

air. *Multi-blade* or *tower dampers* can be furnished so that adjacent blades move in the same direction or in opposite directions. The *opposed blade type* gives better directional air flow characteristics than the parallel blade type.

For long life and trouble free operation, dampers should be constructed with heavy metal frames, blades adequately braced, and ample bearing surfaces of non-corrosive materials. When tight closing is desired, felt may be glued and riveted on the edges and ends of the blades. Special materials for blades and frames are also available.

A *damper operator* is repositioned by a controlling instrument, and is connected to the damper blades as required to give the desired movement. It can be mounted on the damper frames or mounted outside the duct and connected to an extended shaft on one or more damper blades. Suitable brackets are available for floor, wall, or duct mounting of the damper operator.

A *relay* is a device which uses an auxiliary source of energy to amplify or convert the force of a controller into available energy at a valve or damper operator. Various types of relays are designated as follows:

1. An *electro-pneumatic relay*, when electrically energized, starts or stops the flow of air as required.
2. A *pneumatic-electric relay*, when affected by different air pressures, starts or stops the flow of electrical energy as required.
3. A *switching relay* or *pilot valve* may be used to switch the operation of a controlled device from one controller to another, or to reverse the action of a controlled device in response to an impulse from a controller.
4. An *averaging relay* is affected by the forces from two or more controllers, and the resulting flow of energy is in accordance with the average of these forces.
5. A *positioning relay* has a direct connection to the operator of a valve and is affected by both valve or damper position and controller demand. It is repositioned by a thermostat or other controlling device, and is arranged to give a definite position for a given force from the thermostat regardless of friction or pressure variations of the controlled fluid.
6. There are numerous other relays such as *differential*, *retard*, *advance*, and *limit* relays for highest pressure or lowest pressure which are used to provide the desired sequence of the control devices.
7. An *electronic amplifier* is used only in *electronic control* circuits to amplify the micro-currents of electronic controllers to usable voltages required by standard electric actuating devices. It may be either two-position or proportioning.

A *sequence controller* is used to operate two or more devices in a pre-arranged sequence. It is generally used in connection with refrigeration compressors, and may be arranged to prevent simultaneous starting in the event of temporary electrical shutdown or in failure of the control medium.

Manual switches are available in the two-position or proportional types. *Two-position switches* change the flow of energy from one circuit to one or more other circuits; or from one pair of lines to another pair of lines. *Proportioning switches* vary the flow of energy as determined by the manual setting of the switch.

Positive switches are stop-waste, three-way or four-way cocks, and are used to open or close a controller, or make a night and day change-over. Gradual switches may vary the flow of energy to an actuator.

AUTOMATIC CONTROL APPLICATION

Some of the considerations affecting the selection of automatic controls for applications are given in the following paragraphs which describe con-

trols and operation for various types of systems and equipment. The sub-divisions describe combinations of controls and devices that are particularly applicable to that individual type of equipment. Certain portions of any specific automatic control system may also be applicable to other systems, or be used in combination with these control systems.

RESIDENTIAL CONTROL SYSTEMS

The control equipment function in a residence may vary from the regulation of a coal-fired heating plant to the completely automatic control of an all-year air conditioning 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.

Heating Unit Controls

Typical controls for the appliances used to supply heat in residences are as follows:

1. *Hand Fired Coal Burners.* The control of a hand fired coal burner for a boiler or furnace normally consists of a room thermostat operating a two-position electric control motor, which in turn opens the draft damper and closes the check damper on a demand for heat. The motor then closes the draft damper and opens the check damper when the thermostat is satisfied. A limit control on the boiler or furnace should be connected to the motor so that it may check the fire whenever a predetermined temperature or pressure has been exceeded. A manually operated basement switch usually is included on the motor so that the draft may be opened and the check closed when the boiler or furnace is being filled with coal.

2. *Coal Fired Stokers.* Domestic stokers usually are controlled by a room thermostat, a limit control, and a stoker relay. When the thermostat calls for heat, the relay causes the stoker motor to increase the flow of fuel and air to the burner. When the thermostat is satisfied, the relay provides for a reduced flow of fuel and air to the burner to maintain the fire at its minimum rate. The limit control prevents the continuance of the maximum fuel rate if the temperature or pressure in the boiler or furnace exceeds a predetermined value, and also stops the feeding of fuel if the fire goes out.

3. *Automatic Oil Burners.* Automatic oil burner controls normally consist of a room thermostat, a limit control, a combustion safety control, and a control relay. On a call for heat by the thermostat, the relay starts the oil burner motor which supplies oil and air to the burner. An ignition device consisting of an electric spark or a gas flame ignites the oil automatically. If for any reason the oil and gas mixture does not ignite, a time delay mechanism in the relay is operated by the combustion safety control after a predetermined length of time, to cause the oil and air supply to be shut off. If the oil and air mixture ignites properly, the burner continues to run until the thermostat is satisfied, or until the limit control affected by the temperature or pressure in the boiler or furnace stops the burner.

4. *Automatic Gas Burners.* The controls for an automatic gas burner usually include a room thermostat, a limit control, a safety pilot, gas pressure regulator and a gas valve (solenoid, motorized or diaphragm type). Upon a demand for heat at the thermostat, the gas valve is opened, admitting gas to the burner. The safety pilot ignites the gas which continues to burn until the thermostat is satisfied, or until the limit control shuts off the gas valve. The limit control may also reduce (throttle) the gas flame as required to maintain a desired temperature or pressure of the heating medium. If the pilot flame is extinguished for any reason, either before or after the main gas valve is turned on, the 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