

peak time switch. However, the upper heating element is usually connected to the line so that in case the supply of hot water in the tank becomes exhausted the top thermostat can turn on the top heater and heat a small supply of water. The top heater will not heat the water in the tank below its location, but when the off-peak period arrives the lower heater is turned on and the entire tank becomes heated.

### INDUSTRIAL ELECTRICAL HEATING

Electric heating elements have been successfully developed for industrial work such as annealing, brazing, carburizing, enameling, forging, ceramic firing, hardening, metal melting, nitriding and process heating. Industrial ovens and furnaces where precise control of temperature is necessary can be very successfully operated with electric resistance elements at temperatures as high as 1800 F. For higher temperatures the electric arc or high frequency induction methods are often used. Electric heaters for heating oil to high temperatures for secondary circulation in process work are used as a substitute for superheated steam. Special oil can be electrically heated as high as 700 F and pumped at a pressure just sufficient to cause flow. When used in heating coils or jacketed vessels, this gives a safe and convenient automatic system for moderate-sized installations. Mixtures of diphenyl and diphenyloxide are used in liquid or vapor form as high temperature, low pressure, heat transfer mediums. Pitch, waxes, and many chemicals are successfully heated by electricity, but require careful design and adequate automatic control. Lacquers and similar surface films can be very effectively dried by the radiation method. Special electric lamp bulbs have been developed which give off a high percentage of infra-red and similar heat rays. These are mounted in very efficient reflectors. A large part of the heat energy is concentrated on the surface of the work, which results in quick drying with very little loss of heat energy.

### REVERSED CYCLE REFRIGERATION<sup>2</sup>

Reversed refrigeration is frequently referred to as a *heat pump* since the electric motor driving the refrigerating compressor furnishes the motive power to transfer heat from one temperature to a higher temperature level. The compressor acts as a reversible refrigerating unit to extract heat from the outdoor air in winter and deliver it indoors for heating purposes, and, by a reversal, to extract heat from the indoor air in summer and discharge it outdoors.

In normal use a refrigerating machine is arranged to remove heat and

<sup>1</sup>Cooling Homes, A Field for Refrigeration, by A. R. Stevenson, presented at the symposium of the Refrigeration with Gas Committee of the American Gas Association, April 20, 1926.

The Heat Pump, An Economical Method of Producing Low-grade Heat from Electricity, by T. G. N. Haldane (*Electric Review*, Vol. 105, p. 1161-1162, December 27, 1929, and *I. E. E. Journal*, Vol. 63, p. 666-675, June, 1930).

Edison Building Heated and Cooled by Electricity, by H. L. Doolittle (*Power*, Vol. 74, p. 384, September 8, 1931).

House Heating by Pump with 5 to 1 Pick-up Ratio, by Gilbert Wilkes and R. E. Marbury (*Electrical World*, Vol. 100, p. 828, December 17, 1932).

An All Electric Heating, Cooling and Air Conditioning System, by Philip Sporn and D. W. McLennan (*A.S.H.V.E. TRANSACTIONS*, Vol. 41, 1935, p. 307).

Using the Reversed Cycle Refrigerating Principle for a Self-Contained Heating and Cooling Unit, by Henry L. Galson (*A.S.H.V.E. JOURNAL SECTION, Heating, Piping and Air Conditioning*, October, 1935, p. 497).

the heat removed is dissipated to the condenser cooling water. The driving energy is converted into heat most of which is added to the heat removed and extracted. In so-called reversed refrigeration the heat removed together with the heat converted from the driving energy is utilized to heat the building. This conservation of the heat converted from the driving energy enables the reversed refrigeration to show a better performance in heating service than straight refrigeration can show in cooling service. For a detailed description of this cycle see Chapter 24.

### AUXILIARY ELECTRIC HEATING

In conjunction with heating systems of other types, an auxiliary electrical heating arrangement is a convenient means of caring for mild days in the spring and fall which require little heat to make a building comfortable. Likewise, such electrical heating might be used on abnormally cold days to help out the main heating system and by this means reduce the necessary size of the system.

Because of the feeling of comfort that a radiant type heater gives, bathrooms may be heated electrically with this type of heater while the rest of the house is cared for by some other system. Offices and rooms which require heat at periods when the main heating plant is shut down can be conveniently heated electrically. Fan type unit heaters delivering warm air at the floor zone are very effective.

### CONTROL

Because the efficiency of electric heat production is the same for large or small units, it is possible to reduce heat waste to a minimum by applying local heating, locally controlled. Radiant heaters are usually controlled manually but new methods for automatic control are described in Chapter 42 on Radiant Heating. For all convection and fan circulation heaters thermostatic control is essential for economical operation. For duct systems having a variable volume of air flow the electric heater control must automatically vary the heat input in coordination with the changes in air volume and demand for heat.

### CALCULATING CAPACITIES

The methods of calculating heat losses outlined in Chapters 6, 7, and 8 may be used for electric heating exactly as for fuel heating. The total heat requirements in Btu per hour may then be converted into the electrical rating of an equivalent heating system by using the equation:

$$\frac{\text{Total Btu per hour}}{3415} = \text{kw rating of required electric heating} \quad (1)$$

For comparison with steam radiation:

$$\frac{3415 \text{ Btu (one kw hr)}}{240} = 14.2 \text{ sq ft of steam radiation} \quad (2)$$

While many empirical rules based on cubic contents, floor areas, etc., are used in steam heating practice, they should never be used to determine size of equipment for an electrical heating installation.