rated air at 40 F raised to 60 F has a relative humdity of 49 per cent; 60 F saturated air raised to 80 F has a relative humidity of 50 per cent. (See Table 1, Chapter 1). Thus a differential thermostat can be used to maintain a nearly constant relative humidity of 50 per cent by holding the dew-point temperature 20 deg below the dry-bulb temperature.

3. The *total heat* of the air and water vapor mixed with it varies directly with the wet-bulb temperature. For example, the occupants of an auditorium give off sensible heat which tends to raise both the dry-bulb and wet-bulb temperatures of the space; but they also give off moisture which increases the absolute humidity and tends to further raise the wet-bulb temperature an amount which is a direct indication of the heat expended by the body in evaporating this water. This relationship is useful in regulating the total heat, as wet-bulb temperatures can be controlled directly by means of a thermostat having a sensitive element covered with water-fed wicking, similar to a wet-bulb thermometer.

For example, the total heat of air at 80 F and 60 per cent relative humidity is the same as for air saturated at 70 F, *i.e.*, 33.5 Btu per pound, both having a wet-bulb temperature of 70 F. Air at 80 F and 60 per cent relative humidity (70 F wet-bulb = 33.5 Btu per pound) reduced to 70 F and 50 per cent relative humidity (= 58½ F wet-bulb = 25.2 Btu per pound, total heat) must give up 8.3 Btu per pound. If the sensible heat and moisture pick-up in an auditorium is 8.3 Btu per pound of air handled in the conditioning system, the wet-bulb temperature of the air entering the space must be maintained at 58½ F to secure a final condition of 80 F and 60 per cent relative humidity.

Control of Relative Humidity

Relative humidity is controlled by means of instruments called humidistats or hygrostats, or by the proper combination of two or more thermostats. The following are the most commonly used methods:

1. A thermostat is located in or at the outlet of a spray-type air conditioner which maintains a constant saturation temperature of the air leaving the conditioner by varying the temperature of water entering the suction of the pump supplying the spray nozzles, or by varying the temperature of the air entering the conditioner, or both. The temperature of the air entering the conditioner may be varied by use of tempering heaters, or by the proper proportioning of supply and return air entering the conditioner. This thermostat is known as a dew-point thermostat, as it determines the dew-point temperature of the air introduced into the conditioned spaces. A second thermostat in the room, or in the path of the air leaving the room, maintains a constant dry-bulb temperature by varying the amount of sensible heat added to the air leaving the conditioner, or by varying the volume of air introduced into the conditioned spaces. These two thermostats, in combination, control the dry-bulb and dew-point temperatures, which accordingly fix the relative humidity.

2. A wet-bulb thermostat is located in the room, or in the path of the air leaving the room, to maintain a constant wet-bulb temperature by varying the saturation temperature at the air conditioner outlet. A dry-bulb thermostat is located in the room to maintain a constant dry-bulb temperature, which in combination with a constant wet-bulb temperature fixes the relative humidity.

3. A differential thermostat may be used to control relative humidity. This instrument consists of two thermostatic elements, one of which is in the path of the air leaving the conditioner, and the other under the influence of the dry-bulb temperature in the room. Instruments of this kind maintain a constant relative humidity by maintaining a *constant difference* between the dew-point temperature and dry-bulb temperature in the room. (See Item 2 under Air Conditioning Systems). One thermostatic element may be equipped with a moistening device to permit it to operate on wet-bulb temperatures. Such an instrument can be used to control the wet-bulb depression and thus the relative humidity.

4. A humidistat which responds directly to changes in humidity may be used to maintain a predetermined relative humidity with constant or with varying temperature. It may do this: by varying the dew-point temperature of air leaving a conditioner; by varying, with dampers, the proportion of moist and dry air; by varying the amount of moisture otherwise added to the air; or by varying the dry-bulb temperature.

Humidification for Residences

The principles underlying humidity requirements and limitations for residences are summarized in *University of Illinois Bulletin No. 48*[1], as follows:

1. Optimum comfort is the most tangible criterion for determining the air conditions within a residence.

2. An effective temperature of 65 deg[2] represents the optimum comfort for the majority of people. Under the conditions in the average residence a dry-bulb temperature of 69.5 F with relative humidity of 40 per cent is the most practical for the attainment of 65-deg effective temperature.

3. Evaporation requirements to maintain a relative humidity of 40 per cent in zero weather depend on the amount of air inleakage to the average residence, and vary from practically nothing to 24 gal of water per 24 hours.

4. Relative humidity of 40 per cent indoors cannot be maintained in rigorous climates without excessive condensation on the windows unless tight fitting storm sash or the equivalent are installed.

5. The problems of humidity requirements and limitations cannot be separated from considerations of good building construction, and the latter should receive serious attention in the installation of humidifying apparatus.

The following conclusions were drawn from the experimental results reported in the aforementioned bulletin:

1. None of the types of warm air furnace water pans tested proved adequate to evaporate sufficient water to maintain 40 per cent relative humidity in the Research Residence except only in moderately cold weather.

2. The water pans used in radiator shields tested did not prove adequate to maintain 40 per cent relative humidity in a residence similar to the Research Residence when the outdoor temperature approximated zero degrees Fahrenheit.

Central Fan Air Conditioning Systems

In central fan air conditioning systems as described in Chapters 9 and 22, varying amounts of outside and recirculated air are used, except where contamination prevents re-use, and in general, heat is supplied after the air washer, for obtaining humidity control under winter conditions. There are many control variations in use, and Fig. 14 shows a composite diagram, rather than a system of control for a single installation. The control valves for a dehumidifying air washer are shown in Fig. 15. The functions of the control devices shown in Figs. 14 and 15 are as follows:

Winter Operation (with steam)

1. Direct-acting thermostat *A* opens direct-acting valve in steam supply to a low-capacity tempering coil *P*; in sub-freezing weather it is set at 35 F.

2. Direct-acting thermostat *B* in the path of air leaving the second tempering coil *Q* controls direct-acting valve in steam supply to the coil *Q* at 45 F.

3. Direct-acting thermostat *C* controls normally-closed intake *M* and normally-open return air *N* dampers at 50 F. This location of thermostat *C* is primarily for operation with steam heating and at such times as by-pass damper *O* is closed. See discussion under heading *Spring and Fall Operation*.

[1]See Humidification for Residences, by A. P. Kratz (*University of Illinois, Bulletin No. 48*).

[2]66 deg is the optimum winter effective temperature recommended by the A.S.H.V.E. Committee on Ventilation Standards. See Chapter 2.