to move the plunger of a valve in a manner required by its type and construction. For instance, in a single-seat valve, the disc is moved against the seat and held there with sufficient pressure to prevent flow. A three-way valve, however, requires a valve operator that will place the double disc, as required, between the two seats. Each type of valve has special characteristics to which a valve operator must be adapted.

When a valve is used in shut-off service the valve operator simply opens the valve or closes it completely, as required. When the valve is to provide throttling service, a different type of valve operator is used so that the valve may be held at any intermediate position between open and closed. Valve operators use as their power source either compressed air (pneumatic system), electricity (motor-driven type of solenoid type), or a volatile liquid (direct-connected type).

Apparatus Which Operates Dampers

Apparatus which is so mechanically or electrically equipped as to open and close dampers, and possibly give them fixed positions, in accordance with the purposes of the system using the dampers is termed a *damper operator*. Damper operators are made for opening, closing, and positioning the dampers in the ducts of heating, ventilating, or air conditioning systems in the same way that valve operators regulate the valves. They receive their signals from thermostatic or manual switches.

The sources of power used are compressed air, electricity, or volatile liquids. The damper operator is connected to its damper by direct connection or by a linkage, according to conditions, and it can usually be mounted either outside or inside the duct in which the damper is located.

Accessory Apparatus

Accessory apparatus is that additional equipment at the terminals of a control system necessary to make it operative. Every temperature control system requires a number of accessories, which will vary with the different types of systems. For instance, pneumatic systems require a compressor and a storage tank for the air which operates the units, and low-voltage electric systems require a transformer or generator to provide the required current.

Most of the larger control systems will have some sort of central switchboard which may include indicating and recording devices as well as control switches. Thermostat guards are generally used in gymnasiums, schools, and places of assemblage for protective purposes. Time switches and similar devices are often important parts of certain types of control systems. Couplings, mountings, and indicators are often parts of a system.

Connecting Apparatus

Connecting apparatus is that equipment used to connect the various parts of a control system. Because the parts of the system are often some distance apart, the connecting means are important, and the connections must be properly planned and made.

The connecting elements are fairly obvious. The pneumatic system uses compressed air carried in small pipes and tubing. Electric systems

are wired for low-voltage or high-voltage power supply. Systems employing volatile liquids generally use flexible tubing if there is distance between the sensitive bulb and the operating unit. Each form has certain limitations which the designer of the system must consider.

Since few control installations are alike, the manufacturers of control apparatus usually maintain engineering departments staffed by experienced men whose advice may be had on control problems. Progress in automatic control has been rapid in the past few years and the field of automatic control has become specialized.

TEMPERATURE CONTROL SYSTEMS

The control of direct radiation is simple. Each radiator has a valve on its steam or water supply, with a thermostat to govern the opening and closing of the valve to maintain the desired uniform temperature. One thermostat may control the valves on all the radiators in a room, or, if the room is large, more than one thermostat may be used, with each one governing one radiator or a group of them. Unit type thermostatic valves may be used, one on each radiator.

The location of wall thermostats is important. They must be on inside walls where they will not be affected by drafts of either warm or cold air, but where they will be exposed to general room conditions. If vibration is present, they must be mounted on shock-absorbing bases. If the walls are abnormally hot or cold, the thermostats must be mounted on heat-insulating bases. The connecting means can be concealed in the wall, under the floor or ceiling, or behind baseboards or moldings.

Modulating type valves cannot be used successfully on one-pipe steam systems because the partial opening of valves will not allow the condensate to escape against the incoming steam.

A discussion of steam heating systems is given in Chapter 31, and further information on control requirements of direct radiation may be obtained therefrom.

Control of Unit Heaters

Unit heaters are commonly ceiling-hung or floor-mounted units consisting of a steam or hot water coil with a fan behind it to force air past the coil and into the room. Vanes direct the warm air flow. The simplest and commonest way to control a unit heater is to have in the heated space a thermostat which will turn on the fan when heat is required and shut it off when the demand is satisfied. However, where there is natural circulation through the unit, it is advisable to put a valve on the steam or hot water supply line and arrange it so the steam will be turned on only when the fan is running.

As a precaution against allowing the unit heater motors to continue to run if the steam supply fails or is for some reason shut off, either a pressurestat or a thermostat in the supply line, or a thermostat on the return line may be installed to stop the motor when the pressure or temperature in the supply line, or the temperature in the return line, drops below a predetermined point. When the fan and the steam are controlled simultaneously, such thermostat will also prevent the blowing of cold drafts.