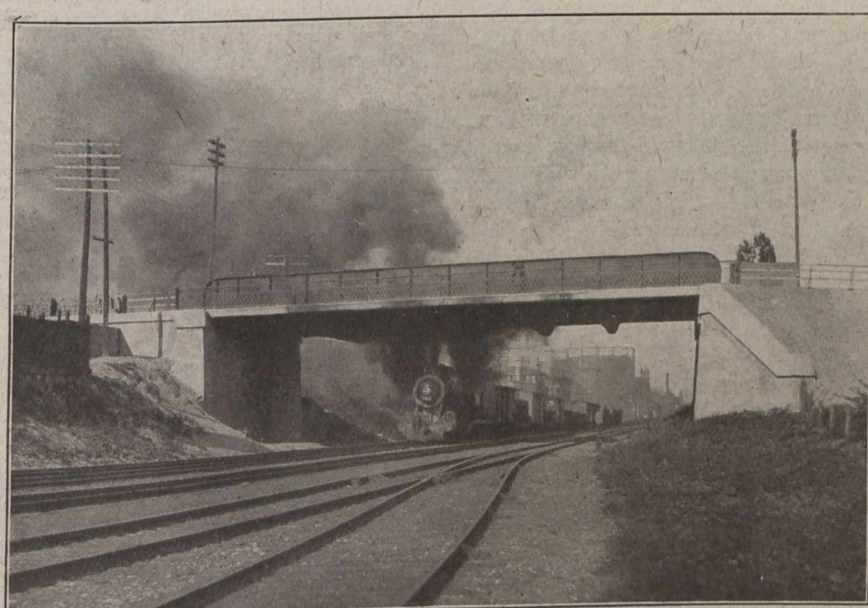

Fig. 1.—General View of Bridge, Looking East.

In a bridge of this type it is a difficult matter to obtain anything but a plain appearance. However, there are several features which very much improve the appearance and do not add very materially to the cost of the bridge. The 16-inch panelled facia girder along the front and the ornamental handrail (Fig. 9) both help in this respect. Fig. 1 shows a general view of the bridge, looking east.

The old timber bridge had head room clearance of 19 ft. 1 in. and space for four tracks. The new bridge gives a head room of 22 ft. 6 ins. and space for six tracks. This increase in height and width necessitated the raising of the grade on Strachan Avenue about 7 ft. at the north end of the bridge. On account of possible land damages, it was essential that this elevation of grade (on Strachan Avenue) should be kept to a minimum. To obtain this, a suspended floor beam type of floor was decided upon, with which it was possible to design a floor 2 ft. 3 ins. from top of paving to underside of floor. This type is only permissible where the tracks below are definitely located. The floor beams are placed so as to come centrally between tracks. This arrangement can be clearly seen in several of the accompanying views.

Fig. 3 shows clearly the structural details of the floor beam. The end connection angles rivet to a web plate which projects down through the bottom flange plates of the girder (Fig. 4), the notch allows for the outstanding flange of the girder and the holes in the gusset plate connect to a 7″ x 3½″ x ½″ stiffener angle on the girder. The stringers bear on the brackets shown on the web of the floor beam and for added general stiffness are also connected to the web with a pair of clip angles.

The centre girder, which weighs 36½ tons, is made up of a web plate 120″ x ⅜″ and flanges as follows: Two L's 8″ x 8″ x ¾″ with four 20″ x 11/16″ cover plates on top flange and two 20″ x ¾″ and two 20″ x 11/16″ cover plates on the bottom flange. The added section in the bottom flange takes the place of the section lost by cutting holes in the cover plates for the webs that carry the floor beams (Fig. 4). The outer girder, which weighs 26½ tons, is made up of a web 96″ x ⅜″ and flange of two L's 8″ x 8″ x ¾″ with two 18″ x ⅝″ and one 18″ x ½″ cover plates on the top flange and three 18″ x ⅝″ cover plates on the bottom flange.

The girders bear on cast steel bed plates. At the expansion end the sliding takes place between two phosphor bronze plates, one inset into the shoe plate and the other into the bed plate. Fig. 5 shows a view of the top of one of the bed plates and illustrates how the inset is machined. A groove on each side is first planed across the casting and then the casting is turned on the plane and the space between the grooves is planed out.

The phosphor bronze plates were shipped loose and were put in place just before the girder was lowered into position. Some time would be saved in the field if a couple

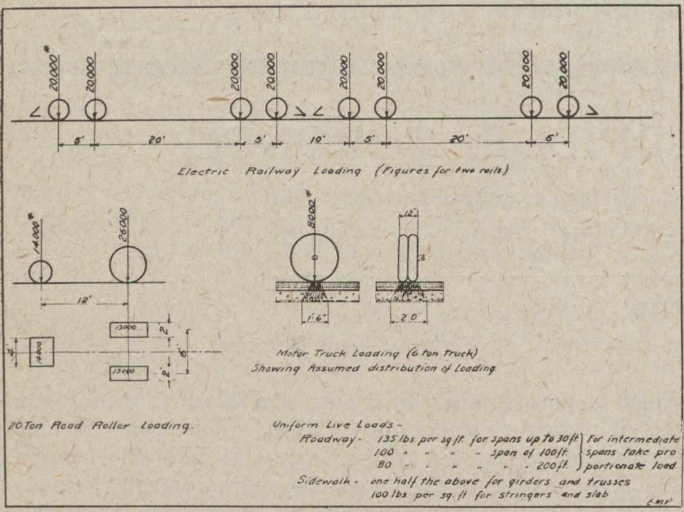

Fig. 2.—Standard Loading Specification, City of Toronto.

of field countersunk tap screws were put in each plate in order to hold them in place during erection.

Fig. 6 shows the method used in the erection of the girders. A gallows frame was erected over one of the tracks and the girders were lifted from the flat cars and then swung into place. By reason of the fact that it was impossible to place the gallows frame in the centre of the span on account of the layout of the railroad tracks, some means had to be adopted to properly balance the girders as they were being lifted. For the first girder, two boxes of steel punchings were used as a counterweight (Fig. 6) but in the other two girders the locomotive crane was

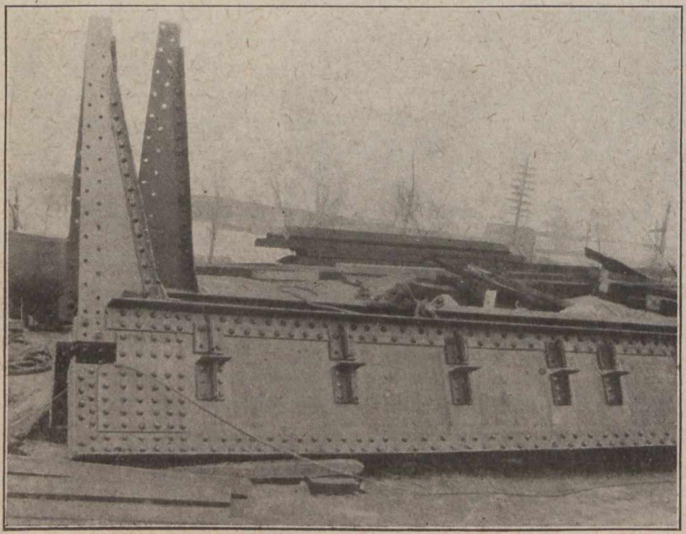
Fig. 3.—Floor Beam.

used to keep the balance by taking a lift on the long end of the girder. This was found to be a much quicker method. The hoisting power was supplied by a steam hoisting engine and a locomotive. The erection was carried out without interrupting traffic on the railroad.

The steel encased in concrete was not painted; the other steel was given a shop coat of paint, made up of 25 lbs. pure red lead to one gallon pure boiled oil. Two coats of paint were applied in the field, the specifications for their composition being as follows: 220 lbs. of pure lampblack ground in pure raw linseed oil (the proportion of lampblack by weight shall be not less than 25 per cent. nor more than 30 per cent. of the mixture); 49 gallons

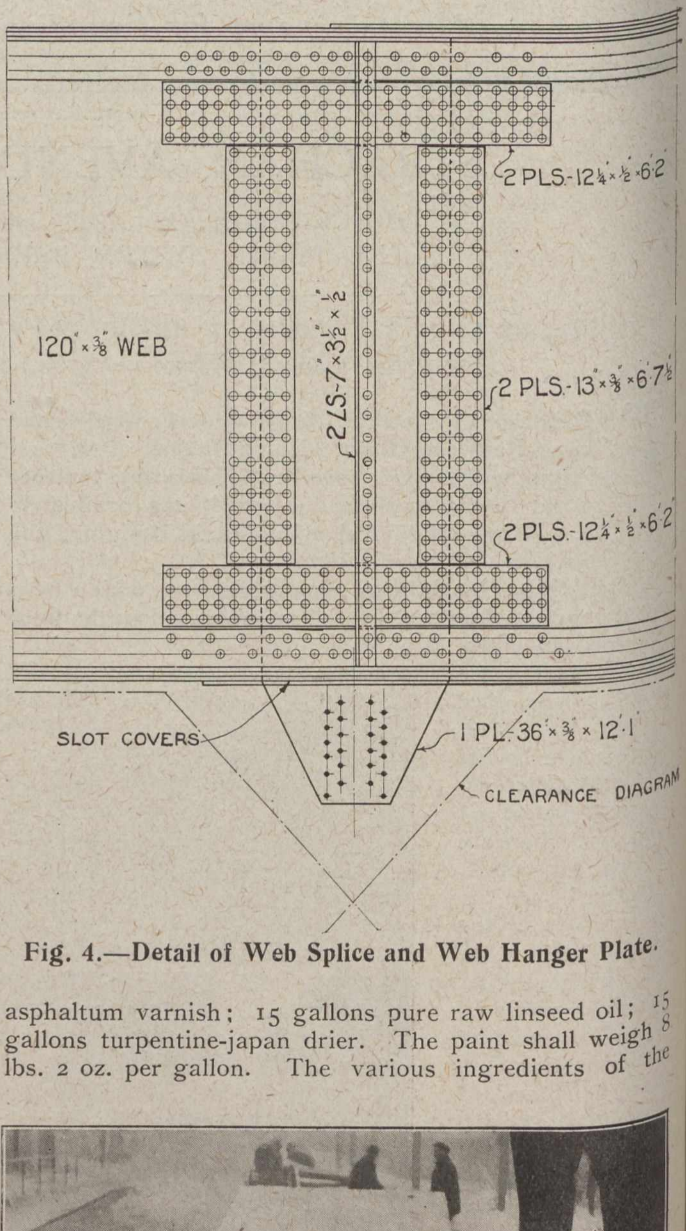

Fig. 4.—Detail of Web Splice and Web Hanger Plate.

asphaltum varnish; 15 gallons pure raw linseed oil; 15 gallons turpentine-japan drier. The paint shall weigh 8 lbs. 2 oz. per gallon. The various ingredients of the


Fig. 5.—Cast Steel Bed Plate, Showing Inset for Bronze Plate.

asphaltum varnish and turpentine-japan drier were carefully specified.

The floor of the bridge is supported on a 7-inch reinforced concrete slab. The pavement is 4-inch creosoted wood block laid on a ½-inch mortar bed. The slab is waterproofed as follows: First, the surface of the concrete slab was thoroughly cleaned and given a coating of hot

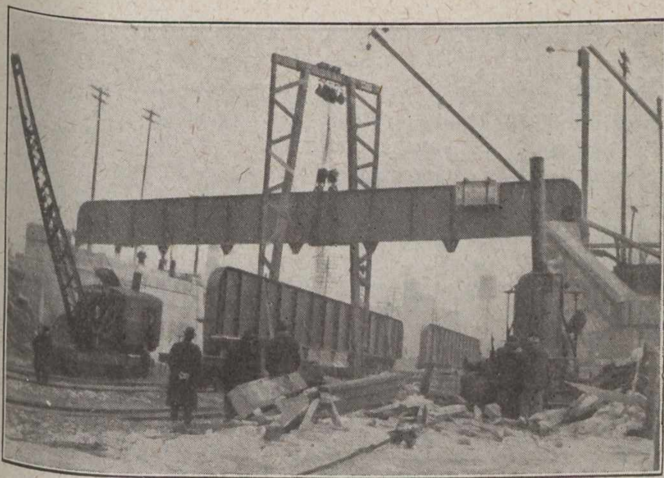

Fig. 6.—Erection of Girder.

asphalt; on this was laid two ply of 8-oz. burlap and then two ply heavy asphalt felt, each layer being well swabbed on with hot asphalt. These fabrics were laid in alternate layers and in such a manner as to permit the layers to break joints and be free from folds or pockets. On top of this was laid a layer of building paper and then 1¼ inches of asphalt mastic. The building paper was used in order to avoid injury to the waterproofing by the hot mastic.

As stated before, all the stringers, floor beams, sidewalk brackets and a portion of the girders are encased in concrete. Square twisted steel was used as reinforcement and No. 2-13-15 expanded metal for beam wrapping. Fig. 7 shows the cross-section of the floor. The hollow terra-cotta tile shown are used for the purpose of decreasing the dead load on the girders. The load taken off the centre girder by this means amounts to 7 square inches of flange section which is quite an item in a heavy girder. The cost of this tile work, in place, is slightly cheaper than concrete. The total dead load taken off the bridge by this means is estimated at 200,000 lbs.

Two factors governed the design of the abutments; first, bedrock is 13 feet below base of rail, and second, the main Garrison Creek storm overflow sewer runs under the abutment. This sewer is 12 feet wide outside and

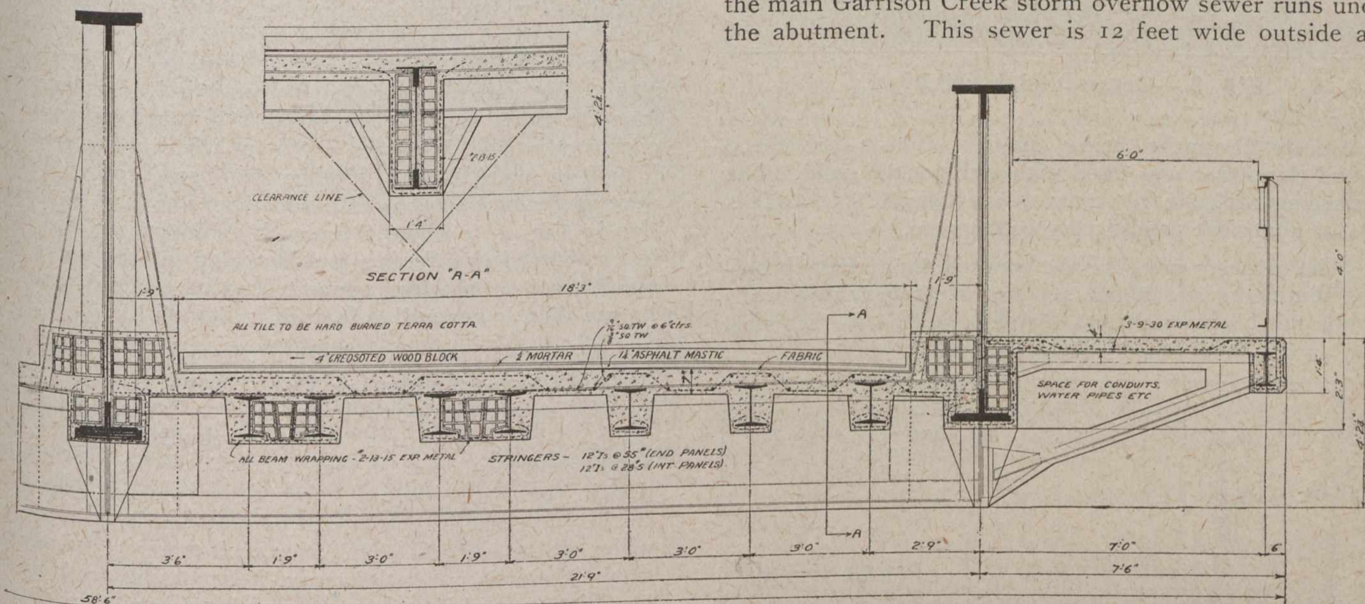

Fig. 7.—Cross-section of Floor.

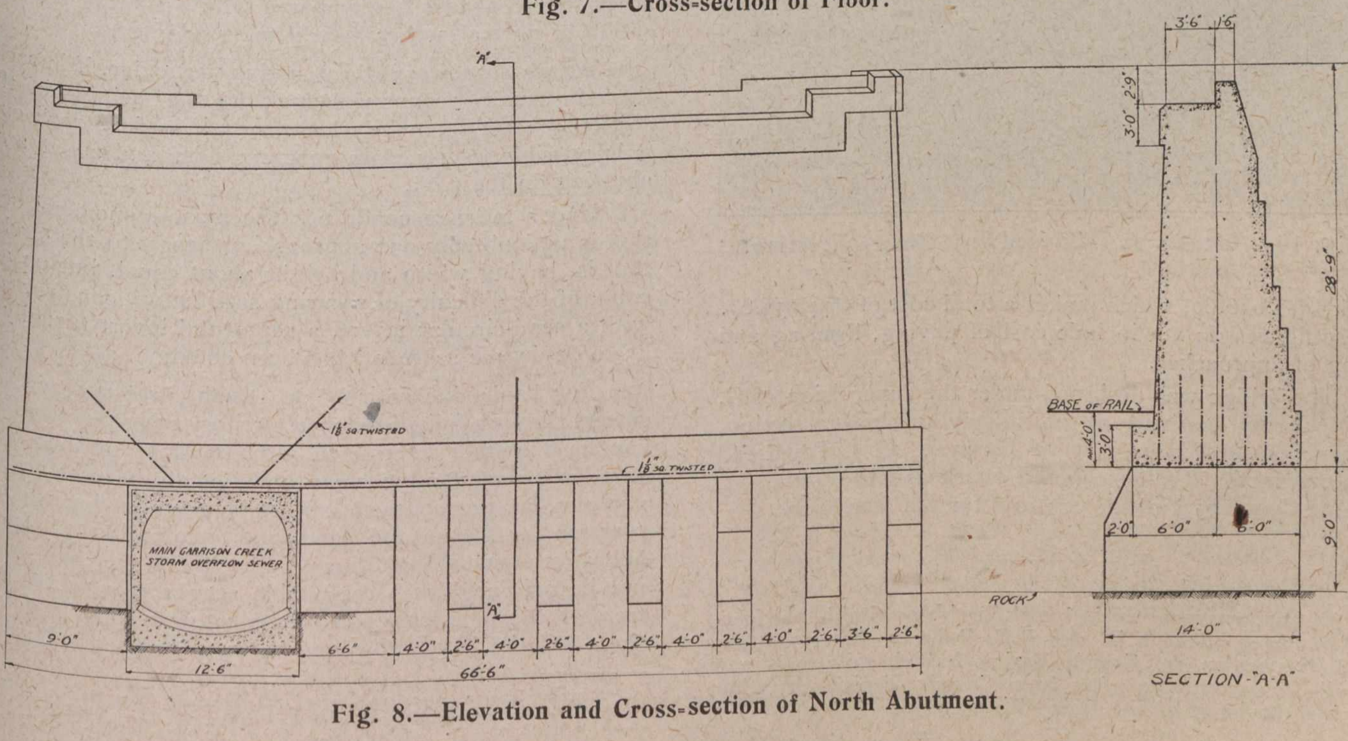

Fig. 8.—Elevation and Cross-section of North Abutment.

rests on the rock. The type of abutment decided upon was a gravity section resting upon 30-inch walls at 6-ft. 6-in. centres carried down to rock and having the main wall reinforced to carry over the sewer. Fig. 8 shows the elevation and a cross-section of the north abutment;

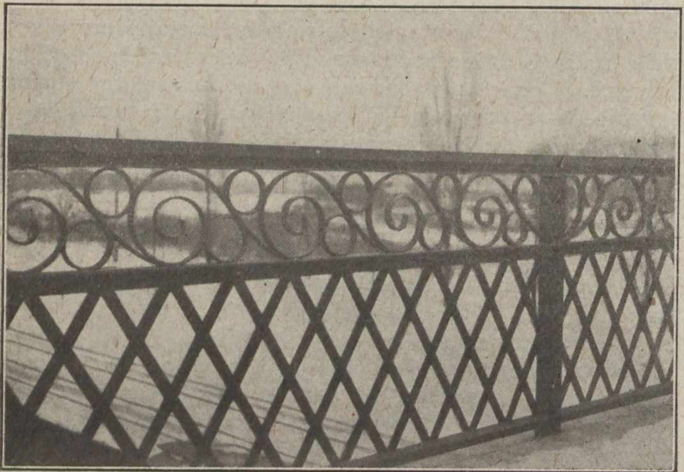

Fig. 9.—Ornamental Handrailing.

the south abutment being similar. The 2-inch space around the sewer was filled with well-packed sand. The reinforcing rods are 1⅛-inch square twisted steel. This type of abutment proved very economical.

The contract price for the concrete floor, waterproofing, abutments and about 400 lin. ft. of retaining walls for the north approach was $33,206.38, and for the steel

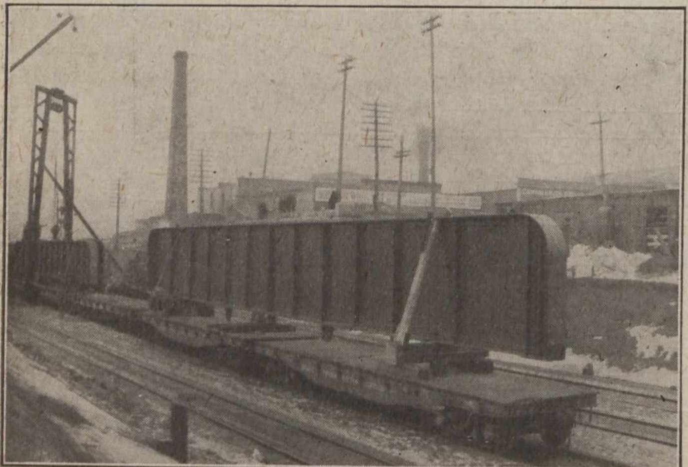

Fig. 10.—Girders as Delivered Just Before Erection.

work, $11,046.69, which makes a total cost of $44,253.07. These figures do not include cost of paving, lighting and filling of approaches.

The bridge was designed under the supervision of G. A. McCarthy, engineer of the railway and bridge section, Department of Works, City of Toronto. C. J. Townsend was contractor for the concrete work and the Dominion Bridge Company had the contract for the steel work.

An announcement made by W. Rathbone Smith, the general manager of the E.D. and B.C. Railway, states that the head of steel on the Grande Prairie branch railway is now at mile 40, or only 10 miles from Grande Prairie city, thus tapping the heart of the Peace River district.

REINFORCED CONCRETE IN SEWERS.*

ABOUT the year 1900 reinforced concrete had been taken up in many fields of construction and applied to long-span arches, and the advantages of its use in sewer construction were soon appreciated. During the next five years, many examples of concrete sewers are found, although with a few exceptions the reinforcement consisted of wire mesh or expanded metal and there was an evident tendency on the part of the majority of engineers to use rather heavy sections similar to the plain masonry types. A few examples are also found of extremely radical designs involving very light sections heavily reinforced. These two extremes suggest the difference between the sewer engineer adapting his designs to reinforced work and the concrete expert breaking into the sewer field. In the last 10 years, all of these ideas have been through the melting pot, and we are beginning to find certain standard types of reinforced concrete sewers used generally. These are the horseshoe type varying in proportions from the semi-circular to those of about equal height and width, and the elliptical, usually constructed as a five-centered arch. Of exceptional advantage under certain conditions the box or slab section is often employed, but under average conditions it is less economical than the other types. The circular sewer is difficult to construct in what is known as "monolithic" work, that is, if built in place, but the circular reinforced concrete pipe developed along other lines has become standard construction in size up to about 8 feet. It is unit work and may be considered as a factory product, and for that reason a much more satisfactory concrete can be secured through its use than is generally obtained in monolithic work.

In many cases, the shape of the sewer will be controlled by local conditions. In wet ground the invert must be kept as high as possible and a broad, shallow section results. For such cases the semi-circular shape is the most economical, and, in fact, is about the limit of distortion in that direction, as computations show that little further decrease in height can be obtained by adopting a wider, flat segmental arch. For such extremes where the semi-circular is not satisfactory, it is possible to design a box section, and if necessary, a multiple box, though this latter should always be compared with a similar multiplication of normal arches before being adopted.

Where the sewer is deep, and in particular, if in rock, there is usually economy in making the heights of the section greater than the widths, and if in deep rock cut, it is possible to use plain concrete sides and a flat arch abutting on the rock.

Under average conditions the most economical section is undoubtedly one approaching nearly to the circle; that is, having width and height about equal, but on account of the difficulty of securing satisfactory construction with a semi-circular invert, a segmental invert (usually a 45 to 60-degree segment) has been common.

For loads due entirely to earth pressure and for sewers through fully developed territory where the loading can be definitely determined, arch sections of the semi-elliptical or similar types can undoubtedly be used to advantage, as the concrete can be worked in direct compression for the normal load and reinforcing put in to allow for unusual conditions. But where the loads cannot be predicted with reasonable accuracy or where extreme loads of opposite character must be provided for, there will be little difference between the semi-elliptical

*Extracts from a paper read before the American Concrete Institute by W. W. Horner, Engineer Board of Public Service, St. Louis, Mo.

and semi-circular sections, and there is undoubtedly a prejudice in favor of the latter.

The great advantage of the reinforced arch for use in sewer construction lies in the economy in material. In large sizes, 8 feet or over, the reinforced concrete sewer requires only from 60 to 80 per cent. as much masonry as the "gravity" type. Also, where the amount of concrete per foot is sufficient to warrant an efficient plant, the unit cost of the concrete should be somewhat less than that of good brick masonry. In addition to the saving in masonry, there is usually an accompanying difference in excavation, and in deep work this may be a material consideration. Finally, there may reasonably be a difference in required size of sewer due to the greater smoothness of good concrete work, which amounts to between 5 and 10 per cent. reduction in mean diameter.

There can be no question that reinforced concrete is the natural engineering solution for the problem of large sewers. If reasonably designed and carefully constructed, it gives the best and cheapest sewer. In the hands of a designer not thoroughly familiar with the conditions surrounding sewer construction and maintenance, or of a contractor not experienced in reinforced concrete work, it is likely to be a dangerous material and it is a much too common occurrence that work is handled under just these conditions. The fact that many of these sewers are built by contractors whose whole experience has been with massive masonry, has not tended to add to the safety of the finished work.

When the excavation is complete, the invert is concreted. In rock or in dry ground, this can be done efficiently, but if water or mud is present, a portion of the concrete is sure to be unsatisfactory. With very bad bottoms, it is often necessary to place a raft of extra concrete and allow it to set before attempting to place reinforcement. If such conditions appear possible, good practice will provide for this work in both specifications and estimate and many reasonably provide for underdrains to relieve the new concrete of damage from water flowing from the trench ahead. Unless the specifications are to provide that the work is to be expensively delayed, it should be noted that there will be quite an amount of working over and across the new invert while the concrete is setting and exposed bars left for splicing are likely to be bent and jarred and their bond value in the invert concrete decreased. Also, because of these stub bars, it is usually impracticable to protect that portion of the invert from dirt and rubbish. While it is generally the custom to leave the sides of the invert rough to furnish a bond with the arch, it is an open question whether the finishing of this concrete smooth is not the lesser evil, as it can then be thoroughly and efficiently cleaned before additional concrete is laid.

Before the arch forms are set, it is necessary to remove cross bracing up to the crown level, and it must be replaced with verticals bedded in the new invert and cross-braced above the crown. Even with the most careful work, this will produce some disturbance with the sides of the trench and may even allow a bulging of the side plank enough to protrude within the neat measurements of the sewer. To widen and rebrace the section from the surface down may be expensive and hazardous as well as disorganizing, and the engineer often faces the problem of modifying the section instead. Instances can be recalled where the contractors have even asked permission to fill the whole trench to the top of the sewer with concrete at their own expense, rather than to attempt the re-excavation, and the construction engineer must be able to decide whether the deficiency in thickness at the sides can be compensated in this manner.

Collapsible steel forms are usually favored for the arch, and if kept well cleaned and oiled, produce the best interior surface, but well-made wooden centres carefully planned will result in more satisfactory work. The choice will usually depend on the contractor's organization and schedule, as greater progress with one outfit can be secured if the collapsible forms are used.

Under the conditions prevalent in this work, the setting and holding of the arch reinforcement in accurate position is especially difficult and the importance of accuracy is rarely appreciated by foreman and laborer. When properly set, the rods are difficult to hold during concreting, as it is often necessary for the men to stand on the reinforcing while spading the concrete. The cost of special chairs or holders for the reinforcement is usually well warranted.

The placing of the concrete is made especially difficult because of the double mat of reinforcing bars, which tend to break up the stream of concrete and to cause a separating out of the aggregate. The concrete is also likely to be lowered in quality by an almost unavoidable leakage of water. The concrete is also contaminated to some extent by earth and rubbish knocked from the surface into the forms. There occurs, also, even in the best regulated work, certain small slips of earth from between the side planking, and it is possible that portions of the clay or loam may be churned into the concrete before it can be cleaned out from the tangle of reinforcement.

In view of the unavoidable construction contingencies inherent in this class of work, the writer would recommend to the designer the following prescription:

1. Use the best grade of concrete and considerable excess of mortar.

2. Do not work concrete at more than 450 pounds, unless the construction conditions are to be exceptionally favorable.

3. The concrete cover outside of the steel should be at least 2 inches.

4. Use a minimum thickness of concrete of about 9 inches unless the work is close to the surface, or is to be built under very favorable conditions, and increase this minimum and also the cover over the steel if the conditions are likely to be very unfavorable.

5. Specify the setting of the reinforcement with especially designed holders. These might be made of cast iron and left in the concrete.

6. If there is any possibility that the trench will be very wet or mucky, provide for a sub-base of concrete and provide means of keeping the trench work away from the work if possible.

7. To secure a concrete that will flow into place with the least assistance, a specification for a 2½ or a 3-minute mix should be seriously considered, as might also the use of hydrated lime. This would naturally result also in a denser and more waterproof concrete and might be a very considerable factor in prolonging the life of the reinforcement.

8. Provide for a lining of vitrified brick for the invert, or at least provide an excess internal area to allow for such a lining at some later date. This is of more importance in maintenance than in construction, as under average conditions it is easier to obtain a reasonably smooth invert with the brick than to attempt to finish the concrete itself.

9. Specify cold weather methods. Concrete can be placed satisfactorily and economically at even a zero tem-

perature, if proper precautions are taken. It should be noted, however, that it is quite easy to over-heat the finished concrete and to drive out a portion of the water.

In the St. Louis work, it has been customary to heat the water by turning exhaust steam into the water tank whenever the temperature goes below 40 degrees or whenever there is frost in the materials. In colder weather, steam coils are used in the sand storage piles and often in the piles of coarse aggregate. It is also customary in freezing weather to place salamanders inside the arches and to hang tarpaulins at each end of the unit constructed. The top of the sewer has generally been protected by a covering of tarpaulin or plank, on top of which manure is piled.

The loads to be considered are: First, direct weight of the earth filling; second, horizontal or inclined pressures induced by the weight of this filling and the adjoining earth; third, pressures due to transmitted surface loads.

The relative values of these pressures will depend on the depth and size of the sewer and on the use to which the ground surface may be put.

Vertical Loads.—It is always safe and usually reasonable to design for vertical loads equal to the full weight of the superimposed earth. Recent investigations of small sewers and pipes have shown that, due to some arching action of the earth itself, the full dead weight is not always applied to the sewer. The allowable reduction, however, seems to be of little importance until the depth of the fill is at least equal to the width of the trench and would only amount to about 25 per cent. when this depth is twice the width. The work of Marston and Anderson indicates that for depths of 10 to 15 times the width, only 30 to 40 per cent. of the load is carried by the sewer. For a sewer more than 8 feet in width, the depth of cover will rarely exceed twice the trench width, so that the reductions are hardly worth taking into account. There must also be reasonable doubt whether the gradual settlement does not finally increase the weight on the sewers considerably above the values given.

Horizontal Pressure.—There is so much doubt as to the correct values of horizontal pressures even for a given soil condition, and the pressures will vary so greatly in the different soils that the designer can only attempt to make a safe guess at the correct amounts to be used.

According to Rankin's theory, the intensity of horizontal pressure cannot be less than one-third of the intensity of vertical pressure for a particular depth and in ordinary clay it is customary to consider it as one-half of the vertical. For saturated ground, the earth will approach the condition of a fluid and the horizontal and vertical pressures would be equal.

Surface Loads.—Where sewers are constructed in city streets, the heaviest surface load would be the weight of a road roller, and this might be taken as 15 tons on an area of 5 square feet, at the surface, distributed downward along an angle of 30 degrees with a vertical. At a depth of 10 feet this would approximately be equal to 200 pounds per square foot on an area of 11 x 15 feet, or roughly equivalent to an additional 2 feet of fill. If there are railroads crossing the line of the sewer, or if it seems at all possible that such roads may be built, the sewer should be designed for locomotive loading in the same way. A fair value for this loading would be 80 tons on an area of 10 x 20 feet at the surface. Distributed as above, this would be equivalent to about 300 pounds per square foot over an area of 20 x 30 feet, at a 10-foot depth and would give the same pressure as 3 feet of additional fill.

For very light covers, these values would, of course, be increased, and it might even be reasonable to provide for impact, but for depths of cover for 6 feet, or more, it is usually satisfactory to treat such loads as additional weight of earth and allow them to increase both the vertical and the horizontal pressures. Allowance for foundations and for piles of material may be handled in the same manner.

Combination of Loading.—For final conditions, that is, after the backfill has reached a state of settled equilibrium, the sewer will be subject to a direct combination of horizontal and vertical pressures. It should be noted that the greatest bending moments in the arch will be due to vertical loads alone. Horizontal pressures usually induce moments of the opposite kind. The combination of vertical and horizontal pressures, therefore, while increasing the direct normal compression in the arch, will give smaller bending moments than those from the vertical loads. While the stress in the arch may finally reach the values derived from a proper combination of the two classes of forces, yet it is quite common for the sewer to be subject only to pressure of one kind during the construction period. Examples of this are as follows:

(*a*) A trench is excavated through hard clay which requires little bracing and will stand vertically for some time. The trench is backfilled with the same material. Then the full weight of the backfill may act vertically on the arch for some time before the sides of the trench finally slip and add also a horizontal pressure.

(*b*) In the example above, the sides of the trench may slip in against the sewer before the backfill is placed, producing heavy horizontal pressure and bending moments of reverse character.

(*c*) A trench through soft ground is held by sheet piling. When this piling is pulled there may be an appreciable time before the earth at the sides closes in and fills the void left by the piling. During this time the vertical loads only will act.

(*d*) In the above example, if the sheet piling is drawn before the backfilling is started, the earth at the sides may move in and produce horizontal pressure with very little vertical load.

Loads of these kinds will only occur while the arch is new, possibly before the concrete has attained more than half of its normal strength. If the design contains a factor of safety of four for combination of pressures, and the concrete is only 10 or 15 days old, the arch would be about on the point of failure for vertical loads.

It would seem, therefore, that the design should provide for vertical loads alone, or at least in combination with a very small horizontal pressure on the arch only (not against vertical side walls). This loading will be critical and from it the dimensions of the concrete and one set of reinforcements will be determined. The arch so determined should then be designed for horizontal pressure in combination with as little vertical loads as may seem possible. From this the reverse reinforcement may be calculated. Finally, it is of interest to compute the stresses under normal combination of the two.

The simplest case of arch design occurs when the sewer is built in a rock cut. In this instance, that portion above the rock may be taken as an arch with fixed ends, provided that the reinforcement extends well below the rock level. Where the sewer rests on rock or other incompressible material, the arch may still be treated as fixed, if sufficient mass is given to the invert to resist the overturning moment in the side walls.

If the sewer is constructed in soft or compressible soil, the whole section, including the invert, should be treated as an elastic bent beam and the loading must include an upward pressure on the invert equal to the total vertical load.

A number of methods have been published for the analysis of the elastic arch. Of these the simplest is that presented in Green's "Trusses and Arches." Professor Green worked out bending moments in the parabolic arch for unit loads. He also presented constants for the semi-circular arch. Green's constants for the semi-circular arch have been extended by Mr. A. E. Lindau (Trans. Am. Soc. C.E., Volume 51), and put into the same tabular form as was originally given for the parabolic arch. Green's analysis is based on a constant ring thickness. It is not correct for the usual case in which the arch increases in thickness from crown to springing line and some idea of the error involved is given in Lindau's paper. Although inaccurate, this method is very convenient, in that by its use we are able to calculate moments directly from the loading without the previous assumption of an arch thickness. For the smaller sewers and not for all purposes and where the variation in ring thickness is not great, it is sufficiently accurate.

In the writer's practice, this method has been developed into a set of formulas applicable to the semi-circular arch. These formulas give the moment at each 10-degree point in terms of the mean radius of the arch and of the depth of fill over the crown. In the more important work, these formulas are used in order to determine approximate dimensions for an arch which is later to be analyzed by one of the more accurate methods. As the accurate methods must be applicable to all shapes of arches and variations in thickness, it is impossible to reduce them to any very simple form.

In detailing the arch from the calculated bending moments, it will usually be found advisable to use two full sets of reinforcement, that is, on the inner and outer face. If it were known positively that reverse moments could never occur, for example, if it were impossible in the case of a semi-circular arch that the horizontal force could predominate, it would be reasonable to omit a portion of one set of reinforcement or possibly to cross one set over from the inner to the outer face, but this generally cannot be insured and the full reinforcement should be put in even if only as an added factor of safety and for the sake of standardization. Another reason why the arch cannot be designed too closely is that any particular section, if multiplicity of sections is to be avoided, must be designed for variations of loading over a considerable range.

In the St. Louis work, where a considerable length of one size sewer and fairly constant soil conditions occur, it has been the practice to design a section for each 5 feet in depth of loading and to detail these sections for soft ground foundation, for hard bottom and for deep rock cut. A designer cannot follow too closely the calculated thickness of the arch, as some consideration must be given to the shape of the outside as well as the inside of the sewer. For example, if the sewer is to be built in a trench with vertical sides, it would be found much simpler to make the outside of the sewer vertical to some point above the spring point of the arch rather than to carry a small batter all the way down to the bottom of the sewer. This is because of the fact that it would cost less to fill in the small wedge-shaped space with concrete than to attempt to place and remove outside forms in the limited space available.

There seems to be no uniformity in practice as to the longitudinal reinforcement. A certain amount of steel is usually required in this direction to properly tie in the transverse bars and ½ or ¾-inch bars are often used on about 2-foot sections in both faces. If the sewer is to be constructed in hot weather and particularly in shallow cut, it might be advisable to increase the amount of longitudinal steel in order to distribute shrinkage cracks, but under other conditions this seems hardly necessary as the range of temperatures in the completed sewer is very small, probably varying from about 40 degrees F. in winter to 70 degrees F. in summer, unless steam or hot wastes are permitted to enter.

RELATION OF SPECIFIC GRAVITY TO DEGREES BAUME.

The use of the Baumé scale is a frequent source of annoyance as well as convenience to those engaged in industries in which it is used, more especially in its connection with petroleum products for use in roadwark. The relation between the two scales has been aptly explained by H. W. Bell in "Western Engineering," who says that a natural and common mistake due to the use of Baumé scale is in the mixing of different gravities of oil to obtain a product of certain gravity on the assumption that the Baumé scale is a direct measure of specific gravity. To illustrate: We have 10,000 bbl. of 16° Baumé oil and wish to know the amount of 25° Baumé oil necessary to add to bring the product up to 20° Baumé. The method of solving by proportion, without converting Baumé to specific gravity easily suggests itself, and the result would be as follows: $10{,}000\ (16) + 25A = 20\ (A + 10{,}000)$, and $A = 8{,}000$, the apparent amount to be added. But Baumé gravity is not a direct measure of specific gravity, and specific gravity $= \dfrac{140}{130 + \text{Baumé gravity}}$. The general form of equation would be $A_s\,G_s + A_a\,G_a = G_x\,(A_s + A_a)$, where A_s is amount of oil at the start; A_a is amount to be added; G_s is specific gravity of A_s; G_a is specific gravity of A_a; and G_x is specific gravity of mixture. Further, let B_s, B_a and B_x be the Baumé gravities of the oil to start, oil added, and the mixture, respectively; and putting in terms of Baumé,

$$\frac{140\,A_s}{130 + B_s} + \frac{140\,A_a}{130 + B_a} = \frac{140\,(A_s + A_a)}{130 + B_x}$$

$$\text{Solving, } A_a = \frac{A_s\,(B_x - B_s)\ \ (130 + B_a)}{(B_a - B_x)\ \ (130 + B_s)}$$

Using this formula and solving the given problem, the amount to be added is 8,493 instead of 8,000 bbl. If only 8,000 were added the theoretical gravity would be 19.86°, and it might easily result in refusal of purchaser to accept the shipment as 20° oil.

In the consideration of the effect of water content upon gravities, we know that they are lowered unless the gravity of the pure oil is 10° or less. To show the effect of water on specific gravity of oil mixture we can write the equation $G_o\,(100 - P) + P = 100\,G_m$ and $G_o = \dfrac{100\,G_m - P}{100 - P}$, where G_o is specific gravity of pure oil, G_m is specific gravity of mixture, and P is the percentage of water. Substituting Baumé degrees for specific gravity and letting B_o and B_m equal the Baumé gravities of pure oil and the mixture, respectively, the result is

$$\frac{140}{130 + B_o} = \frac{\dfrac{14{,}000}{130 + B_m} - P}{100 - P}$$

$$\text{Solving, } B_o = \frac{14{,}000\,B_m - 10\,P\,(130 + B_m)}{14{,}000 - P\,(130 + B_m)}$$

MORE ABOUT THE INFILTRATION GALLERY.

THERE has been considerable comment in the technical press recently on the subject of water supply by infiltration galleries. In this connection we are pleased to reprint some observations on this subject made by Alexander Potter, of New York, taken from a discussion printed in the Journal of the New England Waterworks Association for December, 1915. In the course of this discussion Mr. Potter states that the procuring of water supplies by means of infiltration galleries is not common. Even where the use of infiltration galleries promises to yield good results, engineers often hesitate to make use of them because of the many failures recorded, the causes for which either are not understood, or when understood have not been brought to the attention of the engineering profession.

The proper design of an infiltration gallery should not be at all difficult, for the process which takes place in an infiltration gallery is duplicated in nature by the diffused seepage of the underground waters into surface streams. The fundamental laws governing the ground-water flow of surface streams are fairly well understood, and apply with slight modifications to infiltration galleries. They may be stated as follows:—

1. The ground-water stream flow is fixed and limited to the surplus underground waters accumulating and stored in the valley.

2. The rate of seepage varies with the transverse hydraulic slope of the ground-water table and the porosity of the material through which the ground water flows.

3. When the hydraulic slope is not steep enough to discharge the surplus ground waters as fast as they collect in the valley, the ground-water table rises until equilibrium is established, and vice versa if opposite conditions exist.

4. Except as affected by the seasonal changes of the rising and lowering of the ground-water level, the ground-water stream flow is constant.

There is no reason why the seepage of ground water into an infiltration gallery under proper conditions should not be equally as dependable as the identical natural process of ground-water seepage into surface streams.

An infiltration gallery may derive its supply of water from two distinct sources: A supply derived by intercepting the surface underground waters which were under natural conditions joining the surface waters by diffused seepage, and a supply derived by infiltration from bodies of surface waters adjacent to the infiltration gallery. A carefully made scientific investigation will in nearly every case reveal within quite narrow limits the quantity of water available for an infiltration gallery from the two sources above mentioned, and as long as the draft does not exceed the available supply there is no reason why the yield of a properly designed infiltration gallery should gradually decrease with time, as is only too often the case. The recorded failures of infiltration galleries can, in the writer's opinion, be largely attributed to the erroneous assumption that a pipe laid below water level with open joints or perforations and surrounded by a porous material will continue to deliver the volume of flow developed when first constructed, ignoring entirely the fundamental law of supply and demand.

This is not true with infiltration galleries constructed on the floor of an impervious strata intercepting the transverse ground-water flow in a pervious strata of coarse sand immediately above. Under such conditions infiltration galleries have been very successful.

Under conditions other than that just stated, and where the supply appears to be adequate, there is often noted a gradual breaking down of the infiltration gallery, apparently due to the silting up of the filter media immediately surrounding the gallery. Under the natural conditions of ground-water seepage into surface streams no such silting appears to take place, and when such silting up occurs in connection with an infiltration gallery it can only be due to the peculiar ground-water conditions set up by construction of the gallery. Mr. Potter believes that the silting phenomena are primarily due to the high velocities of the ground water through the filter media immediately adjacent to the gallery, velocities so great that the finer particles of soil are transported to the gallery, gradually clogging the interstices in the filtering media and the gallery proper. This phenomenon of clogging is aggravated by the lowering of the ground-water level in the vicinity of the filter gallery below the top of the gallery. For a definite yield, as the wetted perimeter of the gallery decreases, the entrance velocity increases in inverse proportion. To attempt, therefore, to force an infiltration gallery to the extent of lowering the ground-water table below the top of the gallery, will tend to increase the danger from clogging and materially shorten the life of the infiltration gallery, especially when constructed in the finer sands.

With tubular wells, the question of high entrance velocity in the filtering media surrounding the well screen is not of equal importance; wells are comparatively short-lived, and when clogging does occur it can be remedied by back-flushing or other known methods. No such remedies are available for clogged infiltration galleries. When properly designed so that the yield of the gallery does not exceed the supply available from the surplus underground waters and the supply derived by infiltration from a nearby body of surface water, and the entrance velocities are sufficiently low so as not to transport the finest soil particle, the useful life of the infiltration gallery should be practically unlimited.

The yield from an infiltration gallery constructed in the finer sands should be automatically controlled so that it cannot exceed a certain predetermined amount, in order to prevent the lowering of the ground-water plane below the top of the gallery, so as to keep the entrance velocities within safe limits. This condition can best be secured by restricting the flow from the gallery to an amount which will keep the gallery constantly full of water for its entire length.

In many cases the requirements as outlined herein will for a given yield call for the construction of much longer lines of infiltration galleries, constructed in finer sands than has been the practice in the past, so that in many instances other methods of supply will be found to be more economical. Throughout the country, however, deposits of gravel and sand exist in the valleys of rivers and along lakes and seacoasts, in which infiltration galleries can be economically constructed to yield adequate supplies either from the surplus underground waters or from the water derived by infiltration from adjacent natural and artificial bodies of water, or from both sources.

In tropical countries, where there exists so strong a prejudice against the use of stored surface water for a public water supply, due to the deterioration resulting from the luxuriant vegetable growth abounding in such waters, the use of an infiltration gallery is often advisable. The natural purification which takes place in the water while passing from the surface reservoir to the infiltration gallery has been found to be effective.

CREOSOTE WOOD BLOCK PAVEMENTS.*

By Andrew F. Macallum, B.A.Sc., C.E.

FOR a number of years untreated wood block pavements were laid in this country and the United States, and after repeated failures attention was directed to the use of preservatives. The first experiments made simply placed thoroughly dried blocks in a bath of creosote heated to a temperature of about 210° F. until about three pounds per cubic foot of creosote had been absorbed.

While these pavements were fairly successful, it was soon realized that the best results could not be secured by dipping the blocks, and the blocks were then treated with creosote under pressure until they absorbed from ten to twelve pounds of oil per cubic foot. Such a pavement laid in Indianapolis in 1898 gave such good results that city engineers began to appreciate the possibilities of treated wooden blocks and better results were obtained.

On Tremont Street, in Boston, a wood block pavement treated with creo-resinate process composed of one-half creosote oil and one-half resin, was laid in 1898. The writer saw this pavement about a year ago and it was still in good condition after sixteen years of heavy traffic.

A small piece of similarly treated wood block was laid on the west side of Yonge Street, Toronto, at Front Street, opposite the head office of the Bank of Montreal in 1896, and was still in good condition when taken up for a new pavement about two years ago. The writer also examined such pavements in New York on Church and Warren Streets after they had been in use for nine years under the heaviest kind of traffic and they were still in good condition. In the city of Hamilton probably more treated wood block pavements have been laid than in any other city in Canada and the first pavements laid in 1909 are as good as when laid, and although subjected to the heaviest traffic in that manufacturing city have not, to date, cost a cent for maintenance.

These examples which I have mentioned are but a few of the numerous examples showing permanence and suitability of this form of pavement for streets carrying heavy traffic.

I may also say that it has also been laid on residential streets where the residents assume its greater cost to asphalt for the added comfort through its quietness under traffic.

The wood principally used has been long-leaf (yellow) southern pine, which, from experience, has been found to give excellent results. Most specifications now, however, admit Norway pine and tamarac as a result of experimental pavements laid in Minneapolis, which showed the suitability of these woods. No doubt other species of wood make satisfactory pavements, but on account of the incomplete knowledge of their value as paving blocks, city engineers, as a rule, prefer a wood that has proved satisfactory.

The blocks are from three to four inches wide and vary in depth from 3 to 4½ inches, with a length of from 5 to 10 inches. The depth of blocks should not vary more than 1/16 of an inch for a given size. As for all timber specifications, the blocks should be sound, free from large or loose knots, shakes, worm holes and other similar defects.

The annual rings are usually specified as to average not less than six to the inch and the blocks to average 80% of heart wood or one block not to have less than 50% heart wood.

*A paper read at the 3rd Canadian and International Good Roads Congress.

The preservative used is usually a pure coal tar product free from petroleum oil or its products having a specific gravity of 1.10. Water gas tars have not proven satisfactory and should not be used.

The writer has been corresponding with a number of city engineers with a view of obtaining opinions as to the most satisfactory amount of treatment required per cubic foot of block according to the experience of each city, and in replies from twenty cities in the United States, has ascertained that six of these cities use 16 pounds, two of them 18 pounds, and twelve of them 20 pounds, depending to some extent on local conditions.

The percentage of treatment will vary with the block as the denser and heavier the block the smaller is the quality of oil which it absorbs. The sapwood will absorb a large percentage of the oil, but if the block has not had the moisture first removed from the sapwood the oil will not be able to penetrate. Thus it is invariably found that a block which fails does so in the sapwood and the cause is insufficient amount of oil or poor penetration of the sapwood.

Laying the Pavement.—The base for wood block pavements should be of concrete from five to six inches deep, having the crown parallel to the finished crown on the blocks. An uneven or irregular base is detrimental to any pavement as it is liable to cause a depression in the surface to hold water which the repeated impacts of wagon wheels is certain to increase, giving an uneven surface. Upon this concrete base is placed either a sand or mortar cushion, usually one inch deep with its surface struck by templates to a surface parallel to the contour of the finished pavement. Where sand is used the sand is such that it will all pass through a ¼-inch screen, besides being clean. If a mortar cushion be used, some engineers use a proportion of one of cement to three of clean sand, to which sufficient water is added to insure the proper setting of the cement, while other engineers obtain good results by mixing and placing the cement and sand dry. This cushion is simply a means of securing a uniform surface for the blocks to rest upon and distribute the load. Alongside or between street car tracks, however, or on grades, sand cushions are apt to become uneven or flow, caused by the vibration of the rails or by water getting in alongside the rails, so that under these circumstances a concrete cushion should be used. Away from the car tracks the question of whether a sand or mortar cushion should be used is a matter of opinion. Sand gives a better cushioning effect and the blocks do not have to be rolled so soon after laying as when a mortar cushion is used, but the present tendency seems to favor a mortar cushion.

European practice does away with this cushion altogether, but the concrete base is finished off as smooth as a concrete sidewalk and to the exact contour of the surface of the pavement. This extra care and workmanship obtains results that are excellent in as much as the finished surface of the blocks have no depressions and consequently the wheels cause no impacts.

In most cities it is not possible to lay the blocks shortly after coming out of the treating plant and the hot sun and wind during shipment and before laying is apt to check the blocks and cause oil to exude. The blocks should be piled closely when delivered on the street and sprinkled or dipped in water before laying.

Generally the blocks are laid at right angles with the curbs with an expansion joint at each curb of from three-quarters to an inch and a half, according to the width of the pavement. Alongside the curbs three rows of block are laid parallel to the curbs with the expansion joint next to the curb. Placing a longitudinal row of blocks with an expansion joint on each side is sometimes done, but is not good practice, as the single row of blocks between the joints will almost certainly rise up about the level of the adjoining pavement as the joints close up. Cross expansion joints have been used also by the writer when the treated block used had been piled on a street for several months, but for fresh blocks properly treated they are not necessary on streets of heavy traffic. On streets of light traffic, however, there should be cross expansion joints placed from 30 to 50 feet apart and having a width of about three-quarters of an inch. It is hardly necessary to say that the blocks should be laid with the grain vertical and having the joints in adjacent rows, broken by a lap of about two inches. The blocks should be laid neither too loose nor too tight, so that a block can be raised without disturbing the surrounding blocks, or one-eighth of an inch apart.

After the pavement is laid it should be rolled thoroughly with a roller varying from three to five tons until a perfect surface has been secured with no depressions and the blocks firmly in place. There should be no difficulty in this, as the usual specification for blocks allows of a variation of but one-sixteenth of an inch in depth so that if the foundation and cushion have been properly laid there is usually very little trouble about depth of the blocks.

Alongside street railway tracks and about manholes, special care should be taken in laying the blocks. It is usual in such cases to thicken the cushion so that the blocks shall be about one-quarter of an inch above the wearing surface of the rail or cover, and in a very short time the traffic will rub these blocks down to the level of the rail. Alongside rails to prevent water flowing down and under the blocks two methods are used: one is to place specially cut creosoted plank under the rail head to give a vertical surface against which the blocks are paved and the second and usual method is to plaster the web with a rich mixture of sand and cement to the width of the rail head and the blocks are then laid against this. As with other pavements, it has been found that the girder lip rail is more satisfactory than the ordinary T-rail, unfortunately in use in most towns, for the permanence of the block on the inside or gauge side of the rail. Incidentally, it may be said that no pavement will be satisfactory alongside a street railway track if the rails lack sufficient weight, stiffness and foundation to prevent movement, especially at the joints.

There is diversity of opinion among engineers as to the best joint filler to be used. The American Society of Municipal Improvements, of which the writer has the honor of being president, recommend a suitable bituminous filler when the blocks are laid upon a sand cushion and a sand filler when laid on a mortar cushion. It is claimed for the bituminous filler, which fills the joints between the blocks two-thirds their depth (the remaining depth filled with sand) that it makes an absolutely waterproof pavement, and that it eliminates all expansion difficulties as such block is surrounded with an individual expansion joint. Unless the filler is a suitable asphaltic cement with a high melting point and low penetration, there is apt to be a sticky surplus left on the surface. This filler will cost about 15 cents per square yard more than a sand filler.

A cement grout filler has been used, but unless the traffic can be kept off the pavement for at least 10 days it is little better than a sand filler.

The sand filler is generally used on streets of heavy traffic; the sand being coarse and sharp-grained, and preferably heated before placing. The writer has used with excellent results a bituminous filler between and one foot outside of street railway tracks and a sand filler to the curb where three rows are again treated with a bituminous filler. From results obtained he does not consider the extra expense in using bituminous filler justified for such streets unless the traffic be very light. On bridge floors it is better practice to use a bituminous filler with the blocks. After the pavement is rolled, sand to the depth of about a quarter of an inch is spread over the surface and the street is thrown open to traffic.

This method of construction is satisfactory up to a 3 per cent. grade, beyond which the blocks are laid in a different manner. The crown should be as light as possible, being just sufficient to shed the water freely, which applies also to the pavements between street railway tracks.

When the grade of a proposed pavement exceeds 3 per cent. the question of a suitable pavement, and the method to be adopted in laying it, to meet the requirements of the traffic, becomes of interest. With the variability of conditions to be met with due to our climatic changes the limits of most paving material is soon reached, so far as the inclination of grade is concerned, unless specially manufactured.

The writer inquired from twenty-four cities to ascertain the maximum grades upon which creosoted wood block had been laid and found that one city had laid this pavement on a 7 per cent. grade, one on 6 per cent., three on 5 per cent., and five on 3 per cent. grades. The 5 to 7 per cent. pavements were laid under two methods, described below.

The first method used was probably originated in this city and was used on upper James Street with the block pavement laid there in 1909 on a 5½ per cent. grade. Each block had a piece one-half inch in width and one-half inch in depth, cut off one face so that when the blocks were laid at right angles to the centre line of the street there was a space of a half inch between each row of blocks, giving a good foothold for the horse-drawn traffic. These blocks were pitch filled and the cross grade of the street was sufficient to drain out any water.

The same method was adopted on King Street West in this city, during the same year, and I may say that both of these pavements have been very successful in meeting the conditions of heavy traffic on two of our main streets without a cent being spent for repairs or renewals since being laid.

The special cutting of the blocks in the manner described added considerably to the cost of the pavement, and to obviate this the ordinary rectangular block was used with creosoted laths ⅜ in. x 2 ins. laid between each cross row of blocks. This was pitch filled, as in the first method, and has been just as successful, being to-day in first-class condition, although subjected to fairly heavy traffic for four years.

On Ravenscliffe Avenue, a purely residential street, having a 6 per cent. grade, blocks spaced in this manner were laid. The reason for putting such a pavement on a street like this, having very little traffic, was that the residents insisted on a creosoted wooden block pavement because of its quietness as compared with other pavements suitable for such a grade, and it has fulfilled expectations.

One of the criticisms made of treated wood block pavements is that it is slippery, but in the writer's experience he has found that there is very little difference between these blocks and sheet asphalt pavements. When covered with a light frost or snow, or when the weather is foggy and damp the pavement may become objectionably slippery.

In traffic observations made at Philadelphia, Newark and other cities the evidence shown by the engineers at these places indicated that where treated wooden block and granite blocks were on parallel streets 70 per cent. of the teaming went on the wooden block.

On Stuart Street in the city of Hamilton, the writer laid treated wooden blocks between the street car rails and granite block between the outside rails and curbs, the pavement being on a 5 per cent. grade. Although most of the traffic was of heavy truck teaming nature it was found that fully 80 per cent. of the traffic, except on wet days, was on the wooden block.

The first cost of wood block pavement is undoubtedly higher than that of most of the other paving materials, averaging in the city of Hamilton from $2.85 to $3 per square yard, exclusive of grading. When its cheapness of maintenance, ease of cleaning, low tractive resistance and durability are taken into consideration this pavement with its relatively high first cost will compare favorably and prove ultimately cheaper than one lower in first cost.

EARTH DAMS.

IN *The Canadian Engineer* for January 27th the design and construction of masonry dams were discussed in an article by Messrs. A. P. Davis and D. C. Henny, abstracted from a paper on dams read at the International Engineering Congress in San Francisco. The following discussion of earth dams is from the same paper.

The design of earth dams is not subject to mathematical analysis. It must of necessity be based on the application of general experience. This type of dam, being the result of slow evolution, the experience of recent years has been able to add relatively little to known facts, and any considerable departure from previous practice is mainly in the methods of handling. The magnitude of structures of this class has, however, greatly increased. General requirements are somewhat better understood, while new methods of handling materials have had their effect upon design.

The original conception of an earth dam probably was a mass of material compacted so as to be water-tight throughout, connecting with a tight substratum and disposed to slopes somewhat flatter than the angle of repose. Extensive cores of puddle or heavy walls of masonry were used in the centre of the structure when doubt existed as to the water-tightness of the general mass.

The use of a clay puddle core, with a dam of material more or less open to percolation, has become less frequent than heretofore in ordinary dam construction, while the heavy masonry core, common in early eastern dams, has been greatly reduced in dimensions and has been made less rigid as a diaphragm through the use of reinforced concrete. Where a core is used, it is frequently carried up to only partial height so as to break the path of the water trying to percolate under the base of the dam.

The character of puddle now deemed safest by most engineers is not pure clay, but a mixture of gravel, sand and clay well blended and compacted by a heavy roller, with a small admixture of water. This material is less liable to cracking and slipping than pure clay and absorbs less water. There is, moreover, a greater tendency, where only a portion of the dam is tight, to place this portion as close as practicable to the water face, thereby increasing the backing which supports it; also to employ coarser material for the downstream portion of the dam, for greater stability and better drainage. Hundreds of earth dams have been built within the last two decades under a wide variety of conditions. As failures of earth dams have been generally due to overtopping, to piping under the foundation or along outlet conduits, or to sloughing, special attention has been paid to safeguards against such accidents.

In regard to overtopping, protective measures have consisted of close study of possible flood flow and provision of ample spillway capacity and freeboard. Piping under the foundation, which may occur where connection cannot be made with a tight substratum, is guarded against by lengthening the path of the water through slope flattening, by deep puddle-filled cut-off trenches, sheet piling. Grouting was used in connection with a deep cut-off wall in the case of the Lahontan dam, which is built mostly on mudstone in which many fissures occur. Piping along outlet conduits is prevented by construction on unyielding foundation and by frequent and large cut-off collars. Sloughing is prevented by the use of masses of open drain material in the downstream body of the dam, by drainage pipes, or partially by above methods as well as by extreme care in construction, through limiting water contents and hard rolling with traction engines. In the latter case, it is believed that the clay was rolled into such a compact and rubbery mass as to prevent the penetration of water other than by capillary action.

More scientific processes have been employed lately in the determination of rates of percolation which would take place through materials at hand for dam construction, made necessary, especially in the west, because of general sandiness of surface material. It was found, as in the case of the Cold Springs dam and, subsequently, in the case of the Lahontan dam, that mixtures of available materials could be used which gave rates of percolation about one-ninth that of the tightest material at hand, if used by itself. Thus, it has been economically possible to construct practically tight dams with sandy material. In such cases, mixtures have been graduated so as to increase in perviousness away from the water face, to secure perfect drainage.

In one important case conservative methods of earth-dam construction have been deviated from by omitting sprinkling and rolling and by loose dumping the clayey materials from trestles. The results have been unsatisfactory, as might have been surmised, in causing over 10% of settlement in the height of the structure with water about two-thirds of its intended height, accompanied by bulging, cracking and some leakage, causing fear as to the safety of the structure and an order from the authorities to reduce the height of water in the reservoir.

Slopes of earth dams are generally 3 to 1 on the water face, and 2 to 1 on the dry face, although steeper slopes have been successfully used, as in the case of the Belle Fourche dam, where they are 5 to 1 for a short distance, then 2 to 1 and 1½ to 1 on the water face and 2 to 1, with two 8-foot berms, on the dry face.

In the compacting of the earthy portions of dams, there has been a tendency to thin layers (6-in.) and to the use of heavy rollers 10 to 30 tons, or preferably traction engines, as giving great concentration of loads and avoiding continuous jointing planes.

The most radical departure from former methods of dam construction has been the occasional adoption of the hydraulic method of conveyance and deposition, on works of the greatest magnitude, such as the Gatun and Necaxa dams, and the Calaveras dam in California, now under construction. The use of this process, and the consequent results, constitute perhaps the most interesting chapter in the recent history of dam construction. The interest attaches to this process, not only as a measure of economy in construction, but still more to the results obtainable from the skilful employment of the sorting power of water in separating heterogeneous masses of material into their constituent parts, and placing each where it will do the most good.

The largest and one of the most interesting earthen dams ever built, has recently been completed at Gatun on the Isthmus of Panama. It impounds in Gatun Lake the waters of the Chagres River, and thereby forms the summit level of the Panama Canal, extending from Gatun, about seven miles from the northern terminus of the canal, through the Culebra Cut to Pedro Miguel, a distance along the sailing route of the canal of 32 miles. The area of Gatun Lake at normal high water is about 165 square miles, and its depth about 75 feet. It thus follows that this dam is one of the most important structures on this great work. The Gatun dam, as finally built, contains about 21,000,000 cubic yards of earth and rock, most of it being clay pumped into place by hydraulic dredges. The bottom of the valley is about 10 feet above mean sea level and a wide cut-off trench carries the base of the dam slightly below sea level. Its top is about 105 feet elevation, or 20 feet above normal high water in Gatun Lake. Its maximum width of base parallel to the valley is over 2,000 feet, the upstream slopes averaging about 7 to 1, and the downstream slopes varying between 8 to 1 and 16 to 1, with an average of about 12 to 1. These conservative lines were adopted for a number of reasons, among which the following were the most important:

1. The extremely soft, yielding foundation made it imperative to avoid any large increase of load on any portion over that on the ground adjacent. Hence, steep slopes had to be avoided, especially on the downstream face.

2. The hydraulic fill being presumably less pervious than portions of the natural foundation it was desired as a blanket to the latter, so as to enforce a long line of travel for percolating waters, and to fortify against boils and blow-outs below the dam.

3. The extreme importance of the structure to the integrity of the canal emphasized the importance of using very large factors of safety against destruction by both natural and artificial forces.

The Consulting Board of 1905, which outlined the lock canal project involving the Gatun dam, gave greatest weight to the second consideration above named. That Board proposed to carry the dam to an elevation of 135 feet above sea level, thus giving a freeboard of 50 feet above normal high water.

Subsequent experience convinced the Consulting Board of 1909, that instability of foundation, and of the material of which the dam was to be built was the greatest difficulty to be overcome. Hence, the large freeboard proposed would prove a menace by unnecessarily overloading the foundation at the axis, and it recommended a reduction of height to 115 feet above sea level, thus reducing the freeboard from 50 feet to 30 feet. Further experience led to an additional reduction of 10 feet in height, which is doubtless an improvement in stability, besides saving cost.

Even with such flat slopes at 7 or 8 to 1, difficulty was encountered in holding the hydraulic fill in place till it could be drained and consolidated. In expediting this process, more than half the earth pumped into the dam was carried away with the drainage water. It is the opinion of those best able to judge, that with the conditions presented and materials available, it would not have been practicable to build the dam by that process on much steeper slopes than those adopted for the upper half of the dam.

The hydraulic method of depositing clay implies that it goes into place in a supersaturated condition, often containing 50% of water. The difficulty of holding supersaturated clay in the interior of a high fill was vividly illustrated in the Necaxa dam, which was constructed in Mexico for the Mexican Light and Power Co. Its construction by the hydraulic method was a bold undertaking, the supply canal alone costing $250,000, and the transportation, by running water, of large rock being a prominent feature of the plan.

The upstream slope was 3 to 1, and the downstream slope 2 to 1, both slopes being formed of fragmentary rock, while the interior mass was of clay, all deposited by water. The volume was 2,130,000 cubic yards, forming by far the highest earth dam ever built, its height being 190 feet.

Owing to the slow drainage of the clay body of the dam, it retained a semi-liquid consistency, and when the dam was nearly completed, the lateral pressure of the clay forced the water face into the reservoir, and about 750,000 cubic yards of material followed it. This impressive accident, as well as the experience at Gatun, where bulging up of slopes was experienced, illustrates the instability of undrained clay, and the limitations of the hydraulic method of handling such materials.

For handling sand, gravel, small rock, and mixtures of these materials with clay or silt, the hydraulic method has demonstrated its economy under favorable conditions, and it produces good results when its sorting powers are skilfully employed upon such materials, by depositing the finer particles in an impervious core, and the coarser, on the exterior slopes where they furnish efficient drainage on the lower side, serve as efficient protection against wave action on the upper side and lend stability against sloughing to both.

The Calaveras dam in California, which will be the highest earth dam on record (250 feet) is now being built by the hydraulic method.

The hydraulic process requires great skill, and attempts are now being made to utilize it in the construction of banks in which the materials are to occur in well-mixed condition, the clay to be retained in the interstices of the mixed sand and gravel. To this end, shear boards are used to guide the mixed waterborne material in a way that will cause it to drop its load without segregation. To what extent this method can be made to produce the desired results remains to be seen.

In some cases, as in the Bumping Lake dam in Washington (without core wall) and the Arrowhead dam in California (with core wall), the hydraulic process has been used in washing material from the slopes into a central pool, the material having first been hauled and dumped on the slopes by mechanical methods. Such procedure has advantages where it is feared that the material as dumped cannot be rolled into a tight mass without expensive selection and waste, and where water under gravity pressure is available for cheap assorting and conveying to place.

CHANGE OF ADDRESS.

The United States Cast Iron Pipe and Foundry Company announces the removal of its Southern Sales and Traffic Offices from Chattanooga, Tennessee, to 1002 American Trust and Savings Bank Building, Birmingham, Alabama. This change becomes effective April 1, 1916.

MINERAL PRODUCTION

In response to the call for increased production, the mine owners of Canada last year made the second best record of mineral production in the history of the country. The total value was $138,513,000, compared with $128,863,000 in the previous year, (during which business was almost at a standstill for five months), and $145,634,000 in 1913. This record was made last year, despite decreases in the output of construction material, due in turn to the lack of demand. The war created a demand for nearly all metals and this fact helped materially to swell mineral production. The obtention of by-products of coal also contributed. As a result of the war activity, too, we have become a producer of zinc ore to a small extent and we will have a nickel refinery on our Atlantic seaboard in the comparatively near future. The fact that under war conditions it was desirable that our metals should become available for commercial or national use, entirely within the country and that we should be less dependent, even upon a friendly neutral, for their recovery in smelters and refineries has stimulated the development of our smelting and refining operations. Amongst non-metallic minerals the recovery of benzol and toluol in by-product coke oven operations was a direct result of the war, as was also the activity in the mining and shipment of magnesite and of chrome ores.

Ontario contributed $61,800,000 to the total mineral production last year, more than twice British Columbia's output of $28,932,000 and more than three times Nova Scotia's production of $18,126,000. Ontario leads in gold and silver production and has a monopoly of Canadian nickel production. The coal fields are the chief contributing factor to Nova Scotia's output and the asbestos deposits in the eastern townships help to place Quebec in fourth place among the provinces with a mineral production of $12,159,000 last year.

The total value of metals produced in 1915 was $77,046,000, an increase of $18,000,000 over the previous year. The value of non-metallic minerals was $42,755,000, while structural materials and trade products accounted for $18,712,000. Among the principal non-metallic minerals were coal, natural gas, asbestos, gypsum, pyrites, salt and petroleum. Natural gas production shows a decrease, indicating that the sources which have been heavily tapped in past years, are beginning to give out. Petroleum production also shows a decrease.

While this record of mineral production last year is satisfactory, largely because of an increase compared with the previous year, our output is by no means as heavy as it should be. There is considerable scope for first-class prospecting, for the employment of further capital in the industry, and for the services of the legitimate mining engineer who has too often been forced by the "wild cat" company promoter to take a back place. Mr. John McLeish, B.A., chief of the division of mineral resources and statistics, is to be congratulated upon the dispatch with which he has gathered the material for his preliminary report on mineral production, and from which the figures quoted above are taken. This report has just been issued by the Mines Branch, Ottawa.

The Alberta legislature is authorizing the flotation of a loan of $2,000,000. The funds will be used for the civil service for covering any debt on open account, for paying off floating indebtedness, for any public works and other purposes the legislature authorizes. It will be issued at a rate not exceeding 5 per cent. Hon. C. R. Mitchell is the Provincial treasurer.

COAST TO COAST

Toronto, Ont.—It is expected that the Don section of the Bloor Street Viaduct will be ready for steel by April 1.

Ottawa, Ont.—Legislation has been secured for the construction of a highway between Ottawa and Prescott. The estimated cost will be $600,000.

Fredericton, N.B.—The Fredericton Gaslight Company has submitted a series of proposals relative to the lighting of the city streets by them.

Edmonton, Alta.—According to the report of the Provincial Department of Public Works there were 343 new bridges erected last year and 177 repaired.

Hamilton, Ont.—City Engineer Macallum recommends that the route selected by the C.N.R. through the city be followed by the Hydro Radials.

Vancouver, B.C.—The D. A. Thomas interests are prepared to negotiate with the government as regards the building of a railway into the Peace River country.

Medicine Hat, Alta.—A delegation has interviewed Premier Sifton at Edmonton urging that the C.N.R. be ordered to complete their line between Medicine Hat and Hanna.

Toronto, Ont.—The city has submitted an agreement to the York Township council by which they will supply the adjoining districts with water at 20 cents per thousand gallons.

Edmonton, Alta.—The Alliance Power Company has submitted an offer to the city by which they will agree to operate the city power plant until the new hydro-electric plant is ready.

Winnipeg, Man.—An official statement given out at the Canadian Northern Railway offices here announces the opening of the line from Camrose to Alliance, Alberta, a distance of 59 miles.

Winnipeg, Man.—The Jefferson highway will enter Canada at Emerson and follow the route of the Meridian Road to Winnipeg. When completed, the road will extend from New Orleans to Winnipeg.

Vancouver, B.C.—The annual report of the Provincial Water Board shows that the storage capacity of the small lakes on Seymour and Capilano Creeks is ample for a city many times the population of Vancouver.

Calgary, Alta.—The watermasters of the irrigation district east of Calgary held their second annual convention at Strathmore. Irrigation matters were discussed and lectures were given by government engineers.

Niagara, Ont.—The construction of a canal eight miles long, which will provide a new waterfall here, will be undertaken during the coming summer. The cost will be about $12,000,000 and 600,000 h.p. will be developed.

Moose Jaw, Sask.—City Engineer Mackie has a scheme by which he proposes to bring water from the Saskatchewan River to Caron and thence through the existing pipe line to the city. No particulars are available.

Peterborough, Ont.—The Utilities Commission of the city of Peterborough is authorized to negotiate with the Otonabee Power Company for the purchase of their transmission lines in that city where they do not parallel the Hydro system.

Montreal, Que.—The Montreal and Southern Counties Railway expects to be able to run to Granby by the end of March. The new machinery will shortly be installed in the sub-station. Granby will be the furthest objective point this coming summer.

Lethbridge, Alta.—The provincial bacteriologist has concluded an investigation into the epidemic of typhoid which has been raging here. He states that raw sewage which is dumped into the Old Man River at Macleod is responsible for the epidemic.

Hamilton, Ont.—It is understood that the Dominion Government has consented to defer to Ontario in the control of franchises and charters of local electric railways, and that this policy will be followed by the Railway Committee of the Federal House in dealing with the Canadian Northern Ry. charter extensions for their Niagara lines.

Toronto, Ont.—A $700,000 programme has been outlined by the Harbor Commission in connection with next summer's work. The work in Ashbridge's Bay and at the Humber will be continued, and, in addition, the work of transforming the old harbor will be commenced. It is announced from Ottawa that a permanent head line has been established in the harbor, from Bathurst Street to Yonge Street. The plans provide for the establishing of a 17-acre industrial area at the foot of Bathurst Street, which will be served by 800 feet of dock and 20 feet of water. There will also be modern freight sheds and a factory building. In connection with the new windmill line, the railways have waived their riparian rights between Bathurst and York Streets and the companies will join the commission in an application to the government for approval of the new pierhead and bulkhead lines, and the harbor commissioners will receive the patents to the new lots lying between pierhead and bulkhead lines, Hon. Mr. Rogers and Hon. Mr. Hazen both having signed them.

Letters to the Editor

Stresses in Lattice Bars of Channel Columns.

Sir,—Those of your readers who are interested in the mechanics of materials will be interested in Mr. Pearse's solution for the stress in lattice bars of columns, published in your issue of February 24th. On the hypothesis that there is a bending stress at the centre of a loaded column, the magnitude of which stress is correctly given by the amount of the reduction made in the allowed unit stress on account of the length of the column, Mr. Pearse's method is correct. Unfortunately, on account of an error at the beginning of the deduction of the formula, the result he gets for the stresses is twice too much.

In the discussion of the question of stresses in lattice bars of columns it must not be forgotten that our knowledge of the internal stress conditions of a column under load is very vague. In columns tested to failure, up to a considerable length, there is practically no deflection in the column until the elastic limit of the material is reached, when failure occurs by a local buckling. If a latticed column were perfectly constructed, of homogeneous material, with the two parts exactly straight and of the same area, and if the load were applied absolutely concentric, there would be no bending in the column up to the point of failure. In such a column the lattice bars simply hold the two parts together and would have only very small stresses in them until at the moment the column failed. Practically, there are columns of all conditions, from the one nearly perfect to the one grossly imperfect, and the stresses in the lattice bars will be of all kinds and magnitudes. In longer columns, such as it is practical to manufacture, there will be bending in the column before failure occurs. Bending will probably start as soon as any part of the load is applied. Unfortunately, it is impossible to have any knowledge of the relation between the load, the elements of the column and the amount of the bending; such relationship being purely accidental and not the same in any two cases. For a certain definite load and a corresponding bending, there will be certain stresses in the lattice bars which can be determined with a fair degree of approximation; it being, of course, assumed that the latticing is at least sufficient to make the two parts of the column act as one column.

Nearly all text books, however, in their treatment of the theory of the column, assume that there are certain definite and determinate bending stresses in a loaded column and give formulæ for the determination of the amount of these stresses. Formulæ, such as Mr. Pearse's, may be deduced on the basis of these assumptions and the stress in a lattice bar calculated therefrom. The addition of the stress so calculated to the accidental unknown stress will give a result which will be quite safe to design to, but what will this resulting stress be?

Mr. Pearse, in his derivation of the formula, says that the total stress in channel CR is $2k\frac{A}{2}$, due to bending. This should be $k\frac{A}{2}$, since k is the unit stress due to bending and $\frac{A}{2}$ is the area of the channel. If this corrected value be used throughout Mr. Pearse's demonstration it will give the correct result, which is just one-half that given by his final formula.

The writer has deduced the following solution for the transverse shear, and suggests it as being shorter and more general than Mr. Pearse's.

The curve of a column concentrically loaded, with deflection Δ is $y = \Delta \sin \pi\frac{x}{l}$.

Let M be the bending moment from load P, at point x, and $M + dM$ the moment at $x + dx$.

$$M = Py = P\Delta \sin \pi\frac{x}{l}.$$

$$M + dM = P\Delta \sin \pi\frac{x + dx}{l}$$

Therefore, $dM = P\Delta\left(\sin \pi\frac{x + dx}{l} - \sin \pi\frac{x}{l}\right)$

$$= P\Delta\left[\sin\left(\frac{\pi x}{l} + \frac{\pi dx}{l}\right) - \sin \pi\frac{x}{l}\right]$$

$$= P\Delta\left[\sin\frac{\pi x}{l}\cos\frac{\pi dx}{l} + \cos\frac{\pi x}{l}\sin\frac{\pi dx}{l} - \sin \pi\frac{x}{l}\right]$$

and since $\frac{dx}{l}$ is very small, $\cos\frac{\pi dx}{l} = 1$, and $\sin\frac{\pi dx}{l} = \frac{\pi dx}{l}$, the first term will cancel the last and

$$dM = P\Delta \cos\frac{\pi x}{l}, \frac{\pi dx}{l}.$$

Therefore, $\frac{dM}{dx} = P\Delta\frac{\pi}{l}\cos\frac{\pi x}{l}$ - - - (1)

If M is the bending moment at x, then $\frac{dM}{dx} = S$ is the transverse shear at x, and

$$S = P\Delta\frac{\pi}{l}\cos\frac{\pi x}{l} \quad - - - (2)$$

Let M_c be the bending moment at the centre, f the extreme fibre stress due to M_c, r the radius of gyration, A the area, and c the distance from the neutral axis to the extreme fibre.

Then, $P\Delta = M_c = \frac{fI}{c} = \frac{fAr^2}{c}$,

Substituting in Equation 2,

$$S = f\frac{Ar^2}{c}\cdot\frac{\pi}{l}\cdot\cos\frac{\pi x}{l}\cdot \quad - - (3)$$

This equation gives the transverse shear at any point x in a column.

If $x = \frac{l}{2}$, $\cos\frac{\pi x}{l} = 0$, and $S = 0$,

If $x = 0$, $\cos\frac{\pi x}{l} = 1$ and the shear at the end,

$$S_e = f\frac{Ar^2}{c}\frac{\pi}{l} \quad - - - - (4)$$

If $70\frac{l}{r}$, in the equation $\frac{P}{A} = 16{,}000 - 70\frac{l}{r}$, be substituted for f, then $S_e = 220\frac{Ar}{c}$.

If any straight line formula be used for the value of f, then the value of S_e will be independent of the length. If f be made a function of $\left(\frac{l}{r}\right)^2$, S_e will be greater for long columns than for short ones.

The writer is unable to follow the relationship claimed by Mr. Pearse between the stresses as calculated from his formula and those determined by the tests, the results of which are published in Bulletin No. 44, University of Illinois. In those tests the stresses in all lattice bars seemed to be purely a matter of chance. There were no definite stresses from bending in the columns in either the bars or the channels. In these tests the axis of the pin was parallel to the plane of the lacing, so that the columns had fixed ends in the direction of the lacing. The columns were too short to make the tests of any value in determining the effect of bending, even had they been arranged with the axis of the pins in the other direction. The opinion of the author of that bulletin is that it is impossible to establish any relationship between the stresses in lattice bars and the other elements that enter into the design and construction of columns.

A. H. HARKNESS.

Toronto, March 20th, 1916.

Stresses in Lattice Bars of Channel Columns.

Sir,—The writer has carefully reviewed the article on this subject by Mr. William Worth Pearse, C.E., city architect of Toronto, which appeared in your issue of February 24th, 1916, and begs leave to submit the following comments:—

While the column formulas here used would lead one to suppose that the stresses in columns result from a combination of direct stress and bending, it by no means follows that bending stress alone governs the stresses set up in the lattice bars of a built-up column.

An absolutely perfect column with vertical axis, would merely shorten under load effect and no bending could be produced if the material is isotropic, the load applied centrally, and the modulus uniform within the limits of loading.

However, these are all conditions which can never be realized, so that a perfect column does not exist, and hence any deflection which may occur under load effect must be regarded as the result of a combination of several accidental circumstances.

After a critical examination of practically all modern column tests it appears that columns fail when the maximum stress reaches the yield point of the material. Up to this point the behavior is very uniform with slight deflections except when a column shows some local weakness. Failure follows suddenly either by buckling of a part of the section in the case of latticed columns, or by buckling of outstanding flanges in built-up columns. At the time of local collapse, the column as a whole undergoes a large deflection while the stress drops off.

Just what portion of the ultimate stress is due to bending effect will depend entirely on accidental conditions, such as initial straightness, variations in the elasticity of different parts of the section, eccentricity of loading, distribution of metal in the cross-section, and finally, the degree of fixity at the ends. It matters not how the ultimate is produced, but whenever the sum of the direct stress and bending reaches the yield point, the column fails.

If we may assume our column formulas as representative of average practical conditions based on more or less standard column designs, then no doubt the bending effect may be evaluated from whatever formula we choose to employ.

According to Navier's formula, the maximum unit stress on the extreme fibre of any piece, subjected to direct stress and bending, is given by the formula

$$S_o = \frac{P}{A} + \frac{Mn}{Ar^2} \text{ or } \frac{P}{A} = S_o - \frac{Mn}{Ar^2}, \quad - \quad (1)$$

wherein $\frac{P}{A}$ = average working stress per square inch, and S_o = 16,000 lbs. per square inch, represents the maximum allowable unit stress. M = bending moment; n = distance from neutral axis to extreme fibre; A = area and r = radius of gyration.

In Equation (1) the term $\frac{Mn}{Ar^2}$ represents the unit stress due to bending alone, hence for a uniformly loaded beam on two supports this moment $M = R\frac{l}{4}$ where R = the end reaction or shear.

$$\text{Therefore, } \frac{Mn}{Ar^2} = \frac{nlR}{4Ar^2}\cdot \quad - - (2)$$

Assuming the column formula in most general use, which is

$$\frac{P}{A} = 16{,}000 - 70\frac{l}{r}, \quad - - - (3)$$

the negative term represents the unit stress due to bending precisely as in Navier's formula, hence the bending stresses from Equations (2) and (3) may be equated. Thus $\frac{Mn}{Ar^2} = \frac{nlR}{4Ar^2} = 70\frac{l}{r}$, which solved for R gives Mr. Pearse's Formula (d), for the end transverse shear in the column, as

$$R = \frac{280\,Ar}{n} \quad - - - - - (4)$$

For two sides of the column and single lacing, there will be two lacing bars to carry this shear, and calling θ

the angle which the bar makes with the transverse shear (usually 30°), then the stress in a single lattice bar =

$$s = \frac{R}{2} \sec \theta \quad \text{- - - - -} \quad (5)$$

If the Rankine-Gordon formula is adopted in preference to Equation (3), then the end shear may be deduced in precisely similar manner by writing the formula so as to separate the bending stress from the direct stress, as follows:

$$\frac{P}{A} = \frac{16{,}000}{1 + \frac{l^2}{12{,}000\, r^2}} = 16{,}000 - \left[16{,}000 - \frac{16{,}000}{1 + \frac{l^2}{12{,}000\, r^2}}\right] \quad (6)$$

The last term in Equation (6) now represents the unit stress due to bending alone, and as above,

$$\frac{M n}{A r^2} = \frac{n l R}{4 A r^2} = 16{,}000 - \frac{16{,}000}{1 + \frac{l^2}{12{,}000\, r^2}},$$

which solved for R and reduced, gives

$$R = \frac{5.33\, A\, l}{n\left(1 + \frac{l^2}{12{,}000\, r^2}\right)} \quad \text{- - -} \quad (7)$$

The formula for designing lattice bars, using a factor of safety of 3.25 should have been written as follows:

$$\frac{P}{a} = 6{,}600 - 13.8\,\frac{l}{r} \quad \text{- - -} \quad (8)$$

instead of Mr. Pearse's Equation (18).

Taking the column used by Mr. Pearse, upper right-hand of page 276, where l = 144″, A = 8.92 sq. in. = two 10″ channels at 15 lbs., r = 3.81″, n = 5.72″ and $\frac{l}{r}$ = 38, then by Equation (4),

$$R = \frac{280\, A\, r}{n} = 1{,}663 \text{ lbs. and } s = \frac{R}{2} \sec \theta = 960 \text{ lbs.}$$

Also, by using Equation (7),

$$R = \frac{5.33\, A\, l}{n\left(1 + \frac{l^2}{12{,}000\, r^2}\right)} = 1{,}068 \text{ lbs. and } s = \frac{2}{R} \sec \theta = 617 \text{ lbs.},$$

and for the same column, 24 ft. long, R = 1,616 lbs. by Equation (7).

According to Equation (8), $\frac{p}{a} = 6{,}600 - 13.4\,\frac{l}{r}$ for lattice bars, and a bar 2¼″ × 5/16″ — 10.6″ long with $\frac{l}{r}$ = 118 would be good for a working load of 3,480 lbs. and safe for a load three times this amount.

While above results are ridiculously small, and would not govern lattice bar design, this is all the stress that the bending effect of the column would produce. We must, therefore, look to other more severe conditions to find an answer to this problem.

The reasons for the greater bar stresses obtained from Equation (16) given by Mr. Pearse are due to the erroneous assumptions in his stress distribution, as shown in his Fig. 4, and also to the introduction of the value for Δ from his Equation (7) for which there is no justification. The apparent agreement between the lattice stresses as found from his Equation (16) and those deduced from experiments given in Bulletin No. 44, University of Illinois, is not at all convincing to the writer. These experiments do not show maximum lattice stresses at the ends of columns nor can the ratio 0.0251, for transverse shear to compression load, be regarded as governing except for the peculiar column tested. Hence, it is dangerous to generalize on such a meagre assortment of facts.

Among the conclusions given in Bulletin 44, p. 63, items 8 and 15 are here quoted to show the opinions of the experimenters themselves, which should not be overlooked in connection with the subject under discussion. They are:

8. "It seems futile to attempt to determine the stresses which may be expected in column lacing for central loading by analysis based on theoretical considerations or on data now available."

15. "No relation has been found between the stresses actually observed and the stresses computed by column formulas. The stresses do not increase toward the middle of the length of the column, as may be expected from the Rankine form of analysis, but are quite irregular in their location and distribution."

Other similar remarks are given in various parts of the bulletin.

Since a latticed column is really a framed structure with rather peculiar loading, the stresses in the diagonal bracing or lacing bars will depend entirely on the behavior of the flange members. These flanges being subjected to compression from end to end, the function of the lacing and batten plates will be to transfer longitudinal shear from one flange to the other whenever and wherever the compressive stress is unequally distributed. The maximum value of this shear may, under certain conditions, approach the total load P on the column, and hence the total area of lacing and batten plates should be sufficient to carry this shear. This will serve as a good criterion in designing lattice columns and represents the writer's practice, though the whole subject is largely a matter of standards.

DAVID MOLITOR, C.E.

Toronto, March 20th, 1916.

Re the Constant Angle Arch Dam.

Sir,—The article on this subject in your issue of the 9th inst. is interesting and instructive and makes a good case for the constant angle arch dam.

The design of an arched dam is really a very difficult problem and the calculations of the stresses which take effect in such a structure depend upon an unusually great number of more or less crude assumptions which only have a degree of probable approximate accuracy so that the results must of necessity have a high degree of probable variation from the truth, and it is a matter of astonishment to observe that the designs discussed depend in part for their stability upon what is described as the "initial stresses." Although on the assumption of ideal conditions (rigid abutments and so forth) such stresses exist and lead to the statical relations described, yet practical considerations make these stresses casual, uncertain and unreliable for so important a structure as a high masonry dam. Most straight masonry dams show transverse cracks and they are not unknown in arched dams, and it is the exception rather than the rule to find rock masses in nature of a greater length than 16 feet, which leads to the supposition that temperature, moisture and foundation changes are sufficient—anywhere near the surface—on occasion to release the whole of the lateral extensions of rock, masonry, or concrete masses based upon Poissons Ratio. Further, in the case of a masonry dam the water in the reservoir presses equally hard upon the sides of the reservoir as upon the dam and probably pushes away the arch abutments a quite important amount. Under these circumstances, is it desirable that the "initial stresses" should be relied upon to assist the stability of a masonry dam?

W. GORE, M.Inst.C.E.

Toronto, March 16th, 1916.

Editorial

CANADIAN TIMBER IN DEMAND.

The announcement made by Lord Shaughnessy some few weeks ago in which he stated that the Canadian Pacific Railway Company henceforth will use, as far as possible, only Canadian woods, has been favorably received by the lumber interests throughout the Dominion. The company propose to use Canadian woods for construction and ornamental interior finishing of all their buildings, as well as their railway cars.

The decision is one which may be looked on as a result of efforts of the forestry experts who have been showing Canadian woods at the exhibitions held in the United States and Europe. The Canadian exhibits of woods have been very well arranged, especially the more ornamental woods which are used for interior finish. These magnificent samples have attracted the attention of the commercial world to such an extent that we may expect a big increase in their use. The most important result, however, is the fact that Canadians themselves have seen from these exhibits that it is not necessary to go far afield to secure good wood for any purpose whatever. The increasing use of Douglas fir, western hemlock, red cedar and other beautiful woods which are taking the place of the more expensive hardwoods for interior finish and cabinet work is an evidence of the timeliness of our "getting acquainted," as it were, with our own woods.

The British Columbia Forest Branch is especially deserving of credit for the way in which they have studied the market in their endeavors to supply the products which the Canadian people require. They have launched a big publicity campaign which has attracted widespread attention to the immense resources of the forests of British Columbia. More particularly they have been developing a trade among the farming communities of the West. Bulletins showing plans of various farm houses and stables have been distributed. The farmer may calculate the exact cost of the structure he proposes to build, as a detailed bill of quantities is given.

The use of timber as a structural material seems to have slipped the mind of the engineer and public alike. For years there has been a cry of "what will we do when our timber is all spent?" and the logical result has been that other materials have stepped into the breach. In most cases the substitute has been better than wood, and has perhaps, when first put on the market, been more expensive than the wooden article whose place it was filling. However, with the subsequent rise in the price of timber, due to production costs and scarcity of material, the substitute has gradually become cheaper, not only in first cost but in maintenance.

Recently the lumbering interests of the middle western states commenced a campaign of popularizing wood as a structural material. They claimed that the conservationists of the United States had so influenced the people in the conservation of wood that the lumbering industry had fallen off. Bulletins issued by the Lumbermen's Association have as their object the correction of the impression that the exhaustion of the timber resources is imminent.

According to the report of the Commission of Conservation, Canada very likely only has about one-quarter of the standing timber that our neighbors south of us have. The commission is now taking inventories of the two most westerly provinces and should have them complete in a couple of years. The total stand of timber in the whole of the Dominion of Canada should be known in about five years. When these facts are known will be time enough to boost the use of timber again as a material of construction, providing, of course, that it can compete with the present substitutes. The use of timber as an ornamental material for interior finish will, with the amount used for residences, farm buildings and other small structures, keep our lumbering interests busy enough for the next few years without cutting timber for structural purposes where its value monetarily is bound to be less than any of the materials now in use. Our American cousins can well afford to expend their timber for such purposes when they have such a supply on hand.

STRESSES DETERMINED BY MEANS OF POLARIZED LIGHT.

A number of examples showing the application of polarized light in the determination of stresses in engineering materials and structures were given by Professor E. G. Coker in a lecture before the Royal Institute, London, Eng. The application of polarized light to this use is new, but the phenomenon involved is a century old. Sir David Bennet, in 1816, discovered that transparent materials become doubly refractive when stressed. The discoverer of this property of transparent materials pointed out that stresses in the arched rings of bridges could be rendered visible in a glass model by the aid of the doubly refractive effect produced by a beam of polarized light. On account of the unsuitability of glass for modelling purposes, not much use has been made up to the present of the method. However, in recent years the advent of transparent nitro-cellulose materials, which are easily modelled by means of ordinary woodworking tools has removed this obstacle.

Simple stress is estimated, by this method, from the colors observed. For instance, the action of water in a pipe can be imitated by applying a uniformly distributed stress to the interior of a ring; the arrangement of the color bands indicates that there is a very large stress at the interior surface, diminishing rapidly at first and afterwards more gradually as the outer surface of the pipe is approached.

The new method of determining stresses, even if approximate, should be of great interest to engineers. There are some problems which are beyond solution by mathematical means, which may be solved with enough accuracy to answer immediate needs. Sometimes the design of a whole structure will be jeopardized by the improper estimation of one seemingly small item.

Too often we find that the discoveries of science have been overlooked by the engineer, who usually has very little time to delve into such things. It is the engineer who has chosen pure science as a hobby who usually finds out more about its application to engineering problems.

The Engineer's Library

Any book reviewed in these columns may be obtained through the Book Department of The Canadian Engineer, 62 Church Street, Toronto.

CONTENTS.

BOOK REVIEWS.

Overhead Transmission Lines and Distributing Circuits; Their Design and Construction. By F. Kapper. Translated by P. R. Friedlaender, M.I.E.E. Published by Constable & Company, London. First edition, 1915. 300 pages; 297 illustrations; 7 x 10 ins.; cloth. Price, $4.50. (Reviewed by J. H. Mackay, engineer of transmission work, Toronto Power Company.)

This volume, while written from the standpoint of European practice, should nevertheless prove a desirable acquisition to the library of most engineers interested in the design and construction of transmission lines in America.

While the fundamental principles underlying European design and construction are dealt with in a satisfactory manner throughout the subject matter of the volume, it is interesting, however, to note that the competent American engineer of to-day has paved the way in the matter of efficient long-distance, high-tension construction and transmission. The American engineer, however, gives due credit to his Swiss, French and Italian brothers who were among the pioneers in successfully undertaking and carrying out the tasks of designing, building and operating transmission lines for voltages up to 50,000 or 60,000.

The subject matter of the volume covers the entire field of operations, from the survey for the right-of-way to the completion of the line, and a careful study of the various chapters of the book cannot help but be of interest and value to the reader.

One of the most important matters in conjunction with the successful operation of high-tension transmission lines, is discussed, and illustrated by several cuts showing the various pin and suspension types in general use. The author makes the statement that the mechanical safety of the installation is increased when suspension insulators are used, as their flexibility enables equalization of stresses to take place on straight stretches and at corners, and in case a line breaks on one side of a tower, the tower will not be subjected to much stress, as the chain of insulators will set itself in a slanting position and virtually lengthen the line, thus relieving the tension in it. This statement, while true, is, however, offset by the fact that with suspension insulators the risk from a combination of sleet and wind is much in excess of that which would arise were the same line equipped with insulators of the pin-type. The former line sag depends on, or is governed by, the loading of adjacent spans, and in this connection, the present-day suspension insulator string is not an ideal arrangement.

One notes that in Europe a private right-of-way is seldom secured, and wayleave has to be obtained from possibly hundreds of small property owners before actual construction work can commence; here in America, however, after the generating and distributing points are located, the power company will make a preliminary survey of the most direct route and then purchase outright a strip of property of sufficient width to meet their present and future requirements. After the engineers have decided upon the types of supporting structures, most desirable from the points of strength and economy, then the actual survey for the tower locations is gone ahead with.

Some curves are given, based on European practice, showing approximate costs of a 20,000-volt three-phase line some six miles in length, using various types of construction with span lengths from 130 feet up to and including spans of 650 feet in length. These curves are valuable only in comparison with known cost data obtained under conditions peculiar to America.

In Europe, the initial construction work in connection with a transmission line, or distributing system, is apparently, as a rule, undertaken by contractors, rather than by the company itself, and a chapter deals with forms of agreements and schedules of prices for the various operations to be performed. This method of procedure would, on this continent, however, be open to question, as every large company has its own staff of competent engineers and workmen under its direct supervision and control.

In summing up the work as a whole, it can be said that the book is well illustrated, and the subject matter divided into proper chapters, these chapters again being subdivided under proper headings. The descriptions and numerical examples are such as can be readily understood, thus being of value to the engineer.

In conclusion, it may be noted that we in America, however, must design and build our transmission lines to meet conditions peculiar to our own continent, where the market for the energy produced may be hundreds of miles from its source, thereby necessitating voltages greatly in excess of European requirements, and again, where the temperature may be much below, or greatly in excess of that encountered in middle Europe.

Geodetic Surveying. By Edward R. Cary, Professor of Railroad Engineering and Geodesy, Rensselaer Polytechnic Institute. Published by John Wiley & Sons (Inc.), New York. 279 pages, 5½ x 8 ins., 98 figures and 21 tables, cloth. Price, $2.50 net.

The book has been written with the idea of bringing literature on the subject up to date, as during the past fifteen years some marked improvements in the practice of geodetic surveying have taken place.

The book covers reconnaisance, describing the methods of precise measurement of base lines and various corrections to be applied to angular measurements in laying out the network of triangles for the survey. A chapter on geodetic latitudes, longitudes and azimuth takes up approved methods of calculating these quantities. A great deal of attention is allotted to the instruments used in geodetic work, with methods of adjustment. Precise levelling and trigonometric levelling are dealt with fully and map projections are given a chapter.

One appendix is devoted to practical astronomy, with examples of methods of computing, time, latitude, longitude and azimuth. Another appendix on the method of least squares completes the book.

The author has described many methods employed by the United States Coast and Geodetic Survey, which represent the most advanced practice.

The book should be of particular value as a text-book for use in engineering schools, as all the subjects taught in lectures on Geodesy and Practical Astronomy are contained in the same work. Engineers engaged in geodetic work and precise surveying will find this work useful as a reference. The book is well bound and the illustrations are very good.

Practical Surveying. By Ernest McCullough, C.E., M.Am.Soc.C.E. Published by the D. Van Nostrand Co., New York. 395 pages, 5 x 8 ins., 229 illustrations, cloth. Price, $2.00 net.

The purpose of this book, the author says in his preface, is to meet the needs of students whose mathematical preparation does not extend beyond simple arithmetic. It is intended to be used as a text in high schools or vocational schools and for self-tutored men who wish to become surveyors.

Instruments used in all branches of survey work are described in detail. The chapter on chain surveying is very complete. Under compass surveying are given the use of the instrument in the field, notes on attraction and variation, balancing errors, computing lost courses and areas and plotting the map. Trigonometry is treated in simple language in one chapter, giving both the regular and graphic solutions of plane triangles, with problems; and the use of logarithms is explained. The use of the transit is taken up, and a small amount of space is devoted to stadia work. The chapter on surveying laws is very thorough, treating with the various United States laws which have to do with the surveyor.

The book is well illustrated and the language throughout is very easily understood, making it a very valuable work for students of surveying.

Forest Protection in Canada, 1913-14. Compiled under the direction of Clyde Leavitt, M.Sc.F., Chief Forester of the Commission of Conservation. Published by the Commission of Conservation of Canada. Illustrated, 274 pages, 6 x 9 ins., cloth.

The report contains much information respecting the work of the provincial forest services and of the federal departments entrusted with the care of our forests.

Forest fire protection is assuming a large place in public attention. It is obvious that, if Canada is to continue as a wood-producing country, she must conserve her resources of this natural product. The report treats exhaustively of the fire protection of forest lands along railway rights-of-way. Through co-operative action great headway has been made in securing the reduction of forest losses through fires traceable to railway causes.

The forests of British Columbia and on Dominion lands in the West have been dealt with in reports containing the results of special studies conducted by Dr. C. D. Howe and Mr. J. H. White. The Trent watershed in Ontario has also received especial attention in a report of an investigation by Dr. C. D. Howe in the townships of Burleigh and Methuen. This district is important in that, while of very little value as an agricultural area, it is being repeatedly overrun by forest fires and the little remaining merchantable timber destroyed. It is suggested that the area be placed under the control of the Dominion Forestry Branch for protection from fires and for reforestation.

Elements of Railroad Track and Construction. By Winter L. Wilson, Professor of Railroad Engineering, Lehigh University. Published by John Wiley & Sons (Inc.), New York. 396 pages, 5 x 7 ins., 210 illustrations, cloth. Price, $2.50 net.

This is a revision of an earlier edition, with some seventy pages of additional matter and several new chapters. A chapter on the Practical Turnout, which has been written on the recommendation of the American Railway Engineering Association, is responsible for over half the additional matter. The make-up of the book is open to criticism, owing to the fact that the first 260 pages take up track and maintenance, leaving only 130 pages at the end of the book for railroad construction, trestles, culverts, etc. The very last chapter, which is devoted to "Classes of Grades," is covered in six pages, which is very short, considering the importance of this subject to the maintenance of way engineer. As the size of the train which can be hauled over any division is directly proportional to the ruling grade, and, therefore, has a bearing on the operating costs, the question of economic grades should have received more attention.

The chapters dealing with railroad construction and engineering organization should have been at the front of the book.

The author states that the book has been published as an aid to students of railway engineering to take the place of large treatises, which deal with the work more in detail than the student requires.

Engineering as a Career. A series of papers by eminent engineers. Edited by Prof. F. H. Newell, of University of Illinois, and C. E. Drayer, Secretary, Cleveland Engineering Society. Published by D. Van Nostrand Company, New York. 226 pages, 5 x 7 ins., cloth. Price, $1.00.

This book has been published as a guide to parents and others interested in technical education. The facts presented should be a guide to them or to young men who plan a career along engineering lines without knowing just what is in store for them. It explains the duties of an engineer, whether civil, mechanical, electrical or mining, and tells what qualifications the prospective student of engineering should have before commencing his studies.

The various contributors to the book have, perhaps unconsciously, written the histories of their careers.

This adds value to the opinions which they have freely expressed.

The book should be read by all high school teachers and others who are frequently asked to advise young men in the choice of a career. In a great many cases the advice given by them is founded on the most hazy ideas of engineering, and the student who plans his education on such advice only finds out, often too late, that he is on the wrong track, and his time has been wasted in pursuit of a career for which he is not fitted.

Tacheometer Surveying. By M. E. Yorke Eliot, A.M. Inst.C.E. Published by E. & F. N. Spon, Limited, London, and Spon & Chamberlain, New York. 145 pages, 4½ x 7 ins., 1 plate and 30 illustrations, cloth. Price, $1.50.

This book is for the use of engineering students who require a book which gives information on the actual handling of the work in the field and office. Four chapters are devoted to the elementary study of the subject, and are intended to give the student a thorough knowledge of the simpler work before going into more difficult phases of it. A whole chapter is devoted to the actual field work of a contour survey, from selecting the station points to the final calculation. Another chapter gives the office work in connection with the survey. The calculation of lines and areas and the uses of the slide rule are taken up. The author states that the book has been written with the intention of explaining tacheometry as it is practised in countries outside of England and aiding in the more widespread use of the methods employed.

Railway Regulation. An analysis of the underlying problems in railway economics from the standpoint of government regulation. By I. Leo Sharfman, Professor of Political Economy, University of Michigan. Published by the La Salle Extension University, Chicago. 230 pages, 6 x 9 ins., leather. Price, $2.00.

A book presenting an analysis of the leading problems in railway economics from the standpoint of government regulation in the United States.

The historical facts are presented which have led up to present-day practice and problems. The author quotes figures which show the magnitude of the railway industry and the influence it has had on the development of the nation. The history of railroading under private development and public aid, and the evils of early speculation, are given with some detail, showing how public sentiment gradually turned against the roads. Chapters are devoted to Railway Competition; the Theory and Practice of Rate-making; the Regulation of Railway Rates; Railway Discrimination and various legal decisions of the courts on regulation of roads.

While the book has been written entirely with regard to American railroads, it would be of interest to the student of railway economics.

Elements of Highway Engineering. By Arthur H. Blanchard, C.E., A.M.Am.Soc.C.E., M.Can.Soc. C.E. Published by John Wiley & Sons, 1915. 500 pages, 6 x 9 ins., 202 figures, cloth. Price $3.

In the preface the author states that the book was written for the use of students who required only the fundamental principles and did not desire to take up a special course in highway engineering.

The first five chapters deal with highways in general. The ancient Roman roads are described. They were originally built for military purposes and declined with the fall of the Roman Empire. The reader will note how very similar were the ideas of the ancients with our own in regard to design of roads. Reference to the pioneer work of Tresoguet in France and McAdam and Telford in England is made.

Economics and methods of taxation for road improvement are discussed, with a very full description of methods in use in France. Preliminary investigation, survey and design, grading and machines are each given a chapter.

The following twelve chapters give details of different classes of roads and pavements. Development, with historical data and a glossary of terms, heads each chapter. Very little space is given to natural roads. The remainder of the book is given over to street-cleaning and snow-removal, sidewalks and highway structures, which are very lightly touched on. Useful appendices on highway terms and testing of material are added.

Industrial Leadership. By H. L. Gantt. Published by the Yale University Press, New Haven. Conn. 128 pages, 5 x 8 ins., with nine charts. Price. $1.00 net.

This book contains addresses delivered in the Page Lecture Series, 1915, before the senior class of the Sheffield Scientific School, Yale University. The author states that in his lectures he has attempted to set forth the principles on which industrial democracy can be based so as to be more effective than any system of industrialism which can be developed under autocracy. The great war is evidence of the superiority of autocracy in organizing a nation for both industrial and military efficiency, and if democracy is to compete successfully it must develop methods which will be at least equal to those employed by autocracy.

Civil Engineers' Cost Book. By Lieut.-Col. T. E. Coleman, Royal Engineers. Published by E. & F. N. Spon, Limited, London. 381 pages, pocket size, cloth. Price, $1.50.

This book is compiled for the use of engineers and contractors. Actual costs of construction for various works are given, the details for which have been gathered by the author during a long and varied experience in connection with civil and military engineering works. A chapter on cost of plant and machinery will be very useful. As a general reference book for engineers engaged in countries where English units of currency are in force it no doubt will be found very useful. For Canadian engineers, however, it will serve more as a basis for comparison of costs.

Railway Maintenance Engineering. By Wm. H. Sellew, M.Am.Soc.M.E. Published by D. Van Nostrand Company, New York. 360 pages, 5 x 7½ ins., 194 illustrations and 6 folding plates, cloth. Price, $2.50.

The author states that the book was written primarily as a text book for students, but that some information of an advanced character has been included that will be of value to the practising engineer as a reference book. It would be particularly useful to the location or construction engineer breaking into the maintenance department activities. In case of the reader desiring to go more fully into questions discussed, there is a bibliography at the end of each chapter which will direct his efforts along the lines of research. The first four chapters deal with construction problems; the remainder of the book is devoted to maintenance work. Materials of construction and operation used in the various branches of maintenance are very fully discussed. A chapter on rails, dealing with standard sections, strength and methods of manufacture being particularly well written. In this connection it might be said that materials have received the greatest attention in the book, while methods of construction have been cut short.

Chapters on station buildings, fuel and water stations and icehouses are of value, the chapter on icehouses and methods of harvesting ice being larger than the others. A feature of the book which should commend itself to all maintenance engineers is that all names of makers of various appliances are given, with cost data covering some of them. Numerous tables included in the book will be of service to the practising engineer.

Electrical Pocket Book for 1916. Published by Emmott & Co., Limited, Manchester and London. 240 pages and diary, 4 x 6 ins., illustrated, cloth. Price, 30 cents.

The annual electrical publication of the "Mechanical World" series. A collection of engineering notes, rules, tables and data, with new information introduced and several sections re-written.

Machine Design. By Albert W. Smith, Director of Sibley College, Cornell University, and Guido H. Marx, Professor of Machine Design, Leland Stanford Junior University. Published by John Wiley & Sons (Inc.), New York. Fourth edition, revised and enlarged. 500 pages, 6 x 9 ins., cloth. Price, $3.00. (Reviewed by L. M. Arkley, M.Sc., Mechanical Engineering Department, University of Toronto.)

Chapter I. explains the elementary definitions used in the study of motion in machine parts without regard to the forces causing motion.

Chapter II., called "Motion of Mechanisms," treats of the relative motion of the parts of the slider crank chain, and gives in detail methods of finding the velocity of the reciprocating parts in quick return motions.

In Chapter III. analyses of several well-known straight-line motions are given.

Chapter IV. treats of cams, but in a rather brief way. This chapter could be enlarged to advantage to include such forms as cylindrical and sliding cams.

In Chapter XVII. tooth-wheels, or gears, are discussed at length and in the conventional fashion. Involute and cycloidal tooth outlines are described and methods of design of spiral and bevel gears given.

The subjects discussed in the above mentioned chapters are usually treated separately in books on Kinematics of Machines, as they deal primarily with motion without reference to force, while "energy in machines," taken up in Chapter V., comes naturally under the head of dynamics of machines.

The remaining chapters treat of machine design proper, and take up methods of design of riveted joints, bolts and screws, axles and shafts, journals and bearings, couplings and clutches, belts, ropes, brakes, flywheels, etc., and these subjects are treated in much the same manner as in all standard books on machine design. The last chapter on machine frames is one of the best in the book. In it the stresses developed in the frames of several commonly-used machine tools are analyzed and the best section for resisting these stresses indicated.

This book has probably been written primarily as a text book for students, and used as such should serve its purpose very well, especially if supplemented with exercises in Kinematics and machine design worked out on the drawing-board. From the above it will appear that the book appeals to the teacher of machine design rather than to the practical designer, who finds most useful books containing data on the subject in hand instead of a treatise on first principles.

Metal Statistics, 1916. Published by the American Metal Market and Daily Iron and Steel Report, New York. 368 pages, 4 x 6 ins. Price, 50 cents.

Is given over entirely to tables showing the prices and production of minerals, their manufactured products and various kinds of coal and coke. In most cases the tables include estimates for 1915, but in some places 1915 figures are completely omitted.

Empire Directory and Year-Book. Published by the Sanitary Publishing Company, Limited, London, Eng. 200 pages, 7 x 9 ins., and diary. Price, $1.50.

This is the 34th annual issue of the year-book of "The Sanitary Record and Municipal Engineering." A directory of municipal authorities for the United Kingdom and all British colonies and dependencies, while not complete as regards Canada, would likely be of use to Canadian firms looking for a market in Britain where the information given is more likely correct. Other information relative to municipal and sanitary engineering is given under various chapter headings.

PUBLICATIONS RECEIVED.

Mineral Production of Canada.—The preliminary report of the Mines Branch for 1915.

Timiskaming and Northern Ontario Railway Commission.—Report of the Ontario Government Railway for 1915.

Water Power Commission, Province of Nova Scotia.—Progress report, 1915, with a map showing progress of stream measurement and power investigations.

The Production of Cement, Lime, Clay Products, Stone and Other Structural Materials in Canada.—A report of the Mines Branch, giving statistics for the year 1914.

Iowa State Highway Commission Service Bulletin.—The March number of this interesting little paper, describing a new bridge at Iowa City and other Iowa road news.

Mineral Production, 1915.—Bulletin No. 1, 1916, of the British Columbia Bureau of Mines; a preliminary review and estimate of mineral production during 1915, by Wm. Fleet Robinson, provincial mineralogist.

Department of Mines.—Summary report of the Mines Branch, Ottawa, for 1914, describing investigations in connection with metallic and non-metallic deposits, testing of oils and fuels, examination of minerals and statistics.

Design of Intakes, Scroll Cases and Turbine Draft Tubes for Single Runner Turbines.—By A. G. Hillberg, hydraulic engineer, Park Row Building, New York City. A series of articles reprinted from the Engineering Record. Distributed free on application to the author.

The Colorado Industrial Plan.—A booklet by John D. Rockefeller Jr., in which is reprinted the article "Labor and Capital—Partners" and several addresses by the author respective of working conditions in the coal and iron mines of the Colorado Fuel and Iron Company.

Canada's Iron and Steel Industry.—A 14-page pamphlet, giving the history of the Nova Scotia Steel and Coal Co. Illustrating and describing the various plants and giving a synopsis of the financial affairs of the company.

Metal Mine Accidents in the U.S.—A technical paper published by the U.S. Bureau of Mines, giving statistics of accidents during the year 1914.

Some Engineering Problems of the Panama Canal in Their Relation to Geology and Topography.—Bulletin No. 86 of the U.S. Bureau of Mines. A paper by Donald F. McDonald, who was detailed as geologist to the Panama Canal while it was under construction. The paper has been published by the Bureau of Mines as a contribution to engineering literature because it presents information that shows how geology and topography must be considered by the engineer in planning excavations and in removing loose material and solid rock in the safest and most efficient manner.

Poor's Manual of Railroads for 1916.—The 49th edition of Poor's Manual of Railroads, covering the United States, Mexico and Canada, has just been issued. This valuable reference work presents this year for the first time the margin of safety on individual bonds and stocks in the form of percentage of total net earnings remaining after interest or dividends. This information appears throughout the text in connection with the statements. It gives subscribers first-hand facts upon which to base their estimates of value.

Bond descriptions have been thoroughly revised, particularly with respect to the underlying security. In this work, the Manual has had official assistance. The descriptions contain new italicized headings, such as Interest, Trustee, Secured By, etc., so that the particular kind of information wanted may more readily be found.

All statements are revised to June 30, 1915, including those of companies that report for the calendar year. Information of importance issued prior to February 10, 1916, is also included.

CATALOGUES RECEIVED.

The Milburn Light.—A 52-page, illustrated catalogue describing the various styles of lights and other products manufactured by this company.

Tiffin Motor Trucks.—A very attractive four-page pamphlet giving the specifications of this well-known line of motor trucks. Suitably illustrated. Tiffin Wagon Company, Tiffin, Ohio.

Centrifugal Pumps.—Bulletin No. 108-A issued by the Wheeler Condenser and Engineering Co., Carteret, N.J., being a 34-page catalogue describing their single-stage, double-suction, type D.A.A., centrifugal pump for heads of 0 to 300 feet. Well illustrated.

PERSONAL.

R. C. D. TEMPEST has resigned from his post as resident engineer of the sewer section, Toronto, on account of ill health.

K. H. SMITH, B.A.Sc., recently addressed the Nova Scotia Society of Engineers on "Some Engineering Features of the Pan-Pacific International Exposition."

JOHN KEILLOR, gas engineer, Hamilton, Ont., has received the appointment of superintendent to the Vancouver Gaslight Co., Vancouver, B.C. Mr. Keillor was previously manager of the Hamilton Gaslight Co.

B. G. SLAUGHTER, late vice-president and chief engineer of the Canadian Copper Company, Copper Cliff, Ont., has resigned to accept a position as vice-president of the Tennessee Copper Company, Copperhill, Tenn.

OBITUARY.

WM. W. CHISHOLM, electrical superintendent of the Wallaceburg, Essex and Lake Shore Electric Railway, was electricuted while working around a derailed car near Leamington.

CHARLES SELLERS, president of the Peerless Furnace Co., Toronto, which he founded over twenty-five years ago, died on March 20, aged 82. Mr. Sellers was a native of Glasgow, Scotland, but had resided in Toronto for over 60 years. He was superintendent of the Gurney Foundry Co. for more than 20 years.

OTTAWA BRANCH CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a luncheon of the branch held recently, E. A. Dunlop, M.L.A., gave a very interesting address in which he described conditions at the front as he saw them on his recent visit to the trenches. Mr. Dunlop spoke particularly of the work of Col. Mitchell, head of the Canadian Intelligence Department. Mr. Dunlop was accorded a hearty vote of thanks for his interesting talk.

CANADIAN SOCIETY OF CIVIL ENGINEERS, MONTREAL.

An instructive illustrated lecture and practical demonstration on the subject of "Electrical Precipitation of Solids from Grease," was given by Linn Bradley, of the Research Corporation, New York, before a large gathering of the members of the Canadian Society of Civil Engineers, in the Macdonald Engineering Building.

The lecturer treated with the importance of the subject to every branch of the engineering profession as regarding mining, metallurgical, chemical and electrical industries.

CALGARY BRANCH, CANADIAN SOCIETY OF CIVIL ENGINEERS.

At a dinner of the members of the branch a very interesting talk was given by G. N. Houston, of the irrigation branch. Mr. Houston spoke on "Legislative Control of Engineering Practice." He stated that there was a growing attempt to control the practice of engineering by legislation on both sides of the line. Several engineering societies had attempted to have legislation passed which would state the qualifications required of a man before he could practise as a civil engineer. The bills had, however, been defeated. Until some definition of the term "civil engineer" was arrived at the public would not be protected from incompetent engineers.

The speaker doubted if licensing would cut out incompetence. He proposed in lieu of law that the government supervise all plans and specifications for construction, and also admit as members only men of a very high grade.

"The man to be admitted should be a member of the Canadian Society or British Society, or a society of equal standing or certificate," concluded Mr. Houston.

COMING MEETINGS.

AMERICAN WATERWORKS ASSOCIATION.—Thirty-sixth annual convention to be held in New York City, June 4th to 8th. Secretary, J. M. Diven, 47 State Street, Troy, N.Y.