

gases may be measured by the same methods; but emphasis here is on air measurements¹¹.

For determining the velocity, and therefore the volume of air flowing in a duct, the Standard Pitot Tube⁷ shown in Fig. 5 is probably most often used. When connected as illustrated, this instrument will give readings of both static and velocity pressure directly. From the latter the air velocity may be found from tables, or calculated from the following relation:

$$V = 1096.5 \sqrt{\frac{h_v}{d}} \quad (3)$$

where

V = velocity, feet per minute.
 h_v = velocity pressure, inches of water.
 d = density of air, pounds per cubic foot.

Air flow in a duct is seldom uniform. In general the velocity is lowest

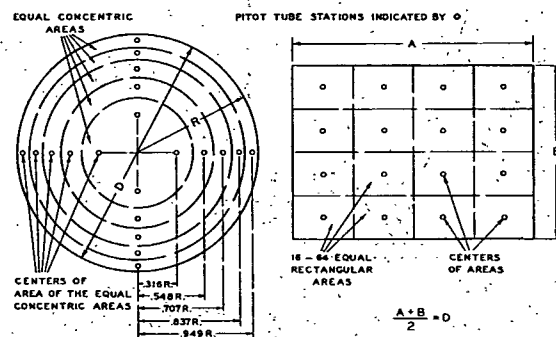


FIG. 6. PITOT TUBE TRAVERSE FOR ROUND AND RECTANGULAR DUCTS

near the edges or corners, and greatest at or near the center. For this reason a large number of readings should be taken in the manner shown in Fig. 6. In the case of round ducts not less than 20 should be taken along two diameters at centers of equal annular areas. In rectangular ducts the readings should be taken in the center of equal areas over the cross-section of the duct. The number of spaces should not be less than 16 and need not be more than 64. When less than 64 are taken the number of equal spaces should be such that the centers of the areas are not more than 6 in. apart.

In determining the average velocity in the duct from the readings given, the calculated individual velocities or the square roots of the velocity heads must be averaged. It is incorrect to use the average velocity head for this purpose.

For small pipes it is sometimes necessary to construct a Pitot tube smaller than the standard size. Such a small Pitot tube should be geometrically similar to the standard tube. Pulsating or disturbed flow will give erroneous results and every effort should be made to remove disturbances in the Pitot tube section.

The velocities used in many ducts are too low for measurement by means of pressure gages and it therefore becomes necessary to resort to other types of instruments.

Many forms of Pitot tubes other than the one described have been used and calibrated¹². A double-ended tube¹³, one end pointing down-stream, and one up-stream, is sometimes used for low velocities, but it should be carefully calibrated for accurate results. A special form of this tube design consists of two straight $\frac{1}{8}$ in. tubes soldered together, closed at the end, and with a 0.04 in. hole in each tube opposite the line of contact. This tube is useful in exploring velocities on exhaust inlets, such as on hoods placed around grinding wheels.

The rounded approach orifice or nozzle of the general type described in the A.S.H.V.E. Unit Heater¹⁴ and Unit Ventilator¹⁵ Codes is an accurate air measuring device. When it is well made, the coefficient closely approaches unity. The discharge from such a nozzle is uniform¹⁶ and provides a good location for calibration of air velocity instruments¹⁷.

The Venturi meter is like the nozzle except for the addition of a down-stream transition section that reduces the pressure drop through the measuring apparatus.

The thin-plate square-edged orifice has a coefficient of approximately 0.60. The exact value depends on the location of the connections, the pressure drop, the diameter ratio of orifice to pipe, and the sharpness of the edge¹⁸.

Another method of air measurement uses the thermal electric principle where, by means of a measured amount of current, heat is put into the air stream. The weight of air flowing is calculated from the heat equivalent of the electrical input and the temperature rise of the air. Heat should be applied uniformly to the mass of air passing, and the small temperature rise must be determined accurately.

In certain applications the air velocity through a duct, heater coil, or heating unit may be most conveniently obtained by computation from the heat given up by the coil and the temperature rise (measured by thermocouples) of the air passing through. It is essential to have a uniform flow over the entire inlet and outlet of the heater at the plane of temperature measurement.

Air Currents in Free Spaces

One of the instruments useful in determining the velocity of air currents in free spaces is the Kata-thermometer. It is essentially an alcohol thermometer with a large bulb. The stem has two marks, one corresponding to 95 F, and the other 100 F. The instrument is heated above 100 F and then the time in seconds required for it to cool from 100 to 95 when located in the air current gives a measure of the non-directional velocity. It is important to have the Kata-thermometer dry before taking the reading. Each Kata has its own factor etched on the stem, and this factor must be used with its cooling formula or chart for obtaining the velocity. The Kata-thermometer is useful in exploring ventilated spaces to determine whether the proper air movement and distribution are being maintained. It is also used in determining the cooling power of the atmosphere, since it loses heat by radiation and convection when dry, and by radiation, convection, and evaporation when the bulb is equipped with a wetted cloth covering¹⁹.

Another instrument for measuring low velocity air currents is the