Low head centrifugal pumps especially designed for hot water heating systems are used to provide the head necessary for forced circulation, and to improve the operation of gravity designed systems. These pumps operate with little noise and low power consumption, two features of prime importance to the satisfactory operation of a forced circulation system. They are installed in the return main close to the boiler, with all returns brought into the suction side of the pump. Gate valves should be installed on either side so that the pump can be removed without draining the system. A by-pass is not necessary as the friction drop through the pump is not sufficient to prevent gravity circulation if the pump should become inoperative.

Specially designed propeller type pumps are used also. This type of

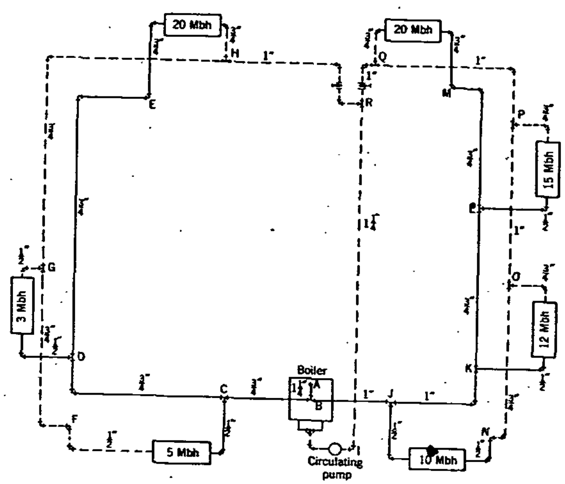

FIG. 3. A FORCED CIRCULATION REVERSED RETURN SYSTEM[a]

[a]Note that the numbers on the radiators indicate thousands of Btu per hour (Mbh) and not square feet

pump is installed in the return and is available for all the commercial pipe sizes used for hot water heating.

The motor may be controlled manually; however, forced circulation lends itself admirably to automatic control. In this case, the motor is controlled by a thermostat which can be tied in with the controls of the automatic firing device. In conjunction with flow control valves this permits an accurate control of the hot water in the radiation.

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 pumps in duplicate to provide for contingencies and to insure continuous operation. In such cases each pump should be made equal to the maximum capacity required.

PIPE SIZES

The pressure heads available in forced circulation systems are much greater than those in gravity circulation systems, consequently, higher velocities may be used in designing the system, with the result that smaller pipes may be selected and the first cost of the installation reduced. As the pipes of a heating system are reduced in size, the necessary increase in the velocity of the water increases both the cost of operation and the initial cost of the circulating equipment. The increased velocity of a forced circulation system offers a number of advantages, such as a much shorter heating-up period and a more flexible control of hot water circulation. This improved performance merits the small increase in operating cost necessary to mechanically circulate the system. The velocity required should be determined by calculation for the particular system under consideration.

Since the velocities in forced circulation systems are higher than those in gravity circulation systems, and since the friction heads in a heating system vary almost as the squares of the velocities, a given error in the calculation or assumption of a velocity is less important in a forced circulation system than in a gravity circulation system and, consequently, it is easier to design a satisfactory forced circulation system than a satisfactory gravity circulation system.

FORCED CIRCULATION

The following examples will illustrate the procedure to be followed in designing forced circulation systems:

Example 1. Assume that the longest path through 7 radiators shown in Fig. 3 consist of 200 ft of mains, 25 ft of radiator connections, 1 boiler, 1 radiator, 1 radiator valve, 1 stop cock, 12 ells, and 2 tees. Also assume that the short branch main contains the same number of fittings and that the main is 150 ft long with 7 ft of radiator connections. Design the piping for this system.

Solution. The friction heads of boiler, radiator valve and tee may be expressed in terms of the friction head in 1 elbow according to the values given in Table 1. Having done this, the longest circuit consists of 225 ft of pipe and 34 elbow equivalents. The friction head of 1 elbow is approximately equivalent to that in a pipe having a length equal to 25 diameters. Assume that the average pipe size in this case will be 1 in. Referring to Table 2, 1 elbow equivalent of 1 in pipe is equal to 2.3 ft and the total equivalent length of the longest circuit is 299 ft of straight pipe. Similarly the equivalent length of the short branch is 231 ft.

Having determined the equivalent pipe length, the next step is to assume the rate at which the water is to be circulated through the complete system. The water may flow through the radiator so that it will cool 10 or 20 F or any other reasonable number of degrees, but in this case, assume a temperature drop of 20 F through the radiation. One gallon of water per minute with a density of 7.99 lb per gal at 215 F will deliver approximately 9600 Btu per hour, with a 20 F temperature drop.

The total radiation load is 85,000 Btu per hour (85 Mbh) and therefore the pump must circulate 4250 lb of water per hour or 8.85 gpm for a temperature drop of 20 F.

Knowing that the rate of flow is 8.85 gpm, the next step is to determine from the pump characteristics which pump will produce a satisfactory velocity. Presume that four sizes of pumps are available delivering 8.85 gpm of water at the following heads: 18 in., 6 ft, 14 ft, and 25 ft. At these heads, the pumps would produce velocities sufficient to make available the following respective friction losses per foot: 60, 240, 562 and 1000 milinches. A comparison with Fig. 4 will show that little advantage is gained from the use of a 60 milinch friction loss, and that the use of a 1000 milinch friction loss will