

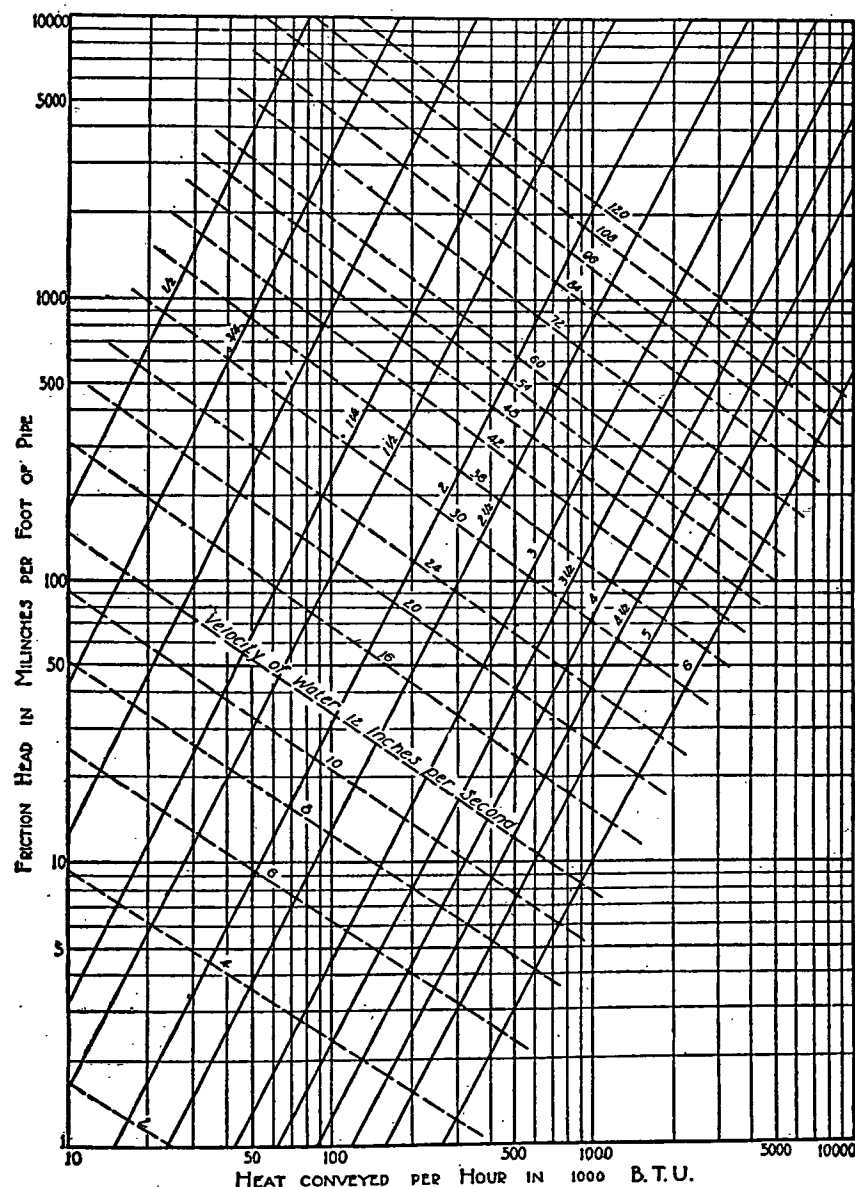


FIG. 4. FRICTION HEADS IN BLACK IRON PIPES FOR A 20 F TEMPERATURE DIFFERENCE OF THE WATER IN THE FLOW AND RETURN LINES

is easier to design a satisfactory forced circulation system than a satisfactory gravity circulation system.

FORCED CIRCULATION

In designing a forced circulation system, black iron pipe sizes may be selected from either Fig. 4 or Table 1, both of which are based on a 20 F temperature difference between the flow and return lines. For other temperature drops, the pipe capacities may be changed to correspond to the desired differentials. Research data are lacking for determining the capacities of copper tube sizes. In the absence of complete test data at the present time, capacities are given in Table 2 for type L copper tube sizes which are based on a recently developed hydraulic formula¹. The friction heads of boiler, radiator valve and tee may be expressed in terms of friction head in one elbow according to the values given in Table 3 for iron pipe, and Table 4 for copper tubing.

The following examples will illustrate the procedure to be followed in designing forced circulation systems.

Example 1. From the plan of Fig. 3 note that the longest circuit consists of 151 ft of iron pipe; 1 boiler; 1 radiator; 1 radiator valve; 1 stop cock; 10 ells and 3 tees; and the shortest circuit consists of 127 ft of pipe; 4 tees; 1 boiler; 1 radiator; 1 radiator valve; 1 stop cock; and 6 ells. Design the piping for this system.

Solution. The friction in the various fittings can be expressed in terms of the friction in a 90-deg elbow from the values given in Table 3. The longest circuit consists of 151 ft of pipe and 44 elbow equivalents. The short circuit consists of 127 ft of pipe and 39 elbow equivalents.

The friction head in one elbow is approximately equal to the friction produced by the same sized pipe 25 diameters in length. Assume that the average pipe size for this system is 1 in. The equivalent length of the longest circuit will be 151 ft plus 100 ft or 251 ft of pipe. The equivalent length of the short circuit will be 217 ft.

Having determined the equivalent length of the circuits, the next step is to assume the rate at which the water is to be circulated in the system. The water may flow through the system so that it will cool any reasonable number of degrees. For the most economical average system a 20 F drop seems to be a satisfactory rate. This entails a slower water flow from the pumping equipment with a reasonable relationship between pipe size and flow. Assume 20 F drop for this system. One gallon of water per minute with a density of 7.99 at 215 F will deliver approximately 9600 Btu per hour with a 20 F drop. The total radiation load is 98 Mbh, therefore the pump must deliver 10.2 gpm or 4900 lb of water per hour.

Knowing that the rate of flow is 10.2 gpm, the next step is to determine from the characteristics of available pumps, which one will produce a satisfactory velocity in the system. Assume that 4 pumps are available for this load which will produce 10.2 gpm at pressure heads of 2, 5, 10 and 18 ft. At these heads the pumps would produce a velocity high enough to make available a friction head per foot of pipe of 96, 240, 480 and 860 milinches per foot respectively. If 95 milinches per foot were used, the gravity head at 215 F average temperature in the mains would be 26 per cent of the total head and should be considered in sizing the system. At 240 milinches per foot the gravity effect is 10 per cent and as this is lower than the delivery variation from the pipe used, it can be neglected. At 480 and 860 milinches the gravity effect is still a smaller percentage of the total, but at these losses in the average system the cost of pumping will more than offset the advantage gained in pipe sizes. Therefore, pipe size this system at 240 milinches per foot which is equivalent to a total loss of 60,000 milinches for the 250 ft equivalent length of pipe.

¹Hydraulic Service Characteristics of Small Metallic Pipes, by G. M. Fair, M. C. Whipple and C. Y. Hsiao (Journal of the New England Water Works Association, Vol. XLIV, No. 4, 1930).