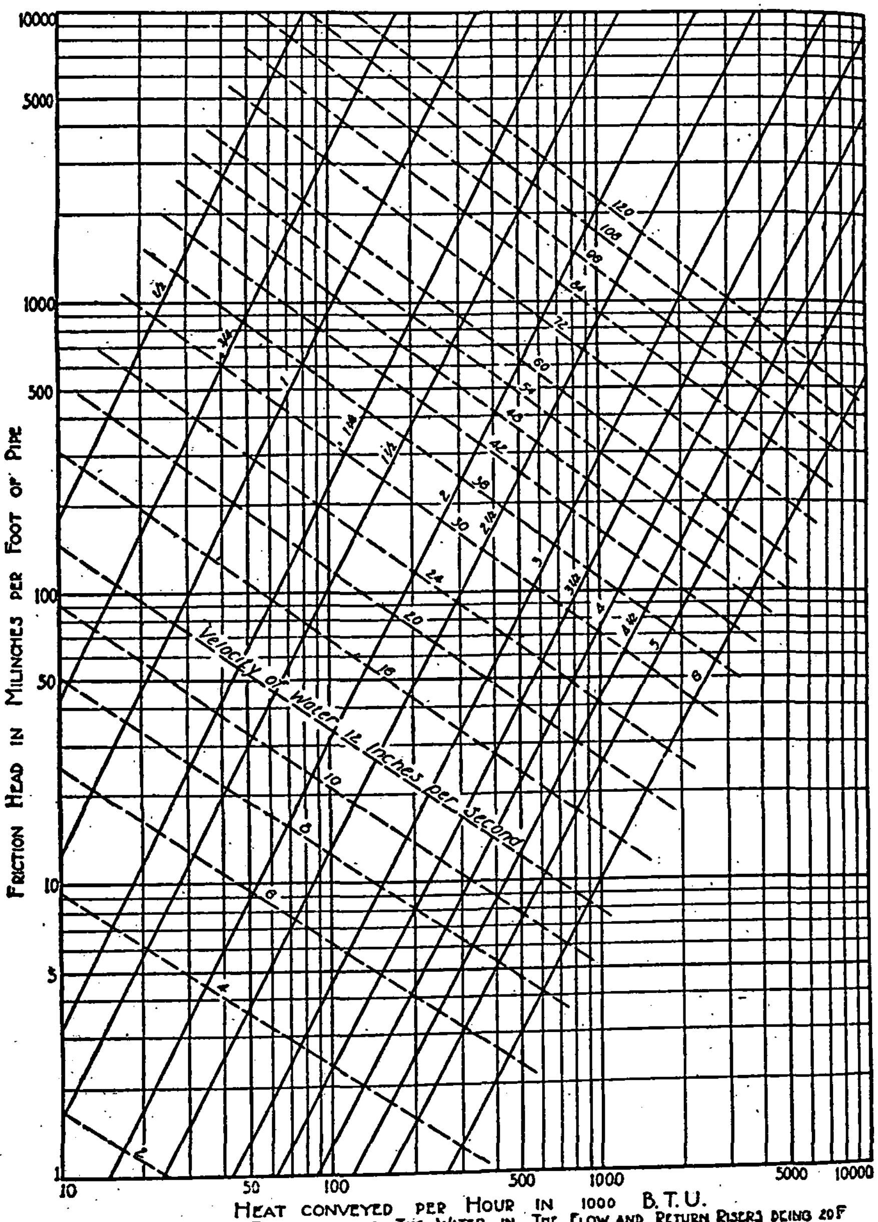

Fig. 4. Friction Heads in Pipes for a 20 F Temperature Difference of the Water in the Flow and Return Lines

Referring to Table 2, 1 elbow equivalent of 1 in. pipe is equal to 2.3 ft and the total equivalent length of the longest circuit is 299 ft of straight pipe. Similarly the equivalent length of the short branch is 231 ft.

Having determined the equivalent pipe length, the next step is to assume the rate at which the water is to be circulated through the complete system. The water may flow through the radiator so that it will cool 10 or 20 F or any other reasonable number of degrees, but in this case, assume a temperature drop of 20 F through the radiation. One gallon of water per minute with a density of 7.99 lb per gal at 215 F will deliver approximately 9600 Btu per hour.

The total radiation load is 85,000 Btu per hour (85 Mbh) and therefore the pump must circulate 4250 lb of water per hour or 8.85 gpm for a temperature drop of 20 F.

Table 1. 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 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:

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

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:

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

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%	16.0
33%	9.0
50%	4.0
100%	1.8

For other percentages the approximate values may be secured by interpolation. When the water is diverted from the tee into a smaller size branch, as in a 1x1x¾-in. tee, approximate values may be secured by means of Formula 2.

The next step in the design is to assume the velocity at which the water is to circulate through the system which may vary materially. As the velocity is increased, the size of the pipes and the cost of the system are decreased, but the cost of operating the circulating pump is increased. The designing engineer should make a careful study to determine the velocity which will produce the most economical installation. With the equipment and piping now available, the most economical pipe velocity is one which will produce approximately a frictional loss of from 150 to 300 milinches per ft. In this case assume a frictional loss of 240 milinches per ft to be produced in the complete circuit of piping. Therefore 299 × 240 = 71,800 milinches or 6 ft static head required of the pump when circulating 8.85 gpm.

The pipe size may now be selected from Fig. 4 making allowance for the fact that the 2 circuits are of unequal lengths. Size the longest pipe circuit first. Section *AB* which is that portion of pipe connecting the boiler to the distributing main, must have a capacity of 85,000 Btu per hour (85 Mbh) and referring to Fig. 4, it will be noted that a 1¼ in. pipe is slightly too large to carry the total load. Therefore a 1¼ in. pipe may be satisfactorily selected for Sections *AB* and *RI*. The load branches at *B* with 28 Mbh in