PROPERTIES OF AIR *

Air is a mechanical mixture of various gases, ordinarily considered as consisting of oxygen and nitrogen, but also containing a portion of moisture and carbonic acid, and a very small part of other constituents. The proportion of these components will vary under different conditions, but ordinarily pure dry air is composed as follows, in per cent.:

	By Volume	By Weight
Oxygen	20.9	23.1
Nitrogen	79.1	76.9

The moisture will vary with the humidity of the air, from 0 to 4 per cent, and the carbonic acid will vary with the purity of the air from perhaps 0.03 to 0.30 per cent, or as usually expressed from 3 to 30 parts in 10,000.

Weight of Air

The weight of the air varies with its temperature and barometric pressure and also with the amount of moisture it contains. The weight of one cubic foot of pure dry air expressed in pounds may be determined by the formula

$$W = \frac{2.6982\ p}{459.2 + t} \qquad (1)$$

where p = absolute pressure in pounds per square inch.
t = temperature of the air in degrees F.

A convenient formula for expressing the weight of dry air at any conditions of temperature and pressure as used by Frank H. Kneeland [1] is

$$W = \frac{1.3253\ b}{459.2 + t} \qquad (2)$$

where b = corrected barometer reading in inches of mercury
t = temperature, deg. F.
1.3253 = weight in lbs. of 459.2 cu. ft. of air at 0° F. and 1" barometric pressure.

A formula expressing the weight of humid air is given in the Smithsonian Meteorological Tables as

$$W = \frac{0.080723}{1 + 0.0020389\ (t - 32)} \times \frac{b - 0.378\ e}{29.921} \qquad (3)$$

where t = temperature, deg. Fahr.
b = height of barometer in inches of mercury
e = pressure due to vapor in the air in inches of mercury.

According to the latest data the above values should be slightly changed, and we will then have the following formulae as convenient forms for calculating the weight per cubic foot of either dry or moist air.

For dry air

$$W = \frac{0.0028862b}{1 + 0.0021758\ t} \qquad (4)$$

For moist air

$$W = \frac{0.0028862\ b - 0.001088\ e}{1 + 0.0021758\ t} \qquad (5)$$

This last gives the weight of a cubic foot of the mixture of air and vapor, either for saturated or partly saturated air.

* From *Fan Engineering*, Buffalo Forge Co.
[1] "Some Experiences with the Pitot Tube on High and Low Velocities," Am. Soc. Mech. Engrs., Dec., 1911.

The weight of the dry air contained in one cubic foot of saturated air may be determined from the formula

$$W = \frac{0.0028862\ b - 0.002886\ e}{1 + 0.0021758\ t} \qquad (6)$$

The weight of vapor or density in pounds per cubic foot of saturated vapor at temperature t is given by the following:

$$D_s = \frac{S\ (144 \times 0.4908\ e)}{53.35\ (459.2 + t)} \qquad (7)$$

where S is the specific weight of water vapor and may be found as

$$S = 0.6221 + 0.001815\sqrt{e} + 0.0000051\sqrt{e^3} \qquad (8)$$

The relationship between the temperature and specific weight of vapor is shown by the diagram on this page taken from W. H. Carrier's paper on "Rational Psychrometric Formulae." *

An approximate value for the weight of water vapor contained in one pound of dry air saturated with moisture may be determined from

$$G = \frac{0.624\ e}{b - e} \qquad (9)$$

It may be noted from the curve that the value of 0.624 for S in the above is only correct at about 70°.

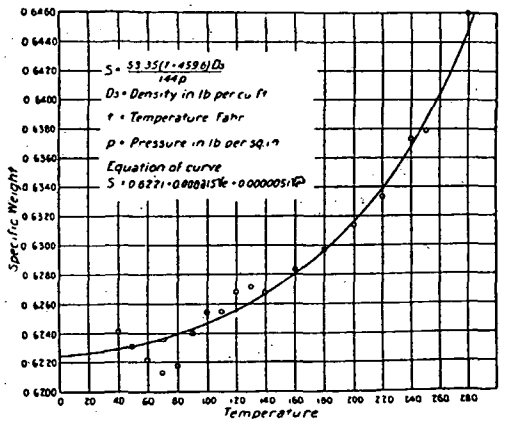

Fig. 1

Specific Weight of Water Vapor

The table No. 1 gives the properties of dry air for various temperatures, and the table No. 2 the properties of saturated air. These are both based on the standard barometric pressure of 29.921 inches.

The table No. 3 giving the weights of saturated and partly saturated air for various barometric and hygrometric conditions will be found especially convenient in making calculations based on other than standard conditions. The weight in pounds per cubic foot of saturated air is given for even barometric pressures and temperatures. The decrement per degree rise in temperature and the increment per 0.1" increase in barometer are also given, thus readily giving the weight of saturated air at any other temperature and pressure. The last column in the table gives the approximate average increment per degree wet-bulb depression which is to be added to the weight of saturated air to obtain the corresponding weight of partly saturated air.

* "Rational Psychrometric Formulae," Am. Soc. Mech. Engrs., Dec., 1911.