liminary calculation 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.

Adiabatic Saturation

Any case of adiabatic mixing in which the resulting mixture is saturated may properly be called *adiabatic saturation*. For example, if enough water at 352 F be sprayed into dry air at 80 F to produce a saturated mixture, the resulting enthalpy will be $h_s = 19.19 + (W_s - 0)\ 324$; and since h_s and W_s are functions of the same temperature, this temperature is determined by the equation to be 53.0 F. Thus, adiabatic saturation of dry air at 80 F by injecting liquid water at 352 F results in a temperature of 53.0 F when saturation is reached.

But in practice, much more is usually read into the term adiabatic saturation, it being generally understood that saturation is to be produced by injecting liquid water at such a temperature as will *coincide* with that at which the saturation curve is reached. *With this understanding it may be said that thermodynamic wet-bulb temperature is the result of adiabatic saturation.* Thus, if liquid water at 48.26 F instead of 352 F be injected into dry air at 80 F a saturated mixture at 48.26 F instead of 53.0 F will be produced. Therefore, 48.26 F is the thermodynamic wet-bulb temperature of dry air at 80 F.

It is possible to produce adiabatic saturation, interpreting the term literally, by mixing two air streams neither of which is itself saturated. In order for this to be possible, the straight line connecting the representative points on the Mollier diagram must cut the saturation curve twice.

Cooling Load

In the calculation of the cooling load for an air conditioned space, the problem usually reduces to determining the quantity of inside air that must be withdrawn and the condition to which it must be brought by cooling, separating and possibly reheating so that return of the conditioned air will have the net effect of removing given amounts of energy and water from the air conditioned space.

Let m denote the weight of dry air withdrawn per hour. With it will be withdrawn *energy* of amount mh_1 Btu per hour and *water* of amount mW_1 pounds per hour, where h_1 and W_1 denote enthalpy and humidity ratio, respectively, of inside air. The weight of dry air returned per hour will be the same as that withdrawn but with it must be returned a smaller amount of *energy*, mh Btu per hour, and a smaller quantity of *water*, mW pounds per hour, where h and W denote enthalpy and humidity ratio of conditioned air.

With this understanding, the requirements of the cooling load problem are,

$$mh = mh_1 - \Delta Q$$
$$mW = mW_1 - \Delta W$$

where ΔQ and ΔW are the *given* amounts of energy and water, respectively, to be removed simultaneously. Eliminating m from these equations,

$$\frac{h - h_1}{W - W_1} = \frac{\Delta Q}{\Delta W} = q \qquad (25)$$

which says that all possible states for the conditioned air lie on a straight line, on the Mollier Chart, which passes through the state point of the Inside Air with a slope determined by the ratio q (Btu per lb water) of the quantities of energy and water to be removed simultaneously. This straight line is called the *condition line* for the given problem.

If the condition line crosses the saturation curve the intersection is called the *apparatus dew-point* (Chapter 21). For, if the air conditioning

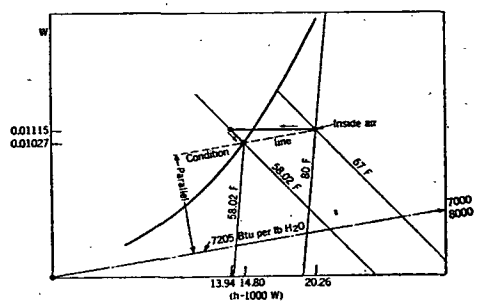

FIG. 8. DIAGRAM ILLUSTRATING EXAMPLE 19

apparatus is set to produce a saturated mixture having the temperature corresponding to this point, the introduction of this saturated mixture into the conditioned space will result in the simultaneous removal of the required amounts of energy and water.

Graphical solution of a cooling load problem is facilitated by the border scale on the Mollier Chart. The numbers around this border scale may be regarded as values of the ratio q (Btu per lb water), each number determining the *direction* of the corresponding condition line.

Example 19. A condition of 80 F dry-bulb, 67 F wet-bulb is to be maintained in a certain clothing store, outside conditions being 95 F dry-bulb, 75 F wet-bulb. The energy gain from normal heat transmission is estimated at 16,000 Btu per hour, that from solar radiation at 48,000 Btu per hour. The energy generated by lights, fans, etc., is estimated at 13,900 Btu per hour. The ventilation requirement is 30,000 cu ft of Outside Air per hour. The number of occupants is 50. Find the apparatus dew-point and the cooling load as analyzed in Fig. 8.

Solution. The thermodynamic properties of Outside Air are: $v = 14.29$ cu ft per pound dry air, $h = 38.26$ Btu per pound dry air, and $W = 0.01402$ lb water per pound dry air. Therefore, the weight of dry air entering with the Ventilating Air is 30,000 ÷ 14.29 = 2099 lb dry air per hour. This brings with it energy of amount 2099 × 38.26