Instead of making the calculation just described, refer to Table 3, and note that, for a first-floor radiator, the capacity of a 1¼ in. pipe is 9,500 B.t.u. Table 3 is based on an average water temperature of 180 deg. When the temperature (average) is higher, the capacities are larger.

To find the sizes of the radiators, it must be remembered that the water is cooled as it traverses the system and that each successive radiator is supplied with cooler water and must, therefore, have a larger

TABLE 3. MAXIMUM CAPACITIES, IN B.T.U., OF RISERS FOR ONE-PIPE SYSTEMS

Flow Riser, Inches	Return Riser, Inches	Capacities in B.t.u.		
		First Floor	Second Floor	Third Floor
¾	¾	3,000	6,500	7,800
¾	1	3,700	8,000	9,600
1	1	5,300	11,400	13,600
1	1¼	6,400	14,400	17,100
1¼	1¼	9,500	21,700	26,300
1¼	1½	10,700	25,000	30,600
1½	1½	13,000	30,200	37,900
1½	2	16,000	38,100	46,100
2	2	23,000	55,700	66,800

Note.—Length of pipe:

First floor—7 ft. 0 in.
Second floor—25 ft. 0 in.
Third floor—43 ft. 0 in.

Each circuit has 16-elbow equivalents. This table is based on a temperature drop of 20 deg. through the radiators and an average water temperature of 180 deg. The resulting pressure heads are:

First floor—129 mil-inches.
Second floor—903 mil-inches.
Third floor—1,677 mil-inches.

If the average temperature is higher than 180 deg. the pressure heads are higher than those shown, and if the average temperature is lower than shown, the pressure heads are lower.

surface than the preceding one, if it is to transmit an equal quantity of heat. In this particular system, if the first radiator is supplied with 205 deg. water, the sixth one will be supplied with 184⅙ deg. water. The average temperatures of the water in the two radiators will then be about 195 and 175, respectively. The temperature differences, water to air, will be 125 and 104. The values of U will be (from Fig. 2, for a 3-col., 38-in. radiator) 1.34 and 1.28; the heat transmitted will be 125×1.34, or 167.5 and 105×1.28, or 134.4 B.t.u. per square foot. The first radiator must have $\frac{9{,}000}{167.5}$ or 53.7 sq. ft., and the sixth radiator $\frac{9{,}000}{134.4}$, or 66.9 sq. ft. In other words, the last radiator must be about 25 per cent larger than the first, if it is to deliver an equal quantity of heat.

Instead of making these complicated calculations for every radiator in a one-pipe system, it may be sufficiently accurate to adopt the following rule:

1. Design each radiator as if it were supplied with water at the maximum temperature used in the system;
2. *Divide* the heating system into four sections so that each section transmits about one-fourth of the total heat;
3. Number the four sections in the order of their distances from the heater, measured along the flow main, so that the first section radiators receive the hottest water;
4. Adopt the calculated sizes for the radiators in the first section and add, respectively, 10 per cent, 20 per cent and 30 per cent to the sizes calculated for the radiators of the second, third, and fourth sections of the heating system.

The one-pipe system with under-foot distribution, designed as outlined, is probably the system which is easiest to construct so that it will

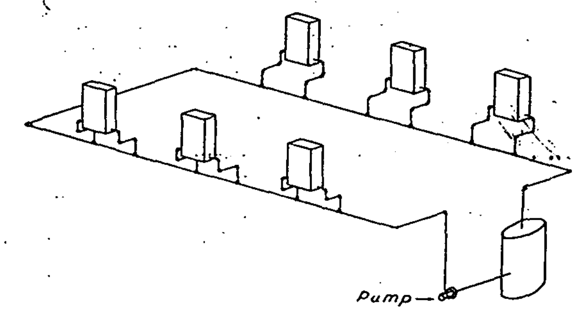

FIG. 8. ONE-PIPE HEATING SYSTEM OF FIG. 4 CHANGED FROM GRAVITY FLOW TO FORCED CIRCULATION

function correctly. The most common error committed in the installation of these systems is that the radiators farthest from the heater are not enlarged sufficiently.

The one-pipe systems with over-head distribution and the two-pipe systems are more complicated, but the underlying principle is the same for all: *The friction head in every radiator circuit must be equal to the pressure head available for that circuit.*

The method of designing the more complicated systems is explained in the respective textbooks to which the reader is referred for additional guidance.

FORCED CIRCULATION SYSTEMS

The principle difference between a gravity circulation and a forced circulation system is that, in the former, the pressure heads are caused entirely by the difference in the weight of the water in the flow and the return risers, whereas, in the latter, the pressure heads are produced largely, in some cases almost entirely, by a pump.

Changing a System from Gravity to Forced Circulation

For example, let Fig. 8 represent the one-pipe gravity circulation system as designed. To change the system from gravity to forced circulation, insert a circulating pump at any point in the main.