adaptability of each arrangement for proper hydraulic balance should be considered.

Air Elimination

If air and various other gases which occur in hot water heating systems are not eliminated from the flow circuit, they may collect in the heating units or piping and reduce the flow of water and the heat output. These gases, designated *air* in this text, are in the piping before it is filled with water, are introduced with the water used to fill and replenish the system, and also are formed to a limited degree from chemical action inside the system and from the movement of low temperature air-saturated water from the

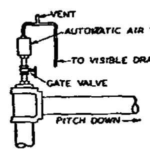

Fig. 12. . . . Typical Automatic Air Vent Valve Installation

expansion tank to the system.[13] Loss of air by absorption in the water may be prevented by a flexible diaphragm preventing contact of water and air in the expansion tank and having adequate movement to permit the expansion of the water in the system.

The air is eliminated from the flow circuits by trapping it into the expansion tank as explained in connection with discussion of *dip tubes* in the section Boiler Room Piping and

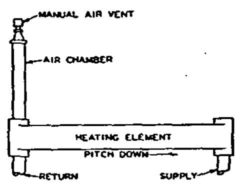

Fig. 13 . . . . Typical Air Vent Valve Installation on Heating Element

by the installation of manual or automatic air vent valves at all high points in the system.

Automatic air-vent valves may be used to eliminate air from the mains and major equipment. Like other mechanical devices, they are subject to malfunction. Small pieces of dirt or scale can lodge on the valve seat, causing it to leak. Corrosion, scale, or sludge in the valve can prevent the valve from opening to eliminate air. All systems should be designed to have a minimum number of automatic air-vent valves, but where a valve is required there should be no hesitancy about using it. In large systems where large numbers of automatic air-vent valves are necessary, provision should be made for service of each valve without draining the system (Fig. 12). The drip from each air vent valve should be piped to a drain to prevent building damage and facilitate inspection for leakage. Automatic air-vent valves should not be installed in piping where temperatures in excess of 215 F can occur without careful analysis of possible temperature-pressure effects.

Each unit of radiation which can act as an air trap should be provided with an air chamber and air-vent valve (Fig. 13). The use of manual air-vent valves or porous plug- or disc-type manual-automatic valves is recommended for radiation.

Piping Principles

Piping should be pitched up in the direction of flow in all cases when pump operation is constant, and wherever possible when pump operation is intermittent to assure consistent air elimination during conditions of either flow or no-flow. Piping is pitched ¼ in. per 10 ft as standard practice.

When changing the size of pipe in horizontal runs, eccentric reducers should be used to keep the top of the pipes in line.

A means of manual capacity adjustment should be provided for each heating unit. Manual valves or adjusting cocks are frequently provided for this purpose. Dampers at the heating element or at the outlet of convection-type units may be used. The heating unit located in the area of a zone thermostat should be equipped with a key-operated adjusting device to discourage tampering by unauthorized personnel.

The piping should be installed to provide for thermal expansion of the pipe without imposing undue stress on connections or equipment. Spring pieces of sufficient length, as required by the diameter of the runout and the amount of expansion to be absorbed, should be installed at connections to radiators and risers. Expansion joints or loops and properly located anchors should be used where required. See Chapter 50 of the 1961 Guide And Data Book.

All mains and risers located in exterior walls should be covered with sufficient insulation to prevent freezing. Trunk mains running between buildings must be protected by conduit or installed in trenches below the frost line and properly insulated. When heating mains are run in locations where they could possibly be immersed in water, the conduit should be watertight.

Circulating Pumps

Circulating pumps used in hot water heating systems can vary from small ⅙-hp booster-type pumps with a capacity of 5 gpm at 6- or 7-ft head to pumps handling hundreds, even thousands, of gallons per minute at heads limited only by the pressure characteristics of the system. The selection of a pump for a system is based on an analysis of operational characteristics of the pump and system. Both first cost and operating cost are involved. See discussion under Pipe Sizing Methods, Expansion Tanks and System Pressure Control. Pumps with mechanical seals have found wide acceptance in hot water heating. Pump characteristics, as affected by system characteristics, should be given consideration to insure nonoverloading conditions in pump motor operation.

Any given pump, when operated with a given fixed-head system, will operate at only one point on its curve, the intersection of the pump curve with the system curve. Pump curves may be obtained from manufacturers. System curves can be constructed by plotting head versus gpm for different flow rates. The head for various flow rates can be estimated by use of the equation:

$$\frac{H_2}{H_1} = \left[\frac{G_2}{G_1}\right]^2 \quad \text{or} \quad H_2 = H_1\left[\frac{G_2}{G_1}\right]^2 \qquad (3)$$

where

H_1 = calculated system head.
H_2 = head at new flow rate.
G_1 = calculated flow rate.
G_2 = assumed new flow rate.

For economic or for operational reasons two similar pumps are sometimes used in parallel on a single circuit. When so used the combined pump curve showing the relationship of flow to head due to operation of both pumps is established by adding the flow capacity of one pump to the flow capacity of the other at identical heads. If two pumps are placed in series, the relationship of flow to head due to operation of both pumps is established by adding the pump heads at identical flows. When using pumps in series, they must be identical or similar since the maximum flow will be limited by the smaller pump. Gate valves should be provided to enable isolation of either pump when only one is in operation.

The Heat Source or Boiler

The most frequently used source of heat is the 30 psi hot water heating boiler, constructed of cast iron or steel in accordance with the *ASME Boiler and Pressure Vessel Code*, Section IV for Low Pressure Heating Boilers. See Chapter 35 of the 1961 Guide And Data Book. Boilers, classed as low-pressure heating boilers, may be used for hot water with pressures as high as 160 psig if the temperature of the water does not exceed 250 F and if they are constructed according to the ASME code for the pressure at which they are operated.[14]

The ASME code requires installation of a relief valve on each hot water heating boiler to limit the pressure exerted on that boiler to the value for which it was designed and tested.[14] Similar requirements exist for converters and electric water heaters. This operating pressure limit for the boiler is an important factor in the design of the hot water heating system. Together with the size and characteristics of the expansion tank, it determines the permissible height from the boiler to the top element or pipe of the distribution system, as discussed under Expansion Tanks. In addition to the pressure relief valve required by the ASME code, a hot water heating boiler should be equipped with a thermometer, located at or near the top of the boiler, and a reliable pressure or altitude gage with a range at least twice that of the maximum operating pressure or altitude allowable for the boiler.

EXPANSION TANKS AND SYSTEM PRESSURE CONTROL

The objectives of system pressure control are to limit the pressure at all equipment in the system to the allowable working pressure of the equipment; *maintain minimum pressure* for all normal operating temperatures in order that air can be vented and cavitation at the pump suction and boiling of system water prevented; and accomplish these objectives with as little addition of new water to the system as possible.

An expansion tank is the primary device used to accomplish system pressure control. The excess water volume in the system resulting from increased temperature is stored in the expansion tank during periods of high operating temperatures and returned to the system when the system water temperature is lower. The expansion tank must be designed to store the required volume of water during maximum design operating temperatures without exceeding the maximum operating pressure allowable, and to maintain required minimum pressure when the system is cold. Some designers provide an automatic fill valve to maintain the minimum

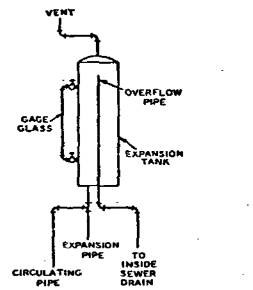

Fig. 14. . . . An Open Expansion Tank

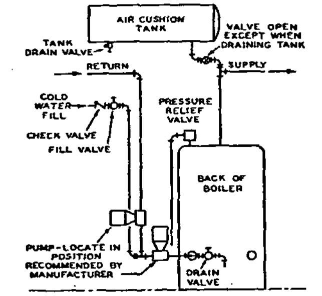

Fig. 15. . . . A Closed Expansion Tank

pressure in the system by supplying water to make up for losses due to leakage. Others prefer that water added to the system be supplied by a manually operated valve.

The relief valve installed on a hot water boiler in accordance with the ASME code performs the function of limiting the maximum pressure at the boiler. Since it is a safety device, it should not be considered an *operating control*.

Systems are designated as open (Fig. 14) or closed (Fig. 15).

The *open tank* system is vented to the atmosphere and is generally limited to installations having operating tempera-