In designing a piping arrangement for a hot water heating system, it is necessary to observe the fundamental rule that the total friction head in any circuit must not exceed the pressure head available for circulating the water. It is necessary to size the pipe in any circuit, so that the friction loss produced by the movement of a sufficient volume of water to handle the heating load will not be greater than the available head.

In designing a hot water heating system, it is necessary to determine:

1. The heat losses of the rooms or spaces to be heated. (See Chapter 7.)
2. The size and type of boiler. (See Chapter 13.)
3. The location, type, and size of heating units. (See Chapter 14.)
4. The method of piping.
5. The type and size of circulating pump (if forced circulation).
6. Suitable pipe sizes.
7. The type and size of expansion tank.

ONE- AND TWO-PIPE SYSTEMS

Piping systems may be divided into two general types, namely, one-pipe and two-pipe systems. These fundamental piping layouts may differentiate between up-flow, down-flow and zoned systems. Also the type of riser and radiator connection may vary considerably. Zoning is important in modern design and it is accomplished by dividing the system into a number of circuits and controlling each circuit individually. In a two-pipe system the piping is arranged so that the water flows through only one radiator during a circuit through the system, so that all radiators are supplied with water at practically the same temperature as that in the boiler. In some one-pipe systems, the water flows through more than one radiator during its circuit. In that case, the first radiator receives the hottest water; the second radiator, somewhat cooler water; the third one, still cooler; and so on. As the temperature of the water supplied to a radiator is lowered, the size of the radiator must be increased and, consequently, the total heating surface for a one-pipe system must be greater than for a two-pipe system for the same requirements. As the velocity is *increased* in a one-pipe system, the drop in temperature is *decreased*, so that water at a higher average temperature is delivered to the radiators. This means that the radiators at the end of the main can be sized on the same basis as the radiators at the beginning of the main. If the system is correctly designed, the resulting error is less than the variation in calculating the heating load for the enclosure.

By making use of improved devices now available, one-pipe forced circulation systems may be calculated by the same procedure described later for two-pipe systems. Operation may be obtained as satisfactory as with a two-pipe system.

Two-pipe systems may be divided into two classes, *direct return* systems (Fig. 1), and *reversed return* systems (Fig. 2). In a direct return system the water returns to the heater by a direct route after it has passed through its radiator and, as a result, the paths through the three radiators shown in Fig. 1 are of unequal lengths, the path through the first radiator being the shortest and that through the third radiator, the

longest. In a reversed return system, the water returns to the heater by an indirect route after it has passed through the radiators, so that the paths leading through the three radiators shown in Fig. 2 are practically of equal length.

The reversed return system has an advantage over the direct return system in that it is more likely to function satisfactorily even though the pipe system is not accurately designed. For example, if in Fig. 2 all pipes are of one size, each of the three radiators will receive approximately the same quantity of hot water because the three paths are practically of equal length, whereas in Fig. 1, if all pipes are of the same size, Radiator 1 will receive more water than the others because the path through it is shorter than those through the other radiators. As a result, Radiator 1 will be filled with water at a higher average temperature than the remaining two radiators, and will therefore dissipate more heat. To prevent this unequal distribution of heat it is necessary to throttle the paths through Radiators 1 and 2 so that the friction heads of the three paths are equal when each radiator receives its proper quantity of water.

The two-pipe direct return system, with its inherent lack of balance, is the least satisfactory type of piping possible, yet is the most widely used.

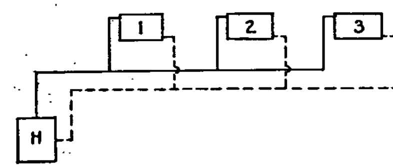

FIG. 1. A DIRECT RETURN SYSTEM

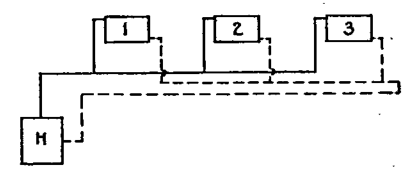

FIG. 2. A REVERSED RETURN SYSTEM

The modern applications of automatic heating require a system to be very nearly in balance so that uniform distribution of heat will be obtained.

Two-pipe systems must be balanced first by calculation and then by test after the plant is in operation. Unbalanced conditions in a forced circulation system are more detrimental to satisfactory operation than in the system circulated by gravity. The selection of orifices for correcting the unbalance must be more accurate. Due to the variations in water delivery from pipes, the accuracy of calculations is decreased, so that more reliance must be placed on actual test work. This is always costly and seldom completely satisfactory.

A comparison of Fig. 1 and Fig. 2 may suggest that a reversed return system requires considerably longer mains than a direct return system. This is not always the case, as will be noted from the reversed return system of Fig. 3.

MECHANICAL CIRCULATION AND CIRCULATORS

The designer of a forced circulation system generally makes use of the pumps commercially available. Pumps of this type will have characteristics which govern the water velocity selected for the heating system. However, available pumps generally have a sufficient range of capacities