pressure, would be ⅛ of 28 in. (28 in. head being equal to one pound per square inch), or 3½ in. Adding 3 in. to overcome the resistance of the return main, and 6 in. as a factor of safety for heating up, gives 12½ in. as the distance the bottom of the lowest part of the steam main and all heating units must be above the boiler water line. The same system, however, installed and sized for a total pressure drop of ⅛ psi, and with a check in the return, would require ½ of 28 in., or 14 in. for the difference in steam pressure, 3 in. for the flow through the return, 4 in. to operate the check, and 6 in. for a factor of safety, making a total of 27 in. as the required distance. Higher pressure drops would increase the distance accordingly.

When conditions are such that condensate cannot be returned to the boiler by the action of gravity, and either traps or pumps must be employed, the system is known as a *mechanical return system*. There are three general types of mechanical condensate return devices in common use: (*a*) the alternating return trap, (*b*) the condensate return pump, and (*c*) the vacuum return pump.

In systems where pressure conditions in the system vary between that of a gravity return and a forced return system, a boiler return trap or alternating receiver is employed and the system may be known as an *alternating return system*.

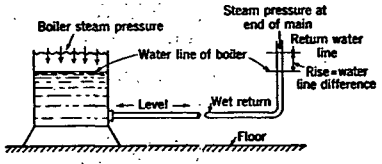

FIG. 1. DIFFERENCE IN STEAM PRESSURE ON WATER IN BOILER AND AT END OF STEAM MAIN

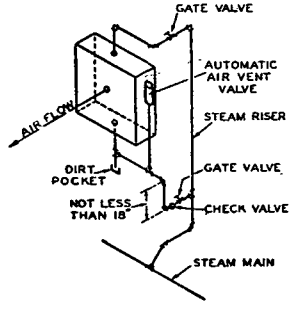

FIG. 2. TYPICAL TWO-PIPE CONNECTIONS TO UNIT HEATERS IN ONE-PIPE AIR VENT SYSTEMS

When condensate is pumped to the boiler under pressures of the atmosphere or above, the system is known as a *condensate pump return system*.

When condensate is pumped to the boiler under vacuum conditions, the system is known as a *vacuum return system*.

In either the *condensate* or *vacuum pump systems* it is highly desirable to arrange for gravity flow to a receiver and to the pump. The pump then forces condensate into the boiler against its pressure.

ONE-PIPE SYSTEMS

One-pipe systems, as previously defined, are systems in which steam and condensate flow in the same pipe. Radiators and other heating units, in general, have only one piping connection from main to unit, although it is possible to employ two connections to the same main as indicated in Fig. 2. Unit heaters in one-pipe systems may also have separate connections to the wet-return.

There are several variations in the piping arrangement of a one-pipe system as follows:

1. Up-feed one-pipe systems where the radiators and other heating units are located above the supply mains. The mains in this instance convey both steam and condensate. Therefore, it is preferable to limit this design to systems with a connected load under 2500 sq ft EDR. Such a system is illustrated in Fig. 3. Typical connections to radiator or risers are illustrated in Figs. 4, and 5 and method of changing sizes of mains in Fig. 6.

Branches from steam mains in one-pipe gravity steam systems should use the

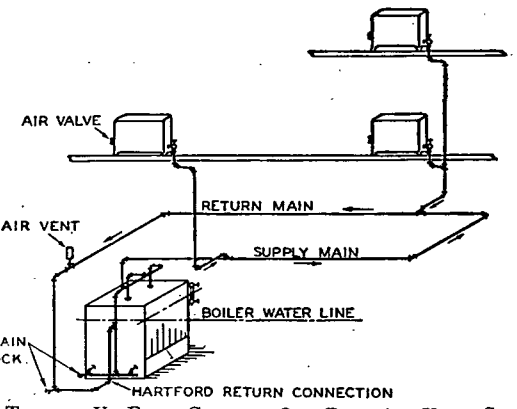

FIG. 3. TYPICAL UP-FEED GRAVITY ONE-PIPE AIR-VENT SYSTEM

preferred connection shown in Fig. 7, but where radiator condensate does not flow back into the main, the *acceptable* method shown in the same figure may be used. This acceptable method has the advantage of giving a perfect swing joint when connected to the vertical riser or radiator connection, whereas the preferred connection does not give this swing without distorting the angle of the pipe. Runouts are usually made about 5 ft long to provide flexibility for movement in the main.

2. Up-feed one pipe system with a connected load in excess of 2500 sq ft EDR, where radiators and other heating units are located above the mains, as illustrated in Fig. 8. It will be noted that the mains are dripped at each riser connection to a wet return, as indicated in Fig. 5, so that the mains carry a minimum of the condensation. This feature is always desirable in the design of any one-pipe steam system. Radiators immediately above the mains may be connected as shown in Fig. 4. Up-feed systems are not recommended for systems higher than four or five stories.

3. Down-feed one-pipe systems, where the radiators and other heating units are located below the supply main. In this arrangement only risers and connections to heating units convey both steam and condensate, and both are flowing in the same direction. The steam main is kept relatively free of condensate by dripping through

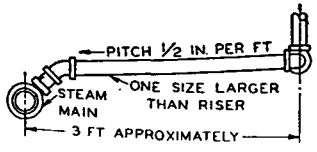

FIG. 4. TYPICAL STEAM RUNOUT WHERE RISERS ARE NOT DRIPPED

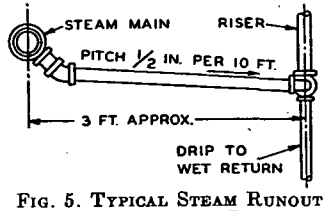

FIG. 5. TYPICAL STEAM RUNOUT WHERE RISERS ARE DRIPPED



FIG. 6. METHOD OF CHANGING SIZE OF STEAM MAIN WHEN RUNOUTS ARE TAKEN FROM TOP

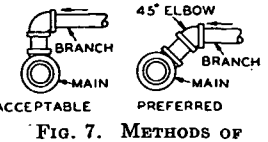

FIG. 7. METHODS OF TAKING BRANCH FROM MAIN