of steel is sufficient to resist this tension at a unit stress well within the elastic limit of these steel bars. The author does not wish to convey the idea that this tension is developed to the extent shown in Fig. 2. A very large proportion of it will be developed by friction between the footing and the supporting earth, and some by the earth backing, which, however, will not be always present.

Design of Counterforts.—Figure 3 shows the forces acting on the counterforts proper. The reaction of the walls, tension in this case, amounts to 93,500 lbs., and its distribution is about as shown in the figure. It reaches its maximum 15 ft. below the water level. This tension is taken care of by thirty-two ½-in. round bars at an average unit stress of 14,900 lbs. This is not a very high value. In the discussion we have ignored the additional stability received from the earth pressure, and also the tensile strength of the concrete in the counterforts, which may be considerable.

The greatest of care must be taken to anchor the walls to the counterforts. In this case, this has been done by threading the ends of the ½-in. tension bars and fastening them with double nuts to two 2½-in. by ⅜-in. plates, 18 ft. long, embedded in the walls, as shown in the reinforcing plan. The object of the double nut is to prevent the possibility of play at the joint.

A study of this figure shows that the counterfort is not a cantilever at all. In a cantilever, the internal resisting forces acting on the plane yz, must balance algebraically, that is, the total tension must be equal to the total compression. This is not the case in the counterfort, as can be readily seen. The forces that act on the counterfort are as follows:

W, the tension exerted by the walls on the counterfort, 93,500 lbs.

P, the horizontal pressure of the water acting against the counterfort proper, 13,600 lbs.

W^c, the weight of the counterfort proper, 16.500 lbs.

Q, the total tension between the footing and the counterfort along the plane yz, 109,250 lbs., shown acting 6.07 ft. from the point y.

Q^1, the shear between the counterfort and the wall of the basin, 109,250 lbs. plus 16,500 lbs.

H, the horizontal shear acting along the plane yz, 107,100 lbs.

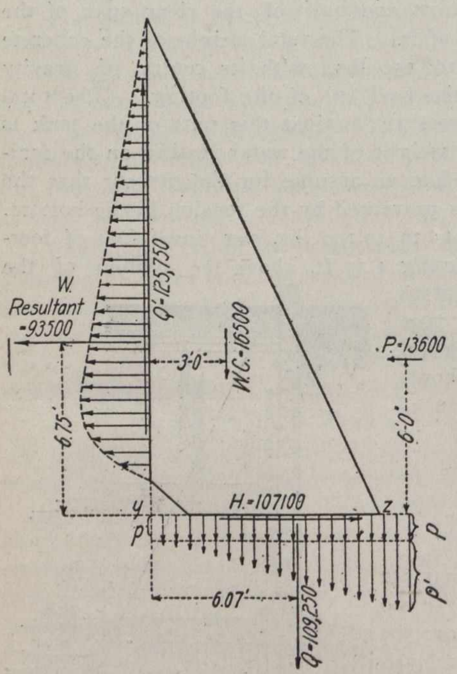

Fig 3.—Stresses Acting on the Counterfort Proper.

The determination of the amount of the pressure Q and its distribution with reference to the plane yz, is a very interesting one, and is for this reason given in detail. Taking moments about a point, y, we obtain the following equation:

$$93{,}500 \times 6.75 + 13{,}600 \times 6 - 16{,}500 \times 3 - p \times 10 \times 5 - \frac{p^1}{2} \times 10 \times \tfrac{2}{3} \text{ of } 10 = 0.$$

In this equation, there are two unknown quantities, p and p^1. A safe assumption to make, since there is no tension at the heel (c) is that $p + p^1$ cannot exceed the sum of the weight of the water above the footing and the weight of the concrete itself. This amounts to 1,350 lbs. per square foot of footing, thus giving the additional equation

$$p + p^1 = 1350 \times 13.33$$

From these two equations we obtain

$$p = 3{,}850 \text{ lbs. and}$$
$$p^1 = 14{,}150 \text{ lbs.}$$

The total resultant tension Q, and its location, can now be readily found, and is given in the figure as 109,250 acting 6.07 ft. from y.

This tension of 109,250 lbs. is taken care of by sixteen ⅞-in. round bars at an average unit stress of 11,350 lbs. The maximum stress in these bars probably reaches 14,000 lbs. per square inch. The bars are anchored in the concrete footing by two 2½-in. by ⅜-in. plates 8 ft. 6 ins. long, to which they are fastened by double nuts.

The distribution of the pressure along the plane yz is a more or less indeterminate one. It depends principally upon the shape and the reinforcement of the footing course. Only in a very special case will its distribution be such as to make the counterfort a cantilever. The method so often followed of designing a counterfort as a cantilever and placing all the steel reinforcement in the back of the counterfort, is an erroneous one. It places in the footing course a concentrated and rather high tension, and at a point where it cannot be properly taken care of, thus producing enormous secondary stresses in the footing, which would be a serious defect in the structure.

Design of Corners.—The reinforcement of the corners of the settling basin is of some interest. This reinforcement consists of a triangular concrete fillet 24 ins. on each side, reinforced with ⅜-in. round bars, each 6 ft. 3 ins. long, and spaced the same as the ¾-in. horizontal reinforcement in the walls of the basin. The adhesion between the steel and the concrete is counted upon to securely tie in the corner. No rigid connection whatever is used for the reinforcement.

Design of Footings.—The footing overhangs the wall for a distance of 4 ft. It is 18 ins. thick at this point where it joins the wall and narrows down to 12 ins. at the outer end. The following computations give some idea as to the methods used in designing this footing.

The upward pressure on the overhanging portion ranges from 2,300 lbs. per square foot to 1,750 lbs. per square foot. The thickness of the footing at c-d, Fig. 2, should be sufficient to keep the shearing stress down to a safe working value. The total upward pressure per lineal foot of footing course, amounts to 8,100 lbs. This gives an average value for the shear of 37.5 lbs. per square inch—a very safe value. Equation 2 can be used to compute the amount of steel required, as follows:

$$As = \frac{M}{1020 \times q}$$

where M represents the bending moment in foot-pounds per lineal inch of footing at the plane c-d, which amounts to 1,410 foot-pounds.

q is 18 ins. minus 3 ins.

Substituting in this equation, we obtain for As, 0.0922 sq. ins. This amount of steel requires a spacing of 4.80 ins. for ¾-in. round bars. A spacing of 6 ins. is shown on the plans. This spacing used is considered ample, as the computations just outlined do not take into consideration the weight of the overhanging footing nor the weight of the earth backing.

The above general outline of the methods used in designing the settling basin conveys some idea of the thor-