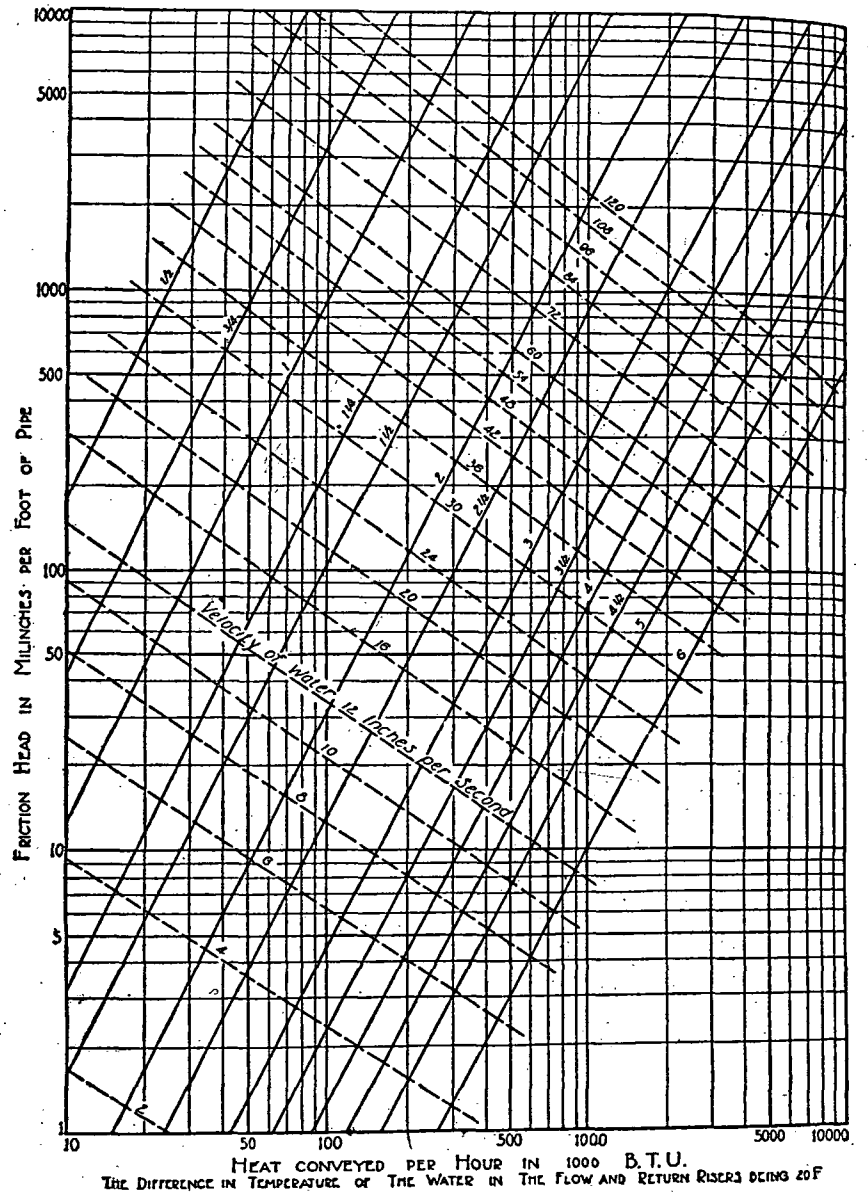

FIG. 4. FRICTION HEADS IN PIPES FOR A 20 F TEMPERATURE DIFFERENCE OF THE WATER IN THE FLOW AND RETURN LINES

to be forced through the system. This rate may vary widely. The water may flow through the radiator so that it will cool 10 deg or 20 deg or any other reasonable number of degrees. In this case, assume a 10-deg drop. Since the system is to dissipate 66,000 Btu per hour (66 Mbh), the pump must circulate 6600 lb of water per hour or 13.8 gpm based on the actual density of water of 7.99 lb per gallon at 215 F. One gallon of water per minute at this density will deliver 9600 Btu per hour (9.6 Mbh) with 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:

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

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%	16.0
33⅓%	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. This also may vary materially. As the velocity is increased, the sizes 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 for the particular case in hand. In this case, assume a velocity of about 1½ fps for a 1¼-in. pipe.

Reference to Fig. 4 shows that for a 1¼-in. pipe and a velocity of 18 in. per second, the friction head is about 100 milinches per foot, or about 2 ft for a circuit of 227 ft, if the pipe sizes for that circuit are chosen so that the average friction head is about 100 milinches per foot of pipe.

The pipe sizes may now be selected from Fig. 4 by making allowance for the fact that Fig. 4 is based on a temperature drop of 20 F and that the system to be designed is to have a temperature drop of only 10 F as follows: Sections AB and KA carry 66,000 Btu per hour (66 Mbh) with a temperature drop of 10 F; if the temperature drop were 20 F these sections would, with the same velocity and the same friction head, carry 132,000 Btu per hour (132 Mbh). Hence, refer to Fig. 4 for 132,000 Btu and a unit friction head of 100 milinches, and note that the correct size would be about halfway between a 1½-in. and a 2-in. pipe. Therefore, select a 1½-in. pipe for Section AB and