63. Gage
64. High Side Float
65. Immersion Cooling Unit
66. Low Side Float
67. Motor-Compressor, Enclosed Crankcase, Reciprocating, Direct Connected
68. Motor-Compressor, Enclosed Crankcase, Rotary, Direct Connected
69. Motor-Compressor, Sealed Crankcase, Reciprocating
70. Motor-Compressor, Sealed Crankcase, Rotary
71. Pressurestat
72. Pressure Switch
73. Pressure Switch With High Pressure Cut-Out
74. Receiver, Horizontal
75. Receiver, Vertical
76. Scale Trap
77. Spray Pond
78. Thermal Bulb
79. Thermostat (Remote Bulb)
80. Valves
    - 80.1 Automatic Expansion
    - 80.2 Compressor Suction Pressure Limiting, Throttling Type (Compressor Side)
    - 80.3 Constant Pressure, Suction
    - 80.4 Evaporator Pressure Regulating, Snap Action
    - 80.5 Evaporator Pressure Regulating, Thermostatic Throttling Type
    - 80.6 Evaporator Pressure Regulating, Throttling Type (Evaporator Side)
    - 80.7 Hand Expansion
    - 80.8 Magnetic Stop
    - 80.9 Snap Action
    - 80.10 Suction Vapor Regulating
    - 80.11 Thermo Suction
    - 80.12 Thermostatic Expansion
    - 80.13 Water
81. Vibration Absorber, Line

IDENTIFICATION OF PIPING SYSTEMS BY COLOR

The color scheme for identification of piping systems, based on material carried, as listed in the following table and shown in Fig. 1, is reprinted from Part V, Fourth Edition, of the Engineering Standards of the Heating, Piping and Air Conditioning Contractors National Association.[1]

Class	Color
F—Fire-protection	Red
D—Dangerous materials	Yellow or Orange
S—Safe materials	Green (or the achromatic colors, white, black, gray or aluminum)
and, when required	
P—Protective materials	Bright blue
V—Extra valuable materials	Deep purple

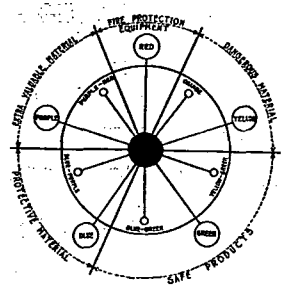

Fig. 1.... Main Classification by Color

[1] See Scheme for Identification of Piping Systems, A13.1-1956, American Standards Association.

CHAPTER 3

THERMODYNAMICS

Mass and Energy Balances, Thermodynamic Properties of Moist Air, Formulas and Tables; Thermodynamic Properties of Water, Formulas and Tables; Degree of Saturation; ASHAE PSYCHROMETRIC CHART; Solution of Air Conditioning Problems by Use of Tables and Psychrometric Chart; U. S. Standard Atmospheres

THERMODYNAMICS is that branch of natural science which deals with energy and its transformations into various forms. In this chapter the discussion will be limited to thermodynamics as it affects the arts of heating and air conditioning. This will necessarily presume some knowledge of the fundamentals of the science on the part of the reader who may also find it desirable to refer to a standard text on the subject, preferably one published after 1930.

MASS AND ENERGY BALANCES

The First Law of Thermodynamics is a statement of the Principle of Conservation of Energy. It may be stated as follows: *The energy added to a system is equal to the increase or decrease of the energy stored in the system, plus the energy which leaves the system.* For a completely contained, or nonflow system, this may be restated as: The heat added to a nonflow system is equal to the change in the internal energy of the system, plus the work done by the system.

$$ {}_1q_2 = U_2 - U_1 + w \qquad (1) $$

For a constant pressure process

$$ {}_1q_2 = H_1 - H_2 \qquad (2) $$

where

${}_1q_2$ = energy added between points 1 and 2.
U = internal energy of system.
w = work done by system.
H = enthalpy of system.

Subscripts 1 and 2 refer to sections of the system between which a change takes place.

For engineering problems, a more important application of the First Law is its use in cases in which, in addition to energy, one or more fluids are crossing the boundaries of the system. The most simple of these is the steady flow system, in which the rates of energy and mass flow across the boundaries of the system are constant, and no mass or energy is stored or released by the system.

Consider a system as illustrated in Fig. 1. The fluid crossing the boundaries of the system carries with it potential energy by reason of its elevation above some convenient datum, kinetic energy by reason of its 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:

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

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.

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 written

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

where

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

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

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

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:

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

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