U. S. Department of Commerce
National Bureau of Standards

Research Paper RP1872
Volume 40, April 1948

Part of the Journal of Research of the National Bureau of Standards

Effect of Support on the Performance of Vane Anemometers

By Galen B. Schubauer and Gerald H. Adams

One of the more important factors affecting the accuracy of a measurement of air speed with a vane anemometer is the manner in which the instrument is supported. An awareness of this fact is important, because the user must devise his own support. It is shown that seemingly minor changes in the support may change the indicated speed by 5 percent, and that holding an anemometer in the hand may increase the indicated speed by as much as 17 percent. In order to insure the reliability of a speed measurement, an interference-free type of support is recommended.

I. Introduction

The accurate measurement of air speed with a vane anemometer depends on an accurate calibration and on conforming strictly to the conditions for which the calibration will be valid. These conditions involve primarily the manner in which the anemometer is supported.

For many years calibrations were conducted at the National Bureau of Standards by means of a whirling arm, a device that moves the instrument along a circular path through the air at constant speed. The instrument was simply fastened to a flat plate at the end of the arm as shown in figure 1, and the arm was rotated at a series of known rates. The accuracy of a calibration by this method was limited by the so-called swirl correction, a necessary but rather uncertain correction applied to the peripheral speed of the arm to take account of the rotation of the air in the room produced by the rotating arm.

In June 1947, it was decided to conduct all calibrations of vane anemometers in the wind tunnel where absolute speed measurements could be based entirely on the standard pitot-static tube. In making the change to the wind tunnel, the question of the proper means of supporting an anemometer was brought to the fore. It was already known that the support could affect the rate of an instrument and that the best way to avoid possible error was to use the same type of support at all times. The flat plate, formerly used with the whirling arm, could be defended only on the grounds that manufacturers in failing to supply a supporting member of any sort presumably left the user free to adopt any support that suited his convenience—even to holding the anemometer in his hand. To throw some light on the importance of this question, it was decided to investigate the performance of several sizes of vane anemometers of the type shown in figures 1 to 5 on the various types of support shown in the figures. The investigation was conducted in the Bureau's 4½-foot wind tunnel.

II. Interference-Free Mounting

If an anemometer is suspended in a wind stream on wires so fine that they are incapable of producing interference, a performance free from support interference may be obtained. By comparing the performance obtained in this way with that obtained on the rod type of support shown in figure 2, it has been found that a rod no greater than ½ in. in diameter produces no measurable interference when it extends directly downstream. Effects from members supporting the rod itself may be made negligible by placing them at a sufficient distance downstream. This requires a minimum distance of the order of 16 times the diameter or cross-stream width of such members. In the mounting shown in figure 2 ample margin has been allowed, and the mounting is interference free. The portion of the rod directly under the anemometer is flattened to about ⅛ in. in thickness. In the investigation of the interference produced

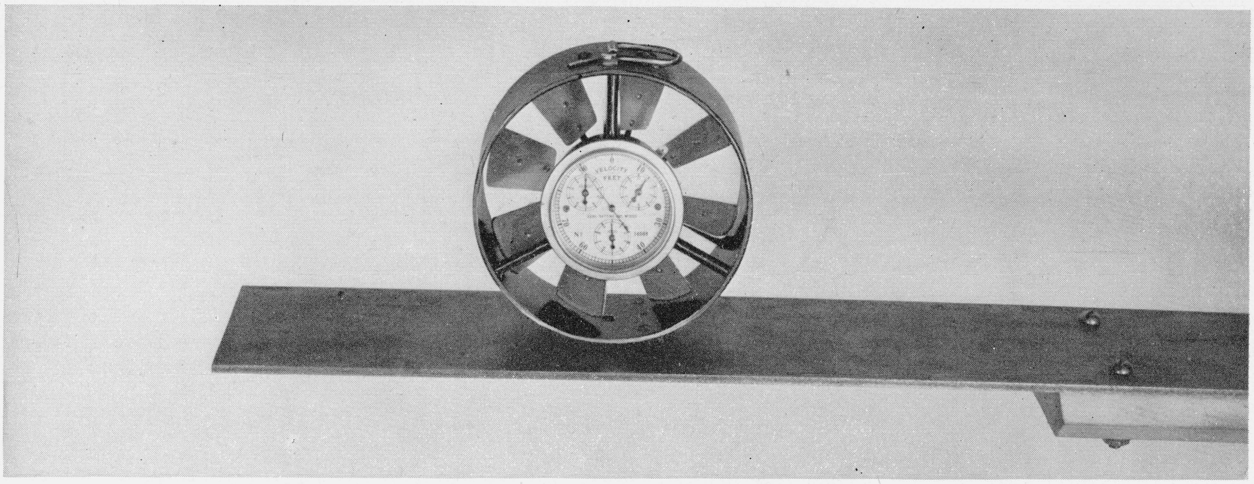

FIGURE 1. *Anemometer supported on flat plate.*

FIGURE 2. *Anemometer supported on rod.*

by other types of support, the performance on the support in question was compared with that on the rod.

III. Other Supports Investigated

1. Whirling-Arm Mounting

The flat plate on which anemometers were mounted in the past for a whirling-arm test is shown in figure 1. A wooden member simulating the end of the arm is shown to the right. The plate is $\frac{1}{8}$ in. thick and 3 in. wide. The distance from the end of the arm to the end of the plate is 12$\frac{1}{2}$ in. The wind moves normal to the face opposite the dial and parallel to the flat side of the plate.

2. Hand Support

The types of hand support shown in figures 3, 4, and 5 were chosen not as recommended methods of support, but rather as manners in which an observer might be inclined to hold an anemometer in making a measurement of air speed. The models are intended to respresent approximately an adult hand and arm. The arm length is not intended to be correct, and the body is not represented. This would correspond to the case where the observer's body is completely outside the wind stream. Figures 1 to 5 all show a 4-in. anemometer, the size referring to the inside diameter of the cylindrical housing.

Figure 3, hand 1, shows one finger through the ring of the anemometer and two fingers supporting the housing. The arm extends to the side and is at right angles to the wind.

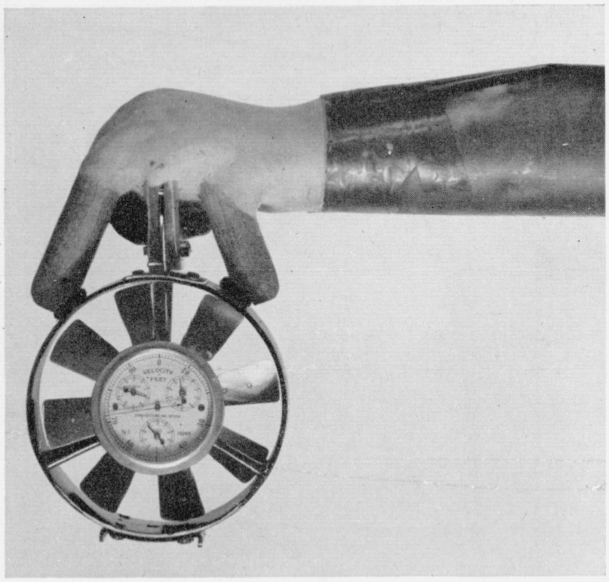

FIGURE 3. *Hand 1 supporting anemometer.*

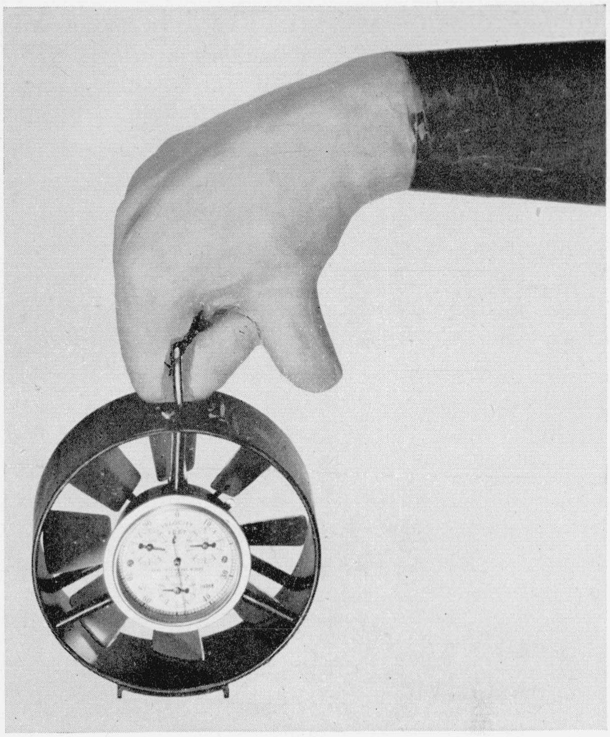

FIGURE 4. *Hand 2 supporting anemometer.*

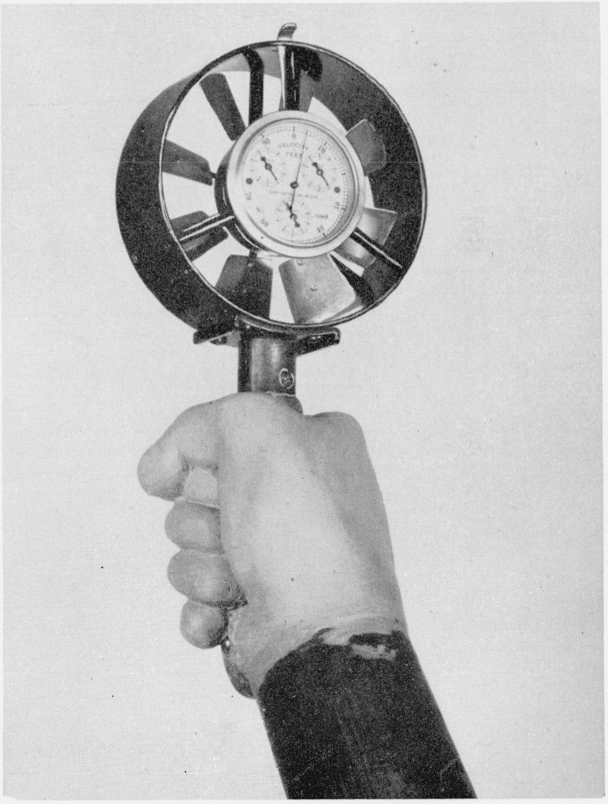

FIGURE 5. *Hand 3 supporting anemometer by short handle.*

Figure 4, hand 2, shows one finger through the ring allowing the anemometer to hang down freely. The arm is at right angles to the wind. The thumb is on the downstream side.

Hand 3 in figure 5 shows an anemometer being held by means of a short handle. The arm is directly downstream inclined at an angle of 45 degrees to the wind.

III. Results

Curves showing the performance of a 3-, 4-, and 6-in. anemometer are given in figures 6, 7, and 8, respectively.

The speed indicated by an anemometer depends on the rate of rotation of the vane wheel, which in turn depends on the setting of the vanes, the diameter of the wheel, the speed and direction of the air through the wheel, and the friction of the instrument. The true speed is the speed of a uniform parallel flow of air that would exist if the anemometer and its supports were absent. The indicated speed may be less than, equal to, or greater than the true speed depending on the factors that control the rate of rotation of the vane wheel.

The performance given in figures 6, 7, and 8 is in terms of the ratio of the indicated speed to the true speed plotted against the true speed. Displacement of the various curves from that marked "rod" shows the altered performance due to the interference of the support. It will be noted that the ratio of indicated to true speed is increased in every case. The reason for this is that the air speed through the instrument increases locally due to the fact that the air must flow around the support.

The changes in indicated speed due to interference are given in table 1 as percentages of the true speed at several values of the true speed. There is an indication that the percentages decrease slightly with increasing speed, but the change is scarcely outside the experimental error. The column of averages may therefore be used as a reliable index of the various interference effects. It will be seen that the interference effects are about the same on the 3- and 4-in. anemometers but somewhat less on the 6-in. anemometer. A decrease with increasing size is to be expected, because the anemometer becomes larger relative to its support. As hands 1 and 2 produced roughly the same effect, hand 1 was used only with the 4-in. anemometer.

TABLE 1. *Change in indicated speed due to interference, expressed as percentage of true speed*

Support	True air speed, fpm					Average
	400	600	800	1,200	1,600	
3-IN. ANEMOMETER						
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Rod	0	0	0	0		0
Plate	5.6	5.6	5.4	5.0		5.4
Hand 1						
Hand 2	15.6	16.1	15.4	14.4		15.4
Hand 3	14.6	14.5	14.1	13.4		14.2
4-IN. ANEMOMETER						
Rod	0	0	0	0	0	0
Plate	5.5	5.3	5.4	5.1	4.7	5.2
Hand 1	18.1	17.1	16.8	16.2	15.9	16.8
Hand 2	18.1	16.9	16.5	16.5	16.8	17.0
Hand 3	11.5	11.8	11.9	11.7		11.7
6-IN. ANEMOMETER						
Rod	0	0	0	0	0	0
Plate	5.6	4.3	3.7	3.3		4.2
Hand 1						
Hand 2	12.7	11.8	11.9	11.9	12.0	12.1
Hand 3	10.7	10.3	10.1	9.7	9.6	10.1

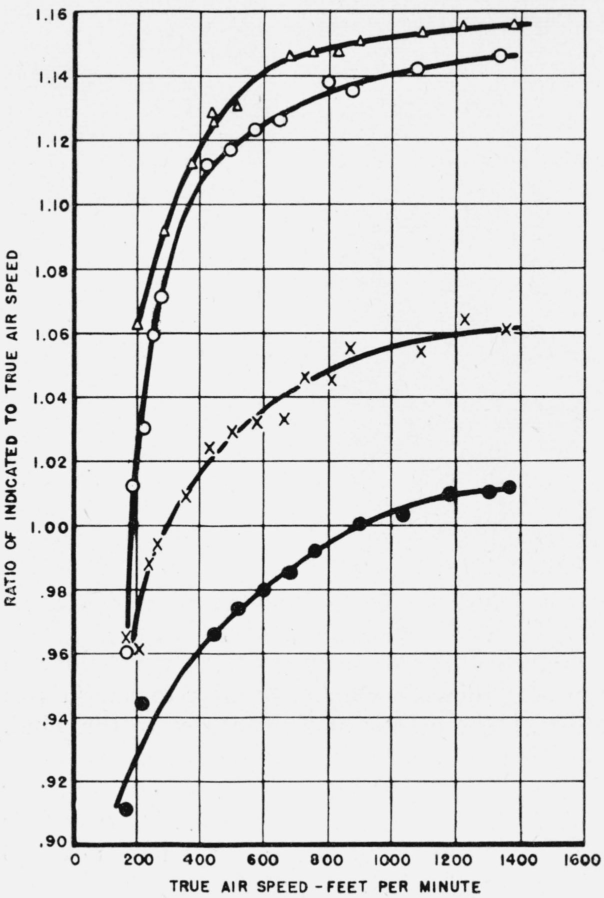

FIGURE 6. *Performance of 3-inch, eight-vane anemometer.*
△, Hand 2; ○, hand 3; ×, plate; ●, rod.

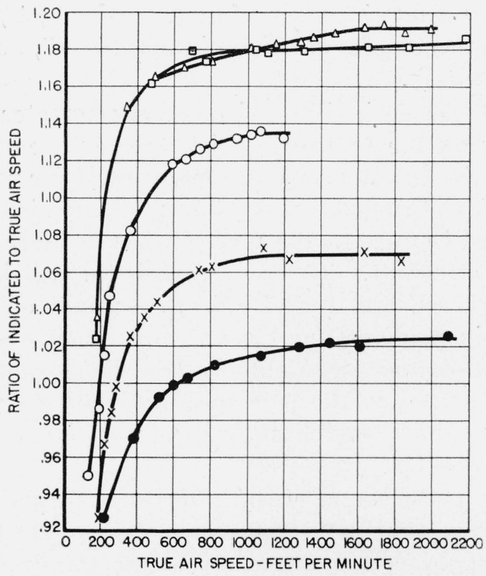

FIGURE 7. *Performance of 4-inch, eight-vane anemometer.*
△, Hand 2; □, hand 1; ○, hand 3; ×, plate; ●, rod.

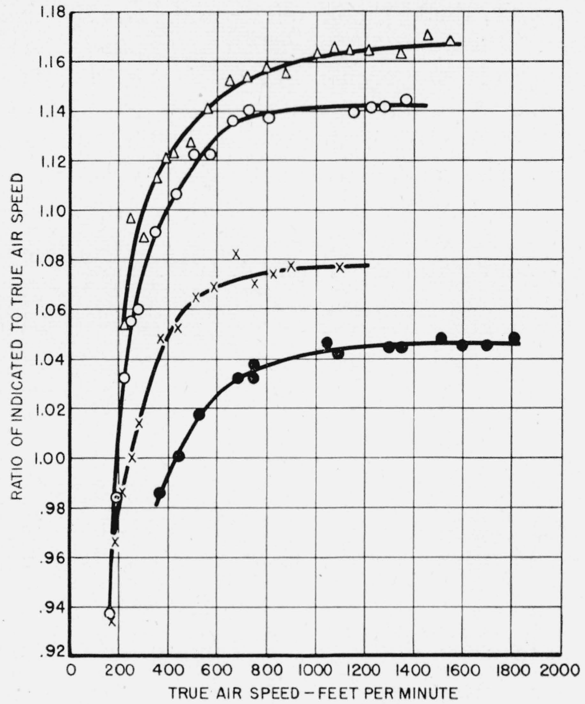

FIGURE 8. *Performance of 6-inch, 10-vane anemometer.*

△, Hand 2; ○, hand 3; ×, plate; ●, rod.

All of the effects demonstrated here are large compared to the inherent accuracy of a calibration curve. The scatter of the points about any one mean curve in figures 6, 7, and 8 shows that a calibration curve is defined to an accuracy of better than 1 percent. However, there may be systematic errors in the measurement of speeds below 400 feet per minute amounting to several percent, so that the scatter of observations is not a reliable indication of the absolute accuracy at the lower speeds. Nevertheless, interference effects are likely to be the major source of error unless the same support system is used at all times. The support, therefore, becomes in effect part of the instrument and changing it amounts to changing the instrument.

Not all interference effects will be as large as those shown here, for the effect depends entirely on the size, position, and shape of the support. If the bulk of the support is to the rear of the anemometer, the effect may be in the opposite direction. It is entirely possible that some disposition of the support may be made such that effects from the side and effects from the rear just

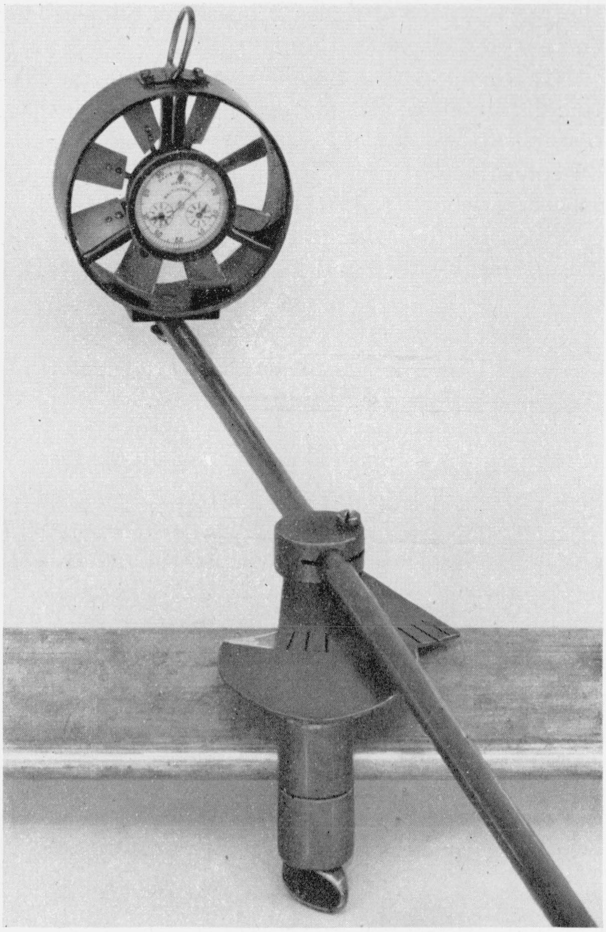

FIGURE 9. *Anemometer on rod clamped to strut.*

cancel. However, proper balance might be difficult to obtain over the entire speed range of an instrument and also would be affected by wind direction. Directional effects on anemometers without support interference have been treated in a previous paper.[1]

IV. Adoption of a Standard Mounting for Calibration Purposes

In considering the question of a standard mounting, it is helpful to keep in mind the fact that any mounting must be regarded as part of the instrument. As an anemometer supplied by a manufacturer should be regarded as a complete instrument, it is assumed that nothing should be added to it. Therefore, as the rod support is equivalent aerodynamically to adding nothing,

[1] Roy H. Heald and Paul S. Ballif, Effect of yaw on vane anemometers, J. Research NBS **19**, 685 (1937) RP1056.

the rod support of figure 2 has been adopted for the purpose of calibration.

Experience with vane anemometers at the National Bureau of Standards has shown that it is possible to employ the rod support under nearly all conditions of use. Even when it is necessary to use a short rod, the interference from the member holding the rod is likely to be small. According to Heald and Ballif (see footnote 1), for example, the clamping device and strut shown in figure 9 had a negligible effect at distances downstream of 1 foot or more. Even at 4 in., the interference effect was only of the order of 1 or 2 percent. The strut in this case was 1¼ in. thick and 3 in. wide and extended completely across the tunnel.

WASHINGTON, November 4, 1947.