velocity, and energy in the form of enthalpy. Additional energy may cross the boundaries of the system in the forms of heat or work. The various forms of energy crossing the boundaries between the sections under consideration may be equated by applying the First Law of Thermodynamics:

$$PE_1 + KE_1 + H_1 + {}_1q_2 = PE_2 + KE_2 + H_2 + w \quad (3)$$

where

PE = potential energy, Btu per pound dry air.
KE = kinetic energy, Btu per pound dry air.
H = enthalpy, Btu per pound dry air.
${}_1q_2$ = heat added between sections 1 and 2, Btu per pound dry air.
w = shaft work withdrawn between sections 1 and 2, Btu per pound of dry air.

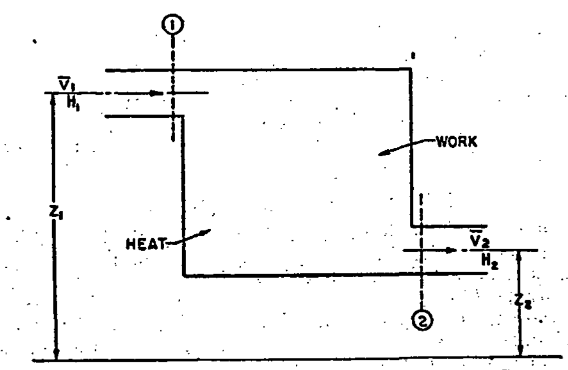

FIG. 1. ENERGY CHANGE BETWEEN TWO SECTIONS OF A SYSTEM

For most psychrometric problems, since the change in the potential energy and kinetic energy terms is negligible compared to the enthalpy change, Equation 3 may be simplified to

$$H_1 + {}_1q_2 = H_2 + w \quad (4)$$

where

H = enthalpy of the flowing medium, Btu per pound of dry air.

The enthalpy of the entire system may be broken down into constituent parts, thus:

$$GH = Gh + Lh_{wl} + Sh_{ws} \quad (5)$$

where

h = enthalpy of *moist* air, Btu per pound of dry air.
h_{wl} = enthalpy of liquid water, Btu per pound.
h_{ws} = enthalpy of solid water, Btu per pound.
L = flow rate of liquid water, pounds per hour.
S = flow rate of solid water, pounds per hour.
G = flow rate of dry air, pounds per hour.

Similarly, an equation expressing the conservation of mass may be written thus:

$$\sum_{in} [G(1 + W) + L + S] = \sum_{out} [G(1 + W) + L + S] \quad (6)$$

where

W = humidity ratio, pounds of water vapor per pound of dry air.

THERMODYNAMIC PROPERTIES OF MOIST AIR

The working substance of the air conditioning engineer is moist air. Air is actually a mixture of oxygen, nitrogen, carbon dioxide, water vapor, and traces of other gases.

The mixture consisting of the components other than water vapor is known as *dry air*. Its composition remains essentially constant under all conditions. In moist air the amount of water vapor varies considerably. To allow for this variation the specific properties of moist air are developed in terms of the relative amounts of water vapor and dry air. Accepted air conditioning practice is to express this in terms of the amount of water vapor per pound of dry air.

Terms frequently used in describing the condition of a mixture of air and water vapor are *humidity ratio, relative humidity, degree of saturation, dry-bulb temperature, thermodynamic wet-bulb temperature, and dew-point temperature.* These terms are defined in following paragraphs.

Humidity Ratio. Weight of water vapor associated with unit weight of dry air, pounds of water vapor per pound of dry air. Humidity ratio has also been called *specific humidity*, and this term is still used in many places.

Relative Humidity. Ratio of the mol fraction of water vapor in the actual mixture to the mol fraction of water vapor in saturated air at the same dry-bulb temperature and barometric pressure.

Degree of Saturation. Ratio of the actual humidity ratio to the humidity ratio of saturated air at the same dry-bulb temperature and barometric pressure.

Relative humidity and degree of saturation are related according to the identity:

$$\phi = \frac{\mu}{\left[1 - (1 - \mu) f_s \dfrac{P_s}{P_o}\right]} \quad (7)$$

where

ϕ = relative humidity, expressed as a decimal.
μ = degree of saturation, expressed as a decimal.
P_o = observed (or barometric) pressure of the moist air.
P_s = saturation pressure of pure water at the prevailing temperature, expressed in the same units as P_o.
f_s = a dimensionless factor which may be regarded as accounting for influences arising when air and water are intermixed. Magnitudes of f_s have been reported by Goff and Gratch[1] and by Goff.[2] Table 1 gives values of f_s for a limited range of conditions.