safety pilot closes the gas valve, thus eliminating the danger of delivering gas to the burner without ignition.

5. *Electric Heating.* Electric heating has become popular in those areas where electric power is plentiful and inexpensive. The electric heating elements may be located in each individual room and turned on and off by thermostats in each room or the heat may be supplied by a central heating system. In the case of a central heating system the control is usually of the proportioning type which energizes from five to ten heating elements in sequence according to the demand for heat by means of a sequence controller consisting of a series of switches operated by a proportioning motor. A limit switch recycles the sequence controller if the furnace or boiler exceeds a predetermined temperature.

Limit Controls

A *high limit* control for steam consists of a pressure control having bellows, responsive to the boiler pressure, which breaks an electric contact when the steam pressure exceeds a predetermined point, thereby preventing the burner from delivering additional heat to the boiler. A low water cut-off should also be used to stop the burner if the water in the boiler drops to a dangerous level.

A high limit control for a hot water boiler consists of an immersion thermostat (usually equipped with a bi-metal helix) inserted in a well in the boiler. This control stops the burner when a predetermined water temperature has been reached in the boiler.

In a warm air system the high limit control is a thermostat including a bi-metal helix inserted in the bonnet of the furnace. It will shut off the source of heat when a predetermined furnace temperature is exceeded.

System Control

There are several types of system control in common use for residential applications. They are usually of the two position (on-off) type or of the proportioning type.

1. *Two Position (On-Off) Control.* The most simple type of domestic control is the type in which the room thermostat starts the burner or other source of heat when the temperature of the air at the thermostat falls below the thermostat setting and stops the source of heat when the air temperature rises above the setting. If forced warm air or forced hot water is used, the fan or circulator may be turned on and off at approximately the same time as the source of heat.

2. *Proportioning Control.* When a proportioning type of control is used, the flame of the burner may be varied or the burner may be cycled (started and stopped) frequently to provide for time modulation so that the heat input to the home is proportioned continuously to the heat loss from the home. The fan of a forced warm air system or the circulator of a forced hot water system may be run almost continuously, thereby providing for the constant flow of heat into the home. Such operation eliminates the cold drafts on the floor as caused by cold air dropping from cool walls and windows during the off period of an on-off system.

Room Thermostats

Room thermostats usually employ a bi-metal element or a vapor filled bellows as the temperature sensitive element. They may be of the plain or single temperature type, or of the day-night type providing for automatic night lowering and morning increase of the control point. The automatic setback type usually includes a clock mechanism which accomplishes this result.

In locating a room thermostat the following rules should be observed:

1. It should always be located towards the center of a relatively open room on the coolest rather than the warmest side of the building.

2. It should never be mounted on an outside wall or other cold surface, or where it is exposed to cold drafts from an outside door.

3. It should never be mounted where it will be affected by heat from a nearby warm surface such as chimneys, pipes or ducts in a wall, radiators; or by direct currents from a warm air register.

4. It should never be located where normal circulation of air is impeded by furniture or an opened door.

5. It should be located where it is safe from mechanical injury.

In a typical home, a satisfactory location for the thermostat can usually be found on an inside wall of the living room or dining room.

Air-Conditioning Systems

Year-round residential air-conditioning systems which provide for heating in winter and cooling in summer should be given the same consideration in selecting the control system as required for commercial air-conditioning systems described later in this chapter since the basic principles are the same and the final results must provide for the comfort of the occupants. Economy in first cost may result in both lack of economical operation and discomfort.

ZONE CONTROL

In residential heating, it is often desirable to divide the house into two or more zones for greater accuracy of control and comfort. Each zone may then be maintained individually at the desired temperature level. The division by zones should be based upon exposure and occupancy and the most common division is usually found to be:

1. Living section (Living room, dining room, den, etc.)
2. Sleeping section
3. Service section (Kitchen, pantry, servant's quarters, etc.)

Zone control for steam and hot water heating systems is employed where it is desired to control the heating effect of a multiplicity of radiators or convectors, located in various heated spaces, through the use of a single regulator. Under certain conditions, particularly in buildings of limited size, it is possible to consider the entire building as a single heating zone. In such cases, the zone regulator, or *master controller*, may operate directly the automatic firing equipment of the boiler or the reducing valve in the street steam main. In large buildings the demands of satisfactory temperature control, however, will make it necessary to sub-divide the heating system into suitable zones.

There are a number of factors to be considered in zoning, in order that heating requirements in a single zone will be approximately consistent throughout its extent.

1. Exposure may be a factor to be considered, with particular reference to prevailing winds, sun effect, and the shelter afforded by surrounding structures and topographical features.

2. Occupancy may be a determining factor, in that the indoor temperature requirements for the activities carried on in various portions of the building may vary and the hours of occupancy likewise may differ.

3. The physical characteristics of the building will enter into the sub-dividing of the heating system into zones by reason of the fact that satisfactory temperature conditions throughout a single zone of given extent may not be enjoyed equally in buildings of dissimilar types of construction. Also, the height of the building and its horizontal extent and form are considerations which must be borne in mind.

4. The cost of the zone control equipment for such additional zones as might seem otherwise desirable often will influence the decision as to the final number of zones to be employed. In buildings of considerable size, accepted practice dictates that there shall be at least one zone for each exposure, although each exposure very possibly should be sub-divided vertically into two or more zones, for the higher structures. Also, the