Eliminating M_3,

$$\frac{W_2 - W_3}{W_3 - W_1} = \frac{h_2 - h_3}{h_3 - h_1} = \frac{M_1}{M_2} \tag{23}$$

according to which: *on the Mollier Chart the representative point of the resulting mixture lies on the straight line connecting the representative points of the two streams being mixed, and divides the line into two segments which are in the same ratio as the weights of dry air in the two streams.* It must not be forgotten that this analysis assumes *adiabatic* mixing.

Example 16. Outside air at 0 F and 80 per cent saturation is to be mixed adiabatically with recirculated air at 70 F and 20 per cent saturation in the ratio, one pound of dry air in the former to seven in the latter. Find the temperature and degree of saturation of the resulting mixture as shown in Fig. 6.

Solution. The humidity ratio and enthalpy of the resulting mixture satisfy

$$\frac{0.003148 - W_3}{W_3 - 0.000628} = \frac{20.23 - h_3}{h_3 - 0.666} = \frac{1}{7}$$

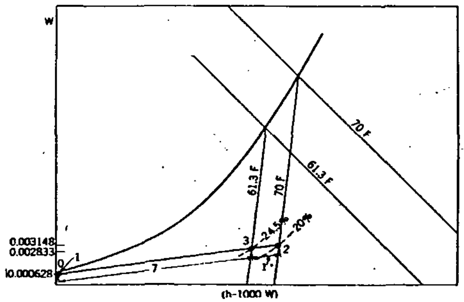

Fig. 6. Diagram Illustrating Example 16

whence,

$W_3 = 0.002833$ lb water per pound dry air.

$h_3 = 17.78$ Btu per pound dry air.

The corresponding temperature and degree of saturation are 61.3 F and 24.5 per cent as is easily verified by use of Table 6. The numerical solution is somewhat tedious, but the graphical solution is easy.

Adiabatic Mixing with Injected Water

Another typical process is that of injecting water (solid, liquid or vapor) into an air stream to mix adiabatically with it. Let the subscripts 1 and 2 refer to the initial and final conditions, respectively; then write

$$1 + 0 = 1 \quad \text{(weight balance for the dry air)}$$
$$W_1 + (W_2 - W_1) = W_2 \quad \text{(weight balance for the water)}$$
$$h_1 + (W_2 - W_1)\, h_W = h_2 \quad \text{(energy balance, no heat absorbed)}$$

The first two are identities and are incorporated in the third. This may be rewritten as follows:

$$\frac{h_2 - h_1}{W_2 - W_1} = h_W \tag{24}$$

and shows that *the process is represented by a straight line on the Mollier diagram, the slope of the line being determined by the specific enthalpy of the injected water.* It must not be forgotten that the analysis assumes adiabatic mixing. *Energy convected with a fluid is not heat.*

Example 17. It is desired to increase the humidity ratio of air at 70 F without changing its temperature. Under what conditions may water be injected in order to accomplish the desired result.

Solution. Under Dalton's Law a line of constant (dry-bulb) temperature is straight on the Mollier diagram and its slope is determined by the specific enthalpy of water *vapor* at the given temperature. At 70 F, $h_W = 1092.3$ Btu per pound; hence injection of steam having this specific enthalpy will cause the representative point to move in a direction parallel to the 70 F isotherm. Saturated steam at 70 F may not be used because its pressure is only 0.7392 in. Hg and it cannot therefore be injected into air at atmospheric pressure. Saturated steam at 667.4 F, 2488 lb per sq inch has the right specific enthalpy and can be throttled into a room at 70 F without altering the room temperature.

Border Scale

On the Mollier diagram is placed a border scale to facilitate the graphical solution of problems in which given quantities of energy and water are added (or withdrawn) simultaneously as in the case of adiabatic mixing

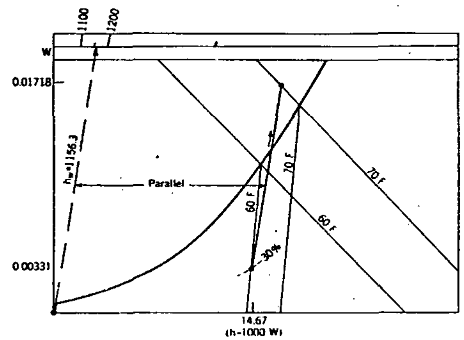

Fig. 7. Diagram Illustrating Example 18

with injected water. All marks in the upper half of this scale point to the lower left corner of the chart and each shows the *direction* that the representative point will move due to adiabatic mixing with injected water having the indicated specific enthalpy. All marks in the lower half of the scale point to the lower right corner of the chart.

Example 18. If dry saturated steam at 20 lb per square inch absolute is injected into air initially at 60 F and 30 per cent relative humidity to raise the temperature to 70 F, what is the final relative humidity and how much water is added per pound dry air?

Solution. The initial humidity ratio is $0.30 \times 0.01103 = 0.00331$ lb water per pound dry air (or direct from chart). The initial enthalpy is $14.39 + (0.30 \times 11.98) = 17.98$ Btu per pound dry air (table) or $14.67 + (1000 \times 0.00331) = 17.98$ (chart). A preliminary calcuation shows that the final mixture contains liquid. The final weight of water per pound of dry air is determined from

$$\frac{33.96 + (W - 0.01574) \times 38.0 - 17.98}{W - 0.00331} = 1156.3$$

where the specific enthalpy of the injected water is 1156.3 Btu per pound. The answer is

$W = 0.01718$ lb water per pound dry air.

Therefore, the weight of water added is $0.01718 - 0.00331 = 0.01387$ lb per pound dry air as shown in Fig. 7.