An *electric controlling element* is used in several of the common types of control action.

For *two-position control* it may simply make and break an electrical contact, to start a burner, motor, etc., or to actuate a spring-return valve or damper operator. Another type makes one contact while breaking another and is used to control unidirectional valve or damper operators. Either type may be used for timed two-position action by the addition of a small resistance heater.

For *floating control* two contacts are employed, but there is a neutral zone between the two contacts where neither is made. This type is commonly used with reversible valve or damper operators.

For *proportional control* a contact is moved across a potentiometer to vary the voltage applied to a relay. The relay controls the operation of a reversible valve or damper operator and is re-balanced as the controlled device is positioned. In another arrangement the controlling element has two contacts and a neutral zone as described for floating control and is re-balanced by a small solenoid which is energized by a variable voltage feedback from the reversible valve or damper operator which it positions.

An *electronic controlling element* consists of an electronic amplifier and an electric relay or relays. The amplifier receives the minute electrical signals from the measuring element and amplifies them sufficiently to actuate the relays. When the electrical signals are to be converted into pneumatic signals an electronic-pneumatic relay, frequently called a transducer, is employed. The electronic controlling element may be two-position, floating, or proportional, depending upon the amplifier and relay arrangement.

A *pneumatic controlling element* is most often of the proportional-action type but may also be used for the other types of control action. It may be classified as non-relay type and relay type.

A *non-relay type* of pneumatic controlling element is the simplest form and employs a restricted air supply and a nozzle or control port. The measuring element varies the opening of the nozzle and the resulting variable pressure is applied to the controlled device. This type is limited to applications requiring small volumes of air.

In a *relay-type* pneumatic controlling element the relay contains both a supply and an exhaust valve usually arranged so that the exhaust valve must close before the supply valve opens. Both valves are closed except when the control pressure is required to change. The variable force for operating the valves may be supplied directly by the measuring element or it may be supplied by a diaphragm actuated by air pressure from a very small nozzle and restrictor arrangement, this air pressure being varied by the measuring element. In either case the control pressure, operating on a diaphragm within the relay, produces a force which balances the force produced by the measuring element.

Pneumatic controllers may be either direct or reverse acting.

A *direct-acting controller* increases the control air pressure as the controlled variable increases. For example a direct-acting thermostat increases the air pressure as the temperature increases.

A *reverse-acting controller* decreases the control air pressure as the controlled variable increases. A reverse-acting thermostat decreases the air pressure as the temperature increases.

Indicating and Recording Features

Controllers may be of the indicating or recording type.

The *non-indicating controller* is most common in heating, ventilating, and air conditioning work, and includes all those in which the measuring element does not provide a visual indication of the value of the controlled variable. If an indication is desired, a separate thermometer, relative humidity indicator, pressure gage, etc, is required. With room thermostats, for example, a separate thermometer often is attached to the cover.

An *indicating controller* has a pointer added to the measuring element or attached to it by a linkage so that the value of the controlled variable is indicated on a suitable scale.

A *recording controller* is similar to an indicating controller except that the indicating pointer is replaced by a recording pen which provides a permanent record on a chart driven by a clockmotor.

Proportional band is a term used in connection with indicating and recording controllers and has the same meaning as throttling range. It is usually expressed in percent of the scale or chart range of the controller.

Types of Controllers

Controllers are mainly (1) thermostats, (2) humidistats, and (3) pressure types.

1. Many thermostats are of the simple, single-purpose type, but there are many others for various special purposes. Various types are indicated in paragraphs (a) to (k) which follow.

a. The *room* type is designed for mounting on a wall and responds to room temperature.

b. The *insertion* type is designed for mounting on a duct with its measuring element extending into the duct.

c. The *immersion* type is designed for mounting on a pipe or tank. It has a fluid-tight connection to allow the measuring element to extend into the fluid. A separable socket or well is often used with immersion thermostats to avoid the need for draining the system when removal of the thermostat is required. Since the separable socket will reduce the response rate of the thermostat, the socket should be no heavier than necessary and should fit snugly around the element.

d. The *remote bulb* type is designed for applications where the point of temperature measurement is at some distance from the desired thermostat location. It is often used for centralized panel mounting of the controller. The remote bulb element may be of either the insertion or immersion type.

e. The *surface* type is designed for mounting on and measuring the temperature of a pipe or similar surface.

f. The *day-night*, or *dual* room thermostat controls at a reduced temperature at night. It may be indexed (changed from day to night operation) individually or in groups from a remote point by a manual or time switch. Some electric types have an individual clock and switch built into the thermostat.

g. The *pneumatic day-night* thermostat uses a two-pressure air supply system, the two pressures often being 13 and 17 psi or 15 and 20 psi. Changing the pressure at a central point from one value to the other actuates switching devices in the thermostat and indexes them from day to night or vice versa. Supply-air mains often are divided into two or more circuits so that switching can be accomplished in various areas of the building at different times, in accordance with use. For example a school building may have the separate circuits: for classrooms, offices and administrative areas, auditorium, and gymnasium and locker rooms.

h. The *heating-cooling* or *summer-winter* thermostat can have its action reversed and, if desired, have its set point changed by the indexing means. It is used to actuate controlled devices, such as valves or dampers, that regulate a heating source at one time and a cooling source at another time. It is often indexed in groups manually by a switch or automatically by a thermostat measuring the temperature of the control agent, the outdoor temperature, or other suitable variable.

i. The *pneumatic heating-cooling* thermostat uses a two-pressure air supply system as described for day-night thermostats.

j. A *two-stage* thermostat is arranged to operate in two successive steps.

k. A *submaster* thermostat has its set point raised or lowered over a predetermined range in accordance with variations in output from a master controller. The master controller can be a thermostat, manual switch, pressure controller or similar device. For example, a master thermostat measuring outdoor air temperature can be used to readjust a submaster thermostat controlling the water temperature in a heating system. Master-submaster combinations are sometimes designated as *single cascade action*. When such action is accomplished by a single thermostat having more than one measuring element, it is known as *compensated control*.

2. *Humidistats* are of either the room or insertion type. Submaster humidistats of either type are sometimes used in conjunction with an outdoor master thermostat to reduce the humidity in cold weather and prevent condensation on windows.

A *wet-bulb* thermostat is often used for humidity control in conjunction with proper control of the dry-bulb temperature. A wick or other means for keeping the bulb wet, and rapid air motion to assure a true wet-bulb measurement are essential.

3. A *pressure* or *static-pressure* controller is made for mounting directly on a pipe