

Other information on orifices and their use is contained in Chapter 4, Fluid Flow. Shaped orifices or nozzles have the advantage if well made that their discharge coefficients are close to unity so that the probability of large errors is less. Orifices of this type have been adopted for several specific purposes and designs are described in the A.S.H.V.E. Unit Heater¹⁷ and Unit Ventilator Codes¹⁸ and in A.S.R.E. Circular 13¹⁹ entitled "Standard Methods of Rating and Testing Air Conditioning Equipment." In some instances nozzles are used in multiple so that the capacity of the testing equipment can be changed by shutting off the flow through one or more nozzles. An apparatus designed for testing the air flow and capacity of air conditioning equipment is described by Wile²⁰ in an article in which pertinent information on nozzle discharge coefficients, Reynolds numbers, and the resistance of perforated plates is also presented. Such apparatus in some laboratories is commonly referred to as a *code tester*.

The Venturi meter is like the nozzle except for the addition of a downstream 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 edge^{21, 22}.

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

The measurement of air current velocities within enclosed spaces such as the rooms of a house is usually a tedious undertaking. However, useful data can be obtained by using the instruments described in following paragraphs if they are maintained in calibration and the user understands the operation and limitations of the instruments²³.

One of the instruments useful for 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 covering²⁴.

Another instrument for measuring low velocity air currents is the heated thermometer anemometer²⁵. This consists of a mercurial glass thermometer with a resistance winding on the bulb. Current is supplied from an external source in a measured amount. The difference between the temperature of this heated thermometer and that of an ordinary thermometer at the same location, together with the current supplied, makes it possible to calculate the non-directional velocity of the air stream.

The heated thermocouple anemometer employs a thermocouple instead of a thermometer²⁶.

Another instrument is the hot wire anemometer which has been made in several patterns. In general, a measured current is supplied to raise the temperature of a fine bare wire above the temperature of the surrounding air. With the use of a very fine wire, minute fluctuations in velocity may be measured, and the area exposed to radiant exchange with heated or cooled surfaces is at a minimum. This instrument is easily adapted to remote reading or recording. A group of them may be connected together to give the average velocity in a space, or the velocity at individual points within a test space, by suitable switching arrangements^{27, 28}.

Deflecting Vane Anemometer

The deflecting vane anemometer consists of a pivoted vane enclosed in a case, against which air exerts a pressure as it passes through the instrument from an up-stream to a down-stream opening. The movement of the vane is resisted by a hair spring and a damping magnet. The instrument gives instantaneous readings of directional velocities on an indicating scale. When used in fluctuating velocities, it is necessary to average visually the swings of the needle to obtain average velocities. This instrument is very useful for studying mixing of air in a room²⁹ and in locating and measuring peak velocities that may be objectionable. Various attachments are available, such as the double tube arrangement for obtaining velocities in ducts, and a device for measuring static pressures. Each instrument and the attachments for it must receive individual calibration.

Propeller or Revolving Vane Anemometer

The propeller or revolving vane anemometer consists of a light revolving wheel connected through a gear train to a set of recording dials that read the linear feet of air passing in a measured length of time. It is made in various sizes, 3 in., 4 in., and 6 in. being most common. Each instrument requires individual calibration. At low velocities the friction drag of the mechanism is considerable. In order to compensate for this, a gear train that overspeeds is commonly used. For this reason the correction is often additive at the lower range and subtractive at the upper range with the least correction in the middle range of velocities. Most of these are not sensitive enough for use below 200 fpm.

Measurement of Velocities at Inlets and Outlets of Ducts

In the field it is often desirable to make volume measurements at the face of the supply openings. It is rare to have access to the interior of duct sections where the flow is sufficiently uniform for measurement. For accuracy the instrument and its application should be checked on a similar approach and grille in the laboratory before use in the field.