

changes in outdoor temperature is an example. This system depends for its operation on a prearranged relationship between outdoor temperature and heat input to the building, and room temperature has no effect on the controller.

As there is no feedback, the control corrects only for those disturbances of room temperature caused by changes in outdoor temperature.

### TYPES OF CONTROL SYSTEMS

Control systems are divided into five main groups according to the primary source of energy:

1. A *self-contained system* combines the controller and controlled device in one unit and employs the power of the measuring system to effect the necessary corrective action. The measuring system derives its energy from the process under control without amplification by any auxiliary source of energy, and may be of the sealed-bellows or remote-bulb type as described under Types of Measuring Elements

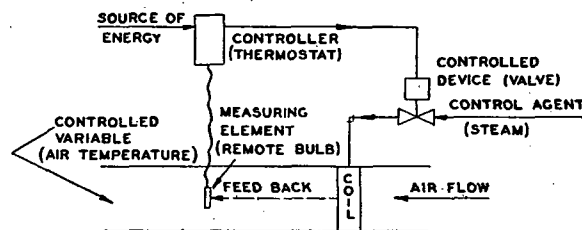


FIG. 1. ESSENTIALS OF A CONTROL SYSTEM

Temperature changes at the bellows or the remote bulb result in pressure or volume changes of the enclosed media which are transmitted directly to the operating device of the valve or damper.

2. A *pneumatic system* utilizes compressed air, usually at a pressure of 15 to 25 psig, as a source of energy. This is supplied to the controller which in turn regulates the pressure supplied to the controlled device.

3. A *hydraulic system* utilizes a suitable liquid under pressure as the source of energy. The pressure often is considerably higher than in a pneumatic system, but in other respects the systems are similar. Hydraulic systems find their chief use in applications where large forces are required for operation of the controlled devices.

4. An *electric system* utilizes electric energy, either low or line voltage as the energy source. The electric energy supplied to the controlled device is regulated by the controller either directly or through relays.

5. An *electronic system* also utilizes electric energy, but employs an electronic amplifier to increase the minute voltage variations of the measuring element to values required for operation of standard electrically-controlled devices. Measuring elements usually are of the resistance type, but thermocouples also are employed. Combination electronic-pneumatic systems utilize compressed air for operation of the controlled device by converting the output of the electronic amplifier into suitable air pressure changes by means of an electronic-pneumatic transducer.

### TYPES OF CONTROL ACTION

Control action may be divided into five types:

1. *Two-position action*, Fig. 2, is the type in which the controlled device can be positioned only to a maximum or minimum position, or can be either *on* or *off*. A thermostat which opens and closes a valve, or starts and stops a burner, is an example.

2. *Timed two-position action* is a common variation of two-position control action in which the time of *on* periods are prematurely shortened. This type of action usually is employed only in room thermostats, and is accomplished by a heater element

### Automatic Control

in the thermostat which is energized during the *on* periods. The percentage of time *on* is varied in proportion to the system load.

*Controller differential* applying to two-position control action, is the difference between the setting at which the controller operates to one position and the setting at which it operates to the other position. As an example, if a pressure controller starts a pump at 12 psi and stops it at 15 psi, the differential is 3 psi. It is sometimes

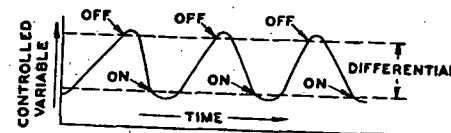


FIG. 2. TWO-POSITION CONTROL

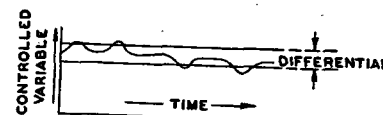


FIG. 3. FLOATING CONTROL SHOWING VARIATIONS IN CONTROLLED VARIABLE AS LOAD CHANGES

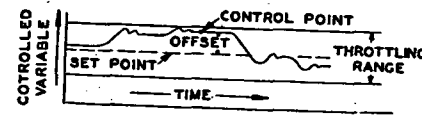


FIG. 4. PROPORTIONAL CONTROL SHOWING VARIATIONS IN CONTROLLED VARIABLE AS LOAD CHANGES

desirable to have a controller in which the differential can be changed by manual adjustment. This is designated as an adjustable differential.

3. *Floating action*, Fig. 3, is the type, as with two-position action, where the controller can perform only two operations: moving the controlled device usually at a constant rate either towards its open or its closed position. Generally there is a neutral zone between the two positions which allows the controlled device to stop at any position whenever the controlled variable is within the differential of the controller. When the controlled variable gets outside the differential of the controller, the controller moves the controlled device in the proper direction. An example of floating control is a fire box draft controller positioning a damper in the breeching of a boiler.

4. *Proportional action*, Fig. 4, is the type where the controlled device is positioned proportionately in response to slight changes in the controlled variable. It does not run through its complete stroke, as is the case with two-position control, nor does it continue to move until the change in the controlled variable resulting from that movement is felt by the controller, as is the case with floating control, but it immediately assumes a position in proportion to the system requirement.

An example of proportional control is a thermostat in a fan discharge duct actuating an automatic valve in the steam supply to a coil to regulate the air temperature leaving the coil. This control would be similar to that shown in Fig. 1.

*Throttling range* is the total amount of change in the controlled variable required