

In *forced circulation* systems flow is produced mechanically by means of a pump driven by electricity, steam, or other source of energy. As forced circulation velocities are higher than those in gravity systems, and as the friction in a heating system varies almost as the square of the velocity, a given error in the calculation or assumption of the velocity is less important in a forced circulation system than in a gravity circu-

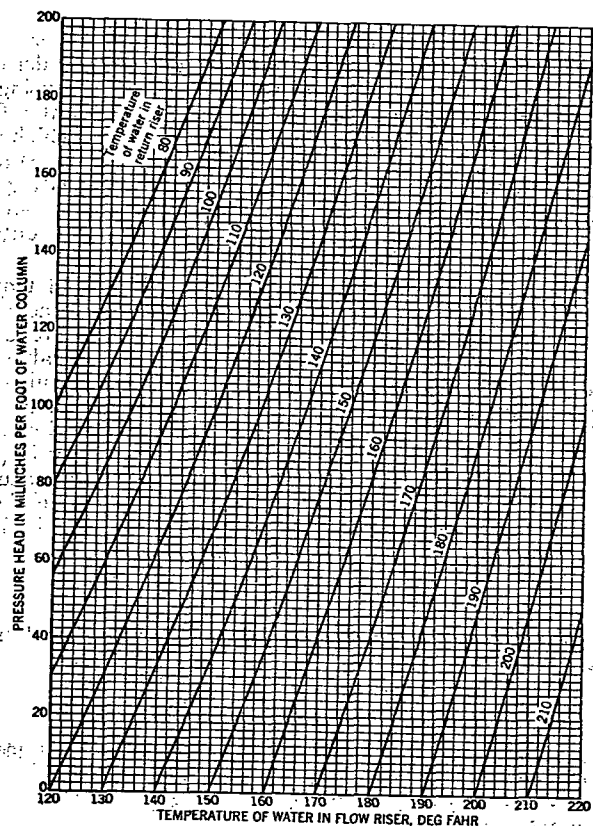


FIG. 1. HEADS RESULTING FROM TEMPERATURE DIFFERENCE (GRAVITY SYSTEMS)

lation system, and, consequently, it is easier to design a satisfactory forced circulation system than a satisfactory gravity circulation system.

FRICTION LOSS

Values of friction loss due to flow of water in the various parts of a heating system must be known in order to design either gravity or forced circulation systems.

The friction loss of fittings is customarily expressed in equivalent number of elbows of the same pipe size which would have the same

TABLE 1. IRON AND COPPER ELBOW EQUIVALENTS^a

FITTING	IRON PIPE	COPPER TUBING	FITTING	IRON PIPE	COPPER TUBING
Elbow, 90-deg.....	1.0	1.0	Angle radiator valve.....	2.0	3.0
Elbow, 45-deg.....	0.7	0.7	Radiator or convector.....	3.0	4.0
Elbow, 90-deg long turn.....	0.5	0.5	Boiler or heater.....	3.0	4.0
Elbow, welded, 90-deg.....	0.5	0.5			
Reduced coupling.....	0.4	0.4	Tee, per cent flowing through branch:		
Open return band.....	1.0	1.0	100.....	1.8	1.2
Open gate valve.....	0.5	0.7	50.....	4.0	4.0
Open globe valve.....	12.0	17.0	25.....	16.0	20.0

^aThe friction in one 90 deg standard elbow is approximately equal to the friction of a length of straight pipe of the same nominal size and 25 diam long. Hence one elbow equivalent in feet of pipe equals 25 diam (in inches) divided by 12.

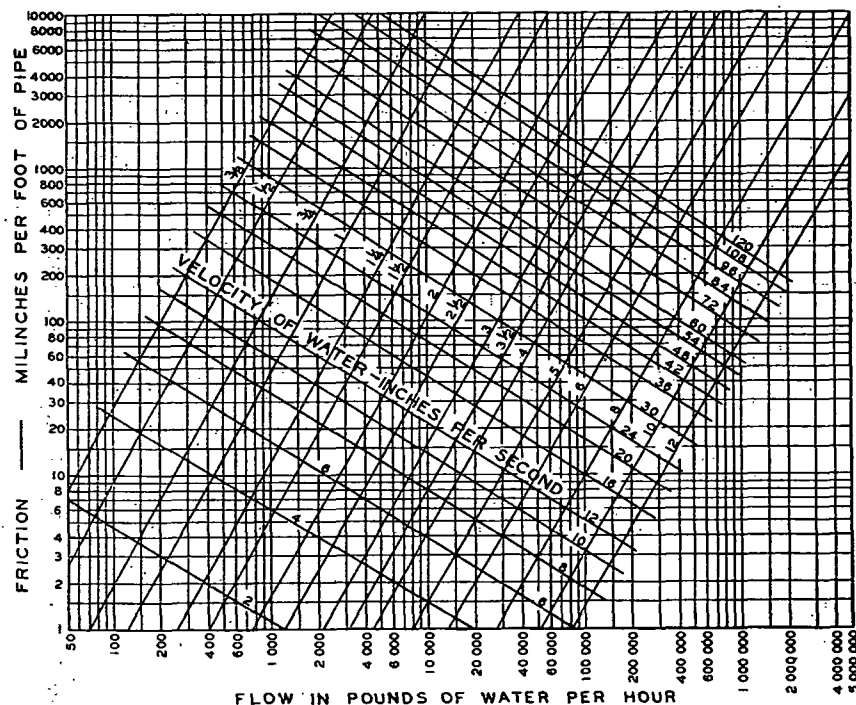


FIG. 2. FRICTION IN BLACK IRON PIPES BASED ON FLOW IN POUNDS PER HOUR

friction loss. An elbow is assumed to have the same friction loss as a straight pipe having a length equal to 25 diameters (nominal) of the elbow.

The resistance of various types of fittings expressed in equivalent elbow resistance is shown in Table 1.

The friction loss in black iron pipes for a determined weight of water may be obtained from Fig. 2. For the frequently used temperature drop of 20 deg the friction loss may be determined directly from the heat