SURGE TANK PROBLEMS—IV.

BEGINNING A STUDY OF THE INFLUENCE OF A SPILLWAY BUILT IN THE SURGE TANK.

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PART 2.

Special Case D—Involving Spillways.

In order to decrease the surge in the surge tank, a spillway may be introduced in the surge tank or in the main conduit. The problem of interest, then, is to determine at what elevation and with what capacity such a spillway should be designed in order that the surge shall not exceed a certain elevation. The case will be investigated under the following assumptions: The spillway is

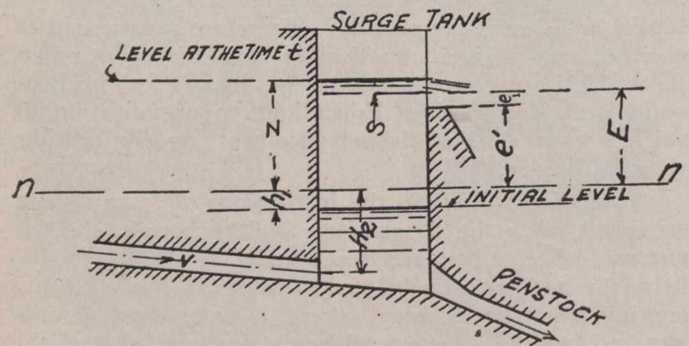

Fig. 7.

attached to the surge tank (Fig. 7). The crest of the spillway is at the distance e' from the static level $n - n$; e' is positive if the crest is above $n - n$ and negative if below. The width of the spillway is b'. The outflow of Q cubic feet per second is suddenly interrupted.

We must take care of several periods of movement. Following a complete shut-down, the water surface in the surge tank will rise to the height of the spillway crest, as is described in case (A).* Next, the rise will continue, but water will flow over the spillway up to a maximum elevation, then decrease to the elevation of the spillway crest. At this moment, the outflow ceases. The movement then takes the form of the case (A), and retains this form thereafter, provided the crest of the spillway is not reached again. Otherwise, the same cycle is repeated or the condition remains one of constant overflow. Therefore, for the first phase the following equations are effective:

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

$$s = \frac{R}{T} e^{-\frac{t}{2T_0}} \sin\left(\gamma - \beta - \frac{t}{T_1}\right) \quad \text{with } tg\,\gamma = \frac{2T_0}{T_1}$$

The integration constants R and β are obtained for the conditions $t = o$, $z = -h_1$, $s = c_1$. The final value of z is in this period of movement e'. From this we determine the time $t_{e'}$, which is necessary for the rise up to the level of the spillway crest and by means of the second equation we determine the final velocity $s_{e'}$. In the second period of movement now beginning, we have overflow on the spillway, that is, according to the familiar formula for spillways $q = \frac{2}{3}\mu b' h' \sqrt{2gh'}$ where $h' = z - e'$ represents the overflow height and we get

$$\frac{q}{A} = c = \frac{2}{3}\mu b' \frac{\sqrt{2g}\,h'^{3/2}}{A} \qquad (82)$$

The introduction of this formula and its derivation in the principal equation (23) would lead to a differential equation higher than the first degree, the integration of which might be accomplished by development in series. For practical purposes, however, an easier but sufficiently exact approximation may be obtained in the following manner:

If we plot the different values of h' computed for the width b' on a rectangular co-ordinate system, the values h' as abscissæ, and the values of q as ordinates (see Fig. 8), we obtain a parabolic curve, passing through the origin. The velocity $s_{e'}$ (which is the final value of the velocity of the surface at the end of the first period of movement) together with A determines a quantity of water $s_{e'}.A$, which is certainly larger than the maximum value of the overflowing quantity during the second period. If we now draw tangents from the point of the quantity curve, which corresponds to $As_{e'}$ and assume as a preliminary approximation that within the heights of

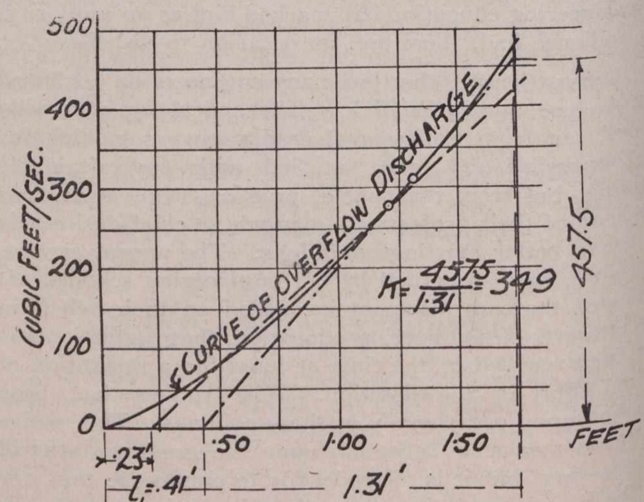

Fig. 8.

the overflow, which corresponds to the intersection of the tangent with the axis of the abscissæ, the overflowing quantity equals zero, which is the same as if we move the elevation of the spillway crest higher up by the same amount, and if we take from this location the water quantity proportional to the height of this new elevation of the spillway crest corresponding to the tangent, then

*See *The Canadian Engineer* for Aug 20, pp. 327-9 and Aug. 27, pp. 368-70.