**Table 1 . . . . Principal Types of Electric Space Heating Systems**

A. Radiators, Convectors, Unit Heaters—Built-In and Portable
  1. Metallic resistor, high or low temperature
  2. Unit ventilator
  3. Baseboard-type resistor
  4. Resistor with fan, including unit heater
  5. Resistor unit placed in room-type air conditioner
  6. Resistor with focusing radiation reflector
  7. Steam radiator with immersion electric element
  8. Floor furnaces

B. Panel-Type Installations
  1. Ceiling panel
     a. Rigid composite panels containing electrically conductive rubber
     b. Flexible composite sheets containing embedded metallic filaments or conductive rubber
     c. Electric conductors embedded in plaster on lath
     d. Electric conductors embedded in plaster or similar material between two layers of plaster board
  2. Wall panel
     a. Rigid panels, as for ceilings
     b. Flexible sheets, as for ceilings
  3. Floor panel
     a. Electric conductors embedded in concrete slab

C. Central Hot Water Systems
  1. Water from electric heater pumped to radiators or convectors in rooms
  2. Same, with thermal storage for off-peak operation
  3. Fuel-fired boiler converted to electricity
  4. Heat pump systems—See Chapter 39

D. Central Warm Air Systems
  1. Resistance-element bank in housing or air duct
  2. Fuel-fired furnace converted to electricity
  3. Heat pump systems—See Chapter 39

peratures become excessive for any reason such as a reduction in air flow. Heaters must be de-energized on fan shutdown. (See Chapter 43 for general information on controls.)

## TYPES OF ELECTRIC SPACE-HEATING SYSTEMS

The inherent adaptability of electric energy for transmission, conversion, and regulation, and the relatively high unit cost in terms of thermal equivalent, as compared with fuels traditionally used for space heating, necessitates and justifies greater attention to efficient utilization.

Types of electric heating equipment and complete heating systems in current use are listed in Table 1. The sequence shown is for convenient reference only, and does not indicate the relative extent of use, quality of performance, or installation cost and operating expense. Installations of all types listed are in successful operation, but performance and cost depend in large measure on proper application to the local conditions.

## EQUIPMENT AND INSTALLATION METHODS

### Convector with Metallic Resistors

Heating units for wall mounting, recessed or surface type, are made with resistors of incandescent bare wire or lower temperature bare wire or sheathed elements. An inner liner or reflector is usually placed between resistors and casing to provide a secondary air passage promoting circulation and minimizing rear casing temperature. Depending on details of unit construction, the convection heat delivery constitutes between 40 and 70 percent of total output, with the remainder dissipated into the room as radiant heat.

Ratings usually are from 1000 to 8000 watts (3400 to 27,300 Btu per hr) with some models down to 500 and up to 15,000 watts. Voltages are the standardized values of 120, 208, and 240. Similar models equipped with air circulation fans are available, giving convection heat delivery up to 90 percent. Other types, using similar components but without a fan, are arranged as *floor furnaces* to be installed between floor joists. A manual switch and thermostat integral with the unit are usually provided.

The location of electric convectors should be governed by the same principles that determine arrangement of steam or hot water convectors with respect to air movement.

Small portable units are available with ratings up to 1650 watts for operation at 120 volts. Higher wattage units are made for 208 or 240 volt application, and require suitable heavy duty receptacles.

### Unit Ventilators

Unit ventilators with electric heating elements of the metal sheath type with extended surface are used to provide heating and ventilating of school classrooms. Overheat switches are usually provided for each element in the heating section to de-energize the elements in case of interrupted fan operation. Ratings are available up to 30 kw in the larger sizes of units. Auditorium unit ventilators of the same type are rated up to 300 kw. The total capacity of the unit ventilator is made up by numerous smaller heating elements so temperature control can be accomplished by energizing or de-energizing the elements one at a time. The application of unit ventilators is described in Chapter 15, Unit Ventilators and Unit Heaters.

### Unit Heaters

Electric unit heaters include a suitable built-in fan which circulates room air over heating elements; they are employed for the same uses as other forms of unit heaters (steam, hot water, gas, oil), if conditions are favorable to electric heating. They are especially adaptable for supplemental heating, for small occupied rooms in otherwise unheated buildings and for unattended equipment enclosures in which temperature must be maintained above freezing. Location and arrangement of such unit heaters are discussed in Chapter 15.

### Baseboard-Type Unit

Metal casing proportioned to resemble and replace conventional baseboard along walls contains one or more resistors placed horizontally. These should be rated from 80 to 250 watts (270 to 850 Btuh) per linear foot of baseboard unit. Resistors may be bare wire, sheathed element, cast grid, finned, or ceramic extended surface. The vertical dimension is usually 4 to 9 in. and projection from face of wall from 1½ to 3½ in. Location follows the same principles applying to hot water type baseboard installation described in Chapter 14. The maximum surface temperature of the housing should be limited to 190 F.

Baseboard-type units using glass panels 6 to 8 inches high and 30 to 42 inches long are available for operation at maximum surface temperature limited to 250 F.

Large high-wattage unit-type heaters are available for ceiling or high wall mounting. These are similar to steam



and hot water unit heaters in appearance and function. Resistors may be placed in room air conditioners to permit operation as forced air heaters when desired.

### Resistor Portable Heater with Focusing Reflector

An example of the focusing-reflector-type heater is the parabolic or circular bowl having, in its center, an incandescent wire coil resistor on a ceramic core, often screwed into a porcelain or other approved type receptacle. Usual ratings are 500 to 1650 watts for 120 volt use. Heat emitted is 75 to 85 percent radiant.

Sectional focusing-trough-type reflectors are made with low temperature resistors or with *quartz lamps* to be suspended from the ceiling or bracketed from the wall. Rated capacities are 200 to 1500 watts per linear foot of unit. Installations of this kind are usually to handle the perimeter heat loss. In a modified form, similar units are employed for infra-red heating and drying in industrial processes.

### Steam Radiator with Immersion Element

Radiators equipped with an immersion element screwed into a bottom opening, are usually sealed after charging with water and antifreeze compound. A safety valve or thermal relief plug is provided to protect against excessive pressure and temperature in case heat dissipation is unduly curtailed by obstructions to air convection. The steam-and-water intermediate heat transfer does not affect overall thermal efficiency, but gives the unit operating characteristics adapted for certain applications. Units may be permanently connected by conduit, or used as portable heaters with cords.

### Ceiling-Panel Installations with Conductive Rubber

Panels of laminated construction containing electrically conductive rubber, with rating of 22 watts (75 Btu) per sq ft, for 115 and 230 volt service, are built in standard sizes 3 x 4 ft, 4 x 4 ft, and 4 x 6 ft. They consist of a layer of special rubber about 1/64 in. thick sealed between layers of phenolic resin-impregnated electrical insulating paper. The assembly is covered on each side with a sheet of aluminum foil. Overall thickness is 1/16 in.; weight is 0.4 lb per sq ft. Metal strips embedded along edges of the rubber sheet serve as potential leads. Electric terminal blocks are provided on each panel and standard raceway moldings are furnished for wiring connections. An earlier type of construction using asbestos-board backing to form rigid panels ¼ in. thick has been discontinued.

Under normal operating conditions, the surface temperature of an automatically controlled ceiling panel is about 100 F. When panels are turned on in a cold room or with continuous operation, the maximum temperature reached is 120 F.

Since it is not permissible to cut heating panels, the entire pattern for ceiling must be planned in advance, with particular attention to coverage near exposed walls. Attachment to smooth surfaces may be made by a special adhesive applied on the ceiling along a 1½ in. fastening margin provided around the four sides of each panel. A highly sensitive room thermostat with narrow operating differential should be used in each room.

### Ceiling-Panel Installations with Embedded Conductors

Resistors or cables for embedding in ceilings to form panel-heating installations are electrically insulated with coverings resistant to high temperature, water absorption, aging effects, and chemical action with plaster, cement, and soil. Cable units identified by a color code are furnished in nominal standard lengths from about 75 to about 1800 ft, and are rated from 200 to 5000 watts for standardized voltages of 120 or 240. The outside diameter of the cables is usually about ⅛ in. Non-heating leads 7 ft long are attached to each unit to connect at thermostat or connection box without running cable beyond the ceiling. The length of cable or leads must not be altered. The identification label showing rating may not be removed. Manufacturer's instructions should be followed regarding installation procedures.

The lath used is of non-metallic fire-resistant type. The cable is secured to the lath with staples spaced not over 16 in. apart. Each cable is tested after fastening on lath, and after first plaster coat has been applied, for continuity of circuit and for insulation resistance of at least 100,000 ohms measured to ground. The minimum spacing between cable passes is 1½ in. and is generally used near cold walls, with up to double that spacing near interior areas of the room. Non-heating leads outside the ceiling should be installed by approved wiring methods. Cables must be kept away from metallic materials and from areas of ceiling additionally heated by recessed or surface mounted lighting fixtures. All general power and light wires should be run above thermal insulation or at least 2 in. above the heated ceiling surface.

For plastered ceilings, non-insulating plaster is applied in two or three coats with the first coat troweled in the same direction in which the cable runs. Ceiling cables, properly engineered, installed, and operated will not cause ceiling cracks. While new plaster is drying out, the system should not be energized and the range and rate of temperature change should be kept low by other heat sources or by ventilation until plaster is thoroughly cured. The use of vermiculite or other insulating plaster is contrary to code provisions since it causes cables to overheat.

For laminated ceiling construction, cables are stapled to non-metallic lath as for plaster, and then a second layer of non-insulating ceiling board is applied with a layer at least ⅛ in. of plaster or similar compound to sandwich the cable firmly in place and improve heat transfer.

A highly sensitive room thermostat with narrow operating differential is recommended for each room. Chapter 30 includes data on panel heating with electric panels.

### Electric Wall Panels

Cable embedded in walls similar to ceiling construction is occasionally found in Europe. Because of possibility of damage due to nails driven for hanging pictures or from building alteration, most codes prohibit such panels in the United States. Interference with radiation caused by furniture placement and interior decorations reduce the desirability of wall panels.

### Radiant Convector Wall Panel

Glass electric heating units, sometimes designated as radiant panels, depend on the heating effect produced by passage of current through a thin coating of conductive material fused to one face of a panel of ¼-in. thick special glass. The conductive layer may be sprayed-on aluminum or *printed* metallic oxide patterned to form a grid several thousandths of an inch thick, or fused-on material to give a uniform coating less than 0.0001 in. thick over the entire active face of panel. Normal glass operating temperatures are 300 to 400 F, with maximum permissible temperature around 650 F.

Electric wiring connections are made by a variety of means