surface in the system is considerably larger than that in a corresponding two-pipe system.

The pipe sizes in gravity circulation systems may be varied. As the pipe sizes are decreased, the temperature drop through the radiators, which produces circulation, is increased and it becomes necessary to increase the temperature of the water leaving the boiler so that the mean temperature in the radiator remains constant. For example, Fig. 8 shows diagrammatically an elementary heating system which will function with either 1½-in. or 1-in. pipe. The radiator is required to deliver 27 Mbh, and the circuit consists of 30 ft of pipe and 20 elbow equivalents.

If 1½-in. pipe is used, the system will operate correctly if the water temperatures 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 sufficient to deliver 27 Mbh under these conditions.

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

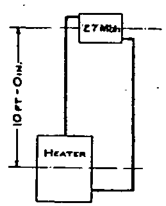

FIG. 8. AN ELEMENTARY SYSTEM

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 theoretically the size of the radiator should be increased about 12½ per cent to deliver the required 27 Mbh (See Table 3, Chapter 6, 1933 GUIDE, also refer to Question 3, page 621).

This 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 in open systems in which the open expansion tank is located sufficiently high to secure a pressure in the boiler equal to 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.

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 F, 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 48 Mbh and a 2½-in. main, 75.4 Mbh. Since the system to be designed is to supply 66 Mbh, a 2-in. pipe is too small and a 2½-in. pipe

TABLE 6. CAPACITIES OF MAINS IN *Mbh*, FOR ONE-PIPE AND FOR TWO-PIPE DIRECT RETURN GRAVITY CIRCULATION SYSTEMS WITH A TOTAL FRICTION HEAD OF 0.6 IN., A TEMPERATURE DROP OF 35 F, WHEN THE MAINS ARE 4 FT ABOVE THE CENTER OF THE BOILER

1	2	3	4	5	6	7	8	9	10	11
PIPE SIZE (INCHES)	EQUIVALENT LENGTH OF PIPE (FEET[a])	EQUIVALENT TOTAL LENGTH OF PIPE IN FEET IN LONGEST CIRCUIT								
		75	100	125	150	175	200	250	300	350
		UNIT FRICTION HEAD, IN MILINCHES								
		8.0	6.0	4.8	4.0	3.4	3.0	2.4	2.0	1.7
1½	3.0	*43.0*	*37.5*	*33.0*	*30.0*	*27.0*	*25.0*	*22.2*	*20.2*	*18.7*
2	4.0	*83.0*	*72.0*	*63.0*	*57.0*	*51.0*	*48.0*	*42.0*	*38.0*	*35.0*
2½	4.5	*140.0*	*115.0*	*100.0*	*90.0*	*81.5*	*75.4*	*67.2*	*61.0*	*56.0*
3	5.0	*234.0*	*204.0*	*175.5*	*160.0*	*143.0*	*133.0*	*110.0*	*107.5*	*100.0*
3½	5.5	*347.0*	*300.0*	*260.0*	*236.0*	*214.0*	*200.0*	*177.0*	*160.0*	*146.0*
4	6.0	*490.0*	*422.0*	*370.0*	*334.0*	*297.0*	*278.0*	*248.0*	*223.0*	*205.0*

[a]Approximate length of pipe in feet equivalent to one elbow in friction head. This value varies with the velocity.

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 12 Mbh 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

TABLE 7. MAXIMUM CAPACITIES OF RISERS[a] IN *Mbh*, AND **Velocities of Water in Pipes in Inches Per Second** FOR ONE-PIPE AND FOR TWO-PIPE DIRECT RETURN GRAVITY CIRCULATION SYSTEMS WITH A DROP OF 35 F THROUGH EACH RADIATOR

PIPE SIZE (INCHES)		EQUIVALENT LENGTH OF PIPE (FEET[c])	1ST FLOOR[b]			2ND FLOOR	3RD AND 4TH FLOORS
				Vel. (In. per Sec.[d])			
Flow	Return		*Mbh*	Flow	Return	*Mbh*	*Mbh*
½	½	1.0				*5*	*6.2*
½	¾					*6.4*	*8.0*
¾	¾	1.5	*9*	2.3	2.3	*10.1*	*14.0*
¾	1		*12*	3.2	2.0	*12.8*	*17.1*
1	1	2.0	*18*	2.5	2.5	*20*	*26.0*
1	1¼		*21*	3.0	2.0	*25.2*	*34*
1¼	1¼	3.0	*26*	3.0	3.0	*43*	*55*
1¼	1½		*34*	4.0	2.5		
1½	1½	3.5	*48*	3.0	3.0		

[a]This table is based on pressure heads of 450, 1800, 3150, and 4500, respectively, for the first, second, third, and fourth floor radiators, and on friction heads of 200 milinches for the first floor radiators and connections, and 700 milinches for all other radiators and their connections.

[b]The riser branches, the piping which connects the risers to the mains, are to be one size larger than the risers.

[c]Approximate length of pipes in feet equivalent to one elbow in friction head. This value varies with the velocity.

[d]Velocities apply to the riser branches.