The relationship of Equation 1 expresses certain familiar laws approximately true for gases at not too high pressures. Thus, *with temperature constant, the volume of a given weight of gas is inversely proportional to its absolute pressure* is a statement of Boyle's Law. If v_1 denotes the specific volume at absolute pressure p_1, then *at the same temperature*, the specific volume v_2 at absolute pressure p_2 is approximately,

$$v_2 = v_1 \left(\frac{p_1}{p_2}\right)$$

Also, *with pressure constant the volume of a given weight of gas is directly proportional to its absolute temperature* is a statement of Charles' Law. If v_1 denotes the specific volume at absolute temperature T_1, then *at the same pressure*, the specific volume v_2 at absolute temperature T_2 is approximately,

$$v_2 = v_1 \left(\frac{T_2}{T_1}\right)$$

Absolute Temperature

For the range 0 to 660 C, the standard temperature scale is the International Centigrade Scale, namely, the readings of a platinum resistance thermometer standardized at the ice-point (0 C), the steam-point (100 C) and the sulphur-point (444.60 C). The corresponding Fahrenheit scale t used in scientific work is derived from the International Centigrade Scale by means of the relation,

$$t = 1.8\ (\text{Int. Cent. Temp.}) + 32 \qquad (3)$$

Temperatures on the absolute Fahrenheit scale are then obtained by adding 459.70 according to the equation

$$T = t + 459.70 \qquad (4)$$

Absolute temperatures computed from Equations 3 and 4 are *practically* identical with the fundamental thermodynamic temperatures to which the zero-pressure values of the product pv for gases are proportional in accordance with Equation 2.

Specific Enthalpy

Most air conditioning processes are of the steady-flow type. In steady flow the energy convected with the fluid crossing a given section is the sum of (a) kinetic energy due to velocity, (b) gravitational energy due to elevation, (c) enthalpy due to the condition of temperature, pressure and composition at a given section. It is clear, therefore, that in order to apply the Law of Conservation of Energy to steady-flow processes, information regarding the enthalpy is needed.

Recent developments in quantum mechanics have made it possible to calculate the zero-pressure specific enthalpy of a gas from spectroscopic measurements, and with a degree of accuracy exceeding that with which this property can be inferred from direct calorimetric measurements. Available data for each gas listed in Table 1 have been assembled and critically examined; and from them have been calculated best values for the specific enthalpy of dry air at zero pressure. These are listed in Table 3. The unit of energy is the Btu which is related to the foot-pound as follows:

$$1\ \text{Btu} = 778.18\ \text{ft-lb}^1 \qquad (5)$$

[1]This conversion factor is not exact by definition, but involves an experimental determination of the relation between the absolute and the standard electrical units of energy. The value 1 int. joule = 1.00019 abs. joule, recommended by Osborne, Stimson and Ginnings [8] was used.

TABLE 3. SPECIFIC ENTHALPY OF DRY AIR AT ZERO PRESSURE[a]

Temp F t	Specific Enthalpy Btu per Lb h_a^0	Mean Specific Heat $[C_p^0]_0^t$	Temp F t	Specific Enthalpy Btu per Lb h_a^0	Mean Specific Heat $[C_p^0]_0^t$	Temp F t	Specific Enthalpy Btu per Lb h_a^0	Mean Specific Heat $[C_p^0]_0^t$
−96	−22.839	0.2393	32	7.796	0.2395	160	38.529	0.2400
−64	−15.186	0.2393	64	15.466	0.2396	192	46.238	0.2401
−32	−7.529	0.2394	96	23.145	0.2397	224	53.962	0.2403
0	+0.131	0.2394	128	30.831	0.2398	256	61.702	0.2405

[a]Prepared by John A. Goff from published data computed from spectroscopic measurements.

In Table 3 are also listed values of *mean zero-pressure specific heat* for the range 0 to t F. This is simply the increase of specific enthalpy from 0 to t F, divided by the increase of temperature or, with 0 F as the reference point, by the temperature itself. The numerical values indicate that a rounded figure of 0.24 Btu per pound can be used in ordinary calculations.

Applying well known identical relations of thermodynamics to Equation 2, the following expression for specific enthalpy, valid at not too high pressures, is obtained

$$h = h^0 + \left[T^2 \frac{d\,(A/T)}{dT}\right] p \qquad (6)$$

where h^0 denotes specific enthalpy at zero pressure. This equation emphasizes that the effect of pressure on specific enthalpy is not so much due to the second virial coefficient A itself as to its variation with temperature. In other words, the pressure effect may be much more important than the corresponding effect on specific volume. Values of the specific enthalpy of dry air at standard atmospheric pressure (29.921 in. Hg) as computed from Equation 6 are given in Table 4.

Reference Point. It is desired to give some prominence to the choice of reference point. As energy, and therefore enthalpy, is purely relative, any convenient state can be selected at which to assign the value *zero* to specific enthalpy. The state chosen is 0 F, 29.921 in. Hg. Perhaps the only really valid argument for this particular choice is that, for ordinary calculations at, or near, atmospheric pressure, a very simple equation can be used, namely,

$$h_a = 0.24t \qquad (7)$$

WATER VAPOR

Saturation Pressure. It is common knowledge that a substance like water can exist in at least three distinct phases, solid (ordinary ice), liquid and vapor; and that under certain conditions two or more phases can *co-exist* in stable equilibrium. For example, steam having a quality of

TABLE 4. SPECIFIC ENTHALPY OF DRY AIR[a] AT 29.921 IN. HG

Temp F t	Specific Enthalpy Btu per Lb h_a	Specific Heat $[C_p]_0^t$	Temp F t	Specific Enthalpy Btu per Lb h_a	Specific Heat $[C_p]_0^t$	Temp F t	Specific Enthalpy Btu per Lb h_a	Specific Heat $[C_p]_0^t$
−96	−23.035	0.2399	32	7.680	0.2400	160	38.454	0.2403
−64	−15.356	0.2399	64	15.363	0.2400	192	46.172	0.2405
−32	−7.678	0.2399	96	23.053	0.2401	224	53.903	0.2406
0	0.000	0.2400	128	30.749	0.2402	256	61.649	0.2408

[a]Prepared by John A. Goff.