MW_i per hour, where h_i and W_i denote the enthalpy and humidity ratio of the *inside air*, respectively. The weight of dry air returned with the *conditioned air* will necessarily be the same as that withdrawn with the *inside air*, but with it must be returned a smaller quantity of energy Mh and a smaller quantity of water MW. Let ΔQ and ΔW denote the given amounts of energy and water to be removed from the conditioned space per hour; then

$$Mh = Mh_i - \Delta Q$$
$$MW = MW_i - \Delta W$$

Eliminating M and letting q denote the ratio of energy removed to water removed, that is, $q = \Delta Q/\Delta W$,

$$\frac{h - h_i}{W - W_i} = q \qquad (11)$$

according to which: *all possible states for the conditioned air lie on a straight line on the Mollier Diagram passing through the state point of the inside air in the direction specified by the numerical value of the ratio q.* This line is called the *condition line* for the given problem. If the condition line crosses the saturation curve, the point of intersection is called the *apparatus dew-point* for the given problem.

The protractor on the Mollier Diagram facilitates the drawing of the condition line and the locating of the apparatus dew-point. For this purpose the numerical value of the ratio q is to be regarded as a value of the *specific enthalpy of water added, Btu per pound.*

Example 12. A condition of 80 F dry-bulb, and 67 F thermodynamic wet-bulb, is to be maintained in a clothing store, outside conditions being 95 F dry-bulb, and 75 F thermodynamic 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 per hour. The number of occupants is 50. Find the apparatus dew-point.

Solution. The properties of *inside air* and *outside air* are readily calculated from the data in Table 1, see especially Example 2.

		Inside Air	Outside Air
μ	=	0.5024	0.3848
h	=	31.514	38.408
W	=	0.01122	0.01413
v	=	....	14.296

The weight of dry air entering with the *ventilating air* is 30,000/14.296 = 2098.5 lb per hour which brings with it energy of amount 2098.5 × 38.408 = 80.595 Btu per hour and water of amount 2098.5 × 0.01413 = 29.659 lb per hour.

The weight of dry air displaced from the store by the *ventilating air* is 2098.5 lb per hour which takes with it energy of amount 2098.5 × 31.514 = 66,132 Btu per hour and water of amount 2098.5 × 0.01122 = 23.541 lb per hour.

Each occupant may be regarded as a normal person standing at rest and evaporating (1386 grains) 0.198 lb of water per hour (value obtained by interpolation between Curves D and C Fig. 7, Chapter 12) at about 79 F. From this source there is water of amount 50 × 0.198 = 9.90 lb per hour and energy of amount 9.90 × 1095.7 = 10,847 Btu per hour added to the conditioned space. In addition each occupant loses 225 Btu per hour by conduction, convection, and radiation, making a total for 50 persons of 11,300 Btu per hour.

The net energy gain is 16,000 + 48,000 + 13,900 + 80,595 − 66,132 + 10,847 + 11,300 = 114,510 Btu per hour. The net water gain is 29.659 − 23.541 + 9.90 = 16.018 lb per hour. Accordingly the direction of the condition line is fixed by the ratio, q = 114,510 ÷ 16.018 = 7148.8 Btu per pound of water.

On the Mollier Diagram, Fig. 9, the direction of the condition line is given by the protractor for a *specific enthalpy of water added* of 7148.8 Btu per pound. The line itself passes through the state point of the inside air and intersects the saturation curve at the apparatus dew-point.

According to Equation 11 the enthalpy h_s and humidity ratio W_s at the apparatus dew-point must satisfy the equation

$$7148.8W_s - h_s = 7148.8 \times 0.01122 - 31.514 = 48.681$$

At 58 F the left-hand member has the value 48.513; at 59 F its value is 50.641; by interpolation the apparatus dew-point is 58.08 F.

It would be a mistake to assume that the refrigeration to be supplied is equal to the net energy to be removed; for in general water is to be removed simultaneously and unless this is removed as liquid at 32 F it will automatically take some energy with it. Thus, unless the water is removed as solid (ice) the refrigeration to be supplied will be somewhat less than the net energy to be removed.

Example 13. Referring to the cooling load problem of Example 12, suppose that the conditioning process consists of cooling a portion of the *inside air* to the apparatus dew-point temperature, separating out the liquid thus formed, and returning the resulting saturated mixture to the conditioned space. Find the quantity of *inside air* that must be processed in this manner and the corresponding quantity of refrigeration required.

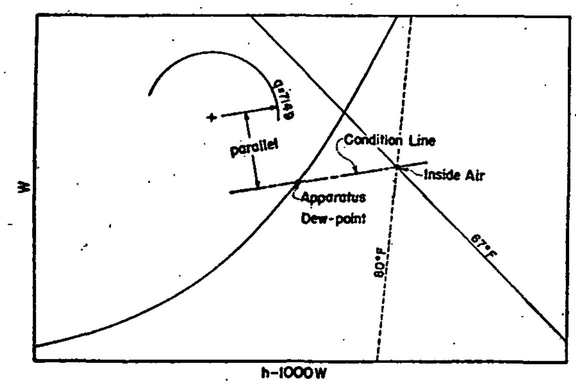

Fig. 9. Illustration of Use of Mollier Diagram in Solution of Example 12

Solution. During the cooling operation the enthalpy of the inside air is reduced to the value,

$$h = 25.17 + (0.01122 - 0.01033) \times 26.20 = 25.193$$

where 25.17 and 0.01033 are the values of enthalpy and humidity ratio at saturation at the apparatus dew-point temperature and 26.20 is the specific enthalpy of liquid water at that temperature. It follows that the quantity of refrigeration required is 31.514 − 25.193 = 6.321 Btu per pound of dry air.

The *inside air* being processed leaves the store with an enthalpy of 31.514 and is returned with an enthalpy of 25.17; it therefore removes energy of amount 6.344 Btu per pound of dry air. This means that the weight of dry air involved in the process is 114,510/6.344 = 18,050 lb per hour and that the total refrigeration to be supplied is 18,050 × 6.321 = 114,090 Btu per hour, or 9.508 tons.

The quantity of liquid separated out during the conditioning process is 18,050 × (0.01122 − 0.01033) = 16.018 lb per hour as required. In leaving the apparatus it takes with it energy of amount 16.018 × 26.20 = 420 Btu per hour. This plus the refrigeration accounts for the total energy removal of 114,510 Btu per hour as required.

On the Mollier Diagram, Fig. 10, the cooling operation is represented by line AB whose length is the quantity of refrigeration per pound of dry air; the separation of the liquid