

The radiator circuits are then checked. The 20 Mbh radiator on this circuit has 3 ft of supply pipe and 13 elbow equivalents while the return is composed of 4 ft and 2 elbows. The unit loss in $\frac{3}{4}$ in. pipe at this delivery is 170 milinches per foot. The total loss in the supply is 3910 milinches. The loss in the return is 1190. Total loss in the radiator circuit is 5100 milinches. Check each radiator circuit in a similar manner.

The total calculated loss for the longest circuit was determined as 60,000 milinches. The maximum loss in the short circuit is 18,630 plus 13,410 plus 15,450 or a total of 47,490 milinches. This difference is caused by the variation in length of the two circuits and may be corrected by using a flow control in the return main to supply the additional resistance or by introducing resistance into each separate circuit to compensate for the difference. A 10 per cent variation will cause no complication as the flow from the various pipes will not exactly follow the curves of Fig. 4 any closer than this value.

Example 2. Design a two-pipe direct return forced circulation system with copper tubing and fittings for the piping layout as detailed in Fig. 5, based on a 20 F temperature drop through the radiation.

The piping circuit from the boiler to the highest radiator on the farthest riser and back to the boiler is 250 ft of pipe. There are about 16 elbow equivalents having an equivalent pipe length of about 50 ft, so that the total equivalent pipe length is 300 ft.

Assume that a circulator is available which will provide a pressure head of 6 ft.

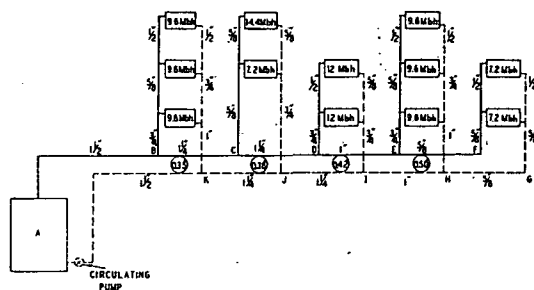


FIG. 5. A FORCED CIRCULATION DIRECT RETURN SYSTEM

Solution. Refer to Table 2, which indicates the total equivalent lengths for pressure heads from 2 to 12 ft. With a circulator having a 6 ft pressure head and a system with a total equivalent length of 300 ft, the piping system will be designed on a basis of 240 milinch.

Checking the piping diagram it will be noted that sections AB and KA, both supply 117.6 Mbh. Referring to the 240 milinch column of Table 2, $1\frac{1}{2}$ in. is shown to be the necessary pipe size. Sections BC and JK carry 88.8 Mbh and require $1\frac{1}{4}$ in. tubing. Sections CD and IJ supply 67.2 Mbh and require $1\frac{1}{4}$ in. tubing. Sections DE and HI supply 43.2 Mbh, which requires 1 in. tubing. Sections EF and GH with a load of 14.4 Mbh require $\frac{3}{4}$ in. tubing.

The risers are pipe sized in a similar manner. To secure proper distribution of hot water in the direct return system among the several risers, it is necessary to introduce resistances to balance the circuit.

The first riser is 80 ft nearer the boiler than the fifth riser. In order that the two may be balanced, that is, operated under equal pressure heads, resistance must be added to the first riser equal to the friction head in the 80 ft of supply main B to F plus the 80 ft of return main G to K for a total of 160 ft of pipe.

Having designed the piping system on a 240 milinch basis, the total friction head in the supply and return mains between the first and fifth risers is therefore $160 \times 240 = 38,400$ milinches, or 3.2 ft which must be supplied by additional resistance in the first riser.

CHAPTER 17. HOT WATER HEATING SYSTEMS AND PIPING

TABLE 6. FRICTION HEADS (IN MILINCHES) OF CENTRAL CIRCULAR DIAPHRAGM ORIFICES IN UNIONS

DIAMETER OF ORIFICES (INCHES)	VELOCITY OF WATER IN PIPE IN INCHES PER SECOND									
	2	3	4	6	8	10	12	18	24	36
$\frac{3}{4}$-in. Pipe										
0.25	1300	2900	5000	11,300	20,800	32,000	45,000			
0.30	650	1450	2500	5700	10,400	16,000	23,000	57,000		
0.35	330	740	1300	2900	5200	8000	12,000	26,000	47,000	
0.40	170	380	660	1500	2600	4000	6800	13,000	24,000	53,000
0.45		185	330	740	1300	2000	2900	6500	12,000	27,000
0.50			155	350	620	970	1400	3200	5700	13,000
0.55			75	170	300	480	700	1600	2800	6400
1-in. Pipe										
0.35	900	2000	3500	7800	14,000	22,000	32,000			
0.40	460	1000	1800	4000	7200	12,000	17,000	37,000	65,000	
0.45	270	570	1000	2300	4100	6400	9300	21,000	37,000	
0.50	160	330	580	1400	2300	3700	5400	12,000	22,000	50,000
0.55		190	330	750	1300	2200	3000	7000	13,000	28,000
0.60			200	440	800	1300	1800	4200	7400	17,000
0.65			120	260	460	720	1100	2400	4300	10,000
$1\frac{1}{4}$-in. Pipe										
0.45	1000	2250	4000	8900	16,000	25,000	36,000			
0.50	660	1450	2600	5800	10,400	16,400	23,000	53,000		
0.55	430	950	1700	3800	6800	10,500	15,000	34,000	60,000	
0.60	280	630	1100	2500	4400	6900	10,000	22,000	40,000	
0.65	190	420	750	1700	3000	4700	6700	15,000	27,000	60,000
0.70		285	510	1150	2000	3100	4500	10,000	18,000	40,000
0.75		190	330	750	1300	2100	3000	6700	12,000	26,000
$1\frac{1}{2}$-in. Pipe										
0.55	850	1900	3300	7400	13,000	21,000	30,000			
0.60	600	1300	2300	5400	8600	16,800	21,000	50,000		
0.65	400	850	1500	3600	7200	10,400	14,000	30,000	53,000	
0.70	260	600	1100	2600	4400	7000	10,000	21,000	39,000	
0.75	180	400	760	1800	3000	5000	7000	14,000	28,000	
0.80		300	540	1200	2200	3200	5000	10,200	19,000	45,000
0.85		200	380	860	1600	2300	3000	7800	13,000	30,000
2-in. Pipe										
0.70	890	1850	3500	7400	14,000	22,300	33,000			
0.80	470	975	1800	3900	7400	11,700	17,000	37,000		
0.90	255	560	1000	2200	4200	6500	9500	20,500	38,000	
1.00	160	340	610	1320	2520	4000	5800	12,500	23,000	49,000
1.10		214	375	850	1600	2500	3700	7900	14,000	30,000
1.20			195	460	950	1360	1910	4200	8100	16,800
1.30				275	525	980	1375	3100	4400	8850

Note.—The losses of head for the orifices in the $1\frac{1}{4}$ -in. and 2-in. pipe were calculated from those in the smaller pipes, the calculations being based on the assumption that, for any given velocity, the loss of head is a function of the ratio of the diameter of the pipe to that of the orifice. This had been found to be practically true in the tests to determine the losses of head in orifices in $\frac{3}{4}$ -in., 1-in., and $1\frac{1}{4}$ -in. pipe, conducted by the Texas Engineering Experiment Station, and also in the tests to determine the losses of head in orifices in 1-in., 6-in., and 12-in. pipe, conducted by the Engineering Experiment Station of the University of Illinois, (Bulletin 109, Table 6, p. 38; Davis and Jordan).