5. A *direct-return* system is one in which the water is returned to the heater along a direct path, so that the total distance traveled by the water is the shortest feasible distance, and so that there is a considerable difference in the lengths of the several circuits composing the system.

6. A *reversed-return* system is one in which the water from the several radiators is returned along paths arranged so that all circuits composing the system, or composing major sub-division of the system, are practically of equal length. A reversed-return system is to be preferred to a direct-return system because it is easier to arrange the circuits so that, in every case, the friction head is equal to the pressure head, and because, in starting the system, all circuits of the reversed-return system being to function practically at the same time, whereas, in a direct-return system, the longer circuits require considerably more time to begin operating than the shorter circuits. The direct-return system is illustrated by Systems 5, 7, and 9. The reversed-return system is illustrated by Systems 6, 8, and 10.

DETERMINING PIPE SIZES

Having settled on the arrangement of the circuits for the system, generally by selecting a scheme similar to one of those shown in Fig. 4, it is customary to assume the pipe sizes and, having done that, to calculate the pressure head and the friction head for every circuit. If the two heads happen to be practically equal, the assumed pipe size is the correct one. If there is a material difference between the two, a change is made in the assumed size of the pipe, or of a portion of the pipe, and a new friction head calculation is made. This process is repeated until the correct size has been found.

To illustrate the method, let it be required to find the correct size for the pipe of the elementary system shown in Fig. 5. This system is to dissipate 12,000 B.t.u. when the temperature of the water is 200 deg. in the flow riser and 180 deg. in the return riser. The center of the radiator is to be 7 ft. above the center of the heater. The pressure head results from the difference in the weights of two columns of water, 7 ft. high, one having a temperature of 200 deg. and the other one of 180 deg. This difference in weight can be calculated. However, it can be determined more easily from the diagram of Fig. 6. It appears from this diagram that for 200 deg. in the flow riser and 180 deg. in the return riser, the pressure head is 90 milinches per foot of water column. The pressure head for the system is, therefore, 7 × 90, or 630 milinches of water.

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.

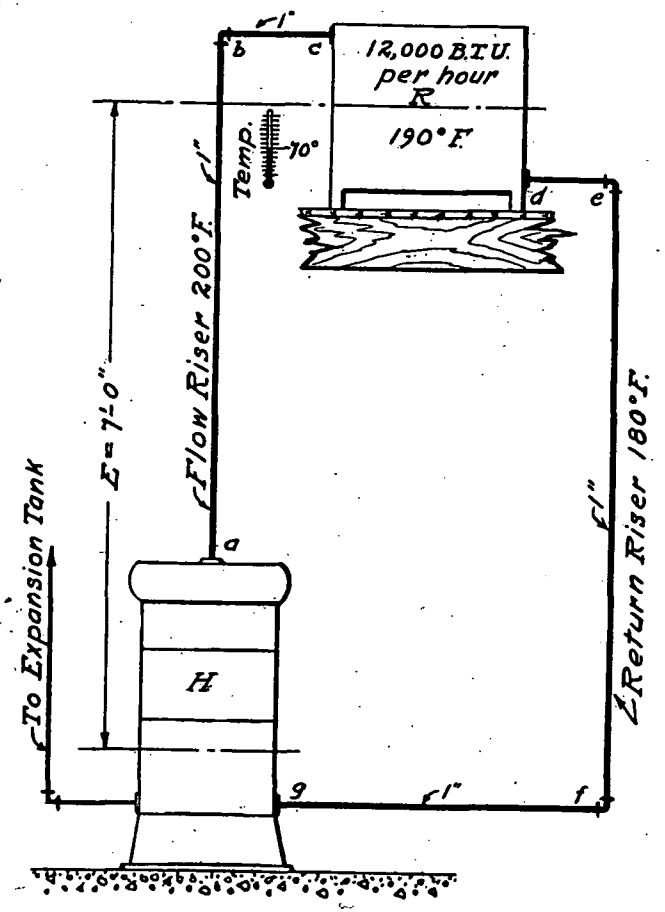

FIG. 5. AN ELEMENTARY HEATING SYSTEM

In other words, the pressure head causing circulation in the system is the same as that produced by a column of water 5/8 in. high.

This calculation shows clearly that the motive force involved in gravity circulation hot-water heating is very small and that great care must be taken to adjust the friction heads to the pressure heads when the water can flow along any one of several available circuits.

To calculate the friction head in the circuit, we note, first, that the circuit consists of 22 ft. of pipe, 3 elbows, 1 heater, and 1 radiator; and, second, from Table 1, that the frictional resistance of 1 heater and 1 radiator is, for each, equivalent to the frictional resistance of 3 elbows. Consequently, the friction head of the entire circuit is equal to that in 22 ft. of pipe and 9 elbows. Assuming, now, that 1-in. pipe is to be used,