LETTER SYMBOLS (Concluded)

v_{as} = $v_s - v_a$, the difference between volume of moist air *at saturation*, per pound of dry air, and the volume of the dry air itself, cubic feet per pound of dry air.

v_s = volume of moist air at saturation per pound of dry air, cubic feet per pound of dry air.

v_T = total volume, cubic feet.

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

W_s = humidity ratio, *at saturation*, weight of water vapor per pound of dry air, pound per pound.

W_s^* = humidity ratio corresponding to thermodynamic wet-bulb temperature t^*, pounds of water per pound of dry air.

w = work done by system.

w = shaft work withdrawn between sections 1 and 2, Btu per pound of air.

Z = elevation above any datum, feet.

$\bar{Z}$ = average elevation, feet.

Subscripts with symbols have following meanings: 1, 2, 3 indicate section of flow; a = air, w = water, wl = liquid water, ws = solid water, s = saturation, m = mixture; * indicates that the value is at thermodynamic wet-bulb temperature.

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CHAPTER 4

FLUID FLOW

Theory of Fluid Flow, Pressure Loss in Circular Pipes, Pressure Loss in Non-Circular Pipes; Flow of Compressible Fluids, Ideal Flow Through Nozzle or Orifice; Flow Measurement, Head Meters, Installation of Head Meters, Pitot Tube, Variable Area Flow Meters

THE flow of fluids is part of the branch of engineering science known as fluid mechanics, which will be discussed here insofar as it applies to the work of engineers in the fields of heating, ventilating, and air conditioning. Probably air is the most frequently handled fluid, but other gases and liquids are often involved. Compressible fluids (gases) and incompressible fluids (liquids) vary somewhat in behavior, though in cases where pressure and density changes are small, the gases may be treated as incompressible fluids.

THEORY OF FLUID FLOW

The following energy equation for one dimensional steady flow processes will serve as a basis for the theory of the flow of fluids. This equation is presented in several ways in various texts, but a suitable form is

$$\frac{V_1^2}{2g_c} + Ju_1 + p_1v_1 + Jq + \frac{g}{g_c} z_1 = \frac{V_2^2}{2g_c} + Ju_2 + p_2v_2 + W + \frac{g}{g_c} z_2 \qquad (1)$$

where

V = velocity in feet per second.
g = gravitational acceleration, in feet per (second) (second).
g_c = gravitational conversion factor = 32.174 (pounds mass per pound force) × ft per (second) (second).
J = mechanical equivalent of heat = 778 foot pounds per Btu.
u = internal energy, in Btu per pound of fluid.
p = pressure in pounds per square foot.
v = specific volume, in cubic feet per pound.
W = mechanical work done by the fluid in foot pounds per pound of fluid.
q = heat transferred to the fluid in Btu per pound of fluid flowing.
z = elevation above some arbitrary datum, in feet.
Subscript 1 refers to the entrance, subscript 2 to the exit.

Introducing the enthalpy h, which by definition is $u + \frac{pv}{J}$, expressed in Btu per pound of fluid, Equation 1 becomes

$$\frac{V_1^2}{2g_c} + Jh_1 + Jq + \frac{g}{g_c} z_1 = \frac{V_2^2}{2g} + Jh_2 + W + \frac{g}{g_c} z_2 \qquad (2)$$

The equivalent differential form for energy Equation 1 is

$$\frac{1}{2g_c} dV^2 + J\,du + d(pv) + \frac{g}{g_c} dz - J\,dq + dW = 0 \qquad (3)$$