control will be adjusted to stop the burner at some higher point in the event that the *operating controller* fails to stop the burner before the higher shut-off point is reached. For example, to maintain a constant water temperature in a hot water boiler, the operating controller may be set to stop the burner when the boiler water temperature reaches 180 F. The *high limit control* should then be set to stop the burner at a higher temperature, say 200 F.

Various interlocks or limit controls are usually included to assure safe operation of these larger burners. A latch switch interlock prevents burner operation if the burner is not in its proper firing position. Another interlock must prove that the burner is in its low-fire position before the burner can be started. Safe draft conditions should be proved before the burner can be started or allowed to run, especially where induced draft fans are involved. A smoke detecting device may sound an alarm and stop the burner if excessive smoke is produced. Also, protection against electrical overloads must be provided.

Primary Controls

Primary controls provide for the safe start and operating procedure of the burner. They are somewhat different for each of the three types of fuel burners.

1. *Stokers.* Stokers are equipped with refueling, or *hold-fire,* controls. These *primary controls* cause the stoker to intermittently feed a predetermined amount of coal during the long *off* periods of the *operating controller* to maintain ignition and to reduce the possibility of having idle fuel beds damage stoker castings. In some cases the *primary control* system includes an *out-fire* feature which stops the feeding of coal into the firebox if the fire goes out.

2. *Oil Burners. Primary controls* required for oil burners depend on the size and type of burner. Some of the more common *primary controls* are discussed in following paragraphs a to d.

a. Domestic oil burners of the vaporizing type usually require a *primary control* which will (1) meter the correct amount of oil into the burner to maintain the pilot flame; (2) regulate the required amount of oil into the burner for its high flame operation; and (3) completely shut off the flow of oil in the event of a flame failure.

b. Domestic oil burners of the pressure atomizing type require a *primary control* which will (1) energize the burner motor and electric ignition; (2) test for the establishment of main burner flame and stop the burner and ignition if flame has not been established; (3) cut off the ignition after a safe burner flame has been established (does not apply to constant ignition type burners); (4) monitor the flame continuously during burner operation and stop the burner in the event of flame failure (manual reset is necessary following a flame failure lock-out); and (5) stop the burner when either the *operating controller* or *limit control* requires it.

c. Commercial and industrial oil burners of the pressure atomizing type have *primary controls* that are essentially the same as those outlined for domestic oil burners of the pressure atomizing type. In addition, some models are equipped with a solenoid oil-shut-off valve to provide a pre-purge period, if desired, and a quick shut-off of the oil flow when the burner is stopped.

d. Commercial and industrial oil burners of the horizontal rotary cup type are usually equipped with a more elaborate *primary control* system. The primary control is often described as a programming combustion safety control. Its most important operations include (1) starting the burner upon a call for heat; (2) providing a pre-purge period before activating the gas-electric ignition; (3) proving the presence of proper ignition before permitting the flow of oil to the main burner; (4) proving the presence of a stable main burner flame within a predetermined period of time; (5) shutting off the gas-electric ignition after a predetermined length of time has elapsed; (6) monitoring the main burner flame during its entire *on* period and stopping the burner quickly in the event of a flame failure (it is usually required that the flow of oil through the burner be stopped within four seconds following a flame failure); (7) stopping the flow of oil through the burner when either the *operating controller* or a *limit control* requires it; (8) operating the burner for a predetermined length of time after the main fuel valve has been closed; and (9) locking out on a flame failure shut-down (the programming control then must be manually reset prior to a restart).

When steam, air or mechanical atomizing burners are automatically controlled, their sequence of control is similar to that described for horizontal rotary cup burners.

3. *Gas Burners.* Some of the more common *primary controls* for gas burners are as follows.

a. Domestic gas burners of the atmospheric type require a *primary control*, to insure safe starting and operating conditions, which will (1) prevent opening of the gas valve unless the pilot is operating properly, and (2) stop the flow of gas through the burner if safe ignition conditions do not prevail at all times.

b. Commercial and industrial gas burners of the atmospheric type require a *primary control* whose function is similar to that for domestic sizes of these burners except in the rate of response to a pilot flame failure. The pilot flame burns constantly and, in general, the primary control system will (1) assure operation only when ignition of the main burner will be safe; (2) start and stop the main burner when required to do so by either the *operating controller* or a limit control; and (3) close the safety shut-off valve in the gas supply line to the burner upon a flame failure or an electrical power failure.

c. Commercial and industrial gas burners of the power type equipped with electric ignition require a *primary control* whose most important operations include: (1) starting the burner motor upon a call for heat by the *operating controller*; (2) providing a pre-purge period before activating the gas-electric ignition; (3) proving the presence of proper ignition before allowing gas to flow to the main burner or shutting off the electric ignitor; (4) closing the safety shut-off valve in the event of a flame failure (it is usually required that the flow of gas be stopped within four seconds following a flame failure); (5) stopping the burner when either an *operating controller* or a *limit control* requires it; and (6) locking out on a flame failure shut-down (the programming control then must be manually reset prior to a re-start).

RESIDENTIAL HEATING AND AIR CONDITIONING

The control equipment function in the residence may vary from the regulation of a coal fired heating plant to the completely automatic control of a year-around heating and cooling system. Regardless of the type of heating or air conditioning system used, the control system should be selected carefully to insure safety and comfort of the occupants as well as economy of operation.

The simplest type of domestic control is one in which the room thermostat starts and stops the burner, as described in the preceding section. It may be used on gravity or forced warm air, hot water or steam systems. In forced warm air or forced hot water systems the fan or circulator usually is controlled by a thermostat in the furnace or boiler and runs whenever the air or water temperature is above a minimum value, as discussed in Chapter 20. If straight two-position control is used for this application, the *on* and *off* periods are relatively long and there is a tendency towards cold drafts on the floor during off periods. If timed two-position control is used, the burner may be cycled (started and stopped) often enough to provide results very comparable to proportioning control. 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, thus minimizing the possibility of cold drafts.

Proportional control is used on residential applications when provisions are made for it in the design of the system. Face and bypass dampers on warm air systems, throttling valves on steam systems and three-way mixing valves on hot water systems are typical examples of controlled devices which permit proportional control. With these arrangements the burner usually is controlled by a thermostat in the furnace or boiler. Proportional control will permit nearly continuous circulation of warm air or hot water, thus reducing cold drafts.

Automatic night set-back through the use of a day-night type room