

diagrammatically an elementary heating system which will function with either $1\frac{1}{2}$ -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 $1\frac{1}{2}$ -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 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 $1\frac{1}{2}$ -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 $1\frac{1}{2}$ -in. pipe, but the mean water temperature

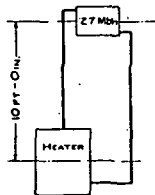


FIG. 8. AN ELEMENTARY SYSTEM

in the radiator is lowered from 190 F to 180 F, and theoretically the size of the radiator should be increased about $12\frac{1}{2}$ per cent to deliver the required 27 Mbh (See Table 3, Chapter 6, 1933 GUIDE).

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 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 48 Mbh and a $2\frac{1}{2}$ -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 $2\frac{1}{2}$ -in. pipe too large. The solution is to use some 2-in. and some $2\frac{1}{2}$ -in. pipe. Since the $2\frac{1}{2}$ -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 $2\frac{1}{2}$ -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 $\frac{3}{4}$ in. and the return riser 1 in., and the riser branches should be 1 in. and $1\frac{1}{4}$ 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 $1\frac{1}{4}$ -in. return risers with $1\frac{1}{4}$ -in. riser branches, and $1\frac{1}{4}$ -in. radiator tappings. Similarly, for 18 Mbh, select $1\frac{1}{4}$ -in. flow and return risers and riser branches, and $1\frac{1}{4}$ -in. radiator tappings.

CHAPTER 33—HOT WATER HEATING SYSTEMS

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 DEG, WHEN THE MAINS ARE 4 FT ABOVE THE CENTER OF THE BOILER

PIPE SIZE (INCHES)	EQUIVALENT LENGTH OF PIPE (FEET) ^a	2	3	4	5	6	7	8	9	10	11
		EQUIVALENT TOTAL LENGTH OF PIPE IN FEET IN LONGEST CIRCUIT ^b									
		75	100	125	150	175	200	250	300	350	
		UNIT FRICTION HEAD, IN MILLINCHES									
		8.0	6.0	4.8	4.0	3.4	3.0	2.4	2.0	1.7	
$1\frac{1}{2}$	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	
$2\frac{1}{2}$	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	
$3\frac{1}{2}$	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	

^aApproximate length of pipe in feet equivalent to one elbow in friction head. This value varies with the velocity.

To develop a rule for determining radiator sizes, assume a system similar to that of Fig. 6, in which the total temperature drop is to be 35 deg and which is equipped with 7 radiators, all radiators dissipating equal quantities of heat. The mean temperature of the water in the radiators will be reduced 5 deg for each successive radiator. If the mean temperature of the water in the first radiator is 200 F, the mean tem-

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 DEG THROUGH EACH RADIATOR

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

^aThis table is based on a flow of 100 gpm per ton of cooling capacity.

^aThis 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 millinches for the first floor radiators and connections, and 700 millinches for all other radiators and their connections.

^bThe riser branches, the piping which connects the risers to the mains, are to be one size larger than the risers.

^cApproximate length of pipes in feet equivalent to one elbow in friction head. This value varies with the velocity.

^dVelocities apply to the riser branches.