the electric heater serves as a tempering tank, absorbing heat from the basement air and requiring the use of less energy in the electric heater.

A typical domestic hot water heater as shown in Fig. 5 is arranged with upper and lower heating elements for the usual type of off-peak heating service. The lower heating element is under the control of the off-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.

CALCULATING CAPACITIES

In calculating electric heating capacity, one kilowatt is equal to 3413 Btu per hour or 14.2 sq ft equivalent direct steam radiation.

All of the energy applied to an electric resistor is transformed into heat. The output of an electric heater is a fixed constant, unaffected by the temperature of the surrounding air, and the total load on an electric heating system is the total wattage of the connected electric heaters.

ELECTRIC HEATING BY INDUCTION AND DIELECTRIC MEANS

These methods differ radically from resistance heating. They have many important industrial uses, and open up a whole new field of special application where extreme speed or control of heat location are vital.

Metals and other electrical conductors can be heated by induction. The work is placed in an alternating magnetic field within, or adjacent to, a coil, and heat is produced in the body of the piece by eddy currents. While induction heating has certain limitations, it has great advantages in certain applications such as melting metals, forging, brazing, heat treating and particularly for localized heating and zonal hardening of metals. It is possible to apply localized heat so rapidly that conduction cannot draw the heat away before it has time to accomplish the desired purpose at a particular spot. Surfaces and local areas can be hardened without distortion or scale formation.

Commercial 60-cycle alternating current may be used in special cases, such as induction heating of large pressure vessels, but special higher frequency generating equipment is generally required. It should be carefully selected for the particular kind of work to be done. Motor-generators with frequencies in the vicinity of 250 cycles per second, are used for many melting furnaces. Motor-generators having frequencies between 2,000 and 10,000 cycles per second, are generally used for heat treating and hardening sizeable parts. For heating or brazing thin sections or small parts, electronic tube oscillators, spark discharge oscillators, or mercury arcs are used to produce frequencies ranging up to 500,000 cycles per second. Work coils used with high frequency induction heating are generally copper tubes through which cooling water is circulated. These must be specially designed for each application.

Non-conductors of electricity can be heated internally by dielectric means by placing the materials in a high frequency electrostatic field between electrode plates. This process is distinctly different from the induction heating process. High voltages and very high frequencies, often up to 50 million cycles, are needed to produce the desired rate of heating. The main field for dielectric heating is with materials which are poor thermal conductors. Food can be sterilized, plywoods bonded, plastics heated, granular or crystalline material dehydrated, deep-pile fabrics dried, and countless other products heated quickly and uniformly. Dielectric heating is well suited to many continuous production processes, as the materials can pass through the heating field quickly and without the necessity of contact with the electrode surfaces.

POWER PROBLEMS

The cost of electric energy varies because of several factors. Distribution costs differ for large and small users. The fact that electricity cannot be economically stored, but must be used as fast as generated, makes it impossible to operate electric plants at uniform loads; hence, even the time of use may affect the cost of electricity. Special low rates are sometimes available during certain prescribed hours of use.

Since cost of production and distribution depends not only upon the quantity of energy used but also upon the maximum rate of use, electric energy is often sold on a demand rate basis. In some cases, the demand charge is based upon the rated connected load; in other cases, upon the maximum demand indicated by a demand meter.

Homes are almost universally supplied with lighting current of 115 volts, which can only be used economically for small heaters. Usually the service lines will not permit more than plug-in devices. The *National Board of Fire Underwriters* permits approved heaters of 1320 watts or less to be plugged into approved baseboard receptacles, but such heaters cannot be served on a circuit supplying much other load without overloading the circuits. There is an increasing trend toward supplying homes with three wire 115–230 volt service. Where homes have such service, larger heaters can be installed. For industrial purposes, heaters should be designed to use polyphase power, which is usually supplied at 208, 220, 440 or 550 volts. All polyphase heaters should be balanced between phases. In ordering electric heaters, proper voltage must be specified, as the heat produced will vary as the square of any variation in voltage.

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