For example, corresponding to 40 per cent saturation at 100 F, the relative humidity is $0.40 + 0.0667 \times 0.40 \times 0.60 = 0.416$ or 41.6 per cent (15b). Conversely, corresponding to a relative humidity of 41.6 per cent, the degree of saturation is $0.416 - 0.0667 \times 0.416 \times 0.584 = 0.400$ or 40 per cent (15c).

Dew-point

If moist air is cooled at constant humidity ratio W and constant observed pressure P, a temperature will be reached at which the air just becomes saturated and formation of a liquid (or solid) phase just commences. This temperature is called the *dew-point* corresponding to the given humidity ratio and observed pressure.

Example 5. Find the dew-point of the humidified air of Example 4.

Solution. The given humidity ratio is 0.006296 which is the saturation value at 44.96 F (Table 6, assuming the total pressure to be 29.921 in. Hg). This is therefore the dew-point of the humidified air.

Example 6. Find the degree of saturation of air having a temperature of 90 F, a dew-point of 60 F.

Solution. Assuming the total pressure to be 29.921 in. Hg, the humidity ratio is given in Table 6 as 0.01103 lb per pound dry air. The saturation humidity ratio at 90 F is 0.03102 lb per pound dry air; hence the degree of saturation is $0.01103 \div 0.03102 = 0.355$ or 35.5 per cent.

Volume

The volume of moist air *per pound of dry air* contained in it is a very useful quantity. It should not be called specific volume; for the adjective *specific* should properly refer to volume per pound of *mixture*. Using Equations 10a and 14 an expression for the volume per pound of dry air is obtained, namely,

$$v = \frac{B_a T}{P} + \mu \left(\frac{W_s B_w T}{P}\right) \qquad (16)$$

Example 7. Find the volume (per pound of dry air) of the humidified air of Example 4.

Solution. $v = \left(\frac{53.35 \times 529.7}{29.92 \times 0.49115 \times 144}\right) + 0.40 \left(\frac{0.01574 \times 85.78 \times 529.7}{29.92 \times 0.49115 \times 144}\right)$
$= 13.354 + 0.40 \times 0.338 = 13.489$ cu ft per pound dry air.

Equation 16 is linear in degree of saturation μ and of the form

$$v = v_a + \mu\, v_{as} \qquad (17)$$

where v_a denotes specific volume of dry air at temperature T and pressure P; and v_{as} denotes the difference between this and the volume of the saturated mixture per pound of dry air v_s. Strict linearity is, of course, a result of the use of Dalton's Law; but it is expected that it can be retained as a very close approximation even when the abandonment of Dalton's Law becomes possible.

Example 8. Work Example 7 using Table 6.

Solution. $v = 13.34 + (0.40 \times 0.34) = 13.48$ cu ft per pound dry air.

By putting $\mu = 1$ (100 per cent saturation) in Equation 16 an expression for v_s, the volume of saturated air per pound of dry air, is obtained. Values for standard atmospheric pressure (29.921 in. Hg) are listed in Table 6.

Often it is preferred to express this information in terms of *density*, that is, weight of saturated air per unit volume. This can easily be done by dividing v_s (volume of saturated air per pound of dry air) *into* $(1 + w_s)$ (*weight* of saturated air per pound of dry air). Thus, at 100 F, 29.921 in. Hg, the density of saturated air is, from Table 6, $1.04293 \div 15.07 = 0.06921$ lb per cubic foot.

Values in Table 9 are intended to aid in determining the density of saturated air at different pressures. Values for temperatures and pressures other than those listed can be obtained by linear interpolation which is aided by the next to last column of figures. Thus, at 100 F, 29.921 in. Hg, the density of saturated air is, from Table 9, $0.06818 + (4.21 \times 0.00024) = 0.06919$ lb per cubic foot, in approximate agreement with Table 6.

A column of figures is included in Table 9 giving the approximate average increase in density per degree wet-bulb depression. This makes it easy to calculate a value for the density of moist air taking into account its moisture content as well as its temperature and pressure.

Volume Chart

A volume chart drawn for a total pressure of 29.921 in. Hg will be found in the envelope attached to the inside back cover of this book. On this chart values of volume per pound of dry air v are plotted as abscissa against values of humidity ratio W as ordinate. The chart is self-explanatory.

Enthalpy

Thermodynamically, Equation 10a implies that the specific enthalpies of dry air and water vapor are independent of pressure and that the enthalpy of moist air (per pound of dry air) is the sum of separate contributions from the dry air and water vapor according to the simple equation

$$h = h_a + \mu\,(W_s h_w) \qquad (18)$$

Equation 18 is also linear in degree of saturation μ and of the form

$$h = h_a + \mu\, h_{as} \qquad (19)$$

where h_a denotes the specific enthalpy of dry air at the given temperature and total pressure; and h_{as} denotes the difference between this and the enthalpy of the saturated mixture per pound of dry air h_s. Provisional values are listed in Table 6.

Example 9. Find the enthalpy (per pound of dry air) of air at 96 F, 60 per cent saturation and 29.921 in. Hg.

Solution. Using Table 6, $h = 23.04 + (0.60 \times 41.58) = 47.99$ Btu per pound dry air.

Thermodynamic Wet-bulb Temperature

If liquid (or solid) water be injected into an air stream it will evaporate and thus increase the humidity ratio of the air. Enough water may be injected to saturate the air. If the process is one of steady flow with *observed pressure constant*; if it is *adiabatic*; and if the temperature at which the air reaches saturation *coincides* with the temperature of the