Then at 70° F. and 29.92" barometer and with dry air

$$\frac{d}{12W} = \frac{62.31}{12 \times 0.07495} = 69.75$$

and we have

$$V = 60\sqrt{2\,gh'\,\frac{d}{12W}} = 4005\sqrt{h'} \quad (13)$$

Thus we see that the velocity at standard conditions stated for a pressure of one inch of water will be 4005 ft. per min., and for one ounce per square inch will be

$$4005\sqrt{1.734} = 5273 \text{ ft. per min.} \quad (14)$$

The weight of dry or saturated air at other temperatures may be found from the tables No. 1 and No. 2, or for any special condition of temperature, barometer, or humidity from the table No. 3, the use of which has already been explained.

The most convenient formulae for determining the velocity or pressure of air under different conditions of temperature, barometer and humidity, when computing test results are the following:

$$V = 1096.5\sqrt{\frac{p}{W}} \quad (15)$$

hence

$$p = \left(\frac{V}{1096.5}\right)^2 W \quad (16)$$

Where V = velocity in ft. per min.
p = pressure in in. of water.
W = weight of air in lbs. per cu. ft.

The quantity of air discharged through an orifice or nozzle due to a difference in pressure may be determined from

$$Q = 1096.5\,C\,A\sqrt{\frac{p}{W}}$$

where C = coefficient of discharge.
A = area of orifice in sq. ft.
p = pressure head in in. of water causing flow of air through orifice.
W = weight of air in lbs. per cu. ft.

For values of coefficient of discharge see "Coefficients of Discharge for Air Measurements", Pg. 177.

In case the pressure is expressed in ounces per square inch these formulae become:

$$V = 1444.5\sqrt{\frac{p}{W}} \quad (17)$$

$$p = \left(\frac{V}{1444.5}\right)^2 W \quad (18)$$

and

$$Q = 1444.5\,C\,A\sqrt{\frac{p}{W}}$$

The value to be used for W to be determined for each specific case, as already explained.

Example. As an example of the application of the above we will assume a case of a fan test made under the same atmospheric conditions as those assumed for the last example. That is, the air to be at 83° F. and 15° depression, with the barometer at 29.40 inches. What will be the velocity of this air at a pressure of 1.5 inches of water as measured by a pitot tube? As determined in the preceding example the weight of air under the above conditions will be 0.07142 lb. per cu. ft. Then from formula (15) we find the velocity to be

$$V = 1096.5\sqrt{\frac{1.5}{0.07142}} = 5024 \text{ ft. per min.}$$

The above formulae are sufficiently accurate for low pressures such as are ordinarily used in fan work, but for high pressures such as are met in compressed air work, the error becomes excessive and it will be found necessary to use the following thermodynamic formulae. For the flow through an orifice from a higher to a lower pressure, where the absolute initial pressure is less than twice the absolute pressure of the discharge region,

$$V_2 = 6552\sqrt{T_1\left[1 - \left(\frac{P_2}{P_1}\right)^{0.29}\right]} \quad (19)$$

where V_2 = velocity in ft. per min. at discharge.
P_1 = absolute initial press. in lb. per sq. in.
P_2 = absolute final press. in lb. per sq. in.
T_1 = absolute temp. degrees F. of entering air.

The discharge through an orifice into a region where the pressure is greater than half the initial pressure, expressed in cubic feet of free air per minute, may then be determined by the formula

$$Q = 218667\,C\,A\,\frac{P_1}{\sqrt{T_1}}\sqrt{\left(\frac{P_2}{P_1}\right)^{1.42} - \left(\frac{P_2}{P_1}\right)^{1.71}} \quad (20)$$

where Q = cu. ft. free air per min.
C = coefficient of discharge.
A = orifice area in sq. ft.

As already shown for dry air at 70° F. and 29.92 inch barometric pressure, the velocity due to a pressure of one inch of water is 4005 feet per minute and for a pressure of one ounce per square inch is 5273 feet per minute. Since the velocity varies as the square root of the pressure, we have

$$\frac{V}{V_0} = \sqrt{\frac{p}{p_0}} \text{ or } V = V_0\sqrt{\frac{p}{p_0}} \quad (21)$$

Taking p_0 as unit pressure, and V_0 the velocity corresponding thereto, assuming dry air at 70° F. and 29.92 inch barometer, the above relation reduces to

$$V = 4005\sqrt{p} \quad (22)$$

When the pressure is taken in inches

$$\text{or } V = 5273\sqrt{p} \quad (23)$$

when the pressure is expressed in ounces.

The table No. 4 gives the velocity of dry air at standard conditions for various pressures expressed both in inches and ounces. The two tables, No. 5 and No. 6, give the corresponding velocities of dry air under standard barometric pressure of 29.92 inches for different pressures and temperatures. One table gives the velocity for even parts of an inch and the other for even parts of an ounce, with the corresponding pressure in the other unit.

Effect of Temperature and Barometric Pressure on Velocity

If considered at the same pressure the effect of changing the temperature of the air will change the corresponding velocity in direct proportion as the square root of the absolute temperatures. That is

$$V = V_0\sqrt{\frac{460+t}{460+t_0}} \quad (24)$$

The tables No. 5 and No. 6 give the corresponding velocities for dry air at various pressures and temperatures, but the velocity for any other temperature may be determined from the above formula.

In connection with fan work we have the same relation—that is at constant pressure, the speed, capacity and horsepower of the fan varies as the square root of the ratio of the absolute temperatures. At constant velocity the weight and pressure of the air handled will vary inversely as the ratio of the absolute temperatures.

The velocity of air at constant pressure not only varies with any change in temperature, but also with every change in barometer. The velocity of the air varies inversely as the square root of the ratio of the barometric pressures. Then we will have