venting back-flow through the pump circuit is provided. Where temperatures higher than normal are maintained in the boiler, the connection of the return to the boiler should follow the manufacturer's recommendations for such service.

Where a multiple boiler installation is used, provisions should be made to prevent the by-passing of water through a boiler which is not being maintained at control temperature. In some cases this provision takes the form of automatic control valves interlocked with the boiler temperature control to be open only when the temperature in the particular boiler is being maintained at operating conditions. In other cases, manual valves are installed in the boiler returns and opened only when the burner switch

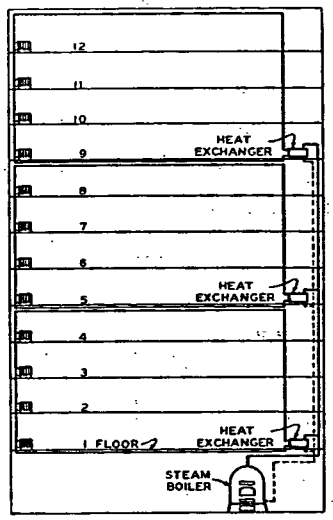

FIG. 20. VERTICAL ZONING OF HOT WATER HEATING SYSTEM IN A 12-STORY BUILDING
(Provision should be made for expansion in each closed circuit.)

which places the firing device at the command of the boiler temperature control is in the *ON* position.

Weighted check valves, or flow check valves, should be installed in the supply piping from the boiler to prevent gravity circulation during periods when the circulating pumps are off. If the piping is arranged with separate supplies to individual zones, a weighted check valve should be installed in the supply piping to each zone.

The Use of Steam with Hot Water Heating Systems

The use of a steam boiler or district steam with a converter has many advantages for tall buildings. The piping for the steam used in this type of a system should follow the principles outlined in Chapter 20, Steam Heating Systems. In tall buildings the system can be zoned vertically as shown in Fig. 20, that is, with a given number of floors per zone and a converter for each zone. This type of design makes the limitation of maximum pressure in the system possible. With a converter type system, the volume of the boiler is removed as a volume of water causing thermal expansion. Since the boiler in a hot water system may hold 30 to 50 percent of the total water volume of the system, the reduction in the size of the expansion tank and the problems involved therewith are of major importance.

The use of steam in extended surface coils for heating air will often be more desirable in a system where steam is available. This type of installation will result in less expensive coils, and simplified coil controls.

Temperature Control in Hot Water Systems

Hot water heating systems permit use of relatively simple automatic temperature control for the purpose of reducing operating costs and providing comfortable temperatures. Indoor-outdoor control may be obtained by direct control of the burner by a temperature controller in the boiler water which is re-set according to outside temperature. Such controls are available from several manufacturers for residential and small commercial installations. A separate high limit control should be used with this type of control. Three-way mixing valves, which blend boiler supply water with return water, or converters with the temperature of the heating water controlled by modulation of the heating source supply may be used on larger installations. Where the mixing valve or converter type control is used, a thermostat located in the discharge of the valve or converter to control the supply water temperature is re-set according to outside temperature.

Provision for *warm-up* by the supply of maximum temperature water should be made where temperature of the supply is varied according to outside temperature. This can be accomplished by use of a warm-up period program control or by use of a space low-limit thermostat set 3 to 5 deg below the room temperature maintained during normal operation.

Control can also be accomplished by use of a room thermostat to operate the burner. This type of control is applicable only to residences or very small commercial installations, where there is no great difference in heating requirement throughout the building. Where a difference in heating requirement throughout the building does exist, it is better to use a modulated supply water control with provision for manual or automatic adjustment of heating unit output in individual spaces.

Economical zone control can be obtained by separate return or supply piping for zones, with a zone thermostat to operate zone pumps or automatic valves.

The control of air handling units in a hot water heating system requires careful consideration. Where the piping required is within economical limits, it is advisable to use a three-way mixing valve and a pump in the return from the coil to achieve control. The heating coil in Fig. 19 illustrates the necessary piping arrangment. Control valves used for air heating units should have plugs or discs of special design for close control of flow. They should be sized accurately for the flow required by the coil at a pressure drop as large as the pump and the piping system will permit.

Precautions should be taken to prevent the freezing of water in a hot water heating system whenever design outdoor temperatures are lower than 20 F, particularily if the system is to be operated on an intermittent basis as in schools where no operation is required on Saturdays or Sundays or during vacation periods. Air handling units which heat outdoor air must have provision to stop fan operation and close outdoor air intake dampers, if the water circulating in the coil drops below a safe level. The outdoor air intake dampers should be interlocked with the fan motor so as to take the closed position whenever the fan is not operating. The possibility of water freezing in the mains can be reduced by the installation of an