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STRESSES IN CIRCULAR PIPES.

WITH SOME NOTES ON THE DESIGN OF LARGE WATER CONDUITS— A CALCULATION OF STRESSES DUE TO INTERNAL WATER PRESSURE, WEIGHT OF THE SHELL, AND BACK-FILL—CIRCULAR PIPE UNSUITED FOR CASES OF LARGE DIAMETER PIPE AND LOW PRESSURE HEAD, OWING TO THE RESULTING BENDING MOMENTS

By T. H. HOGG, B.A.Sc., A.M. Can. Soc. C.E.,

Assistant Hydraulic Engineer, Hydro-Electric Power Commission of Ontario, Toronto.

The analysis of the stresses in circular pipes due to the weight of the material in the pipes themselves, to internal and external water pressures, and to different kinds of loading, is a subject to which little attention has been devoted in engineering literature.

When the pipes are relatively small in diameter, the conditions are such as yield to simple approximate methods of investigation. With the larger sizes of conduits and pipes now being used so extensively in water supply and water power systems, however, the question of the weight of the shell itself, and the differences in pressure at the top and bottom of the pipe when conveying water in a horizontal position, become exceedingly important.

This paper is presented in the hope that it will afford some aid to the engineer in the design of such conduits. The results of the analyses contained in it were arrived at while the writer was working under the direction of Mr. R. D. Johnson, of Niagara Falls. The system followed in the development of the theory of the stresses due to water pressure is along similar lines to the work of C. W. Filkins and E. J. Fort, who developed the stresses in circular rings due to the weight of the rings themselves, and due to external water pressure. Their work is published in the "Transactions of the Association of Civil Engineers of Cornell University," for 1896.

The following discussion takes up the analysis of the stresses in circular conduits due to internal water pressure. The method of combining the stresses due to the weight of the shell and to the water pressure is reviewed; the question of the design of large conduits for the carrying of water is dealt with, and the equilibrium shape as the logical one, in preference to the circular, is described.

Stresses Due to Internal Water Pressure.—It is usually assumed in figuring the stresses due to internal water pressure in circular pipes or conduits, lying horizontally, that it is quite sufficient to take into account only the tension induced in the shell, and that the bending moment may be neglected. This is only true when the pressure head is infinite and may be grossly in error when the pressure head is small, and the diameter of the pipe relatively large. When the latter condition exists there is a greater pressure at the bottom than at the top, and this causes large bending moments in the shell.

Throughout this discussion the ring is assumed supported on a knife edge, and water pressure is assumed level with the crown of the pipe. The analysis also assumes a thin ring of homogeneous material, having a constant modulus of elasticity, and that the changes from a circular form will have little effect upon the dimensions of the ring.

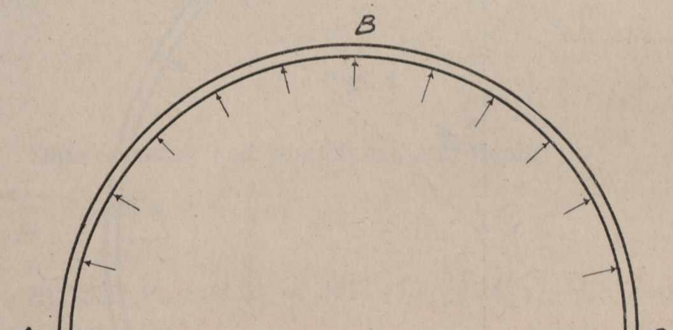


Fig. 1.

These assumptions are merely to facilitate the application of theory. When the results have been obtained, practical considerations which affect these considerations will be discussed.

The following nomenclature will be used throughout the paper:

H = head of water above top of pipe.

r = radius of circular pipe.

M = bending moment in pipe.

M_B = bending moment in pipe at top.

M_D = bending moment in pipe at bottom.

M_{max} = bending moment in pipe at maximum point on side.

T = tension in pipe.

T_B = tension in pipe at top.

T_D = tension in pipe at bottom.

ϕ = angle to different points (expressed in radians).

ϕ_{max} = angle to maximum bending moment point on side.

ϕ_U = angle to upper node point (point of no bending moment).

ϕ_L = angle to lower node point (point of no bending moment).

γ = weight of cubic foot of water.

J = shear at any point.

J_B = shear at top.

J_D = shear at bottom.

d_p = arm of bending moment.

d_o = arm of the bending moment at top of pipe.

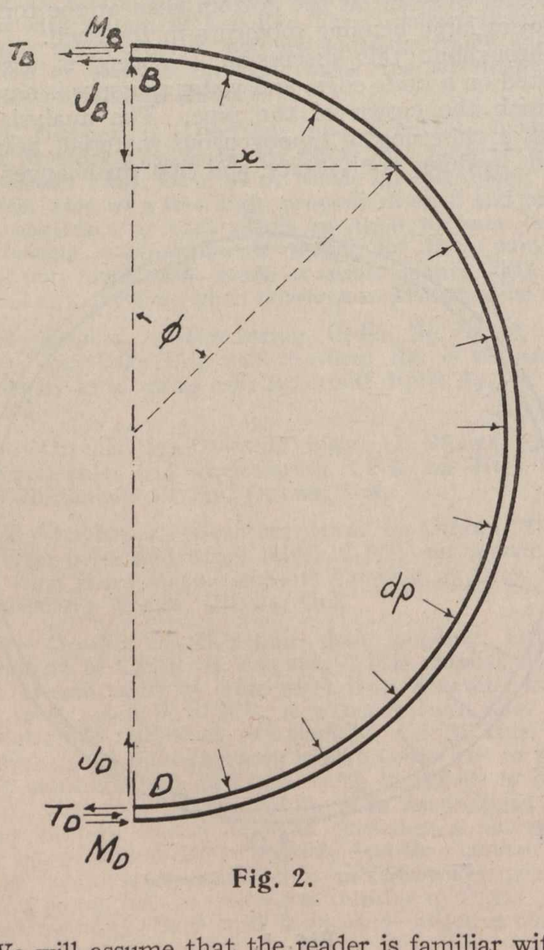


Fig. 2.

We will assume that the reader is familiar with the three general formulae for arch ribs, viz.,

$$\int_D^B \frac{Mds}{EI} = \int_D^B d\phi; \qquad \int_D^B \frac{Myds}{EI} = \int_D^B dx;$$

$$\int_D^B \frac{Mxds}{EI} = \int_D^B dy.$$

The ring is a continuous curved beam to which these situations will apply.

The forces acting upon the pipe may be appreciated by looking at Fig. 1. If we cut the pipe at B and D and consider the forces acting on the section to the right, we obtain the system of forces shown in Fig. 2.

Taking the centre of moments at the neutral axis at D, we obtain:

$$M_D = M_B - 2T_B r + \int_0^\pi r(1 - \cos\phi)\, dp \sin\phi$$

Now,

$dp = \gamma r^2 (1\text{-}\cos\phi)\, d\phi$; and,

$\sin\phi\, dp = \gamma r^2 (1\text{-}\cos\phi) \sin\phi\, d\phi$.

Therefore,

$$M_D = M_B - 2T_B r + \int_0^\pi \gamma r^3 (1\text{-}\cos\phi) \sin\phi\, d\phi.$$

Integrating, we obtain:

$$M_D = M_B - 2T_B r + 2\gamma r^3.$$

Now, consider as a free body that portion of pipe shown in Fig. 3.

$$EI\Delta y = \int Mxds;\ ds = rd\phi = rd\theta;$$

$$-M = M_B - T_B y + \int_0^B pdsx;$$

$$pds = \gamma r^2 (1\text{-}\cos\theta)\, d\theta;$$

$$x = r \sin(\phi - \theta);$$

$$y = r(1\text{-}\cos\phi).$$

Therefore,

$$-M = M_B - T_B r (1\text{-}\cos\phi) + \int_0^\phi \gamma r^3 (1\text{-}\cos\theta) \sin(\phi-\theta)\, d\theta;$$

$$= M_B - T_B r + T_B r \cos\phi + \gamma r^3 \int_0^\phi (1\text{-}\cos\theta) \sin(\phi-\theta)\, d\theta,$$

$$= M_B - T_B r + T_B r \cos\phi + \gamma r^3 (1\text{-}\cos\phi - \tfrac{1}{2}\phi \sin\phi).$$

Therefore,

$$EI\Delta y = \int Mxds = \int Mr^2 \sin\phi\, d\phi,$$

$$= \int_0^\pi \Big[(M_B r^2 - T_B r^3 + \gamma r^5) \sin\phi\, d\phi + (T_B r^3 - \gamma r^5) \sin\phi \cos\phi\, d\phi - \tfrac{1}{2}\gamma r^5 \phi \sin^2\phi\, d\phi \Big]$$

Solving the above equation we obtain:

$$EI\Delta y = -2(M_B r^2 - T_B r^3 + \gamma r^5) + \frac{\gamma r^5 \pi^2}{8};$$

also, $EI\Delta x = \int_D^B M(ds)y = 0$, since B has not moved horizontally, and since its tangent is horizontal.

Now, $y = r(1\text{-}\cos\phi)$; $ds = rd\phi$.

Therefore, $EI\Delta x = r\int_0^{\pi r} Mds - r^2 \int_0^\pi M \cos\phi\, d\phi$

i.e., $0 = r\int_0^{\pi r} Mds - r^2 \int_0^\pi M \cos\phi\, d\phi$.

Substitute value of M found above and solve.

Therefore, $-\int_0^\pi M \cos\phi\, d\phi = \int_0^\pi \Big[(M_B - T_B r + \gamma r^3) \cos\phi\, d\phi + (T_B r - \gamma r^3) \cos^2\phi\, d\phi - \tfrac{1}{2}\gamma r^3 \phi \sin\phi \cos\phi\, d\phi \Big]$.

Therefore, $-\int_0^\pi M \cos\phi\, d\phi = \frac{\pi}{2}\left\{ T_B r - \gamma r^3 \right\} + \frac{\gamma r^3 \pi}{8}$

or, $\int_D^B Myds = \frac{\pi r^3}{2}\left\{ T_B - \frac{3\gamma r^2}{8} \right\} = 0$;

and, therefore, $T_B = \frac{3}{4}\gamma r^2$.

Now, $\int_D^B Mds = 0 = \int_0^\pi \left[M_B r d\phi - T_B r^2 (d\phi - \cos\phi\, d\phi) + \gamma r^4 (d\phi - \cos\phi\, d\phi - \frac{1}{2}\phi \sin\phi\, d\phi)\right]$;

Whence, solving the above,

$$M_B = T_B r - \frac{1}{2}\gamma r^3.$$

Therefore, $M_B = \frac{\gamma r^3}{4}$

Now, $M_D = M_B + 2\gamma r^3 - 2T_B r$

$$= \frac{\gamma r^3}{4} + 2\gamma r^3 - \frac{3\gamma r^3}{2}$$

$$= \frac{3}{4}\gamma r^3$$

Now, $-M = M_B - T_B r + T_B r \cos\phi + \gamma r^3 \left(1 - \cos\phi - \frac{1}{2}\phi \sin\phi\right) = \gamma r^3 \left(\frac{1}{2} - \frac{1}{4}\cos\phi - \frac{1}{2}\phi \sin\phi\right)$,

which is the general expression for the bending moment.

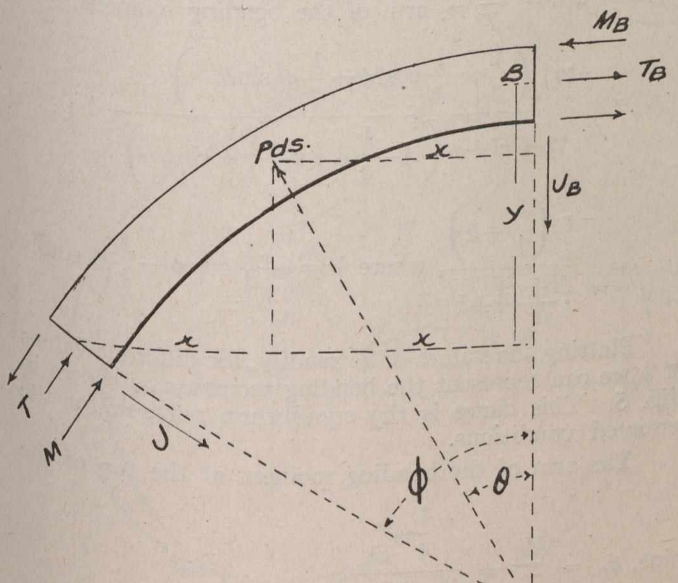


Fig. 3.

To find the shortening of the vertical diameter, substitute the values of M_B and T_B in the equation:

$$EI\Delta y = -2\,(M_B r^2 - T_B r^3 + \gamma r^5) + \frac{\gamma r^5 \pi^2}{8},$$

We obtain, $EI\Delta y = -\gamma r^5 + \frac{\gamma r^5 \pi^2}{8}$,

$$\Delta y = \frac{\gamma r^5}{EI}\left(\frac{\pi^2}{8} - 1\right) = +.2337\,\frac{\gamma r^5}{EI}.$$

To find the lengthening of the horizontal diameter,

$$EI\Delta x = \int_A^B M\,(ds)\,y.$$

$$\therefore -EI\Delta x = \int_0^{\frac{\pi}{2}}\Big[(M_B - T_B r + \gamma r^3)\, r^2\, (1 - \cos\phi)\, d\phi + (T_B r - \gamma r^3)\, r^2 (\cos\phi - \cos^2\phi)\, d\phi - \frac{1}{2}\gamma r^5\, (1\text{-}\cos\phi)\,\phi \sin\phi\, d\phi\Big].$$

Solving, $-EI\Delta x = \frac{\gamma r^5}{4}(1.5\pi - 5)$,

$$= -.0719\,\gamma r^5,$$

Therefore, $\Delta x = .0719\,\frac{\gamma r^5}{EI}$.

The whole change in horizontal diameter,

$$= 2\Delta x = .1438\,\frac{\gamma r^5}{EI}.$$

In order to find the value of ϕ where the moment is a maximum, place $\frac{dM}{d\phi} = 0$.

Therefore, $T_B r\, d\cos\phi - \gamma r^3 d\cos\phi - \frac{1}{2}\gamma r^3\, d\,\phi \sin\phi = 0$.

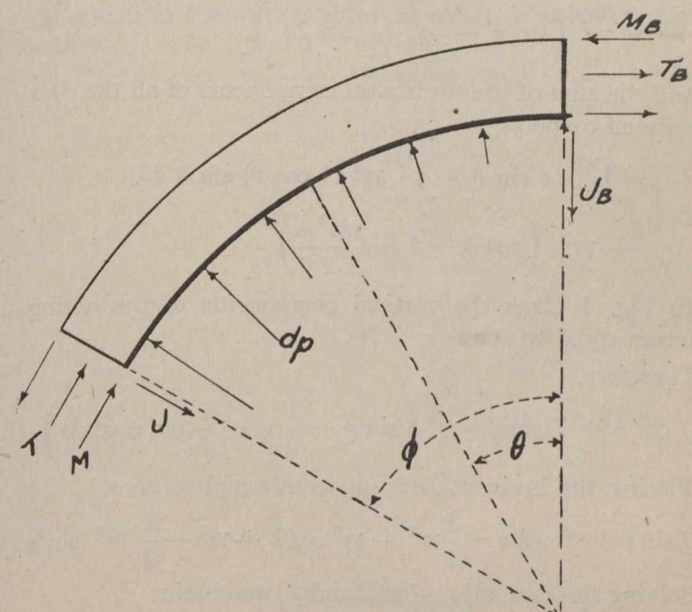


Fig. 4.

Differentiating and simplifying, we obtain:

$$\phi \cot\phi = -\frac{1}{2},$$

$$-2\phi = \tan\phi.$$

By trial we find $\phi = 105° - 13' - 45.4''$; also $\phi = 0$.

Now when $\phi = 0$, the maximum moment $M_B = \frac{\gamma r^3}{4}$.

When $\phi = 105° - 13' - 45.4''$ substitute in the expression for the moment,

$$-M = M_B - T_B\, r + T_B\, r \cos\phi + \gamma\, r_3\, (1 - \cos\phi - \frac{1}{2}\phi \sin\phi),$$

and we obtain,

$$M = -.3203\,\gamma r^3 .$$

Assembling and comparing the values of the moments found, we see that $M_B = +\frac{\gamma r^3}{4}$; $M_D = +\frac{3\gamma r^3}{4}$, and $M_{max} = -.3203\,\gamma r^3$.

Therefore, we see that the moment of the stress couple changes sign (i.e., passes through zero) between M_B and M_{max}, and between M_{max} and M_D.

Place M in the general equation, equal to zero, and solve for ϕ.

$$\gamma r^3 \left(\frac{1}{2} - \frac{1}{4}\cos\phi - \frac{1}{2}\phi\sin\phi\right) = M = 0.$$

Therefore, $\phi \sin\phi + \frac{1}{2}\cos\phi = 1$,

or, $\phi = 50° - 36' - 45''$,
also, $\phi = 146° - 19' - 25''$.

Now, considering Fig. 4, we see that the value of $dp = \gamma r^2 \text{ (1-cos } \theta) \ d\theta$.

Therefore, the sum of the vertical components of all the dp's between o and ϕ

$$= \int_0^\phi dp \cos\theta = \int_0^\phi \gamma r^2 \text{ (1-cos } \theta) \cos\theta \, d\theta,$$

$$= \gamma r^2 \left(\sin\phi - \frac{1}{2}\phi - \frac{1}{4}\sin 2\phi\right).$$

And the sum of the horizontal components of all the dp's between o and ϕ

$$= \int_0^\phi dp \sin\theta = \int_0^\phi \gamma r^2 \text{ (1-cos } \theta) \sin\theta \, d\theta,$$

$$= -\gamma r^2 \left(\cos\phi - 1 + \frac{\sin^2\phi}{2}\right)$$

In Fig. 4 place the vertical components of the acting forces equal to zero.

Therefore,

$$J\cos\phi + T\sin\phi = \gamma r^2 \left(\sin\phi - \frac{1}{2}\phi - \frac{1}{2}\sin\phi\cos\phi\right).$$

Placing the horizontal components equal to zero,

$$J\sin\phi - T\cos\phi = \frac{3}{4}\gamma r^2 - \gamma r^2\cos\phi + \gamma r^2 - \frac{1}{2}\gamma r^2 \sin^2\phi$$

Solving these equations for T and J, we obtain:

$$T = \gamma r^2 \left(1 - \frac{1}{2}\phi\sin\phi - \frac{1}{4}\cos\phi\right).$$

$$J = \gamma r^2 \left(\frac{1}{2}\phi\cos\phi + \frac{1}{4}\sin\phi\right).$$

The above discussion has assumed that the pipe is just filled to the top with water. It is easy to see that the bending moments are not affected by the water pressure after the top is passed. In other words, the bending moments induced in the shell are caused by the difference in pressure between the top and any point on the shell chosen; and this difference remains constant for any head above the top. The tension in the shell, however, varies directly with the head, and is equal to $H\gamma r$, where H is the head on the top of the pipe.

This amount must be added to the above obtained value of the tension to obtain the general expression.

Formulae for Stresses Due to Internal Water Pressure

$$M = -\gamma r^3 \left(\frac{1}{2} - \frac{1}{4}\cos\phi - \frac{1}{2}\phi\sin\phi\right),$$

$$T = H\gamma r + \gamma r^2 \left(1 - \frac{1}{4}\cos\phi - \frac{1}{2}\phi\sin\phi\right).$$

$$J = \gamma r^2 \left(\frac{1}{2}\phi\cos\phi + \frac{1}{4}\sin\phi\right),$$

$$M_B = \frac{1}{4}\gamma r^3,$$

$$M_D = \frac{3}{4}\gamma r^3,$$

$$M_{max} = -.3203\ \gamma r^3,$$

$$T_B = H\gamma r + \frac{3}{4}\gamma r^2,$$

$$T_D = H\gamma r + \frac{5}{4}\gamma r^2,$$

$$\phi_{max} = 105° - 13' - 45''.4,$$

$$\phi_U = 50° - 36' - 45'',$$

$$\phi_L = 146° - 19' - 25'',$$

$$\triangle_x = .0719\ \frac{\gamma r^5}{EI},$$

$$\triangle_y = .2337\ \frac{\gamma r^5}{EI},$$

To show the results clearly, let us plot a bending moment diagram. We can always express the bending moment in terms of the tension multiplied by the arm of the moment. Therefore, if we divide the bending moment at any point by the tension at the same point, we obtain the arm of the bending moment at that point.

Let $d\rho = \frac{M}{T}$ = arm of the bending moment,

$$= \frac{-\gamma r^3 \left(\frac{1}{2} - \frac{1}{4}\cos\phi - \frac{1}{2}\phi\sin\phi,\right)}{\gamma r \left\{H + r\left(1 - \frac{1}{4}\cos\phi - \frac{1}{2}\phi\sin\phi\right)\right\}},$$

$$= \frac{-r\left(\frac{1}{2} + k\right)}{\frac{H+r}{r}r + k}, \text{ where } k = -\frac{1}{4}\cos\phi - \frac{1}{2}\phi.\sin\phi.$$

Plotting the values of $d\rho$ readily, for different values of ϕ we can represent the bending moments as shown in Fig. 5. This curve is the equilibrium polygon for the assumed conditions.

The arm of the bending moment at the top of the pipe, $d_o = \frac{M_T}{T_T} = \frac{\frac{1}{4}\gamma r^3}{H\gamma r + \frac{3}{4}\gamma r^2}$,

$$= \frac{\frac{1}{4}r^2}{H + \frac{3}{4}r},$$

Stresses due to the Weight of the Shell.—The analysis of the stresses due to the weight of the material in the shell of the pipe is similar to the method we have just employed. As this case has been developed in the paper by Mr. C. W. Filkins and Mr. E. J. Fort, referred to in the introduction to this discussion, we will not repeat the discussion here. The following are the formulae deduced by them for the stresses due to the weight of the shell.

$$M = pr^2 \left(\phi\sin\phi + \frac{1}{2}\cos\phi - 1\right),$$

$$T = pr \left(\phi\sin\phi - \frac{1}{2}\cos\phi\right),$$

$$J = pr \left(\phi\cos\phi + \frac{1}{2}\sin\phi\right),$$

$$M_B = \frac{1}{2} pr^2,$$

$$M_D = \frac{3}{2} pr^2,$$

$$M_{max} = -.64076\ pr^2,$$

$$T_B = \frac{1}{2} pr = T_D,$$

$$\phi_{max} = 105° - 13' - 45.4'',$$

$$\phi_U = 50° - 36' - 45'',$$

$$\phi_L = 146° - 19' - 25'',$$

$$\triangle x = .1438 \frac{pr^4}{EI},$$

$$\triangle y = .4674 \frac{pr^4}{EI}.$$

The only new symbol here is, p, which represents the weight of a unit length of the pipe.

Stresses due to Back Fill.—The stresses due to an external concentrated vertical load on the crown of a circular pipe whose thickness is small as compared to its diameter, have been investigated by several writers.

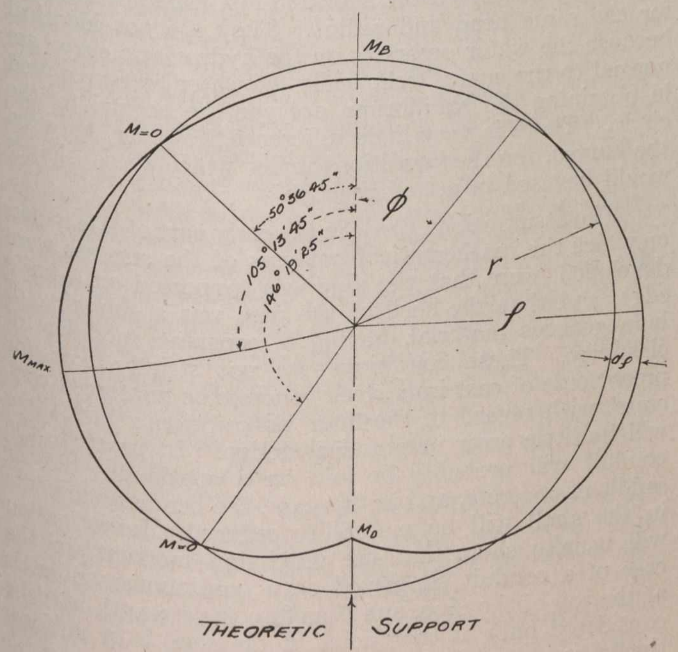


Fig. 5.

Probably the clearest exposition of this case together with the cases of a distributed vertical load, and distributed vertical and horizontal loads is given in Bulletin No. 22, University of Illinois Engineering Experiment Station. "Tests of Cast Iron and Reinforced Concrete Culvert Pipe," by A. N. Talbot. The reader is referred to this discussion.

The bending moment at the crown due to a concentrated vertical load P is equal to $M_B = .159\ Pd$, where d is the mean diameter of the pipe.

The bending moment at the crown due to a vertical load distributed uniformly over the horizontal projection of the ring is equal to $M_B = \frac{1}{16} wd.$, where d is the mean diameter of the ring and w is the total load on a ring of unit length.

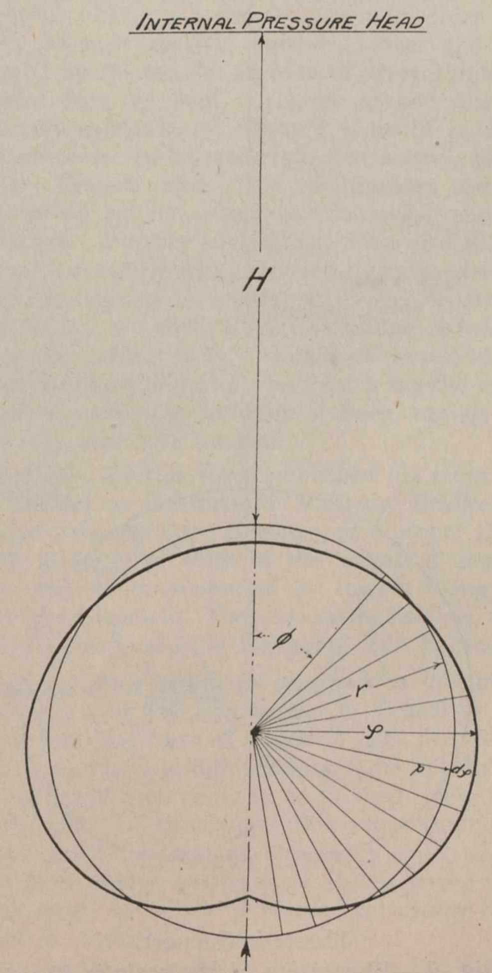
The bending moment at the crown due to a vertical load distributed over the horizontal section of the pipe as before and to a horizontal pressure uniformly distributed vertically against the pipe is equal to

$$M_B = \frac{1}{16}\left(1 - q\right) wd,$$

where w is the total vertical load on the ring, and q is the ratio of the horizontal to the vertical intensity of pressure.

The bending moments, it will be noted, are only given for the crown of the pipe. The reason for this will be clear on following the remainder of the discussion.

The reader is also referred to a paper by B. Haukelid in the June 14, 1913, issue of the ENGINEERING RECORD, on the "Stress Analysis of Circular Tubes." In this paper, Mr. Haukelid takes up the analytical and graphical determination of the stresses in circular tubes under various conditions of loading, and his analysis will be of assistance in connection with the results obtained in this article.



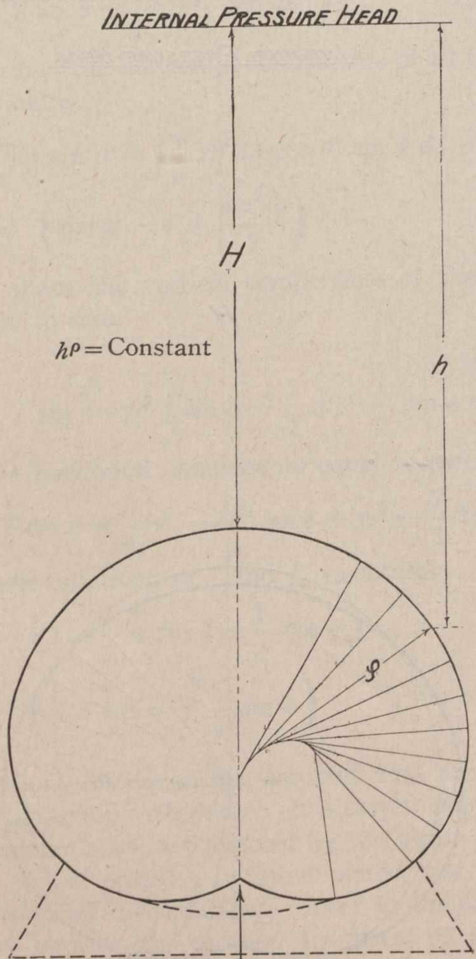
Theoretic Support.

Fig. 6.—Illustration of Equilibrium Curve.

A comparison of the formulae for the stresses due to internal water pressure, with the formulae for the stresses due to the weight of the shell, shows that they can be easily combined. It will be noted that angles from the vertical to the four nodes, or points of contra-flexure, are the same for both cases, and that the bending moments due to both causes are proportional at all points on the circle.

The analysis of the stresses in circular conduits due to internal water pressure has demonstrated the bending moments induced when such conduits are in a horizontal position. Where the diameter of the conduit, in an individual case, is large and the pressure head is comparatively low, these bending moments become very important, so important that it is usually better to use a shape more nearly conforming to the equilibrium polygon. Mr. R. D. Johnson, in a paper before the American Society of Mechanical Engineers, printed in the May, 1910, Journal of the Society, on "The Hydrostatic Chord," presents very clearly the reasons against the use of the circular shape for such conditions. In this paper he also describes the hydrostatic chord, a curve which is eminently satisfactory for use under the conditions.

The hydrostatic chord is the curve which results when a flexible inextensible substance is loaded by fluid pressure which varies according to the head or depth of water at any point. For purposes of illustration, let us assume we have a large soft hose. If this is laid on a horizontal surface, it immediately flattens out. When it is filled with water gradually, it rounds out, but



Theoretic Support.

Fig. 7.—Illustration of Hydrostatic Chord.

with a flattened oblate form. As the pressure is increased it becomes more nearly a circle. As this flexible material cannot take any forces due to bending, it is easy to see that the shell is in a condition of pure tension, that this tension is equal throughout, and of finite value. If, on the other hand, this hose were hung in a vertical position and filled with water, it immediately takes the shape of a circle, as the pressure at any horizontal plane is uniform at all points on the shell.

The hydrostatic chord is the same as the hydrostatic arch with the stresses all reversed. The only investigation of this arch the writer has seen is that found in Rankine's "Applied Mechanics."

Since the tension in the hydrostatic chord is constant at all points in the shell, and this tension is measured by the product of the radius of curvature, and the head at that point, it is an easy matter to construct the shape for any desired condition. The equation of the curve will be $h\rho$ = a constant, where h is the head to any point on the curve, and ρ the radius of curvature at that point.

With the practical elimination of the bending moments in large conduits by the use of this shape, a very considerable saving in the material of the shell will result, and its use under certain conditions is almost a necessity.

The conditions to be met with in the design of large conduits under relatively low-water pressures, are: water pressure, back fill, and the constant weight of the shell. The water pressure will in all probability vary between certain defined limits, also the back fill. By choosing an equilibrium shape midway between the shapes for the limits of the water pressure, the stresses due to the various loads may be reduced to a minimum, and the material of the shell thus will be greatly lessened.

Reverting to Figure 5, the equilibrium polygon for a circular pipe under water pressure, the method of obtaining this polygon shows that any number of these curves may be plotted, as different values of H may be taken, and it is clear that these polygons will all pass through the same node points.

The question may arise in the reader's mind whether the equilibrium polygons shown in Fig. 5 and Fig. 6, and the hydrostatic chord shown in Fig. 7 are not identical for the same head and radius. They are not identical because the water pressures on the hydrostatic curve are normal to the curve itself, while the water pressures used in obtaining the equilibrium polygon are normal to the circle. There is very little difference, however, between the curves, for the conditions under which these shapes would be used in actual practice.

The assumptions, made in the early part of this paper, on which the mathematical analyses of the stresses were developed, were that the pipe was supported on a knife edge, and that the shell of the pipe was a thin ring of homogenecus material, having a constant modulus of elasticity. These conditions are not strictly true for pipes made of cast iron, steel, concrete or reinforced concrete, with regard to the later assumptions; but there will be little error in practical design. In practice, the conduit will probably be laid on a continuous bed or saddle of concrete, and in this case, the bending moments in the shell will be materially reduced. Investigation will usually show that the maximum moment, in the case of a conduit supported on a continuous saddle, is at the top of the pipe, and therefore the strength need be considered only at that point, if the shell is of uniform thickness and uniform material.

If in the judgment of the designer, the size of the conduit, and the water pressures to which it is subjected, are such as to justify the use of the hydrostatic chord for the intermediate pressure head; the bending moment induced in the shell for any head may be computed at any point, by noting the intercept between the equilibrium curves for the intermediate pressure head and the head under consideration. The bending moment will then be equal to the tension at that point multiplied by this intercept.

The tension for any point is obtained from the formula previously derived, viz.,

$$T = \gamma r \left\{ H + r\,(1 + k), \right\}$$

and the value thus obtained for the particular point under investigation is multiplied by the intercept.

The total stress is obtained by combining algebraically the bending stresses due to the weight of the shell, the back fill, and the weight of water, and adding to this amount the tensile stress due to the water pressure.

SOME PHASES OF THE CHANNEL TUNNEL CONTROVERSY.

THE question of a tunnel under the English Channel was referred to in *The Canadian Engineer*, Sept. 11th issue. At the Franco-British Travel Congress, held in London Sept. 23rd, the enterprise was given thorough discussion. The tunnel, viewed as an engineering problem, was dealt with by Sir Francis Fox, whose remarks were, in part, as follows:—

"The grey chalk through which the tunnels would be bored is 87 ft. thick at Dover and 70 ft. thick at Sangatte. It possesses the peculiar property of gradually 'puddling' itself and becoming impervious. Containing no flints, it is, as far as can be ascertained, free from fissures and slides; but should a fissure be encountered, it may be easily and satisfactorily dealt with by means of the system of high-pressure grouting which has been introduced within the last five or six years. A drainage heading would be driven from each side of the Channel, rising towards the centre, and connected at Dover and Sangatte with shafts for pumping and winding.

"The main tunnels would consist of two single-track circular tunnels, each of 18 ft. net internal diameter, and thus large enough to accommodate the rolling stock of the British and French lines, except only their locomotives, for which would be substituted electrical locomotives of ample power to deal with the heaviest trains running upon the main lines. Including the junctions with the main lines of railway in England and France, the total length of each tunnel would be 31 miles, the actual length under water being 24 miles. The tunnels would be placed 36 ft. apart, and lined throughout by cast-iron segments, of ample strength to resist any possible pressure, and grouted on the outside so as to secure a covering of cement which would not only prevent leakage into the tunnels, but also preserve the plates from corrosion. Assuming that 17 yards per day could be maintained for six days per week, the annual progress would be about three miles at each face, so that the driving of the drainage heading would occupy four years.

"Ventilation of the tunnels would be established by blowing air in the direction in which each train was travelling. The traffic being electrically operated, the volume of air required is very largely reduced. To keep the tunnels pure and fresh it would be necessary to supply 45,000 cubic feet per minute on each line of way, travelling at a velocity of 6 ft. per second, which was equivalent to a very light breeze. The prevention of fire in the trains is also one to which much attention has been devoted. In the case of specially built rolling stock for the London and Paris and other expresses no inflammable material should be used, and as the motors of the electric locomotive would be 'armored' against fire in case of short circuiting no danger would arise as regards the electrical working even from the employment of ordinary rolling stock. Assuming, however, that in spite of precautions any stoppage should occur in the tunnels, the passengers would readily pass along the tunnels in the rear of the train, where ample space would be available, as a footpath, clear of the electrical conductors. The tunnels would be lighted throughout by electricity. A separate and special circuit would be provided, so that in the event of the main traction current failing the lights in the tunnels would not be extinguished. Plans and sections for the proposed approach railways on the British side provide sorting sidings and a station near Maxton, just within the borough of Dover. These railways are well laid out to accommodate the traffic, and, in conjunction with the station where the exchange of steam for electric locomotives and all necessary sorting of traffic would take place, would provide full and complete means of communication with both the existing main lines between Dover, London, and the rest of England."

Dealing with the protection of the tunnel in time of war, Sir Francis Fox said there would be no question of the destruction of the tunnel. There was a dip at the Dover end. All that would be necessary would be to open a valve and let in a certain quantity of water. Then nothing could pass through, and the water could not be got out before the declaration of peace.

While dealing with this subject, it is interesting to call to mind some of the other schemes that have been advanced. Those of Henry Fairburn, in 1833, were decidedly clever. The main idea was to take down a considerable portion of the cliff between Dover and Folkestone and fill up the sea for an area of several miles with the material thus obtained. A huge harbor was to be formed at the extremity of the new piece of land, and similar works were to be undertaken at a corresponding point on the French coast. The two harbors were then to be connected by an enormous causeway, about ten miles in length. Further suggestions were that after the harbors had been made and protected by huge sea-walls, communication was to be continued by the construction of a chain bridge, a tunnel, a floating bridge, a bridge of ships, or a great steam ferry. Details of these and many other novel schemes, including one for a marine railway to carry ships across the Isthmus of Suez, occupy some 250 pages of a now rare treatise.

In 1856 Mr. Charles Boyd published his plans for a "Marine Viaduct or Continental Railway Bridge" between Dover cliffs and Cape Gris-nez, at a proper altitude for the safe passage of ships of the largest dimensions. The bridge was to be supported by towers rising from the bed of the Channel. The towers themselves, about 500 feet apart, were to have fog-gongs and lighthouses.

Perhaps the most ingenious scheme was that humorously propounded by the late Angus B. Reach in 1847. This was to take the form of a line of rails on a timber foundation carried by a bridge of boats, "the rails to work on hinges on board each boat, so as to yield freely to the action of the sea." Trains were shown in a sketch running up and down the inclines formed by the trough of the sea. A further joke by the same author was a Channel Balloon Line, in which a train was shown on an aerial platform supported by three balloons.

All these schemes are but marks of the general thought and effort to solve the problem of communication between England and the Continent, which, in spite of the great progress made in maritime navigation, has remained difficult on account of the obstacle of the channel, an obstacle of comparatively recent origin, the result of an erosion produced in a soil which was once continuous.

The study of the channel tunnel has brought to light one interesting fact, and that is the proportion of travellers between England, on the one hand, and France, Belgium, Holland and Germany, on the other, is slightly less than one per cent. of the united populations of these countries. But between France and Germany the proportion is two per cent.; and between France, Belgium, and Holland, eight per cent. M. A. Sartiaux, chief engineer of the French Northern Railway, and an administrator of a French society for the building of a channel tunnel which was constituted in 1875, and which still exists, commented recently upon these proportions in travelling communication thus: "The proportion is remarkably low between England and the Continent, and we should have reason to be astonished at this if we did not know how much the changing of carriages, etc., complicates a voyage, and if we did not know the repugnance of many people to the smallest voyage on the sea.

"On the Continent, and even in England, there are business men who, although lacking nothing in activity, give way before the loss of time and the fatigues of the double crossing. It is necessary, whether going or coming, to resign oneself either to passing a night without sleep or sacrificing a day or half-day. Either of these alternatives is not encouraging. When, in addition, one is a victim to mal-demer, the voyage becomes really formidable. It is easy to understand, then, why many business men only undertake it on rare occasions, and why many tourists hesitate, with all the more reason, to undertake it when their sole pursuit is that of pleasure. . . . With the tunnel the journey between London and Paris would be five to five and a half hours by the most rapid route. But it would do more than take two hours off the present time necessary. It would make it possible, and here is the essential progress, to leave one of the capitals towards eight or nine in the morning, to be in the other at one or two o'clock in the afternoon, to leave it at six or seven in the evening, and to be back home again between eleven o'clock and midnight. Thanks to such a service, the movement of travellers between London and Paris would be doubled, perhaps trebled, at the end of a few years, and the current of business affairs between the two countries would follow a similar progression." M. Sartiaux then goes on to show how the growth of commerce between France and England is very much inferior to the growth between France and other Continental countries. The growth of general commerce between France and England for the years 1904 to 1911 was, on an average, 4.2 per cent. annually. But in the same period the commerce between France and Germany increased by 8½ per cent. annually, climbing up in that time from 1,117 millions of francs to 2,035 millions. "These figures have their eloquence. They show clearly the influence that is exerted by easy communication on commercial development."

Early Tunnel Schemes.—From figures, M. Sartiaux passes on to a short history of the various projects that have been made for the construction of a Channel tunnel, and it is interesting to note that such ideas have always originated on the other side of that important strip of water. As early as 1802 a French engineer named Mathieu had the idea of making a tunnel for a service of diligences, but he could certainly never have carried out his idea. A little later there was an idea, more weird than useful, for laying on the bed of the ocean an enormous iron tube. But it was not until 1867 that there was a serious proposal, based on geological studies of the bed of the Channel. This was made by Thomé de Gamond, and his careful borings in the Channel bed have been of great use to engineers interested since in the project. "In order to complete his scientific efforts Thomé de Gamond formed, in 1869, a Franco-British committee, whose aim was to work on both sides of the Channel towards a concession for the construction of the line. And here was commenced the diplomatic phase of the project, about which negotiations were opened between London and Paris. Far from opposing the idea, the British Government received the first communications favorably, and the reply that our Ambassador then received enabled pourparlers to go on with the greatest hopes of arriving at an entente. The conversation was, in fact, pursued between successive governments, and ended in 1874 in so complete an understanding that a Franco-British commission was formed to fix the conditions in a protocol, which was signed on May 30, 1876."

From then work went forward on both sides, although the most important was done by the French at Sangatte—the spot, by the way, from which Latham made his attempts to fly the Channel. There a long shaft was sunk and a gallery run under the sea to a length of over a mile. The works at Sangatte have never been abandoned definitely, and work could be restarted there again tomorrow if necessary. At Folkestone also a preliminary gallery was made. But work on both sides was stopped by an agitation which arose in England, the end of it being that no more was heard of the Channel tunnel scheme for many years; then, as now, the great objection being the possibility of military invasion.

CEMENT MANUFACTURE IN CANADA.

Concerning the manufacture of cement in Canada, Mr. T. McLeish, of the Division of Mineral Resources and Statistics, has issued the following data in his report on Economic Minerals and Mining Industries:—"Materials used in the manufacture of cement in Canada include marls, limestones, clays and blast furnace slag. The occurrence of cement materials is so widespread and abundant in all parts of the country that the question of their utilization is largely economic, being dependent upon the market for the product, the comparative availibility of suitable raw materials in different localities, the cost of fuel, and the transportation facilities. There are at present 24 completed cement plants in Canada, with a total daily capacity of about 28,800 barrels, besides several plants in course of construction. The total production in 1912 was 7,132,732 barrels, valued at $9,106,556, and in addition, 1,434,413 barrels were imported. The operating plants are distributed as follows:—One at Sydney, Nova Scotia, using blast furnace slag, three in the province of Quebec, two of which are near Montreal, and one near Hull, adjacent to the city of Ottawa, each using local limestone and clay. In the province of Ontario there are 15 plants with a total daily capacity of nearly 16,000 barrels. Of these 11 use marl and four limestone. The marl plants are located at Marlbank, Durham, Owen Sound, Lakefield, Hanover, Blue Lake, Raven Lake, Orangeville and Ottawa. The limestone plants are located at Belleville and Port Colborne. Formerly considerable quantities of 'Natural Rock' cement were made from a suitable calcareous limestone found in the Niagara peninsula, but this has now been entirely superseded in Ontario by the production of Portland cement. In the province of Manitoba, a 'Natural Portland' cement is made at Babcock, south-west of Winnipeg. Alberta has three limestone plants, located respectively at Calgary, Exshaw and Blairmore. A second limestone plant is being constructed at Blairmore, while a marl plant is being constructed near Marlboro about 145 miles west of Edmonton. British Columbia has one rock plant at Tod Inlet, near Victoria, and a second under construction at the same place, while another rock plant is nearing completion at Princeton."

The dock department of New York has decided upon building a drydock big enough to accommodate the "forthcoming 1,000-foot ship." The project will cost about $2,500,000.

VALUE OF THE FIXED CARBON TEST

By H. B. PULLAR,
o Pullar & Enzenroth, Engineering Chemists, Detroit, Mich.

NOTE: *On account of a bitter discussion regarding the propriety of limiting the maximum amount of fixed carbon, the City of Toronto was delayed six months in awarding its contract for supply of asphalt for 1913. The city bought in the open market during the first half of the year, as the Works Department did not seem able to convince the Board of Control that fixed carbon should be limited to 15%. Some of the controllers thought the specification unfair. Moreover, many chemists, paving contractors and city engineers differed in their opinions as to whether the specification was fair or unfair.*

The city engineers of Canada will, within the next two or three months, write their specifications for asphalt supply. THE CANADIAN ENGINEER *believes that a discussion of the desirability or undesirability of the "Fixed Carbon Test" would therefore be particularly valuable at this time.*

During the next couple of months THE CANADIAN ENGINEER *hopes to publish a number of articles from prominent chemists expressing their opinions regarding Fixed Carbon; and letters from city engineers and others who may have well-defined views on this subject are invited. Of seven well-known chemists whose opinions have been obtained by* THE CANADIAN ENGINEER, *two strongly favored limiting fixed carbon to 15%, four favored disregarding the test entirely, while one—Mr. Pullar—suggested a classification of asphalts with a different limit for fixed carbon for each class.*

Mr. Pullar's suggestion is novel and has many points in its favor. In the following article he explains his claim that the maximum limit of fixed carbon for a gilsonite asphalt—for example—must be much lower than the limit of fixed carbon for, say, a Texas asphalt, in order that the gilsonite asphalt be in every way as good a paving material as the Texas asphalt.—EDITOR.

THE question of the value of the fixed carbon test as applied to bituminous materials and the advisability of eliminating this test from specifications, has been the topic of much discussion during recent years, and especially has this been true since the advent of certain asphalts which are good paving materials, even though they may have a high percentage of fixed carbon. Authorities disagree widely as to the value of this test, some advocating its total elimination from specifications, while others advocate a more strict observance of it. The writer, while agreeing with many of the objections to this test, believes that it is too important to totally eliminate from specifications, and when properly used is of the utmost value in helping to determine the quality of a bituminous material.

A particular objection to the fixed carbon test is, of course, the fact that different laboratories use different methods for running it. Such things as different sizes and different kinds of burners, different gas pressures, different crucibles and other details, make the results unreliable. Even in view of these possible varying conditions which might take place, the fixed carbon test is no more "liable to error" than a number of other tests which are applied to bituminous materials, and the elimination of the test for this reason should not be seriously considered.

The ductility test, which has been so strongly advocated by a number of authorities, has never reached the stage of perfection where any one chemist can exactly agree with the results obtained by other chemists. There are a number of ductility machines on the market, all of which are based upon the same principles, but which vary in detail, and which may cause varying results. Some are run by hand, some by motor, and the ductility as taken by different chemists on the same sample has varied as much as 20 cms. on a material having a ductility of less than 90 cms. This apparent inconsistency in tests is not only true of the ductility test, but of other tests which are used for determining the quality of bituminous materials. There is a personal equation in nearly all tests but their value is not eliminated, because of the fact that there is a personal equation and because chemists in different sections of the country cannot accurately check with each other.

The statement made in a recent publication regarding the fixed carbon test in which the writer states "The insertion of this test in any city, county, state or other specifications is purposely or unconsciously done, or caused to be done, by copying or otherwise from one or more persons or agents, who thereby seek to include some and exclude other brands of asphalts and road materials which compete and are perfectly good for use," is both unfair and unjust to a large number of engineers and chemists who believe in this test and who, from practical experience, know that this test, properly applied, is of value.

In order to show that this fixed carbon test is of considerable value and importance, a few results obtained on different samples and a discussion of the samples may prove interesting. A sample of asphalt made from Ohio oil, obtained in 1894, showed a fixed carbon of over 26%, while a sample of asphalt made from Ohio oil from the same field during the past year and which was treated by the same method, showed a fixed carbon of only 4.61%. While it is true this last product was not treated to the same extent as the first one, yet had it been treated to a greater extent it would have under no circumstance given over 10% of fixed carbon. This is proved by the fact that Ohio oil obtained in 1907 and mixed with a high per cent. of gilsonite, only showed a fixed carbon of 9.46%. The high fixed carbon in the first sample mentioned can, without question, be attributed to the fact that in 1894 residuum oil was carelessly produced and a considerable amount of cracking occurred during the process of distillation. The asphalt produced from this oil was very poor in quality and proved a failure when used for paving purposes. There is no other test which so clearly and decisively showed the poor quality of this asphalt as that of fixed carbon.

In 1910 the value of the fixed carbon test was very clearly brought to the writer's attention. Two samples of asphalt obtained by the treatment of residuum oil (the oil being taken from the same district but produced by different refineries) showed a fixed carbon of 9.88% and 12.32% respectively. The quality of the asphalt showing the fixed carbon of 12.32% was very poor and not suitable for bituminous work, while the sample which showed a fixed carbon of 9.88% was good quality and equal to the standard for that class of material. Upon investigation it was found that the oil from which the poor sample was made was a mixture of poor, heavy-grade residuum oil which had been badly cracked during distillation and a lighter gravity residuum oil. There was no other test which so decisively showed the true value of these different materials (which all belonged to the same general class of asphalts) as that of fixed carbon. For the class of product to which this asphalt belonged, a limit of not over 11% of fixed carbon would always fully protect a city against any poor quality of oil. Likewise another bituminous material obtained by the same method, but from oil from a different field, showed a fixed carbon varying from 10 to 14%. Those asphalts which showed the high per cent. of fixed carbon did not prove a success; seemed "dead," and after a few months showed a separation and exudation of oil. They were poor quality and were not suitable for bituminous work. The fixed carbon test more clearly indicated this than any other test known.

The asphalts which have been mentioned above, have all been produced by the treatment of residuum oil with air. However, the value of the fixed carbon test not only applies to this class of asphalts but also to other asphalts produced from different oils and by different methods.

One of the well-known brands of California asphalts which was active on the market a few years ago, showed a fixed carbon of 18.06%. This asphalt was produced by distillation and treatment with air at high temperatures, which resulted in a "cracked" product of poor quality. It is to-day almost unknown, and is not considered by authorities to be a suitable material for road and paving purposes.

Another sample of California asphalt which proved a failure and which was carelessly prepared, showed a fixed carbon of 16.29%, and still another which was a failure showed a fixed carbon of 15.43%. The California asphalts which have given the most successful results, which are produced by the largest and most reliable companies, and which are recommended as standard material by leading engineers throughout the country, vary in their per cent. of fixed carbon from 11 to 14%. There has during the past year, however, appeared upon the market a new brand of California asphalt which seems to be of good quality and which ought to give successful results—the average fixed carbon for this particular brand being 9½%.

It appears from the foregoing facts that the fixed carbon test is therefore a very important test, if not the most important one for determining the quality of the California asphalts. Certain authorities believe that this cracking can be better shown by the solubility in carbon tetrachloride, but the writer has found that the carbon tetrachloride test requires more attention to details and greater care. At the same time it is more "liable to error" than the test for fixed carbon, and also it is more difficult to obtain from it satisfactory results and definite conclusions.

The fixed carbon test is of considerable importance when testing the so-called natural asphalts after they have been fluxed with residuum oil. A poor quality of oil will show up by high fixed carbon; and if properly applied and careful records are kept, this test will probably indicate as much as any other the amount of oil which is being used to flux the "native asphalts."

The probable reason for the recent interest aroused in the fixed carbon test is the advent of the Mexican asphalts. Owing to the peculiar characteristics of the oil obtained from Mexico and the asphalt product resulting from the distillation of this oil, a much higher fixed carbon is properly obtained than would naturally be supposed, averaging between 14% and 18% for the well-known brands. As a maximum of 15% is incorporated in several specifications throughout Canada, therefore making it difficult for the Mexican asphalts always to comply with them, it is only natural that this question be given considerable attention. From other tests and from the practical results which have been obtained, it is apparent that asphalts carefully prepared from the Mexican oils will give satisfactory results, despite comparatively high fixed carbon, and that for this class of materials a higher per cent. of fixed carbon could reasonably be allowed. However, the writer is very much of the opinion that it would be unwise to entirely eliminate this test or not state a definite limit, for, without question, Mexican oils can be as easily cracked as other oils, and the resulting products obtained from cracked Mexican oil will not be of good quality any more than that obtained from cracked oils from other fields. As the fixed carbon test is one of the best indicators for cracked oil, it is of the utmost importance that this test be very carefully considered.

From the foregoing statements it is apparent that there are many different conditions under which the fixed carbon test may prove of value. The writer does not advocate the arbitrary setting of the same per cent. limit on all bituminous materials, nor does he by any means advocate the elimination of this test, but he advocates a more systematic and proper use of it. At the present time a large majority of specifications are drawn up in order to admit a number of asphalts in competition. They are usually so open to the various asphalts which are admitted under them that the producing companies may practically ignore their requirements, and so far as keeping any particular material uniform and of the highest quality, they are of little value. For this kind of a specification a fixed carbon limit of 15% or any per cent. is useless and unjust.

In order to eliminate all undesirable features it would be advisable to draw up specifications dividing the bituminous materials into various classes and to draw strict requirements for each class.

By doing this the fixed carbon, as well as a number of other tests, would prove of very material value. Chemists could then use the fixed carbon test, not only as a help to identification, but as an important test in deciding the qualities of the material under examination.

CONCRETE ROADS.*

By Hon. Frank F. Rogers,
State Highway Commissioner of Michigan.

MUCH of value has been written in the past two years on concrete roads and pavements, but a great deal is in the nature of theoretical discussions quite largely based on laboratory experiments, hence when an opportunity is offered to make a field study of many miles of concrete roads, some of which have seen four years of service, it should not be lost.

The writer makes no claim to being a concrete expert but simply has been fortunate in having the opportunity to study at first hand, and in some detail, the behavior of a large mileage of concrete roadways in Wayne county, Michigan. This county, without doubt, has a larger mileage of concrete roadways than any other county in the United States, or than is possessed by any equivalent area under a single local government in any foreign country. There are now completed in Wayne county about 65 miles of concrete highways outside the corporate limits of cities and villages.

For the reasons above stated the writer desired to spend the time allotted to him in a somewhat detailed study of the local concrete roads which most of you will visit before leaving the city rather than to treat the subject in a more general way. All of the main highways leading out of this city have been concreted to the outermost boundaries of Wayne county and several crossroads have already been concreted. The principal roads are the extensions of Woodward, Grand River, Gratiot and Michigan avenues, while River Road and the extension of Fort Street running southerly are concrete roadways that should not be overlooked.

The State Highway Department, with the co-operation of the road officials of Wayne county, and assisted by Prof. John J. Cox, instructor in highway engineering at the University of Michigan, has just taken up some detailed and rather minute observations of these roads which will extend over a period of years in the hope that after a while a safe estimate can be made of the probable life and cost of maintenance of such pavements as the county is now building, and under such traffic, soil and climatic conditions as prevail in this locality.

The first work in this study will be careful traffic records covering enough time and at such frequent intervals as will give a reliable estimate of the average daily traffic for one year. The first records were taken for one continuous week beginning August 21, and a part of this record, which is given in the accompanying table, will be used for the purpose of the present discussion.

The next step was to start a permanent record showing the present condition of each 25-foot section (the distance between expansion joints) of all the different roads. The observations for this record were made September 2nd, 3rd and 4th and cover 6,384 sections and a little over 30 miles of road. Several pieces of road have not been taken at this time. The oldest roads were built in 1909 and the newest that were taken were built in 1912, having been down one year.

For the purpose of this record the defects in the slabs or sections have been classified as longitudinal, transverse and diagonal cracks and holes. The records were taken in ordinary field books, the left hand column of the left hand page having been previously numbered with an automatic numbering stamp to designate the record number of each slab, while the four columns to the right were headed L—T—D—H, respectively, being the first letters of the words indicating the defects named. Opposite each number and in the proper column vertical, horizontal or diagonal marks were used for symbols to indicate the form of the crack, while small ovals were used to indicate such holes as seemed worthy of note. Tar had been spilled on many spots that were not defective.

The first mile of this road was built in May and June, and opened to traffic in July of 1909, thus giving it full four years of wear. The traffic record of this road shows a daily average of 2,160 vehicles, of which 88.1% were motor-driven.

The soil is clay loam, inclining a little more to sand at the northerly end. A double-track electric railway occupies the westerly side of the street. Between the railway and the concrete roadway is a very shallow gutter under which was laid a tile drain from 2 to 3 feet in depth. On the opposite side is an open ditch, the bottom of which is from 2 to 4 feet below the crown of the roadway.

The pavement is 18 feet wide, has a crown of 3″ and a blind curb 8″ wide and 4″ deep under the outer edges which were somewhat bevelled. The concrete was composed of Portland cement, crushed field stone or cobbles and sand mixed in the proportion of 1:2½:5 for the base, which was 4″ thick. The top layer was made of the same materials, using a 1:2:3 mix and was 2½″ thick.

No very definite data can be secured to determine the wear, which seems to be slightly greater on the side opposite the railway, but measuring from some of the harder pieces of the coarse aggregate which have been worn but little, if any, we have estimated the general wear at about ¼″, which would be an average of 1/16″ per year.

This mile was divided into sections of about 25 feet, separated by expansion joints, there being 209 sections to the mile. The most of the sections were separated by four thicknesses of tar paper separated by thin boards which it was planned to remove as the work progressed, though many of the boards are still in the pavement. Four of the joints were protected by pairs of steel angle bars, separated with tar paper and placed with one leg of each angle back to back so that the other leg of each bar was flush with the surface of the concrete, thus covering a space of about 4½″ at the joints. The concrete wears slowly on each side of the angles, leaving a raised joint that is slightly noticeable when driving over the pavement. This was an experiment which has not been repeated.

Of the 209 sections constituting the first mile on Woodward Avenue, 80 showed longitudinal cracks, 32 transverse cracks and 2 diagonal cracks, while 46 sections were recorded as having holes, making a total of 160 sections which are more or less imperfect, or 76.5 plus % of the entire mile.

The remaining portion of Woodward Avenue, 252 sections, was built in 1910 using the same materials and the same mix. No blind curb was used and the crown was reduced to 2″. The soil on this section is considerably more sandy, especially toward the north end.

On this portion of Woodward Avenue, 29 sections have longitudinal, 22 sections transverse, and 6 sections diagonal cracks. Eleven sections have holes, making a total of 68 defective sections or 27 plus % as compared with 76 plus % in the first mile.

*Read at American Road Congress, held at Detroit, Mich., Sept. 29 to Oct. 4, 1913.

On Gratiot Avenue, in the season of 1910, 9,000 feet of 16-ft. concrete roadway was built. On this pavement gravel and sand were used for the aggregate and a one-layer concrete having a 1:2:4 mix was laid. The soil is a clay loam and rather heavy. This road was not completed until late in the season and was opened to travel in November. It immediately pitted and looked rough and has been covered with a surface treatment of refined tar and fine gravel. It was re-covered this season, using a rather light grade of tar (Tarvia A) but is already shows some tendency to scale off. The experience in some other places leads the Commission to believe that a heavier grade of tar gives better results.

Beyond this portion of the roadway 326 sections of the same width concrete were laid in 1911, reaching the county line. Washed pebbles and sand were used for the aggregate in a 1:1½:3 mix, one course concrete 7″ deep being laid. The records for this piece are as follows: Longitudinal cracks, 11; transverse cracks, 10; diagonal cracks, 3; holes, 6; showing a total of only 30 defective slabs, or 9.2 plus %. The traffic count on this road, taken at the county line, shows 507 vehicles daily, 65.8% of which are motor-driven.

On the Grand River Road 61 sections of two-course concrete, the same as laid in the first mile of Woodward Avenue, were built in 1909. The soil is a clay loam. The records show 11 longitudinal cracks, 2 transverse cracks, 1 diagonal crack and 3 holes, a total of 17 defective slabs, or 27.9 minus %. The traffic count showed 1,064 vehicles, 56.5% of which were motor cars.

In 1910, 341 more sections were added to Grand River Avenue under contract, the specifications being the same as for the north end of Woodward Avenue. Thirty-three of these slabs became more or less pitted, some having quite large holes. They have been repaired by covering with refined tar and stone chips so that no defects could be observed at the time of the count, hence only 308 are shown in the table. The defects noted are as follows: 59 longitudinal, 20 transverse, 29 diagonal cracks and 46 holes, a total of 154 defective slabs or 50%.

In 1911, 515 additional sections of one-course concrete were placed on the Grand River Road. Washed pebbles and sand were used for the aggregate with a 1:1½:3 mix. The Baker steel joint was used in all of this work except the first six sections. The defects noted are as follows: Longitudinal cracks, 8; transverse, 26; diagonal, 3; and holes, 5; making a total of 42 defective sections, or 8.2 plus %.

In 1912, 1,208 more sections were added to Grand River Avenue, reaching to the line between Wayne and Oakland counties. The count on these sections shows as follows: 66 longitudinal cracks, 37 transverse cracks, 6 diagonal cracks and 5 holes, making a total of 114 defective sections, or 9.4 plus %. The soil grew more sandy as the road extended westerly, considerable stretches being almost free from clay or loam.

On Michigan Avenue 481 sections of concrete, 17 ft. 8 in. wide were laid, using washed pebbles and sand for the aggregate in a 1:2:4 mix. The soil for the most part is a sandy loam, but a little heavy. The count shows as follows: 219 longitudinal cracks, 48 transverse cracks, 23 diagonal cracks, 21 holes, making a total of 311 defective sections, or 64.6 plus %. The traffic count shows 1,009 vehicles, 67.5% of which were motor-driven.

In 1911, 1,570 sections were added to this piece of road, using washed pebbles and sand for the aggregate and a 1:1½:3 mix. The soil over which this pavement was laid is a sandy loam running into light sand at the west end. The count shows the following: 219 longitudinal cracks, 80 transverse cracks, 42 diagonal cracks, 14 holes, making a total of 355 defective sections, or 22.6 plus %. In 1912 this road was paved to within 1¼ miles of the county line, and this year completed to the county line, but no record was taken farther west than the east limits of the village of Wayne.

In 1910, 149 sections of concrete 15 ft. wide and 6½″ deep were laid on the River Road, using gravel and sand for the aggregate and a 1:2:4 mix. The soil over which this road runs is for the most part heavy clay. The count shows as follows: 49 longitudinal cracks, 5 transverse cracks, 6 diagonal cracks and 2 holes, making a total of 62 defective sections, or 41.6 plus %. The traffic count shows 538 vehicles daily, of which 78.9% were motor-driven.

In 1911, 434 sections were added to this road some distance below the village of Trenton. The pavement was 15 ft. wide, 7″ thick, built of washed pebbles and sand for the aggregate, using a 1:1½:3 mix. The count for this stretch of road shows as follows: 165 longitudinal cracks, 17 transverse cracks, 13 diagonal cracks and no holes, a total of 195 defective sections, or 44.9 plus %.

In 1912, the gap between this piece of road and the southerly limits of the village of Trenton was closed in with a similar pavement to that just described, comprising 213 sections. The count of this piece shows defects as follows: 14 longitudinal cracks, 8 transverse cracks, 4 diagonal cracks and no holes, making a total of 26 sections, or 12.2 plus %.

The same year there was added to the south end of the work done in 1911 something over two miles of concrete roadway, but of this only 208 sections were counted. Of the sections counted, 17 show longitudinal cracks, 9 transverse cracks, no diagonal cracks and no holes, a total of 21 defective sections or approximately 10%. The soil of the entire road was heavy clay.

In 1910, one-half mile of gravel concrete of a 1:2:4 mix, 12 ft. wide and 6½″ deep was built on Fort Street. This concrete, like that already referred to on Gratiot Avenue, was built rather late in the season, and was opened to traffic in November. It immediately pitted to such an extent that it has since been coated with refined tar and fine washed gravel, about ¼″ in size. This covering makes an excellent surface and wears fairly well. Of course it was impossible to observe any further defects in the concrete at this time. Continuing south, in 1912 450 sections of concrete 12 ft. wide, 7″ deep, and of 1:1½:3 mix were added. The count on this piece of road follows: Longitudinal cracks, none, although another observer has reported there are 2; transverse cracks, 19; diagonal cracks, 9; and holes, 1. Total defective sections, 29, or 6.5 minus %.

From the foregoing, it is strikingly apparent that the percentage of defects varied greatly in the different roads. A careful study of this variation in connection with the age of the pavement will soon convince one that mere age has not produced the defects noted. For example, 252 sections built on Woodward Avenue in 1910 show but 27% defective slabs, while 308 sections built on Grand River Avenue, the same year and under the same specifications, show 50% of defective slabs. There are two noticeable differences. Grand River Avenue was built by contract on a clay loam soil while the portion of Woodward Avenue named was built by day labor under the direct supervision of the engineers of the County Road Commission, on a soil more sandy and, presumably with a little better sub-drainage. Again, 481 sections built on

Michigan Avenue the same year with sand and pebbles for the aggregate and a 1:2:4 mix show 64.6% of defective slabs. This was on clay loam soil. We might also mention 149 sections built on the River Road in 1910 on heavy clay soil, under the specifications last named, which show but 41.6% of defective slabs.

The most noticeable feature concerning these defects is that the longitudinal cracks almost always appear in groups, seldom singly. This indicates that there must be some local conditions in the foundation, due to insufficient drainage, soil conditions, newly made fills or uncompacted sub-grades that cause these defects. Longitudinal cracks almost invariably appear on fills and on cuts, apparently with as much frequency in the latter as in the former. It would seem that cracks on the fills are due to the settlement of the embankment, and in the cuts the presence of water and frost in the sub-grade. Briefly, the writer's opinion is that these cracks are due, first, to the settlement of the newly made fills, and second, to water that has not been completely removed from the subgrade, plus frost. If these causes could be thoroughly eliminated it would seem possible to build concrete roadways to the width of 15 or 16 feet, where sufficient expansion joints are used, without fear of trouble from longitudinal cracks.

It has been argued by the Morse-Warren Engineering Company, in a recent publication, that it is impossible to build concrete pavements (wider than 12 ft.) which will remain free from longitudinal cracks without using longitudinal joints, unless the pavement is so thick as to make the price practically prohibitive. The table accompanying this report, which shows 450 sections of 12-ft. roadway on the Fort Street road, would seem to bear out this assertion, but a mile of concrete on the Eureka Road, which the writer did not get time to inspect, shows a great number of longitudinal and transverse cracks in a 12-ft. concrete roadway, where the soil conditions are the same as on the Fort Street road referred to. The only apparent difference is that the former is a 1:2:4 mix and the latter a 1:1½:3 mix, washed pebbles and sand being used for the aggregate in both cases.

But long stretches of pavement, 16 ft. wide and now two years old, on Grand River and Michigan Avenues, which show no longitudinal cracks, would seem to prove that this statement is not necessarily true, and that a sufficient amount of money spent in compacting and draining the foundation or in reinforcing the concrete over newly made fills, would produce pavements free from the objectionable longitudinal crease, whether natural or artificial. Most persons are agreed that transverse cracks are almost always due to defective expansion joints. It has been thoroughly demonstrated, both theoretically and practically, that 25 feet is frequent enough for the expansion joints, and it is quite possible that they might be placed farther apart with safety—probably not less than three to 100 feet.

The diagonal cracks are doubtless due to causes which are a combination of those noted under longitudinal and transverse cracks. Many diagonal cracks were noted where the corners only were broken off, frequently on adjoining corners of adjacent slabs, indicating that the slabs were united through the expansion joints with a bond stronger than the tensile strength of the concrete on either side of the joint.

The holes noted are perhaps of less importance than the different kinds of cracks. In a few instances they are rather large, sometimes a square yard or more in area, but such places are very rare and most of the holes noted are due simply to some foreign substances getting into the concrete, like clay, wood or some fragment of an inferior rock that might chance to be a part of the aggregate. This was more noticeable where crushed cobbles were used for the coarse aggregate than where washed pebbles were used.

Any one familiar with the quality of rocks which constitute Michigan cobbles will understand that the principal objection to this material for an aggregate on concrete roads is the varying qualities of these rocks, ranging from soft to hard granite, quartzite and trap. A study of the roads where these materials have been used shows much more wear in the spots where the softer rocks happen to be at the surface.

Up to the present time the defects noted, except the pitted conditions of the concrete roads which have been re-surfaced in the manner already described, are not serious and are not causing any additional expense for up-keep. In the past two years the expansion joints on all the old work, whether reinforced or not, have been coated with refined tar and sand once a year. Thus far, the cost has ranged between $50 and $100 per mile, depending on the distance of the work from the base of supplies. These repairs are proving adequate and satisfactory, and while the defects noted are something of a reflection on the present method of building concrete roadways, they are really no reflection on the use of concrete as a suitable material for making hard and durable surfaces over our country highways wherever traffic conditions warrant, and the community has the ability to pay the cost of high-class road surfaces. There is no question as to the necessity of some form of very permanent roadway near the city of Detroit, neither is there any question as to the ability of Wayne county to pay for a roadway that is good enough and permanent enough to meet the requirements of its traffic. In the writer's opinion, Wayne county has made no mistake in choosing concrete as a paving material for its main roads.

DISCUSSION ON "CONCRETE ROADS."

By A. N. Johnson.*

It is evident that if one portion of a concrete road surface exhibits a special weakness it must be due to non-uniformity of the concrete. This will happen if soft pieces of material are in the aggregate. Many gravel banks contain enough soft pebbles to render the gravel useless for concrete-road work, though frequently these soft pebbles have somewhat the general appearance of the sound material and, unless a careful examination is made, will not be detected.

Another cause for local weakness in concrete is the non-uniform distribution of the mortar and the aggregate. It frequently happens, particularly with very wet mixtures, that the coarser aggregate will not be thoroughly distributed but will occasionally be separated into small collections or nests of the larger pieces, which contain a very small amount of mortar. There is no mixer that has come under the writer's observation which will mix and deposit a batch so uniformly that all portions will contain the proper amount of coarse aggregate and mortar. It is necessary, therefore, in the construction of a concrete road to have one or two men constantly at hand to correct such uneven distribution by shoveling out the

*State Highway Engineer, Illinois.

pockets of coarser aggregate to be found in the centre of nearly every batch that is deposited on the road and replacing these pockets with mortar, which usually runs to the bottom and edges of the batch.

The causes of the other three defects noted by Mr. Rogers (see Engineering Record, Oct. 11, 1913, page 409)—longitudinal cracks, transverse cracks and diagonal cracks—are perhaps more difficult to ascertain in a given instance. The data presented have been rearranged according to the age of the various pieces of road in the table following. In order to have a proper basis of comparison the number of cracks per mile has been computed for the roads built in 1909, 1910, 1911 and 1912 respectively.

At once one is struck with the increase in the number of cracks with each succeeding year. This increase is particularly marked during the first three years, but apparently falls off sharply during the fourth year.

A notable coincidence is that the curve showing the total number of cracks per mile of all kinds is approximately a straight line for the first three years, or, in other words, the increase in the number of cracks was approximately the same for each of these years.

There is also considerable agreement of the curves for the longitudinal, transverse and diagonal cracks during the first three years, but no such agreement for the fourth year. It is to be borne in mind, however, that for the fourth year data are given for only two pieces of road about 1.3 miles in length. However, as these pieces were laid with a leaner mixture than much of the other work and constitute the first concrete work done by the Wayne County Commissioners, all the evidence would point to the conclusion that this stretch of road would show at least as many defects as will appear later in the other roads.

The value of future observations to be made at intervals of not less than three months will be evident. These observations should note carefully all the cracks that are found, both as to their character and, particularly, as to their distribution, so that in the future the location of new cracks as they appear may be known, as well as the approximate time of the year when they occur.

It can be fairly assumed that the slabs of concrete are approximately of the same strength, offering practically the same resistance to all exterior forces to which they are subjected.

Among the forces which would cause the slabs to crack are variations in temperature, extraordinarily heavy traffic loads and unequal settlement of the foundations. It is more than probable that the cracks are due to no one of these causes alone, but rather to their accidental combination. If the changes in temperature were the prime cause, it could be expected that all slabs would show approximately the same number of cracks, for the reason that all portions of the road are subjected approximately to the same temperature variations. But an examination of the roads shows many slabs in continuous stretches which have not cracked at all, regardless of the age of the road. It can, therefore, be concluded that temperature changes alone are not sufficient to cause cracking of the slabs in general.

While extraordinarily heavy moving loads may not be so generally applied to all the slabs, and therefore not cause as uniform an appearance of cracks, yet if this be a principal cause it could be expected there would be a large number of contiguous cracked slabs. But there is practically no evidence to indicate that there have been loads heavy enough to cause the pavements to crack from this reason alone.

The third cause that has been mentioned—unequal settlement of the foundation—is one that would not be generally distributed; for while settlement might occur in one place, there very likely would be considerable distances where it did not occur. Moreover, it will be appreciated that the manifold conditions which would produce unequal settlement would cause an erratic occurrence of any results from this source. And the haphazard occurrence of the cracks would indicate that the cause is not general throughout the length of the roads. The writer is, therefore, of the opinion that the majority of the cracks are due primarily to unequal settlement of the foundation or subsoil beneath the broken slabs. It is quite possible that settlement by itself would perhaps not be sufficient to cause the slab to crack, but on the passage of heavy traffic or with the movement of the slab under temperature changes there would be added just enough extra stress to overcome the strength of the slab and produce the crack. If, therefore, it is possible to guard against unequal settlement of the foundation, one of the chief sources of cracks in the pavement will be overcome.

The writer has observed that the concrete slabs usually do not crack until after they have been in service about a year. The first cracks generally appear during the late spring and early summer following construction. An explanation is that during the winter and early spring the ground is well saturated with moisture and dries unevenly; the consequent settlement is, therefore, not uniform. Special precaution with the underdrainage should accordingly be taken to provide thorough and uniform draining.

The writer does not believe that it is necessary to place expansion joints as close together as 25 ft. On three pieces of work constructed under his supervision in 1912, totalling 2.3 miles, none of the sections was less than 50 ft. in length, many being 60 and 75 ft., and one or two as long as 100 ft. The number of cracks per mile in these roads at present is: Transverse cracks, 9.1; longitudinal cracks, 9.1, or 18.2 cracks per mile. The total number of cracks in the 1912 work on the Wayne county roads, using 25-ft. sections, is 19.1. It will be necessary to have much more data before it can be definitely concluded as to how frequent the joints should be; but from the observations that have been made it seems that the joints may be made further apart than 50 ft. rather than nearer together.

Lest a wrong impression should be gained from the emphasis laid upon the defects found in the Wayne county roads, the writer would state that from a number of personal inspections he feels that the Wayne County Commissioners have amply justified their adoption of this form of construction.

A NEW TYPE OF ENGINE.

A new type of rotary engine has been invented by a Birmingham firm. A model is being shown in London, where it is described as "England's answer to her critics—an engine that is far and away better than even the Gnome." It is claimed that the engine, which is driven by petrol, is almost vibrationless, while its weight is only 2½ pounds per horse-power. It has no fly-wheel, no crank-case and no camshaft. The new engine is expected to have far-reaching effects on the motor car, the motor boat and the aeroplane.

SANITARY SURVEYS OF RIVERS.*

By J. R. Malek, C.E.,
Assistant Provincial Sanitary Engineer, Regina.

In dealing with the subject of this paper, the writer wishes to state that the object in view is to make a few general remarks on the necessity of carrying out sanitary surveys of rivers and the general lines employed in carrying out such work, but does not propose to deal with sewerage purification works or water filtration plants situated on the banks of rivers and streams in this or other countries.

Object.—Sanitary surveys have all been carried out chiefly with a view to ascertaining the state of the streams which have been subject to contamination, either by the discharge of crude sewage of adjacent towns into the river or else by the general refuse of communities along their banks or through industrial wastes and the waste water from mines or quarries or other works too numerous to mention.

It need hardly be mentioned here that the duration of the work and the observations to be taken, may extend over any period from a few days, weeks or months to possibly one or two years, according to the ultimate object in view or to the size and varied conditions to be met with in the various rivers or waters under observation.

Results of Pollution.—Unfortunately, it is only too true that as civilization has advanced and the number of factories and towns have become the centres of manufacturing industries, that the tendency has been in the past to use these courses in their near vicinity as an easy and inexpensive means of getting rid of the ever-increasing filth and rubbish to be expected to collect from such centres, with never a thought bestowed on the trouble and future sickness in the shape of epidemics of typhoid, dysentry, cholera and diphtheria, not only to themselves, but to the towns and villages lower down on the same stream, which may be their nearest water supply, but to the farmers and dairymen whose animals water themselves in the river or at the pools left on the shoals.

The older countries have long ago realized the necessity of investigating the serious condition of their waterways, and extensive sanitary surveys have been carried out by some of their most eminent scientists, engineers and surveyors, with a view to ascertaining the extent of the contamination, which "Findings" are submitted in the shape of reports to the governments concerned.

The United States and Canada, both comparatively new countries, are likewise realizing the dangers likely to arise from the present state of pollution of their streams, rivers and great lakes.

In the States, two recent surveys will, no doubt, be fresh in the minds of those present (a) the thorough and exhaustive sanitary survey of the "Potomac River" by Asst. Surgeon J. Goldberger, the full report of which is given in the "Report on the Origin and Prevalence of Typhoid Fever in the District of Columbia," which was brought out in 1907 in the form of a report by the United States Government, (b) the very recent extracts on the report by Messrs. Forbes and Richardson, of the sanitary survey of the "Illinois River," in connection with the pollution caused by the sewage discharge from the Chicago Drainage Canal.

The Canadian Engineer, of July the 13th, 1912, published extracts from the report by Mr. James Meadows, sanitary engineer to the Board of Health at Quebec, on the survey of the Ottawa River, carried out by him.

The object of this survey was to arrive at the difference in the state of the river in 1910, compared to the condition when Dr. Wyatt Johnstone made his in 1891, when the population for Ottawa and Hull combined was only half what it was in 1910.

Dr. W. Johnstone, in July, 1891, found that samples taken at a point five miles below Ottawa, had 500 bacteria per cubic centimeter, the next highest return was at Thurso, a town thirty miles below Ottawa, when it was 201 bacteria per c.c., from this point they gradually diminished.

In September, of the same year, his next survey was carried out at a point 25 miles below Ottawa, the samples taken showed the number to be 1,530 bacteria per c.c. at a point 65 miles below the capital, they had diminished to 48 per c.c.

The survey carried out by Mr. Meadows in 1910 shows in nine years a very great increase of pollution in the river, owing to the increase of population and the discharge of sewage and factory wastes that was taking place.

At Pembroke, the samples taken gave 110 bacteria per c.c., at 113 miles lower down and seven miles below Ottawa, they showed 700 bacteria per c.c. The next highest reading was 1,000 per c.c. at a distance of 179 miles, after which it decreased rapidly.

In the October survey of 1910, when the water was at its lowest level, the samples taken showed that at Pembroke there were 43 bacteria per c.c., at Ottawa, 106 miles lower down, the samples had 100 per c.c., at 113 miles, or seven miles below Ottawa, 1,600 per c.c. The highest taken was at a point 133 miles away when the samples taken showed 1,900 per c.c. It there dropped to 1,450 per c.c., at a distance of 179 miles from Pembroke.

The above is given to show how severely even such a large river as the Ottawa may suffer through continued pollution taking place and the great value a sanitary survey is, in enabling the authorities to get a clear understanding as to its conditions.

Professor Heider, in 1893, in his extensive and prolonged sanitary survey of the River Danube, into which Vienna discharged its sewage, found that it was carried along the right bank of the stream, preserving its own bacterial characteristics and not mixing perfectly with the water of the river for a distance of more that 24 miles. Where sudden dips take place in the river bed it has been found that these act like sewage tanks accumulating sludge.

In a recent river survey carried out by the writer for a civil action in which the discharge of crude sewage by a small town was causing considerable damage to property lower down along the side of the stream for which the owner clained damages, the sewer pipes had been placed in a diagonal line across the river, thereby forming a kind of groyne, throwing the current on to the opposite bank, which, owing to the gravel shoal that had been formed, set up a back current on to the plaintiff's land, causing lighter solids to settle along the bank and seriously damaging his property.

At a distance of 20 yards from the mouth of the pipe, the bed of the river shelved down and for some distance formed a saucer like hollow. It was noted when the river got to summer or normal levels, that the ordinary current had little or no effect on the deposits lying at the bottom and even with a "freshet," which increased the depth of the water by an additional five feet, it made no appreciable difference. It was found after careful examination

*Read before the Third Congress of the Canadian Public Health Association, Regina, Sask.

that only after a rise of 8 feet above the normal, a portion of this matter got away, and that in the ordinary way the rapid shelving of the river's bed caused the current to pass over it, whilst the surface water was considerably disturbed, the portion beneath was not in the least affected until a heavier "freshet" came down and scoured out.

Dominion Health Commission.—It is with considerable satisfaction that we see that the Dominion Government has recently formed a Health Commission of 18 members to look into and report on the health of the cities and towns upon the banks of our rivers and streams in this country when it is to be hoped that they will frame such laws and regulations as will prohibit the discharge of untreated sewage and trade wastes, as well as other impure matters, which are liable to injure the health of the community at large, into the waterways, which should be looked upon not as ready-made sewers, but as valuable national assets.

Surveys.—To get a general and fair estimate of what is taking place will of a necessity demand not only an inspection to be made during the open seasons or summer months, but also during the winter period when the streams and watercourses are "ice" bound, to note the changes taking place as well as to obtain an idea of the rate of flow or the state of aquatic and animal life during this period.

To sanitary engineers and sanitarians, sanitary surveys open up a very vast and at present almost unexplored "field" of operations, and as the population increases (as it does year by year), close investigation of the state of all waters will demand their unceasing attention if the preservation of the public health is to be their principal object.

The government of this province has already set an example to its sister provinces by organizing sanitary surveys on a systematic scale of all its waterways and creeks, and perhaps a review of the methods now being employed to ascertain the conditions that are prevailing will not come amiss.

In the first instance, "waterways" to be surveyed, if within a reasonable distance, are always first visited to gain an idea as to the best means of surveying them in a thorough and expeditious manner to enable the engineer who is employed to make an exhaustive report.

Plans are then obtained of the section or area to be taken in hand, which, if on too small a scale, are enlarged to such a size as shall allow corrections to be made and measurements clearly marked thereon.

"Field sheets" are also prepared, such as will be suitable to meet the requirements of town or country, with the necessary questions printed on, to gather the data it is necessary to obtain and on which the report will be based.

Large plans should be avoided, 24 in. x 20 in. are found the most convenient for outside work, each of which should be marked in "alphabetical" manner and pinned one on top of the other to a light drawing board or on to stout cardboard, which is swung over the back, when not in use, thus leaving the hands free.

Record plans on large sheets should in the meantime be prepared in the office as well as a "Record Book" into which is entered all the information obtained, so that it can be referred to from time to time or when it is necessary to take up the record part of the survey.

The surveys should be conducted at least twice in the same year, but owing to the extreme climatic conditions met with in this country, it is impossible to lay down any hard or fast rules on such a point, so much will depend upon the district, stream and the purpose for which the work is being carried on.

Where work in towns is concerned or such houses affected or likely to affect the survey situated along the banks of streams and creeks, information should be obtained and everything done to gather such data as shall enable a full report to be compiled.

A gauge is placed in the stream and the height of the water is taken, with the hour of the reading as well as the day, month and year, tests are also made as to the rate of flow of the current and the quantity of flow in gallons per second, the course of the current is noted and erosions due to this cause are also marked in as well, whilst large shoals of gravel and such as would be likely to affect the general run of the current are marked in on the plan.

A thorough examination of the banks is to be undertaken with a view to ascertaining the nature of the pollution taking place as well as the nature of any pools left behind which are likely to cause the breeding of flies (especially when near human habitation or from which dairy cows and others might be likely to water at) the bed of the river, creek or stream, where visible, is examined and a note of such aquatic plants growing there, also of the animal life or fish life, as well as that of insects. Soundings in shallow pools may be frequently taken where necessary. This may be taken by means of wading with a six-foot pole or rod marked in feet, inches and half inches, where deeper water is encountered and boats are not available, a waterproof tape with a conical lead may be employed and run over a pole with a small guide pulley at the end, the lead should have a slightly scooped-out bottom which, if greased, will serve the double purpose not only of sounding, but will also give a sample of the bottom which should be examined at the time, or kept for a more opportune moment when a fuller examination may be carried out.

Where sewer outfalls occur these should be noted on the plans with all the necessary measurements taken and, if run out into the river, the angle should be carefully noted.

Sewage fungus should be looked for at these points, and a sample obtained for examination by the chemist, who may be employed to analyze the samples at the labatory, the returns of which will be put in the final report.

Samples.—The writer always prefers to leave the taking of samples till the last, so that there may be as little delay as possible in getting them in to be tested owing to the rapid changes that take place where delay owing to distance is likely to occur, a little addition of formaldehyde or chloroform to the sample for dissolved oxygen test will usually help to keep it in the same state as when taken for about 48 hours.

The bottles to be used should be glass bottles with tight-fitting glass stoppers (for preference) well sterilized, covered with a small piece of cloth tied down. When taking the sample the fingers are to be kept clear from the mouth of the bottle, which should be well rinsed in the water to be sampled and then filled to within half an inch of the stopper.

In conclusion, the writer would suggest that where important surveys are to be made, samples should always be taken and analyzed by a competent chemist, especially when it happens that the survey is being carried out with a view to finding out the actual conditions prevailing in the river as the preliminary step to arranging for a supply of water for a town.

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CONTENTS OF THIS ISSUE.

WATER PRESSURES IN LARGE CIRCULAR CONDUITS.

With the expansion that has taken place during recent years in the utilization of water resources, both for power and for industrial and domestic consumption, there has been an accompanying increase in variety of the problems connected with the design of pipe-lines. One that has risen to a degree of importance calling for rapid and accurate solution bears upon the use of circular pipes. The use of conduits of larger diameters has become widespread, although it cannot be said that the stresses to which they are subjected are a matter of common knowledge, or have always been taken into account in the design.

Water powers that were considered economically impossible of development in the past are now being harnessed and brought into commercial use by the installation of long feeder penstocks. Also, increased density of population on every side demands an adequate supply of pure water, with which is frequently associated the necessity of pipe lines of great length and of large carrying capacity. These conditions are likely to develop rapidly as time goes on.

It is true that the use of circular pipes of relatively small diameter has not entailed serious difficulty for the designer. With the use of conduits of larger diameters, under certain conditions, however, various elements of design come in for careful treatment. One phase of the problem has been almost totally ignored. It comprises the large bending moments that are created in the shell of a circular conduit lying in a horizontal position, and filled with water.

This most important phase is dealt with in the first article in this issue of *The Canadian Engineer*, and we feel that we are particularly fortunate in being able to present this analysis by Mr. Hogg. The subject, to our knowledge, has never been treated in engineering literature before.

The article also includes a general discussion of the analysis of the stresses in, and the design of, water conduits, which should prove of interest to the engineering profession.

OTTAWA'S PROPOSED AQUEDUCT.

Ottawa City Council very wisely rejected, last week, the proposal to amend Sir Alexander Binnie's report, substituting a 58-inch pipe line, with a carrying capacity of 33,000,000 gallons, for the 54-inch pipe line that was recommended. (See *The Canadian Engineer*, Oct. 16th, 1913, page 595, *et seq.*) The argument favoring the adoption of a conduit of larger diameter, was based upon the fact that, at the present rate of growth of population, the city would be obliged to set about increasing its water supply in six or seven years, which will be about three years after the line is completed. It is claimed that, with the present rate of consumption ranging from 175 to 190 gallons per capita per day, the city will soon attain a population that will demand a greater daily supply than the 25,000,000 gallons which the proposed 54-inch pipe, emptying into the service reservoir, would provide.

In his report, Sir Alexander Binnie threw particular emphasis upon the enormous waste of water in Ottawa. It was stated that it could be reduced to 100 gallons per head per day; and his report was based upon this figure. Doubtless, measures will be taken forthwith to stop the leaks in pipes and house fittings, since it is plain that, owing to defects in such connections, over 100 gallons per day is lost for each head of population. Thus, without coercive measures to reduce the quantity actually used by consumers, the present distribution may be improved so that the 54-inch pipe would provide a supply sufficient for many years to come.

What the City Council might well have done, however, would have been to discuss the advisability of a duplicate pipe line for this 235,000-foot aqueduct leading from the outlet of Long Lake to the service reservoir. Although the pipe line, as projected, will be eight or nine feet below the surface of the ground, it must pass through loamy and swampy ground, and has several streams and rivers to cross by means of bridges, the largest of which will have a 150-foot span. Coupled with severe winter weather, these conditions are such as to indicate the advisability of a duplicate line to guard against water famine in case of an obligative emptying of the pipe for repair. A 12-day reserve, which the service reservoir is designed to hold, may be found altogether too inadequate and the time may be too short in which to get equipment and materials to the defective spot in the aqueduct, and the necessary repairs completed.

The water supply of a city is something that demands greatest care to be taken in its design, construction and operation, to eliminate all dangers of interruption for any length of time. A great deal depends upon design. It is not often that the designing engineer escapes criticism if deficiencies appear even after the system has been in operation some little time. In Ottawa's case, duplication of pipe line should be given more consideration at this stage.

THE HIGHWAY COMMISSION AT BELLEVILLE.

No fewer than thirty-five representatives from surrounding municipalities greeted the Public Roads and Highway Commission at its sitting in Belleville on Nov. 4th. Their suggestions were for the most part of a practical nature, showing that the road question has been receiving sound consideration and that the counties are anxious to assist the movement just as far as they possibly can. Among the recommendations brought forward there are few that the Commission can pronounce outside the scope of early realization, if the agitation for better roads throughout older Ontario meets with the recognition that is its due.

A few of the suggestions, expressive of the general feeling of the Belleville meeting, are as follows:—

(1) To prevent a still greater decline in Ontario's rural population, something must soon be done to improve the roads.

(2) A permanent Road Commission should exist, to obviate an undue amount of patchwork in county road building.

(3) Counties should be grouped, for purposes of road standardization.

(4) There should be more Government inspection of roads, and the Government should force counties to begin maintenance duties earlier after construction.

(5) More regard should be shown, where possible, for the lighting of county roads.

The following recommendations of the Road Committee of the County Council of Hastings were presented by Mr. N. Vermilyea, president of the Good Roads Association:—

"That legislation be passed prohibiting the manufacture of new vehicles and the renewal of old ones carrying 1,500 pounds or over with a less width of tire than four inches, and five years only be allowed for changing to the same width the tires of existing vehicles of similar capacity.

"That a tax of fifty cents per horse-power be imposed in lieu of the existing license fee upon all autos up to and including twenty horse-power, 75 cents per horse-power on autos above twenty horse-power and up to and including thirty horse-power, $1 per horse-power upon all autos above thirty horse-power, and that the money so raised be applied for highway improvement.

"That expenditures hereafter upon all county roads and bridges shall be borne one-third by the county in which they are situated and two-thirds by the Government of the province; that it is of supreme importance that the cost of maintenance should be borne in the same proportions as the cost of construction by the county and province respectively; that as we consider county roads should be constructed in such places only as will be in the general interest, we are opposed to a frontage tax; that the highway connecting the producer with the producer's market receive first consideration, and that such roads be selected where the council of each county shall approve."

COST OF OPERATING ELECTRIC TRUCKS.

Of interest to Canadian manufacturers and contractors are the figures contained in a report recently presented at the Electric Vehicle Association in Chicago, on the costs of motor truck operation. The estimates cover a wide variety of sizes and operating conditions. As a matter of fact, the operation of a motor truck is beset with so widely varying conditions—differing with every city, every trade and almost with every installation—as to make figures, as a rule, very unreliable as a guide though, of course, they do frequently tell what certain owners have succeeded in doing. The contribution mentioned above, however, is the work of a special committee, and its figures are based on a large range of electric vehicle installations in various cities. The following is from a table appending the report:—

Capacity, lbs.	700	1,000	2,000
Approximate price	$1,500	$2,200	$2,600
Fixed charges—			
Interest at 6%	$ 90	$132	$156
Depreciation at 10%	150	220	260
Fire insurance at 1%	15	22	26
Liability insurance	100	100	100
	$355	$474	$542
Maintenance—			
Battery upkeep	$170	$180	$200
Tire upkeep	130	150	180
Mechanical parts upkeep	50	60	80
	$350	$390	$460
Garaging—			
Electric power	$120	$140	$170
Storage and washing	180	180	180
Garage labor	100	120	16
	$400	$440	$510
Annual operating cost	$1,105	$1,304	$1,512

Daily cost (312 days)		$3.54	$4.18	$4.84
Drivers per day		2.00	2.00	2.50
Total daily cost		$5.54	$6.18	$7.34
Capacity, lbs.	3,000	4,000	7,000	10,000
Approximate price	$3,000	$3,400	$4,000	$4,500
Fixed charges—				
Interest at 6%	$180	$204	$240	$270
Depreciation at 10%	300	340	400	450
Fire insurance at 1% ...	30	34	40	45
Liability insurance	100	100	100	100
	$610	$678	$780	$865
Maintenance—				
Battery upkeep	$240	$285	$365	$415
Tire upkeep	230	280	400	600
Mechanical parts upkeep	90	100	125	150
	$560	$665	$890	$1,165
Garaging—				
Electric power	$240	$300	$360	$400
Storage and washing ...	180	180	180	180
Garage labor	180	200	250	300
	$600	$680	$790	$880
Annual operating cost ..	$1,770	$2,023	$2,460	$2,910
Daily cost (312 days) ..	$5.67	$6.48	$7.88	$9.32
Drivers per day	2.50	2.50	3.00	3.00
Total daily cost ...	$8.17	$8.98	$10.88	$12.32

Edison battery equipment will have lower maintenance and higher power consumption than above.

Depreciation at 10 per cent. should provide one complete equipment renewal in 10 years, which is not figured in maintenance as above.

Interest should strictly be at 3 per cent. as depreciation fund gradually reduces investment.

HANDLING OF IDLE PLANT.

THE systematic methods of handling plant, in the construction of the Panama Canal are still in evidence, despite the fact that much of it has already been retired from service. The *Canal Record* recently published official rules for the laying up of all idle equipment. They are valuable as general information to engineering contractors, who have the same procedure to follow at frequent intervals. They are as follows:—

Locomotives.—Boilers should be emptied and thoroughly cleaned of all scale and foreign matter. Boilers should then be filled with water, leaving space enough for at least two barrels of crude oil or a sufficient amount of crude oil to cover the internal surfaces of boiler and tubes. This oil should be put in at dome, then blow-off cock should be opened up and boiler drained. The same instructions apply to locomotive tanks as to boilers. The front end of locomotives and fireboxes of all boilers should be thoroughly cleaned and brushed off with wire brush and given a coat of tar paint. This paint can be put on with a spray. The coal space on all locomotive tanks should be thoroughly cleaned and scaled and surface given a coat of tar paint. All exterior surfaces of equipment should be painted if necessary, using the standard grade of paint which is commonly used for that purpose. The jackets on all boilers should be given a coat of white lead and tallow. Smoke stacks should be covered with sheet-iron covering made specially for this purpose. Main rods of locomotives should be disconnected and all bearing and bright surfaces receive a coat of white lead and tallow. Eccentric straps and blades should be removed from locomotives and placed with main rods in the cabs, and cabs boarded up. The steam chest cover should be lifted, cylinder heads removed, and all surfaces treated with a coating of white lead and tallow. It will be necessary to remove the valves and pull pistons in order to get at the parts, which should be replaced, steam chest and cylinders closed, and the crossheads blocked in order to eliminate the moving of the pistons in cylinders. The air pumps and the feed pumps on all equipment should be opened up and surfaces treated with a coat of white lead and tallow. The cap on engineer's brake valve on locomotives should be lifted and the surfaces of the valves, etc., slushed with vaseline. All exterior surfaces of cab fittings should be given either a coat of white lead and tallow or vaseline. Interior surfaces of triple valves and injectors need not be treated, as they are brass. Journal box cellars on all drivers and engine truck wheels should be well packed, also journal boxes on tanks.

Steamshovels.—The same general rules for the care of locomotives will apply to steamshovels. All engine pistons, valves, rods, eccentric straps, "A" frame collar and swing circle to be removed; shafts lifted from bearings, wearing surfaces cleaned, doped with white lead and replaced. Boilers should be stripped with lagging, and cleaned as outlined for locomotive boilers. Water tanks should be taken off shovels, inspected, and if found in bad condition they should be scrapped. Roofs should be painted with tar paint; also coal platforms and dippers. Other parts now covered with oil or grease can be protected with a coat of crude oil, which will be sufficient protection.

Unloaders, Cranes, Spreaders, Hoisting Engines, Trackshifters and Piledrivers.—Machinery should be gone over and given a coat of white lead and tallow, as outlined for steamshovels.

Miscellaneous Machinery, Including Shop's Machinery and Tools.—Air pumps and feed pumps on all equipment should be opened up and surfaces treated with a coating of white lead and tallow. All bearings, journals and bright surfaces of all machinery and equipment should be given a coat of white lead and tallow.

PAVING BRICK FROM FURNACE SLAG.

AN extensive industry is being developed in the north of England, at Middlesborough, based upon the utilization of blast-furnace slag. It is described by Mr. Frank G. Bolles in a recent Daily Consular and Trade Report. Several companies are now engaged in the work and are apparently very successful both as to results obtained from the brick as well as commercially. The method pursued in the manufacture of these bricks is as follows:

A suitable manufacturing site is selected near the blast furnaces which are to supply the slag, this plant being connected by an industrial railway upon which the molten slag is carried from the furnace to the molding machine. The latter consists of a metal wheel which may be of any suitable diameter, but which in the case examined was approximately 30 ft., this wheel being supported upon a vertical shaft. The spokes of the wheel are made of round rods and the construction of the wheel itself is quite similar to the wire-spoked wheel used for vehicles. The metal rim upon which the molds are bolted is approximately three-fourths inch thick and 6 in. wide. In the plant examined this wheel carried 120 molds 9 ins. long, 3½ ins. thick, and 4 ins. deep, which is the standard size for paving brick. A variety of other molds are used, but the bulk of the work is of the paving-brick size. The molds are made of two pieces, the front end or right side being an arm in one piece which is bolted to the rim of the wheel, while the left side, back end, and bottom is another piece. The latter is hinged to the part which is secured to the rim of the wheel and held for casting purposes by a catch on the front end of the stationary piece. On the right side of the mold is cast a lip which assists the operator in more readily striking the mold when pouring the hot slag. Before casting the molds are dusted with a powder, the appearance of which would indicate it to be Portland or other cement.

The car which carries the slag is of plate steel with a fire-brick lining, the top being covered over with a removal cap, in the centre of which is a hole approximately 18 ins. in diameter, through which the slag is poured when the car is filled at the furnace. At the bottom of this car is a tap similar to those used upon blast furnaces. The car of molten slag is run alongside the wheel, the trough tc the tap extending over the molds; the clay plug in the tap is knocked out and the molten slag runs into the mold. As soon as it is filled an operator, by means of a handwheel mounted upon a sheet-steel heat deflector and connected through rods and miter gears to the centre of the molding wheel, turns the latter so that the next mold comes under the flow of hot slag, and so on until all the molds are filled. By the time that the wheel has made a quarter revolution the cast brick has sufficiently cooled to that they may be dropped out of the molds by knocking off the catch which holds the bottom in place.

As soon as they have dropped to the ground they are taken by laborers to the annealing furnaces, into which they are thrown in a promiscuous heap. These furnaces, of which there were six in the plant examined, held approximately 1,100 brick at one charge. The heat retained in the brick when they are thrown into the furnace, together with a very small amount of fuel, again brings them to a cherry red, and as soon as the furnace has been filled it is closed and allowed to cool gradually, 24 hours usually being required before the bricks are removed.

The capacity of the slag car is approximately 3½ tons, from which 360 to 400 paving bricks are made. The bricks, when cleaned up, having all of the rough corners knocked off which have been left in the process of casting, weigh about 14 pounds each. These bricks are proving very efficient for street paving and are being exported to Canada, the United States, and many other countries.

OIL VERSUS COAL AS FUEL.

According to British Trade and Commerce reports, opportunity has been taken of the considerable development in the use of oil as a fuel in the place of coal to revise the rules in connection with the burning and carrying of oil fuel, the flash point of which does not fall below 150 degrees Fahrenheit. These rules were originally adopted in 1902, and advantage has been taken of the experience since acquired to bring the regulations up to date.

CROSS SECTIONS OF BREAKWATERS TO WITHSTAND WAVE ACTION.*

By Col. Frederic V. Abbot,
U.S. Corps of Engineers; M. Am. Soc. C.E.

TWO prime factors, exposure and cost, determine the best form of cross section to adopt for a breakwater. Exposure varies with the fetch of waves and with the depth of water at the structure and the front between it and the open ocean. At Charleston, S.C., with moderate depths and outlying shoal areas to break the full force of the ocean waves, a rubble mound cross section has served well for the jetties, built to deepen the channel, but serving also as breakwaters to reduce the force of waves in the jetty channel. In construction care was taken to avoid using small stone for a hearting and covering it with selected large stone, as has been frequently done in Europe. Run of the quarry was used up to about low-water, the drilling and blasting being conducted so as to produce as large a percentage of stone of 7-ton weigth as possible. Above low-water level a skeleton was made of stone from 1 to 7 tons in weight dropped directly along the axis up to a height somewhat above high-water level, and left with side slopes as steep as they would stand; this skeleton was covered with quarry run also dumped directly along the axis with natural side slopes up to a height of 10 or 12 feet above high-water. The first heavy storm would knock this grouting and the upper part of the skeleton down, beating the smaller pieces in among the undisturbed larger pieces of stone forming the skeleton, and distributing the balance on the slopes. The grouting was then replaced to the former height, taking this time much less stone than at first, and a new storm was awaited. It generally proved to be necessary to repeat this process three times before the cross section assumed a final permanent form, with crest approximately at high-water level. Writing from memory only, it is the writer's impression that at the outer ends of the Charleston jetties, 20,000 feet from shore, the mound was ultimately nearly 90 feet wide at mean low-water with a crest about 5 feet above; the crest, which was very smooth and level, was about two-thirds of the way from the seaward to the harbor side of the 90 feet lying between low-water levels on the two sides. At depths greater than 15 to 25 feet on seaward side, depending on the local protection afforded by outlying shoals, the slopes were nearly 1 on 1, and from those depths to the crest the seaward surface was convex toward the sea, the slope becoming very gentle for the 2 feet immediately below the crest. The upper surface was singularly uniform and smooth, considering the great size of many of the stones. The harbor side was similar but much steeper throughout. This form of cross section permits waves to mount the slope and fall over into the harbor with the least abrasion and injury to the structure, and it has resulted from the action of the very forces it is intended to resist. The engineer has simply supplied material, which waves have molded into final shape. The stilling effect of such a structure is not as great as that of one designed to throw the entire wave back to the front, but, except in very heavy weather, the water between the Charleston jetties is not rough enough to inconvenience any vessel adapted to ocean traffic. An advantage of this method of construction is that each par

*From Col. Abbot's article on the subject in "Professional Memoirs" for Nov.-Dec., 1913.

of the structure has a cross section just sufficient for its individual exposure, and therefore no stone is wasted to give a section stronger than is needed; repairs are extremely easy if a shifting of the other shoals exposes any part of the superstructure to heavier seas than existed there when it was built. The last stone was deposited on the jetties about twenty years ago, and I am told that there has been no sensible degradation of the crest level in that time, although a number of West Indian hurricanes have passed over the harbor and done vast damage to the city and to shipping in the inner bay.

The Galveston jetties were originally built with rather small stone hearting covered with heavy stone sides and cap; the storm of 1901 produced disastrous effects; as soon as the capping or side covering was broken the interior washed out and the whole structure ravelled and collapsed for considerable distances.

At the Columbia River jetties the exposure and outlying depths are so great that a random cross section somewhat similar to that at Charleston has so far proved impossible to maintain above mid-tide without using enormous quantities of stone. Failures prove more than successes, and it is possible that at that point some form of cross section like the Columbo sloping block or the Sandy Bay coursed squared stone might have been cheaper in ultimate cost. The preparation of a suitable flat base for such an accurately laid superstructure would, however, have been vastly difficult and costly on the Columbia River bar.

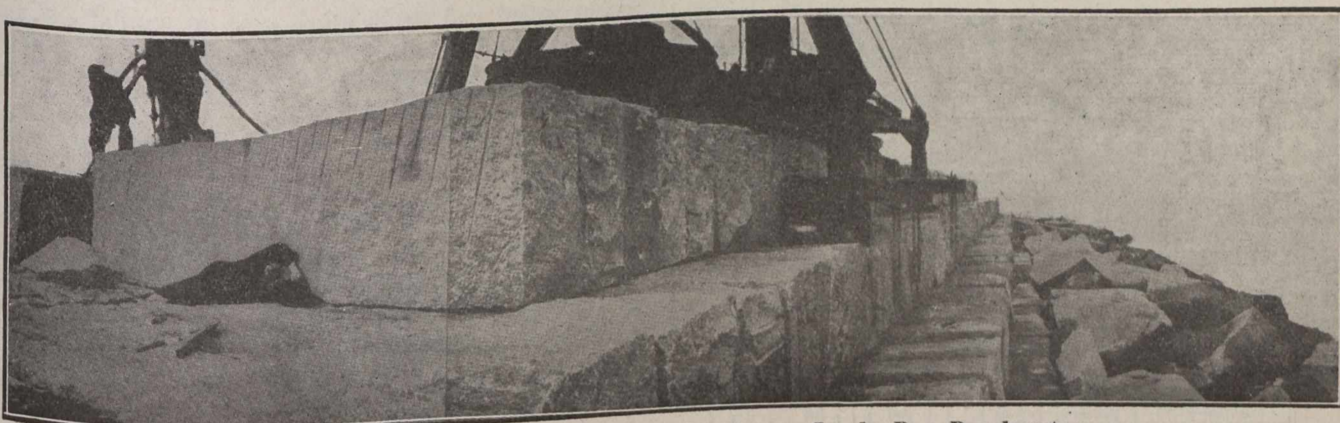


Fig. 1.—Drilling Holes for 30-ton Capstones, Sandy Bay Breakwater.

At Point Judith, where the exposure is perhaps comparable with that at Charleston, a moderate rubble mound, with a superstructure of large blocks set to form a regular cross section, with predetermined surfaces of heavy rubble on the top and seaward side, has stood for years with comparatively small repairs, but when they have been necessary the regularity of the structure has made them costly because a number of stones, only slightly displaced, had to be taken up and reset to restore the bond and to avoid conspicuous irregularities. Where lines are straight, or surfaces are planes, the eye is quick to detect any elevation, depression, or bulge, and this is a serious disadvantage of too regular outlines in break-

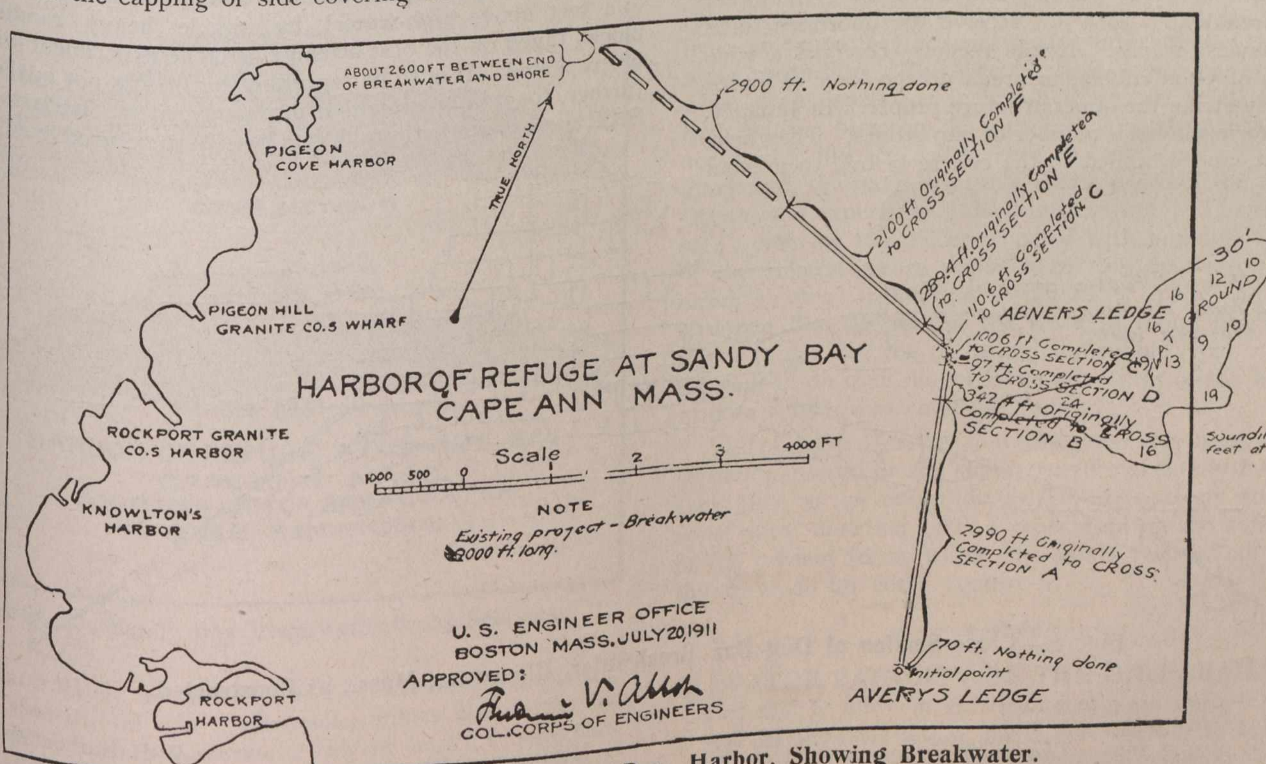


Fig. 2.—Plan of Sandy Bay Harbor, Showing Breakwater.

waters where the forces in action are so great as to make deformations probable. Where integrity of the structure depends on bond or a smooth surface for waves to mount on, such deformations are not only very unsightly but seriously impair capacity to withstand subsequent storms.

At Gloucester, Mass., a very carefully built breakwater, with a superstructure of extraordinarily narrow cross section (side slopes of 1 on 0.7) has safely withstood storms of great severity and waves of great force, but the breakwater does not receive the unbroken force of the heaviest waves. It has recently received a wide sea apron of 5-ton rubble, to break up the force of waves before they strike the superstructure proper. In January, 1913, a storm moved a number of cap stones. They have been reset, and dowelled to the course below, to prevent sliding.

At Sandy Bay conditions are extreme. For long distances the depth of water is 800 feet; the exposure is to the northeast, from which direction come the heaviest storms; there are no outlying shoals to protect the part of the breakwater lying in the deepest water. A heavy rubble mound forms the base of the structure. An attempt to bring it up to 18 feet above mean low-water (9.4 feet above high-water) by simple heavy random blocks failed on the first attempt, and the experiment was not repeated. It is to be regretted that it was not pushed further, for it is possible that ultimately, as at Charleston, S.C., a cross section would thus have been secured exactly

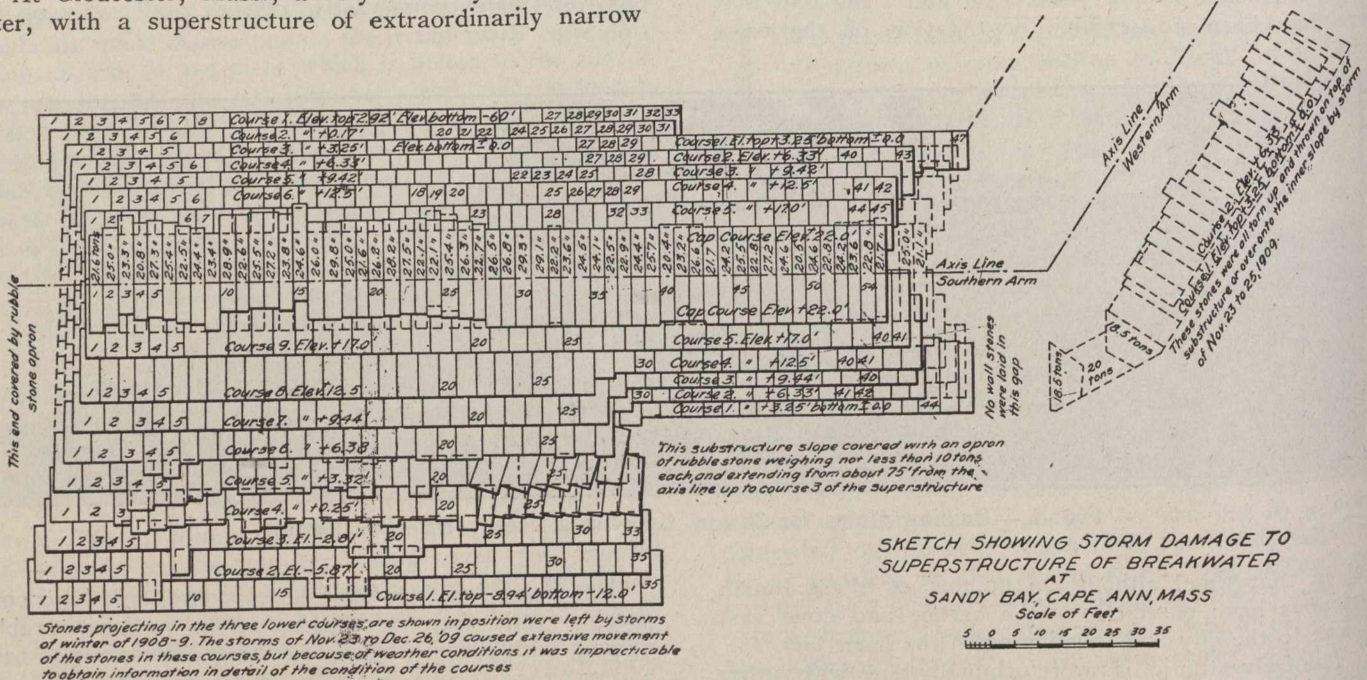


Fig. 3.—Diagram of Storm Damage, Sandy Bay Breakwater.

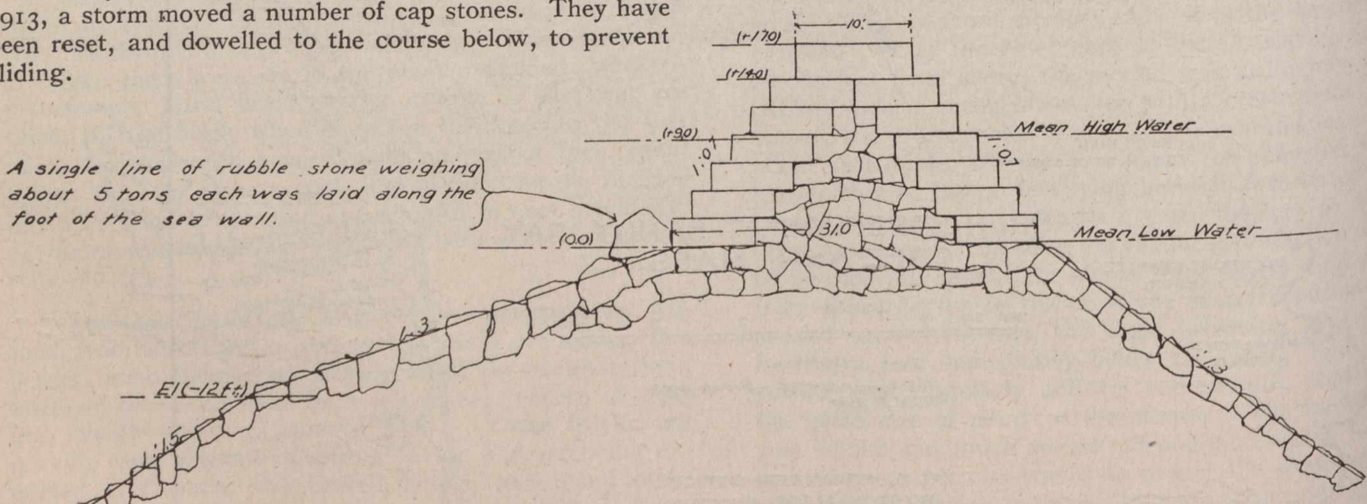


Fig. 4.—Cross Section of Dog Bar Breakwater, Gloucester, Mass., as Constructed.

NOTE:—*Caps* are 3 foot rise, vary in width of face from 3.2 feet to 4.6 feet and weigh 8 tons to 11.5 tons with an average weight of 9.25 tons. *The walls* are in six courses in a rise of 14.0 feet or theoretically 2.33 foot rise per course. In construction the stone was quarried 2.2 foot rise for the first 5 courses, and the 6th course was cut to the rise necessary to secure the approximate grade of bed for the caps, resulting generally in slightly heavier stone in the 6th course.

The length of stone in the walls was specified to be not less than 7 feet nor more than 8 feet. The dimensions and weights of stones computed on an average length of 7.5 feet are as follows:—

	Sea Wall.	Harbor Wall.
Maximum width of face	5.6 feet	6.0 feet
Minimum width of face	2.5 feet	2.2 feet
Average width of face	3.4 feet	3.2 feet
Weight of maximum stone	8.2 tons	8.7 tons
Weight of minimum stone	4.0 tons	3.2 tons
Weight of average stone	4.9 tons	4.7 tons

Substructure:—Specifications required that in the seaward slope no stone should be used weighing less than 3 tons and that average weight of stone in each cargo should be not less than 4 tons. In rubble mound generally and harbor slope the stones ranged in weight from 500 pounds to 4 tons.

adapted to the exposure. The depth is so great, however, that an enormous quantity of stone would have been needed to give sufficient base for the part affected by wave action, which here extends to 30 feet below mean low-water, as shown by actual surveys. In designing a superstructure for this breakwater, all engineers have attempted to keep the width of foundation a minimum on account of the great quantity of stone needed to fill out the slopes of the substructure in 80 to 90 feet of water. From the bottom up to a depth of 30 feet below mean low-water the mound stands stable with slopes of 1 on 1; from that level up to mean low-water heavy rubble seems

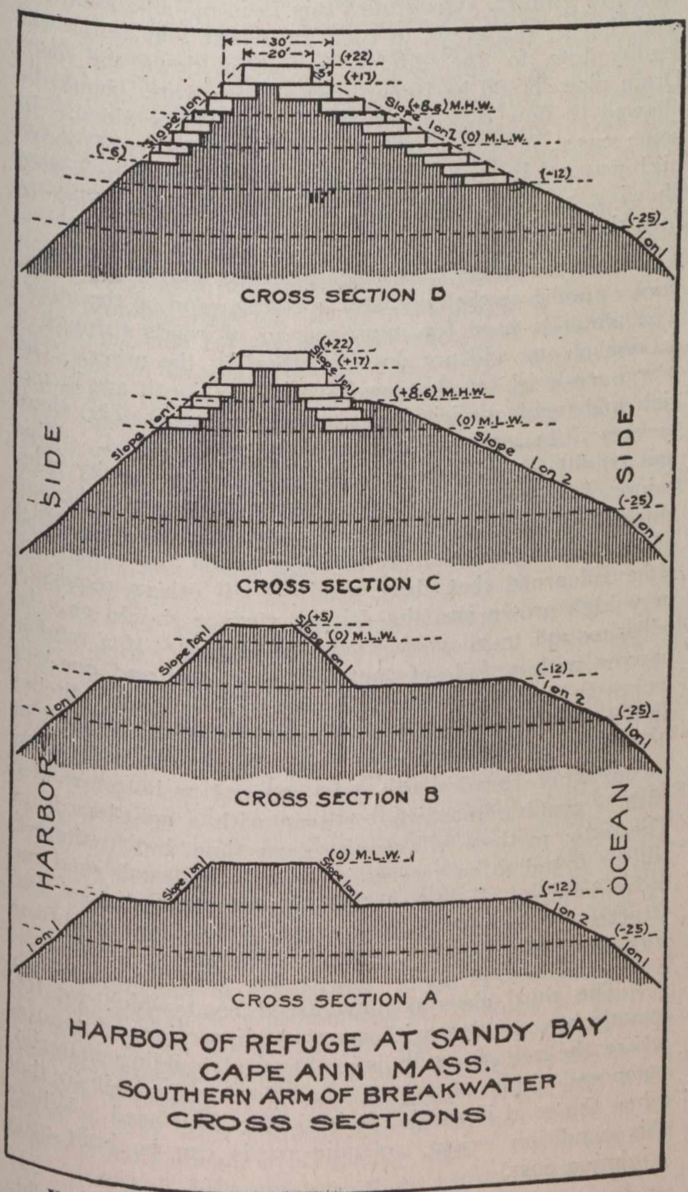


Fig. 5.—Sandy Bay Breakwater Cross Sections.

to stand safely at about 1 on 2. The first experiment with closely laid, uncut dimension stones was to set by divers on the seaward side a row of heavy rectangular headers at level—12 referred to mean low-water, and a similar row at level—6 on the harbor side, filling between the rows with medium heavy rubble. Successive rows of dimension stone blocks were laid on these foundation rows, so as to give a stepped seaward slope of 1 on 2, and a stepped harbor slope of 1 on 1 up to level + 17, where the two rows were only about 5 feet apart at the inner ends of the headers. Capstones, 20 feet long and 5 feet rise, were set to bond the two walls. This superstructure withstood several winter storms, but in 1908 displacement of stones (see illustrations herewith) showed that for a permanent superstructure the cross section was insufficient.

The latest form is due to Col. Edward Burr, who kept the harbor side of the superstructure unchanged, except that the lowest course is now at low-water and not 6 feet below. The capstones are as before, but each is supported against sliding toward the harbor by a 2-inch dowel pin set in a hole in the underlying course of the harbor wall, and solidly grouted in place. Below the cap the seaward face is built in steps sloping 1 on 1 and not 1 on 2, with the main object of giving greater lap of the upper stones on those in the lower courses, to resist the tendency to pull out to the front—the way in which the prior section failed most signally. In both harbor and land walls he stopped the dimension stone steps at mean low-water in order to secure better inspection of the bedding of those most important blocks. The berm created by drawing back the foot of the seaward slope was utilized by using is as a shelf to hold 10-ton rubble, which was brought up to high-water level in front of the dimension stone. The rubble tends to shatter the waves before they reach the superstructure proper.

In 1909 a short section of this new superstructure withstood almost unchanged the heaviest storms of the past twenty years, and in accordance with recommendations of the Department, Congress has appropriated sufficient funds to build 800 feet of this cross section, of which 200 feet are on the western arm, and 600 feet are on the southern arm. This will be a sufficient length to develop the full destructive force of waves to which the southern arm is exposed, and if it prove sufficiently resisting the rest of that arm can safely be built to that cross section. There is an outlying shoal, submerged from 30 to 10 feet in local peaks, which gives that arm some protection. The western arm, however, crosses a wide, deep depression in which there are no depths less than 80 feet between the structure and the ocean to the northward and eastward; here the exposure will be the maximum, the fetch being the whole width of the Atlantic Ocean, and experience gained in the work will be the only safe guide for the officer charged with building the part of the superstructure opposite to this depression. The writer's own inclination would be to make the superstructure like the rest of the work, if found practicable, but to widen out the berm and the rubble front slope by the deposit on that side of large quantities of the heaviest granite rubble that could be bought.

The writer believes that Congress has been wise in suspending work on the superstructure of Sandy Bay until such time as an exceptionally violent easterly storm of some days' duration gives further data on the sufficiency of the present form, which has safely resisted all waves that have so far come against it.

ELEVATOR CAPACITY OF THE G.T.P. RAILWAY.

At present there are on the G.T.P. Railway in Manitoba 25 elevators with a capacity of 757,000 bushels; in Saskatchewan, 178 with a capacity of 5,350,000 bushels; in Alberta, 25 with a capacity of 745,000 bushels; and at Fort William, the largest elevator in the world with a capacity of 5,750,000 bushels. For the prairie provinces, the total capacity is 6,852,000 bushels; including the Fort William elevator, the grand total on the G.T.P. Railway is 12,602,000 bushels.

THE TREATMENT OF UNSURFACED ROADS.

It is stated that there are 2,100,000 miles of roads throughout the United States that are unsurfaced, or rather, that have never been re-surfaced. These roads are composed of materials which run from the finest silt to the hardest granite, and the treatment of one will naturally be entirely different from the treatment of another. It would be difficult to ascertain the various soils or natural earths that go to compose the wearing "surface" of these unsurfaced roads. Yet, they must be carefully maintained, owing to the absence of suitable surfacing materials in numerous sections of the country, and the high cost of handling by railroads, preventing their being surfaced with stone, gravel or other suitable material.

At the American Road Congress in Detroit, Mr. W. S. Keller, State Highway Engineer of Alabama, read a paper dealing with unsurfaced roads, and their maintenance. He divided this type of road into three classes, as follows:—

First, the ordinary country road opened when this country was young, leading from one settlement to another or from a farmer's home to that of his nearest neighbor. These roads were not opened through any process of law, in fact, there was no law governing roads in those early days, but by following trails of least resistance, removing trees and such rocks as would not permit the axles of wagons to clear, the pioneers of this country made it possible to travel, in a way, from place to place. We have many roads in Alabama now in use that were opened and traveled during the wars of long ago. Of course, such roads were opened hurriedly and little or no attention was given to grades or alignments. Settlers, taking advantage of work that had been done, built their homes along these military roads or traces as they are frequently called. In the construction now of more modern roads, it is difficult to better the alignment of these roads on account of homes, churches and schools which have been built close to these highways. However, in many places, these roads have been and are being changed to meet the demand of traffic of to-day. The genuine bad roads of the South belong solely to this class. They cannot be maintained for the reason that they have never been constructed and the great amount of work necessary to keep them in passable condition disheartens the man who by law is compelled to work them. Until these roads are re-located, avoiding heavy grades and marshy bottoms, sharp angles and useless twists and graded so that they will have good drainage, we may expect them to be bad.

The second class of unsurfaced roads are the ordinary graded earth roads which have proper alignment, grade and drainage. The construction of an earth road is simple, but sometimes the simplicity of it causes the average county commissioner or supervisor to overestimate his ability as a road builder. The proper construction of an earth road consists first of a careful inspection by the proper official to determine what beneficial changes in grade and alignment can be made, taking into consideration initial cost and cost of maintenance. The centre line and grade of the road should be established by an engineer. After the centre line has been established and width of road bed agreed on and grade established, construction work can begin. The proper and efficient grading force for the work should consist of a foreman, eight or ten good two-horse teams with drivers, one wheel and one drag scraper for each team and one extra wheeler and drag for emergencies, one good railroad grading plow, one grading machine, one split-log drag, one dump man and one loader with five or six extra men for grubbing and other work. The foreman should be an experienced grading man who understands handling earth and knows when it is proper to use drag scrapers, wheel scrapers or wagons. The road should be so graded that the ditches or gutters are parallel with the centre line of the road and uniform distance from it. When completed, the road should be uniform in width and surface should be smooth and even, free from holes and high places with a uniform crown with a fall of one inch to one foot from centre to gutters. On grades this ratio of fall should exceed that of the grade to such an extent that water will readily flow to the ditches instead of down the road. Drain pipe should be freely used and no water should be allowed to flow over the road if it can be avoided. In some cases it is not practical to build the road above high-water. In such cases danger signs should be posted showing at what stage the water becomes too high to ford the stream.

We have in the South nearly every kind of soil from sticky gumbo on the one hand to coarse sand on the other. The methods used for improvement of roads through a section of one will not do altogether for the other. The worst roads by far that we have in the South are in our rich and fertile prairie lands where, unfortunately, there is very little road building material to be found. This soil readily absorbs water and becomes very sticky after rains. It expands freely and dries rapidly when the sun shines and becomes very hard under the tamping effect of teams and vehicles. From observation and experience I have learned that these roads of all others require a very high crown and the driving surface should only be wide enough to allow two vehicles to pass. If a road is narrow with a fall of not less than one and one-half inches to the foot, water will shed rapidly to the ditches and the entire surface will dry out quickly. A road of this kind can be constructed quickly and at little expense, except where grades are to be reduced or bottoms filled with a grading machine, or even with a split-log drag. The latter method will require more time, but in the end will be found to be very satisfactory. No earth road can be maintained in good condition unless it is so constructed as to drain well and unless it is kept free from ruts and holes.

The third class of unsurfaced road which we frequently have to deal with are those in sections of country where the soil or earth is really road building material, composed either of gravel, sand-clay or top soil so that when the road is graded it is, in fact, surfaced. Where this condition exists, splendid roads can be built at a minimum cost.

The maintenance of unsurfaced roads is radically different from the maintenance of surfaced roads. For instance, the patrol system used on macadam roads would be entirely inadequate for earth roads. One man can keep up two or three miles of macadam road where he would unquestionably be unable to keep in good condition a like amount of unsurfaced road. With the use, however, of a team and drag, he would be able to keep in good condition twenty miles of ordinary graded earth road. Some very zealous advocates of the drag claim everything for it, from the removal of stumps and rocks to the ditching of roads. I am a great believer in the drag, but from experience, I know that obstructions must be removed and proper drainage provided for before it is effective. It has been difficult with the road men of the South to convince county authorities that this little machine is of value. The writer, when in charge of road work in a Tennessee County, inaugurated a system of dragging that proved very successful. Ten roads were graded a distance of three miles each. The grading was completed in November. With surface of these roads fresh and loose, it was a foregone conclusion that the winter rains would soften them to the extent that they would become impassable under heavy traffic. Contracts were made with a farmer on each of these roads to keep them dragged during the months of December, January, February and March and the price paid was 30c. an hour for a man and team. The county furnished the drags. As an inducement to the men to do good work, the county offered prizes of $25, $15 and $10 for the best kept roads. Specifications for dragging and rules governing the contest were furnished each contestant. One important rule was that the prizes would be awarded to the men who kept their roads in the best condition at the least cost. In order that the engineer might keep in close touch with the work, postal report cards were furnished each man and they were required to fill them out every Monday, showing the distance dragged, hours consumed and cost for the previous week, and mail them to the office of the engineer. In this way it was practically impossible for a dishonest man to render an account for more time than he really consumed without it being detected or if he worked more than was necessary, the reports of the other contestants, when compared with his, disclosed it. On the other hand, if one should be neglecting his work by not dragging sufficiently it was likewise detected. This thirty miles of road was kept in splendid condition despite the fact that two heavy snows fell during the four months. The most interesting fact connected with the contest was the road that was awarded first prize cost the county only $15, or $5 per mile.

In many Southern States the roads are maintained, or at least are supposed to be, by what is known as statute labor, which means a man subject to road tax may work out his tax under the direction of a beat or district overseer. Such labor is practically worthless, and few men are required to work out the stipulated number of days. As it seems to be impossible to entirely abolish statute labor, the question that confronts us now is, what is the best system coupled with this labor to use in the maintenance of our roads. Good results have been accomplished in several counties in Alabama by putting the work in the hands of a few regularly employed foremen who give all of their time and attention to the work, instead of leaving it to many beat overseers who work when it suits their convenience, or do not work at all when it suits them, as it usually does. These foremen are furnished with two or three teams with regular drivers, wagons, scrapers and grading machines, split-log drag and necessary small tools and as many beats or districts assigned to each as he can work. A census is taken in each foreman's territory at the first of the year of all men subject to road duty, and he is furnished with a list of names and is required to work every man who has not paid the required amount of cash into the county treasury in lieu thereof. No foreman is allowed, under penalty of dismissal, to receive cash from work hands, but such hands as desire to pay must make their payments to the proper county official at the court house. This method has proven good in most cases, but as a general thing the best results cannot be accomplished by permitting men to work out their road tax.

TRIANGULAR RAILWAY TIES.

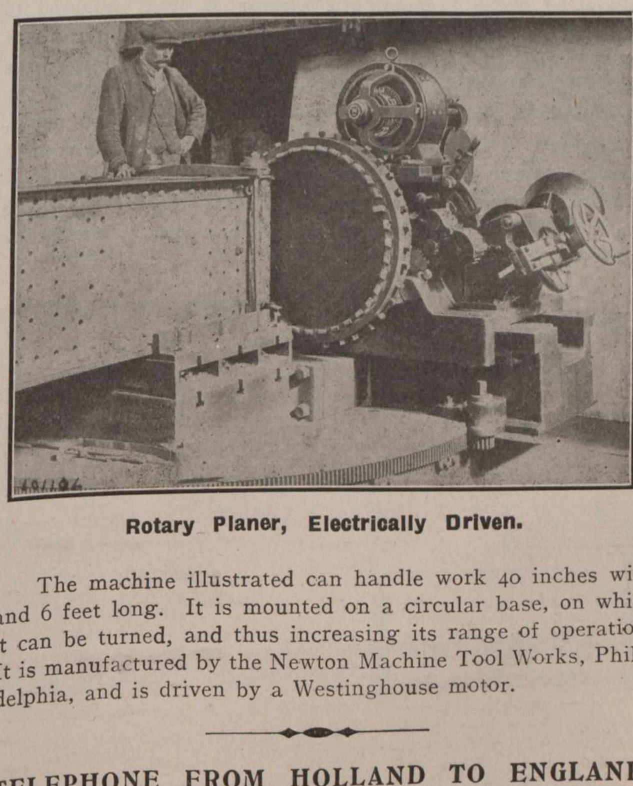
During the past twelve years upwards of four million triangular ties have been laid by the Great Northern Railway, from 150,000 to 200,000 now being inserted annually. Ties of this shape have an advantage which the following description will disclose:—

In their manufacture either two or four ties are cut from a log, timber cutting four ties being preferred, as the annular rings of such ties are convex and provide better drainage. After a log is squared it is cut diagonally into either two or four pieces 16 in. long on one side and 8 in. in depth. Triangular pieces 2 in x 2 in. in size are cut from each of the two upper corners, leaving the upper face of the tie 12 in. wide. The ties are 8 ft. long. They are treated with a 6 per cent. solution of zinc chloride, equivalent to an injection of ¾ lb. of zinc chloride per cubic foot of timber.

It will be noted that ties of this type are more or less self-tamping, especially at the rail ends, and it has been found to reduce somewhat the expense of joint maintenance in gravel ballast. When not used in conjunction with the ordinary rectangular ties, the triangular tie is believed to give promising results, as some of the best track now in use is thus carried.

MOTOR-DRIVEN ROTARY PLANER.

The accompanying illustration shows an interesting form of planer for very large work, such as facing the ends of columns, cast-iron bed-plates, stringers, etc., and machining engine frames and other heavy castings. The cutting tools are arranged in a circle, which rotates when in operation.



Rotary Planer, Electrically Driven.

The machine illustrated can handle work 40 inches wide and 6 feet long. It is mounted on a circular base, on which it can be turned, and thus increasing its range of operation. It is manufactured by the Newton Machine Tool Works, Philadelphia, and is driven by a Westinghouse motor.

TELEPHONE FROM HOLLAND TO ENGLAND.

A submarine telephone is to be laid between Holland and England. The length of the cable will be 105 miles. According to the present project, the total expense will be near $3,000,000, and will be borne conjointly by the two countries.

SEWAGE PUMPING MACHINERY AND APPLIANCES.

By Gerald Priestman,
President, Merritt Hydraulics Company, Philadelphia, Pa.

Various types of sewage pumping apparatus are in general use, each type being adapted to its own particular work and the selection in any one case must rest largely upon the decision of the engineer. The pumping of sewage differs from the pumping of water in that provision must be made when handling sewage, to take care of the solids, grit and any foreign matter—rags, sticks, etc., which may enter the pump. In other words, the sewage pump or lifting apparatus must be entirely reliable. A shut-down may affect the health of a whole community.

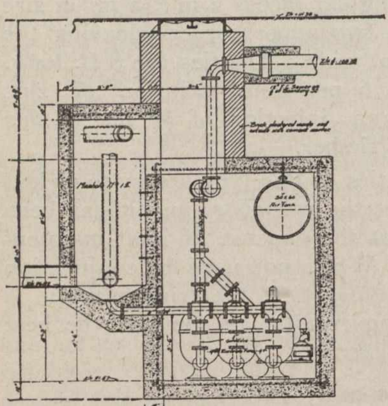


Fig. 1.

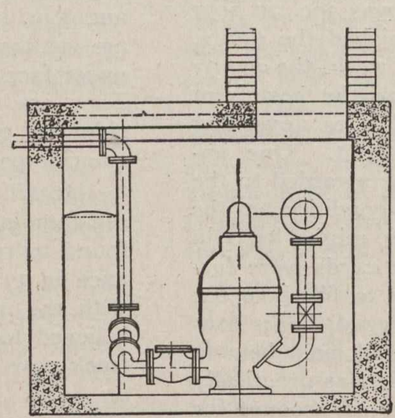


Fig. 2.

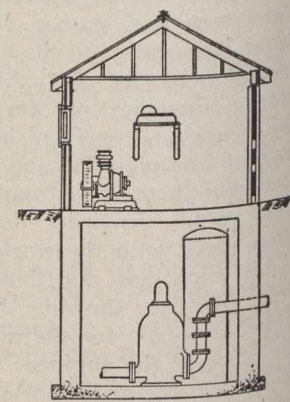


Fig. 4.

Pneumatic Ejectors.—Since all rubbing surfaces or moving parts are eliminated and the sewage is lifted entirely by a piston of air, the pneumatic ejector is well adapted to pumping crude and unscreened sewage. Fig. 1 illustrates a typical isolated sewage pumping plant with three Priestman ejectors and air tanks installed complete in a pit below the street level. An installation of this kind would be made, for instance, to pump sewage from a low lying district of a sewerage system up to a main outfall sewer, saving the excavation and construction work necessary to lay the large main sewer at a deeper level so as to permit drainage by gravity.

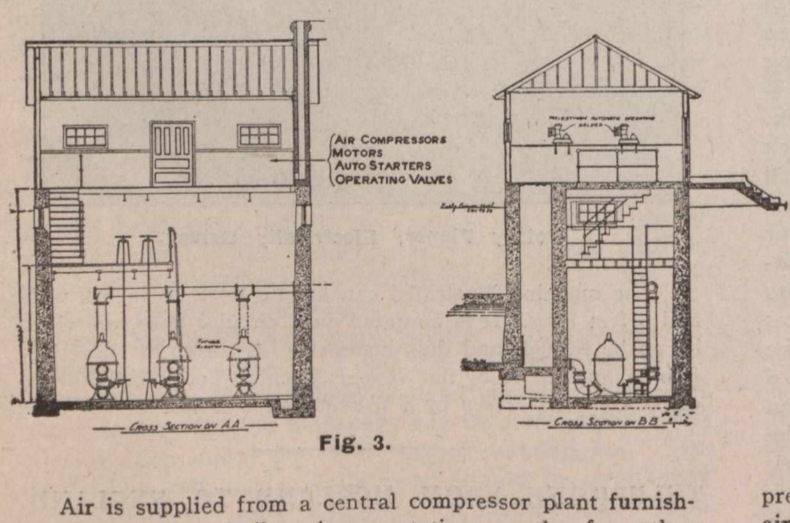


Fig. 3.

Air is supplied from a central compressor plant furnishing air to other similar ejector stations or else for other work. Besides the air tank and ejectors there is also installed in the pit, the ejector operating valve. With this type ejector, the air valves may be located at some convenient and accessible place near the top of the pit and are independent of the ejector bodies themselves, being connected with them by small piping only. The operation is as follows: Sewage gravitates to the ejector bodies; as it rises to the top it entraps and compresses the air present in the small bell. This bell is connected by small piping to the operating valve. The slight compression acting on a diaphragm in the valve is sufficient to operate it so that the main air valve is opened and air is admitted to the ejector to displace and discharge the sewage. The valve is also designed and set so that the air supply is cut off after a predetermined interval before all the sewage has been displaced so that the remainder of the discharge takes place while the air is expanding and the greatest economy is secured.

Fig. 2 shows another isolated compressor station of somewhat different arrangement and with only one ejector. Where there is only one pumping plant to be installed a complete ejector plant with motors, compressors and auxiliaries is installed in a suitable station, as shown in Figs. 3, 4 and 5. In Fig. 3 the ejector proper is in the pit below the street surface, while the air compressors, motors, auto starters and operating valves are in the house immediately above the pit. The advantage of operating valves which may be located at a distance from the ejectors, is apparent; the valves are located above the street level along with the compressors and auto-starters, where they can all be readily inspected and oiled by the engineer. Fig. 4 shows the operating valves located on the wall to the right of the small compressor, both above the street level, while the ejector and air tank are below in the pit. Fig. 5 shows a complete system below ths street level in a very compact station.

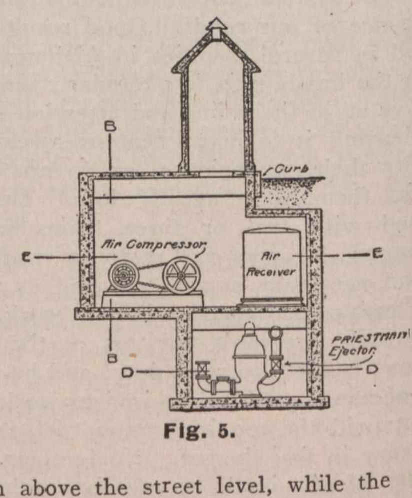


Fig. 5.

The advantages of the pneumatic ejector have already been pointed out, namely, the absolute reliability of operation depending on the fact that the power is transmitted, not by plungers, pistons, impellers, screws or similar devices, but by a piston of compressed air. The mechanism for opening the valve to admit the compressed air as, for instance, a

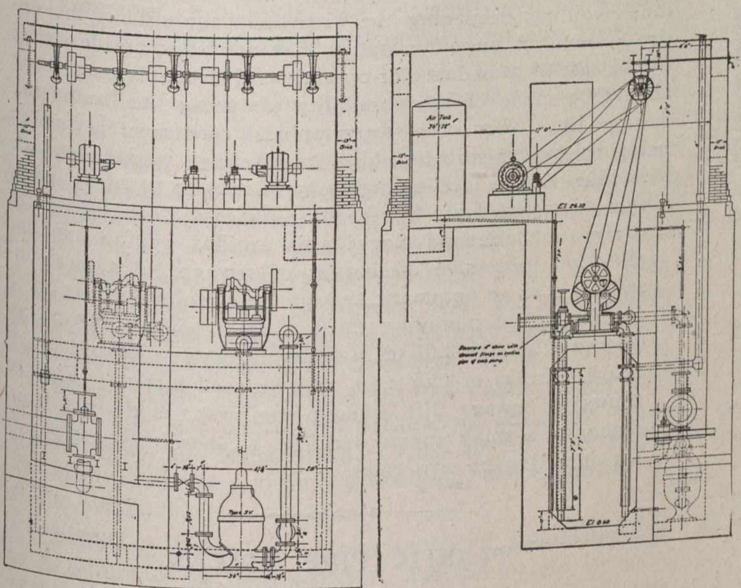


Fig. 6.

float rising with the sewage, may also be replaced by a piston or spring of compressed air which acts upon a suitable diaphragm in the valve mechanism. By this arrangement all moving parts are entirely eliminated in every stage of the operation of the ejector, nothing coming in contact with the sewage but air.

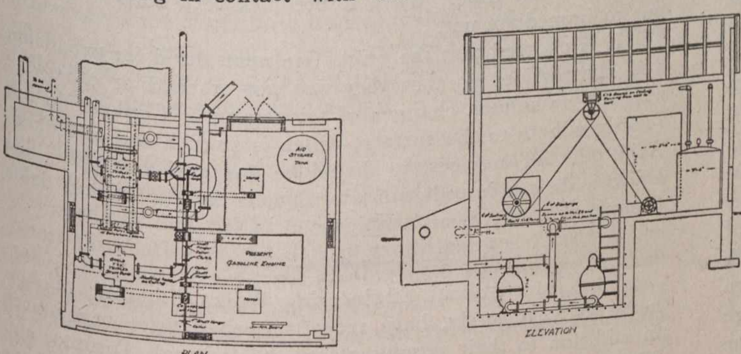


Fig. 7.

But while the pneumatic ejector is very reliable, it is open to some objection on the grounds of inefficiency in large plants operating continuously. In small plants, the reliability of the pneumatic ejector and the fact that it handles crude and unscreened sewage and thus requires no attendance, cleaning of screens, and is entirely fool-proof make the question of efficiency of minor importance. This is even more the case where the sewage flow is intermittent. The compressor automatically maintains the air supply in the tank and when there is no demand the air compressor is shut down. The ejector does not operate until it is filled and it may discharge once an hour or twice a minute, depending upon the rate at which sewage gravitates to it. On the other hand, a small pump of the centrifugal or plunger type may be operating for long periods at far under its full capacity, thus underloading the driving motor as well, with resulting fall in efficiency.

The main reason for the higher efficiency of the pump, as compared to the pneumatic ejector, is that with the pump the drive is direct, whereas, with the pneumatic ejector the driving motor must first compress the air, which in turn discharges the sewage, but an improvement in the efficiency of ejectors is obtained, however, by using the air expansively. By cutting off the air supply at a pre-determined point expansion occurs during the discharge of the remaining volume, so that the air is released from the ejector body at a pressure approximating that of the atmosphere instead of the full pressure of the air in the storage tank.

Centrifugal and Plunger Pumps.—If the sewage is thoroughly screened, a centrifugal pump will handle it at somewhat lower efficiency than that when handling pure water, as the solids and grit and grease which cannot be screened out cause corrosion and incrustation of metal parts. Screens must always be supplied, but even these will not prevent rags and other foreign matter from entering the pump impellers where they are passed with difficulty and very often become entangled and cause vibration and reduction of the pump capacity, and eventually requiring a shut-down.

By making the screens finer, a larger proportion of the solids may be prevented from entering the pump, thus increasing its reliability but, on the other hand, necessitating more frequent cleaning of the screens and more careful attention to the working of the plant. The

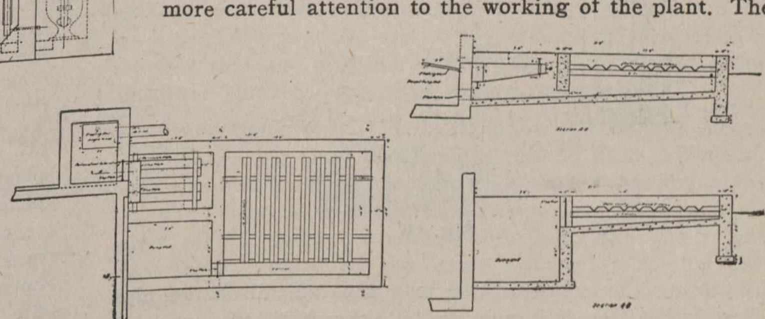


Fig. 8.

accumulation of screenage becomes foul and dangerous to health and the removal of the screenings themselves is costly and troublesome.

Priestman Natural Compound Pumping System.—The ordinary stationary screens have not proved satisfactory, as pointed out, because they require constant attention and become rapidly choked and the removal of the screening is very objectionable and costly work. But screens cannot be done away with or else the pumps will clog. The Priestman natural compound

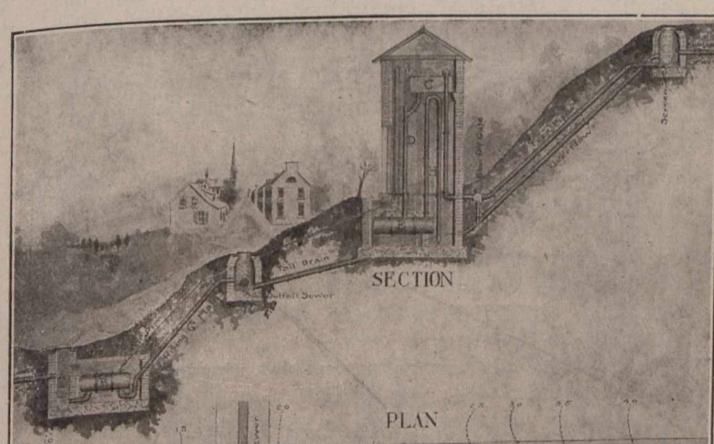


Fig. 9.

pumping system has been perfected in order to overcome these difficulties by separating the solids in the sewage from the liquids by pre-tanks and then lifting them separately by pumping apparatus best adapted to each service from the standpoint of both reliability and efficiency.

Instead of the ordinary screens the solids are separated out by pre-tanks in which baffles, collecting weirs, self-cleaning screens, etc, are so arranged that the solids are retained in one portion of the tank and the clarified liquid passes on to another. The solids, which make up only a few per cent. of the total volume, gravitate into Priestman pneumatic ejectors and are discharged by compressed air into the delivery main

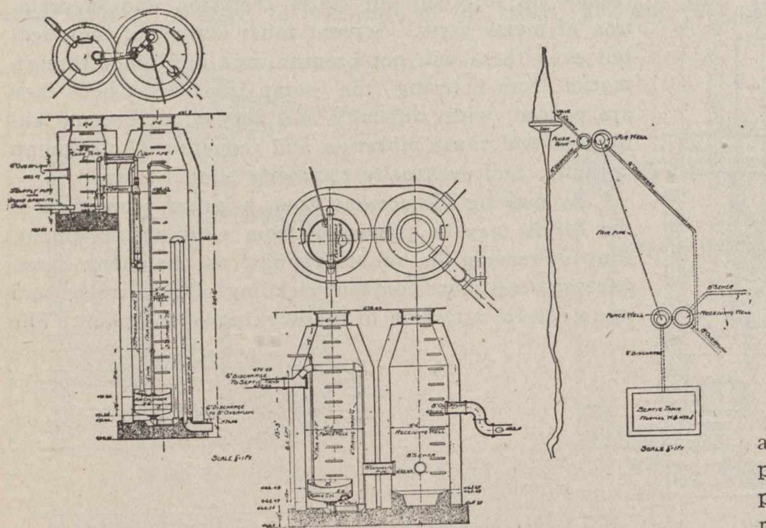


Fig. 10.

by-passing the pump or else to a separate discharge pipe. The clarified liquid is pumped by either high efficiency centrifugal or plunger pumps. The pumps can be driven by motors, gas or oil engines or steam turbines. The air compressor is small and may be readily driven by belting or from the shaft of the main driving motor or engine.

Figs. 6 and 7 show the sewage pumping stations designed on the Priestman natural compound pumping system comprising Priestman ejectors for the sludge and high efficiency triplex plunger pumps for the clarified sewage. Instead of the plunger pumps, centrifugal pumps could also be used. Fig. 8 shows the pre-tank as used in the installation shown in Fig. 7. The drawing shows the inlet chamber, the sludge chamber, weir chamber and the pump well from which the clarified sewage is lifted while the sludge gravitates to the ejectors.

Automatic Sewage Lifts and Water Power.—By use of the automatic sewage lift, sewage may be pumped by sewage,

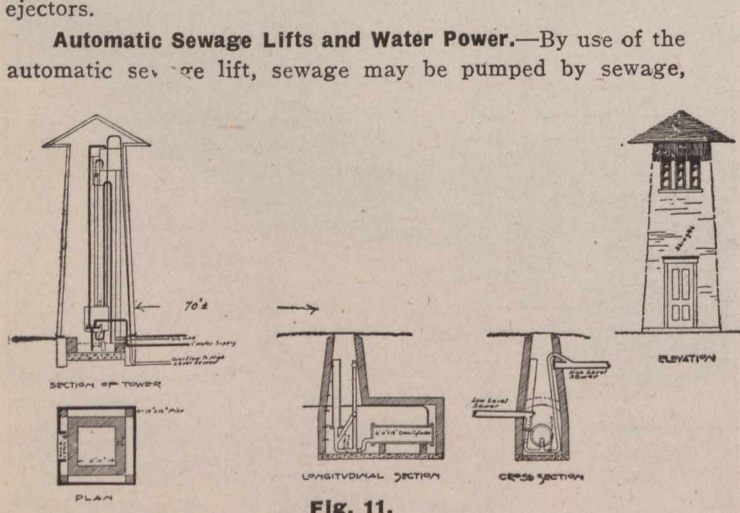


Fig. 11.

without cost, or else with the water power lift by water. As conditions do not always permit of the use of the lifts, they are not found so generally in service, but the entire absence of operating cost with these devices warrants their consideration under all circumstances.

The cost of a sewage system may be decreased by draining a low-lying district separately and lifting the sewage, thus avoiding deepening the excavation throughout the entire system. A pumping station may not be advisable owing to the cost of attendance of operation. In such cases a study should be made of the possibility of using the automatic sewage lift. Very often topographical conditions permit of using the power stored in high level sewage to compress air so that the low level sewage may in turn be lifted by using this compressed air furnished at no cost. The lift is entirely automatic and clogging is avoided by the flushing effect of successive discharges of sewage. A typical installation of an automatic sewage lift is shown in Fig. 9.

Instead of pumping the low level sewage by power derived from the fall of high level sewage, water from a nearby stream or city main may be used instead. Fig. 10 shows a sewage lift wherein the power is derived from damming a small stream and Fig. 11 shows a water power lift operating on city water.

PLASTIC FIRE BRICKS.

Boiler-door arches and furnace linings in one solid piece are now said to be practicable, owing to an invention of plastic fire brick by the late Lester Betson. The brick is pounded into the shape desired. It is quite stiff, and will remain as placed, it is said, without the use of forms or molds, except for a simple temporary support in a door-opening or under an arch. It is then set by means of a slow fire in a short time. When it becomes very hard it may be put to immediate use.

It is claimed that the bricks are neutralized for expansion and contraction, so that they are not cracked or otherwise affected by sudden changes of temperature. Clinkers do not readily adhere to the surface, which is smooth and unbroken. As it fills all crevices, it should be gas and air-tight. The brick is being introduced into Canada by the Inland Sales Company, Limited, of Winnipeg.

The International Engineering Works, Limited, of Amherst, N.S., Canada, have recently opened three new offices in addition to their regular offices at Montreal, Toronto, etc. These representatives are George M. Taylor, 816 Burrards Street, Vancouver, B.C.; J. F. Tracey, 321 Edmonton Street, Winnipeg, Man., and Grodwards Company, Cobalt, Ont.

The experiments of British railway companies which are considering the adoption of wireless telegrapry for railway signalling, marks a new departure in the progress of wireless and in the advance of railway science. The Midland, and the London and Southwestern railway companies have experimented with the Prentice automatic system, a Canadian invention, based upon co-operation between electrical and mechanical devices on a traction engine. (See *The Canadian Engineer* for Sept. 18th, page 470.) The London and Southwestern has laid a high frequency wave wire on the centre track and a series of insulated wires beneath a locomotive to receive radiant energy worked from these.

A green light in the engine cab indicates that the line is clear, and when the section ahead is not clear a red light shows. An audible warning is given and the brakes are applied automatically. The Midland Railway is using an improved pattern of the Railophore system employed on German state railways, rendering the passing of set danger signals impossible. Four distinct signals in the engine cab are followed by automatic brake application.

COAST TO COAST.

Vancouver, B.C.—Plans are being prepared for $5,000,000 worth of new civic work in Vancouver for next year.

Moose Jaw, Sask.—Reliable authority is given for the announcement that a union station is assured for Moose Jaw, though its situation is yet undecided.

Vancouver, B.C.—The Trout Creek bridge, the highest railway trestle bridge in British Columbia, is now completed for traffic. It has been erected at a cost of $11,000, is about 250 feet high and almost of the same length.

Yorkton, Sask.—The C.N.R. has called off its men from further grading work at Yorkton, and the grade from Wroxton is almost completed, though there is no certainty as to the time when steel will have been laid to this centre.

Ottawa, Ont.—Expenditures by the Public Works Department last year aggregated $18,844,223, according to the annual report, now being issued. Of this amount, $10,177,831 was spent on harbors, including dredging, and $7,420,885 on public buildings.

Brantford, Ont.—The present source of supply for gas to Brantford is far from sufficient, and complaints are general in the city about the low pressure of gas. To relieve the situation, work on the trunk line from Tilbury field, which will supply St. Thomas, London, and Woodstock, is being rushed to completion, and it is expected that Brantford will be connected in January.

Victoria, B.C.—Work costing in the neighborhood of $30,000 has been completed on the roadbed of the Victoria and Sidney Railway. The roadbed has been re-ballasted practically from Victoria to its terminal at Sidney, the bridges have been rebuilt, and a new gasoline-electric car has been introduced which is giving satisfaction. The result is that the public are now furnished with a really first-class suburban service.

Selkirk, Man.—Many citizens were present on November 2nd to witness the turning on by Mayor Ross, of Selkirk, of the switch that put in motion the motors of the first large power installation of the Selkirk municipal electric light and power department, e.g., the planing mill, box and grain door factory of the Wm. Robinson Company. The municipality is selling its power at the 3 cent rate, with further reduction for large consumption.

Fort William, Ont.—The C.P.R. rocker bridge across the McKellar River between Islands One and Two at Fort William, has been completed and will be used to carry trains to the new $2,000,000 coal dock and to the new freight docks. The bridge has been erected at a cost of $200,000, will carry double railway tracks, and may be used to serve for extensions of the street railway to island terminals.

Montreal, Que.—Last spring low-lying river banks covered with mud and snow outlined the shore stretching from the Black Diamond line wharf past Sohmer Park to the foot of Papineau Avenue. Now along this section of shore has been constructed a rampart of new wharfage, the wharf from the Black Diamond line shed sloping up to a level with the high wharves approached from Commissioners Street; and from behind this rampart comes the sound of the rush of work on the foundations of the steel sheds, which will be erected doubtless on the new wharves next season.

Moncton, N.B.—The condition of Moncton streets has been the cause of much local dissatisfaction and criticism. The city has used for paving purposes wooden blocks, slag, and macadam; but the results have been unsatisfactory. This is partly due to the difficulties a new city always experiences in paving operations; for streets are being continually dug up for sewerage, gas, water, and other installations. Moncton has almost settled the question of good sidewalks; and the citizens are now feeling that the authorities should direct their efforts towards an efficient system of street paving.

Cornwall, Ont.—The contractor, Mr. G. R. Phillips, of Cornwall, has completed the new pier at the eastern entrance to the Cornwall Canal. The work has been going on for the past year and a half. The pier is 600 feet long, and the style of construction conforms with the usual style of such structures. The entrance has also been widened and will relieve the congestion of craft frequent at the foot of the canal. A pier somewhat similar was erected about two years ago above lock 17, and with the addition of this new pier, navigation at the eastern end of the Cornwall Canal will be rendered much more safe.

Victoria, B.C.—Of the four piers to be constructed near the Ogden Point breakwater, three are to be 800 feet in length, and one 1,000 feet. They will be capable of accommodating the largest vessels that will be used in the Pacific trade for many years to come. Three thousand and four hundred feet of dockage, which will be provided by the piers for which tenders have been invited, will be doubled when all four piers have been completed. The importance of this work to the local cities and to the province is magnified by the fact that all material to be used in the construction, stone and concrete, will be of local manufacture.

Grand Falls, N.B.—The installation of a modern electric light system has been completed at Grand Falls. When the light was turned on for the first time, out of 400 lamps, only one was found to be out of commission. In addition to the street lamps, many churches, public buildings and private have been lighted by the same system; and the town has erected a large concrete sub-station, and is employing an electric pump for the waterworks system, instead of steam pump, which was not sufficiently powerful. The power is being supplied by the Maine and New Brunswick Electrical Power Company, Limited, whose power-house is situated at Arooscook Falls.

Halifax, N.S.—At Halifax, a pier is being constructed which, when complete, will be the most modernly equipped for accommodating oceanic travel in the world. The work requires 1,818 concrete piers, the largest ever used for a like purpose; and these are being driven into the harbor bottom by the biggest pile-driver in the world. The whole pier will be 700 feet long by 235 feet wide, provided with the best possible railway accommodation; and the superstructure will be a two-story fireproof immigration building of solid concrete, 200 feet wide, and almost as long as the pier. When finished, Halifax will possess the most excellent of immigration facilities.

South Vancouver, B.C.—Plans for local improvements for South Vancouver, now before the Municipal Council, will when carried out make that city one of the most modern municipalities in the Dominion. By-laws for the construction of a municipal electric light and power plant and a municipal gas plant have been taken up and given readings. They are now awaiting the approval of the ratepayers. Petitions asking the council to refer the by-laws to the property-owners for a vote at the time of the municipal elections or sooner are being circulated and largely signed. If these petitions are signed by ten per cent. of the voters, the by-laws will be referred to the ratepayers in due course, and if they are passed steps will be taken at once to begin the construction of the plants.

Port Alberni, B.C.—The city of Port Alberni, the new city at the head of the Alberni Canal, now possesses in its new $120,000 waterworks system, one of the finest supplies of water in the Province, equal in clearness and purity, it is said, to the celebrated Capilano brand. The supply is brought from a dam at an elevation of 614 feet, situated seven miles from the city, and which collects the water as it comes falling over the rocks from its glacial source above the Golden Eagle basin. The retaining wall, which is a solid, massive piece of work, is constructed of huge, cribbed logs, filled in between with rocks. The building of this wall was a long, costly operation, as owing to floods the work was arduous, and delay was occasioned by the half-built wall being swept away when a sudden flood, caused by heavy rains, undid in a night the labor of weeks. The wall was built up again and is substantial enough to resist any pressure that can be brought to bear upon it. The water enters the intake pipe through the latest system of cleaning and screening chambers, which collect all small debris which would have a tendency to enter the pipe. Five miles of 16-inch continuous wood stave pipe, discharging three and a half million gallons a day, and capable of providing for 25,000 people, convey the water to the city limits, after which 10 and 12-inch steel pipes are used through the main streets, smaller wire-wound pipe, tapping the mains, being used for laterals. The average pressure on the mains is 70 pounds to the square inch, thus allowing a good head for fire-fighting purposes.

PERSONAL.

STANLEY M. OBORN, A. M. Can. Soc. C.E., A. M. Inst. C.E., has resigned from the Toronto City Engineer's office and has begun practice as a consulting civil engineer and architect.

SIR ALEXANDER BINNIE, whose recommendations Ottawa is acting upon in connection with her water supply, has been asked by the city to assume the duties of chief engineer of the accepted Thirty-one Mile Lake proposal.

CHAS. MURPHY, general superintendent of the Canadian Pacific Railway Company, at Winnipeg, and formerly general master of transportation, and local superintendent at Toronto, will likely accept an appointment to the Dominion Railway Commission, to begin duties January 1st, 1914.

W. G. MILLER, Provincial Geologist and Inspector of Mines for Ontario, was entertained by a dinner in his honor at the Toronto Club recently, in recognition of his scientific accomplishments and the public service he is rendering to Canada in connection with his administration of Provincial duties respecting geology and mining.

J. G. McMILLAN, B.A. Sc., has been appointed Inspector of Mines for the Cobalt district, succeeding T. F. SUTHERLAND, who, as reported in our issue of June 26th, 1913, became Chief Inspector of Mines for Ontario on July 1st, succeeding E. T. CORKILL. Mr. McMillan returned recently from Hudson Bay, where he conducted harbor surveys for the Dominion Government. He is a graduate in mining of the University of Toronto.

OBITUARY.

The death occurred, recently, of Sir William Henry Preese, known in England as the "father of wireless telegraphy." He was in his 80th year. Sir William introduced both the telephone and talking machine into England and was the inventor of many patents connected with the telegraph and telephone. For several years he was engineer-in-chief and electrician to the British Post Office and was at one time president of the Institute of Civil Engineers.

The death is also reported of Alfred Russel Wallace, one of the leading British scientists, in his 91st year. During his life he made unusually large and valuable contributions to natural science and economics, and travelled in every part of the world in pursuit of his studies. He was a prominent authority on the land question and a strong advocate of land nationalization.

CANADIAN SOCIETY OF CIVIL ENGINEERS, OTTAWA BRANCH.

Mr. G. R. G. Conway, chief engineer of the British Columbia Electric Railway, addressed the Ottawa Branch recently, on the construction of the Coquitlam Dam. This work, which has just been completed, is of special interest to engineers from the fact that in the construction hydraulic process was used. By this process streams of water under great pressure are turned on the hillsides, washing out the stones, clay, etc., which flow through flumes to the place where the dam is under construction. This continual falling builds up the dam which is packed solid by the great weight of water coming over the falls into it. The water in this particular lake has been raised about 60 feet.

This work proved to be exceedingly expensive, as the water supply for New Westminster comes from the same lake, and for this fact the land which was to be flooded by the raising of the water had to be cleared of all vegetable matter that might contain microbes. The total cost of clearing the land was about $666,000. This was of particular interest to Ottawa engineers, because in raising the level of Thirty-One Mile Lake the ground to be flooded must also be cleared of all vegetable matter.

COMING MEETINGS.

UNITED STATES GOOD ROADS ASSOCIATION.—Convention will be held at St. Louis, Mo., November 10th to 15th. Secretary, J. A. Rountree, L021 Brown-Marx Building, Birmingham, Ala.

NATIONAL MUNICIPAL LEAGUE.—Annual Meeting will be held in Toronto, November 12th to 15th. Secretary, C. R. Woodruff, 705 North American Building, Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.—Forty-seventh Annual Convention, to be held in New Orleans, La., December 2nd, 3rd and 4th.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.—Annual Meeting will be held in New York, December 2nd to 5th. Secretary, W. H. Reed, 154 Nassau Street, New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The Annual Meeting will be held in New York, December 2nd to 5th, 1913.

AMERICAN ROAD BUILDERS' ASSOCIATION.—Tenth Annual Convention to be held in First Regiment Armory Building, Philadelphia, Pa., December 9th to 12th. Secretary, E. L. Powers, 150 Nassau Street, New York, N.Y.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.—Annual Meeting to be held in New York, December 10th to 13th. Secretary, C. D. Odsen, Polytechnic Institute, Brooklyn, N.Y.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.—Seventh Annual Convention will be held at Great Northern Hotel, Chicago, December 29th to 31st. Secretary, I. W. Dickerson, Urbana, Ill.

AMERICAN CONCRETE INSTITUTE.—Tenth Annual Convention to be held in Chicago, February 16th to 20th, 1914. Secretary, E. E. Krauss, Harrison Building, Philadelphia, Pa.

ORDERS OF THE RAILWAY COMMISSIONERS OF CANADA

Each week on this page may be found summaries of orders passed by the Board of Railway Commissioners, to date. This will facilitate ready reference and easy filing. Copies of these orders may be secured from *The Canadian Engineer* for small fee.

20684—October 31—Authorizing C.N.O.R. to connect, temporarily, with G.T.R. near town of Pembroke, Ont.: Provided Co. (C.N.O.R.) bear and pay all expenses incurred in construction, maintenance and removal of said connection.

20685—November 3—Approving general plan showing crossing of G.T.R., and Muskrat River, and detail plans of substructure of proposed bridge.

20686—October 27—Refusing application of Port Hammond and District Improvement Association, Port Hammond, B.C., for order requiring C.P.R. to put into effect same or similar week-end fares from Port Hammond to coast cities as now in effect from Vancouver to Port Hammond.

20687—October 27—Authorizing Esquimalt and Nanaimo Ry. to cross track of Wellington Colliery Co., Limited, or Canadian Collieries (Dunsmuir), Limited at or near Trent River Ry. Co., construct safety switch at or near station 290 on line of Wellington Colliery Co., Limited, and station flag man at said crossing for purpose of flagging all trains over same. And directing each of said Cos. bear and pay half cost and expense of constructing and maintaining said crossing, and half cost and expense of constructing, maintaining and operating safety switch, and wages of said watchman.

20688—October 27—Authorizing Wellington Colliery Ry. Co., to cross Esquimalt and Nanaimo Ry. at mile 5.924, subject to certain conditions.

20689—October 30—Establishing collection and delivery limits of Canadian and Dominion Express Cos., in city of Owen Sound, Ont.

20690—October 29—Authorizing C.P.R. to construct spurs for Fort William Starch Co., Limited, Toronto, Ont., from a point on easterly limit of right of way of main line, Man. Div., in Lots 6 and 7, Con. D., Island No. 2, Fort William, Ont.

20691—October 29—Authorizing, pending installation half-interlocking plant, C.P.R. to operate trains over branch line, crossing C.N.R. adjoining Neebing Avenue, Fort William, subject to certain conditions.

20692—October 29—Authorizing C.P.R. to construct spur for Rutley Lumber Co., Limited, Regina, Sask.

20693—October 27—Approving location C.P.R. station at Oakshela, in N.W. ¼, Sec. 34-16-6, W. 2 M., at mileage 8.0 on Co.'s main line, Moose Jaw Subdivision.

20694—November 3—Authorizing C.P.R. to construct, subject to terms of proposed agreement, temporary spur for Carter Halls-Aldinger Co., Limited, Winnipeg, Man.

20695—October 30—Authorizing C.P.R. to open for traffic portion of double track from mileage 25.5 to 28.0, Broadview Subdivision, a distance of 2.5 miles.

20696—October 28—Authorizing C.P.R. to construct sidings for the Toronto Structural Steel Co., Limited, Toronto, Ont., from a point on existing siding track, within limits of right of way of Ry. Co., in Lot 8, Con. 5, Tp. York, in northwesterly direction across Oak Street, town of Weston, into premises of said Steel Co., in Lot 9, Con. 5, Tp. York, Co. York, Ont., at mileage 4.46, Ont. Division.

20697—October 30—Amending Order No. 19127, dated April 25th, 1913, to provide that authority to construct sidings and cross Gilkinson Street, Hamilton, Ont., granted under said order, be subject to certain conditions. That consent of city to said crossing be not taken as in any way prejudicing its position when question of grade separation arises. That time for construction and completion of work, limited by Order No. 19127, as amended by Order No. 19312, dated May 19, 1913, be extended for three months from date of this order.

20698—October 30—Extending, for a period of ninety (90) days from date of this order, time within which G.T.R. complete siding and spurs therefrom into premises of Toronto Structural Steel Co., Limited, on Lot 9, Con. 5, Tp. York.

20699—October 31—Approving plans and specifications of Bogart Drain, where same crosses G.T.R. on N. ½, Lot 9, Con. 4, Tp. of Elgin, Ontario.

20700—October 31—Approving station site and station of G.T.P. Ry. at Tyee, mileage 26.5, Prince Rupert East, in Lot 27, Rge. 5, Coast District, B.C.

20701—October 31—Amending Order No. 19215, dated May 6th, 1913, by adding clause "2" to provide for cost of maintaining subway over Thompson Road, Tp. Bertie, Co. Welland, Ont., as follows:—15 per cent. by Pere Marquette R.R. Co., 47½ per cent. by G.T.R., 30 per cent. by M.C.R., and 7½ per cent. by Tp. of Bertie.

20702—October 31—Authorizing G.T.R. to construct siding into premises of Gidley Boat Co., town of Penetanguishene, Ont.

20703—October 30—Amending Order No. 19759, dated July 4th, 1913, by striking out Sec. 2 and substituting therefor following:—"That consent of city to crossing be not taken as in any way prejudicing its position when question of grade separation, or any further protection that may be required at crossing, arises."

20704—October 30—Amending Order No. 19764, dated July 4th, 1913, by striking out Sec. 2 and substituting following:—"That consent of city to said crossing be not taken as in any way prejudicing its position when question of grade separation, or any further protection that may be required at crossing, arises."

20705—November 3—Approving location C.N.R. third-class station at Bengough, Sask.

20706—October 31—Approving revised location C.N.R. Greenway Branch through Secs. 2 and 3, Tp. 3, Rge. 23, W.P.M., Man., from mileage 78.95 to mileage 80.21.

20707—October 31—Approving location C.N.O.R. station grounds at Deseronto, Tp. Tyendinaga, Co. Hastings, Ont., at mileage 134 from East Don.

20708—October 31—Authorizing M.C.R.R. to construct siding, or coke track, into premises of the American Cyanamid Co., in Tp. Stamford, Co. Welland, Ont. And approving and authorizing clearances as shown on said plan. Ry. Co. to construct and complete said siding within three months from date of this order.

20709—November 3—Authorizing C.P.R. to construct spur from Haley's Station, Ont., into premises of Renfrew White Granite Co.

20710—November 4—Authorizing C.P.R. to construct spur into premises of McCormack Manufacturing Co., Limited, in Lot 9, Con. 1, Tp. London, Co. Middlesex, Ontario.

20711—October 28—Authorizing T., H. & B. Ry. to construct spur, with two branch lines or offsets therefrom, in city of Hamilton, Ont., to serve Canadian Westinghouse Co., Limited, subject to and upon certain conditions.

20712—November 3—Approving locations of C.N.O.R. station grounds, namely—At Alice, mileage 96.65 from Ottawa, and at Hiam, mileage 91.6 from Ottawa, Tp. Alice, Co. Renfrew.

20713—October 28—Authorizing C.N.R. to construct across eleven (11) highways on its Alsask Southeasterly Line, Sask.

20714—October 28—Approving C.N.R. location of Station at Chandler, Saskatchewan.

20715—November 4—Authorizing C.N.R. to construct across five (5) highways on its Calgary-Macleod Branch, Prov. Alta.

20716—November 3—Authorizing C.N.O.R. to take, for purpose of carrying out diversion approved by Order No.

19871, dated July 22nd, 1913, portion of Lot 22, Con. 9, Tp. Fitzroy, Co. Carleton, Ont., property of S. Reid, Learmouth.

20717—October 30—Approving revised location C.N.R. Maryfield Branch through Tps. 5 and 6, and Rgs. 25 to 29, W. 2 M., Sask., from mileage 194.82 to 224.58.

20718—November 3—Amending Order No. 20469, dated October 1st, 1913, by striking out words, "and no objection to the granting of the application having been filed by city of Winnipeg, although duly notified as appears by affidavit of service of notice of the application, filed," and substituting therefor words following, in recital to said Order, namely: "and reading the objection on behalf of the city of Winnipeg, filed."

20719—October 28—Approving location C.P.R. station at Outram, **Sask.**

20720—November 4—Authorizing, subject to terms and conditions contained in agreement, with exception of provision that spur be moved on demand of Municipality, C.N.R. to construct spur for P. Hrynczuk from a point on Oak Point Branch, near Roy (Pacific) Ave., Rural Mun. Rosser, across said Avenue and through Lots 26, 58 and 59, Block 8, Plan No. 774, property of P. Hrynczuk, to Ross Ave., Mun. Rosser, Man.

20721—November 3—Extending, until December 1st, 1913, time within which C.P.R. complete work of diverting Nine Mile Road, in Lots 6 and 7, Con. 9, Tp. South Gower, Co. Grenville, Ont.

20722—November 4—Authorizing C.P.R. to construct extension to existing siding for W. Booth Lumber Co., Limited, Toronto, Ont., on land lying westerly of right-of-way of Company's main line, Ont. Div., and northerly of road allowance between Cons. 1 and 2, Etobicoke, Ont.. at West Mimico.

20723—November 4—Authorizing C.P.R. to construct spur for Steel Equipment Co., Limited, Ottawa, Ont., on part Lot 17, Town of Pembroke, Ont., at mileage 106.52 from Ottawa.

20724—November 4—Authorizing C.P.R. to open for traffic portion of its double track from Ernfold to mileage 70.0 on Swift Current Subdivision, Sask.

20725—October 29—Authorizing, subject to terms and conditions of resolution, C.P.R. to construct new double-track bridge at Napier St., Iberville, Que., mileage 19.5, Farnham Subdivision.

20726—November 4—Authorizing C.P.R. to construct, by means of grade crossing, two extra tracks across Deveber Ave., Mun. of Taber, Alta.

20727—November 4—Authorizing C.P.R. to construct Bridge No. 35.92, White River Sub. Div., Lake Superior Div., near Goldie, Ontario.

20728—October 29—Authorizing C.P.R. to construct Bridge No. 0.32 at Lorne St., city of Kamloops, B.C.

20729—October 29—Authorizing C.P.R. to construct, by means of grade crossings, its ballast pit spur across highways from mileage 0 to 3.05 of said ballast pit spur, at mileage 3 from Bassano, on Bassano Easterly Branch.

20730—October 29—Authorizing C.P.R. to construct, by means of grade crossing, its ballast pit spur aross highway between Sec. 19-6-11, and Sec. 24-6-12, W. 4 M. on Weyburn-Sterling Branch.

20731—October 28—Approving location C.P.R. station at Mara, B.C., in N.E. ¼ Sec. 8-20-8, W. 6 M.

20732—October 28—Authorizing, subject to terms of proposed agreement, Canadian Bridge Co., Limited, to construct foot-bridge and grade crossing over Pere Marquette R.R. at Walkerville.

20733—October 27—Authorizing C.P.R. to construct, at grade, extension to passing track across Boundary St., Didsbury, Alta.

20734—November 3—Authorizing C.P.R. to construct road diversion in Sec. 4-23-27, W. 3 M., Sask., on Swift Current Northwesterly Branch. To construct, by means of grade crossing, its Swift Current Northwesterly Branch Line across said diversion, at mileage 96.3 on said branch line from Swift Current.

20735—October 27—Authorizing V.V & E. Ry. & Nav. Co., and C.P.R. to operate their trains over crossing at Burrard Inlet, city of Vancouver, B.C., without their being brought to a stop.

20736—October 29—Authorizing Montreal Light, Heat and Power Co. to lay concrete water tunnel under C.P.R. in Municipality of Ville LaSalle, Que., on south side of Lachine Canal, opposite to Lot No. 1021.

20737—October 30—Authorizing G.T.P. Branch Lines Co. to construct spur for Union Coal Co., Limited, in Sec. 36-31-24, W. 4 M., Alta.

20738—October 29—Authorizing G.T.P. Ry. to construct spur turning out from its main line on 21st St. into Block 12, Inglewood Subdivision, city of Edmonton, Alta.; crossing of Brazeau Avenue, to be constructed in accordance with "Regulations."

20739—November 4—Directing that rating of 4th class provided in Canadian Freight Classification for blaugas and Carbonic Acid Gas be provided, also for oxygen and Acetylene gases in carloads. 2. Refusing application for a reduced less than carload rating of Oxygen gas.

20740—October 28—Authorizing C.P.R. to construct, subject to terms and conditions contained in agreement, by means of a bridge four tracks on its main line, Alta. Div., Lethbridge Sub. Div., over and across Westminster Road, Lethbridge, Alta.

20741—November 5—Authorizing C.N.R. to construct Bienfait-Estevan Branch over a coal mine, situated in S. ½, Sec. 19-2-6, W. 3 M., Saskatchewan.

20742—November 6—Directing that Pere Marquette R.R. Co., at its own expense, employ and maintain a watchman at crossing of highway 1¾ miles west of Kingsville, Ont., pending installation of bell at said crossing.

20743—November 5—Relieving North Shore line of C.P.R., from providing further protection at crossing of first public highway west of the west switch at Little St. Martin, Que.

20744—October 9—Relieving G.T.R. from providing further protection at crossing of public road one mile east of Wyoming, Ont.

20745—November 5—Approving locations C.P.R. stations at Tribune and Bromhead on Estevan-Forward Branch, Saskatchewan.

20746—November 6—Approving location C.P.R. station at Westerham, in S.E. ¼, Sec. 34-22-27, W. 3 M., Swift Current Northwesterly Branch, Province of Saskatchewan.

20747—November 5—Extending, until December 31st, 1913, time within which C.P.R. install electric bell, required under Order No. 20017, dated August 11th, 1913, at crossing of Main Street, village of Shelburne, Ontario.

20748—November 6—Authorizing C.P.R. and Quebec, Montreal and Southern Ry. Cos., to operate their trains over crossing at mileage 18.81 from Farnham, Que., without their first being brought to a stop.

20749—November 6—Extending, until November 30th, 1913, time within which C.P.R. install gates at crossing of Centre Street, Chatham, Ont., required under Order No. 19051, dated April 14, 1913.

20750—November 6—Authorizing C.P.R. to open for traffic portion of its Weyburn-Stirling Branch from mileage 0 to 49.2, east of Stirling, Alberta: Provided speed of trains be limited to a rate not exceeding 25 miles an hour.

20751—November 6—Authorizing C.P.R. to operate bridge crossing St. Lawrence River at mileage 41.9, Farnham Subdivision.

20752—November 6—Authorizing C.N.R. to construct across eleven (11) highways on its Alsask Southeasterly line, Sask.

20753—November 6—Authorizing C.P.R. to construct, for Godson Contracting Co., Limited, an extension to existing track and a passing siding track in Lot No. 16, Con. 10. Tp. Darlington, at mileage 53.43 on Ry. Co.'s main line, Ontario Division, Toronto Subdivision.

20754—November 7—Authorizing C.P.R. to construct Bridge No. 9.17 on Nipigon Subdivision, over Maggot River, Ont.; and rescinding Order No. 20084, dated August 18th, 1913, in so far as it authorizes construction of said bridge.

20755—November 6—Authorizing C.P.R. to construct spur for Kettle River Co., Minneapolis, Minn., from a point on existing spur in N.E. ¼, Sec. 8-11-4, E.P.M. at North Transcona, Manitoba.

20756—November 6—Authorizing G.T.R. to construct siding into premises of the Canada Stove and Furniture Co. on Lot 409-342, 259, 250, 264, parish St. Laurent, Quebec.

20757—November 6—Authorizing Galbraith and Sons, to construct tramlogging road under V.V and E.R. and Nav. Co.'s trestle bridge, No. 73, near Lincoln, B.C.