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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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EFFECT OF LONGITUDINAL STEPS ON SKIPPING CHARACTERISTICS OF PB2Y-6 FLYING BOAT

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Naval Air Test Center

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SUMMARY

Landing tests were made with the PB2Y-6 flying boat to determine the effect of production step vents and forebody longitudinal steps on skipping. It was found that skipping occurred at higher landing trims without either step vents or longitudinal steps. The step vents alleviated skipping somewhat but were not considered large enough to be completely effective. The longitudinal steps caused a marked decrease in skipping which was not further affected by the addition of step ventilation.

INTRODUCTION

Information given on page 18 of reference 1 indicates that external longitudinal steps on the forebody of a dynamic model of a flying boat constituted a powerful method for reducing the skipping of that particular model. The discussion in reference 1 indicates that the longitudinal steps effectively doubled the step height; a model which had quite unsatisfactory landing characteristics without them became satisfactory after their installation.

It is generally conceded that the skipping characteristics of the PB2Y-6 flying boat are not satisfactory. Reference 2 indicates that the airplane would have good hydrodynamic landing stability if the step height could be doubled. Since external longitudinal steps on the forebody appeared to offer the possibility of effectively doubling the step height, the Bureau of Aeronautics requested that such steps be installed on the forebody of a PB2Y-6 for test. It was thought that useful information could be obtained at the same time relative to the influence of the production step vents on the skipping characteristics of the PB2Y-6. Wind-tunnel tests of longitudinal steps on a similar hull are presented in reference 3.

AIRPLANE DESCRIPTION

A PB2Y-6 airplane was used to conduct the tests. The airplane was equipped with Pratt & Whitney R-1830-94 engines, with Curtiss electric, three-blade, $12\frac{1}{2}$-foot-diameter propellers, and with two standard production step vents. The special internal vent cover plates, mounted flush with the hull bottom, could be opened and closed from inside by means of a $\frac{3}{8}$-inch tube with an attached locking device. External longitudinal steps were installed on the underside of the hull forebody during the latter part of the tests; the location and construction details of these steps are shown by figure 1.

A descriptive arrangement drawing of a PB2Y-6 airplane is given as figure 2.

TEST METHOD

Tests were conducted at a gross weight of 58,000 pounds with the center of gravity located at 28 percent of the mean aerodynamic chord. Flaps were in the full-down (40°) position for all landings.

An NACA trim-angle indicator (see reference 4 for description) was mounted directly in front of the copilot and was calibrated to show the inclination of the longitudinal axis of the airplane.

Landings were made with the following four configurations:

1. Without longitudinal steps; vents closed
2. Without longitudinal steps; vents open
3. With longitudinal steps; vents closed
4. With longitudinal steps; vents open

The final approach to each landing was made at an engine speed of 2550 rpm. The manifold pressure was adjusted to obtain a rate of descent of less than 50 feet per minute, and the desired trim angle was obtained by using the NACA trim-angle indicator in conjunction with the proper elevator setting. Once contact was made with the water, neither the power setting nor the elevator position was changed until the landing run was completed.

At least 10 landings were made at each critical trim angle. The average of the wind velocities for all landings was 10 knots.

Deformation of the steps, resulting from water loads imposed during the first series of landings, is shown in figures 3 and 4. Rather than restore the steps to their original shape, reinforcing patches were attached, and the remainder of the test was conducted with the steps in the deformed condition.

DISCUSSION OF RESULTS

The results of the skipping tests of the PB2Y-6 airplane are presented in graphical form in figure 5 and in summary form in the following table:

	Vent position	Trim angle for skipping
Without longitudinal steps	Open Closed	Above 4.5° Above 3°
With longitudinal steps	Open Closed	Above 9° Above 9°

Indicated airspeeds varied from 76 knots at a trim angle of 2° to 60 knots at a trim angle of $10\frac{1}{2}^{\circ}$. True water speeds varied from approximately 66 knots to 50 knots at trim angles of from 2° to $10\frac{1}{2}^{\circ}$, respectively.

Since the primary purpose of the test was to determine the trim angle at which the initial skip occurred and since severe skipping developed at the higher trim angles, the airplane was not landed above a trim angle of 7° without longitudinal steps installed. However, with longitudinal steps installed, landings free from skipping were possible up to and including a trim angle of 9°. Upon contact with the water above a trim angle of 9°, the nose-down pitching moment was sufficiently strong to cause porpoising or a pitching oscillation which resulted in skipping. At a trim angle of approximately 8.5°, the forebody and afterbody of the airplane hull contacted the water simultaneously.

The critical trim angles for skipping were slightly lower during calm water landings.

CONCLUDING REMARKS

Landing tests were made with the PB2Y-6 flying boat to determine the effect of production step vents and forebody longitudinal steps on skipping.

The standard production step vents had only a small effect on increasing the range of trim angles free from skipping.

Longitudinal steps on the forebody constituted a powerful method for improving the landing stability of the PB2Y-6 airplane used in the tests. It was found that they are subject to rather high water loads and hence care should be exercised in their design should they be used on a production airplane.

Naval Air Test Center
Patuxent River, Md., May 27, 1946

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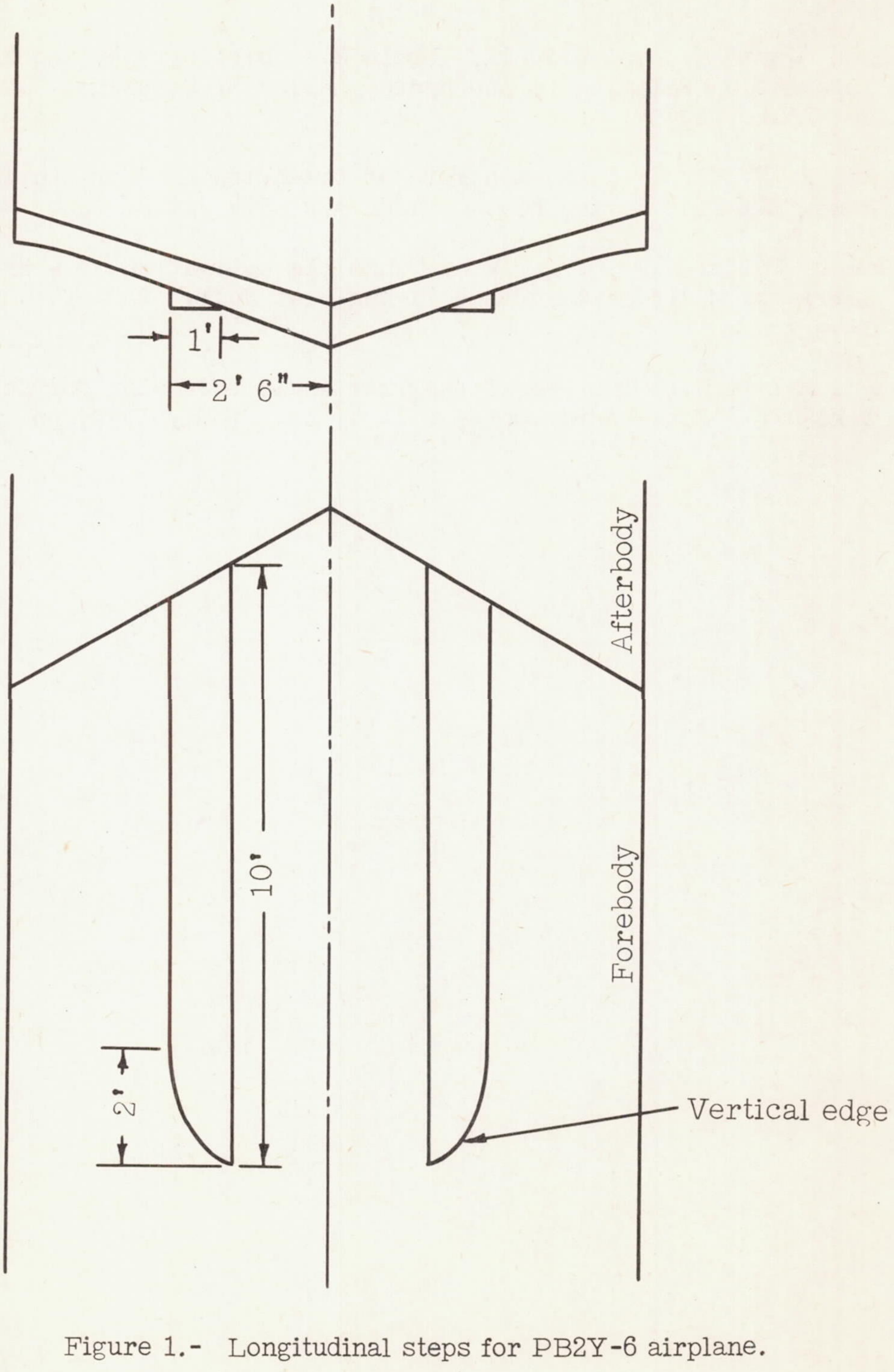


Figure 1.- Longitudinal steps for PB2Y-6 airplane.

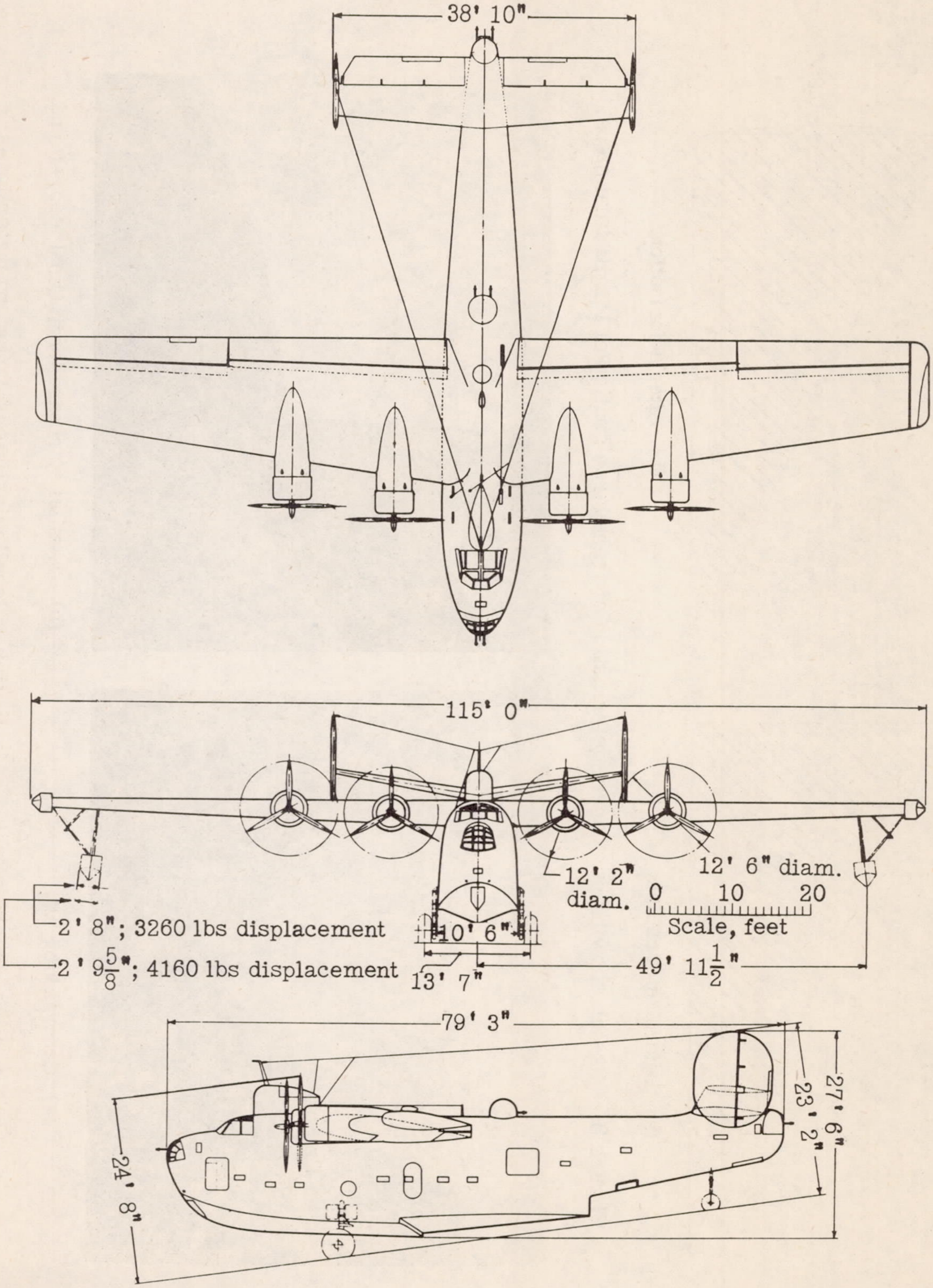
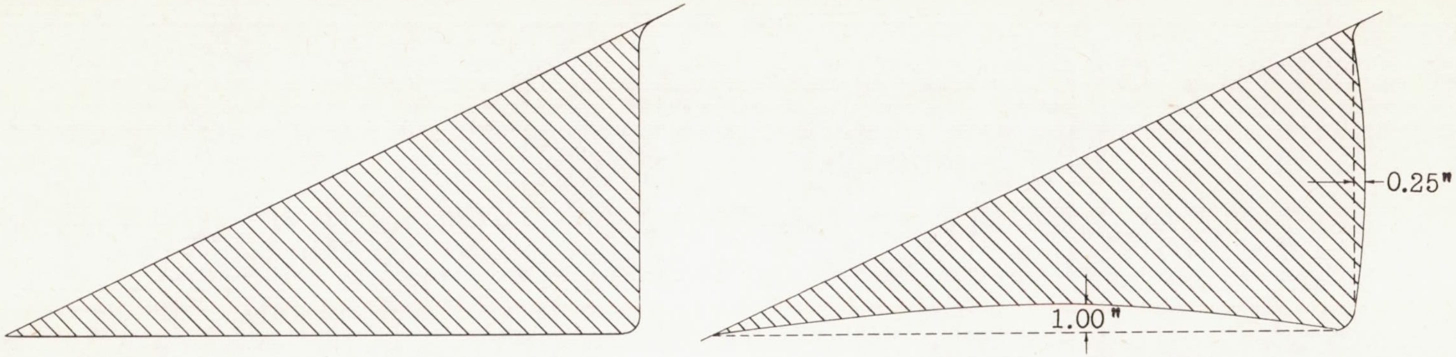


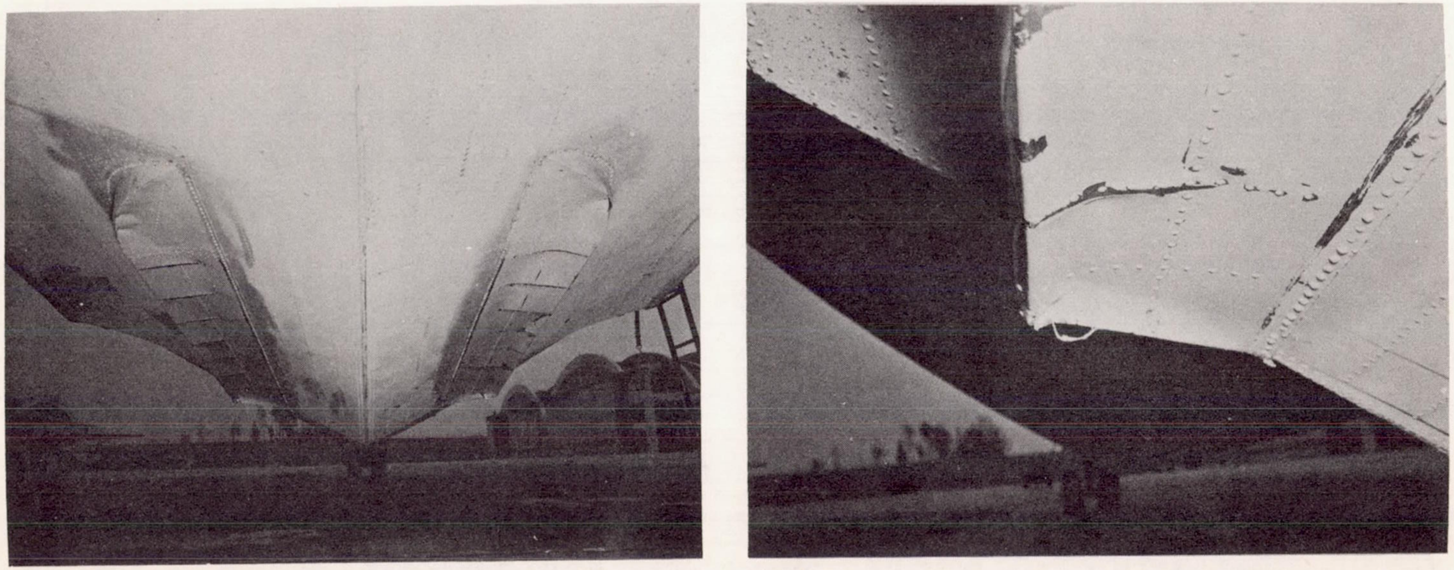
Figure 2.- Descriptive arrangement of PB2Y-6 airplane.



(a) Before deformation.

(b) After deformation.

Figure 3.- Sketch showing permanent deformation of transverse section of longitudinal steps.



(a) General view aft.

(b) Detail of starboard longitudinal step; aft end.

Figure 4.- Photographs showing deformation of longitudinal steps caused by water loads.

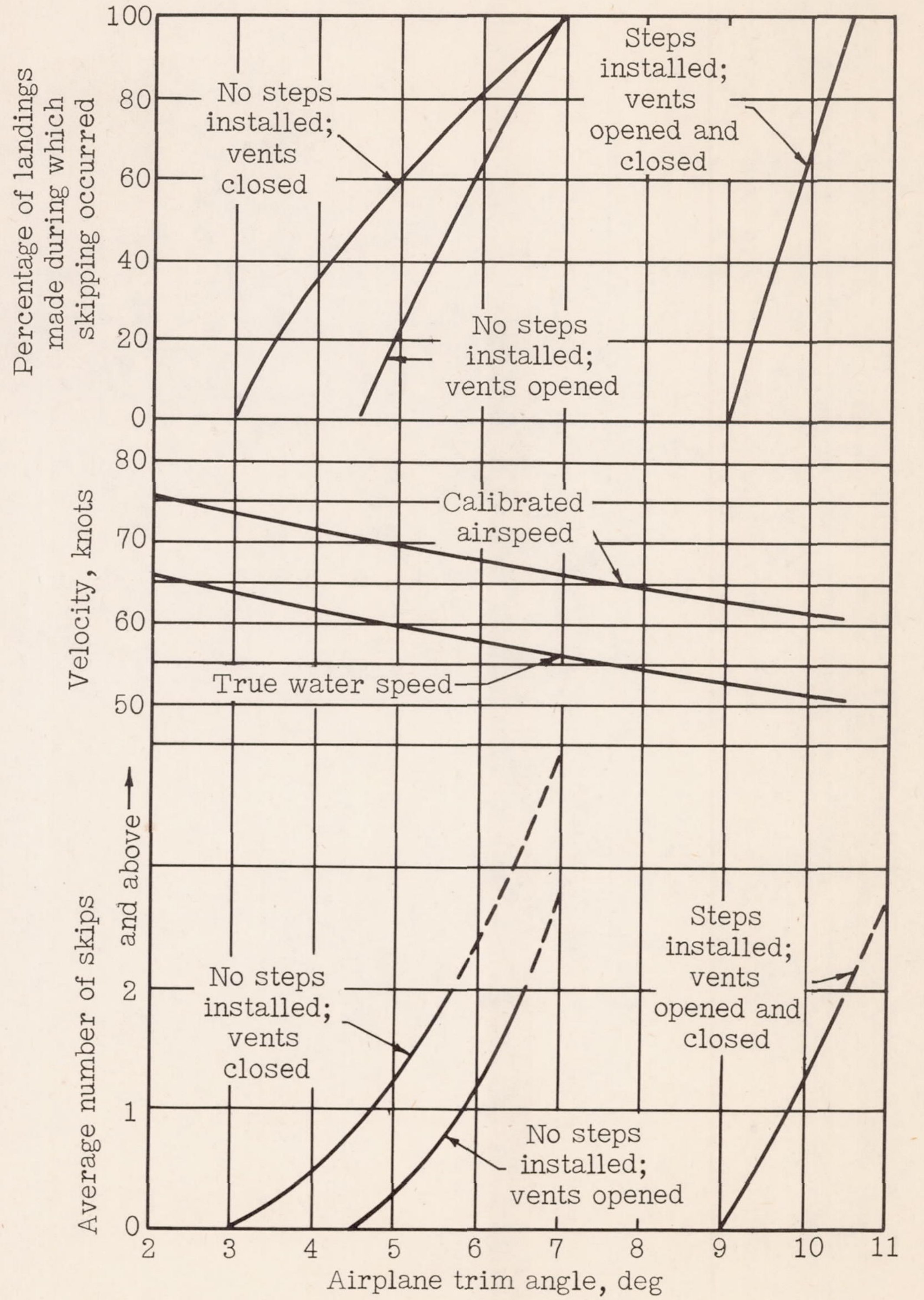


Figure 5.- Skipping characteristics of PB2Y-6 airplane. Velocity and trim-angle measurements were made the instant airplane contacted water.