## APPLICATION OF CONTROLLING DEVICES TO A TYPICAL SYSTEM

Fig. 1 shows the location of controlling devices for a year 'round air conditioning system such as shown in Chapter 20, Fig. 3. A control diagram for pneumatic control equipment is shown in Fig. 2 for convenience in explaining the function and sequence of operation of the control in Fig. 1, but obviously the individual controls may also be of self-contained or electrically operated type provided they obtain the same control of valves and dampers.

The auxiliary controlling devices indicated may all be mounted together on an instrument board which may also contain a framed copy of the control diagram and the description of the automatic control cycle. Air gages, identified by suitable inscription plates, may be installed in the branch connections to and from the auxiliary devices on the instrument board to indicate the functioning of the various devices.

A description of the automatic control cycle follows:

When the fan motor is stopped, solenoid air valve E-1, actuated from the fan motor circuit, is de-energized and exhausts its branch to close minimum outdoor damper D-1, reposition three-way air valve V-a to close heating coil valve V-1, and remove main air from remote bulb indicator dew-point thermostat T-1, thereby closing maximum outdoor damper D-2 and opening return air damper D-3.

When the fan motor is started, E-1 fills its branch, thereby opening minimum outdoor damper D-1, repositions V-a to permit T-3 and T-4 to control V-1 and supplies main air to T-1 to permit same to operate D-2 and D-3.

During the summer cooling season, manual indexing switch S-1 is positioned to fill its branch, whereby it supplies main air to dew-point thermostat T-2, positions three-way air valves V-e and V-f to permit T-3 to control face damper D-4 and by-pass damper D-5, positions three-way air valve V-b to close heating coil valve V-1, positions three-way air valveV-c to remove the control of maximum outdoor damper D-2 and return air damper D-3 from dew-point thermostat T-1 and place these dampers under the control of dew-point thermostat T-2.

When S-1 is positioned as noted, remote bulb dew-point thermostat T-2 functions on a rising temperature to first gradually open maximum outdoor damper D-2 while simultaneously closing return air damper D-3 and on a further slight temperature rise, gradually positions chilled water valve V-2 to pass chilled water to the dehumidifier. The reverse operating sequence occurs on a falling dew-point temperature. Should the outdoor wet-bulb temperature rise above the desired indoor wet-bulb temperature, positive acting outdoor wet-bulb thermostat T-5, positions three-way air valve V-d to remove dampers D-2 and D-3 from the control of T-2, thereby closing outdoor damper D-2 and opening return air damper D-3.

On a rising return air temperature T-3 functions to open face damper D-4, while simultaneously closing by-pass damper D-5 as required to maintain the desired return air temperature. The reverse operation occurs on a falling return air temperature.

During all seasons except the summer cooling season, manual switch S-1 is positioned to exhaust its branch, thereby making dew-point thermostat T-2 inoperative and positions chilled water valve V-2 for continuous recirculation, positions three-way valve V-b to permit heating coil valve V-1 to be operated as required, positions three-way valve V-c to permit T-1 to control D-2 and D-3, positions three-way valve V-e to permit T-3 to operate through low limit discharge thermostat T-4 to control heater valve V-1 and positions three-way valve V-f to open normally closed face damper D-4 and close normally open by-pass damper D-5.

When switch S-1 is positioned as noted, remote bulb dew-point thermostat T-1 functions on a rising temperature to gradually open maximum outdoor damper D-2, while simultaneously closing return air damper D-3 as required to maintain the desired dew-point temperature. The reverse operation occurs on a falling dew-point temperature. When the outdoor wet-bulb temperature rises above the desired dew-point temperature, the dew-point temperature will rise accordingly until such time as the system is indexed for summer cooling and chilled water is made available to drop the dew-point temperature.

Return air thermostat T-3 functions on a rising temperature to pass air through low limit discharge thermostat T-4 to gradually close heating coil valve V-1. Should the discharge temperature fall below the operating point of T-4, this thermostat will release air from its branch to gradually open V-1 as required to maintain the desired low limit discharge temperature regardless of the operation of T-3.



# *Instruments and Test Methods*

*Temperature Measurement, Pressure Measurement, Measurement of Air Movement, Air Change Measurements, Measurement of Relative Humidity, Dust Determination, Heat Transfer Through Building Materials, Measurement of Heat Exchange for Comfort Conditions, Combustion Analysis, Smoke Density Measurements, Carbon Monoxide Measurements*

THIS chapter presents a description of many test instruments used for heating, ventilating and air conditioning tests and presents a discussion of their use.

## TEMPERATURE MEASUREMENT

Changes in the intensity of heat may be determined by several methods* such as measuring the change in volume of a liquid, the change in internal pressure of a confined gas, the current set up between dissimilar metals joined in a circuit, or the change in resistance of an electrical circuit.

### Thermometers

The most common method used is the change in volume of a liquid such as mercury or alcohol enclosed in glass. Mercurial thermometers may be used for measuring temperatures from $-40$ F to approximately 1000 F. The lower limit is set by the freezing point of mercury. Since the boiling point of mercury is only about 675 F, the space above the mercury in thermometers designed for higher temperatures must be filled with an inert gas under pressure. Alcohol thermometers may be used for temperatures from $-94$ F to $+248$ F.

The more accurate thermometers are individually calibrated and have divisions etched on the stem. The two most common reference points are the freezing and boiling points of water. On the Fahrenheit scale, which is most commonly used in engineering work, there are 180 divisions between these points. On the Centigrade scale which is used by chemists and physicists, there are 100 divisions in this range. The temperature in degrees Fahrenheit equals $^9/_5$ of the temperature in degrees Centigrade, plus 32.

For permanent installations, glass thermometers are often protected by metal jackets and equipped with metal scales. Due to the heat capacity and heat conductance of the jacket, it is more difficult to obtain the true temperature at a point with these than with the exposed etched stem type. The latter is usually preferred for test purposes. Where used to measure temperatures in a duct, it may be inserted through a cork or rubber plug. Care must be taken to locate the bulb at the point where the temperature is desired and in many cases several must be used to get a correct average.

The probable error in etched stem thermometers is plus or minus one scale division, which makes calibration after manufacture necessary for most test work. Mercury thermometers are usually calibrated for complete stem immersion.

When incompletely immersed, a stem correction should be made for the

*For a comprehensive treatment of temperature measurement the reader is referred to Temperature, Its Measurement and Control in Science and Industry, a symposium sponsored by the *American Institute of Physics* and published by Reinhold Publishing Corp.