The results obtained with Equations 13 and 14 agree well with values given in Table 6. They are not in such close agreement with values given by Keenan and Keyes in Table 8.

Example 6. Find the enthalpy of an air-vapor mixture having a dry-bulb temperature of 85 F and a wet-bulb temperature of 70 F and a barometric pressure of 29.0 in. Hg.

Solution. From Equation 2a and Table 6,

$$e = 0.7387 - \frac{(29.0 - 0.7387)(85 - 70)}{2800 - (1.3 \times 70)} = 0.05822.$$

From Equation 5,

$$W = 0.622 \frac{0.5822}{29.0 - 0.5822} = 0.01274.$$

From Equation 14,

$$h = (0.24 \times 85) + [0.01274 (1059.2 + 0.45 \times 85)] = 34.38 \text{ Btu per pound dry air.}$$

Since the enthalpy is nearly constant along a wet-bulb temperature line in any air-water vapor mixture, it may be found, approximately,

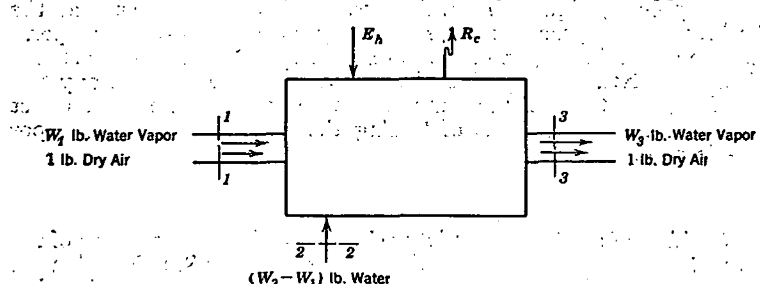

Fig. 1. Diagram Illustrating Energy Equation 15

when the wet-bulb temperature is known by using the temperature in Table 6 as wet-bulb temperatures and reading the corresponding enthalpy from the last column, provided the barometric pressure is 29.92 in. Hg.

ENERGY EQUATION

An energy equation can be written that applies, in general, to various air conditioning processes, and this equation can be used to determine the quantity of heat transferred during such processes. In the most general form, this equation may be explained with the aid of Fig. 1 as follows:

The rectangle may represent any apparatus, *e.g.*, a drier, humidifier, dehumidifier, cooling tower, or the like, by proper choice of the direction of the arrows.

In general, a mixture of air and water vapor, such as atmospheric air, enters the apparatus at 1 and leaves at 3. Water is supplied at some temperature, t_2. For the flow of 1 lb of dry air (with accompanying vapor) through the apparatus, provided there is no appreciable change in the elevation or velocity of the fluids and no mechanical energy delivered to or by the apparatus,

$$h_1 + E_h + (W_3 - W_1)\, h_2 = h_3 + R_c$$

or

$$E_h - R_c = h_3 - h_1 - (W_3 - W_1)\, h_2 \qquad (15)$$

where

E_h = the quantity of heat supplied per pound of dry air, Btu.
R_c = the quantity of heat lost externally by heat transfer from the apparatus, Btu per pound of dry air.
W_1 = the weight of water vapor entering, per pound of dry air.
W_3 = the weight of water vapor leaving, per pound of dry air.
h_2 = the enthalpy of the water supplied at t_2, Btu per pound.
$h_3 - h_1$ = the increase in the enthalpy of the air-water vapor mixture in passing through the apparatus, Btu per pound of dry air

$$= 0.24\,(t_3 - t_1) + W_3\,(1059.2 + 0.45\, t_3) - W_1\,(1059.2 + 0.45 t_1)$$

The net quantity of heat added to or removed from air-water vapor mixtures in air conditioning work is frequently *approximated* by taking the differences in total heat at exit and entrance.

For example, in Fig. 1, an *approximate* result is:

$$E_h - R_c = \Sigma_3 - \Sigma_1 \qquad (16)$$

From the definitions of *total heat* and *enthalpy*, it may be demonstrated that Equation 16 is exactly equivalent to Equation 15, when, and only when, $t'_3 = t'_1 = t_2$; *i.e.*, when the initial and final wet-bulb temperatures and the temperature of the water supplied are equal. The one process that meets these conditions is adiabatic saturation, and for this process either equation will give a result of zero. For other conditions, Equation 16 is approximate but satisfactory for many calculations.

The following problems illustrate the application of these principles:

Example 7. Heating (data from Example 3). Assuming the water to be supplied at 50 F, the net quantity of heat supplied is, from Equation 15,

From Equation 15,

$$E_h - R_c = h_3 - h_1 - (W_3 - W_1)(50 - 32)$$
$$h_3 = (0.24 \times 70) + [0.00618\,(1059.2 + 0.45 \times 70)] = 23.54 \text{ Btu per pound leaving dry air}$$
$$h_1 = (0.24 \times 0) + [0.000548\,(1059.2 + 0.45 \times 0)] = 0.58 \text{ Btu per pound entering dry air}$$
$$E_h - R_c = 23.54 - 0.58 - [0.005632\,(50 - 32)] = 22.86 \text{ Btu per pound dry air, net heat supplied}$$

Example 8. Cooling (data from Example 4). If the condensate is removed at 54 F the quantity of heat removed is found from Equation 15, by proper regard to the arrow direction in Fig. 1,

From Equation 15,

$$E_h + R_c = h_1 - h_3 - (W_1 - W_3)(54 - 32)$$
$$h_1 = (0.24 \times 84) + [0.01248\,(1059.2 + 0.45 \times 84)] = 33.85 \text{ Btu per pound entering dry air}$$
$$h_3 = (0.24 \times 54) + [0.00887\,(1059.2 + 0.45 \times 54)] = 22.57 \text{ Btu per pound leaving dry air}$$
$$E_h + R_c = 33.85 - 22.57 - [0.00361\,(54 - 32)] = 11.20 \text{ Btu per pound dry air, net heat removed}$$

Using Table 6, the initial enthalpy of the air-vapor mixture, since the wet-bulb temperature is 70 F, is 33.96 Btu per pound of dry air.

The final enthalpy is, from Table 6, since the exit air is saturated, 22.55 Btu per pound. Hence, using Equation 16, the quantity of heat removed is, approximately, (33.96 − 22.55) or 11.41 Btu per pound of dry air. The degree of approximation to the correct result is evident in this example.