Combining equations 37 and 38 and solving for the ratio $(h_2 - h_1)/(W_2 - W_1)$,

$$\frac{h_2 - h_1}{W_2 - W_1} = \frac{Q}{G_w} + h_w \qquad (39)$$

Example 8: Moist air at 20 F dry-bulb temperature and 0.80 degree of saturation is heated and humidified until it is at 120 F dry-bulb temperature and 71.5 F thermodynamic wet-bulb temperature. Water at 55 F is supplied. If the air flow rate is 20,000 cfm at the initial conditions, how much heat is required?

Solution a: From the data of Table 2. The initial humidity ratio is 0.80(0.002152) = 0.00172; the initial enthalpy is 4.804 + 0.80(2.302) = 6.6456; the initial specific volume is 12.084 + 0.80(0.042) = 12.118. The degree of saturation at the final state may be determined from Equation 8 which may be rewritten as

$$h_{a2} + \mu h_{aa2} + h_w^*(W^* - \mu W_{s2}) = h^*$$

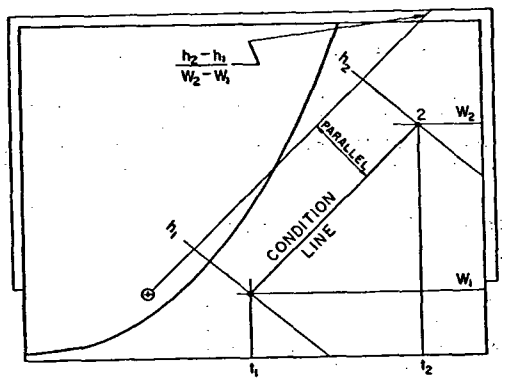

FIG. 16. SOLUTION OF EXAMPLE 8 ON A.S.H.V.E. PSYCHROMETRIC CHART

The values of these properties are: $h^* = 35.39$; $W^* = 0.01668$; $h_w^* = 39.61$; $h_{aa2} = 90.70$; $W_{s2} = 0.08149$; $h_{a2} = 28.84$.

Making the proper substitutions and solving for degree of saturation,

$$\mu = 0.0681.$$

The final humidity ratio is therefore 0.0681(0.08149) = 0.005549; the final enthalpy is 28.84 + 0.0681(90.70) = 35.02 Btu per lb dry air.

The rate of water addition is obtained from Equation 38.

$$G_w = \frac{20{,}000}{12.12}(0.005549 - 0.00172)$$

$$= 6.32 \text{ lb per min.}$$

The heat supplied is obtained from Equation 37.

$$Q = G_1(h_2 - h_1) - G_w h_w$$

$$= \frac{20{,}000}{12.12}(35.02 - 6.65) - 6.32(28.08)$$

$$= 46{,}667 \text{ Btu per min.}$$

Solution b: From the A.S.H.V.E. Chart. Locate the initial and final states on the chart and connect them with a straight line. Through the reference point on the chart, draw a line parallel to the line connecting the initial and final state points, the condition line, and read the value of the ratio $(h_2 - h_1)/(W_2 - W_1)$ as 7500 from

the protractor on the chart (Fig. 16). From Equation 39

$$\frac{h_2 - h_1}{W_2 - W_1} = \frac{Q}{G_w} + h_w = 7500$$

The rate of water supply was determined in *Solution a*, but will be found from the chart. It is

$$G_w = \frac{20{,}000}{12.1}(0.0055 - 0.0017)$$

$$= 6.28 \text{ lb per min}$$

$$Q = G_w(7500 - h_w)$$

$$= 6.28(7500 - 23)$$

$$= 46{,}900 \text{ Btu per min.}$$

TABLE 6. PRESSURE AND TEMPERATURE FOR ALTITUDES IN U. S. STANDARD ATMOSPHERE

ALTITUDE FEET Z	PRESSURE IN. OF HG P	TEMP F t
− 1,000	31.02	+62.6
− 500	30.47	+60.8
0	29.921	+59.0
+ 500	29.38	+57.2
+ 1,000	28.86	+55.4
+ 5,000	24.89	+41.2
10,000	20.58	+23.4
15,000	16.88	+ 5.5
20,000	13.75	−12.3
25,000	11.10	−30.1
30,000	8.88	−47.9
35,000	7.04	−65.8
40,000	5.54	−67.0
45,000	4.36	−67.0
50,000	3.436	−67.0

U. S. STANDARD ATMOSPHERE

The definition of the U. S. Standard Atmosphere is important to the air conditioning engineer as an essential standard of reference. The basic assumptions in defining the Standard Atmosphere are:

1. There is a linear decrease in temperature T with altitude up to the limit of the isothermal atmosphere at 35,332 ft. Thus,

$$T = T_o - 0.003566\,Z \qquad (40)$$

2. The air is dry.
3. Air is a perfect gas obeying the laws of Charles and Boyle:

$$PV = RT$$

4. Gravity is constant at all altitudes with the standard value.
5. The temperature of the isothermal atmosphere is −66 F.

Standard values at sea level, which are part of the definition of the Standard Atmosphere, are:

Pressure	29.921 in. Hg
Temperature	59 F