the various fluids. In dealing with air we are dealing with a fluid highly elastic, capable of being compressed and expanded to a very large extent, according to the pressures applied and the temperature, while water is practically incompressible, and varies only slightly with the temperature. One feature is, however, common to both water and air. It takes four times the pressure (or gradient) to double the velocity of water in any given pipe or watercourse, and nine times the pressure to give three times the velocity, and the same rule holds good with air in airways. In both cases, in any particular watercourse (or airway) *the velocity of water (or air) will vary with the square roots of the pressures applied.*

The great difference between water and air is, that while with water it requires only four times the power to obtain four times the pressure, with air it requires eight times the power to obtain four times the pressure. Therefore, with air eight times the power gives four times the pressure and four times the pressure gives twice the velocity, or, it requires eight times the power to double the velocity. In like manner air requires twenty-seven times the power to give nine times the pressure, and nine times the pressure gives three times the velocity, or it requires twenty-seven times the power to give three times the velocity. *The velocity of air is proportional to the square roots of the pressures and to the cube roots of the powers applied.*

All that ought to be required to calculate the quantity of air in cubic feet per second or minute, passing through any airway of rectangular form, is the height, width, and length of the airway in feet, and the pressure (or exhaust as the case be) in pounds per square foot or in inches on the water-gauge, or, to put it shortly, sufficient data to obtain the value of A, R, and S, in the following equations:—

AIR FORMULÆ.

Let A = sectional area in square feet.

R = mean depth $= \frac{\text{area}}{\text{perimeter}}$.

L = length of air-course, in feet.

P = pressure, in pounds per square foot.

$S = \frac{P}{L}$ = pressure divided by length.

V = velocity, in feet per second.

Q = A × V = quantity, in cubic feet per second.

Formula No. 1. $113 \sqrt{RS}$ = velocity, in feet per second.

Formula No. 2. $113 \sqrt{RS} \times A$ = quantity, in cubic feet per second.

Formula No. 3. In airways having the same areas, perimeters, and pressure, but of different lengths, the quantities of air passing through will be inversely proportional to the square roots of the lengths.

Formula No. 4. In square (or circular) airways having the same lengths and the same pressure, the air-carrying capacity will be proportional to the square roots of the fifth powers of the sides of the respective squares (or diameters if circular).

Formula No. 5. The quantities of air passing through airways of any form (length and pressure being the same) is proportional to the areas of the respective airways multiplied by the square roots of their respective mean depths.

Formula No. 6. The velocity of air in airways (length and pressure being the same) is proportional to the square roots of their respective mean depths.

Formula No. 7. The velocity of air passing through any particular airway is proportional to the square roots of the pressures applied—that is, twice the pressure will give 1.414 times the velocity; three times 1.732 times the velocity; four times twice the velocity; and, of course, the quantities will be in the same relative proportions.

Formula No. 8. The velocity of air in airways (area and perimeter being the same) is proportional to the square root of S, and in all cases where the character of the airways is similar, to the square root of RS.

Formula No. 9. In channels (air or water ways) of any specified area, perimeter, and length, and also of the same character—that is, similarly rough or smooth, similarly uniform in area and perimeter, and similarly straight or crooked—*the same velocity will be produced in air with a pressure equal to 1.5524 in. on the water-gauge as will be produced in water with a pressure equal to 100 ft. of water.*

Formulæ Nos. 1 and 2 are applicable to air only, and the results are actual in ordinary airways. Nos. 3, 4, 5, 6, 7, and 8 are applicable to both air and water. Formula No. 9 is theoretically correct, and in the calculations marked B, where water formula for water and air formula for air are compared, water with 100 ft. of head and air with 1.5524 in. on the water-gauge water and air velocities are practically the same in both cases. In the calculations marked B channels of two different areas, 4 ft. by 4 ft. and 8 ft. by 8 ft., each 1,000 ft. in length, are calculated in both cases by air formula and by water formula, water with 100 ft. of head and air with 1.5524 in. on the water-gauge, and the result shows the theoretical correctness of Formula No. 9. In the calculations marked B the water formula $102{\cdot}76 \sqrt{RS}$ with a coefficient of 0·32 has been used, which is about equal to $4\sqrt{2gRS}$ in the "Miners' Guide" formula, because the airways in mines are very rough—not uniform in area and perimeter—and have many bends, so that a smaller coefficient is necessary for airways in mines than for the roughest of watercourses.

In hydraulic calculations the "hydraulic mean depth" means the area of a section of flowing water divided by the perimeter (or wetted border of the sectional area), and represents the depth of water that would cover the perimeter if it were stretched out in a horizontal position. The hydraulic mean depth of a circle is one-fourth of the diameter; of a square is one-fourth the