

The length shown in the table nearest to this length is 200 ft. In the 200-ft column, a 1½-in. pipe is slightly too small and a 2-in. pipe is too large. The 1½-in. pipe will therefore be selected. For Sections *CD* and *IJ*, supplying 175 sq ft (42,000 Btu), a 1¼-in. pipe is too small and a 1½-in. pipe is too large, so 1½ in. will be selected for the flow and 1½ in. for the return line. For larger systems, it will be economical to operate with higher friction heads, and tables similar to Tables 3 and 4, which are based respectively on total friction heads of 6 and 18 ft, may be prepared.

TABLE 4. CAPACITIES OF PIPES IN EQUIVALENT SQUARE FEET OF HEATING SURFACE and in 1000 Btu, and Velocities of Water in Pipes in Inches Per Second FOR FORCED CIRCULATION SYSTEMS WITH A TOTAL FRICTION HEAD OF 18 FT AND FOR A MAXIMUM TEMPERATURE DROP OF 10 DEG^b

1	2	EQUIVALENT TOTAL LENGTH OF PIPE IN FEET IN LONGEST CIRCUIT				
PIPE SIZE (INCHES)	EQUIVALENT LENGTH OF PIPE (FEET) ^c	200	400	600	800	1000
		UNIT FRICTION HEAD, IN MILINCHES				
		1080	540	360	270	216
½	1.0	53 12.7 32	36 8.6 23	30 7.2 18	26 6.2 15	23 5.5 13
¾	2.0	115 27.5 40	78 18.7 28	63 15.1 22	57 13.7 19	48 11.5 17
1	2.5	230 55.0 48	154 36.8 34	125 30.0 27	110 26.4 23	94 22.6 20
1¼	3.0	510 122.0 59	340 81.5 42	276 66.0 33	243 58.3 28	210 50.5 25
1½	4.0	760 182.0 66	510 122.0 46	410 98.2 37	360 86.2 31	310 74.2 27
2	5.0	1550 371.0 80	1050 252.0 56	850 201.0 45	750 180.0 38	630 151.0 33
2½	7.0	2500 598.0 91	1700 407.0 65	1350 323.0 51	1200 287.0 43	1000 240.0 38
3	9.0	4600 1110.0 107	3300 790.0 76	2500 598.0 60	2200 527.0 51	1850 443.0 44

^aBased on 240 Btu per square foot.

^bFor other temperature drops the capacities of pipes are to be changed correspondingly. For example, for a temperature drop of 30 deg, the capacities shown in this table are to be multiplied by 3. The velocities remain unchanged.

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

Example 2. Design a direct return two-pipe forced circulation system for the layout shown in Fig. 5. For this system the length of the pipe line from the boiler to the highest radiator on the farthest riser and back to the boiler is about 250 ft. There are about 16 elbow equivalents having an equivalent pipe length of about 50 ft, so the total equivalent pipe length is about 300 ft.

Solution. The same pipe size tables may be used as those developed for the reversed return system of Fig. 3. Since this system is somewhat larger than that shown in Fig. 3, Table 3 which provides for a friction head of 6 ft may be used instead of Table 2 which provides for a friction head of only 2 ft.

Referring to the column for an equivalent total length of 300 ft for Sections *AB* and *KA*, each supplying 490 sq ft (117,600 Btu), it will be found that a 1½-in. pipe is too small and a 2-in. pipe is too large. Consequently, a 1½-in. pipe is selected for the flow line *AB*, and a 2-in. pipe for the return line, *KA*. For Sections *BC* and *JK*, each supplying 370 sq ft (88,000 Btu), a 1½-in. pipe is only slightly too small and it is selected. The remaining pipe sizes are selected in a similar manner and recorded in Fig. 5. This system has 490 sq ft and must supply 117,600 Btu per hour. For a temperature drop of 10 deg, 23.52 gpm of water must be circulated. The pump to select is one which has its highest efficiency when it is delivering 23½ gpm against a 6-ft head.

To secure a correct distribution of hot water among the several risers it is necessary, as previously stated, to introduce special resistances to balance the several risers, as follows:

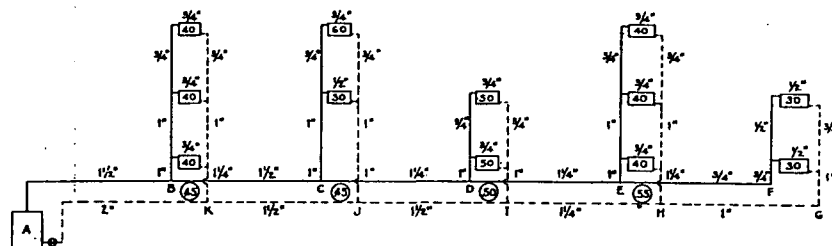


FIG. 5. A FORCED CIRCULATION DIRECT RETURN SYSTEM

The first riser is 80 ft nearer the boiler than the fifth riser. In order that the two may be balanced, i.e., that they may operate under equal pressure heads, resistance must be added to the first riser equal to the friction head in the 80 ft of flow main from *B* to *F* plus that in the 80 ft of return main from *G* to *K*.

It will be noted from Table 3 that the unit friction head is about 240 milinches per foot. The total friction head in the flow and return mains between the first and fifth risers is therefore 160 × 240 or 38,400 milinches, or a little more than 3 ft, which must be supplied by additional resistance in the first riser to prevent its having an advantage over the fifth riser.

This resistance can be supplied by a calibrated and adjusted modulating valve or by an orifice resistor in a union. If the orifice resistor is to be used, its size may be selected from Table 5 as follows:

The lower part of the first flow riser supplies 120 sq ft (28,800 Btu). According to Table 3, it should be a 1-in. pipe and would have a velocity of 22 in. per second, if it were supplying 100 sq ft. Since it is supplying 120 sq ft, the velocity will be about 26 in. per second. From Table 5 it will be found that for a 1-in. pipe and a velocity of 24 in. per second, a 0.45-in. orifice will produce a loss of head of 37,000 milinches. For a velocity of 26 in. per second, the loss of head will be somewhat more, probably about 43,000 milinches; the difference between it and the required resistance will be about 10 per cent which is permissible, and the 0.45-in. orifice is selected.

The sizes of the orifice resistors for the second, third, and fourth risers are selected in a similar manner and found to be 0.45 in., 0.50 in., and 0.55 in. respectively.