3. All piping must be installed so that it is free to expand and contract with changes of temperature without producing undue stresses in the pipes or connections. For this purpose it is generally sufficient to allow for a variation in length of 1 in. for 100 ft of pipe.

4. The pipe system must be installed so that each circuit has its correct friction head. To bring this about, it is necessary, in some cases, to minimize the friction, *i.e.*, to make the pipe line as short as possible and to provide as few fittings as possible, and in other cases, it is necessary to increase the length of the pipe and the number of fittings so that, for every circuit, the friction head will be equal to the available pressure head.

The connections from the boiler to the mains should be short and direct to reduce the friction head. It is frequently possible to avoid an elbow and to reduce the length of the pipe by running the pipe in a diagonal direction, either in a horizontal or in a vertical plane.

The mains and branches should pitch up and away from the heater and generally not less than 1 in. in 10 ft. The flow main should always be covered; the return main should be covered except where it is to provide the heating surface for the basement.

The connections from mains to branches and to risers should be such that circulation through the risers will start in the right direction. Hence, in a one-pipe system, the flow connection must be nearer the heater than the return connection. In a correctly-designed two-pipe system, the pressure in the flow main is higher than that in the return main, and a slight variation in the distances of the flow and return connections from the heater is not material, but it is generally best to have the two connections about equidistant from the heater.

In some cases it may be advisable to take the flow connection off the top of the main and the return connection into the side, but in most cases both connections should be at an angle of 45 deg. This method shortens the lines and substitutes 45-deg ells for 90-deg ells.

Connections of flow risers to radiators should be to the upper tapping, unless, for æsthetic reasons, connections to the lower tappings are preferred. Connection of the return riser to a radiator should be to the lower tapping and on the end at which the return riser is located. When hot water enters at the top of a radiator it will distribute itself along the entire length of the radiator, and as it cools, settle gradually to the bottom; the cool water may then be taken out of the radiator at either end.

With forced circulation and high velocities, it is advisable to let the water enter at the top of the radiator and leave at the bottom of the opposite end. With gravity circulation and low velocities it makes little difference whether the water leaves at the same or at the opposite end at which it enters.

The connections of the risers to the radiators should be such that provision is made for the vertical expansion of the risers. This can be accomplished as indicated in Fig. 10 by using one tee and two ells for each connection. These connections should be pitched upward or downward, whichever may be necessary to prevent the formation of air pockets.

Radiator valves generally are not necessary. When used, they should be placed in the return connections.

Chapter 9

STEAM HEATING SYSTEMS AND PIPE SIZES

Gravity and Mechanical Systems; Transmission Mains and Service Piping; Flow of Steam in Pipes; Design of Steam Heating Systems.

A DIRECT steam heating system is one in which steam (at, above or below atmospheric pressure) is the medium by which heat is transmitted from the boiler (or other source of steam supply) to the heating units located in or adjacent to the rooms or spaces to be heated. The heating units and boiler are connected by means of a system of supply and return piping. There are many types of steam heating systems, the classification depending upon the piping arrangement, the accessories used, and whether the water of condensation is returned to the boiler by gravity or by mechanical means. The various terms used in describing these systems are defined in Chapter 1.

DISTRIBUTING MAINS AND SERVICE PIPING

The piping for steam distribution is divided into two classes: (1) distributing mains; (2) service piping.

Transmission mains are defined as those that convey steam for a considerable distance either through or between buildings such as in district heating plants. In this type the steam is usually generated and transmitted to the building under high pressure. The velocities of flow used in the transmission mains are limited by the available or allowable drop in pressure.

Service piping is defined as that which conveys the steam and condensate in the building, starting either at the boiler or other source of supply and comprising the mains, branches, risers, run outs and return piping. This part of the system usually is low pressure and the pipe sizes are larger than for the distributing piping, as the velocity of the steam is lower and the available or allowable drop in pressure is small. See Tables 9 to 16 for the service pipe sizes for various systems.

FLOW OF STEAM IN PIPES

The rate of flow of dry steam or steam with a small amount of water flowing in the same direction is in accordance with the general laws of gas flow and is a function of the length and diameter of the pipe, the density of the steam and the pressure drop through the pipe. This relationship has been established by Babcock in the formula given at the top of Table 1. In columns 1, 2, 3 and 4 of this table, the numerical values of the factors for different pressure losses, pipe diameters, steam densities and lengths of pipe have been worked out in convenient form