

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-sensitive element, having bellows responsive to the boiler pressure. It opens 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 fuel supply when a predetermined furnace temperature is exceeded.

Room Thermostats

Room thermostats are of three types, depending on the temperature sensitive element which they employ. These are: (1) the bi-metallic type which distorts with temperature changes; (2) the vapor-filled bellows type which expands or contracts with temperature changes; and (3) the electronic type which employs resistance wires and microcurrents which vary with temperature or humidity changes. The first two types employ either electric currents or compressed air to amplify their effect. In the electronic type the micro-currents are amplified by means of electronic amplifier relays. The amplified effect in each instance is used to actuate the operators for valves, dampers, stokers, oil burners, gas burners, etc. Room thermostats may be of the plain or single temperature type, or of the day-night type providing for automatic night decrease and morning increase of the control setting. The automatic setback type usually includes a clock mechanism which accomplishes this result. Opinions vary regarding the amount of fuel that can be saved by automatic setback. Tests made both in the Warm-Air Heating Research Residence and the $I = B = R$ Research Home at the University of Illinois indicate that, on thermostatically controlled systems, a possible fuel saving of from 7 to 10 percent may be obtained by reducing the house temperature 6 to 10 deg from about 10:00 p.m. to 5:30 a.m.³

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 direct rays of the sun, by heat from a nearby warm surface such as chimneys, pipes or ducts in a wall, or 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 protected 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. In larger buildings the thermostat or thermostats should be placed in occupied

areas on inside walls or columns. They should never be placed in corridors, lobbies, foyers, etc. unless they are used for the control of these areas only.

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 one 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 which 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 minimizes 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.

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; the most common division is usually found to be:

1. Living section such as living room, dining room, den.
2. Sleeping section.
3. Service section such as kitchen, pantry, servant's quarters.
4. Recreational areas.

Further discussion of zone control will be found in the general section on Zone Control given later in this chapter.

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, since the basic principles are the same and the final results must provide for the comfort of the occupants. A reduction in investment in first cost for automatic controls may result in wasteful operation of the system and discomfort for the occupants.

STEAM HEATING SYSTEMS

There are several means of obtaining centralized control of heat output of radiators in heating systems whether the steam comes from a local boiler or from underground mains.

1. *Controlling the rate of steam flow* into the radiators. This is accomplished by equipping the radiator inlets with orifices, and controlling the flow of steam through them into the radiator as a result of the difference in pressure between the supply and return connections.
2. *Controlling the temperature of steam* in the radiators by varying its pressure. This involves the use of high vacuums to obtain low steam temperatures. This must be supplemented by some other type of control for low heat output.