

empirical expression and to substitute a logical unit based on the Btu. The Mb, the equivalent of 1000 Btu, and the Mbh, the equivalent of 1000 Btu per hour, which have been approved by the A.S.H.V.E., are used in this chapter on hot water systems to replace the square foot of radiation formerly used.

ONE- AND TWO-PIPE SYSTEMS

Pipe systems may be divided into two general types, namely, *two-pipe* and *one-pipe* systems. 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 a one-pipe system, 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 that for a two-pipe system for the same service.

The use of forced circulation in one-pipe systems, however, practically eliminates this objection. As the velocity is *increased* in a one-pipe

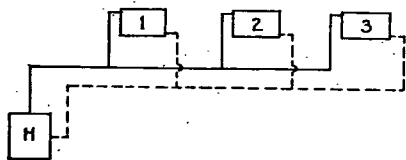


FIG. 1. A DIRECT RETURN SYSTEM

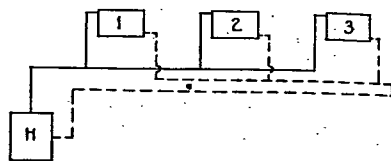


FIG. 2. A REVERSED RETURN SYSTEM

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, forced circulation one-pipe systems may be calculated by the same procedure described later in the chapter for two-pipe systems. Operation as satisfactory as with a two-pipe system may be obtained.

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. 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.

It would seem, then, that the *reversed return* two-pipe system, in which design errors are minimized, should be the logical choice.

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. For example, note the reversed return system of Fig. 3.

MECHANICAL CIRCULATION AND CIRCULATORS

The designer of a forced circulation system generally makes use of pumps available on the market unless he is able to buy to his specifications. Special equipment raises the initial cost of a system, so it is usual practice to incorporate stock pumps into the design wherever possible. Pumps of this type will have characteristics which govern, to a degree, the velocity selected for the heating system, yet a group of stock pumps has sufficient range of capacities to permit maintenance of an economical velocity. For example, suppose a system is to be designed to handle a 96 Mbh load, with a 20 F drop allowable in the system. 10 gpm will be required of the circulating equipment. Check pump characteristics to see which one will deliver 10 gpm against a head sufficiently high to allow a friction drop great enough to produce a satisfactory velocity in the piping system.

It is worthy of note that velocities may be too high, producing objectionable noises in the system. Higher velocities may be used with satisfactory results in industrial applications than in domestic systems.