Thermostats should be of high sensitivity type with a manual switch and have other characteristics like those described for conductive-rubber panel installations.

Electric Wall Panels

Although less common than ceiling or floor panel systems, walls may similarly be utilized for electric panel heating. However, possibility of damage to the electrical conductors or to their insulation, from nails driven for hanging pictures and from building alterations, as well as radiation interference caused by furniture placement and interior decorations, requires consideration. Care must be exercised to assure compliance with any applicable codes or safety regulations.

Electric Floor Panels

Resistor cables of the same types which are used for ceiling panels are employed also for floor panel systems in concrete slabs. The thickness of the concrete slab is usually made a minimum of 3 in. when placed directly on soil. Precautions to be observed in construction of floor slabs for panel heating are covered in Chapters 12 and 24. Cement finish $1\frac{5}{8}$ in. thick is poured and trowled above the cables. They are stapled at the specified spacing to wood nailing strips laid on the rough concrete slab. It is desirable that cables be secured in place either with a $\frac{1}{8}$ to $\frac{1}{4}$-in. layer of cement wash or thinned grout before the final $1\frac{1}{2}$-in. cement or terrazzo finish is applied, or by tacking at 2 ft intervals with daubs of cement, plaster-of-Paris, strips of masking tape or other non-conductive material. When the slab is made of light-weight insulating concrete, cables should be secured by tape or cord stapled directly to the slab as in the case of plastered ceilings. With monolithic finish, nailing strips are omitted and the cable is strung on frames with nail spacers; frames are removed when enough concrete has been poured to hold the cable in place. If desired, magnesite flooring, asphalt tile or wall-to-wall carpeting may be used on the floor.

Spacing between adjacent turns or loops of cable, and clearance from reinforcing steel bars or other metal bodies embedded in concrete, for prevention of magnetic hum, are the same as for plaster ceilings. Non-heating leads should have rigid conduit between the wall outlet box and floor. They terminate beneath the surface of the final coating. Porcelain or phenolic bushings to separate the leads should be placed with the leads pass from raceway into the slab. Cable circuits should be tested for continuity during the time they are being laid and again while the top concrete layer or cement finish is being poured.

Under ceramic tile floors, the cables are embedded in grout before tiling is laid. In the case of bathrooms, laundry rooms, basements subject to flooding, or other locations where wet floor conditions are likely, soil heating cable of lead-sheathed or other special water- and corrosion-resistant types may be required under local regulations.

Central Hot-Water Systems

Heating systems of hot-water type using conventional radiator or convector units, discussed in Chapter 22, may be operated electrically by means of heat exchangers containing immersion elements (resistors) of the required capacity. Control of the resistor circuit by a thermostat within the exchanger is usually desirable. The water holding capacity of exchanger should be made sufficient to minimize frequency of cycling of the heavy electric load from the resistor, and for safety. Resistors may be interlocked with the circuit of the water circulating pump, so that they can be energized only when circulating pump is in operation under control of the room thermostat.

For off-peak operation, where rate schedules for electric power make this desirable, a water heating tank of large storage capacity is employed. The system may be designed for a maximum water temperature of 250 to 275 F at pressures of 60 to 75 psig. An automatic valve is required to provide 140 to 160 F temperature at the pump, by mixing hot water from the tank outlet with cool water from the return main. Another method for heat delivery employs the *flash* principle, withdrawing water at high storage temperature into a low-pressure separating chamber where steam is obtained as a result of the pressure reduction; however, power for pumping is substantially greater with this steam-accumulator method. In practice, tanks up to 1200 gal with immersion elements of 25 to 30 kw have been used for installations with design heat requirements up to 90,000 Btu per hr. Thermal insulation on the tank piping must have low heat transmission in order to cut down the daily and seasonal standby losses. Design of such off-peak systems requires careful analysis of all factors, both thermal and economic. High investment, space required for equipment, and other practical considerations tend to limit the application of this type of electric heating.

Central Warm-Air Systems

These systems usually employ heaters consisting of resistors mounted in a frame or housing, as mentioned under Electric Heating Units earlier in this chapter. In many cases, arrangement of the supply and return duct system can be planned advantageously to facilitate future addition of equipment for summer air conditioning.

Conversion of Existing Heating Systems

Changeover of existing conventional fuel-type house heating systems to electric operation, by substituting resistors in place of the fuel equipment in the combustion chamber of a warm-air furnace or boiler, is seldom desirable. Excessive thermal losses from such central equipment and lack of adequate refinements in the distribution facilities and controls, will usually cause high operating cost. However, where heat delivery into the system is accomplished by a steam or hot-water coil assembly located within a duct system, replacement or supplementing with a bank of resistors like those employed in electric unit heaters is sometimes advantageous. A case of this kind occurs where standby heating is needed to maintain safe or comfortable temperature in isolated rooms, during emergency conditions or when the normal electric service for lighting and motors is not in use.

Heat Pump Systems

Where summer air conditioning is wanted in addition to heating, the heat-pump type of all-year system, which utilizes a refrigeration compressor unit in conjunction with a central-plant installation, is finding a number of applications. It reduces electric input demand and consumption for heating to about one-half or one-third that with the resistance method, the reduction depending mainly on temperature level of the heat source used and on the type of heat distribution system and its controls. In general, the conditions most favorable to heat pumps occur where, due to climate or operating requirements, the compressor capacities needed both for heating and for cooling service are the same, or nearly so. Customary