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SURGE TANK PROBLEMS

AN INVESTIGATION OF SURGE TANK REGULATION DETERMINING BY GRAPHICAL AND ANALYTICAL METHODS PROPER SOLUTIONS OF PROBLEMS CREATED BY LONG PIPE LINES.

By **PROF. FRANZ PRASIL,**

Authorized Translation by E. R. Weinmann and D. R. Cooper, Hydraulic Engineers, New York City.

PART I.

IN case the main conduit leading to a turbine is comparatively long, beginning at the intake on a comparatively light slope (canal, tunnel or low-pressure pipe) and concluding in a short steep slope leading directly to the turbines, (high-pressure pipe or penstock), it is common practice to construct at the junction an open tank, called the surge tank, by which the main conduit is separated into two parts, in which with a constant discharge of the turbines the flow in the conduit is constant, and with a variable turbine discharge a variable conduit flow results. In the first case, the water surface in the surge tank is lower than the water surface at the intake by an amount dependent upon the flow in the low-pressure pipe. This difference of head is determined by the friction head in the main conduit. In an increment of time just as much water flows into the surge tank as flows out of it through the penstocks to the turbines.

In the second case, the inertia of the moving mass in the main conduit prevents this equality of inflow and outflow. The water surface in the surge tank has variable heights, that is, it rises or falls above and below the elevation due to the steady flow. The extent of this fluctuation of the water surface depends upon the dimensions of the main conduit, the amount of flow, and also on the size and form of the surge tank. In this case, if an overflow or an excessive lowering or too large fluctuations of the water surface are to be prevented, the surge tank must be dimensioned according to the area and length of the main conduit and according to the inflow and outflow. In this article the problems leading to the determination of the dimensions will be discussed, and the methods, partly analytical and partly graphical, involved in the solution of these problems, will be developed upon the assumption that the main conduit from the intake to the surge tank consists of a pipe or tunnel running full under pressure.

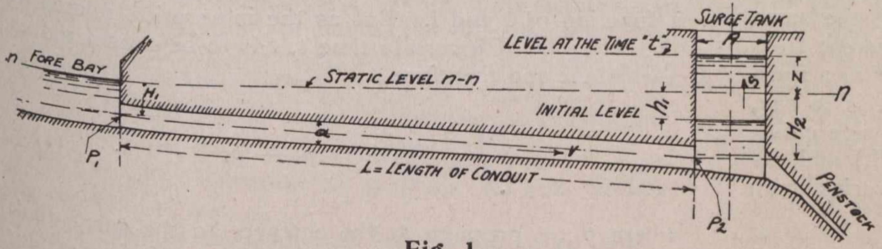

Fig. 1.

I. Introduction.

The investigation is developed (see Fig. 1) under the following additional assumptions:

(1) The intake is provided with a spillway whose dimensions are such that the elevation $n-n$ in the forebay may be considered as constant during the period under investigation.

(2) The sectional area of the main conduit is constant.

(3) The volume of the conduit, compared to the volume of the surge tank and compared to that part of the volume of the forebay which is affected, is so large that the influence of both of these masses of water toward decreasing the flow may be neglected.

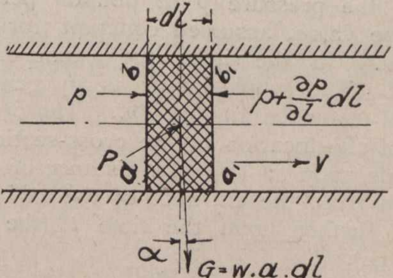

Fig. 2.

(4) Elastic and temperature conditions are neglected.

In the derivations of the formulæ, the following abbreviations are used:

L = Length of main conduit in feet.

a = Sectional area of main conduit in square feet.

p = Wetted perimeter of main conduit in feet.

v = Velocity of water in main conduit in feet per second at the time "t".

v_1 = Normal velocity of water in the main conduit in feet per second, during the period of steady flow.

v_2 = Initial velocity in the main conduit in feet per second, at the time $t = o$.

(v, v_1 and v_2 are average values and are assumed as constant throughout the entire length of the main conduit).

H_1 = Vertical distance from the water surface $n-n$ in the forebay to the centre of gravity of the entrance to the main conduit.

H_2 = Vertical distance from the water surface $n-n$ in the forebay to the centre of gravity of the entrance to the surge tank.

Q, Q_1, Q_2 = Volumes of water, corresponding to time t, the time during steady flow, and for time $t = o$ (beginning).

h, h_1 and h_2 = Friction heads corresponding to the pipe dimensions and velocities v, v_1 and v_2.

z = Vertical distance from the elevation $n-n$, of the water surface in the surge tank at the time t, taken positive above $n-n$ and negative below $n-n$.

A = Sectional area of surge tank in square feet for the elevation determined by z, so that in general A is a function of z.

s = Velocity of the water surface elevation in the surge tank, positive when rising, negative when falling, as an average value assumed constant in the section A.

q = Volume of discharge through the penstock at the time t, in cubic feet per second.

$c = \frac{q}{A}$ = the discharge velocity of the volume q, in feet per second, with respect to A.

More notations will be introduced during the course of the investigations.

II. Derivation of Principal Equations.—Referring to Fig. 2, the distance between two adjacent cross-sections of the main conduit $= dl$, and therefore $\frac{w.a.dl}{g}$ = mass of the water between the two sections (w = weight of cubic unit of water, g = acceleration due to gravity).

At the left side cross-section at the time t, there exists the pressure p in pounds per square foot, an average value, assumed constant for the entire cross-section. In the right, the pressure is p' at the same time t. The whole of p' is in general different from that of p, by the amount dp. The pressure p is a function of the location of the cross-section, that is to say, depends upon l; (l = the distance of the left side cross-section from the entrance of the main conduit) and depends further upon the time t (the flow varies with the time).

$$dp = \frac{\delta p}{\delta l} dl + \frac{\delta p}{\delta t}.dt \quad - \quad - \quad (1)$$

Since p and p' occur at the same time, p' is different from p by the difference due to the distance between the cross-sections, and therefore in the foregoing formula the differential dt of the time $= o$. Therefore, $dp = \frac{\delta p}{\delta l}.dl$ (2). The following forces act upon an element of unit mass, in the direction of flow, that is, in the direction of v:

1st. The weight component $P_1 = w.a.dl \sin\alpha$ (3) where α = the inclination of the axis of the main conduit from the horizontal, $dl.\sin\alpha = dH$ = vertical distance between the centres of gravity of the sections $a\,b$ and $a_1\,b_1$.

$$P_1 = w.a.dH \quad - \quad - \quad (4)$$

2nd. The difference between the reactions due to the pressure p and $p + \frac{\delta p}{\delta l}.dl$ which is

$$P_2 = p.a - (p + \frac{\delta p}{\delta l}.dl)\,a = -a\frac{\delta p}{\delta l}dl \quad - \quad (5)$$

Contrary to the direction of motion the friction exerts a force. Let K be the amount of the friction in terms of the velocity v and we get $P = -wa.dl.K$ (6) where K represents a pure number with respect to its dimension.

According to the general fundamental law: mass × acceleration = acting force, it results (as $\frac{dv}{dt}$ is the acceleration with respect to the velocity v at the time t) that,

$$m.\frac{dv}{dt} = P_1 + P_2 - P \quad - \quad - \quad - \quad (7)$$

$$\frac{w.a.dl}{g} = w.a.dH - a\frac{\delta p}{\delta l}dl - w.a\,dl.K \quad (8)$$

$$\frac{dl}{g}.\frac{dv}{dt} = dH - \frac{1}{w}\frac{\delta p}{\delta l}dl - K\,dl \quad - \quad - \quad (9)$$

The velocity v has the same value at the time t in the whole length of the main conduit. The case is therefore the same for $\frac{dv}{dt}$ and K. Therefore, if we integrate between the limiting values $l = o$ and $l = L$ or $H = H_1$ and $H = H_2$ relative to a motion from the intake to the main conduit, we get the following:

$$\frac{L}{g}.\frac{dv}{dt} = H_2 - H_1 - \frac{1}{w}\int_0^L \frac{\delta p}{\delta l}dl - KL \quad (10)$$

In the integral $\int_0^L \frac{\delta p}{\delta l}.dl$, p is, as demonstrated, a function of t and l. But as the integration relates to the condition at a certain time t, t is to be considered as a constant and therefore

$$\int_0^L \frac{\delta p}{\delta l}dl = p_2 - p_1 \quad - \quad - \quad (11)$$

where p_2 = pressure at the entrance to the surge tank p_1 at the entrance to the main conduit, KL is nothing other than the friction head h for the entire main conduit at the time t. Now, we may say that

$$\frac{p_2}{w} = H_2 + z + \frac{p_0}{w};\quad \frac{p_1}{w} = H_1 + \frac{p_0}{w} \quad (12)$$

in which $\frac{p_0}{w}$ equals the water column equivalent to the atmospheric pressure, and the following equation results:

$$\frac{L}{g}.\frac{dv}{dt} + z + h = o \quad - \quad - \quad (13)$$

Having assumed a flow in the main conduit from the intake to the surge tank, we consider now the flow as reversed (from the surge tank to the intake) and keep the direction for the measurement of the length l the same, then we must consider that the friction now acts in the direction of an increase of l, contrary to the first instance. In this case we get the equation

$$\frac{L}{g}\frac{dv}{dt} + z - h = o \qquad (14)$$

For any case we may combine both equations into a fundamental formula:

$$\frac{L}{g} \cdot \frac{dv}{dt} + z \pm h = o \qquad (15)$$

in which the plus refers to the velocity from intake to surge tank and the minus sign for the reverse movement. If we now introduce for h a function, the value of which has the same sign as v, then the double sign may be dropped and the whole movement may be represented by the equation:

$$\frac{L}{g} \cdot \frac{dv}{dt} + z + h = o \qquad (16)$$

A second fundamental equation may be developed from the condition of continuous flow, that is to say, the volume of water which flows to the surge tank in the time element dt must be equal to the sum of the changes of volume in the surge tank and in the volume flowing out of the tank at the same time ∴

$$v.a.dt = s\,A\,dt + q.dt.$$

$$a.v = As + q = A(s + c) \qquad (17)$$

The questions which are of principal interest are:

1st. How is the movement of the water surface in the surge tank with regard to time affected by given dimensions of the main conduit and the surge tank and given conditions as to overflow?

2nd. What dimensions must the surge tank have to agree with given conditions as to the main conduit and outflow, in order that the fluctuation of water level does not exceed certain amounts, determined by local conditions? The following cases will be investigated:

(a) Sudden partial or entire cessation of the outflow.

(b) Sudden starting of the outflow.

(c) Gradual cessation, or starting, variable outflowing conditions; and

(d) Influence of a spillway built in the surge tank.

The formulæ will be developed in the first case for a constant sectional area of surge tank, and under the assumption that h is proportional to v, i.e., $h = n.v$.

It will be shown that it is possible to investigate all cases according to a uniform method, analytically and graphically, with the assistance of the well-known theory of damped and forced undulations. The inaccuracies which result because h is proportional to v^2 and the corrections which must be applied to the results of the first method will be shown in the final study. With the simplifying assumptions already mentioned, we get from equation (17)

$$v = \frac{A}{a}(s + c) \qquad \frac{dv}{dt} = \frac{A}{a}\left(\frac{ds}{dt} + \frac{dc}{dt}\right) \qquad (18)$$

This applied in equation (16) and the whole equation divided by

$$T^2 = \frac{L}{g} \cdot \frac{A}{a} \quad (19), \text{ we get } \frac{ds}{dt} + \frac{dc}{dt} + \frac{z}{T^2} + \frac{h}{T^2} =$$

$$\frac{ds}{dt} + \frac{n.A}{T^2.\,a} \cdot s + \frac{z}{T^2} + \frac{n\,A}{T^2 a} \cdot c + \frac{dc}{dt} = o \qquad (20)$$

If we introduce as an abbreviation:

$$T_o = \frac{T^2.\,a}{n\,.\,A} \qquad (21)$$

and consider that

$$s = \frac{dz}{dt} \qquad \frac{ds}{dt} = \frac{d^2z}{dt^2} \qquad (22)$$

then follows the principal equation:

$$\frac{d^2z}{dt^2} + \frac{1}{T_o} \cdot \frac{dz}{dt} + \frac{z}{T^2} + \frac{c}{T_o} + \frac{dc}{dt} = o \qquad (23)$$

$$\text{The values } n \text{ and } T = \sqrt{\frac{A\,L}{a.g}}$$

$$\text{and } T_o = \frac{T^2}{n} \cdot \frac{a}{A} = \frac{L}{n.g} \qquad (24)$$

are times with regard to their dimensions. Starting with this principal equation, we may investigate the different cases as follows:

III. Special Cases.

Case A.—Sudden Shut-down.

Preceding a shut-down, Q_1 cubic feet per second flows out of the surge tank. During the normal condition in the main conduit, the velocity $= v_1 = \frac{Q_1}{a}$ wherefore $q = Q_1$. The water surface in the surge tank is h_1 feet lower than the static level $n—n$. The time t is measured from the beginning of the shut-down, therefore from $t = o$, q becomes ϵq if ϵ is the proportion of the steady flow subsequent to the shut-down in relation to the flow preceding the shut-down.

After the sudden shut-down, the following phenomena occur in the surge tank: The water surface rises with variable velocity until it reaches a maximum height. When the highest elevation is reached, the reverse movement occurs. The velocity increases as the water level recedes, then decreases until the lowest level is reached, after which an ascending movement occurs but to a somewhat less height than before, and so on, until the normal conditions with the constant flow $\epsilon.Q_1$ become established. The movement of the water level belongs in the category of the damped oscillations.

(1) Analytical Investigation.—The formula (23) for this case, under the condition that

$$c = \frac{q}{A} = \frac{\epsilon\,Q_1}{A} = \epsilon\,c_1 = \text{a constant } \left(\frac{dc}{dt} = o\right) \qquad (25)$$

becomes

$$\frac{d^2z}{dt^2} + \frac{1}{T_o}\frac{dz}{dt} + \frac{z}{T^2} + \epsilon\frac{c_1}{T_o} = o \qquad (26)$$

Since $h_1 = n.v_1 = n\,c_1\,\frac{A}{a} = c_1\,\frac{T^2}{T_o}$, it follows that

$$\frac{\epsilon c_1}{T_0} = \frac{\epsilon h_1}{T^2} \qquad (27)$$

If we introduce $z = y - \epsilon h_1$, therefore $\frac{dz}{dt} = \frac{dy}{dt}$;

$$\frac{d^2z}{dt^2} = \frac{d^2y}{dt^2} \qquad (28)$$

from (26) follows a differential equation of the second order

$$\frac{d^2y}{dt^2} + \frac{1}{T_0} \cdot \frac{dy}{dt} + \frac{y}{T^2} = 0 \qquad (29)$$

This is a linear differential equation of the second order with constant coefficients. For the solution we say:

$$r^2 + \frac{1}{T_0} r + \frac{1}{T^2} = 0$$

The solution of this quadratic equation will give us the values of the differential equation:

$$r = -\frac{1}{2T_0} \pm \sqrt{\frac{1}{(2T_0)^2} - \frac{1}{T^2}}$$

We know that according to the theory of the linear differential equations three solutions may be found.

If the radical is positive or zero, the solution of the differential equation represents a non-periodical function, that is:

$$y = R_1 . e^{-\frac{t}{2T_0}} + R_2 t e^{-\frac{t}{2T_0}}$$

$$\text{if } \frac{1}{T_1^2} = \frac{1}{T^2} - \frac{1}{(2T_0)^2} = 0 \qquad (30a)$$

$$y = (R_1 e^{+\frac{t}{T_1}} + R_2 e^{-\frac{t}{T_1}}) e^{-\frac{t}{2T_0}}$$

$$\text{if } \frac{1}{T_1^2} = \frac{1}{T^2} - \frac{1}{(2T_0)^2} = \text{negative} \qquad (30b)$$

But,

$$y = R e^{-\frac{t}{2T_0}} . \sin(\beta + t/T_1)$$

$$\text{if } \frac{1}{T_1^2} = \frac{1}{T^2} - \frac{1}{(2T_0)^2} = \text{positive} \qquad (30c)$$

represents a damped harmonic.

These three conditions, due to the different values of the radical of the quadratic equation can be written also, substituting for T and T_0 the values of equations 24:

$\frac{1}{T_1^2}$ becomes zero if $T = 2T_0$ or $\frac{A}{a} = \frac{4L}{n^2 g}$ (31a)

$\frac{1}{T_1^2}$ becomes negative if $T > 2T_0$ or $\frac{A}{a} > \frac{4L}{n^2 g}$ (31b)

$\frac{1}{T_1^2}$ becomes positive if $T < 2T_0$ or $\frac{A}{a} < \frac{4L}{n^2 g}$ (31c)

As mentioned before, equations 30a and 30b, with the conditions of 31a and 31b, represent non-periodical function, that is:

Form 1 is the expression for a damped oscillation;

Forms 2 and 3 represent non-periodical movements, i.e., a transition from one quiescent level to another without any oscillations.

As will be seen later from an example, n has in most cases a value which lies between 2 and 1 seconds; therefore, the condition for a non-periodic water level fluctuation is:

$\frac{A}{a}$ is equal to or greater than $\frac{L}{35}$.

Now, for $L = x$ miles

A should be equal to or greater than $150 . x . a$.

This case may well occur when a pond is used as the surge tank. With artificially constructed surge tanks $\frac{A}{a}$ is considerably smaller; the following investigations are therefore limited to the first form of oscillations. As $z = y - \epsilon h_1$, equation (30) may be written

$$z = -\epsilon h_1 + R e^{-\frac{t}{2T_0}} \sin(\beta + t/T_1) \qquad (32)$$

and the differentiation with respect to t gives (since $\frac{dz}{dt} = s$)

$$s = R e^{-\frac{t}{2T_0}} \frac{1}{2T_0} \left\{ \frac{2T_0}{T_1} \cos(\beta + t/T_1) - \sin(\beta + t/T_1) \right\} \qquad (33)$$

If we substitute $tg\gamma = \frac{2T_0}{T_1}$ and consider that

$$\frac{1}{T_1} = \frac{1}{T^2} - \frac{1}{4T_0^2} \qquad (34)$$

we get:

$$s = \frac{R}{T} . e^{-\frac{t}{2T_0}} \sin(\gamma - \beta - t/T_1) \qquad (35)$$

and the integration constants R and β are determined from the initial conditions, i.e., from the location and the condition of movement of the water level in the surge tank at the time $t = 0$.

It will be noted from the description of the phenomena for that case that for the shut-down and in the very moment of it, the water surface is at the distance h_1 under the elevation $n - n$. Therefore, for $t = 0$, $z = z_0 = -h_1$. The initial value for $s = s_0$ at the time $t = 0$, must be assumed as

$$s_0 = \frac{Q_1 - \epsilon Q_1}{A} = (1 - \epsilon) c_1 \qquad (36)$$

This assumption does not only consider a sudden shut-down, but assumes also a sudden beginning of a uniformly distributed velocity in the water surface of surge tank. This assumption is true for the limiting cases because a short duration of the shut-down does not appreciably affect the results, as we shall see from the investigation of the influence of a shut-down of short duration. Here follow the equations for the determination of the integration constant when $t = o$:

$$R \sin \beta = -(1 - \epsilon)\, h_1 \qquad (37)$$

$$R \sin (\gamma - \beta) = +(1 - \epsilon)\, c_1 T \qquad (38)$$

The latter equation may be transformed to:

$$R \cos \beta = (1 - \epsilon)\left[\frac{T_0}{T^2} - \frac{1}{2\,T_0}\right] h_1 T_1 \qquad (39)$$

By introducing the values in the bracketed term, we find that this term is proportional to the difference

$$\left(\frac{a}{A} - \frac{n^2 g}{2\,L}\right) \qquad (40)$$

The difference is therefore positive if $\frac{A}{a}$ is less than $\frac{2\,L}{n^2 g}$, i.e., with the same assumptions for n and g as before:

$$A < 17.5 . x . a$$

This has influence on the determination of the value of β, as in the case mentioned $\sin \beta$ is negative and with $\frac{A}{a} < \frac{2\,L}{n^2 g}$ the $\cos \beta$ becomes positive, i.e., β must lie in the fourth quadrant. If $\frac{4\,L}{n^2 g} > \frac{A}{a} > \frac{2\,L}{n^2 g}$, the bracketed expression and $\therefore \cos \beta$ must be negative, β lies in the third quadrant. For the last formula, we may find for the determination of R and β the equations:

$$R = (1 - \epsilon)\, h_1 \frac{T_1 T_0}{T^2} \qquad (41)$$

$$tg\beta = -\frac{1}{T_0/T_1 - \frac{1}{4}\, T_1/T_0} \qquad (42)$$

41 is obtained by addition of the squared equations 37 and 39;

42 is the quotient of $\dfrac{\text{equation 37}}{\text{equation 39}}$

We see that the amount of shut-down has influence on the size of R, but not on the size of β. With respect to the occurrence of the movements (see equations 32 and 35) we find that the movement is a damped oscillation with a duration of δ secs $= 2\pi T_1$.

Maximum and minimum values of z or y occur when $\frac{dz}{dt} = o$.

This is the case when $\sin (\gamma - \beta - t/T_1) = o$. See Equation 35.

$$\frac{t}{T_1} = \gamma - \beta = \gamma - \beta + \pi = \gamma - \beta + 2\pi = \text{etc.} \qquad (43)$$

This value used for equation 32 gives the following maximum values:

$$z \max_1 = -\epsilon h_1 + Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta)} \sin \gamma$$

$$z \max_2 = -\epsilon h_1 + Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta + 2\pi)} \sin \gamma, \text{ etc.} \qquad (44)$$

and the following minimum values:

$$z \min_1 = -\epsilon h_1 - Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta + \pi)} \sin \gamma$$

$$z \min_2 = -\epsilon h_1 - Re^{-\frac{T_1}{2\,T_0}(\gamma - \beta + 3\pi)} \sin \gamma, \text{ etc.} \qquad (45)$$

Due to $z = y - \epsilon h_1$

$$\frac{y \max_2}{y \max_1} = \frac{y \max_3}{y \max_2} = \ldots\ldots\ldots$$

$$= e^{-\frac{T_1}{2\,T_0} . 2\pi} = \frac{y \min_2}{y \min_1} = \frac{y \min_3}{y \min_2} = \ldots . \qquad (46)$$

The amplitude of this oscillatory motion is decreasing.

If t = infin. z becomes $-\epsilon h_1$
s becomes zero

(To be continued.)

STRENGTHENING THE FORTH BRIDGE.

When the Forth Bridge was designed, 32 years ago, the loads and the train speeds calculated for were considerably in excess of those then assumed as probable for a long period, but the advance in these respects, particularly in the weight and power of locomotives and the loads behind them, has been enormous. Therefore, although the limits have not yet been reached so far as the strength of the bridge is concerned, the directors of the Forth Bridge Company have decided further to anticipate the developments of the locomotive engineer, and to reconstruct part of the flooring and troughs in which the railway track is laid over the bridge. It has been decided at once to proceed with a trial section, to be followed by a reconstruction from end to end of the bridge. The directors have arranged for the carrying out of the work by the original builders, Sir William Arrol and Co., Limited, Glasgow, and Messrs. Baker and Hurtzig will be the engineers, in association with the engineer-in-chief of the North British Railway Company, Mr. W. A. Fraser.

It is estimated that 2,500 tons of structural steel will be required for the renewal of troughs and floor from end to end of the bridge; of this total, the addition to the weight of the present steelwork of the bridge is only 750 tons. The work will take some years to execute, as operations can only be carried on during summer months, and it is proposed not to interfere with traffic on week-days, while even on Sundays one line only will be closed.

TIME OF SETTING CEMENT.

It was pointed out by Mr. S. M. Williams, in a paper read before the American Society for Testing Materials, that the factors accountable for the variable results obtained in the time of cement setting make a marked difference in the laboratory results. His paper summed up the results of considerable investigation throughout which the various influences were properly controlled and recognized. The following factors are enumerated as likely to cause errors of considerable magnitude.

1. Variation in the amount of work done on the material may cause a difference of more than two hours in the time of initial setting and cause a normal cement to appear quick setting;

2. Variation in atmospheric moisture or humidity of storage during the setting period may cause the inital time of setting to vary as much as two hours;

3. Variation in atmospheric heat or temperature of storage during the setting period may vary the time of setting as much as 1 or 2 hours.

The determination is also affected, to a less extent, by factors peculiar to the Vicat and Gillmore methods.

Throughout this series of determinations an attempt was made to keep all conditions uniform except the one whose effect was to be noted. In practice, the results obtained on two consecutive days may be affected by several factors which might combine to increase or decrease the range of values. For instance, a cool, damp day may be followed by a warmer day with a high relative humidity. The two factors on the first day both tend to retard the setting of the cement, while the high temperature of the second day, tending to shorten the time of setting, is opposed by the high humidity which reduces the amount of evaporation. To avoid the effects of these variables requires the use of a storage closet whose temperature and humidity can be controlled.

The variation in time of setting as determined by the same observer, thereby eliminating all errors due to personal equation introduced by several observers, is clearly shown, and indicates that neither method will give results consistent enough to justify the reporting of results within the limits of a few minutes.

The other variables, such as formation of the test specimen and manipulation of apparatus, are of smaller importance, compared with those of mixing and curing, but these errors may combine to increase those caused by the above.

The results obtained by varying the amount of work indicate that the test, as made at present, can be relied upon only to identify normal or slow-setting cements. The necessity for vigorous working in order that a normal cement may not be judged quick setting, defeats the object of the test when it is applied to a very quicksetting material, and may cause the set to be broken.

A study of the results makes it evident that neither the Gillmore or Vicat methods can be relied upon to give uniform results unless all factors which influence the rate of hardening are taken into account and controlled, and they further explain why comparative tests in a number of laboratories upon the same material have been found to give most variable, non-dependable results, cement often being adjudged quick-setting in one laboratory and slow-setting in another.

The British Columbia Manufacturers' Association will hold its annual convention in Victoria. September 22 and 23. One of the chief subjects proposed for discussion is "Transportation."

CHARACTERISTICS OF SAFE DRINKING WATER.*

By Dr. Allan J. McLaughlin,
Chief Sanitary Engineer and Director of Field Work, International Joint Commission.

Cities using sewage-polluted water without purification invariably have very high typhoid fever rates. The installation of a filtration plant to purify the polluted water supply almost without exception effects a prompt and remarkable reduction in the typhoid fever rate. This reduction is usually so great that municipal officials are satisfied that their water supply is perfect, when in reality there is still something to be desired. When a city with typhoid fever rates consistently above 100 deaths per 100,000 population has a reduction coincident with the installation of a filtration plant to a rate between 20 and 30, there is good ground for general rejoicing because of the undeniable saving of human lives. Nevertheless, the raw water may be of such a character that an unreasonable burden is imposed on the filtration plant, and under such circumstances, in spite of fair efficiency, the plant delivers an effluent which is unsafe at times.

With the general sanitary conditions which pertain in American cities and a safe public water supply, there is no valid excuse for typhoid rates above 20 deaths per 100,000 population. There is excellent evidence to show that if all the water-borne typhoid were eliminated in northern cities the rate for typhoid fever would be less than 10. As a matter of fact, there is a group of American cities which is fast approaching European cities in the matter of low typhoid fever rates. These are the cities which have gone farthest in making their water supply safe, and while their yearly typhoid fever rates are not always expressed in a single figure, their rates are usually below 12. In these cities with safe water supplies the general sanitary conditions, exclusive of water supply, are not conspicuously better and in some instances are very much worse than those found in cities with polluted water supplies and high typhoid fever rates.

There is a large group of cities in which, following the substitution of a filtered for a polluted public water supply, the rates have been greatly reduced but still remain too high. These cities should not be satisfied with typhoid fever rates of from 15 to 30, but it behooves them to make a searching investigation to determine whether the raw water imposes an unreasonable burden on their filtration plant, or if their plant is efficiently operated and delivering a safe water at all times.

This brings us to the question of what is safe dringing water? In order to say that a drinking water is hygienically safe one must be assured that it contains no pathogenic bacteria. The efficiency of water purification plants varies from day to day and from hour to hour, and an opinion upon the absolute safety of a given water supply can not be rendered unless many bacteriologic analyses, made at short intervals during each 24 hours, show an absence of B. coli. While an absolute dictum is thus most difficult to secure, it is not difficult by daily bacteriologic analysis to determine that a water does or does not give a reasonable index of safety. Instead of attempting to find the germs of typhoid fever, Asiatic cholera, and dysentery in water, we accept the presence of B. coli as an index of pollution with sewage, for the reason that the chances of finding B. coli are very much

*Presented at a conference of the International Joint Commission at New York City, May 26 and 27, 1914.

better than the chances of finding the specific germs in the small quantity of water examined.

When we consider the grossly polluted water supplies used by many of our large cities until recent years, we must admit that even if the present effluents from filter plants do not show constant absence of B. coli, still they must be classed as reasonably safe, or relatively safe water.

In order to secure statistics from some of our largest filtration and purification plants a circular letter was sent out to about 40 cities. About 15 responded, and in most instances the statistics covered at least one year. The list included mechanical or "rapid" sand filtration, slow sand filtration, precipitation and disinfection, and disinfection alone.

Table I. shows the average number of B. coli per 100 c.c. in both raw water and filtered or treated water.

TABLE I.

City.	Number of samples.	Type of filtration.	B. coli per 100 c.c. of— Raw water.	Filtered or treated water.
Toledo, Ohio	342	Mechanical filtration.	804	0.02
Minneapolis, Minn..	418	do	75	.1
Grand Rapids, Mich.	365	do	92	.3
Birmingham, Ala. ..	205	do	196	1.0
	174	do	400	.2
Cincinnati, Ohio ...	240	do	1,175	1.4
Binghamton, N.Y. .	420	do	59	1.2
Columbus, Ohio ...	365	do	606	1.3
Washington, D.C.	348	Slow sand	2,501	1.4
Providence, R.I....	600	do	732	4.3
Reading, Pa.	138	do	68	5.8
Baltimore, Md.	306	Alum and hypochlorite.	1,349	2.5
Richmond, Va.	237	do	460	8.0

Some of the results are of special interest, and the statistics for these cities are presented by months.

Toledo, Ohio.—The Toledo plant is of the mechanical-gravity type. Hypochlorite is applied to the raw water before sedimentation in quantities of 15 to 30 pounds per 1,000,000 gallons. Then aluminum sulphate is used as a coagulant.

Table II. shows the results by months in Toledo.

TABLE II.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
1913—			
January	25	1,848	0
February	26	145	0
March	26	2,238	.3
April	30	1,105	0
May	29	1,270	0
June	28	67	0
July	27	300	0
August	11	600	0
September	30	280	0
October	29	286	0
November	27	766	0
December	23	530	0
1914—			
March	31	1,000	0
January, 1913, to March, 1914	342	804	.029

The Toledo plant, by the use of heroic doses of hypochlorite, is able to convert a bad raw water into a safe effluent, but in spite of this fact the necessity for constant efficiency in treating such a raw water every hour in every day from January to June places an unreasonable responsibility on the plant. From June to October a fair raw water is furnished. In November and December the B. coli per 100 c.c. in raw water was again too high.

Minneapolis, Minn.—Excellent results are also obtained in Minneapolis by a mechanical or rapid sand filtration plant. Minneapolis differs from Toledo in that the hypochlorite is applied to the filtered water and not to the raw water in quantities of three-tenths to four-tenths parts per million available chlorine. The raw water at Minneapolis is very much better than that of Toledo.

Table III. gives the average number of B. coli per 100 c. c. in both raw and filtered water by months in Minneapolis.

TABLE III.

Season.	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
1913—			
February	26	23	0.7
March	31	39	0
April	30	8	.3
May	29	44	0
June	30	25	0
July	31	73	0
August	31	85	.6
September	30	79	0
October	31	53	0
November	30	85	0
December	30	100	0
1914—			
January	30	100	0
February	28	90	.3
March	31	242	.6
February, 1913, to March, 1914	418	75	.19

Cincinnati, Ohio.—The Cincinnati plant utilizes plain sedimentation followed by coagulation and mechanical filtration. Sulphate of iron and caustic lime are used, the latter to assist the action of the iron sulphate and not for softening purposes. Hypochlorite is added to the filtered water for about five months in the year. About 1 pound is used to each million gallons of water. Hypochlorite is used during January, February, March, April, and May, which covers the period of muddy water and high bacterial counts.

TABLE IV.

Season	Number of days' samples.	Average B. coli per 100 c.c. of Raw water.	Filtered water without "hypo."	With "hypo."
1913—				
September	28	964	2.1	...
October	31	358	1.5	...
November	30	1,990	2.7	...
December	31	1,841	3.0	...
1914—				
January	31	1,232	9.1	0.6
February	28	1,260	3.5	1.2
March	31	825	2.4	.06
April	30	933	20.0	.4
Sept., 1913, to April, 1914 ..	240	1,175	5.6	1.4

The results are very interesting. A bad raw water which threatens to overtax the purifying capacity of the filters is successfully handled by the use of hypochlorite as an auxiliary. The results shown in Table IV. indicate that in January, February, March, and especially April, 1914, the plant without the aid of "hypo" was unable to successfully cope with the bad raw water. With the aid of "hypo" a good effluent was secured.

Columbus, Ohio.—At the mechanical filtration plant of Columbus, Ohio, lime, soda ash, and aluminum sulphate are used. Hypochlorite is occasionally used applied to the settled water before filtration. Table V. gives results by months for the year 1913. With a bad raw water excellent results are obtained. Mr. Hoover, the chemist in charge, attributes these results to the free use of lime. This seems probable as very little hypochlorite is used.

TABLE V.

Season. 1913—	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
January	31	3,462	1.6
February	28	272	1.0
March	31	782	0
April	30.	931	2.3
May	31	196	1.9
June	30	283	0
July	31	378	5.1
August	31	277	.6
September	30	294	0.3
October	31	131	1.2
November	30	178	1.3
December	31	33	.3
January to December	365	606	1.3

Washington, D.C.—Washington, D.C., has a slow sand filtration plant. There is large reservoir capacity and some alum is used in times of high turbidity. No hypochlorite or chlorine is used at any time. The general average for the Washington plant for 348 samples shows

TABLE VI.

Season. 1913—	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
January	25	4,582	7.4
February	23	502	1.0
March	25	2,871	.5
April	26	20,910	4.1
May	26	661	0
June	25	910	0
July	26	5	0
August	24	88	0
September	25	412	.5
October	27	622	4.7
November	23	1,167	.5
December	25	538	.5
1914—			
January	25	640	0
February	23	211	.5
January, 1913, to February, 1914	348	2,501	1.4

1.4 B. coli per 100 c. c., which must be classed as a very good effluent. A close study of the results for individual months shows that there is great fluctuation in the character of the raw water. There was a very bad raw water in January, 1913, and April, 1913, and the results show that this unreasonable burden was probably too much for the purifying capacity of the plant. Table VI. shows the results of filtration in Washington, D.C., by months:

Birmingham, Ala.—The water supply for Birmingham is derived from two separate sources, as follows:

(*a*) Five Mile Creek. which is a stream to the north of the city, having a minimum flow of four and one-half million gallons, with a watershed area of 16.1 square miles and a population density of 31.9 per square mile. Five million gallons daily is supplied from this stream except during the dryest seasons. The waters of Five Mile Creek are diverted at a point 6 miles from the city and brought by gravity through a closed conduit to the North Birmingham purification plant, which consists of sedimentation basins and rapid sand filters of 5,000,000 gallons nominal capacity and sterilization by hypochlorite. The analysis marked "North Birmingham" show the raw and the treated water of this supply during the year 1913.

(*b*) Cahaba River: The watersheds of Cahaba River lie to the east of Birmingham. The west prong or Big Cahaba furnishes the supply, except when its minimum flow is less than the daily pumpage, in which case the East Cahaba is drawn upon by means of a small diversion dam below the junction of the two rivers. To supplement the dry-weather flow, a dam has been built on the east fork, or Little Cahaba, and a large impounding reservoir of 1,250,000 gallons created, known as Lake Purdy. The total watershed area is 205 square miles. The area above Lake Purdy is 49.7 square miles. The density of population on the entire shed is estimated at about 20 per square mile.

The pumping station on the Big Cahaba, 2 miles above the diversion dam at the junction of the two forks, forces the water to a purification plant on Shades Mountain. The purification plant consists of two large sedimentation reservoirs, holding 118,000,000 and 28,000,000 gallons from which the water flows by gravity through a rapid sand filtration plant, having a present nominal capacity of 19,000,000 gallons daily, with eight additional million under construction. The filters discharge into a clear-water basin of 3,000,000 gallons capacity, from which the water flows by gravity to the city, a distance of four miles.

Cahaba Plant.
(No chlorination.)

Season. 1913—	Number of days' samples.	Average B. coli per 100 c. c. of— Raw water.	Filtered water.
Jan. 1 to Feb. 28	25	305	0.28
March 1 to April 10	35	305	.56
April 11 to May 21	35	87	.00
May 22 to July 21	35	204	2.28
July 23 to Oct. 20	35	112	1.4
Oct. 22 to Nov. 28	16	23	0.0
Dec. 1 to Dec. 30	14	323	4.2
Jan. 1 to Dec. 31	205	196	1.0

North Birmingham Plant.
(With chlorination.)

1913—			
Jan. 1 to Feb. 6	31	700	0.3
June 9 to July 25	33	800	.6
July 28 to Sept. 12	35	1,337	.3
Sept. 15 to Nov. 3	34	288	0.0
Nov. 4 to Dec. 31	41	240	.0
Jan. 1 to Dec. 31	174	400	.2

The two Birmingham plants furnish very interesting data also on the value of hypochlorite as an aid in handling a bad raw water. The Cahaba plant uses no hypochlorite. In December, 1913, raw water, with an average of 323 B. coli per 100 cubic centimeters, seemed to overtax the purifying capacity of the plant. A load of 204 B. coli per 100 cubic centimeters in June and July seemed to be about the limit that the plant could care for, although in the period from January 1 to April 10 an average of 305 in the raw water was reduced to less than 1 B. coli per 100 cubic centimeters in the effluent. The North Birmingham plant has a worse raw water to deal with. This plant uses hypochlorite as an adjuvant. The average for raw water of 700, 800, and 1,337 B. coli per 100 cubic centimeters was reduced to less than 1 B. coli per 100 cubic centimeters in the effluent. From September to December, with a fair raw water averaging 240 and 288 B. coli per 100 cubic centimeters, a perfect result was obtained with entire absence of B. coli in the 71 samples.

Following a sanitary survey of the cities and towns in the basin of the Great Lakes, the writer recommended, among other things necessary, that a standard for filtered or treated water be established which should be a minimum requirement for the prevention of the spread of water-borne disease in interstate traffic. The Surgeon General of the Public Health Service appointed a commission in January, 1913, to fix such a standard. The report of this commission will be published soon. The majority of the members favored a standard of four negatives out of five 10-cubic-centimeter tests for B. coli. The writer expressed this standard in a different way, recommending a standard of not more than 2 B. coli per 100 cubic centimeters of water, taking the average of many samples by Phelps' method.

Allowing a sufficient margin of safety, filter plants with a decent raw water should produce effluents of less than 2 B. coli per 100 cubic centimeters, and it is the opinion of the writer that a modern water-purification plant which delivers an effluent which has more than 2 B. coli per 100 cubic centimeters is either inefficiently operated or is dealing with a raw water which imposes an unreasonable burden upon the plant. Accepting tentatively the standard of less than 2 B. coli per 100 cubic centimeters as a good drinking water, although not perhaps an ideal drinking water or a safe drinking water at all times, the results indicate that this standard is attained by both "rapid" sand and slow sand plants, even with a very bad raw water. Cincinnati and Washington, D.C., are good examples of each type. Close examination of the daily records at Washington and Cincinnati show that while this excellent average is attained for the year, there are periods when the capacity for purification seems to be overtaxed by the very bad raw water. At Cincinnati, the use of hypochlorite seems to compensate for the deficiency in purification by the standard process, but in Washington the excellent general average of 1.4 is only attained by the almost perfect purification effected during periods when the raw water is fairly good.

There is a strong tendency in America to accept any raw water, however bad, as a source for a municipal filtration plant. This often imposes an unreasonable burden and responsibility upon the water-purification plant. Now, filter plants are not infallible. They are mechanisms which must be properly constructed and efficiently operated under careful bacteriologic control in order to secure a safe effluent. They are operated by human agency and subject to the results of human error. It is true that properly constructed and efficiently operated filter plants can produce safe water from a very bad raw water, especially by the use of hypochlorite or liquid chlorine as an adjuvant. The responsibility of effecting such purification every hour of every day in the year is unreasonable and unfair. Many plants are now struggling with a raw water of such a character that a safe effluent is only obtained at the price of eternal vigilance, perfect operation every day in the year, and the free use of auxiliary chemicals. The raw water demanding such extraordinary treatment is, like a sword of Damocles, constantly threatening disaster. There is no margin of safety under such conditions.

I believe that a sufficient margin of safety should be given to all filter plants by reducing the pollution of the raw water to a point where it would not impose an unreasonable burden or responsibility upon the plant. I believe that in reckoning the bacterial purifying capacities of filtration plants hypochlorite or liquid chlorine should not be considered, but that a raw water should be furnished of such a character that the plant could turn out constantly a safe effluent without the aid of chlorine. This would reserve the chlorination as an additional margin of safety for use in extraordinary fluctuations of the raw water or during accidents to the plant or interruptions in its ordinary efficiency.

GRANITE MINING IN UNITED STATES.

In a recently-issued United States Geological Survey bulletin on Graphite, it is stated that to-day there are more abandoned graphite mines and mills in the United States than the number in operation. The number of times that some of these properties have changed hands in the course of a few years evinces a record of misrepresentation and disappointment that can hardly be equalled in any other branch of mining, and many properties have been notoriously associated with stock manipulations of doubtful character. It should be clearly understood by anyone who contemplates the development of one of the flake graphite deposits that the technology of concentrating such materials is yet in its infancy; that there are no well established systems of treating the materials, such as exist, for example, for the treatment of gold or copper ores; and that the product obtained is variable in quality and in market value and subject to severe competition with foreign graphite. The largest part of the foreign graphite that comes into the country is brought in by firms, who either control or own foreign mines or have purchasing agents abroad, and are, therefore, in a position to take immediate advantage of any change in the markets at home or abroad. In general, the cost of producing flake graphite is so high and the price at which it is sold so low that even under the most economic conditions the margin of profit is small. Moreover, certain rocks that carry graphite contain other minerals in such intimate association with the graphite as to preclude any possibility of successful concentration—such, for example, are rocks in which graphite flakes are interleaved with mica—and a careful study of the material by an expert should precede any attempt at development.

One large power-station after the other is being built in Norway, where the water-power has given a tremendous impetus to the development of the country's industry. The Sandefaldene Company is about to exploit the different falls in the Sande water system, for which the different lakes, some of them lying at a considerable height, will be regulated so as to serve as reservoirs. There will be constructed three power stations in the valley, and a larger one at the sea, the aggregate power being about 80,000 horse-power, divided between the four stations with respectively 42,000, 10,000, 8,000 and 20,000 horse-power. The whole of the power will be transmitted to the sea, where it will be used by an American concern—the Union Carbide Company—which has contracted for 40,000 horse-power, with the option of another 40,000 horse-power. The Sandefaldene Company has secured large areas at the sea for the new town which will no doubt spring up there within the first few years.

DETERMINATION OF THE LEGAL CHARACTER OF QUEBEC RIVERS AND THEIR CLASSIFICATION.

THE Quebec Streams Commission was appointed in 1911. One of its duties was to consider whether it was expedient to have the rivers of the Province classified as navigable and floatable rivers, or otherwise, according to uniform rules, and to submit such rules, if advisable. The work, during the past two years, has included an investigation of the nature and causes of existing difficulties, jurisprudence in connection with the legal character of rivers, foreign legislation, character and importance of the rivers, and practical conclusions to be deduced. In the second annual report of the Commission, recently published, these studies are shown to have been quite exhaustive. Classification of rivers was based on the area of the basins drained. Watercourses with drainage basins over 300 square miles in area were considered important, from the viewpoint of the utility of which each is susceptible. From this point of view of importance is deduced the legal character of the stream. The report lists 187 such rivers falling under this category, besides those in the territory of New Quebec. Thirteen of these rivers have drainage basins exceeding 11,000 sq. mi. each in area.

With respect to the investigation, the Commission expresses the belief that it is now necessary:—

1. To proceed to classify rivers according to uniform rules;

2. To change the formula, which serves to determine their legal character in the Province so as to remove the difficulties now encountered in connection with such determination;

3. To adopt a more convenient formula on a fixed, stable and certain basis susceptible of extended and decisive application;

4. To adopt as the principle in classification the importance of the river, stream or watercourse from the standpoint of the various uses of general interest for which it may serve;

5. To adopt a classification which shall be at once collective and individual or nominal without, however, being limitative in so far as the right of the Province to modify it is concerned;

6. To take as the standard for such determination the extent or area of the drainage basin whose waters are received by the river or watercourse;

7. To adopt for individual classification the list laid down by the Commission of the best rivers in the Province, the area of whose basin is known. This would mean recognizing the principle admitted in France that the administrative authority is alone competent to define the natural fact, the actual condition which constitutes sovereignty instead of leaving the duty of defining such legal character as at present;

8. To recognize that these rivers possess or are capable of assuming the importance deemed sufficient to create sovereignty, that is which justifies or compels its recognition.

In the report of the engineer, it is pointed out that in Quebec adequate information has not been previously collected concerning rainfall within the province, and that data covering a lengthy period of years possesses a great value in work of this nature. There are 45 rain-gauging stations in Quebec, 17 of which were established in 1913. He advocates extensive improvements in this respect. Similarly, water gauges for all the principal rivers are a need that is emphasized.

DESIGN AND CONSTRUCTION OF ELEVATED TANKS.*

By W. O. Teague, Boston, Mass.

THE elevated or gravity tank for fire protection systems has been from the first an important limited secondary source of water supply, and its value has increased greatly with the increase in number and size of tanks installed generally throughout the country, especially in those cities and districts where the public water supply is of low pressure. The tanks are usually located above buildings in cities and on detached towers in the country.

The tanks were first made of wood, but there are now as many being made of steel. Wooden tanks have been built up to 10,000 gal. capacity, although they are rarely larger than 60,000 gal., for above this capacity the steel tank is cheaper and more practicable. The cost of a 60,000-gal. tank of wood or steel erected on a 75-ft. steel tower is about $3,000. Steel tanks are built in large sizes, one of the largest being of 1,200,000 gal. capacity; this one is 50 ft. in diameter and 90 ft. high, and is supported by a steel tower 130 ft. high.

Failures of tanks in service, involving loss of life and destruction of property, have shown the need of more care in the designing and construction of them. To insure the best results, the following features should have attention:

Wooden Tanks.—The tightness and durability in the wooden tank depends chiefly upon the quality of the lumber and the details of its construction. Selected tank stock only should be used consisting of white cedar, cypress, white pine, Douglas or Washington fir, or redwood, and the lumber should be free from sap, loose or unsound knots, worm-holes and shakes, and be thoroughly air-dried. Both the staves and bottom are usually made up of 2½-in. stock dressed both sides, for tanks up to 16 ft. in diameter and 16 ft. deep; for larger tanks 3-in. stock is used. Plank for this purpose should be full length without splices.

The strength of the wooden tank depends principally upon the size and spacing of the iron hoops. The importance of the matter of the hooping will be appreciated when it is realized that overstressing of even one hoop may result in bursting of the tank. The wooden tank being originally merely a development of the barrel where flat hoops were necessary to permit of tightening by driving them toward the enlarged middle, it was natural to use also flat hoops for the tank and the tank was also made tapered so that the hoops could be tightened by driving, although later they were tightened principally by hoop lugs. It was claimed that the tapered shape had also the advantage of preventing the hoops from dropping down over the tank, if it was allowed to remain empty and the staves to shrink from drying.

The tapered shape of tank is not important, however, since a tank which has been allowed to dry up has been seriously damaged thereby and cannot be made tight without extensive repairs, sometimes necessitating the rebuilding of it. In fact, most tanks are now made without taper and the hoops are found to remain where placed. The tapered tank costs somewhat more to build since the staves must be fitted more carefully and the design undoubtedly would have been entirely discarded long ago, except that some architects and purchasers believe a

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*Abstract of paper presented at the Annual Meeting of The American Society of Mechanical Engineers, 1913.

tapered tank presents a more pleasing appearance. The amount of taper is so small, being usually 1 in. per ft., thus giving a batter of ½ in. per ft. to each side of tank, that its absence is hardly noticeable except on very high and small diameter tanks. The only objection to the tapered tank, however, is its extra cost.

In the early studies of this subject, many serious failures of tanks were traced to weakening of the flat hoops by their rusting at the back where they bore against the staves, due to moisture from rain being retained

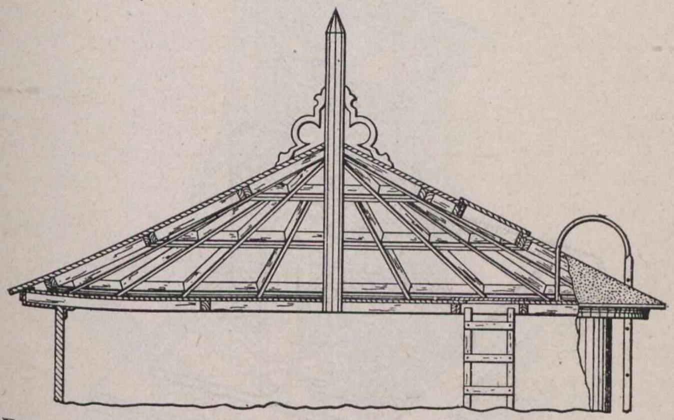


Fig. 1.—A Good Design of Double Roof for Elevated Tank.

between the surfaces of the hoop and staves. These failures were largely unpreventable, as it was difficult to properly inspect the condition of the hoops, and also impossible to paint them while the tank was in service. The use of hoops of round rod without welds has remedied this trouble as their surface is nearly all exposed for inspection and painting, and also they are not so subject to corrosion since the exposed surface of a round rod is much less than that of a flat bar or band of the same cross-sectional area.

Another point of weakness in the flat hoop is at its connection to the cast iron lugs which is usually made by riveting. The use of round rod hoops, however, permits of a satisfactory connection to the lugs, but at first many tank failures resulted from the use of light cast iron lugs. These are now made of malleable iron. The hoops are so placed on the tank that the lugs do not come in a vertical line.

Round rod hoops are so spaced that the stress will not exceed 12,500 lb. per sq. in. when computed from area at the root of the thread. The proper spacing can readily be found from the following formula:

$$\text{Spacing of hoops (in.)} = \frac{\text{Safe load for given hoops (lb.)}}{2.6 \times \text{diameter (ft.)} \times \text{depth (ft.)}}$$

The depth used is the distance from overflow to point where hoop is to be located. The top hoop is placed 2 in. from the top of the staves and the spacing between hoops should in no case exceed 21 in. An extra hoop or two is placed at the croze to take the additional strain due to the swelling of the bottom planks.

The tank roof, since it in no way serves to retain the water, has usually been nothing more than a makeshift cover. In the early days a single flat roof was used on outdoor tanks, but this held the snow and ice and required strong joist supports to keep it tightly in place. The snow also interfered seriously with the opening of the hatch to give access to the interior of the tank. A conical roof was then built over the flat one which remedied these difficulties. It also greatly increases the efficiency of the roof in preventing radiation of heat from the tank water in winter as it provides a dead air space between it and the flat roof in addition to the one between the latter and the water, thus reducing the cost of heating in freezing weather. The conical roof also gives a better appearance to the tank top. A well built roof is shown in Fig. 1. It should be tightly fitted around the tank top to maintain the dead air spaces.

Much trouble has resulted from leakage in the wooden tank, because it has not been firmly supported. The wooden tank is locally weak, not being of unit construction, and the lack of firm support has permitted working of the joints. It is supported only from the bottom, none of the weight being carried by the staves. Wooden beams were first used as supporting members, and these were placed on the roof of a building or tower as a grillage, and the tank bottom set on them. In time the wood rotted because of moisture from the tank bottom, permitting the tank to settle and causing leakage; there was also danger of collapse of tank because of this weakening of the joists. The use of steel I-beams as grillage members, as shown in Fig. 2, avoids these difficulties. The beams should not be spaced over 18 in. clear between edges of flanges, and the tank bottom is placed directly on the steel.

Steel Tanks.—The simplest form of steel tank is the flat bottom one and tanks of this type give satisfactory service, provided the bottom is supported by a steel grillage as in the case of the wooden tank. One possible source of trouble is from corrosion of the bottom, and to prevent this in so far as possible the bottom plates are made somewhat thicker than is necessary for strength alone, and the grillage I-beams are of a height and spacing to permit of inspection and painting of the bottom.

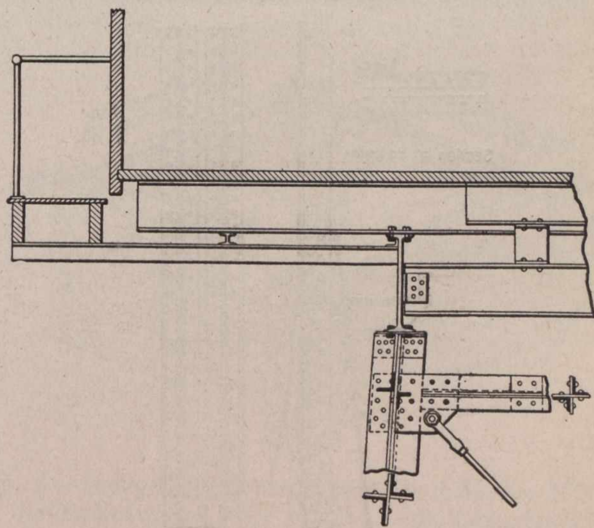


Fig. 2.—Detail View of Arrangement of Steel I-beam Grillage for Support of Tank.

When the tank is to be placed on a concrete tower, it may rest directly on a reinforced concrete slab with the bottom thoroughly grouted in place with neat cement.

The preferred form of a tank to be placed on a steel tower is that having a hemispherical or elliptical bottom. The construction in this form is cheaper than for the flat bottomed tank as the bottom is self-supporting and a steel grillage is unnecessary. The entire bottom is also accessible for inspection and painting, and corrosion is reduced to a minimum since the plates are exposed to the air.

Plates for use in steel tanks are made somewhat thicker than is necessary for strength in order to make them durable against corrosion. The minimum thickness is ¼ in., except that ⅛-in. plates are used for roofs. The plates composing the lowest cylindrical ring are 5/16 in. thick for 60,000-gal. tanks and larger, and the bottom plates 5/16 in. thick for tanks 75,000 gal. and larger.

One of the weaknesses of steel tank construction in the past has been poorly designed connections of the tank shell to the posts of the supporting tower. When the posts have a batter, as is usually the case, the inward thrust due to the horizontal component of the weight is provided for by a circular girder consisting of ¼-in. plate 24 in. wide, attached to the lowest cylindrical ring by an angle and stiffened by angles or a channel at the outside edge, as shown in Fig. 3. The posts also connect to the tank shell at this point and the design is such that the load will be transferred from the shell to the centre line of the posts so as to avoid eccentric loading. A number of tanks built without circular girders have failed by the posts crushing in the tank plates. Others with the girder, but having eccentrically loaded connections to the posts have failed by bending of the upper posts.

As the hydrostatic pressure on the tanks is comparatively small, it is not necessary to provide standard riveting for the thickness of plates used. The joints of the plates should be riveted so that the unit stresses on the net section of the plates and rivets will not exceed 7,500 lb. for shearing and 20,000 lb. for bearing. The horizontal joints are single lap riveted, except between the lowest cylindrical ring and the bottom, which are double lap riveted. The vertical joints also are single lap riveted except those in the lowest cylindrical ring, which are double lap riveted. The rivets are entered from the outside and driven from the inside and inside seams caulked. One of the strong features of the steel tank is that when

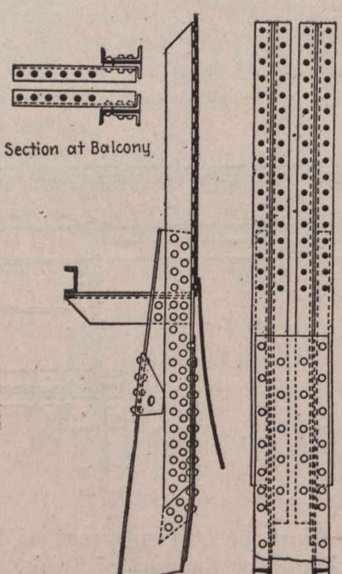


Fig. 3.—Detail of Attachment of Tank Shell to Tower Post and Circular Girder Construction.

once made tight, it gives practically no trouble from leakage.

Towers for Elevated Tanks.—Towers to support wooden tanks were originally built of wood, but with the increases in size of plant buildings and extensions of them, considerably larger tanks and higher towers were required, and the builders, realizing the inadequacy of wooden construction under these conditions, began to make towers of steel. The managements not being experienced in structural steel designing, naturally selected the simplest design possible for the towers. The posts and girts consisted usually of two angle irons, placed apex to apex and strapped together at intervals of several feet by tie-plates shop-riveted to the angles. The column sections were spliced by angles which were shop-riveted at one end to the post; the other end was field-bolted in erecting the tower, as this was the simplest form of connection and the easiest one to make. Furthermore, it had the advantage that the bolting could be done by the regular erecters which made it unnecessary to have first-

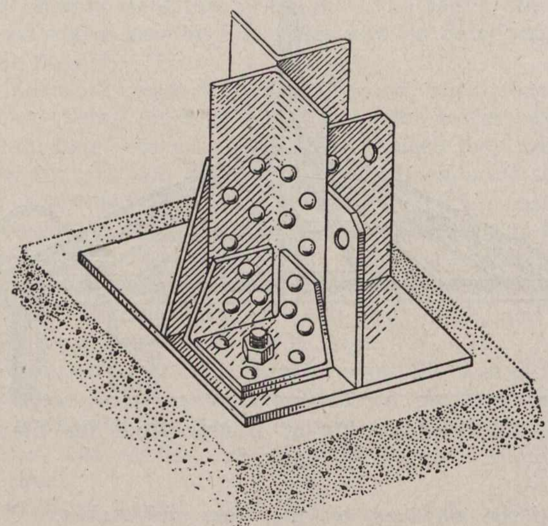


Fig. 4.—Typical Construction of Footing for Angle Iron Column.

class mechanics in the erecting gangs and to carry special tools. This, however, was not good construction and the manufacturers are now field-riveting these connections.

The struts were at first connected directly to the posts by bolts. This construction is objectionable because the bolts are apt to work loose and it does not brace the parts. The construction now used is that of gusset plates riveted to the posts and girts. The wind rods were also connected directly to the posts at the girts. The bolt holes, as originally inserted through the post angles, weakened the posts since they reduced the net section. The rods are now connected to the gusset plates. The arrangement of these parts is shown in Fig. 2. The diameter of bolt and thickness of plate are proportioned to provide proper bearing strength. The posts and girts of steel towers erected to support steel tanks, and to some extent wood tanks, are now largely made of channels latticed on both sides or having a plate on one side. Other shapes such as the Bethlehem H-beam and two channels with an I-beam between to form an H-section are also used to some extent.

Competition in the manufacture of these structures has resulted in the use of too high unit stresses and as a result the posts, figured on a conservative basis as represented in case of their structural work such as bridges, had a factor of safety of less than four and sometimes as low as two and one-half and failure has resulted. To obtain safe towers it became necessary, therefore, to set maximum allowable stresses. The loading of the structure consists of the weight of the structural and ornamental steel work, platforms, roof, piping, etc. The live load consists of the weight of the total volume of water; the movable load on the platform is assumed to be 30 lb. per sq. ft. and the wind load: The wind pressure is assumed at 30 lb. per sq. ft. on flat vertical surface and the wind load on the tank is taken as this pressure times 6/10 the projected area of tank and roof, and in the case of steel tanks, the curved bottom. The total wind load on the posts, struts, wind rods, ladders and riser boxing is assumed at 200 lb. per linear foot of height of tower.

All parts of the structure are proportioned so that the sum of the dead and live loads shall not cause the stresses to exceed those allowable. The principal stresses in such

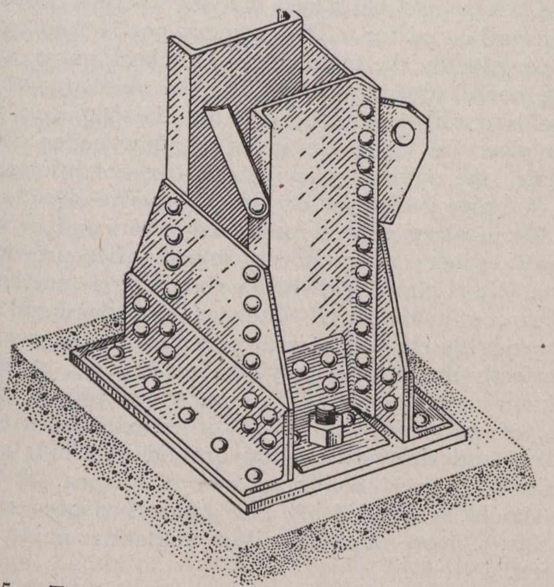


Fig. 5.—Typical Construction of Footing for Channel Column.

a tower structure are axial compression on gross section of columns and struts, axial tension on net section of wind rods, bending on extreme fibres or net section of rolled shapes, built sections and struts, and shearing of rivets. The axial compression on gross section of columns and struts is determined from the following expression: $17,100 - 57\frac{L}{R}$, where L is the unsupported length of the members from centre to centre of connections in inches, and R the least radius of gyration in inches; the ratio $\frac{L}{R}$ should not exceed 125 for columns and 150 for struts and minor members and the maximum compression allowable as thus determined is 12,000 lb. per sq. in. The axial tension on net section of wind rods must not exceed 12,500 lb. per sq. in.; the bending on extreme fibres or net section of rolled shapes, built sections and struts 16,000 lb. per sq. in., and the shearing for shop-driven rivets, 10,000 lb. per sq. in. and field-driven rivets 7,500 lb. per sq. in.

The lower ends of the posts have not been as carefully designed as their importance requires. Frequently, in angle iron towers particularly, no special attempt has been made to properly distribute the load to the base plate attached to the post footing. Cast iron plates were first used and the concentrated loading caused these to crack, resulting in collapse or in throwing the structure dangerously out of plumb with possibility of failure of the foundation under this post. The present use of steel plates has improved conditions, but the design must be such as to distribute the load to them as shown in Figs. 4 and 5, which are designs that are being used quite generally.

In anchoring the columns to the foundations, the diameter of the bolt at root of thread should be such as to withstand the maximum uplift due to the wind with tank empty, and to resist the shearing force at base plate. The bolts should be made from round wrought iron or mild steel rods without upsets.

Foundations and Supports.—The foundation piers to support steel towers are usually made of concrete, consisting of one part portland cement, three parts clean sand and five parts broken stone. They are usually pyramidical in shape and proportioned to suit soil conditions. The allowable bearing pressures on soil will range from 1 to 5 tons per sq. ft., depending on the quality of the soil. Where the soil is moist or rather loose, a girt should be provided at the base of the tower to prevent spreading of the posts. The allowable bearing pressures for footings should not exceed 400 lb. per sq. in. for Portland cement concrete and 200 lb. per sq. in. for ordinary brick work with Portland cement mortar, except when tank is to be rested on building walls, when the bearing plate should be figured on the basis of 125 lb. per sq. in.

The weight of the foundation pier when buried at least two-thirds of its height should be equivalent to the calculated net uplift due to wind pressure with the tank empty, that will be transmitted to it; otherwise it should be one and one-half times that amount.

Where the tank structure is above a building, and the building walls are depended upon to act as supports, great care should be taken to determine that the construction is safe against collapse. In many cases, tanks are supported by building walls not originally built to carry them, but where a sprinkler system was later installed it was considered more convenient and cheaper to use the walls than to erect a detached tower for the tank. This has frequently been done without making a thorough inspection first of the condition of the walls, and, largely through ignorance, the necessary care was not taken to distribute the load. Many failures have consequently resulted and there are no doubt numerous cases of this kind where the tanks are apt to fall at any time.

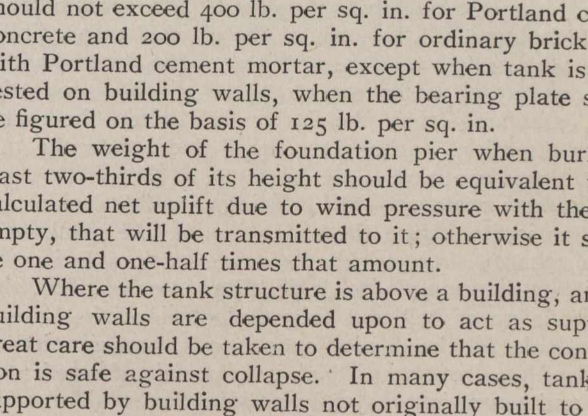


Fig. 6.—Design of Efficient Frost-proof Square Boxing for Enclosure of Riser Pipe to Tank Connection.

Inspection should be made of the quality and condition of the brick and mortar or other material used in the construction. The wall foundations should be examined as to construction and bearing on soil or rock. The condition of the bond between abutting walls should be noted and a general inspection made for sizable cracks in the walls. The thickness of walls and size and spacing of window and door openings should be measured and calculations then made to determine if the load of tank, water and trestle can be safely distributed over the walls. All unnecessary openings should be bricked or otherwise solidly filled in, and it may be necessary to sacrifice some openings to obtain the required strength. When the walls cannot be altered to support the load, the additional support required can be obtained by carrying steel beams down inside the walls to a solid foundation, provided these do not interfere with occupation of or possesses carried on in the building. Otherwise it will be necessary to provide a separate steel tower.

The proper strength of foundations is especially important because of the greater probability of loss of life from the falling of a tank from above a building as compared with the falling of a tank on a detached tower. The monetary loss is liable, of course, to be also much greater, as the water will undoubtedly wreck the building and cause heavy water damage. The building departments of cities endeavor to obtain proper construction, but unfortunately they do not always succeed. The possibility of trouble is increased because of the divided responsibility of the tank builder and the architect. The former seldom concerns himself as to the strength of the supporting walls, assuming that the latter has given the matter proper attention, so he goes ahead and erects the tank according to contract.

General Features.—Tank fittings should receive careful attention to insure the reliability of the equipment. The discharge or riser pipe is more serviceable if made up of cast or wrought-iron pipe, flanged or coupled, than one made up of bell and spigot pipe, since the latter is apt to leak at the leaded connections, necessitating removal of the frost-proof boxing to permit of repairs. A tank and tower is constantly swaying from side to side and this tends to loosen up leaded joints. Furthermore, the increased rigidity of the flanged and coupled pipe permits the use of a minimum number of tie rods. There are usually four rods connected, one to each post, at girt connections.

The connection of the discharge or riser pipe to wooden tanks has usually been made by extending the pipe through ordinary cast-iron slip flanges bolted to the tank bottom on each side of the opening. The hole in the planks was cut larger than the size of the pipe to form a packing space which was filled when parts were first assembled. A better construction was used for steel tanks having a stuffing box and gland. Both types of joints were found to be unserviceable, however, the former because the joint could not be tightened when leakage occurred, and the latter principally because the iron to iron parts rusted together, which resulted in the breaking of some pipe fittings and the emptying of the tank. Properly designed expansion joints forming tank connections for wooden and steel tanks have a bronze gland and ample clearance between the iron parts to prevent binding by corrosion. The packing space is large and the joint is extended within the tank bottom to form a settling basin, to prevent sediment getting into the yard pipe and clogging the sprinklers at time of fire.

A tightly constructed frost boxing should be placed around the discharge or riser pipe, and arrangements made for keeping the water heated by a hot water heater or a steam coil in the bottom of the tank. Designs of three-ply, two air-space boxings are shown in Fig. 6.

A tank level indicator or telltale is necessary to give a positive indication that the tank is full at all times. After many serious fires it has been learned that the tank had been partially or wholly empty at the start of the fire, and the lack of water had handicapped the fire protection devices. Tanks may be left empty due to neglect, but usually so because of false indication of the telltale. The most used type of device for this purpose is the float in the tank water, operating a target sliding on a scale fixed to the outside of tank. Obviously, these are subject to sticking due to their mechanical construction and exposure to snow and ice in freezing weather. The ordinary pressure gauge has been largely used but cannot be positively depended on, since it is seldom, if ever, tested and the parts stick, causing false readings. There are several types of electrical telltales operated by a float, but these are complicated and easily gotten out of adjustment. Attention is also necessary to maintain the electrical current.

The most reliable telltale is undoubtedly the mercury gauge. It should be placed indoors where it will be observed and cared for. The mercury pot is then piped to the riser pipe on the tank side of the check valve, and the gauge board adjusted after filling the mercury pot. The gauge is readily tested by opening the pet cock on the water pipe. If water continues to flow under constant pressure, the apparatus is in operative condition; otherwise, the pipe is clogged or there is a valve closed.

The painting of steel tanks and towers and of the iron hoops of wooden tanks is very important to prevent corrosion. Steel plates and shapes should be given the usual priming coat at the shop. The surface of the metal should be thoroughly cleaned of mill scale, rust and grease and be perfectly dry before applying the paint. A good paint for the first coat is made by mixing 20 lb. of red lead and 10 lb. of zinc oxide with 3 qt. of boiled linseed oil, the red lead and zinc oxide being ground in. This amount of paint will cover about 50 sq. yd. of surface. A second coat should be applied after structure has been erected. For this a more durable oil or asphaltum paint should be used.

The inside of a steel tank should be repainted, usually every two years, or oftener, if the paint shows signs of peeling or wear. The outside of the tank and the tower should be repainted at about five-year intervals. The surface should be carefully cleaned either by sand blast or by steel brushes or scrapers.

The iron hoops of wooden tanks should receive a priming coat as for structural steel and a second coat after assembly. They should be repainted when necessary. The advisability of painting wooden tanks exposed to the weather is an open question, although a large percentage of the tanks are painted. There is no doubt but that paint protects wood under ordinary conditions, but the objection raised to its use on tanks is on the ground that the tank water percolates through the staves and is prevented from evaporating as it is held under the paint and this is likely to set up dry rot in the wood. It is well-known, however, that dry rot does not occur when wood is completely immersed but rather when it is in a moist condition in the presence of some heat. This objection is not considered well-founded and as a rule the tanks are undoubtedly preserved by painting.

The life of properly constructed equipments depends largely upon the care and attention given to them by property owners. The tanks should be used only for fire protection. The practice of using a foot or so of water from the top of the tank for mill purposes is objectionable as the tank collects a larger amount of sediment from the water which is constantly being supplied than it does when used for fire service only. This sediment is likely to settle in the sprinkler pipes and either clog them completely, or, if the sprinklers are open, seriously interfere with their discharge. If water is drawn from the bottom for mill purposes the tank may be empty when needed for fire service. Furthermore, the fluctuation in water level is apt to result in shrinkage of the upper ends of the staves of wooden tanks, causing leakage and hastening corrosion in the steel tank by the repeated wetting and exposure of the sides to the air.

SLAG AS A ROAD-SURFACING METAL

Slag is a product obtained during the reduction of iron ores, and has been used to a small extent as a surfacing material for highways and to a large extent as ballast for railroads. The slag that is used in this capacity is generally silicate slag, resulting from the smelting of iron ores in blast furnaces, and is produced by a combination of a flux and the earthy matter of the iron ore. As is well known by all persons familiar with the smelting of iron ore, blast furnaces are charged with alternate layers of fuel, ore and a flux, usually limestone, fresh material being added from the top as the charge works down. The blast is introduced through tuyeres near the bottom of the furnace, and except during the time of charging and tapping these furnaces, it is continual. The iron, reduced from its ore by carbonic oxide or other reducing agents, descends toward the furnace together with the slag which results from the union of the earthy matters or the gangue of the ore and the flux; the slag, being of less specific gravity than the molten pig iron, flows upon the surface of it.

The quality of the slag necessarily varies, the variations being due to the complex action of the blast furnace; to differences in quality of the ore, fuel and flux at various intervals; to lack of uniformity in charging and to differences of temperature, atmosphere, etc.

As the slag reaches a certain point in the furnace, it is continually running off, and amounts to approximately one ton for each ton of iron that is made.

From the above, it will be readily seen that the production of blast furnace slag and the reduction of iron ore into pig iron results in an immense tonnage production of this slag material each year.

The physical differences of slags, even upon casual inspection, are very obvious. They differ in hardness, density, porosity and color. Slags which contain approximately 40 per cent. silicate, 40 per cent. lime and 20 per cent. alumina are considered to be about the best for road-surfacing purposes. When these percentages vary greatly, slags are apt to be weak and to disintegrate when exposed to air or water.

There are two methods of disposition of slag as it is drawn from the blast furnace. The one usually used is that in which the slag is drawn off in the molten condition into large automatic dump ladles, holding approximately 150 tons each. These ladles are then hauled along a track to the edge of a bluff, where they are dumped, allowing the slag to run out in thin layers to cool. The surface of the slag bank soon solidifies, although the bank formed remains warm for a considerable length of time, and it is generally believed that slag banks should be allowed to harden for at least two years before the slag can be used to advantage for highway purposes.

The other method of disposing of this slag when it is being drawn from the blast furnace is to run it into a large vat of water, where, due to the action of the liquid, is formed what is known as granulated slag, a fine, crispy, glassy product, which, has been used with some success as a substitute for sand in concrete mixtures, although in general this granulated slag is disposed of as waste material or used to form embankments in place of earth.

Slag as a road surface has been used occasionally during recent years, in localities where there is a scarcity of suitable sand and gravel for road metal. The New York State Highway Commission considered the feasibility of its use last winter, in some of the counties in the south-western part of the State. Samples were tested at Albany to ascertain whether the characteristics of this material were such as to justify its use. The results were such that the Commission authorized the specifying of its use in various types of construction. An article appearing recently in the official organ of the Commission, and written by F. S. Strong, one of its division engineers, is based upon this departure. From it this information has been obtained.

The types in which the use of slag is allowed include plain concrete pavements, concrete pavements with bituminous surfacing, Hassam concrete pavements, water-bound slag macadam with and without glutrin, some with limestone screenings and some with slag screenings, and bituminous-bound slag macadam highways. Much of this work is now under contract, and a considerable portion of it will be completed this year. The material is also being used to some little extent as a surfacing material in the repairing of old macadam pavements.

It is believed that the careful and continuous future inspection of the highways built of slag will produce valuable information and statistics of its merits as a road metal.

A big bulk of the slag available in the section of the State referred to consists of blast furnace slag. However, in the further reduction of pig iron in the production of steel, various processes are used, as, for instance, in the open-hearth furnace, where the crude metal is further purified, here again a flux is used which rises to the surface of the molten mass as slag. Slag formed in this operation has been used but very little on account of the small quantities available for highway purposes, although it possesses many desirable qualities, such as hardness, toughness and excellent cementing qualities.

The use of this latter form of slag will be taken up below in the discussion of streets constructed in the city of Cortland during the last ten years with excellent results.

In the vicinity of Youngstown, Ohio, in 1909, the office of public roads in co-operation with the Carnegie Steel Company conducted a series of experiments to determine the best method of utilizing this slag for road construction. In the experiments at this place, the blast furnace slag was taken from a bank that had aged about two years, the material of which came from six blast furnaces of the same type. A steam shovel was used to load the slag from the bank into large gondola cars. These cars were drawn to a gravity screen, where the slag was dumped into a chute and passed over the screen to separate into proper sizes. After passing over this screen, it was taken by rail to a site about one and one-half miles from the road upon which it was to be used, unloaded and hauled to the road.

These experiments as shown by the bulletins issued by the office of public roads, proved very interesting, and demonstrate that there is a field for blast furnace slag in the construction of highways, and the results were so favorable that the various counties and the State Highway Department of Ohio have adopted standard specifications for the use of this material. Various reports of inspections made of these roads show that they have stood up well, and, owing to the cheapness in the first cost of this material and the lightness in weight, the investment in a slag furnace macadam pavement from an economic standpoint would seem to compare favorably with that of a stone macadam pavement.

Since the completion of these experiments, which were conducted with slag which was not run through a crusher but was taken directly from bank and screened, slag pavements have been constructed from commercial blast furnace slag, the slag being carefully sorted to obtain the best materials and run through a regular stone crusher in order to obtain the proper sizes for use in the various courses of macadam, resulting in superior types of construction and more uniform and lasting types of pavements.

In the vicinity of Buffalo, where there are many large blast furnaces, this slag has been used to some little extent for highway work, although no intelligent effort was made to obtain a high-class construction, due to the lack of available money for said purposes in the localities where the work was done. Yet this material is found to consolidate under traffic without rolling, harden and smooth out, making an excellent country road. Where incisions were made in some of these roads for various purposes, it was found almost as difficult to cut through this material as to cut through a concrete foundation for brick pavement.

At the beginning of 1913 a plant was established in connection with the Buffalo Union Iron Furnace to take over the slag product of these blast furnaces and produce therefrom a commercial product to be known as crushed screened slag for railroad ballasting and highway surfacing purposes. During the season of 1913 a considerable amount of this material was used on town highways, and reports received from various town and county superintendents in districts where this material was used, stated that satisfactory results were obtained, although thus far it is too early to reach any conclusion as to the definite wearing qualities of this material.

In reference to the use of slag product in the open-hearth process in the manufacture of steel, perhaps some of the most successful work of this kind in the construction of streets or highways is that which has been done in the city of Cortland. In this city the first slag street was constructed ten years ago as a waterbound macadam highway, and, according to the city authorities, has given excellent results ever since. They also have other waterbound slag roads which have been built eight years with practically no repairs of any nature. During the last four or five years the city authorities have used a bituminous material asphaltic binder in the construction of the slag streets, using the penetration method with excellent results. The slag after being cooled is crushed in an ordinary stone-crusher, the larger pieces being used in the bottom course, which is bound with loam. For the body of the top course, a slag varying in sizes from ¾ in. up to 2 in. is used. This top course has a finished depth of 3 in., and is bound with a gallon to a gallon and a half of asphaltic binder to the square yard; is then filled with slag screenings and rolled. These streets have also the appearance of sheet asphalt pavements and are standing up well under fairly heavy traffic.

The report which was distributed by the international joint commission appointed by the governments of the United States and Canada to investigate the pollution of the international waterways along the boundaries, dealt exhaustively with the sources of water supply and the contamination of these supplies by sewage. It pointed out that steamboats crossing the lakes take drinking water from contaminated areas 16 miles from land, that the water supply at Detroit and Windsor, and the western frontier of Ontario is not only exceedingly bad, but dangerous, and that some deaths are undoubtedly due to the infected water service for drinking purposes on the ferries plying between Windsor and Detroit.

The water power branch of the interior department of the Canadian government is arranging to put in the Canadian building at the Panama Exhibition at San Francisco an exhibit, showing the vast power resources of the Dominion. The exhibit is to include a series of models of typical power plants from the Atlantic to the Pacific. They will be arranged in a semi-circle in front of an enormous landscape painting of the Dominion, which is now being executed by Gibson Catlett, Toronto. The painting will be 75 feet long by 9 feet high.

DETERMINATION OF CARBON IN IRON AND STEEL.

THE following direct method for the determination of carbon content of iron and steel is outlined in an article, by W. D. Brown, appearing in a recent issue of Metallurgical and Chemical Engineering: The essentials for complete combustion are an initial temperature of the furnace of about 1800° F., the burning of the metal in nearly pure oxygen, and an unlimited supply of the latter during combustion. If the metal is pushed into the furnace and a slow stream of oxygen started, combustion will begin before all the air has been displaced and will be in a mixture of air and oxygen; possibly the combustion of the iron will be complete before the oxygen has completely displaced the air and the only work remaining for the oxygen is to displace the carbon dioxide in the tube. When the combustion begins, oxygen should be supplied as fast as the iron will combine with it, that the temperature may be raised to the highest point; about 3000° F. will be momentarily obtained and all the carbon will be oxidized. These requirements of starting combustion in oxygen and an unlimited oxygen supply have been met in the method described below. In addition the supply of oxygen has been made automatic.

Apparatus.—The electric furnace contains a silica tube ⅞ in. in diameter and 24 in. long; in it ignited asbestos is loosely placed from the exit end to within 3 in. of the middle of the furnace; this acts very well as a catalizer, and is necessary when burning pig iron, at least. Oxygen is obtained in 100-ft. cylinders on which is a pressure reducer and regulator which supplies oxygen at a pressure from 1 to 3 lbs. as desired. The regulator is connected to brass piping containing four tees and globe valves for four electric furnaces (more could be added as desired), thereby one tank is used for the four furnaces. Oxygen enters the silica tube through one hole of a two-hole stopper. In the other hole is a 12-in. copper or glass tube, ¼ in. outside diameter; on the end of the tube is a No. 00 single hole rubber stopper. Through this stopper and tube a plunger rod of No. 9 nichrome wire, 24 in. long, to which is riveted a sheet of nickel about ½ in. diameter, is inserted. This is used to push the boat into the hot part of the furnace after the oxygen has displaced the air and while the current is flowing, and can be made in any laboratory; the No. 00 stopper can very well be replaced by a small stuffing box, in which case the copper tubing is shorter. The oxygen being free from CO_2, no purification is necessary. Both ends of the silica tube are cooled by copper water jackets.

The exit end of the tube is connected by a rubber stopper to a glass stopcock, which is used to regulate the flow of gas. The stopcock is connected to a 5-in. drying tube filled loosely with phosphoric anhydride. It has been found that a zinc tube is not necessary, as the sulphur trioxide fumes are caught by the asbestos and phosphoric anhydride.

The drying tube is connected by a rubber tubing, on which is a pinchcock, to a Vanier potash bottle. This bottle contains a solution of potassium hydroxide (purified by lime) of 100 grams per 100 c.c. water. The inner tube is filled with phosphoric anhydride and a covering of glass wool placed thereon. Filled in this manner, the bottle will last for 100 determinations. The part which fails first is the phosphoric anhydride; a solution will form in the bottom of the drying chamber and will gradually grow until there is no more dry anhydride; this marks the life of the bottle.

On the construction of the Vanier bottle depends the success of the method; it must be so made that a speed of 400 c.c. per minute may be obtained without the gases passing out the lower end of the inner coil, which can be done if the lower end points or slants downward instead of being horizontal. The exit end of the coil should also be opposite the entrance to the drying chamber to prevent the splashing of the potassium hydroxide solution into the phosphoric anhydride.

The Method.—A blank is first run in the following manner: With all connections closed, the oxygen is turned on the line and the pressure varied until three lbs. are obtained. One or more bottles are then connected to the furnace or furnaces and the stopper inserted in the entrance of the silica tube, the stopcock in the bottle is then turned, the pinchcock opened, and the globe valves from the oxygen line opened full. Oxygen should then pass through the bottle at a rate of approximately 400 c.c. per minute, the pressure in the line dropping to 2 lbs. If the speed of the gas is not as great as this, the reducing valve should be so regulated as to increase the pressure. It may happen that one bottle will go faster than the other; in that case, the stopcock at the exit end of the furnace is to be partially closed so that all bottles have the same speed. When this condition has been obtained—the right pressure in the oxygen line and the stopcocks just right, no change is made until it is necessary to renew the bottle or tank. The stream of oxygen is continued for five minutes, the oxygen is then shut off at the globe valves on the oxygen line and, as soon as the flow of gas slackens in the bottle, the pinchcock on the rubber tubing leading to bottle is closed and, when the flow has completely stopped in the bottle, the stopcock is turned, the bottle is removed and weighed, preferably with a tare. This is repeated until the variations between weights is not more than three decimiligrams.

For the actual test, 1.36 grams of steel between 20 and 60 mesh or half gram iron, are weighed and transferred to a groove in alundum contained in a nickel boat. The bottle is connected to the furnace as above and the stopper turned, the pinchcock being closed. The boat is placed just within the silica tube, the two-hole stopper carrying the pusher is then inserted in the tube, the pinchcock opened and the oxygen turned on full at the globe valve. Oxygen then passes through at the rate of approximately 400 c.c. per minute; if the rate varies perceptibly from this it can be regulated by stopcocks at exit of silica tube. After gas has passed through for one minute, the boat containing the drillings is pushed into the centre of the furnace by shoving in the nichrome wire mentioned before, while the current of gas continues. In about one minute the drillings have become heated sufficient to burn freely and combustion then is very rapid, being complete in twenty seconds. During the combustion an unlimited supply of oxygen is at hand, as the globe valve is open full and the regulator is set for a definite pressure. The oxygen then passes through to sweep out the carbon dioxide formed, five minutes after the boat is pushed back being sufficient. The globe valve is then shut off and, when the flow of gas has slackened, the pinchcock is closed, followed by the closing of the stopcock as above described. The bottle is disconnected and weighed; increase in weight in grams, multiplied by 20 gives %C. when 1.36 grams steel has been used.

In routine work, one analyst weighs up four (or less) tests, places boats in furnaces and starts the gas flowing. During the one minute's wait, he examines stoppers, etc., for leaks, then pushes boats back and leaves furnaces for other work, returning in five minutes for the completion of the determination. This method can be used for the determination of carbon in steels ranging from 0.07 per cent. to 1 per cent. carbon, as well as on pig iron. Not only is the accuracy greater than with color determinations, but the time required for analysis by combustion is less than by color.

RAILWAY COMMISSIONERS' ORDER RESPECTING LOCOMOTIVE DEFECTS.

An important order has recently been issued by the Board of Railway Commissioners for Canada to railway companies under its jurisdiction. By it locomotive engines of railway companies subject to the jurisdiction of the Board will not be allowed to leave terminals, or to be used at terminals, in traffic service, on which any of the following defects exist, viz.:

1. Steam Leaks.—Steam leaks from any part of the locomotive which render it impossible for the engineer to see signals in sufficient time to enable him to bring his train to a stop within the required distance.

2. Air Brakes.—Air brakes on locomotives or tenders not in serviceable condition.

3. Wheel Defects.—Locomotives with steel or steel-tired leading engine truck wheels, leading or trailing driving wheels, or tender wheels with flanges worn 1/16 below M.C.B. wheel defect gauge for cars of less than 80,000 pounds capacity.

Locomotives with cast iron engine truck wheels and cast iron wheels under tender weighing over 130,000 pounds with flanges worn 1/16 below M.C.B. defect gauge for cars of 80,000 pounds capacity, or over.

Locomotives with cast iron wheels under tender weighing 130,000 pounds, or less, with flanges worn 1/16 below M.C.B. defect gauge for cars of less than 80,000 pounds capacity.

Locomotives with truck or tender wheels having shelled out or flat spots over 2½ in. long, or so numerous as to endanger the safety of the wheel.

Steel tires on locomotives worn hollow ⅜ in. in depth, or which are worn below safe limit of thickness. Railway companies to file with the Board their standard limit of thickness of tires on all classes of locomotives, for approval.

Flat or shelled out spots on locomotive driving wheels 3 inches long.

4. Springs.—Locomotives with defective springs on any part of locomotive or tender which are unable to carry their respective weights when locomotive is standing.

It is further ordered that the railway companies are required on or before the first day of January, 1915, to equip their locomotives with double windows in the front of the cabs during the winter season, November 1st to April 30th; the same to be made air-tight.

The order is the result of replies to a circular issued to the railway companies on February 24th last, and the reports of the operating officers of the Board, the railways consenting to the adoption of the regulations regarding locomotive defects as outlined above.

During the past 2 years, approximately $2,500,000 has been spent by the C.P.R. on the Dominion Atlantic Railway. The whole road is being modernized in its bridges and tracks. The biggest individual job was at the Bear River bridge, where $1,500,000 was spent. Other new bridges are those across the Avon, at Windsor, over the Gaspereau River, and at Weymouth. The C.P.R. will formally take over the road when it is brought up to the required standard.

MOOSE JAW 11th AVENUE SUBWAY.

THIS work comprises the construction of a subway 66 ft. wide under the Canadian Pacific Railway tracks and connecting the northern and southern portions of the city as divided by the Canadian Pacific Railway main line. The subway is situated two blocks east of Main Street at the north end at Manitoba Street and 11th Avenue, and passes diagonally under the tracks, connecting with 10th Avenue one block east of Main Street at its south end, which terminates at a concrete bridge over the Moose Jaw River.

The length of the subway is some 1,040 feet. A double line of street car tracks is laid from end to end with steel standards along the centre line. The vehicular roadway has a minimum clearance of 13 ft. 4 in. under the lowest members of the steel bridgework carrying the five C.P.R. tracks. The roadway, which is laid at a 4% grade, is 46 ft. between curbs, and paved with vitrified blocks laid on a concrete base varying from 5 in. to 18 in. in thickness according to the condition of the subsoil. On each side of the roadway 10-ft. concrete sidewalks with curb and gutter are provided for pedestrians.

Reinforced buttressed concrete retaining walls are built along each side, and heavy concrete abutment walls support the bridgework carrying the tracks. The elevation of the crown of the road at the lowest point, that is, under the centre of the tracks, is 1,751.14, being some two feet below the mean water level of the Moose Jaw River, which borders the south end of the subway. At the lowest point of the gutters catch basins are provided to take the storm water, which is thence conducted by 8-in. and 10-in. stoneware sewer pipes laid under the sidewalks, discharging into the low level of the river below the C.P.R. dam some 1,500 feet distant. The sidewalks in the lower portion of the subway have been constructed 3 feet above the roadway so that their lowest level is well above the high-water level of the river, and consequently immune from any possibility of being submerged during any flood.

Iron railings are provided for the protection of the public along the curbs of the raised sidewalks, and along the back edge of the sidewalks at the south end, which is bounded by the river on each side, or more correctly, by Moose Jaw River on the east and Thunder Creek on the west side, which join at the before-mentioned concrete bridge at south end of the subway.

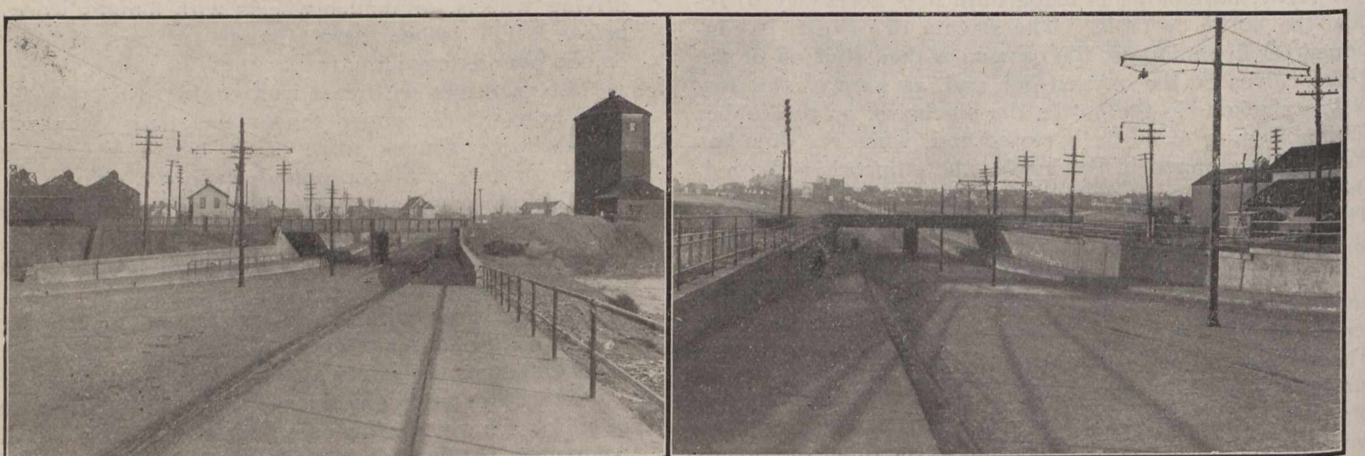
Owing to the close proximity of the river, it was necessary to support the bridge abutments and a considerable portion of the retaining walls on closely piled foundations. These piles varied in length from 12 ft. to 18 ft., being driven to absolute refusal in practically every case. Also, to avoid the ill effect of a saturated sub-base by percolation from the river, Neponset waterproofing was laid on a concrete bed below the main concrete road-base throughout that portion where the road surface was less than 1 foot above the high-water level of the river.

The total cost of construction of the subway amounted to about $130,000, of which the cost of bridgeworks for the C.P.R. tracks was about $38,000.

There were some 22,500 cu. yds. dry excavation moved at about 60 cents per cu. yd., 2,000 cu. yds. of wet excavation at $2.60 per cu. yd., 5,000 sq. yds. of brick paving, which cost about $54 per 1,000 delivered on the site. These paving bricks were obtained from Denver, Colorado, and the price laid on 5-in. concrete base and 1½-in. sand cushion was about $3.50 per sq. yd.

The work was commenced in May, 1912, and completed in October, 1913, being closed down for about five months during the winter. However, practically all the excavation had been completed and sufficient progress made to allow of a good roadway being left open for both vehicular and pedestrian traffic throughout the winter.

The subway forms the main thoroughfare between the north and south of the city, and has, therefore, been so constructed that although subject to continuous heavy traffic the cost of maintenance should be small, and at the same time the initial outlay has not been excessive.



Subway at 11th Avenue, Moose Jaw, Under the Canadian Pacific Railway Tracks.

The plans were originally designed in 1911 by Mr. J. M. Wilson, then city engineer, and Mr. R. G. Saunders, his assistant city engineer, being revised by Mr. Antonisen, the city engineer in 1912, and the work carried out by Messrs. Wilson, Townsend and Saunders under the supervision of a member of the city engineer's staff, Mr. B. C. Ward, as resident engineer. Mr. Geo. D. Mackie is now city engineer and commissioner, and to him we are indebted for the above information.

GRANITE IN BRITISH COLUMBIA.

An important matter to Vancouver is the discovery on Texada Island, 50 miles from the city, of an inexhaustible ledge of mottled ganite. Some of the stone was, says an American consular report, quarried experimentally, and the polished slabs used in the new Victoria Theatre. A $150,000 company has leased the ledge from the Government, and will develop the quarry, building a gravity tram line to the water edge, whence the stone can be transported cheaply to Vancouver for dressing. During the past five years over $3,000,000 worth of marble has been imported into Vancouver for interior work on new buildings. In the future most of the stone for such work will be quarried in British Columbia.

SEWAGE DISPOSAL IN EUROPE.

It is obvious that sanitary engineers of this continent have decided advantages in being able to glean from the European types of sewage disposal works those features that are best and most efficient for use in this country. Proper combinations and adaptations of English and German types, together with whatever improvements ingenuity may suggest, should produce sewage disposal works of the highest order, there being no prejudicial feeling for one type and against another, such as exists in Europe.

A brief review of sewage disposal works in some of the European cities is given by Geo. E. Dalesman, principal assistant engineer, Bureau of Surveys, Philadelphia, in a paper recently presented to the American Waterworks Association. The following observations are conducive to a general understanding of the disposal situation in Europe as it appears to the interested observer:—

The use of underground channels to carry off the liquid wastes from dwellings is a very ancient practice. In the beginnings of ancient Rome there were built large conduits, in use to this day. On the Island of Crete, the home of the Aryan progenitors of the ancient Grecians, recent excavations show that underground drainage channels were systematically constructed at least 3500 years B.C. The construction of these channels as a system, however, may be said to have begun in the nineteenth century.

Scientific and effective treatment and disposal of the liquid wastes was discussed in the last quarter of the nineteenth century, experiments inaugurated and many works constructed during that time; but during the early years of the present century the art has made much progress, works have been built in accordance with the most successful lines of experiment, and many additions made to the earlier works.

Sanitation. — While sanitation comprises many branches, that represented by the term sewage disposal is one of large influence upon the general health of a community.

Prior to the introduction of sewage systems in large cities, death rates were high, and for centuries at intervals of a few ears or decades, their populations were swept away by plague or pestilence, fostered and spread by admixture of noisome liquid wastes with the drinking water. Repetitions of these visitations were accepted as natural, until modern science showed that by the introduction of proper systems for carrying away liquid wastes the mortality could be lessened. Striking examples are the city of Havana and the Canal Zone, made habitable and safe by the introduction of sanitary conveniences.

Municipalities, especially in the crowded European centres, took up the matter of improving old conditions with vigor, full-size experimental installations were made, gradually developing into complete systems for the collection and disposal of the sewage.

The agitation for better sanitary municipal surroundings has given rise to keen debates, and has set up many champions of a radical change, calling for the exclusion of sewage matters from streams and rivers.

Calmer judgment and extensive experiments have tempered these views, until at present it is recognized that the streams themselves are, and have been, effective agents in transforming organic or putrescivle matter into a mineral or innocuous state up to a certain limit, dependent upon the amount of available oxygen in the water.

European Conditions.—The examinations of sewerage systems in European cities are valuable on account of the concentrated population and the results achieved by the introduction of sewage treatment systems in lowering their death rates, even with a water consumption of from one-fourth to one-sixth of that in American cities. This, resulting in a far more concentrated sewage, calling for different treatment than our own, necessitates also the treatment of a volume of storm water when polluted by the sewage, ranging from four to six times the dry weather flow, a condition which does not arise with our more dilute sewages.

By reason of their concentrated populations and the smaller size of European rivers, with their small diluting volumes, the urgency of installing sewage treatment works has been greater, to protect their restricted water supplies and to avoid nuisances that would in some cases make their cities noisome places of abode.

Again, on account of their nearness to Asiatic cities, the homes of plague and pestilence and their open harbors, sanitary safeguards are essential.

Owing to restricted parking areas and the possibilities of river embellishment, by the removal of sewage pollution, they have been enabled to make of their rivers the most attractive features of their cities, for bathing and the enjoyment of people in their hours of relaxation.

American Conditions.—The American cities have grown rapidly from villages, and the village practice of building a culvert to the nearest stream has until recent years survived. The drains from various villages have grown into a system with many outlets discharging crude sewage into the larger streams.

Large streams like the Schuylkill River, suitable for water supply, have gradually been eliminated from the lists of available sources, the rivers themselves have become septic tanks, and of recent years, even rivers like the Delaware and Hudson have been polluted, so as to require effective treatment before their waters can be used for domestic consumption, a prodigal waste of natural resources.

A few years ago the old-fashioned cesspool was in vogue, and we can remember when protests were filed against the building of sewers. Now, since no block of dwellings can be disposed of without them, builders solicit drainage facilities as the first step in the improvement.

A few years ago black, dirty, sewage-polluted water was consumed by local residents without question, and affliction with enteric diseases in consequence was taken as a matter of course. The improved water supply has educated our people to other views.

In port operations, formerly, any filth could be thrown from vessels or dumped into the river. To-day it is recognized that to compete for the world's commerce we must remove from sight and smell all nuisance.

To-day pollution of water supplies will not be tolerated, and a reduction in the deaths due to preventable disease appeals so strongly, that the great insurance companies have banded themselves together, with millions of capital behind them, to study their causes and remedies with a view to stamping them out.

We are just learning to be less prodigal and to devise ways and means to conserve our advantages, to protect our streams, to be dissatisfied with their pollution with sewage; but it will take some educational campaigning before the people at large will understand the value to the communities of sewage treatment.

Advances in the Art.—The advance made in the art, due to large sums spent in full-size experimental installations, in efforts to free natural watercourses from pollution, has been steady and positive, each forward step taken after experience in operation or research warranted it.

In the first instance, farms irrigated with sewage were operated, but this practice has been abandoned, except where by reason of the great cost of the installation, it is not practicable to change the treatment.

Screening and tank treatment, sometimes coupled with sand filtration, have been substituted in some instances.

Throughout England, where rivers are comparatively small, plants are undergoing reconstruction, and some form of bacterial treatment in beds is being added to the preliminary treatment. In some cases it has been found to be economical to turn the earlier works into scrap and build entirely new as at Leeds.

In English sewage disposal plants, the disposal of sludge, except where it is carried to sea, has been generally inadequate. This is now considered by many the most vital problem.

In Germany, by several processes the problem of sludge disposal has been successfully solved.

As to the present status of the art the following statements may safely be made:—

Sewage even of exceptional concentration can be effectively treated, so as to secure a clear, odorless, sparkling, non-putrescible effluent before discharging into a stream, the securing of which is a matter of cost, and, therefore, an economic as well as a constructive problem.

Sludge resulting from sewage treatment can be rendered innocuous, practically inodorous, wholly unobjectionable, after which it may be dealt with in various ways.

Desired results may be secured by certain combinations of treatment at a fraction of the cost of other recognized scientific methods of treatment in satisfactory operation.

Relation to Water Supply.—It is considered by some eminent sanitary engineers that they are justified in placing sewage disposal next in importance to water supply in the list of public utilities. This is based upon the value of protecting the streams from nuisance, to conserve sources of water supply and to protect the health of the people.

As a water supply is taken from a river, its application to a populous community produces sewage, and, as its natural destination is a return to the stream, used possibly again for water supply, it gives rise to an economic problem as to the proportionate share which should be borne in the treatment of both the water and sewage.

The theory of excluding all sewage from return to a stream, held some years ago, is untenable, and with this recognized and the necessity of utilizing the diluting volume of the river and its available oxygen to continue the treatment begun in disposal works, the problem resolves itself into an economic one.

The uses to which the waters of a river are to be applied are controlling factors in the standard of effluent to be secured.

The comparative economy of treating sewage to a high degree of purification or of taking a lower standard and increasing the degree of water treatment, must be solved by each community.

When comparing the amounts of available chlorine required in water and sewage effluent treatments it has been found that of three turbid raw water supplies, the average amount of available chlorine required to render the manufactured product free from bacteria resembling B. Coli is p.p.m.: of three other raw surface waters, 0.3; of four examples of sand filter effluent, there were required 0.33.

For the effluent of sewage works under average conditions, which had been subjected to settlement, there were required 6 parts; that which had passed percolating filters, 3 parts, and that which had in addition been subjected to secondary settling, 2 parts.

In general, therefore, it is cheaper to treat water when practical disinfection can be secured by the admixture of from 0.3 to 0.7 p.p.m. of available chlorine instead of attempting to secure an uncertain comparative result in the treatment of sewage effluent by the admixture of from 2 to 6 parts, with a probability of having to resort to an equal amount of treatment for the water notwithstanding the sewage treatment.

In Germany, with its concentrated populations, rivers are considered by the rivers boards as proper places for the disposal by dilution of sewage submitted to fine screening and settling tank treatment, from which rivers are taken the water supplies usually from driven wells or filter galleries along their banks.

Judging from the exceptionally low typhoid death rates in these cities, any condemnation of the practice must be supported by arguments from other sources.

Grit Chambers.—Frankfurt, Huddersfield. Sewage reaching treatment works from a combined sewer system must be subjected to passage through a grit chamber to remove sand and coarse gravel. This is accomplished by an increased flow area, to reduce the velocity to 15 inches per second or less. The types in use in Frankfurt, Dusseldorf and in the Emscher district are good examples. Deposited solids are usually removed by elevator bucket dredges having transverse motion on tracks. This admits of operation without putting the grit chamber out of service.

Screens.—Hamburg, Frankfurt, Dresden, Bolton. Screening in England is for the purpose of removing such solids as would clog pumps or would be not readily reduced in tank treatment; therefore, it is coarse screening, the bars being spaced about 2 inches.

In Germany, however, it is considered in many places as a complete and efficient treatment; therefore their manufacture and maintenance have received much more attention. Usually there is a coarse screen of about 3 inches spacing composed of bars to protect pumps or valves. The screening processes proper consist in the main of three types designated as Hamburg, Frankfurt and Dresden.

The Hamburg type consists of a curtain inclined at an angle running over drums, brush-cleaned. The apertures of the screen are about ⅜ inch. Where there is a large tidal range and fluctuating depth in the sewers, this is most effective and can be operated with slight nuisance although it is cleaned by brush with difficulty.

The Frankfurt screen consists of five vanes cleaned by a comb, the prongs of which alternate with the spaces of the screen. The combings are passed to a table, which disappears under a knife edge, the scrapings going to a belt, the screen being easily cleaned and very efficient.

The Dresden screen, introduced in about fifty European plants in Germany, Austria and Russia, is the most improved and simplest in its operation. The cleanliness that can be maintained is hard to believe unless seen, being entirely without nuisance or objectionable features. The spacing is about 1-12 inch. Its efficiency will average over 50 per cent. solids removed. Screens, however effective, cannot compete with properly designed tanks.

Tanks.—Frankfurt, Birmingham, Essen 2. Without entering into the comparative merits of settling, septic, sedimentation, Emscher or other forms of tanks, a number of types are shown.

Where the sizes of rivers and the consequent dilution is large, and water supplies are not jeopardized, the rivers boards of Germany have after examination pronounced fine screening of sewage a sufficient protection of the rivers.

Where smaller rivers must be used for final disposal or water supplies must be protected there is added some form of tankage treatment.

Septic tanks as at Wilmersdorf deal with a concentrated sewage, are foul smelling, though the final effluent is satisfactory.

In sedimentation tanks as at Frankfurt, each unit has a storage period of one and one-half hour; cleaning is resorted to once a week. The type tank involves the placing of a unit out of service when being cleaned, resulting in odors noticeable underground at 150 feet distance.

Throughout England the septic tank is in use designed for storage periods of from twelve to twenty-four hours.

The difference between the German practice of about two hours and the English practice of eighteen hours' storage, calling for from five to ten times larger tankage area, is due to the smallness of the English rivers and the necessity of taking out as large a percentage of solids as practicable.

Methods of cleaning tanks of deposit are various, that at Bolton consisting of a squeegee having considerable merit.

At Frankfurt the sloping sides and bottom enable the sludge to flow to a central sump, whence it is pumped to centrifugal dryers.

Compare the area of the tanks in Birmingham (12 acres) for 900,000 inhabitants with that of Essen Nord (½ acre) for 190,000, which illustrates the difference in area as given above, required according to the practice in these two countries.

The so-called two-story tanks, called Emscher tanks because used in the Emscher district, are twofold in their operation. They provide a sedimentation chamber for about two hours' storage, and a digestion chamber for sludge, there being a diaphragm to separate the liquid from the solid parts of the sewage. The gases generated by the decomposing sludge do not pass through the sedimentation chamber; therefore the liquid remains fresh as distinguished from septic or smelly sewage. The biological processes carried on in the digestion chamber successfully mineralize the sludge, so that when withdrawn, usually by hydraulic pressure, due to difference in head between tank water and sludge outlet, the product is without objectionable odor, and is like garden soil, suitable for filling in low ground if not utilized for fertilizer.

The tank can be cleaned without placing out of service, and is to-day on many points the most efficient type in use.

Tank treatment, even with long storage periods without supplementary treatment, is not sufficient to prevent extreme pollution of the small English rivers, whereas with the larger German rivers, it is efficient, with short storage periods.

Contact Beds.—Sheffield. A form of bacterial bed in use largely in England and America is the contact bed, consisting of a basin enclosed by walls, filled with cinders, fine stone or other materials, into which sewage, usually after being submitted to tank treatment, is admitted slowly, allowed to stand some hours, then slowly emptied, and allowed to stand empty for some hours, the oxygen admitted during the withdrawal of the liquid serving to provide food for the bacteria acting upon the solids attached to the surface of the material in the bed. The so-called slate beds may be so classed because of the similarity of operation.

Two good examples are at Manchester and at Sheffield, the first caring for the sewage of about 250,000, the latter of about 470,000 inhabitants.

The process is regarded as effective, but as the amounts that can be treated are small, about 500,000 gallons per acre per day, about one-fourth of the amount which may be treated in other more rapid processes, percolating filters, for example, with a consequent larger area and larger maintenance charges, more intensive processes are talked about, but as much capital is locked up in such large plants it is difficult to make radical changes.

Percolating Filters. — Wilmersdorf, Birmingham, Huddersfield, Bolton, Salford. Percolating filters consist of beds of cinder, broken stone, gravel or other hard material, thoroughly underdrained, upon which the sewage, subjected to preliminary treatment, is applied by some form of distributor, usually to spray the liquid; rotating arms, longitudinally travelling trough, fixed nozzles, or by means of a network of perforated pipes laid on the surface of the filter. With the exception of the circular filters, 65 in number, at Wilmersdorf, near Berlin, with rotating arms, and a few small scattered examples there are none of these beds in Germany, although experimental installations have been in use, and their ultimate use is forecasted, notably in Hamburg and Leipzig.

An experimental station of large size has been in operation in connection with the work at Paris, France, as a result of which the speaker was informed by M. Verrière, the chief engineer, that in the forthcoming report for the remodelling of the system percolating filters would be recommended in place of the existing farms.

In England the use of the percolating filter is most extensive, not as a matter of choice, but from necessity.

The prevalence of cities with large populations, and the many manufacturing villages forming a chain between, with the comparatively small sizes of the rivers and the great amount of pollution which reaches them, in some cases equalling their flow volumes, have forced more complete treatment of waste liquids than can be obtained by screening and tank treatment alone. This is especially the case in the manufacturing sections, Warwickshire, Lancashire and Yorkshire. Ten years ago it was the view of Sanitary Engineers that septic tanks would reduce and liquefy 90 per cent. of the sludge deposited in them; now it is known that between 10 and 20 per cent. is the average reduction.

Within twenty years millions of pounds sterling have been expended upon works, but some are being consigned entirely to the scrap heap, as at Leeds, many others are being planned to supplement present treatment by percolating filters, and many are in a process of alteration.

When it is considered that by resorting to these filters the rate of treatment for English sewages can be doubled over the best contact bed system, the matter of area of ground and construction cost alone shows economy.

With strong English sewages composed largely of manufacturing wastes, there is considerable odor from these spraying filters. The small white moths or flies that infest them are an intolerable pest. Experience shows that this nuisance is greatly reduced by surrounding the filters with close stone walls and placing a fine surface medium.

Sludge Disposal.—Of all matters reaching a sewage treatment plant, that of proper disposal of the sludge, or residue from tankage treatment is the most serious. A dozen plants can be named, the efficiency of each of which from an operating standpoint is unquestioned, with the single exception of sludge disposal. The methods of disposal vary with the local conditions. They comprise, irrigating on farm land, underdrained lagoons, burying in trenches, pressing and drying, centrifugal drying machines, briquetting and burning, canal boats to farms, steamer to sea, digestion in tanks and drying on sand beds then used for filling.

The effectiveness from the standpoint of lack of nuisance about the works is as follows: (1) digestion, drying and filling, (2) steamer to sea, (3) drying under heat. The remaining methods are ineffective.

1. The speaker has stood in the centre of a 6-acre tract of air-dried sludge, 50 per cent. moisture, of depth varying from 3 to 12 feet, in damp weather, without detecting any more odor than would be noticed from a freshly ploughed unfertilized field. Example—All over the Essen district.

2. Pumping to steamer and disposal at sea is positive in the removal of all nuisance except during cleaning of tanks. Examples—London and Manchester.

3. During cleaning of tanks and during drying by centrifugals, it is smelly within the building; after drying by heat, there is no further objectionable odor. Example—Frankfurt a. Main.

It may positively be asserted, therefore, that with certain treatments the sludge problem is satisfactorily solved.

When sufficient fats are present in the sludge (about 25 per cent.) they may be profitably recovered as at Bradford.

Notable Treatment Works.—Notable as being the best of their kinds are the following works:

Hamburg—Grit chamber screening and dilution in the Elbe.

Dresden—Grit chamber and fine screening with dilution in the Elbe.

Vienna—Efficient collecting systems with dilution in the Danube.

Frankfurt a. Main—Grit chambers, screens, settling tanks, sludge dried in centrifugals, further dried by heat and burnt under boilers to produce electric current.

Wilmersdorf—Primary settling tanks, percolating filters, secondary tanks, sand filtration, sludge in lagoons.

Cologne and Dusseldorf—Fine screening and tankage, with dilution in the Rhine.

Berlin and Paris—Farms.

London—Screens and tanks with dilution in the Thames, sludge to sea.

Manchester and Sheffield—Screens, tanks and contact beds.

Birmingham—Detritus tanks, settling tanks and percolating filters, sludge to lagoons.

Salford—Grit chambers, settling tanks, roughing filter, percolating filters, sludge mixed with chemicals, pressed and dried.

Many others will outclass these when new works shall be in operation.

River Fronts.—One of the most noticeable results of the establishment of sewage disposal works, is in the ability to improve and embellish river fronts.

In London not many decades ago the stench from the sewage polluted Thames invaded the Houses of Parliament and pleaded the cause of sewage treatment. The cleaning up of the Seine at Paris, the Spree at Berlin and other rivers was accomplished only after centuries of warning sounded by the periodical visitation of pestilence. River nuisance has been successfully avoided in European cities by the construction of interceptors along the river banks.

Lessons.—The choice of a certain process can not be made because of its reputation for effectiveness, but the design must be determined upon only after all phases of the local conditions are considered, starting with the characteristics, size and volume of the river into which final disposal is to be made, and adopting the most economical system, the effluent from which will not unduly overload the river, and which will utilize the available diluting capacity of said river, or parts of a river.

The lessons learned from an inspection of European cities may be briefly summed up as follows: Collecting systems are designed with the most minute attention to economy, therefore along scientific lines.

The quality of material and workmanship in sewer construction are superfine, due in a measure to mechanics' wages being one-third of ours.

For the best developed screening appliances we must look to Germany.

Tanks, both on account of economies in areas and scientific design for construction and operation have been developed to a better standard in Germany than elsewhere.

Percolating filters, and the operation thereof may be best studied in England. Scientific experimentation on this system has been more thoroughly carried out in Paris.

The investigations upon river dilution have been carried on more thoroughly in Germany.

Sludge disposal, except where it is carried to sea, has not been solved in England. In Germany, it has been satisfactorily solved by several methods.

The English sanitary world is hopeful that we are on the eve of developing a more intensive, economical and effective means of treatment than the percolating filter.

The engineers in charge of the new "third lock" at the Soo Canal in Sault Ste. Marie, Mich., have predicted that before the end of the month, this lock, with a length of 350 feet greater than any other lock in the world, will be open to navigation. The new lock has a total length of 1,350 feet, a width of 80 feet, and a depth sufficient to permit boats of 24-foot draft to pass through it. With the locks already in operation at this point, the new lock will permit a gross tonnage to pass through from the waters of Lake Superior to the lower lakes that is ten times greater than the expected annual tonnage of the Panama Canal. Three locks are now in operation in the canal, two on the American side of the St. Mary's River and one on the Canadian side. Two additional locks are under construction on the American side, one being that known as the "third lock."

The display of Canada's natural resources at the Canadian National Exhibition this year will be a record in its completeness. The farm, the forest, the mine, the fisheries and the sources of other industries will be depicted in a most comprehensive manner. The federal and provincial governments are preparing extensive exhibits.

The Dominion Creosoting Co. (Limited), of Vancouver, has received from the Bengal and Northwestern Railway Co. of India an order for 160,000 creosoted railway ties. The specifications call for the best quality of seasoned Douglas fir, to be treated with 12 pounds of creosote per cubic foot, under specified temperature and pressure conditions. If the Douglas fir ties prove satisfactory for railway construction in India it is probable that other large orders for similar supplies from British Columbia will follow, and the creosoting industry of the province will be given a decided impetus from India.

The loss sustained by the G.T.P. Steamship Co., in the fire which destroyed recently the company's pier at Seattle, Wash., is estimated at $350,000. Damage was also done to the Coleman dock, both the pier and dock being located in the very heart of the Seattle waterfront, which brings the total estimated damage caused by the fire to about $500,000.

VOLUME CHANGES IN CEMENT AND CONCRETE.

PROF. A. H. WHITE, of the University of Michigan, has carried out a scientific investigation, covering many years, into the changes that Portland cement undergoes after hardening in water and being alternately exposed to wet and dry. Three years ago he presented a paper on the subject before the American Society for Testing Materials. Since 1911 he has continued his experiments, to find his earlier results confirmed. Further, it has been shown that the destructive action of these forces of expansion and contraction may be even more serious than was previously thought probable. Prof. White's later results formed the basis of a paper which he read recently at the 17th Annual Convention of the Society. His paper is a continuation of the preceding paper, and discusses the effect of high and low temperatures in addition to the effect of varying moisture. The results are dealt with in detail, and form an extensive treatise. A summary of them are given below:—

The tests confirm the theory that Portland cement in reacting with water forms a colloid which expands when wet and shrinks when dry. It does not become irreversible and lose this property, even after 20 years' exposure to the weather or after heating to 600° F. The length of a bar which has passed through a cycle of drying and wetting is not usually the same as it was before the cycle, but may be longer or shorter. Under ordinary conditions the bar remains elongated because water acts more rapidly, and the compressive strength of the expanding colloid is more than the tensile strength of the contracting colloid. This is especially true in concrete or in mortar where the particles of aggregate forced apart by the expansion lock in their new positions so that the bar remains permanently elongated. With neat cement, where the only aggregates are the unattacked particles of clinker, the bar may be made to grow shorter. By suitable alternations at elevated temperatures a bar of neat cement has been made to shrink in length 4.6 per cent. and under identical conditions, a bar of 1:3 sand mortar to elongate 0.75 per cent. Bars sawed from a sidewalk taken up in good condition after 20 years' service were made to attain a further elongation of 0.175 per cent. for the top coat and 0.130 per cent. for the base after a series of prolonged wettings and dryings at room temperature. This is an expansion equivalent to that which might be expected from a temperature variation of 300° F.

Concrete which has been properly made, and in which the colloid has been properly developed, has its interstitial spaces so filled with dense colloid when it is thoroughly soaked in water that there is no liquid water present in the pores. Such concrete may be frozen without any expansion. In fact, it will contract with temperature change at almost exactly the same rate as cast-iron. If the concrete has been poorly prepared or if there has been insufficient opportunity for the cement to develop its colloid by reacting with water, then its pores when wet will contain liquid water which will expand as usual on freezing, with possible resultant disintegration.

Concrete kept constantly wet from the time it is poured will expand rather slightly, and after a few years will be practically in equilibrium with its surroundings, and will not suffer further change since the pores have become filled with a dense colloid, which prevents water from acting on the unchanged cement. Such concrete will contract at low temperatures at the same rate as cast-iron, but will otherwise be unaffected by freezing, and may be considered a permanent structure. It will be in compression throughout because of the development of the colloid and will, therefore, be strong. The slow development of the colloid of the cement in contact with water explains the decrease in leakage frequently shown by dams and reservoirs after they have been put into service.

Concrete which is allowed to dry soon after it is poured, and which thereafter remains exposed to the air but protected from rain, will be weak because its colloid has been insufficiently developed. Further, it will—if its ends are restrained—be in tension because it shrinks as the colloid becomes dehydrated. Even this concrete will, however, react with the moisture of the air and will probably gain strength in the process, so that concrete used in the interior construction of buildings will probably meet its severest test within the first few months after it is poured. Concrete of this type will nevertheless have a relatively poorly developed colloid and will be porous. If it becomes wet and freezes, it will expand and the expansion may be permanent.

Concrete which is exposed to the weather is put to a very severe test. It expands and contracts when alternately wet and dried, and probably retains this property indefinitely. It has no stable condition, but is always slowly changing. The changes are progressive, especially where the concrete is occasionally kept thoroughly wet for perhaps a month at a time. This period is sufficient to cause the colloid to expand quite fully. At first the only effect is to make the concrete more dense and to fill up the pores. After several years the mass begins to expand as a whole. The particles of gravel are forced apart, and, wedging in their new positions, fail to return when the concrete dries again. The next time the concrete is wet an added quantity of water enters and reacts with still unchanged cement, with the result that there is larger expansion. This progressive elongation is the cause of the pressure ridges and upheavals found frequently in old cement sidewalks. It has been shown in this paper that sidewalks after 20 years' service still possess this capacity for further progressive expansion. This phenomena is, of course, more serious in damp climates than in dry ones, and in moist locations than those which are well drained. The author has seen cement sidewalks in exceptionally well-drained situations which showed very little signs of deterioration after 20 years of service.

When concrete dries the surface dries relatively rapidly and the shrinkage is considerable, especially if it is rich in cement. This shrinkage of the surface while the rest of the structure is still wet and expanded causes hair-cracks to appear on the surface, even when the unit is small and entirely unrestrained. Each subsequent expansion and contraction will cause this hair-crack to deepen. The disintegrating effect will undoubtedly be accentuated by impacts such as concrete highways receive from traffic.

The changes of volume due to moisture are more apparent with mixtures rich in cement than with lean mixtures. In sidewalks and pavements it would, therefore, be expected that the rich top coat would expand and contract to the greater extent. This is frequently the case, and its results may be seen in sidewalks where the top has split off the base, due to differential expansion. However, the rich mixture with its greater tensile strength tends to contract to its original length more perfectly than the mixture with less cement and more gravel, and in pavements and sidewalks the leaner base is buried in the ground, where it remains wet for a longer period. Under proper conditions, therefore, the base may ultimately expand more than the top coat and give the concave effect to a walk or pavement which is not infrequently observed.

Frost is not much to be feared as an initial instrument of disintegration of properly mixed cement which has been given a fair chance to develop its colloid, since the amount of liquid water in the pores of the concrete is too small to cause serious expansion. If disintegration has started from other causes, water may enter in larger quantities, and on freezing may cause serious injury.

If concrete, and particularly rich concrete, is to remain exposed to the weather, the only way to keep it in good condition is to so place it or protect it so that it will not be subject to great fluctuations in its moisture content. The most trying conditions are those which concrete highways have to meet. As pavements are now being laid, they seem certain in many localities to prove a serious disappointment to those who are building them with the expectation that they will be permanent structures.

MONTREAL TRAMWAYS' GOOD REPORT

A good report has been presented to the shareholders of the Montreal Tramways Company, it having earned over 30 per cent. on its stock, while showing substantial increases both in gross and net earnings. For the year ended June 30th, the gross earnings showed a gain of $388,577, or 5.7 per cent., and the net earnings an increase of $215,127, or 7.9 per cent.

The following table compares the chief items of the reports of the two years:—

	1914.	1913.
Gross earnings	$7,142,804	$6,754,227
Expenses	4,206,114	4,032,664
Net earnings	$2,936,689	$2,721,562
Less—		
City's percentage of earnings	527,383	489,079
Bond interest	787,768	721,151
Debenture interest	800,000	800,000
Taxes	84,700	73,000
Leaving—		
Net income	$ 736,836	$ 638,331
Dividends	242,056	156,382
Surplus	$ 494,780	$ 481,949
Reserves	275,000	223,670
Bond discount	82,236	63,714
Net surplus	$ 137,543	$ 194,564

The company's net income was $736,836 for the year, after payment of the city's percentage of earnings. Interest charges and taxes were $98,505, or 15.3 per cent. higher than the previous year. On the average paid-up capital stock for the year this represented earnings at the rate of 30.4 per cent. After dividends had been paid, a surplus balance of $494,780 remained, or $12,831 more than the previous year. From this balance $275,000 was transferred to reserve funds and $82,236 was applied to write off discount on bonds sold.

The balance sheet reveals an advance in current liabilities from $1,475,995 to $1,646,238, with a decline in current assets from $3,725,925 to $1,893,482. This is explained by the fact that new construction was undertaken last year to the extent of about $1,000,000 more than was originally intended, while in the previous year the company had a large sum credited to its account with its bankers against the projected sale of bonds covering plant additions. As expenditures have now been to an amount in excess of $1,000,000 for which the company has the right to issue bonds or stock, the liquid position can be strengthened by the sale of securities at any time.

The company reports that during the year the sum of $2,711,572 was expended on new construction, against $976,008 the previous year; the sum of $829,706 was also expended on maintenance and charged to operating expenses while a further amount of $417,124, charged to renewal account also went towards the upkeep of the properties.

A SWISS REINFORCED CONCRETE ARCH BRIDGE.

An arch bridge which shows the fine architectural possibilities of reinforced concrete is in course of erection near Langwies, Switzerland, for carrying a metre-gauge electric railway over a valley. The general elevation of one-half of the bridge is shown in Fig. 1, the dimensions being in metres. The main arch is 100 m. (328 ft.) in span between the centres of the rib at the springings, and it was only after a considerable amount of discussion that the Swiss Railway Department allowed the use of reinforced concrete for a span of this magnitude; the rise is 42 m. (138 ft.), and on each side of the main span there are four spans of 16 m. (52 ft.) The arch was designed as an elastic hingeless arch, the platform girders approach spans being treated as continuous beams, expansion joints being provided at the top of the double pillars. The central span comprises two separate arched rings, the thickness of which is about 7 ft. at the crown. The width of either rib at the top of the crown is 3¼ ft., and being battered lengthwise it increases regularly from crown to springing. The two arched rings are tied together by means of rigid cross-beams.

The main girders of the outer spans are constructed in the form of beams with a varying moment of inertia, and are connected with their supports in such a manner that a certain amount of movement is possible. The bearing-plates at the points of support of the pillars of the outer spans have been reduced to a narrow margin of area, with the view of ensuring a hinge effect.

The construction of the viaduct has been designed from the point of view of ensuring a maximum saving of material and a minimum as regards actual stresses. This was rendered more possible owing to the live load on the bridge being a comparatively light one in proportion to its dead weight. This also explains the application of two cross-tied arched ribs instead of a monolithic ring, although the latter form has also been carefully taken into consideration. The stress calculation of the viaduct has been based on the assumption of a test-load train that comprises two locomotives of 65 tons service weight each (the type of the Rhaetic Railways), and an unlimited number of adjoining goods trucks that are coupled in one direction. With regard to the stress calculation of the secondary girders, viz., the railroad deck and the minor spans, an addition to the above live load of 15 per cent. has been considered. The additional forces that have been taken into account comprise:—

(1) A temperature change of + 15 deg. (Centigrade).
(2) Contraction due to setting — 20 deg.
(3) Braking forces—one-seventh of the total weight of the loading train-axles.
(4) Wind pressure: (a) 20 lbs. per sq. ft. when the bridge is in super-loaded condition; (b) 30 lbs. per sq. ft. when the bridge is in unloaded condition.

The modulus of elasticity has been assumed: $m = 15$.

The safe maximal compressive stress of concrete:

$c = 500$ lbs. per sq. in.,

providing the dead weight of the bridge is combined with the most unfavorable superload (live load);

$c = 640$ lbs. per sq. in.,

providing all the secondary and additional forces are taken into account, i.e., temperature, contracting due to setting, braking-forces and wind pressure.

The safe shearing stress of concrete is assumed:

$s = 60$ lbs. per sq. in.

Safe tensile stress of steel for reinforcement: $t =$ 14,200 lbs. per sq. in., provided the dead weight of the bridge is combined with the most unfavorable super-load (live load);

t = 17,000 lbs. per sq. in.,

provided all the secondary and additional forces are taken into account.

The above figures are based upon the assumption that the concrete (that is mixed on the spot and is daily controlled and tested by a Martens' set of registering apparatus) shows the following minimum standard strength after 28 days of setting time:—

2,880 lbs. per sq. in.

when being rammed on the spot in a plastic condition (poured concrete);

3,550 lbs. per sq. in.

when being rammed on the spot in a moist condition.

The peculiar arch-centring is interesting. The upper part of the falsework has been constructed in the form of a fan built up with round timbers obtainable on the spot in great lengths, at a low price and of good quality. This timber scaffolding is supported by three reinforced concrete towers which have been constructed in the form of framework or skeleton towers. These reinforced concrete towers were employed for the following reasons: it was not advisable to obstruct the valley too much by the falsework, as the scaffolding is exposed to danger from floods, and is thus liable to damage at times when the snow melts and the two mountain brooks, which join just on the building site, carry down enormous masses of water and pebbles. For this very reason the erection of a scaffolding composed of uprights was out of the question, and the tower system only was suitable. Timber-work towers would have obstructed the passage more than reinforced concrete towers, and furthermore they would not have possessed the same amount of stability. The substructure and the foundations would in any case have required the use of reinforced concrete, even if timber-work towers had been erected, as the driving of wooden piles was absolutely impossible on account of the nature of the subsoil, which is composed of coarse pebbles and is intermixed with loose blocks.

The total settlement of the main arch had to be reduced to a minimum, and this also was another reason for using reinforced concrete for these towers. When the central arch was closed the arch centring showed a total settlement of, roughly, 1.2 inches, inclusive of .4 inches which occurred through the headpieces of the diagonal struts cutting into the capping-pieces of the stringers.

The erection of the viaduct was begun late in 1912, but at the commencement of the work operations had to be confined to foundations of the abutments, winter setting in before time and causing an interruption of the work for several months. Not before April, 1913, could the work be resumed, and the concrete work of the large arch was completed on October 6th, in 1913. The winter, of course, again interrupted the work, but it was continued this season.

We are indebted to Concrete and Constructional Engineering for the above illustration and particulars.

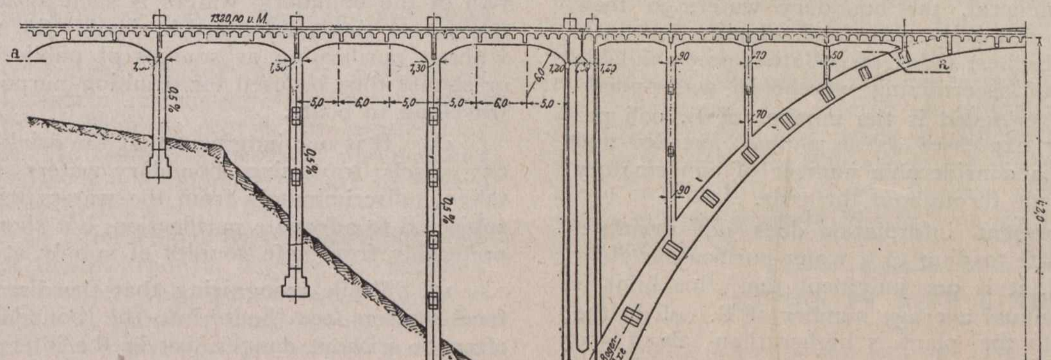


Fig. 1.

Recently the Society of Road Standardization of America sent out from Chicago its first survey in the interest of standardized roads. The road experts engaged upon this initial trip are G. E. Minor, formerly connected with the Old Trails Association, the National Highways Association, and the Indiana Good Roads Association, and H. W. Denis. Their route will proceed through seven states from Chicago to the Pacific coast, the termination of which is to be San Diego, Cal. The primal purpose of the survey is to lay out, map, and log 60,000 miles of the best and most travelled roads in the United States so as to bring to a maximum simplicity the matter of following roads to the destination desired. The Society is formed by men interested in the subject of good roads in general and transcontinental highways in particular.

On July 19, the largest electric lamp in the world was lighted and will continue to shed light for some weeks in the New York navy yard. This lamp is a searchlight which has just been installed and is capable of throwing light for a distance of 100 miles. It is called the Beck searchlight, and is the invention of Heinrich Beck, a German scientist, who is conducting tests of his lamp for the United States Government. Measured at 2 miles from the lamp, 450,000,000 candle-power is obtained from a lamp with a 44-inch reflector. The present 44-inch lamp in use on the world's best ships, gives only 60,000,000 candle-power. For coast defence a 60-inch reflector is now in use. Such a reflector hitched to the Beck searchlight gives a billion candle-power, as against 180,000,000 candle-power now obtained.

POLLUTION OF BOUNDARY WATERS.

THE following conclusions relating to water purification and sewage treatment have been arrived at as the result of a conference of consulting sanitary engineers, held at the request of the International Joint Commission in connection with its investigation of the pollution of boundary waters between Canada and the United States. Messrs. George W. Fuller, Earle B. Phelps, George C. Whipple, F. A. Dallyn, W. S. Lea and T. J. Lafreniere are the engineers who participated in the conference, the first three being in practice in the United States, and the second three in Canada. They were submitted a list of questions by the Commission.

The resulting discussion is summed up in the following résumé, which was signed by all except Mr. Dallyn:—

1. Speaking generally, water supplies taken from streams and lakes which receive the drainage of agricultural and grazing lands, rural communities, and unsewered towns are unsafe for use without purification, but are safe for use if purified.

2. Water supplies taken from streams and lakes into which the sewage of cities and towns is directly discharged are safe for use after purification, provided that the load upon the purifying mechanism is not too great and that a sufficient factor of safety is maintained, and, further, provided that the plant is properly operated.

3. As, in general, the boundary waters in their natural state are relatively clear and contain but little organic matter, the best index of pollution now available for the purpose of ascertaining whether a water-purification plant is overloaded is the number of B. coli per 100 c.c. of water expressed as an annual average and determined from a considerable number of confirmatory tests regularly made throughout the year.

4. While present information does not permit a definite limit of safe loading of a water-purification plant to be established, it is our judgment that this limit is exceeded if the annual average number of B. coli in the water delivered to the plant is higher than about 500 per 100 c.c., or if in 0.1 c.c. samples of the water B. coli is found 50 per cent. of the time. With such a limit the number of B. coli would be less than the figure given during a part of the year and would be exceeded during some periods.

5. In waterways where some pollution is inevitable and where the ratio of the volume of water to the volume of sewage is so large that no local nuisance can result, it is our judgment that the method of sewage disposal by dilution represents a natural resource, and that the utilization of this resource is justifiable for economic reasons, provided that an unreasonable burden or responsibility is not placed upon any water-purification plant, and that no menace to the public health is occasioned thereby.

6. While realizing that in certain cases the discharge of crude sewage into the boundary waters may be without danger, it is our judgment that effective sanitary administration requires the adoption of the general policy that no untreated sewage from cities or towns shall be discharged into the boundary waters.

7. The nature of the sewage treatment required should vary according to the local conditions, each community being permitted to take advantage of its situation with respect to local conditions and its remoteness from other communities, with the intent that the cost of sewage treatment may be kept reasonably low.

8. In general, the simplest allowable method of sewage treatment, such as would be suitable for small communities remote from other communities, should be the removal of the larger suspended solids by screening through a ¼-in. mesh or by sedimentation.

9. In general, no more elaborate method of sewage treatment should be required than the removal of the suspended solids by fire screening or by sedimentation, or both, followed by chemical disinfection or sterilization of the clarified sewage. Except in the case of some of the smaller streams on the boundary, it is our judgment that such oxidizing processes as intermittent sand filtration, and treatment by sprinkling filters, contact beds, and the like, are unnecessary, inasmuch as ample dilution in the lakes and large streams will provide sufficient oxygen for the ultimate destruction of the organic matter.

10. Disinfection or sterilization of the sewage of a community should be required wherever there is danger of the boundary waters being so polluted that the load on any water-purification plant becomes greater than the limit above mentioned.

11. It is our opinion that, in general, protection of public water supplies is more economically secured by water purification at the intake than by sewerage purification at the sewer outlet, but that under some conditions both water purification and sewage treatment may be necessary.

12. The bacteriological tests which have been made in large numbers under the direction of the International Joint Commission indicate that in some places the pollution of the boundary waters is such as to be a general menace to the public health should the water be used without purification as sources of public water supply, or should they be used for drinking purposes by persons travelling in boats.

13. It is our judgment that the drinking water used on vessels traversing boundary waters should not be taken indiscriminately from the waters traversed, unless subjected to adequate purification, but should be obtained preferably from safe sources of supply at the terminals.

14. While recognizing that the direct discharge of fecal matter from boats into the boundary waters may often be without danger, yet in the interest of effective sanitary administration it is our judgment that the indiscriminate discharge of unsterilized fecal matter from vessels into the boundary waters should not be permitted.

Mr. Dallyn's revision of the résumé report is not essentially different from the above. He insisted on the elimination of paragraphs 5, 7 and 11, which he considered to be an expression of self-evident facts. He also substituted "monthly" for "yearly" averages in determining the number of B. coli per 100 c.c. of water (clauses 3 and 4).

SHRINKAGE OF ALLOYS.

The excessive shrinkage of brass or bronze alloys necessitates a core which will be crushed readily by the molten metal. Large cores should be made with a soft interior, and this is generally accomplished by filling the interior of the core with cinders, powdered coke, or similar material. The core material must be fine, and this requires the use of finer sands for brass-foundry cores than those usually used in iron foundry work. When a brass casting has been poured and is shaken from the mould, care should be taken to keep the core sand from mixing with the molding sand. The cores for brass and bronze castings are sometimes blown out by shaking out the molds while the castings are still fairly hot, and then dipping the castings in water. The steam generated in the cores blows out the core sand, and gives the castings a better color. Iron castings would be broken by this treatment, but brass castings are rendered softer.—American Machinist

Editorial

THE WAR AND CANADA'S IMPORT TRADE.

The remarkably abrupt quietus which trans-Atlantic commerce received upon the breaking of the war cloud in Europe has been followed by a disturbing indefiniteness as to the duration of the interruption to import trade. In any event, Canadian imports for the year 1914 will be considerably at variance with the uniformly increasing figures for recent years. Last week's announcement of the British naval authorities that the Atlantic routes between England and America were free from danger of molestation by foreign warships is not sufficient assurance for an early resumption of the Atlantic trade other than to and from the British Isles. It is something to be able to send merchandise across safely, but the market conditions at points of destination are considerably more important. Until the war is over and hostilities between the great powers at an end, Canada need not expect that her needs will receive attention, in some European markets at least. Trade with Germany, for instance, is impossible, being stopped completely. In order to continue its present lines of industrial and engineering activity, this country might as well proceed forthwith to look elsewhere for the supplies for which it has been in the habit of paying Germany her good money.

Leaving as unscathed the big bulk of engineering supplies which Canadian manufacturers have provided, and are likely to continue to provide in considerably greater quantities, the remaining needs of national and municipal sustenance and development must be looked after almost entirely by trade with Great Britain and the United States. The latter enjoys over eighty per cent. of Canada's total import trade in engineering supplies. Under present conditions this percentage is likely to increase materially, and Britain's share should undoubtedly do the same. The impression has become prevalent in England during the past week or more that British manufacturers should endeavor at once to secure the overseas' orders which Germany has hitherto had.

The report for the year 1913 of Mr. C. Hamilton Wickes, British Trade Commissioner in Canada and Newfoundland, contains some import statistics that speak for themselves in this respect. The gross receipts of all classes of metal manufactures, machines, machinery, equipment and hardware in 1913 amounted to $198,500,000, an increase of $58,500,000 over 1912. Classifying them and adding percentages, they are as follows, values being given in £:—

(1) Simple Manufactures of Metal.

Source.	Value in £.	Per cent.
United Kingdom	2,410,000	12.7
United States	16,000,000	85.0
Other countries	410,000	2.2

(2) Machines, Machinery and Equipment.

United Kingdom	1,260,000	8.6
United States	13,160,000	90.3
Other countries	150,000	1.0

(3) Hardware.

United Kingdom	780,000	12.4
United States	5,160,000	81.8
Other countries	350,000	5.7

Of the gross imports of metals, machinery and hardware, amounting to $198,500,000, those which are classed as "Competitive merchandise" amount to $155,900,000, the United States' share being 83.03 per cent. and Great Britain's, 14.08 per cent.

In connection with this showing, the British Trade Commissioner states: "Only by the share of this trade (Competitive merchandise) which is secured should the efforts of the British manufacturers be judged, and only by these figures should the value of the Dominion market to manufacturers of the United Kingdom be estimated."

With these figures in mind one may venture an opinion as to the effect of the European disturbance upon the general trend of Canadian imports. Evidently the elimination of imports from Continental Europe means an increased demand upon home industries. Second to it, there should be an increased import trade from Great Britain and the United States. For engineering supplies not procurable at home, our cousins to the south will undoubtedly come in for a large share (owing to advantages of easy and rapid access to the market, like currency and similar requirements of customers). British manufacturers will naturally take full advantage of the opportunity now open to supply from her own industries all imports that were hitherto European, and overcome the recognized inconveniences of different standards of manufacture, fluctuation of prices owing to exchange, etc. Obviously, too, better acquaintanceship with the Canadian market and trade conditions will go a long way to minimize the difficulties that one sometimes reads about in the British press. Besides which, the nations which get the business in war time are likely to keep it in peace.

SURGES IN PIPE LINES.

Advancement in the field of hydraulic engineering during the past ten years has been rapid, compared with the history of previous development of this branch of the profession. Turbine efficiencies have been raised from the possible maximum of eighty per cent. to present-day results of ninety-three per cent., or an actual increase of sixteen per cent. in the power which it is possible to derive from any particular development. Runners for a great range of conditions are easily obtained in these times, with specific speeds ranging from ten to one hundred and capacities in single wheels up to almost any horse-power. Hydraulic governors have practically reached the stage of perfection; little more can be asked from the mechanical standpoint for the regulation of water-power plants.

There is one feature of the design of hydro-electric developments, however, that has not progressed with the same rapidity as those just mentioned. We refer to the regulation of the water columns in those plants having long feeder pipe lines and penstocks. For this reason it is with considerable pleasure and satisfaction that we draw the attention of our readers to a treatise on surge tank problems, the first part of which appears in this issue.

Probably the reason for tardy analyses such as this, compared with like investigations in other phases of hydro-electric design, lies in the fact that it is only of recent years that such long penstock lines, with their associated problems, have been installed.

Interest, however, has been aroused to the point of keenness regarding the best method of securing close speed regulation, commercially and economically. A recent discussion in an engineering contemporary, published in the United States, regarding the means used on the Los Angeles aqueduct for regulating the surges due to changes of load on the power plant shows that the methods employed in that instance were far from being economical, at least $200,000 having been spent in excess of what would have been the necessary outlay if another solution to the problem had been applied.

Professor Prasil's work will, therefore, be read with interest and benefit by engineers who have had to do with the design of plants for these conditions. One serious defect in the analysis that will be noted as the discussion continues, is the fact that frictional losses in the pipe or penstock are assumed to vary with the first power of v, instead of 1.8 power or with the square of v, as is actually the case. Evidently the integrations resulting from the use of the correct power have been too difficult for mathematical manipulation and the writer has accordingly been compelled to approximate.

The paper will bear careful study, however, as it throws considerable light upon a most difficult subject, and the translators are to be congratulated upon having put it into shape for readers of English. It is hoped that those who are interested will enter into a discussion of this subject, for as yet far too little is known, or has been published, dealing with the most efficient and proper means of handling the inertia of long water columns.

STEEL CASTINGS FOR THE QUEBEC BRIDGE.

Sixteen grillage castings for the new Quebec Bridge have just been completed. They are worthy of note because they are much larger than any steel castings previously made in Canada. The weight of each is about 43 tons. Each is 21 ft. x 6 ft., 8 in. x 4 ft. in dimensions. Owing to the intricate design of the interior of these castings necessitating a large number of cores the making of the moulds required a high degree of skill and accuracy. The material used in them is a high grade of steel, being scrap metal procured from the wreck of the old Quebec Bridge.

Upon their arrival at the bridge site they will be bolted in pairs, two pairs to each concrete pier carrying the main columns of the bridge.

COMMISSION GOVERNMENT AT EDMONTON.

Following are a number of the clauses adopted by Edmonton as a part of their new commission form of government charter:—

1. That by a two-thirds vote of the electors the charter may be amended without reference to the legislature; except in matters affecting franchises and the borrowing powers of the city.
2. That the commission council shall consist of five commissioners elected at large.
3. That commissioners shall be elected to duties, so that there will be elections to fill the office of commissioner of finance, commissioner of public works, commissioner of utilities, commissioner of safety and health, and commissioner of parks and markets.
4. Commissioners shall be elected for four-year terms.
5. There will no longer be any election for mayor, the commissioners after each annual election selecting their chairman, who is to be called "mayor" from among their own number.
6. Anyone who is qualified to be a candidate for commissioner who is a British subject, is 21 years of age and can read and write English. Commissioners at the time of their election do not have to be residents of the city.

JAPAN'S OIL DISCOVERY.

NOT long ago a great flow of oil gushed suddenly from the Kurokawa oil wells in Japan, and has since shown no sign of diminishing in flow. It is not only of such magnitude that it is producing more than twice the volume of all the other wells combined in that empire, but also of great moment in the history of the oil industry the world over, since the oil flow is simply a steady flow, unattended by the pressure, difficult of control, which has always been experienced in similar cases.

A report was made recently by K. Ito, superintendent of the investigation department of the Nippon Oil Company, under which firm the development of the well is being carried out. The company commenced work on the well early in April, and, after drilling through ordinary earth and rock to a depth of some 1,110 feet, a strata, known as the "shell," was encountered at midnight of May 25th. The drill pierced through this shell or crust at a depth of 1,368 feet into what is apparently the lead-bed of an extraordinary deposit. It is from this bed that comes the present flow.

Not only is the manner of the flow from this well most unprecedented, but what is more unusual is the fact that the other five wells of the company located in the same district, which previously required suction pumping, have also commenced a steady, easy flow.

The output was, at first, somewhat difficult to handle, as no provision had been made for such an unusual quantity. A sump at the top of the hill, which had been constructed to receive the flow, was soon filled, and the overflow was conducted down into upper-level paddy fields, where a dyke was quickly erected around the outside of several cho, thus forming a very large sump. This, in turn, was soon filled, and the overflow was again conducted down into the valley below, where another large sump was hastily constructed, enclosing several paddy fields. Four or five other sumps are now being constructed on this lower level, into which the flow will be directed.

The new well has been capped with a four-way head, which has reduced the output from 480,000 to 120,000 gallons per day, and when the sumps now under construction are completed and filled, the flow will again be reduced. The other five wells have had to be checked entirely owing to want of labor to control them.

The company will find no difficulty in utilizing its output to the best advantage. The imperial navy, as well as the imperial railways, are in need of oil for fuel, and this discovery fills a long-felt want. It is the intention of the company to dispose of the greater part of the production in the crude state, refining only that quantity which may be conveniently handled by its refineries at Tsuchizaki.

Of course, where oil is concerned, no definite or positive idea as to the extent of the lead-bed can be ascertained. But American experts, who were engaged by the company to assist the superintendent of the company's investigation department in his examination and tests, are of the opinion that the flow comes from a bed of lead-sand, and will continue for an unlimited length of time.

Trinidad asphalt mastic has been found to be a satisfactory material for lining concrete tanks which are subjected to the action of sulphuric acid. Many other materials were tried, according to the Engineering and Mining Journal, but none were found suitable except the asphalt mastic, which showed no deterioration after a year's test.

Coast to Coast

Mildmay, Ont.—Recently, at Mildmay, the Mildmay Electric Co., Limited, celebrated the inauguration of its new electric power installation in the town.

Sidney, B.C.—At the new industry which has been installed by the Sidney Rubber Roofing Co, Limited, tanks for fuel oil which have the largest capacity of any north of San Francisco, have been installed.

Stratford, Ont.—The new hydro-electric street lighting system was completed and tested in Stratford on July 31. The lamps are strong nitrogen-filled ones and have been pronounced very satisfactory.

Toronto, Ont.—It is stated that it is understood that the Toronto Hydro-Electric Commission will shortly announce its concurrence with the plans of the Ontario Commission and reduce its rates in accordance with the scale suggested by the superior body.

St. John, N.B.—On August 10, the new cable for carrying the telephone business between the eastern and western sides of the harbor was laid. The cable is of special construction, doubly protected in order to ensure its safety on a rough bottom swept by strong currents. It is 3 inches in diameter, 2,100 feet in length and weighs 32,572 pounds. Sixty pairs of 19 gauge wires are carried in the cable, these being entirely for trunk line use between the two exchanges.

Athabasca, Alta.—Of the 258 miles of length of telegraph line between Athabasca and Fort McMurray, upon which, it is reported, work has recommenced, 118 miles were completed last year as far as Duncan's Creek. It is not expected that the work will be completed as far as Fort McMurray this year. Offices will be opened as the line is constructed at Pelican and House River; and operators will be placed in charge at these points. A telegraphic line will also be constructed from Athabasca to Lac la Biche.

Belleville, Ont.—At present, Mr. John Elliott, president of the Belleville board of trade, is chief of a party consisting of other past presidents of the city's board of trade accompanied by an engineer, which is in England examining into the merits of various road-surfacing materials and investigating roads laid therewith. Mr. Elliott is reported to have stated that he is particularly impressed with the Morland-Hughes system of road construction, as shown on the Upper Richmond Road and Putney Heath North, Borough of Wandsworth, and is prepared to recommend the system for Canada.

Victoria, B.C.—On the Pandora Street paving and double-tracking at Victoria, B.C., good progress is reported, and the work is rapidly nearing completion. The street is being paved by sections, and while none of the work is absolutely complete and ready for traffic, the first coating has been laid and is ready for the asphalt in many places. The double-tracking has now been laid over the entire length, with but a few gaps where there has been delay owing to the cement work; and the line will be ready for regular car traffic as soon as the concrete is laid.

Port Arthur, Ont.—The net three months' profit from the operation of the Hydro-Electric Commission of Port Arthur has been reported to the city council of Port Arthur as $12,-803. Details announced for the operation of the system for the last three months state that the gross profits from operating amount to $23,732 from which is deducted the fixed charges representing interest, sinking fund and annual instalments amounting in all to $10,928. The actual revenue which has been gathered by the city official during the period is $43,933, and the operating expenditure for the period was $20,201.

Victoria, B.C.—The E. and N. Railway Company has inaugurated and has commenced service upon 44½ miles of roadbed in British Columbia extending between Parksville and Courtenay. The distance between Victoria and the present northern terminus is 140 miles, and it takes 7 hours to complete the journey. The roadbed is declared to be a permanent form of construction. The steel used is heavy; and concrete and steel trestles span all streams and rivers where bridge construction could not be avoided. There are now over 200 miles of railway in the E. and N. system, a great part of which has been installed since the C.P.R. took over its control some 5 or 6 years ago.

Calgary, Alta.—Manager Director A. W. Dingman, of the Calgary Petroleum Products Company, has issued a statement to the effect that any reports specifying in figures the production of the company's No. 1 discovery well are absolutely incorrect. At present a certain attempt is being made to pump the well, but drilling will have to be carried to a greater depth and the pumping apparatus put in shape before anything concerning the actual production of the well can be ascertained. The company has considerable oil in the first 12,000 gallon tank and a good deal also in the second 12,000 gallon tank, but it is impossible to measure the production of the well yet. However, it is nothing like 250 barrels a day under present conditions. Mr. Dingman said that the drill at No. 2 well of the company has now entered a hard formation and drilling is found to be a little more difficult. This well is 1,560 feet deep.

Montreal, Que.—The new Marconi stations to be constructed by the Dominion Government at Montreal and Quebec, and relative to which it has been stated that plans for the Montreal station are practically completed, will be of the standard 5½ k.w. type. The Montreal station will be equipped for communication with the Kingston and Quebec stations. The apparatus at the present station in Montreal sends messages generally only as far as the Three Rivers station 70 miles away, although it sometimes communicates with vessels more than twice that distance. The Government will build the new stations which will be operated by the Marconi Wireless Company of Canada. The erection of the Montreal and Quebec stations will give the Marconi Company a string of wires capable of communicating, without interruption, from the head of the lakes as far east as Cape Race and Belle Isle. It is not now expected that either station will be constructed previous to next spring, or until the war situation will have cleared.

Nanaimo, B.C.—Messrs. Walter Thomas and A. E. Mainwaring of Nanaimo, B.C., are the joint patentees of a process by means of which gas may be produced in enormous quantities and at a greatly reduced cost. The inventors have in mind an ambitious scheme for the supply of cheap gas for fuel and light for the whole southern end of Vancouver Island; and their expectations are apparently justified by the results of the process as demonstrated in the experimental plant at Nanaimo. The commercial scheme would involve the conveying of gas through suitable mains through great distances as is done already in California, Portland, Tacoma, and Seattle. It is calculated that the installation of a suitable plant for manufacture under the Thomas patents, and conveyance through pipe lines to a sufficiently large number of consumers would place the whole south end of Vancouver Island on a natural gas basis, the estimated charge of fuel and consumers' gas being 50 cents per 1,000 feet. The project, if carried out, will involve the manufacture and distribution of not less than 1,000,000 feet of gas per day.

Hudson Bay, Ont.—Included in the programme of work under way this year at Hudson Bay and Strait and being effected by the Marine and Naval Departments of the Dominion Government, is the locating of 3 wireless stations in the strait and at the entrance to the bay, so as to give a continuous line of communication from Port Nelson and Port Churchill to the Atlantic; but the construction of these will not commence until next year. The charting of Hudson's Strait is also being done by the steamer Acadia, while other Government vessels are taking soundings and mapping the harbors at Port Nelson, Fort Churchill, and at the mouth of the Nottaway River. Two lighthouses are to be commenced this year, one on each side of the entrance to Port Nelson, while another one will be built on a newly-charted shoal some miles out in the bay. The charting being done at the mouth of the Nottaway River is preparatory to the construction of the proposed railway from there south-east to the National Transcontinental, in connection with the alternative route from Port Nelson across the northern end of James Bay and thence by rail to Montreal, for which last season an appropriation of $1,000,000 was passed by the Government for preliminary surveys.

Edmonton, Alta.—The city commissioners of Edmonton have decided to allow the firm of Sanderson and Porter of New York, and all other concerns intending to submit offers for furnishing power to the city, four weeks from July 21 in which to prepare and submit these, which shall include in the unit prices given the operation and maintenance by the tenderers of the present steam plant as a stand-by plant, the city to retain ownership of the same. To such prices must be added the annual interest and sinking fund incident to the investment of the plant. Also, all firms must submit a statement of financial backing, a certificate or title of lease of the waters and poundage rights, plans, profiles, level covering, the development contemplated, the head proposed to be developed, length of study of the proposed development, and the name of the engineers who will carry out the work; the city to audit all accounts of construction, from the inception to completion; the company to agree not to capitalize by bonds, stock, or otherwise in excess of the actual construction costs; the city to participate in all profits annually over 8 per cent., and the city to have the right to audit all operating accounts as well as to be given power to decide other questions which the commissioner of operation considers imperative in protecting the city's business.

Victoria, B.C.—A report on last month's operations at the Ogden Point breakwater states that such remarkable progress has been witnessed that the foundations of the breakwater were in view at extreme low tide inshore and everthing was in readiness for the commencement of the concrete structure, which will be a huge reinforced wall stretching far out into the harbor. The official statistics for the month of July show that no less than 361,131 tons of rubble were dumped on the site of the breakwater. The actual figures are as follows: core, 22,545 tons; rubble, 338,586 tons. The total rock dumped during the last three weeks of the month exceeded the record month of last year. A grand total of 1,604 tons of granite blocks were also laid by divers during the month just closed. At the present time the operations of the divers are confined to the shore end of the breakwater, where huge granite blocks, weighing anything from 5 to 15 tons each, are being laid in courses; and as the rubble farther out is brought up to the desired level, these courses will be continued seawards. Good progress is also being made in dumping rock at the site of the new piers under construction by Grant Smith and McDonnell. Throughout July a total of 13,332 tons of rubble were deposited; and much faster progress will be maintained now that everything is complete for the shipment of rock from the new quarry at Esquimalt.

Ottawa, Ont.—Tests made recently by the city bacteriologist of Ottawa, Mr. Jos. Race, show that Ottawa River water is four times superior to Ottawa well water in purity. The tests have been made to ascertain whether the supply of water from the river is reasonably safe for drinking and domestic purposes. Mr. Race concludes his report by sanctioning its use as such. Discussion of the report which has been furnished by R. L. Haycock, acting waterworks engineer, to the waterworks committee, on the same question was adjourned until next week when the committee will also make a report to the city council. In the meantime, Mr. John McRae, civil engineer of Ottawa, will co-operate with Mr. Haycock in preparing estimates of the costs of a number of changes which Mr. Haycock suggests in his report. One of the most radical changes proposed is the removal before winter of the concrete beams supporting the intake pipe recently relaid, which, in the opinion of the acting waterworks engineer, will increase the accumulation of ice and frazil and endanger the safety of the intake pipe. An estimate will be made also on the cost of installing an auxiliary electrical pump at the Queen Street West station for use in case one of the hydraulic set of pumps should break down. Further, estimates will be made on the costs of the projects to connect to the 40 and 42-inch intake pipes and to join the two aqueducts at the pumphouse.

Medicine Hat, Alta.—About one-half of the great irrigation canal which has been under construction by the Southern Alberta Land Company for the past 5 years at an expenditure of close to $5,000,000, has been sufficiently completed to hold water; and about two weeks ago water was allowed to flow into Lake McGregor. The entire undertaking is so well advanced that only about $250,000 will now be necessary to complete the system. The work of constructing the canal begins about 22 miles southwest of Gleichen, where a big dam of cement work has been constructed across the Bow River and forms the intake of the canal. From there it continues about 30 miles to Lake McGregor. This lake is about 22 miles long, is formed by the construction of two huge earth dams across what is known as Snake Valley, and is about 40 feet high at the north end and 30 feet at the south; while in places it will be about 2 miles wide. It is estimated that from 3 to 4 months will be required to fill this area for the requirements of the immediate future. From the lake, the canal continues south and east along the Little Bow River, the entire length of the channel being in the neighborhood of 180 miles. The major portion of the work on the east end is now nearing completion, but it is not probable that it will be in readiness to turn into the lower canal until some time next spring. In the construction of this canal there have been some most difficult engineering problems; and some of the heaviest of the work has had to be replaced.

Esquimalt, B.C.—It is expected that an early date will see the completed establishment of the Esquimalt sewerage system. About $60,000 has so far been expended. The municipality was divided into two sections—B and D—for the present sewerage work. Section B empties into the northwestern main, which is the Victoria main outflowing at Macaulay Point. D section enters the sea at the foot of Grafton Street. The contractors for the B section, Messrs. Agnew and Young, had 9 miles of pipe to install, of which they have laid 4½ miles. Most of the light work has been done; and when the rock boring and more difficult excavating for the tunnel through the Macaulay Rocks has been completed—which work is expected to take about 2 months' time—sewer connection will be established for householders through the local sewers with the northwest sewer. City Engineer Rust states that the rock excavation work is proceeding very satisfactorily, and that up to the present the cost has been somewhat less than the estimate. In D section 2 miles of pipe had to be laid, of which 1½ to 1¾ have been finished. This work will be complete in little over a month. There will for the present be more connection with the D main than with the B section. At the foot of the streets being connected with D section, a rock formation extends along the shore; and here blasting and stone crushing is being carried on, rapid progress being made. On most of the streets the sewer trenches have been filled in, every street in the district having been excavated. Two strong concrete embankments have been built at the foot of the streets leading to the water. The contract will probably be let very shortly for the laying of the pipes in the Esquimalt village section. This section will cover the whole west end of the municipality not drained by the other sections.

PERSONAL.

D. H. MARTIN has been appointed chief engineer for Jas. Corbett and Sons, Limited, who have one of the subcontracts for Section 5 of the Welland Ship Canal.

FRANK C. ASKWITH is provisionally in charge of roads and bridges for the city of Ottawa, since the resignation of Mr. Arch. Currie. R. L. HAYCOCK has been placed provisionally in charge of the waterworks and sewerage department, succeeding Mr. A. N. Beer, resigned.

A.S.T.M. EXECUTIVE.

The officers of the American Society for Testing Materials for the year 1914-15 are:—President, A. W. Gibbs; vice-president, A. A. Stevenson; secretary-treasurer, Edgar Marburg; council, Robt. Job, F. W. Kelley, A. Marston and S. S. Voorhees.

CANADIAN FORESTRY CONVENTION POSTPONED.

Owing to the war the president and directors of the Canadian Forestry Association have, after the most careful consideration, decided to cancel the arrangements for the forestry convention which was to be held in Halifax, September 1st to 4th, 1914, and to postpone the convention indefinitely. Whatever it is decided to do in the future, due notice will be given thereof to the members and all others concerned. Attention is particularly directed to the fact that all railway arrangements as published have been cancelled, and that anyone going to Halifax within the stated dates will have to pay full fare back to starting point. All persons receiving notice are requested to make it known to any others who they know were preparing to go to Halifax.

OBITUARY.

The death is reported of Mr. H. W. Anthes, managing director and secretary-treasurer of the Anthes Foundry, Limited, of Toronto and Winnipeg. Mr. Anthes was in his sixty-fourth year.

HARDNESS OF WOODS.

Woods are going rapidly out of fashion in railroad car construction, when only a few brief years ago they formed the entire structure of cars.

The relative hardness of woods is calculated from hickory which is the toughest and hardest wood in popular use. Estimating hickory at 100, we get for white oak, 84; white ash, 77; dog wood, 74; scrub oak, 73; white hazel, 72; apple, 70; red oak, 69; white birch, 65; black walnut, 65; black birch, 62; yellow and black oak, 60; hard maple, 56; white elm, 58; cedar, 56; cherry, 55; yellow pine, 53; chestnut, 52; yellow poplar, 51.

COAL EXPORTS FROM GREAT BRITAIN.

The total amount of coal exported from Great Britain in 1913 exceeded that of 1912 by ten million tons. Cardiff topped the list as usual, according to a consular report. From the Manchester ship canal the export amounted to about 1,100,000 tons, but these figures are insignificant when the facilities for shipment are taken into account. The quay space at Partington coal basin occupies 20 acres and there are 22 miles of railway sidings. Six tips are in use fitted with hydraulic machinery and each tip has a capacity of 300 tons per hour. Manchester is the nearest point of shipment for the Lancashire, Derbyshire and Staffordshire collieries.

EFFECT OF SODIUM HYDROXIDE ON IRON.

In a paper by J. H. Andrew in the Transactions for March, 1914, of the Faraday Society, it is stated that wrought iron corrodes slowly, becomes highly crystalline, and eventually brittle by immersion in a concentrated aqueous solution of sodium hydroxide at 100° C. for several months. The corrosion is attributed to electrolytic action between the two phases, crystalline and amorphous, of which the metal is constituted, iron going into solution at the anode (forming sodium ferrite), hydrogen being liberated at the cathode. Part of the hydrogen is occluded by the metal, being first absorbed by the amorphous constituent, thereby forcing the crystals apart, and ultimately causing the iron to become crystalline and brittle. The brittleness decreases with time, an equilibrium being finally established between the metal and the gas, and is due rather to the molecular rearrangement induced by mere occlusion or evolution of hydrogen than to the mere presence of the latter in solution. The potential difference between the amorphous and crystalline phases and hence the rate of corrosion decrease as the latter phase becomes hydrogenized, the passivity of iron produced by immersion in caustic soda being due to this cause. Similar results were obtained with electro-deposited iron, but steel containing 0.5 per cent. carbon was much less affected by sodium hydroxide solution. The recrystallization of electro-deposited iron upon cooling through the Ar_3 point is also considered to be due to the evolution of hydrogen.

COMING MEETINGS.

CANADIAN FORESTRY ASSOCIATION.—**Annual Convention to be held in Halifax, N.S., September 1st to 4th, 1914. Secretary, James Lawler, Journal Building, Ottawa.**

NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.—Secretary, Will P. Blair, 832 B. of L.E. Building, Cleveland, Ohio. Eleventh annual convention and paving conference, Buffalo, N.Y., September 9th, 10th, 11th, 1914.

ROYAL ARCHITECTURAL INSTITUTE OF CANADA.—**Seventh Annual Meeting to be held at Quebec, September 21st and 22nd, 1914. Hon. Secretary, Alcide Chausse, 5 Beaver Hall Square, Montreal.**

CONVENTION OF THE AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.—**To be held in Boston, Mass., on October 6th, 7th, 8th and 9th, 1914. C. C. Brown, Indianapolis, Ind., Secretary.**

AMERICAN HIGHWAYS ASSOCIATION.—**Fourth American Road Congress to be held in Atlanta, Ga., November 9th to 13th, 1914. I. S. Pennybacker, Executive Secretary, and Chas. P. Light, Business Manager, Colorado Building, Washington, D.C.**

AMERICAN ROAD BUILDERS' ASSOCIATION.—11th Annual Convention; 5th American Good Roads Congress, and 6th Annual Exhibition of Machinery and Materials. International Amphitheatre, Chicago, Ill., December 14th to 18th, 1914. Secretary, E. L. Powers, 150 Nassau St., New York, N.Y.

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.

22294—July 24—Amending Order No. 22160, dated July 8th, 1914, to provide that Henry Ray, Tp. March, Ont., deposit in a chartered bank to credit of Board of Ry. Commrs. for Canada, sum of $500 in lieu of and for purposes of bond required under Order 22160 to be filed with the Company.

22295—July 23—Authorizing C.P.R. to construct spur into premises of International Supply Co., Limited, on Lot F, Medicine Hat, Alberta.

22296—July 27—Directing that C.N.R. construct spur 1,900 ft. long to connect with spur serving Estevan Coal and Brick Co., subject to certain conditions, Ry. Co. to construct and complete spur as soon as Bienfait-Estevan Branch is open.

22297—July 29—Authorizing, until Nov. 30th, 1914, C.N.R. to open for traffic its North Battleford Northwesterly line from Edam, mileage 38, to Turtleford, mileage 57: Provided speed of trains be limited to rate not exceeding 15 miles an hour.

22298—July 31—Authorizing Esquimalt and Nanaimo Ry. to open for traffic, McBride Jct. to Courtenay, Vancouver Island, B.C.; and rescinding Order No. 27546, dated Oct. 13th, 1914.

22299—July 30—Dismissing application G.T.R. for authority to construct, at grade, spur track serving Elias Rogers Co., Coal Dealers, Toronto, Ont., across Toronto, Grey and Bruce Ry. (C.P.R.) at point south of St. Clair Ave., Toronto.

22300—July 28—Authorizing Toronto Eastern Ry. and Oshawa Electric Ry. to operate trains and cars, for period of 6 months from Aug. 6th, 1914, over crossing in Town of Oshawa, Ont., subject to provisions of Section 277 of Railway Act.

22301—July 29—Amending Order No. 22297, dated July 3rd, 1914, by striking out words "Swift Current," in 2nd line of paragraph 2 of operative part of Order, and substituting therefor words "Moose Jaw."

22302—July 27—Directing G.T.P. Ry. to carry out certain conditions for purpose of providing good and sufficient accommodation and facilities at Spruce Grove, Alberta.

22303—July 31—Directing that spur located between King St. and Pembina Bridge, Entwistle, Alta., be removed; that spur for 5 cars be installed east of King St., with trailing point switch toward King St.; G.T.P. Ry. to arrange to handle carload freight for Village of Entwistle and those who require it at that point.

22304—July 31—Authorizing Corporation City of Toronto to reconstruct bridge, partly in City of Toronto and partly in Twp. York, carrying highway over Belt Line of G.T.R.; cost of construction be paid—60 per cent. by Corporation of City of Toronto; 20 per cent. by Twp. York; and 20 per cent. by G.T.R.; cost of maintenance be borne by Corporation of City of Toronto.

General Order, No. 130—July 28—Disallowing schedules of Boston and Maine R.R., C.P.R., Central Vermont, G.T.R., G.T.P. Ry., G.N.R., Maine Central, M.C.R.R., Rutland R.R., N.Y.C. and H.R.R., T., H. and B. Ry., and Wabash Railroad, in so far as their purpose is to increase tolls previously charged for exclusive use of drawing-rooms or compartments in sleeping and parlor cars locally between points both of which are in Canada.

22305—July 31—Authorizing Winnipeg, Selkirk and Lake Winnipeg Ry. to construct and operate its Middlechurch Branch running to Stonewall, across spur of C.P.R. running to stone quarry at Stony Mountain, Man.; if at any future time protection is required at crossing, Applicant company provide same at its own expense.

22306—July 29—Authorizing G.T.P. Saskatchewan Ry. to operate over crossings of C.P.R. Weyburn-Lethbridge and Soo Branches, by its Weyburn Branch, in Sec. 20-8-14, W. 2 M., at Weyburn, Sask, until Oct. 15th, 1914, pending installation of interlocking plant: Provided crossings be protected by flagmen appointed by C.P.R., at expense of G.T.P. Sask. Ry.

22307—July 27—Directing that, within 60 days from date of this Order C.L.O. and W. Ry. install improved type of automatic bell at crossing of Frontenac Road, in Village of Parham, mileage 26.97.

22308—July 29—Authorizing, subject to terms of Indenture of Lease, M.C.R.R. to construct spur for Union Carbide Co. of Canada, Limited, crossing Bain Ave. and Welland Canal Tow Path, Twp. of Crowland, Co. Welland, Ontario.

22309—July 29—Authorizing Alta. Central Ry. to open for traffic its line West of Red Deer, mileage 0.00 to 64.5.

22310—July 31—Authorizing Union Bank of Canada, Moose Jaw Branch, to release and repay to S. A. Hamilton Co., Limited, sum of $1,100 deposited with it to credit of Board, together with accrued bank interest, if any.

22311—July 29—Authorizing Board of Highway Commissioners for Saskatchewan, at own expense, to construct highway over G.T.P. Branch Lines Co.'s Regina Boundary Branch, on Extension of Queen St., Townsite of Colfax, Sask.

22312—July 31—Authorizing G.T.P. Ry. to construct an extension to bridge over Fraser River, mileage 468.4 Prince Rupert East, B.C.

22313—July 30—Authorizing C.N.R. to construct revised line across C.P.R. in S.W. ¼ Sec. 19-40-26, W. 4 M., near Lacombe, Alta., subject to certain conditions.

22314—July 29—Authorizing C.N.R. to operate its trains, temporarily, for construction purposes only, for period of 60 days from date of this Order, pending installation of interlocking plant, over crossing of C.P.R. in Lot 101, Parish of St. Paul, Man.: Provided trains be flagged over crossing by watchmen appointed by C.P.R. at expense of C.N.R.

22315—August 4—Extending the area for the collection and delivery of express freight by Express Companies in the city of Windsor, Ontario, and rescinding Order No. 19533, dated June 9th, 1913.

22316—August 1—Directing that G.T.P. Ry. construct a station, not to be below Standard of No. 1 B.R.C., and a one-pen stock yard at Ribstone, Alta.; work be completed by September 15th, 1914. Ry. Co. stop trains Nos. 1 and 2 on flag signal, at Ribstone, for passengers and express.

22317—July 24—Directing that G.T.R. construct spur into premises of Standard Crushed Stone Co., Limited, near Windmill Point Station, Ontario, subject to certain conditions.

22318—August 1—Extending, until October 31st, 1914, time within which G.T.R. complete subway at Thompson Road, Tp. Bertie, Ont.

22319—July 30—Authorizing C.L.O. & W. Ry. (C.P.R.) to operate its trains across C.N.O.R. in Lot 27, Con. 2, Tp Pickering, until Sept. 15th, 1914, temporarily, pending installation of interlocking plant: Provided crossing be protected by flagmen appointed by C.N.O.R. at expense of C.L.O. & W. Ry.

22320—August 1—Authorizing C.P.R. to construct road diversion in Sec. 34, Tp. 5, and Sec. 3-6-24, W. 3 M.; and construct, by means of grade crossing, its Weyburn-Stirling Branch Line across East and West road allowance between Sec. 34, Tp. 5, and Sec. 3-6-24, W. 3 M., Sask., at mileage 272.7 of said Branch Line.

22321—August 1—Authorizing C.P.R. to construct its Weyburn-Stirling Branch Line across twelve (12) highways, between mileage 65 and mileage 75 (mileage 0 being at Stirling).