

ment 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 in locating and measuring peak velocities that may be objectionable in air conditioned spaces. Various attachments are available, such as a double tube arrangement for obtaining velocities in ducts, and a device to measure static pressures. Another attachment will be mentioned later under the measuring of velocities at inlets and outlets. 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, therefore, they are not commercially available for the low velocity range met with in air conditioned spaces. Further discussion follows under air measurement at inlets and outlets.

Measurement of Velocities at Inlets and Outlets of Ducts

In the field it is often advisable to make volume measurements at the face of the supply openings. Often it is hard to get into the duct system, or it is difficult to find sections where the flow would be sufficiently uniform. The many types of approaches and grilles used make a high degree of accuracy almost impossible. For the best accuracy the instrument and its application should be checked on a similar approach and grille in the laboratory before use in the field. Where extreme accuracy is not required, such as in balancing a system, various instruments may be used at the face of the grille.

Tests have shown that the propeller type anemometer can be used successfully on the heavier type of supply grilles, such as square mesh of the cast, or pressed pattern¹⁴. The core area is divided into equal squares, and the anemometer is held against the face of the grille for the same length of time in each. To get the air volume in cubic feet per minute, the average corrected velocity in feet per minute thus obtained is multiplied by the average of the gross and net free area of the grille in square feet and by a correction coefficient determined as 0.97 at velocities from 150 to 600 fpm and as 1.00 at higher velocities.

On exhaust grilles, the anemometer traverse is made as described previously. The air volume may be determined by multiplying the corrected velocity in feet per minute by the gross or core area of the

¹⁴A.S.H.V.E. RESEARCH REPORT No. 857, 911 and 966—Measurement of the Flow of Air Through Registers and Grilles, by L. E. Davies (A.S.H.V.E. TRANSACTIONS, Vol. 36, 1930, p. 201, Vol. 37, 1931, p. 619, and Vol. 39, 1933, p. 373).

grille in square feet and by a coefficient for average conditions of 0.80. This coefficient takes care of the interference of the bars of the grille and the effect on the anemometer of the air entering an exhaust grille through 180 deg¹⁵.

When a propeller type anemometer is held in a stream of varying velocities, it tends to indicate higher than the true average, that is, the speed of the propeller is nearer to the top velocity in its area than it is to the minimum velocity. This is the main reason for the large difference in ratings of unit ventilators by the anemometer method and by air volume measurements in a duct approach to the inlet¹⁶.

Any of the other anemometers described can be used within their range at the face of supply grilles when properly applied. In principle it is a case of finding the velocity at many points and using the average thus found with the correct discharge area at that cross section. The deflecting vane anemometer equipped with a jet on the end of a rubber tube has been found especially convenient and accurate on supply grilles¹⁷. On modern air conditioning grilles the core area is used without a correction coefficient when the jet is held one inch away from the face of the grille. At this distance the constriction due to the thin bars has disappeared since the small air jets have reunited, and the air stream has not yet spread beyond the core dimensions. With deflecting grilles the exploring jet should be turned to the angle giving a maximum reading. This method of using this instrument is only applicable to supply grilles and cannot be used on exhaust grilles because of static pressure differences at the location of the jet and the instrument case.

While hardly a quantitative instrument, smoke is very useful in studying air streams and currents. The application of a more accurate instrument is often made more exact by a preliminary exploration with smoke. A mixture of potassium chlorate and powdered sugar in equal portions gives a very satisfactory non-irritating smoke. It is fired by a match, and since considerable heat is evolved, it should be placed in a pan away from inflammable objects.

AIR CHANGE MEASUREMENTS

Atmospheric air contains a certain amount of carbon dioxide. Its concentration is increased within enclosures by the carbon dioxide given off by occupants. The air changes through all means: open windows, infiltration, and mechanical ventilation, may be measured by the carbon dioxide concentration¹⁸. The Petterson-Palmquist apparatus has been accepted as the standard device for the determination of carbon dioxide in air. The principle used is absorption by caustic potash solution of the carbon dioxide in a known volume of air, and a remeasurement of the volume in a finely graduated capillary tube. Since the concentrations are in the order of 3 to 10 parts in 10,000, extreme care must be used to

¹⁵A.S.H.V.E. RESEARCH REPORT No. 1092—The Flow of Air Through Exhaust Grilles, by A. M. Greene, Jr., and M. H. Dean (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 387).

¹⁶A.S.H.V.E. RESEARCH REPORT No. 936—Investigation of Air Outlets in Class Room Ventilation, by G. L. Larson, D. W. Nelson and R. W. Kubasta (A.S.H.V.E. TRANSACTIONS, Vol. 38, 1932, p. 463).

¹⁷A.S.H.V.E. RESEARCH REPORT No. 1076—Air Distribution From Side Wall Outlets, by D. W. Nelson and D. J. Stewart (A.S.H.V.E. TRANSACTIONS, Vol. 44, 1938, p. 77).

¹⁸A.S.H.V.E. RESEARCH REPORT No. 959—Indices of Air Changes and Air Distribution, by F. C. Houghten and J. L. Blackshaw (A.S.H.V.E. TRANSACTIONS, Vol. 39, 1933, p. 373).