TABLE 3. IRON AND COPPER ELBOW EQUIVALENTS

FITTING	IRON PIPE	COPPER TUBING
Elbow, 90-deg	1.0	1.0
Elbow, 45-deg	0.7	0.7
Elbow, 90-deg long turn	0.5	0.5
Open return band	1.0	1.0
Open gate valve	0.5	0.7
Open globe valve	12.0	17.0
Angle radiator valve	2.0	3.0
Radiator	3.0	4.0
Boiler or heater	3.0	4.0
Tee, per cent flowing through branch:		
100	1.8	1.2
50	4.0	4.0
25	16.0	20.0

and this will require ¾-in. pipe. Section PQ carries 10 Mbh and requires ½ in. pipe. To size the return start from the boiler and proceed backwards. Section IR carries 40 Mbh and from Fig. 3 a 1-in. pipe is required. Section RS carries 30 Mbh which is only slightly over the capacity of a ¾-in. pipe, so use ¾ in. Section ST carries 20 Mbh and requires a ¾-in. pipe. The radiator branches are determined in the same manner. It is evident from the chart that it is impossible to maintain a constant friction loss per foot and therefore as the delivery varies there will be a change in the desired friction loss per foot of pipe.

TABLE 4. PIPING CHECK CHART

LOAD, *Mbh*		PIPE LENGTH FT	ELBOWS	PIPE SIZE IN.	UNIT HEAD MILINCHES PER FT	FRICTION MILINCHES	TOTAL LOSS MILINCHES
Supply Main							
AB 98		37	1	1¼	240	9600	9,600
BC 58		2	4	1¼	90	1080	10,680
CD 38		16	1	1	155	2790	13,470
DE 23		9	0	¾	220	1980	15,450
EF 11		12	0	½	240	2880	18,330
FG 4		16	1	½	50	850	19,180
Return Main							
HI 98		5	5	1¼	240	4320	4,320
IJ 58		11	1	1¼	90	1260	5,580
JK 54		16	1	1	300	5400	10,880
KL 47		11	0	1	230	2530	13,410
LM 35		9	0	1	140	1260	14,670
MN 20		15	1	¾	170	2890	17,560
Radiator Circuits							
CN 20	*Supply*	3	13	¾	170	3910	5,100
	Return	4	2	¾	170	1190	
DM 15	*Supply*	3	19	½	420	9250	12,130
	Return	4	17	¾	96	2880	
EL 12	*Supply*	14	20	½	270	9180	18,630
	Return	15	20	½	270	9450	
FK 7	*Supply*	3	19	½	100	2200	4,300
	Return	4	17	½	100	2100	
GJ 4	*Supply*	8	5	½	50	650	1,950
	Return	9	17	½	50	1300	

It is desirable to check the various circuits so that if the variation from the calculated resistance is too great, it may be compensated by adding additional resistance at the proper point. This may be accomplished by sizing the short circuits by the procedure previously outlined. Prepare a chart such as Table 4 to be used in calculating the resistance of each circuit.

Section AB carries 98 Mbh with a unit head of 240 milinches per foot. In section AB there are 37 ft of pipe and 1¼ in. elbow. At 240 milinches per foot this is equivalent to 9600 milinches total loss in this section. Section BC carries 58 Mbh with a length of 2 ft and 4 elbows. The unit loss in this section is 90 milinches per foot. Loss in this section is then 1080 milinches. Section CD carries 38 Mbh and has 16 ft of pipe and 1 elbow. The unit loss in 1-in. pipe is 155 milinches. The loss in this section is 2790 milinches. The balance of the supply main and the return main are handled in a similar manner.

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 ¾ 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

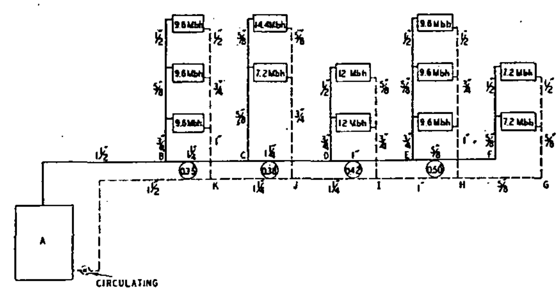

FIG. 5. A FORCED CIRCULATION DIRECT RETURN SYSTEM

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. 3 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.

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, 1½ in. is shown to be the necessary pipe size. Sections BC and JK carry 88.8 Mbh and require 1¼ in. tubing. Sections CD and IJ supply 67.2 Mbh and require 1¼ 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 ⅝ in. tubing.

The risers are pipe sized in a similar manner. To secure proper distribution of hot