fair assumption as to the allowance can nearly always be made. In this case, on account of the small amount of reinforcement in tension over the counterforts, this reduction has been taken as 25 per cent.

For the design of a tank, equations 1 and 2 can be put in a more convenient form, as follows:

Replacing M by its value $\frac{(w \times X \times L)^2}{10 \times b}$, where w is the weight of the water, $62\frac{1}{2}$ lbs. per cu. ft., X the depth of the water, L the clear span between counterforts, b the width considered, namely 12 ins., we get,

$$q = 0.247L \times \text{square root of } X \qquad \text{(Equation 3)}$$

$$As = \frac{(.00051XL)^2}{q} \qquad \text{(Equation 4)}$$

Equation 3 gives the minimum effective depth of the beam or slab at any depth (X ft.) below the surface of the water. Equation 4 gives the amount of the steel reinforcement required per inch width of beam when the effective depth (q) is fixed. It cannot be used, however, when the percentage of steel reinforcement exceeds 0.83 per cent.

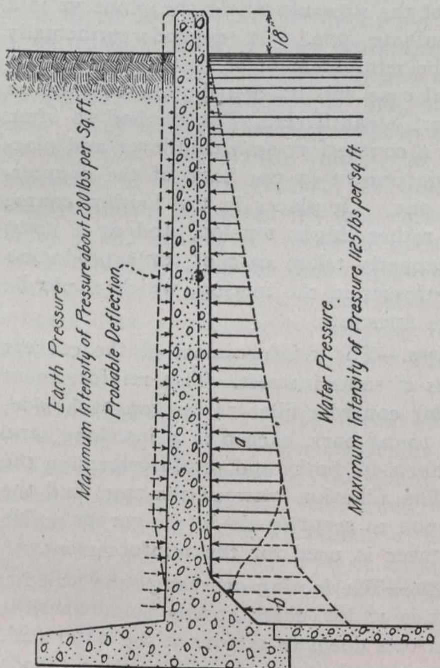

Fig. 1.—Diagram of Forces Acting on the Walls.

Figure 1 shows the forces that are acting on the walls. The water pressure increases from zero at the water surface to a maximum of 1,125 lbs. per square foot at the bottom. Only a portion of this pressure, namely, that portion marked a, is carried by beam action to the counterforts. That portion marked b and shown by the dashed arrows, is carried by cantilever action directly to the footing. The diagram shows that the walls receive their maximum stress as a beam at a point approximately 15 feet below the water level. The minimum thickness of concrete wall that it is possible to use under the conditions assumed is computed as follows from equation 3: Substituting in this equation, we have

$$q = 0.247 \times 12.08 \times \text{square root of } 15 = 11.55 \text{ ins.}$$

Allowing $2\frac{1}{2}$ ins. of concrete to cover the steel, we obtained a minimum thickness of 14 ins. The plans show the thickness of the wall at this depth to be 17 ins. On account of the low cost of the concrete materials and the comparatively high cost of the steel reinforcement, it was deemed more economical to use a heavier section than the minimum that could be used. In places where concrete materials are costly, it would be possible to construct the side walls 8 ins. thick on the top and 15 ins. thick at the bottom.

The amount of steel reinforcement, As, that would be required 15 ft. below the water level can be readily obtained by means of equation 4: $As = \frac{.00051XL^2}{q}$.

Substituting for X, 15 ft; for L, 12.08 ft., and for q, 14.64 ins., we obtain, As = .0763.

The spacing of $\frac{3}{4}$-in. round rods will be .4418 (the area of a $\frac{3}{4}$-in. round rod divided by .0763 (the amount of steel required per lineal inch), giving 5.79 ins. as the spacing. The drawing shows the spacing to be 5.5 ins. at this point.

In Fig. 1 is shown graphically by dotted arrows the earth pressure acting against the wall from the outside. It is proposed to back up the walls of the basin on three sides, as shown on the plan. As there is a possibility that this backing may be removed at any time, no allowance whatever has been made for the additional stability given to the tank by this backing.

Attention is called to the connection of the walls of the tank to the bottom. The pressure from within forces the side walls outward, the deflection reaching the maximum half-way between the counterforts. The connection of the walls to the footing must be either a sliding joint to permit of this movement, which is impracticable, or sufficient reinforcement must be provided to prevent the possibility of rupture at this point. Fig. 1 shows diagrammatically, but in a somewhat exaggerated form, the deflection of the side walls at the centre of the span when the reservoir is full of water. The rigid connection spoken of is a concrete fillet 18 ins. on the side, reinforced with $\frac{1}{2}$-in. round bars spaced 12 ins. on centres. This rigid connection transfers by cantilever action some of the hydrostatic pressure against the lower portion of the wall directly to the footing. The amount of this pressure transfer is shown diagrammatically by the dashed arrows in Fig. 1, marked b.

Figure 2 shows all of the forces except the earth pressure, acting on a section of the tank 13 ft. 4 ins. long, including one counterfort and half of the clear span of the walls on either side of it. The total weight of the concrete for this section is 106,150 lbs., with its centre of gravity located 9 ft. from the heel (o) of the footing. The total horizontal water pressure against this part of the tank is 135,000 lbs. and the weight of the water resting on the footing is 150,000 lbs. Let us assume for the present that the sliding of the wall is prevented by the tension in the bottom. This tension amounts to 10,100 lbs. per lineal foot of footing and is shown acting 1.25 ft. above the bottom of the footings. All these forces are shown in their true positions in this figure.

Since the forces shown acting on this portion of the structure are in equilibrium, we have

$$z = \frac{\Sigma M_o}{\Sigma W} \text{ or}$$

$$\begin{aligned} 106{,}150 \times 9 &= +955{,}350 \\ 150{,}000 \times 5 &= +750{,}000 \\ 135{,}000 \times 7.5 &= 1{,}012{,}500 \\ -135{,}000 \times 1.25 &= -168{,}750 \\ \hline \Sigma M &= 2{,}549{,}100 \\ z &= 9.95 \\ \Sigma V &= 256{,}150 \end{aligned}$$

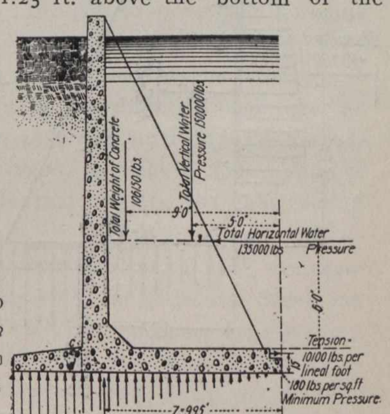

Fig. 2.—All Forces Acting Except Earth Pressure.

This shows that the resultant pressure on the footing, namely, 256,150 lbs., pierces the base 9.95 ft. from the heel, which is practically two-thirds of $15\frac{1}{2}$ ft., the width of the base. Consequently, the distribution of the foundation pressure on the footing is in the form of a triangle, about as shown in the figure. It reaches a maximum pressure of 2,300 lbs. at the toe and nearly zero at the heel. Sufficient steel is provided for in the bottom to take care of a tension of 10,100 lbs. per lineal foot of footing where it joins the 6-in. concrete bottom. This reinforcement consists of $\frac{3}{8}$-in. round rods spaced 6 ins. centres. The plan erroneously shows these bars to be placed 12-in. centres. This amount