the removal of the controller bulb without the necessity of draining the vessel to the bulb level.

A *differential thermostat* has two flexible capillary tubes fitted with plain bulbs, or with bulbs having flanges or having threaded connections. One sensitive element is subjected to the controlled temperature and the second element is exposed to the temperature which is to determine the controlled temperature. The instrument functions to maintain a definite relation between the two temperatures.

A *remote bulb or extended tube controller* may be of liquid, vapor, or gas filled type. A bulb of this type of instrument is connected to the instrument head by means of a flexible capillary tube of the desired length. The external diameter, bore, and material used to form the capillary vary with the type of control system.

An *indicator controller* is a controller fitted with a pointer, thermometer, or gage which indicates the controlled condition.

A *recorder controller* is a controller, combined with a clock mechanism and chart, which both controls and records the controlled condition.

A *time cycle controller* is a controller equipped with a clock mechanism which automatically raises and lowers the control point of the instrument to meet a required time schedule.

A *hygrostat or humidistat* is an instrument for controlling relative humidity. It may be of a room, insertion, indicating or recording type, and may be direct or reverse acting.

Many forms of hygroscopic materials, such as human hair, wood, bi-wood and membrane of selected type, are used as the sensing medium for these instruments. Where the controlled condition ranges below 20 per cent or above 70 per cent, or the dry-bulb temperature is above 100 F, careful selection of the hygroscopic element is essential.

A *static pressure controller* is frequently used to provide a constant pressure in a duct system in which the volume of air supply is varied to maintain temperature or some other condition, and usually it operates to reposition dampers installed in the fan vortex or other selected location. It usually functions to maintain a pressure differential between the atmosphere and the pressure or vacuum of the controlled condition. It is frequently necessary to pipe the neutral chamber to a selected location to obtain a true basic condition.

A *velocity regulator* is a controller actuated by the velocity of the medium which it controls.

A *solenoid air valve or electric pneumatic switch* is an electrically actuated three-way air valve which may be either direct or reverse acting. It is frequently used in connection with fan ventilating systems to close outdoor intake dampers and heater coil valves during the period when the fan motor is stopped.

A *pneumatic relay or cumulator* is a device fitted with a readjusting diaphragm to which a separate pilot connection is made. It is installed in the branch between the controller and the controlled valves or dampers, and functions to accelerate, magnify or reverse the action of the controller. Direct acting relays increase the branch pressure on an increasing pilot pressure. Reverse acting relays decrease the branch pressure on increase of pilot pressure.

A *duplex cumulator or relay* is a device having two pilot connections either of which will vary the branch pressure on a changing pilot pressure.

An *averaging cumulator or relay* is a device arranged to vary the branch pressure as dictated by the average of the pressure of two or more pilot connections.

A *multiple cumulator or relay* is a device having more than two pilot connections any one of which will vary the branch pressure on a changing pilot pressure.

A *control valve* may be considered as a variable orifice designed to control the flow of liquids, gases and other fluids.

The use of the flat disc type of valve is usually restricted to on-off control requirements. Throttling valves are generally equipped with selected forms of plug to produce the flow characteristics required for the special problem. Special plugs can be shaped to produce almost any desired flow characteristics. The three types of plugs most widely used are the V-port skirt type, the throttle plug, and the ratio plug.

A *diaphragm valve* is a valve which is operated by a diaphragm attached to the valve stem. Increasing air pressure on the diaphragm moves the valve against the pressure of opposing springs which return the valve to its normal position on a decreasing diaphragm pressure. The pressure range required to fully reposition a valve has four limiting factors, viz., the size of the diaphragm top, the tension of the selected spring, the packing gland friction and, for all single seated valves, the pressure of the controlled media against which the valve must hold.

A *direct acting or normally open diaphragm valve* will assume an *open* position due to spring action when all operating power is removed.

A *reverse acting or normally closed diaphragm valve* will assume a *closed* position due to spring action when all operating power is removed.

A *double seated balanced or semi-balanced valve* is designed for use with high pressures and is practically balanced regardless of the pressure differential across the plug. The diaphragm tops for valves of this type need only have ample power to close the valve against the tension of the opening spring plus the friction of the valve packing gland. While plugs and seats for this type of valve can be arranged to provide for tight seating for special purposes, such a requirement is not ordinarily expected.

A *three-way mixing valve*, having two inlets and one outlet, is fitted with a double faced disc, operating between two inlet ports, which functions to close one port as the other is opened, and is used for mixing service.

A *three-way diverting or by-pass valve* has one inlet and two outlets with two separate discs operating on the outside of the respective valve seats to close one as the other is opened; and is used for diverting service.

A *pilot positioner or valve positioner* is an auxiliary control device repositioned by the controller pressure and having a direct connection to the valve stem. It permits the full available air pressure to be used on the diaphragm top to overcome hysteresis, packing gland friction and pressure variation of the controlled media, to position the valve precisely in accordance with the controller pressure.

A *pneumatic damper motor* is a diaphragm or bellows assembly operating against resisting springs to reposition an arm or lever assembly. They may be attached directly to the damper frame, either inside or outside of same, or fitted with brackets for wall or floor mounting. The springs used to return the motors to their normal positions are available in several tensions to permit their operation in selected sequence. Pilot positioners may be applied to damper motors in the same manner as described for diaphragm valves.

Pneumatic dampers in either the single blade or multi-louver type should be substantially built in heavy frames, properly braced to hold true against any sag in the supporting structure, in order to prevent distortion of the louvers and binding of their supporting trunnions. When large dampers are used for open and shut control, the regular multi-louver type of damper serves the purpose. Where accurate volume control is desired with gradual positioning of the damper blades, the adjacent louvers should be arranged to move in opposite directions in order to properly proportion the available free area through the damper from its fully open to its fully closed position. Multi-louver dampers with louvers which all move in the same direction provide full free area through all but their top and bottom louvers when the louvers reach 45 deg open position. Where fairly tight closing is desired, the damper frames should be fitted with solid stops against which the louvers can close and where additional precautions are necessary, rubber or felt stripping may be glued and riveted to the louver edges. The metal frames of the smaller dampers are usually made of ¼-in. stock. Solid stops are usually ½ in. deep. The free area of the duct enclosing the damper is thereby reduced 1½ in. in each dimension through the damper. Where channel frames are used, the restriction is increased accordingly. Damper louvers should be suspended on non-corrosive trunnions. Thrust bearings are necessary to properly support large vertical louvers. Where ball or roller bearings are required for special conditions, they should be of the non-corrosive type.

DESIGNATION OF TEMPERATURE CONTROL

Temperature may be controlled from three basic conditions:

Dry-bulb Control: The controller element senses the dry-bulb temperature.

Wet-Bulb Control: The controller element senses a true wet-bulb temperature. Wicking of selected material suspended from the controller element to a water trough directly below the element is one of the mediums frequently used to obtain wet-bulb temperature. True wet-bulb temperatures can only be maintained with clean wicking and air motion of not less than 600 fpm. The use of distilled water in the wet-bulb reservoir is desirable. Since the wet-bulb temperature indicates the heat content, this form of control while requiring additional and intelligent care to maintain true wet-bulb conditions, has many definite uses.

Dew-Point Control: A saturated condition at a predetermined temperature is maintained.

AUTOMATIC CONTROL TERMINOLOGY

The following is a generally accepted terminology referring to the operations of controls in a central air conditioning system.

Control Point: The desired constant condition of the controlled media to be main-