Electric Radiant Heat vs. Steam Convection, by Douglas Dow (*Electrical World*, August 10, 1940, pp. 61-62).

Practical Aspects of Heating Residences by Electricity, by F. L. Lawton and P. Tellier et al (*Electrical News & Engineering* (Canada) July 1, 1934, pp. 32-33 and 40; July 15, 1934, pp. 29-32; August 1, 1934, p. 17; July 1, 1933, pp. 16-20; July 15, 1933, pp. 21-22; August 1, 1933, pp. 23-25).

Off-Peak System of Electric Heating for Buildings, by Elliott Harrington (A.S.H.V.E. Transactions, Vol. 37, 1931, p. 323).

Electric Heating of Residences, by Edgar Allan Loew (University of Washington, *Engineering Experiment Station*, Part I, *Bulletin* No. 15, December, 1921; Part II, *Bulletin* No. 20, November 15, 1923).

Reversed-cycle Refrigeration for Air Conditioning Work, by Regis D. Heitchue (*Refrigerating Engineering*, May, 1941, pp. 317-321).

South American Way on This Buenos Aires Job Was to Use a Heat Pump, Melvin A. Ramsey (*Heating, Piping and Air Conditioning*, March, 1941, pp. 167-170).

The Sixth Ingredient—The Heat Pump—The Importance of Its Development in Making the All-Electric Home a Reality, by Philip Sporn (*E.E.I. Bulletin*, August, 1944).

Description and Performance of Two Heat Pump Air Conditioning Systems (Using Well Water and Outside Air as the Heat Source), by Philip Sporn, and E. R. Ambrose (A S.H.V.E. Transactions, Vol. 50, 1944).

Heating of Non-Magnetic Electric Conductors by Magnetic Induction, by R. M. Baker (*Electrical Engineering*, June, 1944).

What High Frequency Heat Treating Can Do (*Electrical Manufacturing*, July, 1943, Vol. 32, Number 1).

Electronic Devices Aid Metallurgical Research, by E. V. Potter (*Electrical Engineering*, May, 1944).

Designing an Induction Heating Product, by Charles R. Underhill (*Electrical Manufacturing*, June, 1944).

CHAPTER 31

Panel Heating and Radiant Heating

Influence of Heat Radiation on Human Comfort, Objectives of Radiant Heating, Practical Problems of Radiant Heating from a Physiological Standpoint, Fundamental Computations, Application Methods, Calculation Principles, Measurement and Control

IT has been pointed out in Chapter 12 that the human body loses heat to its environment in three ways; by convection, radiation, and evaporation. The Effective Temperature Chart takes account of convection and evaporation, but does not provide for such radiative effects as occur when room air and its surrounding surfaces differ widely in temperature.

INFLUENCE OF HEAT RADIATION ON HUMAN COMFORT

When, however, the body is exposed to radiation from a hot surface or is radiating to a cold surface, the factor of radiative heat gain or heat loss may be important. This phenomenon is most marked in the case of exposure to the sun's radiative heat. On a cold day, with no wind blowing, while standing in the sunshine, one may feel perfectly comfortable but, when a cloud passes over the sun, one may instantly feel much cooler. The cloud acts as a shield to interrupt the radiant heat from the sun. The change in feeling of comfort is due to the instant change in rate of heat loss from the body caused by the shielding effect of the cloud. A shielded thermometer under the same condition would register no change in temperature.

The rate of heat loss by convection depends upon the average temperature difference between the surface of the body and the surrounding air, the shape and size of the body, and the rate of air motion over the body.

The rate of heat loss by radiation depends upon the exposed surface area of the body, and upon the difference between the mean surface temperature of the body and the mean surface temperature of the surrounding walls or other objects. This latter temperature is called the Mean Radiant Temperature (MRT).

Because these two types of heat loss supplement each other, a required rate of total heat loss can result either from a relatively low air temperature and a relatively high MRT, or vice versa.

At the temperature which produces comfort (and at all lower temperatures) the production of sweat is low and the heat loss by evaporation is relatively low and relatively constant, irrespective of the relative humidity of the atmosphere. Under such conditions the heat loss from the body is chiefly related to the combined effect of convection and radiation. The heat demand of the environment, so far as these two factors are concerned, may be measured by Operative Temperature, which is defined by the following formula, modified from that of Gagge[1] by the expression of air velocity in feet per minute and temperature in Fahrenheit degrees.

$$t_o = 0.81\, t_w + 0.135 \left[\sqrt{V}\, t_A - \left(\sqrt{V} - 1.40 \right) t_s \right],$$