between the calculated heat losses and the actual heat losses, and also smaller than the average difference between the calculated radiator sizes and the nearest stock sizes selected.

GRAVITY CIRCULATION

For gravity circulation, the one-pipe system shown in Fig. 6 and the two-pipe, direct return system shown in Fig. 7 are probably in most common use.

The one-pipe system has the advantage that it can be easily designed and constructed so that it will function correctly. It has the disadvantage that the radiator nearest the boiler is the only one which receives water at approximately the temperature at which it leaves the boiler. All other radiators receive cooler water and must be increased in size proportionally with the result that the total heating surface in the system is considerably larger than that in a corresponding two-pipe system.

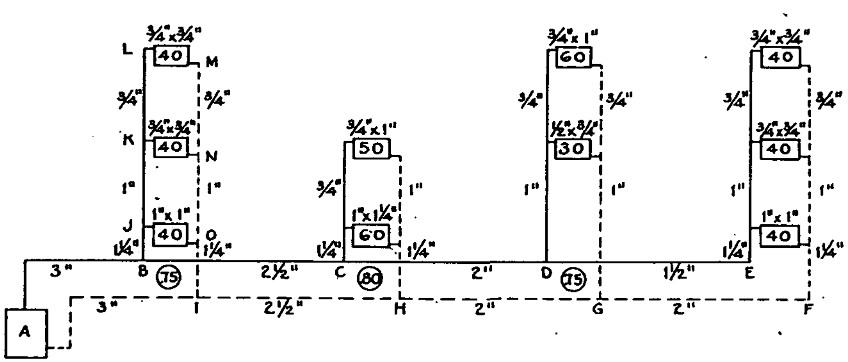

FIG. 7. A TWO-PIPE DIRECT RETURN GRAVITY CIRCULATION SYSTEM

The pipe sizes in gravity circulation systems may be varied materially. As the pipe sizes are decreased, the temperature drop through the radiators which produces circulation, is increased and it becomes necessary either to increase the temperature of the water leaving the boiler or to increase the size of the radiators. For example, Fig. 8 shows an elementary heating system diagramatically. This system will function with any reasonable pipe size; either a 1½-in. or a 1-in. may be used as follows: Let the radiator be required to deliver 27,000 Btu per hour (requiring 113 ft of equivalent heating surface), and let the circuit consist of 30 ft of pipe and 20 elbow equivalents. If a 1½-in. pipe is used, the system will operate correctly if the water temperature in the flow and return risers are 200 F and 180 F, respectively. The mean water temperature in the radiators will then be 190 F and if the radiator is located in air having a temperature of 70 F, the size of the radiator must be 152 sq ft. (See Table 3, Chapter 6).

If 1-in. pipe is used, the system will function correctly with water temperatures in the flow and return risers of 210 F and 170 F, or of 200 F

and 160 F. In the first case, the mean water temperature is again 190 F and the same size radiator may be used as with the 1½-in. pipe, but the temperature of the water leaving the boiler must be raised from 200 F to 210 F. In the second case, the temperature of the water leaving the boiler is the same as for the 1½-in. pipe, but the mean water temperature in the radiator is lowered from 190 F to 180 F, and consequently, the size of the radiator must be increased from 152 to 171 sq ft.

This illustration indicates the extent to which pipe sizes and radiator sizes may be decreased by increasing the temperatures of the water in the boiler as is possible in closed systems, and also in open systems in which the open expansion tank is located sufficiently high to secure the same pressure in the boiler as that existing in the boiler of the closed system.

Example 3. Design a one-pipe gravity circulation system for the layout shown in Fig. 6. Assume that the main circuit consists of 150 ft of pipe, 7 elbows, and one boiler.

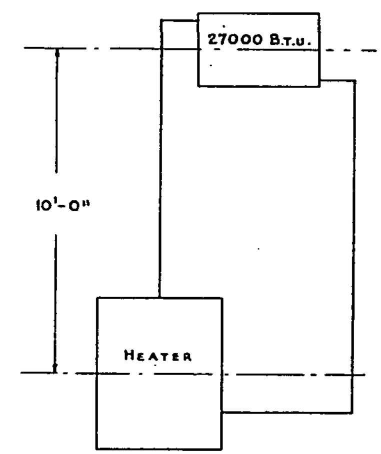

FIG. 8. AN ELEMENTARY SYSTEM

Solution. Replace the boiler by 3 elbow equivalents and assume that the size of the main will be about 2 in. According to Table 6, Column 2, a 2-in. elbow is equivalent to 4 ft of pipe, and the total equivalent length of the main will be about 150 plus 40, or 190 ft. Assuming that the center of the boiler will be about 4 ft lower than the horizontal portion of the main and that the temperature drop in the system is to be 35 deg, Table 6 may be used to determine the size of the mains. Note from Column 8, for a 200-ft length, that a 2-in. main will supply 200 sq ft and a 2½-in. main, 314 sq ft of equivalent heating surface. Since the system to be designed is to supply 275 sq ft, a 2-in. pipe is too small and a 2½-in. pipe too large. The solution is to use some 2-in. and some 2½-in. pipe. Since the 2½-in. is nearer the correct size than the 2-in., select 2-in. pipe for the first 50 or 60 ft out of the boiler and 2½-in. for the remaining pipe back to the boiler.

Tables 7 and 8 may be used to design the radiator risers and connections. According to Table 7, for 50 sq ft of equivalent heating surface, the flow riser should be ¾ in. and the return riser 1 in., and the riser branches should be 1 in. and 1¼ in. respectively. Note that according to Table 8, both radiator tappings should be 1 in. To simplify the construction, select 1-in. flow risers with 1-in. riser branches and 1-in. radiator tappings. Also select 1¼-in. return risers with 1¼-in. riser branches, and 1¼-in. radiator tappings. Similarly, for 75 sq ft of equivalent heating surface, select 1¼-in. flow and return risers and riser branches, and 1¼-in. radiator tappings.