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## EFFECT OF SUPPORT ON THE PERFORMANCE OF VANE ANEMOMETERS

### INTRODUCTION

In June 1947 it was decided to use the wind tunnel rather than the whirling arm for calibrating vane anemometers at the National Bureau of Standards. While the scatter of observations in a wind tunnel was usually greater than that obtained with the whirling arm, the absolute accuracy on the whole was known to be greater because the uncertainty associated with swirl about a whirling arm was avoided.

In making the change to the wind tunnel, the question of the proper means of supporting an anemometer was brought to the fore. Since vane anemometers were supplied without support members of any sort, it was customary to fasten the anemometer on a flat plate at the end of the whirling arm as shown in figure 1. It was known that the support had some effect on the rate of the instrument, and to avoid possible error the instrument should be supported in the same way in use. However, a flat plate was hardly a logical type of mounting for a user to choose, It was suspected too that an observer might at times hold 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  $4\frac{1}{2}$ -foot wind tunnel.

### INTERFERENCE - FREE MOUNTING

If an anemometer is suspended in a wind stream on wires so fine that they are incapable of producing interference, the 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  $1/2$  inch in diameter produces no measurable interference when it extends directly downstream. Effects from members supporting the rod itself may be reduced to negligible proportions 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 1/8 inch in thickness. In the investigation of the interference produced by other types of support, the performance on the support in question was compared with that on the rod.

## OTHER SUPPORTS INVESTIGATED

### (a) 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 1/8 inch thick and 3 inches wide. The distance from the end of the arm to the end of the plate is 12 1/2 inches. The wind moves normal to the face opposite the dial and parallel to the flat side of the plate.

### (b) 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 represent 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-inch anemometer, the size referring to the inside diameter of the cylindrical housing.

Figure 3, hand No. 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 4, hand No. 2 shows one finger through the ring allowing the anemometer to hang down freely. The arm is at right angles to the wind.

Figure 5, hand No. 3 shows an anemometer being held by means of a short handle. The arm is directly downwind inclined at an angle of 45 degrees to the wind.



## RESULTS

Curves showing the performance of a 3-inch, a 4-inch, and a 6-inch 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 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 of 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-inch and 4-inch anemometers, but somewhat less on the 6-inch anemometer. A decrease with increasing size is to be expected because the anemometer becomes larger relative to its support. Since hands No. 1 and No. 2 produced roughly the same effect, No. 1 was used only with the 4-inch anemometer.

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 one 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 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 are treated in reference 1.

#### THE 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. Since an anemometer supplied by a manufacturer should be regarded as a complete instrument, it is assumed that nothing should be added to it. Therefore since the rod support is equivalent aerodynamically to adding nothing, 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 reference 1, for example, the clamping device and strut shown in figure 9 had a negligible effect at distances downstream of one foot or more. Even at 4 inches the interference effect was only of the order of one or two percent. The strut in this case was 1 1/4 inch thick and 3 inches wide and extended completely across the tunnel.

#### REFERENCE

1. Heald, Roy H. and Ballif, Paul S.: Effect of Yaw on Vane Anemometers. National Bureau of Standards Journal of Research, Vol. 19, Research Paper RP 1056, Dec. 1937.





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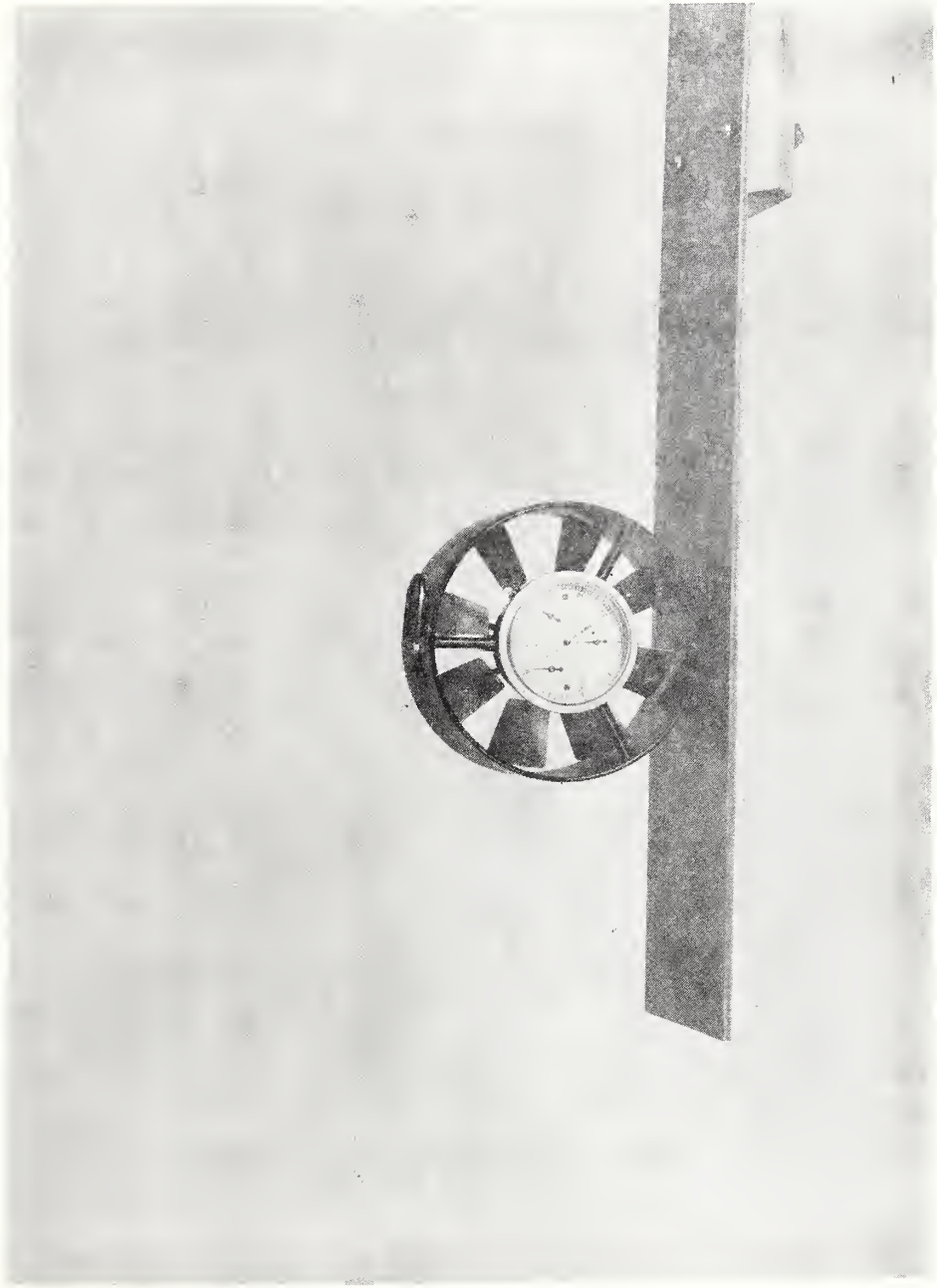


TABLE 1

Change in Indicated Speed Due to Interference,  
Expressed as Percentage of True Speed.

<u>Support</u>	<u>True Air Speed, fpm</u>					<u>Average</u>
	400	600	800	1200	1600	
	3-Inch Anemometer					
Rod	0	0	0	0	-	0
Plate	5.6	5.6	5.4	5.0	-	5.4
Hand No. 1	-	-	-	-	-	-
Hand No. 2	15.6	16.1	15.4	14.4	-	15.4
Hand No. 3	14.6	14.5	14.1	13.4	-	14.2
	4-Inch Anemometer					
Rod	0	0	0	0	0	0
Plate	5.5	5.3	5.4	5.1	4.7	5.2
Hand No. 1	18.1	17.1	16.8	16.2	15.9	16.8
Hand No. 2	18.1	16.9	16.5	16.5	16.8	17.0
Hand No. 3	11.5	11.8	11.9	11.7	-	11.7
	6-Inch Anemometer					
Rod	0	0	0	0	0	0
Plate	5.6	4.3	3.7	3.3	-	4.2
Hand No. 1	-	-	-	-	-	-
Hand No. 2	12.7	11.8	11.9	11.9	12.0	12.1
Hand No. 3	10.7	10.3	10.1	9.7	9.6	10.1





**FIGURE 1 - FLAT PLATE**

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*FIGURE 2 - ROD SUPPORT*







**FIGURE 4 - HAND NO. 2**



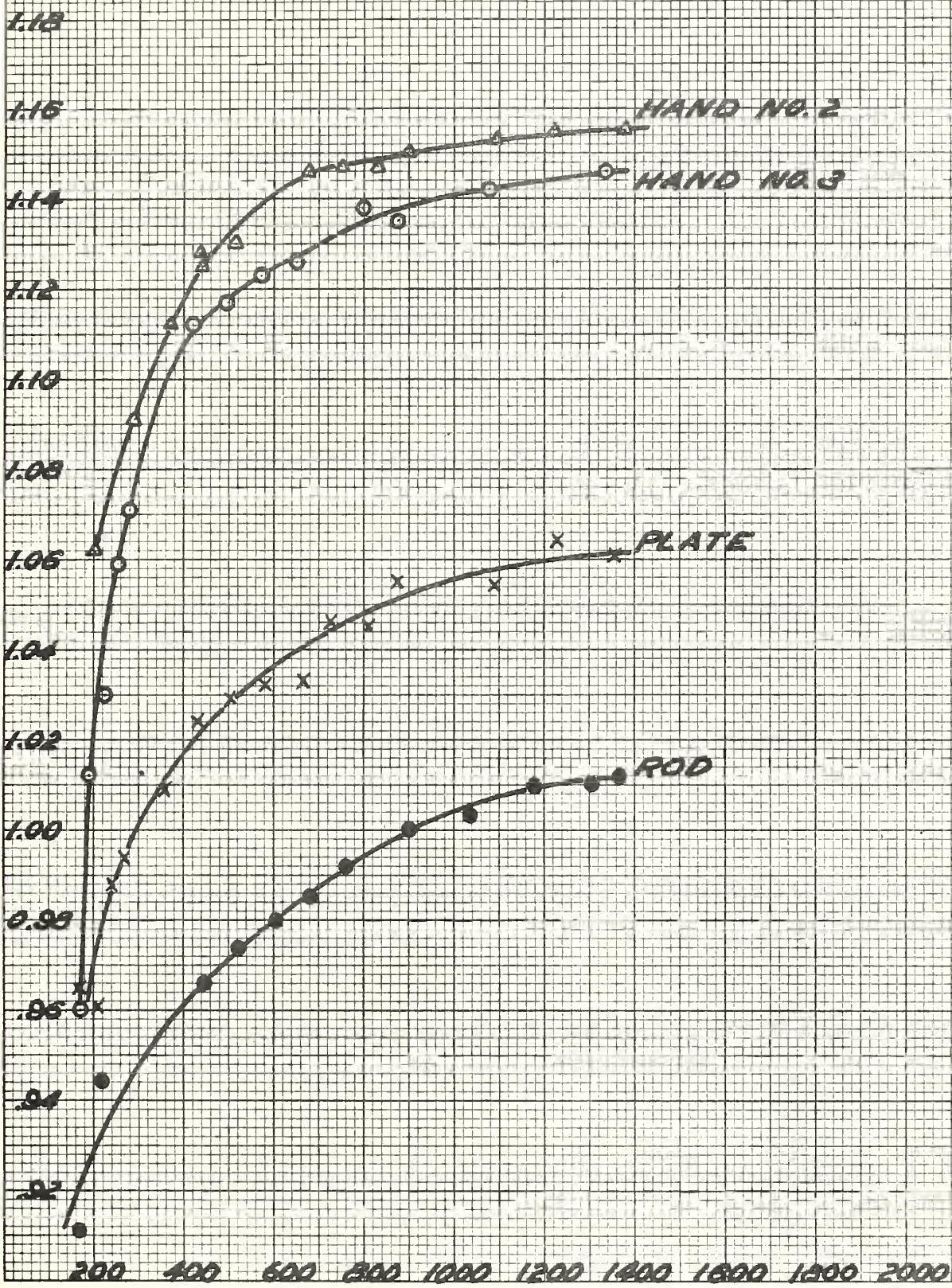


**FIGURE 5 - HAND NO. 3**



# 3-INCH 3-VANE ANEMOMETER

RATIO OF INDICATED TO TRUE AIR SPEED



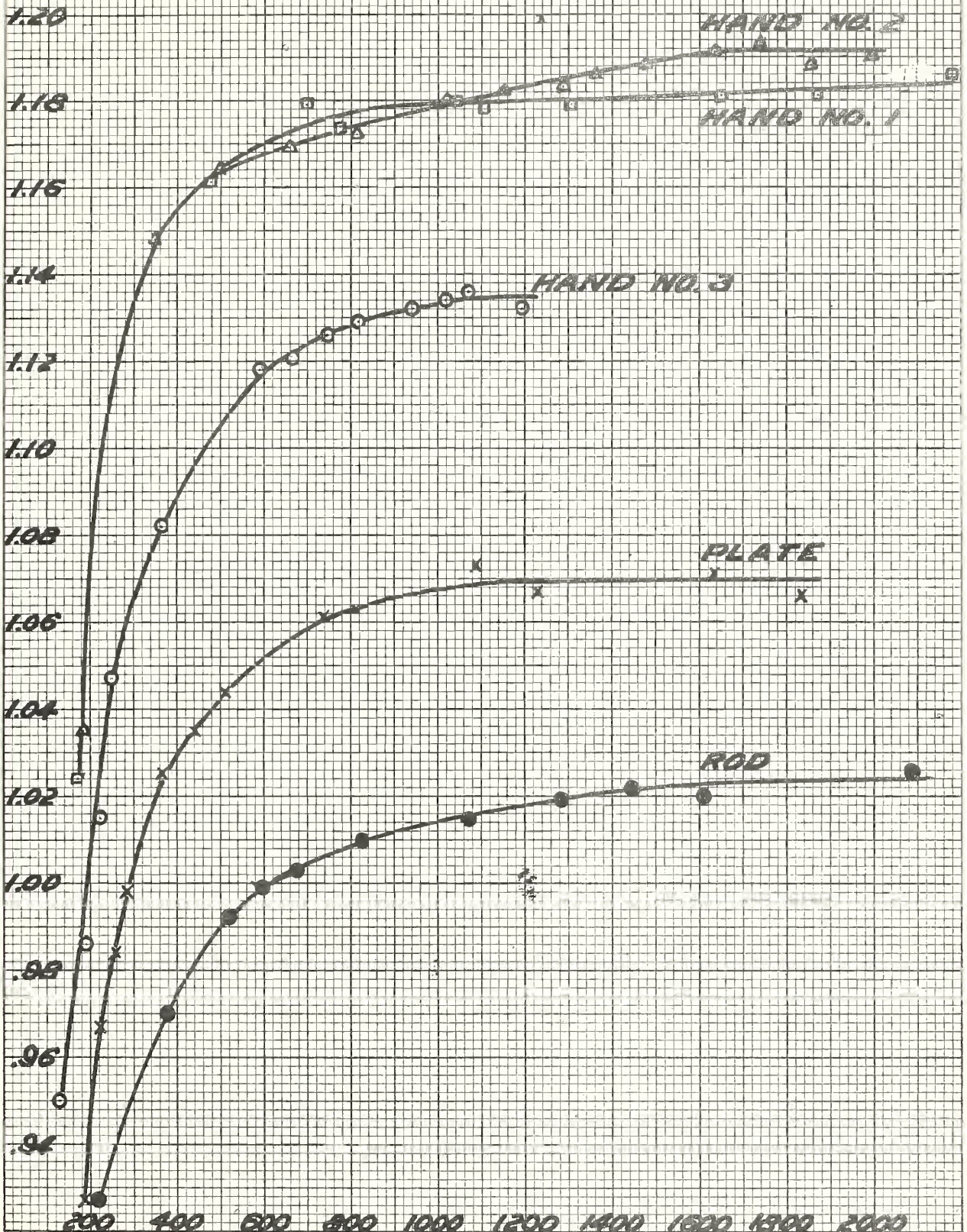
TRUE AIR SPEED - FEET PER MINUTE

FIGURE 6



# 4-INCH 3-VANE ANEMOMETER

RATIO OF INDICATED TO TRUE AIR SPEED



TRUE AIR SPEED - FEET PER MINUTE

FIGURE 7





# 6-INCH 10-VANE ANEMOMETER

RATIO OF INDICATED TO TRUE AIR SPEED

1.18  
1.16  
1.14  
1.12  
1.10  
1.08  
1.06  
1.04  
1.02  
1.00  
0.98  
0.96  
0.94  
0.92

HAND NO. 2

HAND NO. 3

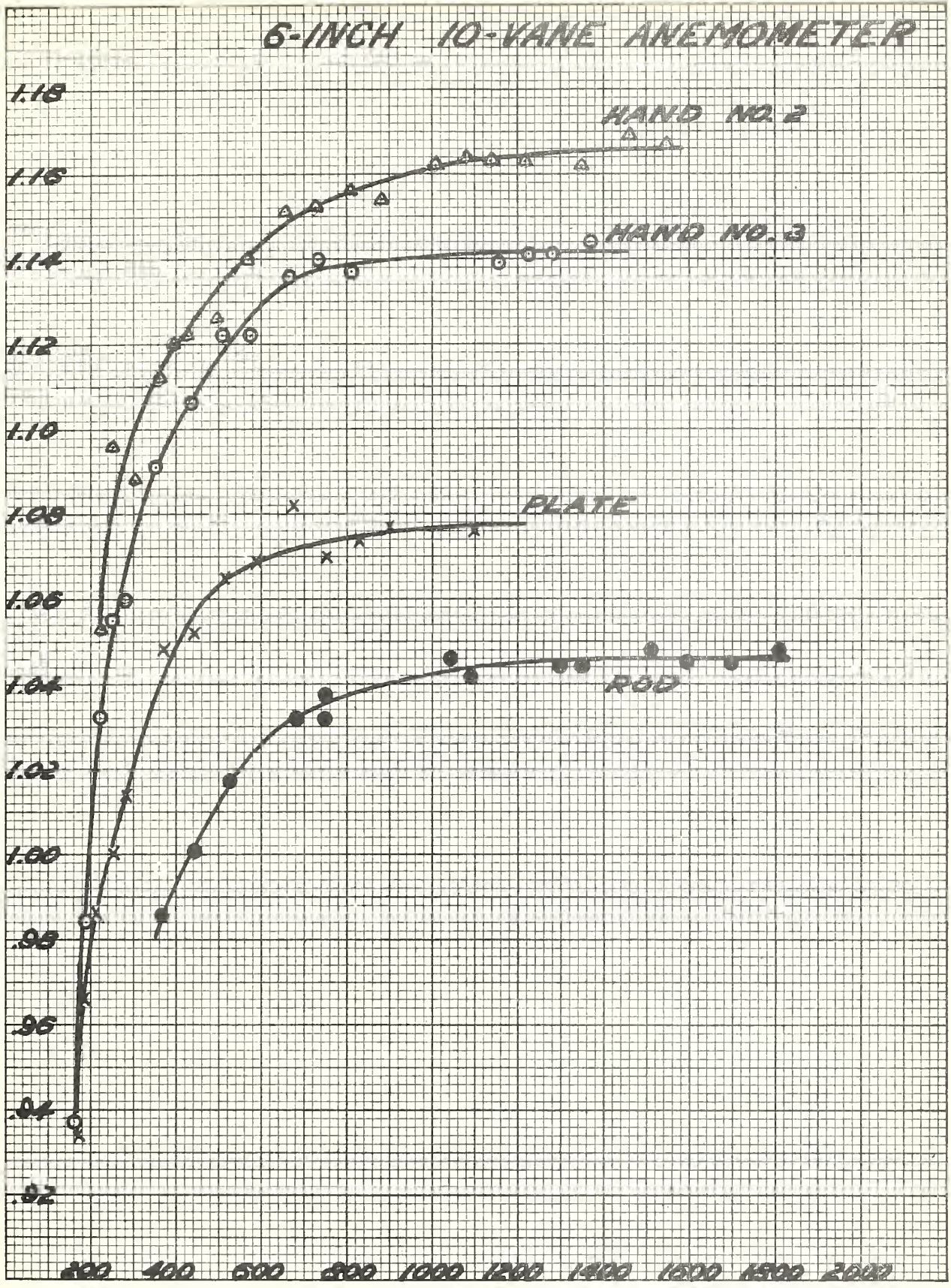
PLATE

ROD

200 400 600 800 1000 1200 1400 1600 1800 2000

TRUE AIR SPEED - FEET PER MINUTE

FIGURE 8





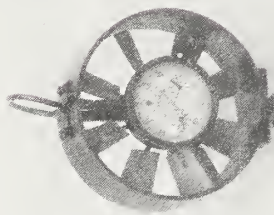


FIGURE 9 - ROD AND STRUT SUPPORT

