the rise in the water level at the far end of the return, due to the difference in steam pressure, would be ½ 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 ¼ psi, and with a check in the return, would require ¼ 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*.

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

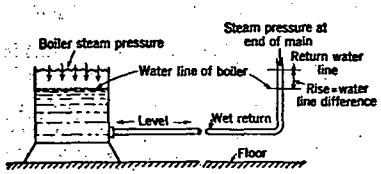

FIG. 1. DIFFERENCE IN STEAM PRESSURE ON WATER IN BOILER AND AT END OF STEAM MAIN

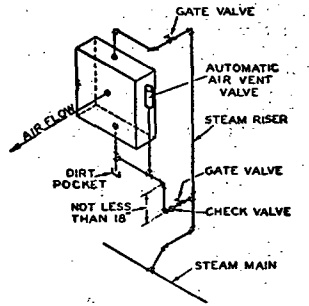

FIG. 2. TYPICAL TWO-PIPE CONNECTIONS TO UNIT HEATERS IN ONE-PIPE AIR VENT SYSTEMS

When condensate is pumped to the boiler under vacuum conditions, the system is known as a *vacuum pump 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. Such a system is illustrated in Fig. 3. Typical connections to radiator or risers are illustrated in Fig. 4, and method of changing sizes of mains in Fig. 5.

2. Up-feed one-pipe systems where the radiators and other heating units are located above the mains, and the mains are dripped at each radiator connection to a wet-

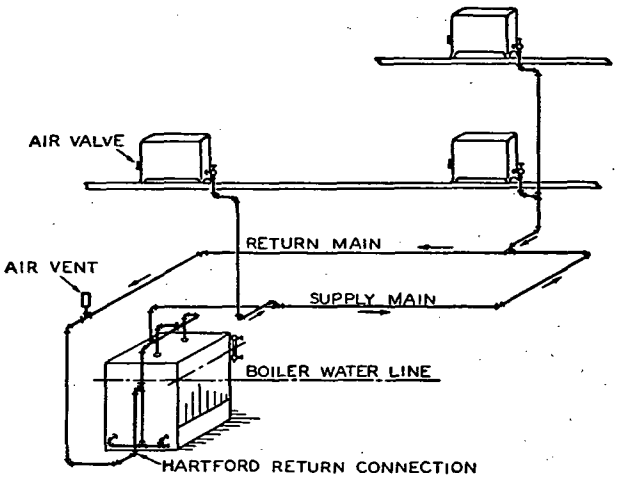

FIG. 3. TYPICAL UP-FEED GRAVITY ONE-PIPE AIR-VENT SYSTEM

return, so that the steam main carries a minimum of the condensate. This system is illustrated in Fig. 6. Typical connections to radiators and risers are illustrated in Fig. 7. Up-feed systems are not recommended for systems higher than four 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 the drop risers.

Each radiator or heating unit in a one-pipe system must be supplied with a thermostatic air valve which functions to relieve air from the heating unit under pressure, and to close when steam itself heats the thermostatic element of the valve.

To improve steam circulation in one-pipe systems quick-vent air valves should be provided at the ends and at intermediate points where the steam main is brought to a higher elevation, or where dropped below the water line. It is desirable to install the air-vent valves about a foot ahead of the drips, as indicated in Fig. 6, to prevent possible damage to their mechanisms by water.

Air valves are of two general types, the pressure and the vacuum types. The pressure type permits the inflow of atmospheric air to the system when the steam pressure in the system falls below atmospheric pressure. The vacuum type, which contains a small check valve, prevents the air from flowing back to the system and thereby maintains vacuum conditions in the system, and a consequent evaporation or generation of steam

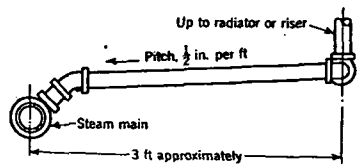

FIG. 4. TYPICAL STEAM RUNOUT WHERE RISERS ARE NOT DRIPPED

FIG. 5. METHOD OF CHANGING SIZE OF STEAM MAIN WHEN RUNOUTS ARE TAKEN FROM TOP