and boiler outlet (tank). Assuming no friction loss between the discharge of the pump and the expansion tank, the minimum pressure, P_f, must be increased above that discussed for A, Fig. 17 by the head of the pump. The maximum pressure, P_o, is determined as described for A, Fig. 17. This arrangement is commonly used in residential and other small installations without operating difficulties.

When the pump discharges into a boiler and the tank is connected to the pump suction line as in C, Fig. 17, the boiler is subjected to an increase in pressure equal to the pump head when the pump operates. The required minimum pressure, P_f, is as described for A, Fig. 17. The tank final operating pressure, P_o, equals the boiler working pressure, as discussed under A, Fig. 17, minus the pump head. With this arrangement, the boiler pressure rating and relief valve setting may have to be higher than required for other arrangements.

Attic tanks are used for the purpose of tank size reduction. When used, as shown in D, Fig. 17, a gage located at any point between the tank and

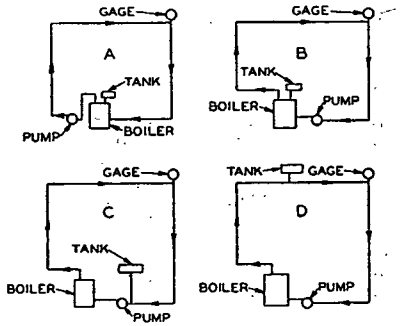

FIG. 17. EFFECT OF PUMP LOCATION AND EXPANSION TANK CONNECTION

the discharge of the pump will show an increase in pressure when the pump operates, while any point between the tank and the suction line of the pump will show a decrease in pressure. This decrease in pressure on the suction side of the tank connection requires that a pressure equal to friction loss between the tank connection and the suction of the pump should be added to the vertical distance the tank is located below the high point of the system to obtain the minimum tank pressure, P_f. Since the pump is located between the expansion tank connection and the boiler, the maximum tank pressure, P_o, would be obtained as described under C, Fig. 17, except that pump effect on the boiler pressure is reduced by the friction loss between the tank connection and the boiler. If the pump were discharging from the boiler instead of into it, the pump operation would not affect P_o.

The following *Examples 4, 5,* and *6* illustrate the principles applying to sizing of closed expansion tanks.

The system used in the examples has: (1) a water volume of 1000 gal, (2) a high point of the system at the top of a return riser 25 ft from the top of the boiler directly above the boiler room, (3) a circulating pump having a 20 ft head, and a 30 psi boiler with an ASME rated relief valve as the item of equipment having the lowest pressure rating. The P_a is atmospheric pressure, 34 ft of water, absolute, in all examples. The design average water temperature is 200 F. Friction losses between the high point of the system and the boiler are assumed to be negligible.

Example 4: Determine the size of expansion tank required when connected as shown in A, Fig. 17.

Solution: Installation is as shown in A, Fig. 17 with the expansion tank at the same level as the relief valve. The net expansion of the water in the system is represented by the term $(0.00041\,t - 0.0466)V_s$ of Equation 4 and, hence, is

$$(0.00041)(200) - 0.0466](1000) = 35.4 \text{ gal.}$$

As stated, P_a is 34 ft of water, absolute. Referring to the discussion for A, Fig. 17, P_f, the minimum pressure, is equal to the height of the system above the expansion tank, 25 ft, plus 4 ft for positive venting, a total of 29 ft of water, gage, or 63 ft of water, absolute. P_o is equal to the relief valve setting, 30 psi × 2.31 ft of water, 69.3 ft of water, gage, or 103.3 ft of water, absolute.

Substituting in Equation 4:

$$V_t = \frac{35.4}{\frac{34}{63} - \frac{34}{103.3}} = 170 \text{ gal.}$$

Example 5: Determine the size of expansion tank required when connected as shown in B, Fig. 17.

Solution: All conditions remain the same, except that the expansion tank connection is at the discharge of the pump rather than at the suction. When the pump operates, the pressure at the top of the return riser is reduced by an amount equal to the head of the pump. Therefore, to maintain a positive pressure at the top of the system, the minimum pressure must be increased an amount equal to the head of the pump, 20 ft of water. P_f, the minimum pressure equals 29 plus 20, or 49 ft of water, gage, or 83 ft of water, absolute. The required volume by Equation 4 is

$$V_t = \frac{35.4}{\frac{34}{83} - \frac{34}{103.3}} = 440 \text{ gal.}$$

Example 6: Determine the size of expansion tank required when it is connected as shown in D, Fig. 17.

Solution: The expansion tank is located at the top of the system with the result that the height of the system has no effect on the required minimum pressure, P_f. However, the tank is located far enough from the pump so that friction loss in the piping between the pump and the tank must be considered in determining the pressure effect of pump operation on system pressures. Assume that the tank is located at a point such that the friction loss between the tank connection to the system and the suction of the pump is 8 ft, with the resistance in the return riser to the boiler still considered negligible.

The pressure in the expansion tank remains the same whether the pump runs or not. Therefore, since 8 ft of friction loss exists between the expansion tank and the pump suction at the top of the return riser, the pressure in the expansion tank must be increased by that amount to maintain a positive air venting pressure at that point.

P_f, the minimum pressure in the tank should be the sum of 4 ft for positive venting pressure and 8 ft, for pump effect or 12 ft water, gage, which is 46 ft of water, absolute. Since the pump is located between the expansion tank connection and the boiler, P_o, the maximum pressure *in the tank,* must be less than the operating pressure of the relief valve by an amount equal to the effect of pump operation on the boiler pressure. In this case, the effect of the pump is reduced by the friction loss between the expansion tank and the boiler. The head of the pump, 20 ft, less friction as discussed, 8 ft, is equal to 12 ft.

P_o, then, is 69.3 less 12, which is 57.3 ft of water, gage, or 91.3 ft of water, absolute. Other factors remain as discussed in the other examples. Substituting in Equation 4 the required expansion tank size is:

$$V_t = \frac{35.4}{\frac{34}{46} - \frac{34}{91.3}} = 96 \text{ gal.}$$

In Examples *4, 5* and *6*, the calculated size of the expansion tank has been indicated. It is customary practice to select a standard tank size not less than that calculated.