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RESEARCH MEMORANDUM

for the

Naval Research Laboratory, Department of the Navy

CALIBRATION TESTS OF A GERMAN LOG RODMETER

By Elmo J. Mottard and Everette R. Stillman

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SUMMARY

A German log rodmeter of the pitot-static type was calibrated in Langley tank no. 1 at speeds up to 34 knots and angles of yaw from 0° to $\pm 10\frac{3}{4}^{\circ}$. The dynamic head approximated the theoretical head at 0° yaw but decreased as the yaw was increased. The static head was negative and in general became more negative with increasing speed and yaw. Cavitation occurred at speeds above 31 knots at 0° yaw and 21 knots at $10\frac{3}{4}^{\circ}$ yaw.

INTRODUCTION

Calibration of a German log rodmeter was requested by the Naval Research Laboratory, Department of the Navy, for comparison with similar calibrations of other rodmeters. The German rodmeter is a pitot-static type having a static orifice at the bottom of a streamline strut and three dynamic orifices on the leading edge of the strut. Static and dynamic pressures were measured at speeds up to 34 knots and for angles of yaw from 0° to $\pm 10\frac{3}{4}^{\circ}$.

DESCRIPTION OF THE RODMETER

Photographs of the rodmeter, which was furnished by the Naval Research Laboratory, are presented in figure 1. The location and dimensions of the static and dynamic orifices on the streamline strut are shown in figure 2. The streamline strut, which was $20\frac{3}{8}$ inches long was fitted to the bottom of a $2\frac{3}{4}$-inch-diameter supporting tube. The pressure lines for transmitting pressures from the orifices to the top of the supporting tube were already installed.

INSTALLATION AND PROCEDURE

The installation is shown in figure 3. The rodmeter was rigidly attached to the towing carriage so that the center dynamic orifice was 18 inches and the bottom of the strut $20\frac{11}{64}$ inches below the water surface. The rod had no rake and the centerline, therefore, was perpendicular to the surface of the water. At 0° yaw, a plane through the dynamic orifices and the trailing edge of the strut was parallel to the direction of motion.

The pressures were transmitted, by means of rubber tubing, to two mercury manometers. A pump and an air trap were provided for the dual purpose of filling the lines with water from the tank and for removing the air from the water in the lines. The specific gravity of the water in the tank was 1.014 at a temperature of 72° F.

The bottom of a steel channel, shown in figure 3, served as a blocking plate which prevented the downward passage of air to the orifices. The sides of the channel served as spray shields.

Before each test run the reading of each manometer was observed, and whenever the readings indicated the presence of air in the lines the air was removed by drawing water into the air trap, lowering the pressure in the trap until most of the dissolved air was removed, and allowing the water to run back into the lines again. This procedure was followed in order to prevent the release of dissolved air in the static line during the test runs.

RESULTS AND DISCUSSION

Deflections of the manometers were converted to pressures in feet of water by the formula

$$h = \frac{d}{30.48}\left(\frac{\rho_1}{\rho_2} - \frac{1}{2}\right)$$

where

h head, feet of water

d deflection of manometer, centimeters

ρ_1/ρ_2 ratio of density of mercury to density of the water in tank (13.359 for these tests)

The values of h are applicable to water of any density in which the rod may be used.

Rod coefficients were calculated by the formula

$$C = \frac{V}{\sqrt{2gH}}$$

where

C rod coefficient

H head at dynamic orifice minus head at static orifice, feet of water

V measured velocity, feet per second

g gravitational acceleration, (32.2) feet per second per second

The variation of the head at the dynamic orifice, the head at the static orifice, and the rod coefficient with velocity for yaw angles up to $\pm 10\frac{3}{4}^{\circ}$ are shown in figure 4. The curves showing the variation of rod coefficient with velocity were obtained from the faired curves of the dynamic and static head.

The dynamic head was positive in every case and approximated very closely the theoretical head $\frac{V^2}{2g}$ at 0° and $\frac{3}{4}^{\circ}$ yaw. The dynamic head decreased with increasing angle of yaw but was greater for right yaw than for corresponding left yaw. The head at the static orifice was negative in every case and became more negative with increasing speed and yaw. At $10\frac{3}{4}^{\circ}$ yaw the static head reached a maximum negative value of about –6 feet of water at a speed of about 25 knots. Further increase in speed resulted in a decrease in the negative head, which was probably caused by cavitation. Cavitation first occurred in the region of maximum thickness of the rod a few inches up from the tip and was observed at speeds above approximately 31 knots with the rod at 0° yaw, 25 knots at $5\frac{3}{4}^{\circ}$ yaw, and 21 knots at $10\frac{3}{4}^{\circ}$ yaw.

CONCLUDING REMARKS

The results of the calibration tests made with the German log rodmeter indicated that the dynamic head approximated the theoretical head at 0° yaw and decreased with increase in angle of yaw. The head at the static orifice was negative and in general became more negative with increasing speed and yaw. Cavitation was observed in the region of maximum thickness of the rod at speeds above 31 knots at 0° yaw and 21 knots at $10\frac{3}{4}^{\circ}$ yaw.

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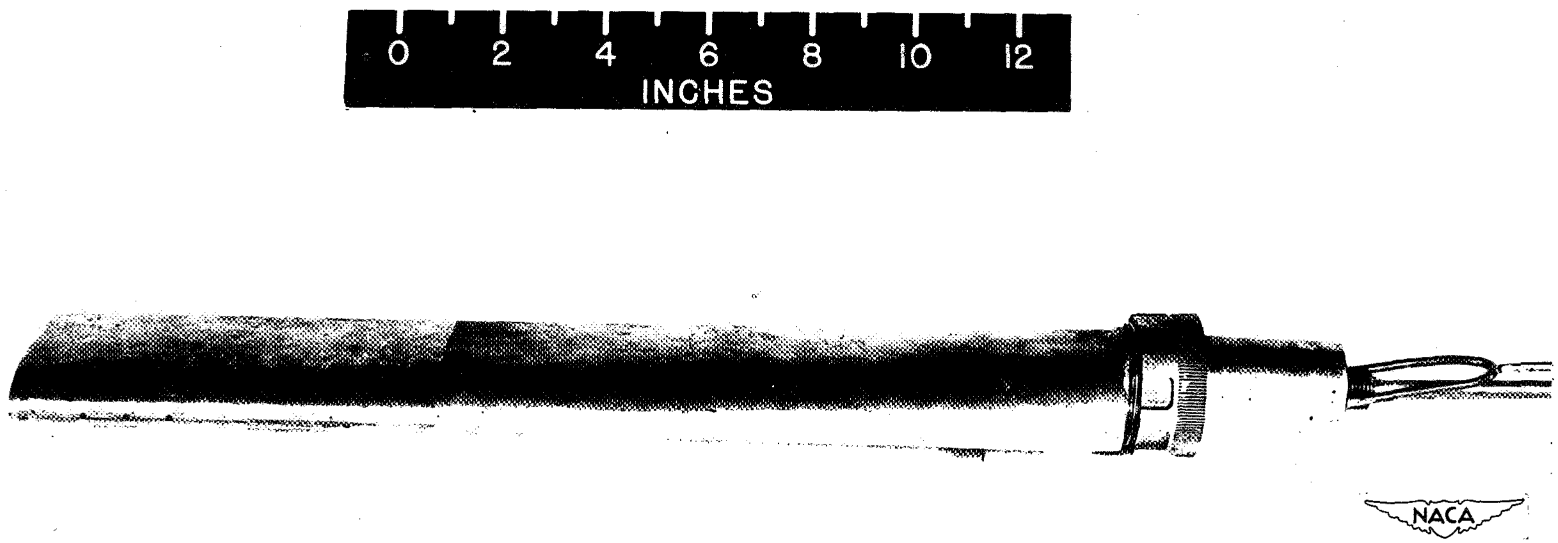
(a) Three–quarter view of base.

Figure 1.– German log rodmeter.



(b) Front view of rodmeter.

Figure 1.- Concluded.

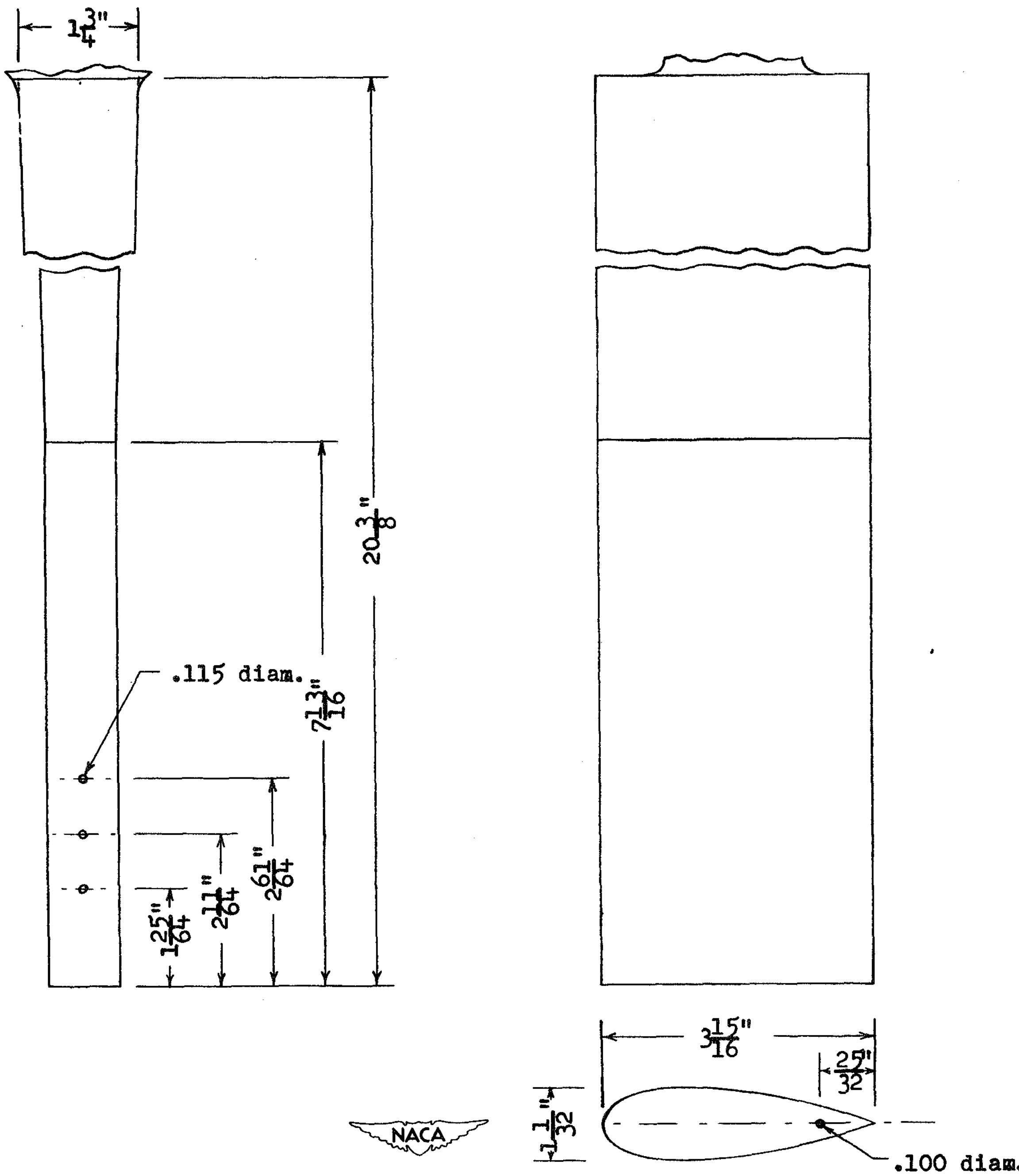


Figure 2.— Dimensions of the head of the German log rodmeter.

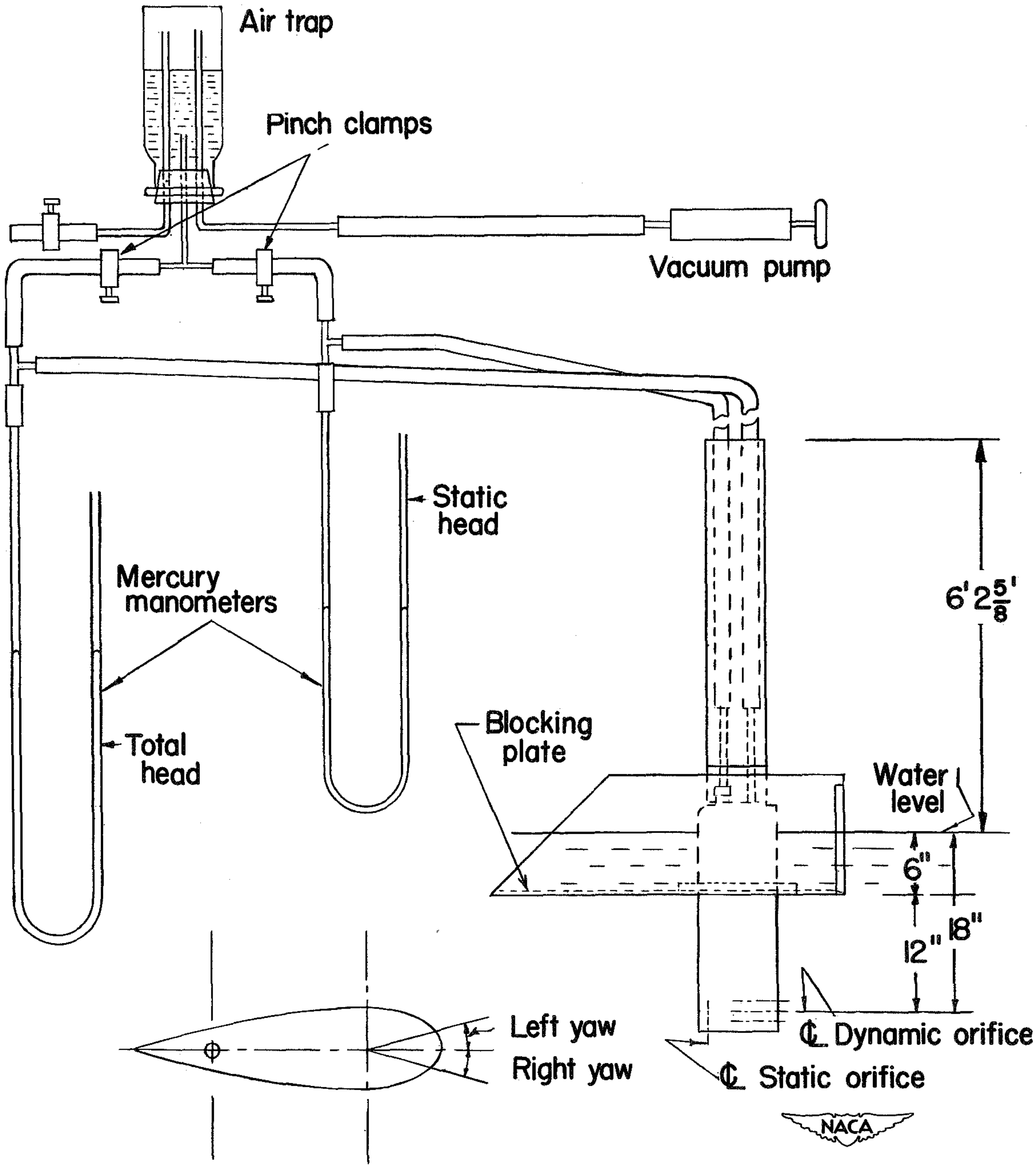
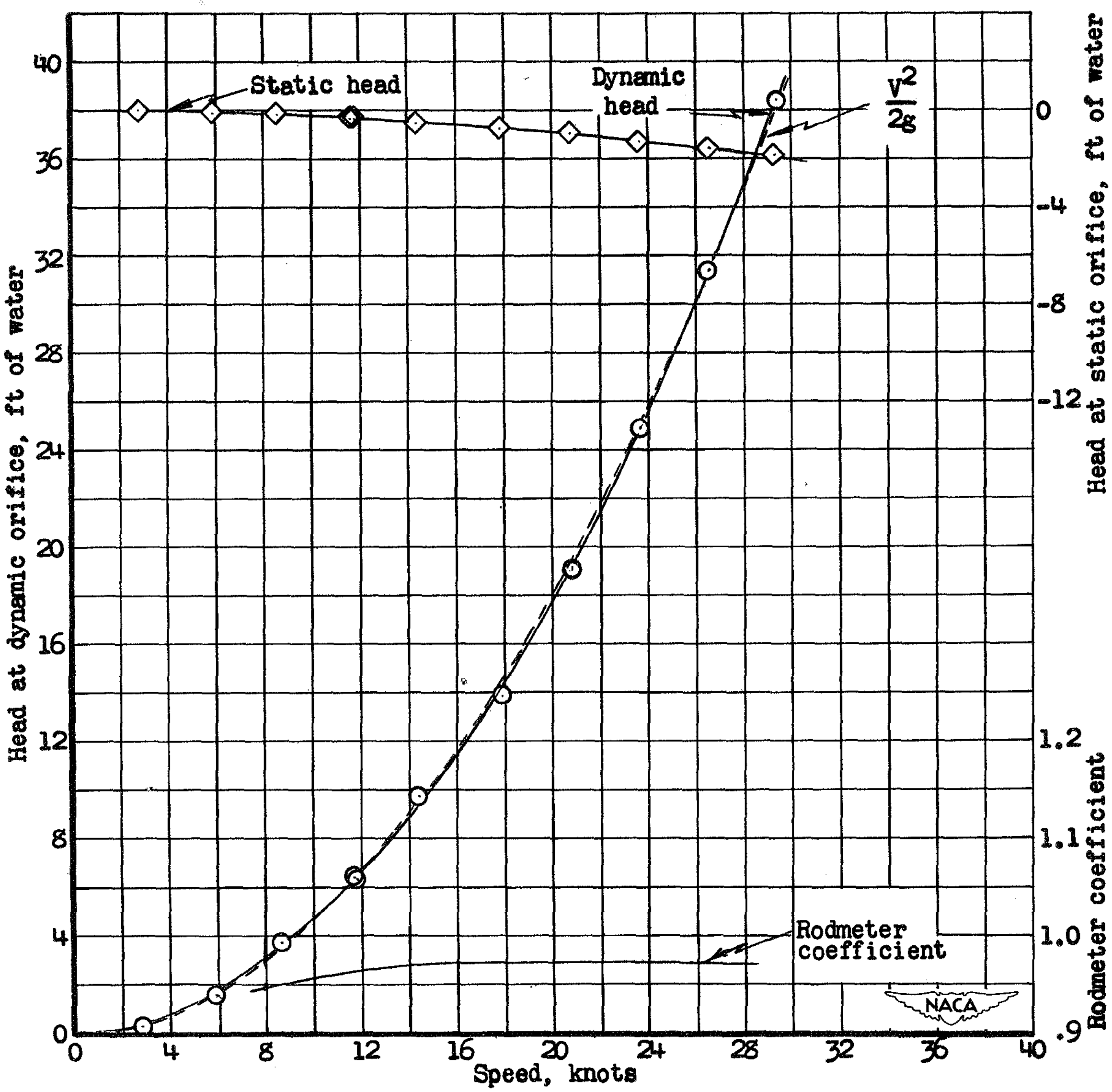
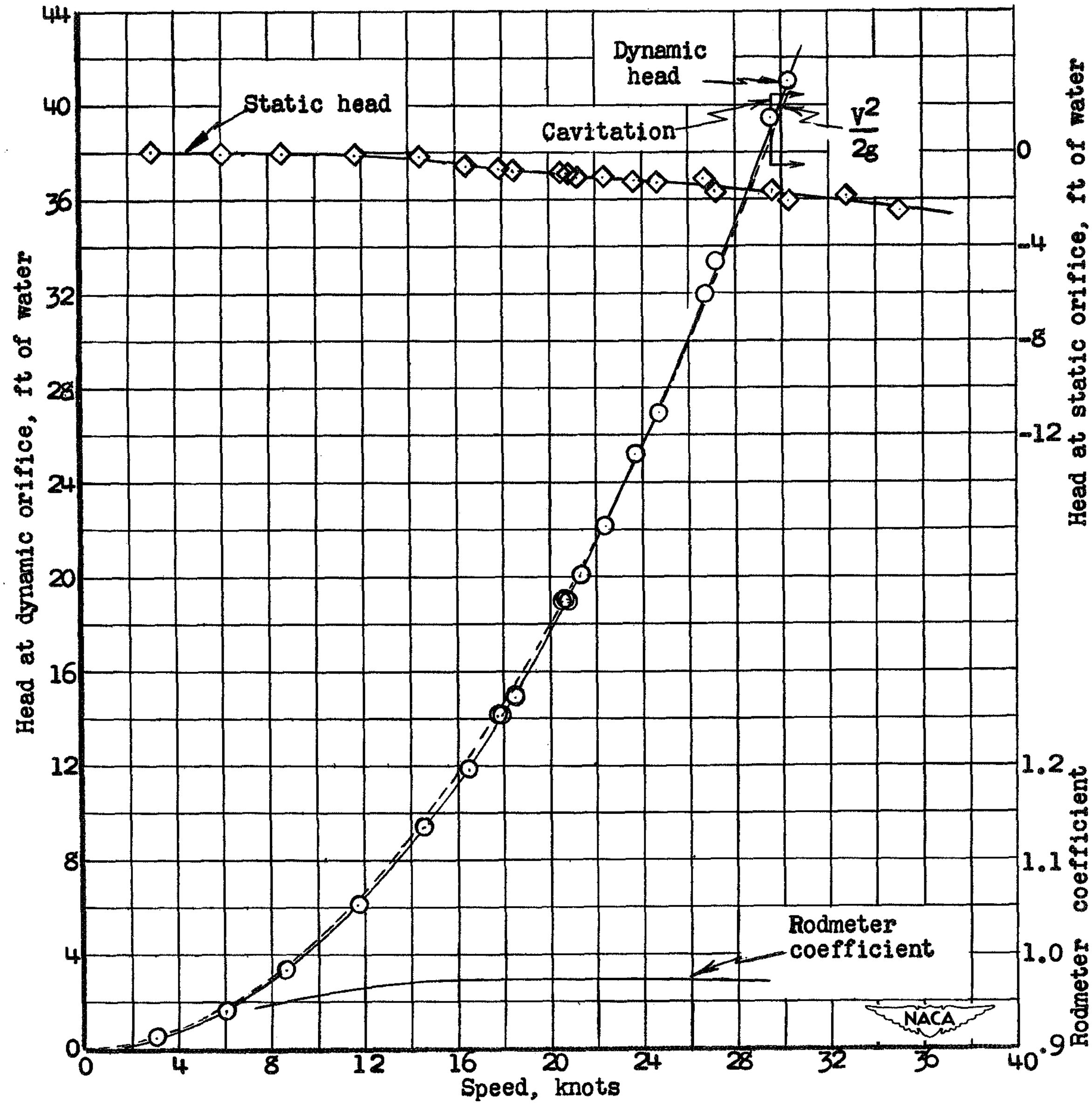


Figure 3.— Apparatus for calibration of the rodmeter.



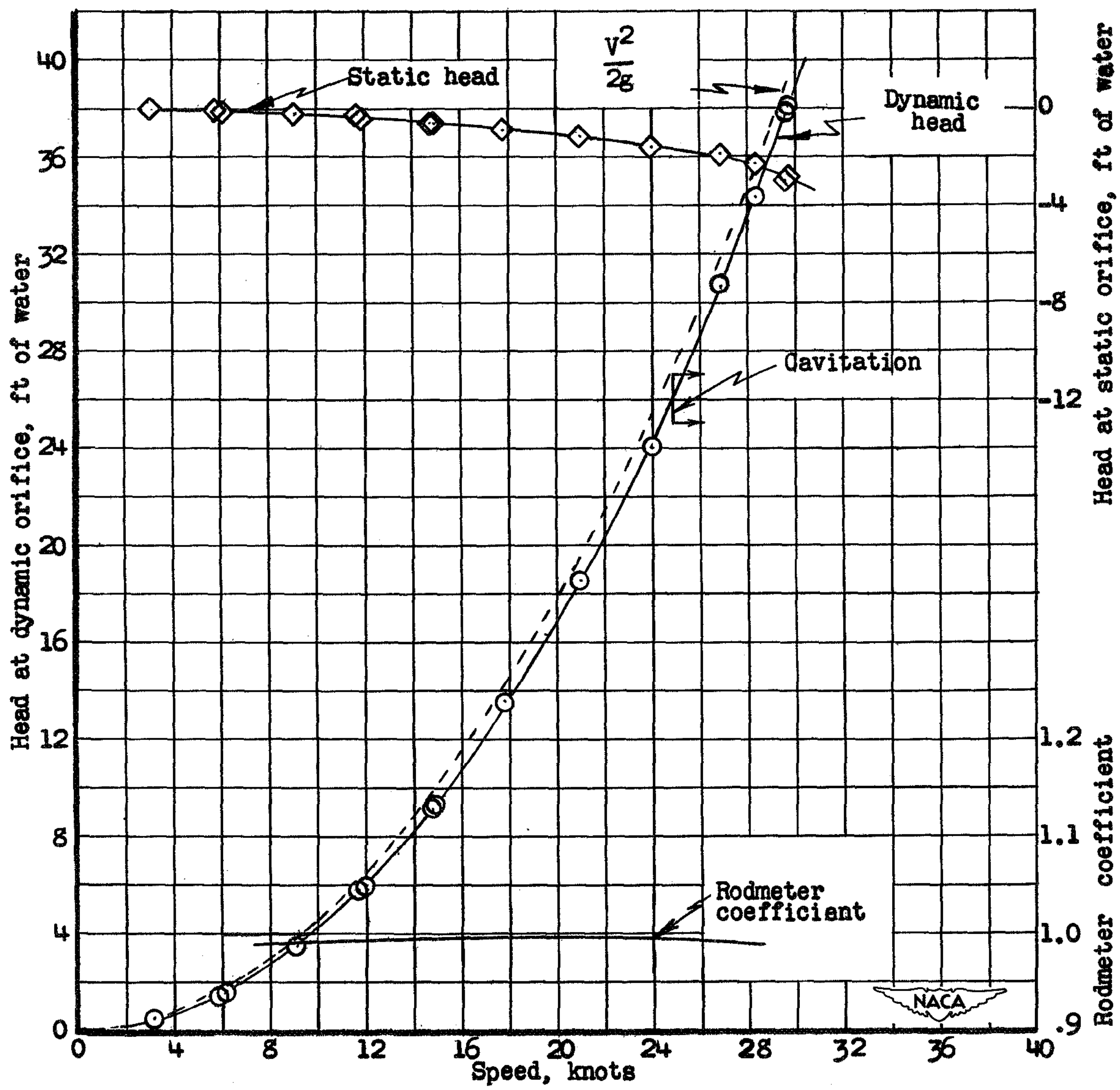
(a) 0° yaw.

Figure 4.– Calibration of German log rodmeter.



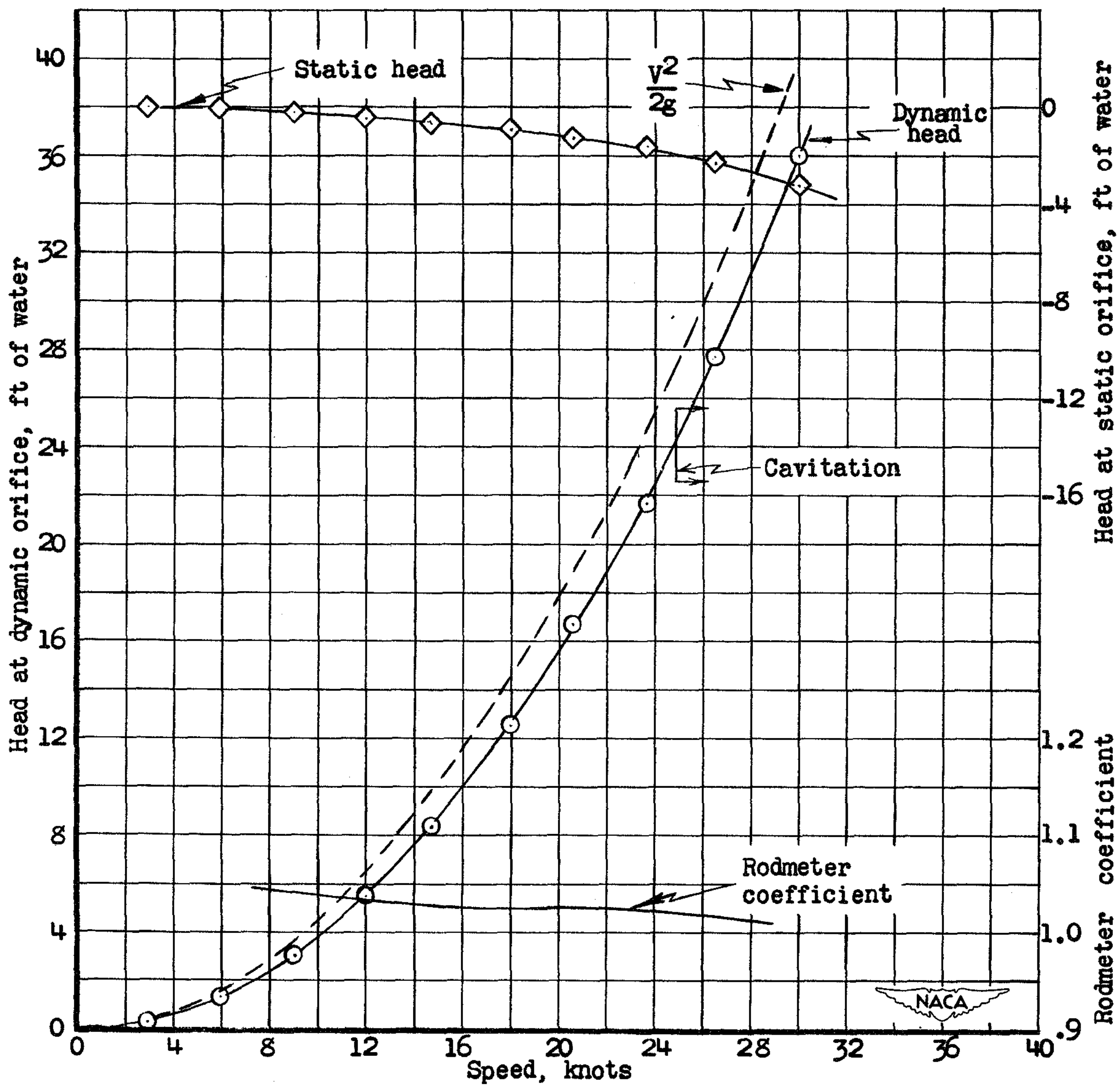
(b) $\frac{3}{4}^{\circ}$ right yaw.

Figure 4.– Continued.



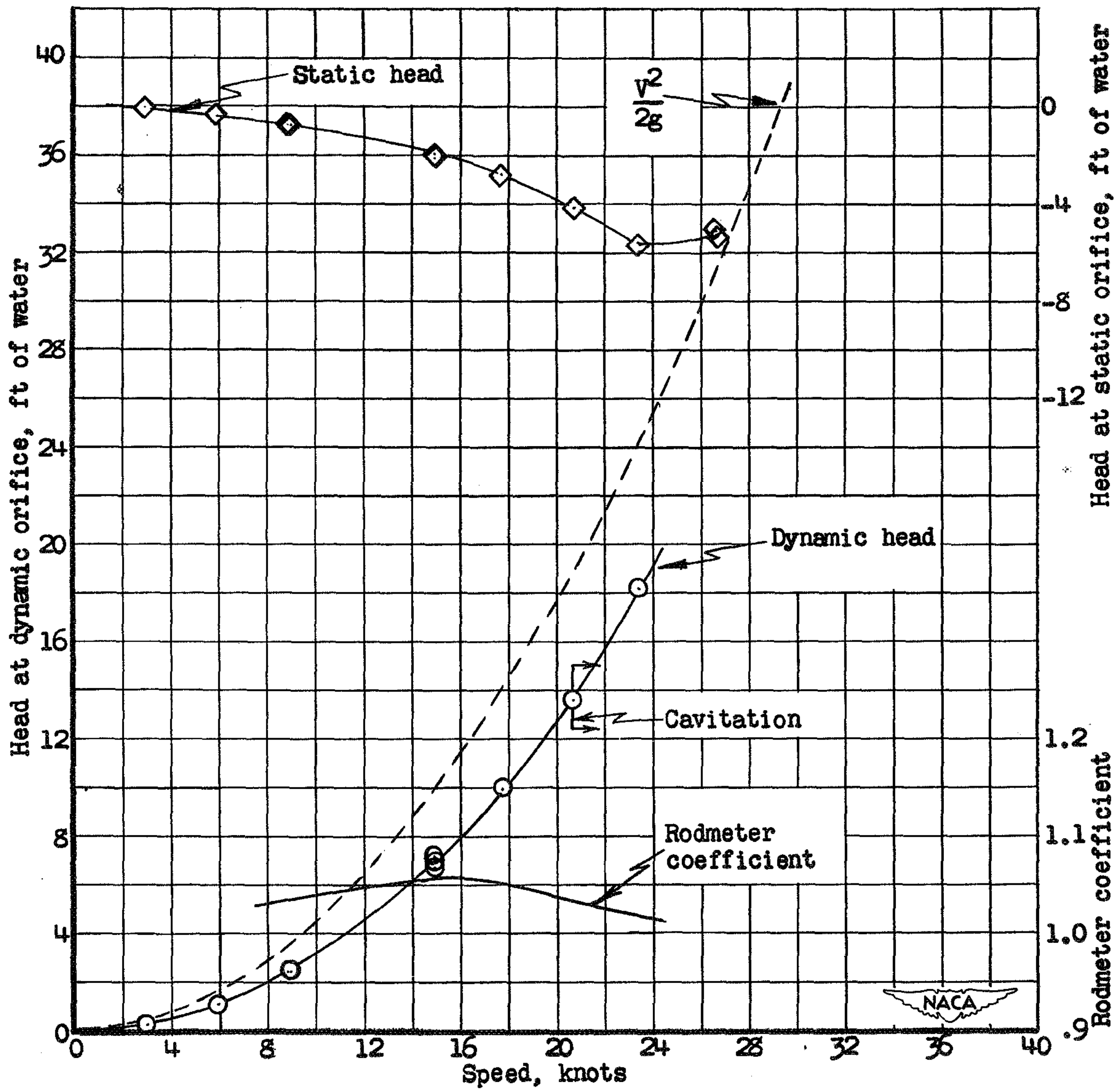
(c) $5\frac{3}{4}^{\circ}$ right yaw.

Figure 4.– Continued.



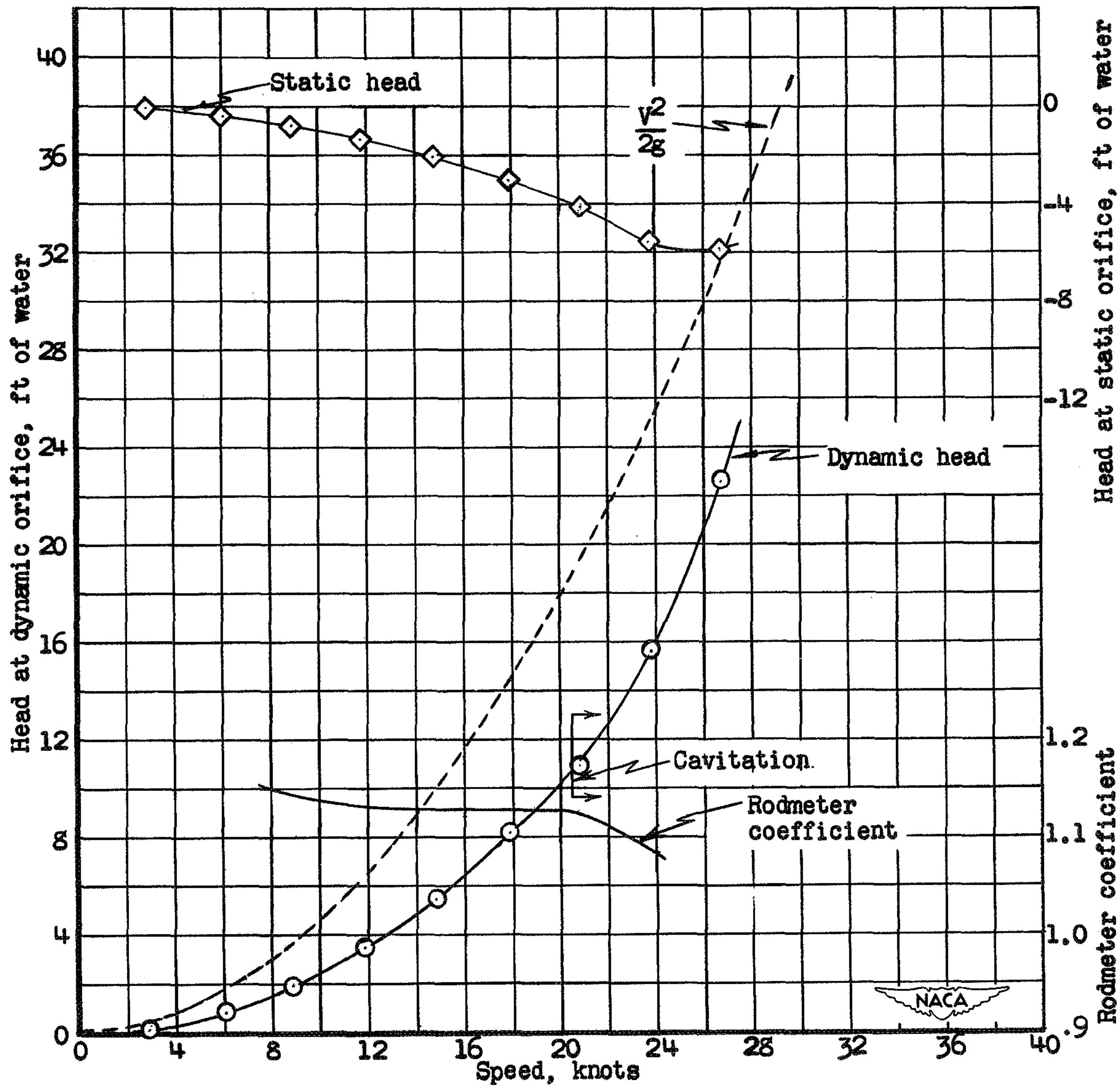
(d) $5\frac{3}{4}^{\circ}$ left yaw.

Figure 4.– Continued.



(e) $10\frac{3}{4}^{\circ}$ right yaw.

Figure 4.– Continued.



(f) $10\frac{3}{4}^{\circ}$ left yaw.

Figure 4.– Concluded.