temperature at this point of intersection is by definition the dew-point temperature for state 1.

Further cooling through successive equilibrium states is accompanied by condensation. The succession of states for the total system, moist air and liquid water, is represented by a continuation of the $W = W_1$ line into the liquid vapor region. (Temperatures below 32 F would involve the solid-vapor region). Consider that the final temperature is t_3. The final enthalpy is then h_3; the liquid water formed is $(W_1 - W_3)$, where point 3 is at the intersection of the isotherm through 2 and the saturation curve; the final humidity ratio of the moist air is W_3; and this final moist air has dew-point, wet-bulb and dry-bulb temperatures all equal to t_3.

Example 4: How much heat must be removed from 20,000 cfm of air at 95 F dry-bulb temperature and 0.50 degree of saturation to cool the air to 70 F, saturated?

Solution a: From the data of Table 2. The initial humidity ratio is 0.50(0.03763) = 0.01837 lb of water vapor per lb of dry air; the initial enthalpy is 22.827 + 0.50(40.49) = 43.072 Btu per lb of dry air; the humidity ratio at saturation at the

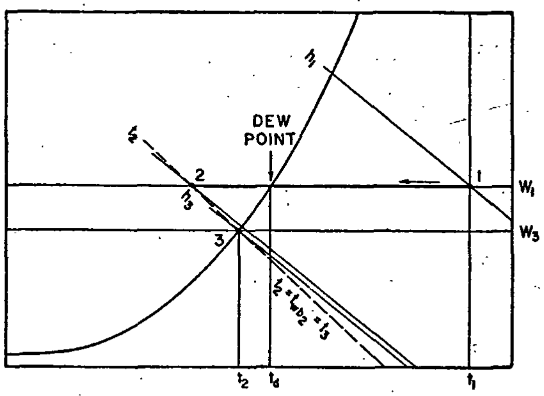

Fig. 8. Cooling of Air at Constant Pressure Shown on A.S.H.V.E. Psychrometric Chart

final temperature is 0.01582 lb of water vapor per lb of dry air; the quantity of liquid formed is 0.01837 − 0.01582 = 0.00255 lb of water vapor per lb of dry air; h_{w3} at 70 F is 38.11 Btu per lb of water; the initial specific volume is 13.980 + 0.50(0.822) = 14.391 cu ft per lb of dry air.

Fig. 9 illustrates the process diagrammatically. The energy equation for the process is

$$Gh_1 = Gh_3 + G(W_1 - W_3)h_{w3} + {}_1q_3$$

or

$$_1q_3 = G[h_1 - h_3 - (W_1 - W_3)h_{w3}]$$

$$= \frac{20{,}000}{14.391} \times (43.072 - 34.09 - 0.00255 \times 38.07)$$

$$= 12{,}350 \text{ Btu per min.}$$

Solution b: From the A.S.H.V.E. Chart. Two methods may be used to solve the problem by use of the psychrometric chart. The simpler is to use the region to the left of the saturation line (Fig. 8). From point 1 draw a horizontal line on the chart until it intersects the constant temperature line in the liquid-vapor region corresponding to the final temperature, 70 F. This is shown as point 2 on the diagram. Then,

$$_1q_3 = G(h_1 - h_2)$$

The initial enthalpy is 43 Btu per lb of dry air; the initial specific volume is 14.4

cu ft per lb of dry air; and the final enthalpy is 34.2 Btu per lb of dry air. The solution of the problem is

$$_1q_3 = \frac{20{,}000}{14.4} \times (43 - 34.2) = 12{,}200 \text{ Btu per min.}$$

The other method is to use an energy balance,

$$_1q_3 = G[h_1 - h_3 - h_{w3}(W_1 - W_3)]$$

The initial humidity ratio is 0.0183 lb of water vapor per lb of dry air, and the final humidity ratio is 0.0158 lb of water vapor per lb of dry air. Therefore, the heat to be removed is

$$_1q_3 = \frac{20{,}000}{14.4} \times (43 - 34.1 - 0.0025 \times 38.07)$$

$$= 12{,}130 \text{ Btu per min.}$$

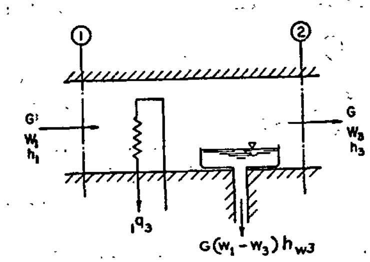

Fig. 9. Illustration of Process of Example 4

Adiabatic Mixing of Two Steady Flow Air Streams at Constant Pressure

The process is diagrammed in Fig. 10. By applying the principles of the conservation of mass and energy, three equations may be written:

Mass balance for the dry air,

$$G_1 + G_2 = G_3$$

Energy balance for the process,

$$G_1h_1 + G_2h_2 = G_3h_3$$

Mass balance for the water vapor,

$$G_1W_1 + G_2W_2 = G_3W_3$$

Eliminating G_3 and combining the three equations yield the equation,

$$\frac{h_2 - h_3}{h_3 - h_1} = \frac{W_2 - W_3}{W_3 - W_1} = \frac{G_1}{G_2}. \quad (34)$$

Example 5: Outside air at 0 F dry-bulb temperature and 0.80 degree of saturation is to be mixed adiabatically with recirculated inside air at 70 F dry-bulb temperature and 0.20 degree of saturation, in the ratio of one pound of dry air in the former to four in the latter. Find the temperature and degree of saturation in the resulting mixture.

Solution a: From the data of Table 2. The only unknown properties are the humidity ratio W_3 and the enthalpy h_3 of the resulting mixture. These may be determined from Equation 34. Thus,