air. The amount of steam condensed (heat input) varies in proportion to the air volume, but the surface temperature of the steam coils remains about the same. Electric heat is quite different, being a constant source of energy. If the volume of air flow over electric heating elements is changed, and no change is made in the electrical power connections, there will be a corresponding change in the temperature of the air delivered because the electrical energy input remains constant and the surface temperature of the heating elements will vary as is necessary to force the air to accept all the heat. With electric heat the total heat is constant

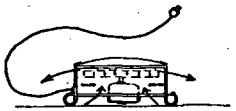

FIG. 5. SMALL PORTABLE FAN UNIT ELECTRIC HEATER

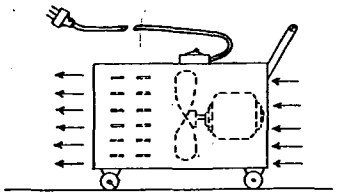

FIG. 6. LARGE INDUSTRIAL TYPE PORTABLE FAN UNIT ELECTRIC HEATER

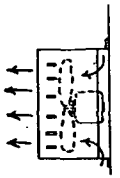

FIG. 7. SMALL FAN UNIT ELECTRIC HEATER

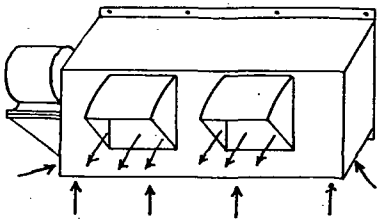

FIG. 8. LARGE INDUSTRIAL TYPE FAN UNIT ELECTRIC HEATER

unless some compensating action is performed by control. Automatic modulation to vary the electrical heat input and synchronize it properly with the air flow has been successfully applied to central fan systems.

ELECTRIC STEAM HEATING

Electric steam heating differs from fuel heating only in the use of *electric boilers* to generate steam. Small boilers usually have heating elements of the enclosed metal resistor type immersed in the water. Boilers of this construction may be used on either direct or alternating current since the heat is delivered to the water by contact with the hot surfaces. To lessen the likelihood that the heating elements will burn out, they are made removable for cleaning off deposits of scale which will restrict the heat flow. Boilers of this type are useful in industrial plants which require limited amounts of steam for local processes, and for sterilizers, jacketed vessels, and pressing machines which need a ready supply of steam.

Electric boilers are entirely automatic and are well adapted to intermittent operation. It frequently is economical to shut down the main plant boilers when the heating season ends, and to supply steam for summer needs with small electric boilers located close to the operation.

Large electric boilers are usually of the type employing water as the resistor. Only alternating current can be used, as direct current would cause electrolytic deterioration. Large boilers of this kind have electrodes immersed in the water where heat is generated directly. In Canada and Europe many successful installations have been made, but in the United States the cost of electric power, in comparison with fuels, does not favor their general use.

ELECTRIC HOT WATER HEATING

Electric hot water heating occupies much the same position as electric steam heating. It is useful in many moderate-sized installations, but large ones are seldom economical in this country. Electric boilers for supplying domestic needs for hot water are inexpensive, entirely automatic, and are insulated to prevent excessive heat losses. Similar boilers in large sizes are useful for industrial needs for hot water. When lower power costs can be secured, by confining the heating to certain fixed hours water may be heated and stored in well-insulated tanks for use when needed. In large industrial plants it is often possible to balance power loads by this means and to avoid running the fuel-fired steam boilers at night or over week ends. In Europe use has been made of this hot water storage principle for heating. Experiments have been made in this country for heating houses, but the cost of serving individual homes with the necessary heavy electric power loads has proved unprofitable at rates comparable to other forms of heating. The problems incident to installing large storage tanks in home basements, and the lack of flexibility under variable weather conditions, are also unfavorable factors.

OIL HEATING

Electric hot oil heating is useful in some industrial work 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.

HEAT PUMP

The electric heat pump is not strictly an electric heater, as it does not directly convert electrical power into heat. It operates a compressor electrically which 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. This system has been used in evenly-balanced climates where the heating requirements in winter are about the same as the cooling requirements in summer.

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 are not an effective means of control and manual operation or control by eupatheoscope is necessary. For all convection and fan circulation heaters thermostatic control is useful. For small heaters having ratings up to about 1500 watts, there are direct-acting thermostats which are satisfactory, but for larger heaters it is advisable to use relays