The pressure head for the main system is produced by the difference in weight of the 205 deg. water in the flow risers and the 180 deg. water in the return risers, the two risers being 3 ft. 6 in. high.

The weight of 180 deg. water is 60.58, and that of 205 deg. water is 60.00 lb. per cubic foot. The difference in the weights of the two columns of water is 3½ x 0.58, or 2.03 lb.

The pressure produced by this weight is the same as that produced by a column of water (of average weight, 60.29), having a height of $\frac{2.03}{60.29}$, or 0.033 ft., or 0.4 in.

TABLE 1. ELBOW EQUIVALENTS

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 Tee	2.2
1 Open gate valve	0.5
1 Open globe valve	12.0
1 Angle radiator valve	2.0
1 Radiator	3.0
1 Heater	3.0

These relations are very nearly correct for the low velocities existing in gravity circulation; for the higher velocities employed in forced circulation, they are sufficiently accurate because every radiator has practically the same number of valves and tees in its circuit and is, therefore, affected equally by any variation from the ratios given above.

Instead of calculating the pressure head, it may be found from Fig. 5, as follows: Find 205 at the upper margin of the diagram, follow the corresponding vertical line downward until it intersects the curved line designated 180. From that point, follow the horizontal line to the left margin of the diagram and read 114 mil-inches per foot of water column. Multiply by 3½, and find 399 instead of 400, as calculated.

The size of the main must now be selected so that its friction head is 400 mil-inches or less. The friction head of the main is made up of the friction heads in 125 ft. of horizontal main, 10 ft. of vertical main and connections, seven elbows, and one heater.

Reference to Table 1 shows that the friction in one heater is equal to that in three elbows; the total friction may then be assumed to be due to 135 ft. of pipe and 10 elbows.

Assume 3 in. as the size of the main and refer to Fig. 7. This diagram is designed for a temperature difference, in flow and return risers, of 20 deg.; in the present example, the temperature difference is to be 25 deg.; the velocity of the water in the main will, therefore, be only $\frac{20}{25}$, or $\frac{8}{10}$ as much as it would be if the temperature difference were 20 deg. Hence, to apply the diagram of Fig. 7, use only $\frac{8}{10}$ of the total heat; *i.e.*, 0.8 × 54,000, or 43,200 B.t.u., and proceed as follows:

Find 43.2 in the lower margin of the diagram, follow the corresponding vertical line to its intersection with the 3 in. pipe line and also with the

3 in. elbow line and read a friction head of 1 mil-inch per foot of pipe, and 5 mil-inches per elbow. The total friction head is 135 × 1, plus 10 × 5, or 185. A 3 in. pipe is too large. Assume a 2½ in. pipe and find the friction head to be 135 × 3, plus 10 × 12, or 525. A 2½ in. pipe is too small. Select a 3 in. pipe or construct the main partly of 3 in. and partly of 2½ in. pipe.

Instead of making the calculation just described, reference may be made to Table 2. Find the horizontal pipe length of 125 ft. in the left

TABLE 2. MAXIMUM CAPACITIES IN ONE THOUSAND B.T.U. OF MAINS FOR ONE-PIPE SYSTEMS FOR A DROP IN TEMPERATURE OF 25 DEG. AND A HEAD OF 3 FT. 6 IN.

LENGTH OF HORIZONTAL MAINS, FEET	SIZE OF MAINS—INCHES						
	2	2½	3	3½	4	5	6
50	41	59	100	140	195	346	552
75	35	51	90	130	179	320	500
100	31	48	83	121	165	293	450
125	30	44	75	113	153	280	425
150	27	40	70	104	143	265	405
175	25	38	66	98	136	252	390
200	24	35	63	93	130	239	377
225	23	34	61	90	125	225	367
250	22	33	60	88	120	223	358

Note.—For given capacities, the permissible lengths of the mains are practically directly proportional to the heads. If the head is more than 3 ft. 6 in., the values given in this table may be increased correspondingly.

column of the table, follow the corresponding horizontal line to the right and note that the capacities of the 2½ in. pipe and the 3 in. pipe are respectively, 44,000 and 75,000 B.t.u. per hour, and conclude that the 2½ in. pipe is too small and the 3 in. pipe too large, as calculated.

To design the connections for one of the radiators, *i.e.*, to design one of the six minor systems, proceed as previously described for the design of the major system. Assume that the radiator is on the first floor and that the vertical distance of the radiator tapping above the main is 18 in., that the temperature drop through the radiator is to be 20 deg., and that the average maximum water temperature is to be 195. From Fig. 3, it is evident that the pressure head for the 18 in. column will be 138 mil-inches. The friction head is caused by about 7 ft. of pipe and 16 elbow equivalents. From Fig. 6, it is evident that for 9,000 B.t.u. and a 1 in. pipe, the friction head will be 7 × 10, plus 16 × 20, or 390 mil-inches. A 1 in. pipe is too small. For a 1¼ in. pipe, the friction head will be 7 × 3, plus 16 × 6, or 117. A 1¼ in. pipe is slightly too large. A 1¼ in. pipe would be selected.