

flow and return risers joining the flow and return mains to the boiler will be about 0.6 in. of water, or about one-fortieth of the pressure head produced by the circulating pump selected for the system of Fig. 3.

Table 6 may be used to determine the size of the main as follows: Refer to Column 8 and note that for Sections *AB* and *IA*, which supply 440 sq ft of equivalent heating surface, a 3-in. pipe is too large and a 2½-in. pipe is too small; hence, select 2½ in. for Section *AB* and 3 in. for Section *IA*. For Sections *BC* and *HI*, which supply 320 sq ft of equivalent heating surface, a 2½-in. pipe is almost exactly the correct size and is selected for both sections.

For the forced circulation system of Fig. 5, the pressure head produced by the circulating pump is used to force the water through the mains and also through the risers. Gravity circulation systems have two distinct pressure heads. One is produced by the difference in weight of the water in the flow and return risers adjacent to the boiler, and is the boiler pressure head, which in this case, is 0.6 in. The other pressure head is produced by the difference in weight of the water in the flow and return risers adjacent to the radiators, and is the radiator pressure head. If the temperature drop through the radiators is about 35 deg, and if the story heights of the building are 9 ft and the distance from the center of the first floor radiator to the average level of the main is 3 ft, the radiator pressure head of the first floor radiator is about 450 milinches and the pressure heads of the radiators on the upper floor are 1350 milinches greater than those on the next lower floors.

Tables 6 and 7 are based on the assumption that the boiler pressure head must be equal to the friction head in the mains and that the several radiator pressure heads must be equal to the respective radiator and riser friction heads.

To design the radiator risers, use Table 7 and begin with the set nearest the boiler. The first floor risers must supply 120 sq ft of equivalent heating surface. According to the table, 1½-in. flow and return risers will supply 109 sq ft; if the return riser is increased to 1½ in., the capacity will be increased to 142 sq ft. This is considerably larger than necessary and 1¼-in. flow and return risers are selected. However, it must be remembered that the riser branches, *i.e.*, the connections from the flow and return mains to the flow and return risers, are to be one size larger than the risers, *i.e.*, 1½ in.

The second floor risers must supply 80 sq ft of equivalent heating surface. According to the table, the capacity of 1-in. flow and return risers is 83 sq ft, and that size is selected.

The third floor risers must supply 40 sq ft of equivalent heating surface. If a ½-in. flow and a ¾-in. return riser are used, the capacity will be 33 sq ft; if both risers are ¾ in., the capacity will be 58 sq ft. The ¾-in. pipe is selected for both risers.

To design the radiator connections, use Table 8 and note that for the first floor radiator connections the capacity of a ¾-in. flow and 1-in. return is 38 sq ft, and that of a 1-in. flow and a 1-in. return is 52 sq ft. The former is more nearly the correct size, but since it is difficult to secure a good flow through first floor radiators, the 1-in. flow and return connection is selected. For the two upper floors, the capacity of a ¾-in. flow and return connection is 43 sq ft, and that size is selected.

As explained in the design of the forced circulation system of Fig. 5, the two-pipe direct return system of Fig. 7 will not function correctly unless its four sets of risers are balanced among themselves. This necessary balancing is accomplished by adding resistances to all risers except the one farthest from the boiler equal to the excess boiler pressure heads available for those risers, above the boiler pressure head available for the farthest riser. For example, the first set of risers is 60 ft nearer the boiler than the last set. Since the flow and return mains are designed for a friction head of 3 milinches per foot (see Table 6, Column 8), the boiler pressure head available for the first set of risers is 360 milinches in excess of that available for the fourth set. The velocity in the riser branch is 3 in. per second (see Table 7) and, therefore, according to Table 5, a 0.75-in. orifice in a 1½-in. union should be used. This will provide a resistance of about 400 milinches. In the same manner it is found that for the second set of risers a resistance of 240 milinches is required and

that a 0.80-in. orifice in a 1½-in. union will provide a resistance of 300 milinches. For the third set of risers, a resistance of 120 milinches is required and a 0.75-in. orifice in a 1¼-in. union will provide sufficient resistance.

CIRCULATING PUMPS

Circulating pumps for hot water systems may be used to provide the motive head for forced circulation systems as already described, or to improve the operation of gravity-designed systems. Small specially-designed centrifugal pumps installed on a by-pass with the necessary gate or check valves near the point where the return main enters the heater, may be employed. Specially-designed, electrically-driven, propeller-type circulating pumps, or units may also be employed. The latter are usually installed directly in the return main and are available for all com-

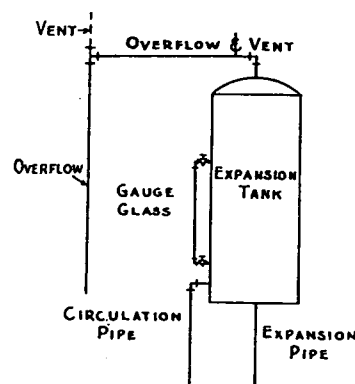


FIG. 9. AN OPEN EXPANSION TANK

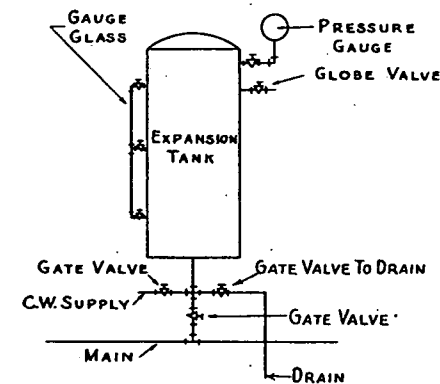


FIG. 10. A CLOSED EXPANSION TANK

mercial pipe sizes used for hot water heating. The motor switch may be under manual control or automatic control using thermostatic elements or tied in with the oil or gas burner switch which starts and stops the burner. For large capacities these units may be installed in multiple.

For exceptionally large installations such as central heating plants, circulating pumps of the centrifugal single stage type, having an average operating efficiency of 70 per cent against heads up to 125 ft, are sometimes used. It is generally advisable to install the pumps in duplicate to provide for contingencies and to insure continuous operation. In such cases each pump may be made equal to two-thirds of the maximum capacity required.

EXPANSION TANKS

When water at ordinary temperature is heated or cooled, its volume is increased or decreased. This variation in the volume of the water in a heating system is generally provided for by means of an expansion tank into which the water can flow from the system during the heating-up