sufficient pressure is maintained in the highest radiator to prevent boiling when the water is heated to the maximum temperature for which the system was designed.

The line 9, 10, 11, 12, 5, is drawn so that the vertical distances from its points to the corresponding points of the base line show the pressure in the respective parts of the main when the water is being forced through the main by the circulating pump, neglecting the slight reduction in pressure head caused by the velocity head. An inspection of Fig. 13 shows that, with the expansion tank located at the suction end of the pump, the pressure in the first building is considerably higher than necessary. It also shows that if the expansion tank were located at the line 3, 7, 11, the pressure at that point would remain constant and the pressure would fall below the line 7, 8, 5, and above the line 7, 6, 5. In that case, the expansion tank would need to be at a higher elevation than if located at the pump. This comparison explains the relation which exists between the location and the required elevation of the expansion tank.

In some very large central systems the loss of water from the system is so great that make-up water must be supplied continuously and the expansion tank is not required.

REFERENCES

Arrangements of Mains in Hot Water Heating Apparatus, by W. M. Mackay (A.S.H.V.E. TRANSACTIONS, Vol. 3, 1897).

Volume of Water in Hot Water Heating Apparatus, by W. M. Mackay (A.S.H.V.E. TRANSACTIONS, Vol. 7, 1901).

Circulation of Hot Water, by J. S. Brennan (A.S.H.V.E. TRANSACTIONS, Vol. 11, 1905).

Residence Heating by Direct and Indirect Hot Water, by E. F. Capron (A.S.H.V.E. TRANSACTIONS, Vol. 11, 1905).

Comparison of Quick Circulating Systems of Hot Water Heating, by C. Guitton (A.S.H.V.E. TRANSACTIONS, Vol. 13, 1907).

Determination of Pipe Sizes for Hot Water Heating Systems, by F. E. Giesecke (A.S.H.V.E. TRANSACTIONS, Vol. 21, 1915).

Friction of Water in Iron Pipes and Elbows, by F. E. Giesecke (A.S.H.V.E. TRANSACTIONS, Vol. 23, 1917).

Effect of Pressure on Hot Water Circulation, by F. B. Rowley (A.S.H.V.E. TRANSACTIONS, Vol. 29, 1923).

Effect of Temperature upon the Friction of Water in Pipes, by F. E. Giesecke (A.S.H.V.E. TRANSACTIONS, Vol. 31, 1925).

Friction of Water in Elbows, by F. E. Giesecke (A.S.H.V.E. TRANSACTIONS, Vol. 32, 1926).

The Design of Gravity Circulation Hot Water Heating Systems, by Prof. F. E. Giesecke.

Pipe Sizes for Hot Water Heating Systems, by F. E. Giesecke and Elmer G. Smith [A.S.H.V.E. JOURNAL (*Heating, Piping and Air Conditioning*), June, 1929].

Cooling of Water in Iron Pipes, by F. E. Giesecke, *Heating, Piping and Air Conditioning*, August, 1929, p. 267.

Pipe and Orifice Sizes for Small Gravity Circulation Hot Water Systems, by E. G. Smith [A.S.H.V.E. JOURNAL (*Heating, Piping and Air Conditioning*), February, 1930].

Loss of Head in Submerged Orifices, by F. E. Giesecke [A.S.H.V.E. JOURNAL (*Heating, Piping and Air Conditioning*), July, 1930, p. 611].

Chapter 12

RADIATORS AND CONVECTORS

Unit of Heat Output; Factors Affecting the Heat Emission; Types of Heaters; Location of Heaters; Selection of Heaters.

THIS chapter relates to the various types of heat emitting elements which may be broadly classified as radiators and convectors. Direct radiators, direct-indirect or exposed heaters emit heat by radiation and conduction whereas concealed built-in heaters, cabinet heaters or indirect heaters emit heat mainly by the processes of convection. An exposed cast-iron radiator emits from 10 per cent to almost 30 per cent of its heat by radiation, according to determinations made at the Research Laboratory of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. The balance or major portion of its emission is, of course, by conduction to the air in contact with the heated surfaces. Thereupon the heated air, through convection, sets up a circulation which tends to distribute the heat more or less uniformly in accordance with the manner in which the convection currents are utilized.

When a cast-iron radiator or one of the newer non-radiating heaters provided with extended conducting surfaces is enclosed within a wall or cabinet, it emits practically no heat by radiation, but functions by conduction and convection. Hence the term *radiator* or *radiation* applied to such heaters is distinctly a misnomer, which should not be perpetuated. And it should be equally emphasized that air is heated by conduction in contact with a heated surface, while convection is that phenomenon by which heat is distributed within a fluid, liquid or gas by movement of the fluid, liquid or gas.

The following is a glossary of the terms used:

1. *Conductor* or *radiator*—a heater exposed to view, and which transfers heat by radiation to objects which it can "see" and by conductance to the air currents which pass over it.

2. *Recessed conductor*—a heater set back into a wall recess but not enclosed in any way. A flat surface wall panel heater is a panel conductor.

3. *Convector*—a heater which is enclosed in a duct or cabinet and which gives off the heat to an air stream, which passes into the room which is to be heated.

4. *Cabinet convector*—a heater placed in an enclosure located within the room which is to be heated.

5. *Indirect convector*—a heater placed exterior to the room which is to be heated. There are both gravity indirect convectors and blast indirect convectors.

6. *Direct-indirect heater*, or conductor—convector—a heater arranged so that some of its sections operate as convectors, being partially housed in so as to heat air which enters from outside the room, while other sections and part of the housed sections may operate as conductors.