TABLE 3. IRON ELBOW EQUIVALENTS[a]

1 90-deg elbow	1.0
1 45-deg elbow	0.7
1 90-deg long turn elbow	0.5
1 open return bend	1.0
1 open gate valve	0.5
1 open globe valve	12.0
1 angle radiator valve	2.0
1 radiator	3.0
1 boiler or heater	3.0
1 tee	(Note[b])

[a]The loss of head in one elbow can be expressed in terms of the velocity head by the formula:

$$h = \frac{v^2}{2g} \qquad (1)$$

where

h = the loss of head in feet, v = the velocity of approach in feet per second, and $2g$ = 64.4 ft per second per second.

[b]The loss of head in tees when water is diverted at right angles through a branch of the tee varies with the per cent diverted. When the water diverted is less than 60 per cent of that approaching the tee, the loss of head, in elbow equivalents, may be expressed as follows:

$$h_e = \frac{v_1^2}{v_2^2} \qquad (2)$$

where

h_e = the loss of head in elbow equivalents, v_1 = the velocity of approach, v_2 = the velocity of water diverted at right angles.

Values in elbow equivalents for the most common percentages of water diverted in a 1x1x1-in. tee are as follows:

25 per cent	16.0
33 per cent	9.0
50 per cent	4.0
100 per cent	1.8

TABLE 4. COPPER ELBOW EQUIVALENTS[a]

1 90-deg elbow	1.0
1 45-deg elbow	0.7
1 90-deg long turn elbow	0.5
1 open return bend	1.0
1 open gate valve	0.7
1 open globe valve	17.0
1 radiator valve	3.0
1 radiator	4.0
1 boiler or heater	4.0
1 tee	(Note[b])

[a]The loss of head in an elbow can be expressed in terms of the velocity head by the formula:

$$h = \frac{0.7\,v^2}{2g} \qquad (3)$$

where

h = loss of head in milinches, v = velocity in inches per second, and g = acceleration of gravity (386 in. per second per second).

[b]The loss of head in copper tees:

$$N = 0.7\,\frac{(v_1^2 + v_2^2)}{v_2^2} \qquad (4)$$

where

N = number of elbows that would cause the same loss as the tee when the velocity of water in the connecting pipe is v_2,
v_1 = velocity of the water in the pipe entering the tee, and
v_2 = velocity of the water in the pipe discharging from the tee at right angles to v_1.

Values in elbow equivalents for most common percentages of water diverted in a 1 in. x 1 in. tee.

100 per cent	1.2
50 per cent	4.0
30 per cent	16.0
25 per cent	20.0

The pipe sizes may be selected from Fig. 4 or from Table 1 which has been derived from Fig. 4.

Size the supply main of the longest circuit first. Section AB carries 98 Mbh. From Fig. 4 it will be noted that at 240 milinches per foot, a 1¼ in. pipe carries 98 Mbh. Therefore, use 1¼ in. pipe in Section AB. Section BO carries 40 Mbh. A 1 in. pipe carries 48 Mbh at 240 milinches per foot. Use a 1 in. pipe. Section OP carries 20 Mbh 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. 4 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.

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 5 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.

TABLE 5. 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	
	Return	4	2	¾	170	1190	5,100
DM 15	*Supply*	3	19	½	420	9250	
	Return	4	17	¾	96	2880	12,130
EL 12	*Supply*	14	20	½	270	9180	
	Return	15	20	½	270	9450	18,630
FK 7	*Supply*	3	19	½	100	2200	
	Return	4	17	½	100	2100	4,300
GJ 4	*Supply*	8	5	½	50	650	
	Return	9	17	½	50	1300	1,950