to points 1 and 2 so that $W_3 = W_1$ and $t_3 = t_2$. Points 1 and 2, being on a line of constant thermodynamic wet-bulb, satisfy Equation 20; thus,

$$h_1 - h_3 + (W_2 - W_1)\, h'_{w,2} = h_2 - h_3$$

where h_3 has been subtracted from both sides. Under Dalton's Law, $h_2 - h_3 = (W_2 - W_1)\, h_{v,2}$; moreover, $h_1 - h_3$ may be replaced by $\bar{s}_1 (t_1 - t_2)$ where $\bar{s}_1$ is often referred to as *mean humid heat* and may be calculated with good approximation from

$$\bar{s}_1 = 0.240 + 0.444\, W_1 \tag{21}$$

Finally, introducing latent heat of vaporization at the wet-bulb temperature, namely, $(h_{fg})_2 = (h_w - h'_w)_2$, Equation 20 becomes, after omitting the subscript 2,

$$\frac{t_1 - t'}{W_s - W_1} = \frac{h_{fg}}{\bar{s}_1} \tag{22}$$

it being understood that W_s is the saturation humidity ratio and h_{fg}, the latent heat, at the wet-bulb temperature t'. Equation 22 was derived by Carrier [1].

Example 12. Work Example 10 using Equation 22.

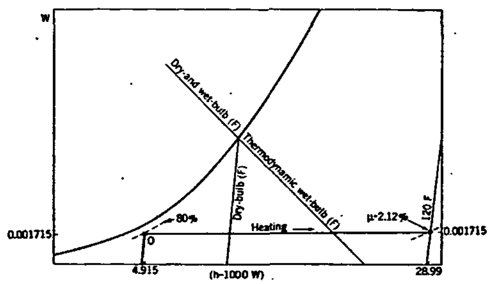

FIG. 3. DIAGRAM ILLUSTRATING EXAMPLE 13

Solution. A trial-by-error method is involved. Taking 48 F as a trial value of t', $(80 - 48) \div (0.007072 - 0) = 4520$; but $1066.7 \div 0.240 = 4440$. The trial value must, therefore, be revised upward, the final solution being 48.26 F as in Example 10.

TYPICAL AIR CONDITIONING PROCESSES

Illustrative Examples. The use of Table 6 and the Mollier diagram in analyzing typical air conditioning processes is best explained by the use of illustrative examples. In each of these examples, the observed pressure is assumed to be standard atmospheric pressure (29.921 in. Hg).

Example 13. Heating. Air at 20 F and 80 per cent saturation is to be heated to 120 F. Analyze the process as illustrated in Fig. 3.

Solution. The initial humidity ratio is $0.80 \times 0.002144 = 0.001715$ lb per pound dry air (table). This same value is read directly on the chart. The initial enthalpy is $4.798 + (0.80 \times 2.290) = 6.630$ Btu per pound dry air (table) or $4.915 + (1000 \times 0.001715) = 6.630$ (chart).

The final degree of saturation is $0.001715 \div 0.08093 = 0.0212$ (table); hence the final enthalpy is $28.80 + (0.0212 \times 90.09) = 30.71$ Btu per pound dry air (table) or $28.99 + (1000 \times 0.001715) = 30.71$ (chart).

The increase in enthalpy is the quantity of heat to be supplied, namely, $30.71 - 6.63 = 24.08$ Btu per pound dry air (table). Since humidity ratio W and therefore $1000W$ is constant, this is also simply the horizontal distance between the representative points on the chart; thus, the heat to be supplied is also $28.99 - 4.915 = 24.08$ Btu per pound dry air (chart).

The final volume is $14.60 + (0.0212 \times 1.90) = 14.64$ cu ft per pound (table); or direct from the volume chart. Therefore, if 20,000 cfm of heated air is to be supplied, the quantity of heat required is $(20{,}000 \div 14.64) \times 24.08 = 32{,}900$ Btu per minute.

Example 14. Cooling and Separating. Air at 95 F and 50 per cent saturation is to be cooled to 70 F and the liquid separated out. Analyze the process as shown in Fig. 4.

Solution. The initial humidity ratio is $0.50 \times 0.03652 = 0.01826$ (table). The initial enthalpy is $22.80 + (0.50 \times 40.25) = 42.93$ Btu per pound dry air (table) or $24.67 + (1000 \times 0.01826) = 42.93$ (chart).

The final state is in the two-phase region and consists of 0.01574 lb water per pound dry air in the vapor phase, and 0.00252 lb water per pound dry air in the liquid phase. The final enthalpy is therefor $33.96 + (0.00252 \times 38.0) = 34.06$ Btu per pound dry air (table) or $15.80 + (1000 \times 0.01826) = 34.06$ (chart).

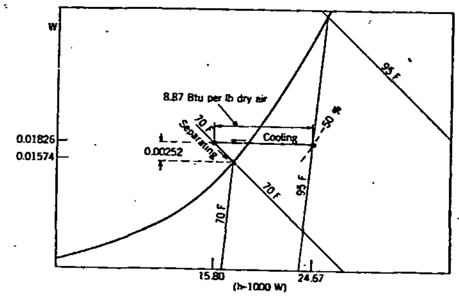

FIG. 4. DIAGRAM ILLUSTRATING EXAMPLE 14

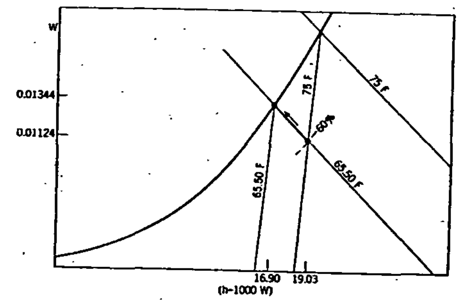

FIG. 5. DIAGRAM ILLUSTRATING EXAMPLE 15

The decrease of enthalpy is the refrigeration to be supplied and is $42.93 - 34.06 = 8.87$ Btu per pound dry air (table). Since the weight of water per pound of dry air is constant, this is also the horizontal distance between the representative points on the chart, namely, $24.67 - 15.80 = 8.87$ Btu per pound dry air (chart).

The initial volume is $13.97 + (0.50 \times 0.82) = 14.38$ cu ft per pound (table); or direct from the volume chart. Therefore, if 20,000 cfm of initial air is to be processed, the refrigeration required is $(20{,}000 \times 8.87) \div (14.38 \times 200) = 61.7$ tons. The weight of water to be removed is $(20{,}000 \times 0.00252) \div 14.38 = 3.51$ lb per minute.

Example 15. Adiabatic Saturation with Recirculated Spray Water. Air at 75 F and 60 per cent saturation is saturated adiabatically with spray water which is recirculated. Find the resulting temperature and the weight of water added per pound of dry air as outlined in Fig. 5.

Solution. The recirculated water will assume the thermodynamic wet-bulb temperature of the entering air which will also be the temperature of the resulting saturated mixture. The humidity ratio of the entering air is $0.60 \times 0.01873 = 0.01124$ lb water per pound dry air (table); its enthalpy is $17.99 + (0.60 \times 20.47) = 30.27$ Btu per pound