than average to carry over the periods when the off-peak element is timed out, without too frequent demands on the regular heating element which takes the high domestic lighting service rate. Some utilities now offer a schedule which, beyond a stipulated minimum, lowers the rate for all service if an electric water heater is installed.

INDUSTRIAL ELECTRICAL HEATING

Electric heating elements have been successfully developed for innumerable industrial furnaces such as annealing, brazing, carburizing, enameling, forging, ceramic firing, hardening, metal melting, nitriding and process heating. Industrial ovens where precise control of high temperatures is necessary can be very successfully operated with electric resistance elements where temperatures as high as 700 F are required. 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 600 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.

COOLING AND REVERSED CYCLE HEATING BY ELECTRICAL REFRIGERATION[1]

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 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 2 on Refrigeration.

[1]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. 68, p. 666-675, June, 1930).

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).

Edison Building Heated and Cooled by Electricity, by H. L. Doolittle (*Power*, Vol. 74, p. 384-351, September 8, 1931).

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.

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).

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 house or 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 cared for electrically.

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. Wherever radiant heaters are used, thermostats can be used which operate through changes in air temperature but such thermostats can not integrate the combination effect of the radiant and convected heat. More accurate control can be had by the eupatheoscope, described in the Chapter 38 on Radiant Heating. For all convection and fan circulation heaters thermostatic control is useful. Heaters up to 5000 watts on 230 volt current can be thermostatically controlled by direct acting wall thermostats. For larger size heating elements the thermostat should operate a relay which in turn interrupts or closes the circuit to the heating element.

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:

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

For comparison with steam radiation:

$$\frac{3415 \text{ Btu (one kwhr)}}{240} = 14.2 \text{ sq ft of steam radiation}$$

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.

For electrical heating actual heat losses should be figured accurately because the utility company rates and minimum charge items are commonly based on the size of equipment installed, so that cost of operation might be penalized by rule-of-thumb sizing of the heating equipment.