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HYDRODYNAMIC-STABILITY TESTS OF A MODEL OF A FLYING BOAT AND OF A PLANING SURFACE HAVING A SMALL DOWNWARD PROJECTION (HOOK) ON THE PLANING BOTTOM NEAR THE STEP

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By James M. Benson

SUMMARY

Stability tests of two dynamic models in NACA tank no. 1 were carried out to investigate briefly the effects of adding a small projection (hook) on the planing bottom of the forebody near the step of a seaplane. Tests with a wedge-shape and a half-round projection extending the full width of the model and extending downward about eight-tenths of 1 percent of the beam had rather large effects upon all trim limits and also upon the landing stability. All trim limits were lowered, about 4° at high speeds, and the tendency to skip on landing was increased.

INTRODUCTION

The planing bottom of a seaplane of current design generally has no longitudinal curvature in the forebody near the step. Tank tests of models (references 1 and 2) have indicated that some desirable effect upon the resistance and trimming-moment characteristics may be obtained by use of a small hook at the step. Service trials of a flying boat fitted with a hooked step have shown very undesirable stability characteristics (see reference 2), particularly at landing; this effect has caused the Bureau of Aeronautics to discontinue the use of that form of bottom. During tests of dynamic models in NACA tank no. 1, it has been observed occasionally that relatively small irregularities on the forebody near the step - for example, wrinkles in the film used to cover the bottom - caused a noticeable reduction in the lower trim limit of stability.

The present tests were carried out to determine the effect upon stability characteristics of adding a hook at the step with a view toward reproducing on a model the landing instability observed by the Bureau of Aeronautics. The tests were also undertaken to explore the magnitude of the effect caused by irregularities of the bottom that may be introduced unintentionally by alterations of a model during dynamic tests. A simple, wedge-shape strip with the apex forward was attached to the model for obtaining the stability characteristics of a hook on the forebody. A half-round strip made from a wooden dowel, which was 1/8 inch in diameter for the model having a beam of 16 inches, was used to simulate an extreme case of wrinkling in the film used to cover and seal the bottom of the model. The tests included measurements of the trim limits of stability and observations of the landing stability.

APPARATUS AND PROCEDURE

Profile and bow views of the model of a flying boat are included in figure 1. Dimensions of the model are as follows:

Beam, maximum, inches . . . . .14.24 (1.00 beam)
Beam, at step, inches . . . . 13.86 (0.97 beam)
Length of forebody (bow to step), inches 51.70 (3.63 beam)
Length, over-all, inches . . . . 124.05 (8.71 beam)
Angle of dead rise at step, excluding chine flare,
degrees 20
Angle between forebody keel and afterbody keel at step,
degrees 6.8
Wing area, square feet 25.6
Wing span, inches 200
Length of M.A.C. (wing), inches 20.12
Angle of incidence of wing, M.A.C. to forebody keel,
degrees 3.2
Horizontal tail area, square feet 3.51
Pitching moment of inertia, slug-feet^2 . . . . 6.9
Distance of c.g. forward of step, inches.From 3.56 to 6.00
Distance of c.g. above forebody keel at step, inches.12.23

The construction of the model is similar to that generally used in dynamic models for tests at the NACA tank. (See reference 3.) A second model, that of a planing surface, was used for a part of the tests. The planing surface has a $22\frac{1}{2}^\circ$ V-bottom and a beam of 16 inches and is the same as that described in reference 4. Modifications to the models and dimensions of the hook and the half-round are shown in figure 2.

The tests were carried out as described in reference 3 to determine the lower trim limit of stability, to determine the upper and the lower branches of the upper trim limit of stability, and to observe the tendency of the models to skip on landing.

EXPERIMENTAL RESULTS

The results of the tests of the model of a flying boat are shown in figures 3 and 4. All trim limits are shown to be lowered markedly by the addition of a hook. At the higher speeds, the reduction is about 4°. The slopes of the curves are affected considerably, especially the slope of the lower trim limit which passes below zero at about 29 feet per second. The effect that may be most important practically is the reduction in the upper trim limits at high speeds which causes a great increase in the probability of high-angle porpoising. An increase in the depth of step from 5 percent of the beam to about 9 percent did not appreciably improve the upper trim limits obtained with the hook.

During take-offs and landings the model exhibited rather violent instability, tending to leap out of the water at speeds below a safe flying speed and to skip persistently after landing. This behavior on take-off and landing is in agreement with the reported experience of the Bureau of Aeronautics. The very undesirable skipping characteristics apparently would outweigh any advantage gained in lowering the lower limit by addition of a hook of the type that was tested. A much longer hook extending, for example, one beam forward of the step, might have less objectionable skipping characteristics and, at the same time, have some beneficial effects upon the lower limit and the resistance.

The planing surface described in reference 4 was fitted with a hook at the trailing edge and tested briefly. Substantially the same results were obtained as are shown for the lower trim limit of the complete model of a flying boat. In addition to tests with the hook, the planing surface was also tested with a half-round 1/8 inch in diameter - first, on the transom immediately above the trailing edge (fig. 2) and, second, on the planing bottom adjacent to the trailing edge. With the half-round on the transom no change in the stability characteristics was noted, an indication that considerable rounding of the trailing edge may be introduced without affecting appreciably the lower trim limit. With the half-round on the planing bottom, the lower limit was reduced markedly as in the case of the hooked step. The planing surface as it was set up could not be safely run at the low trims required to determine the critical trim with the hook or the half-round on the planing bottom, and quantitative data were not obtained.

CONCLUSIONS

The results obtained with the wedge-shape hook and with the half-round were in qualitative agreement. They indicated that a downward projection on the planing bottom of the forebody near the step extending only a short distance forward would affect strongly the trim limits and also the landing stability, reducing all the trim limits and tending to cause severe skipping. The results also indicated that the effect might be much the same for a wide range of cross-sectional shapes that might be used for the projections.

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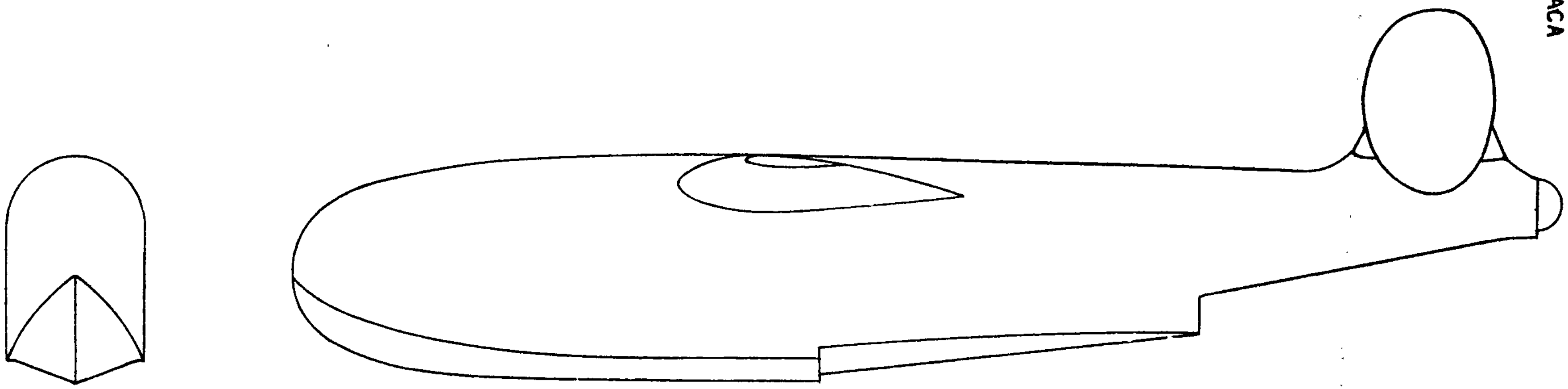
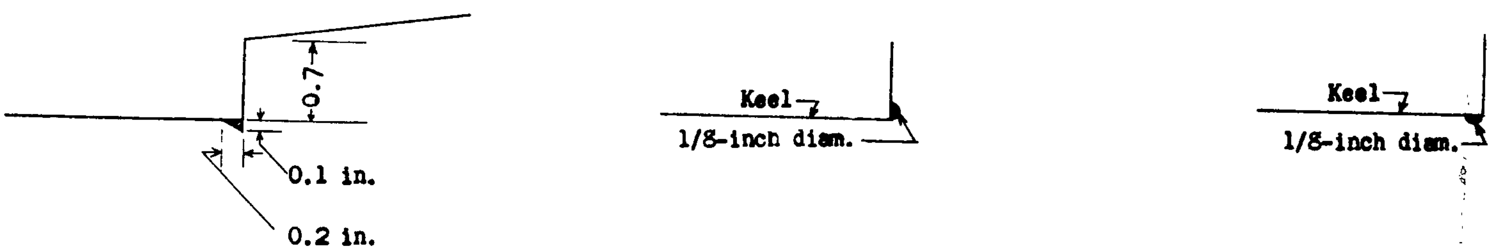


(a) Bow view of hull.

(b) Profile.

Figure 1 .- Model of flying boat.

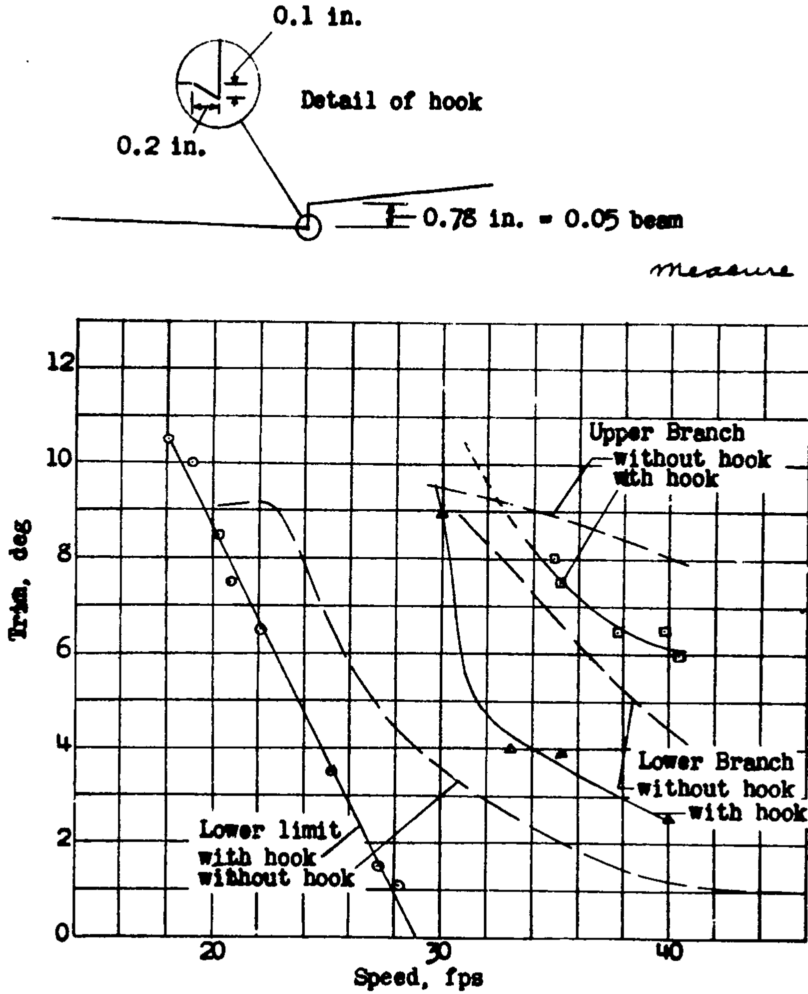


(a) Hook on model of flying boat.

(b) Half-round on transom of planing surface.

(c) Half-round on planing bottom.

Figure 2 .- Modifications to models.



measure with 1/40"

Figure 3 .- Trim limits of stability for model with wedge-shaped hook and depth of step 5 percent beam. Curves for original model (without hook) shown for comparison.

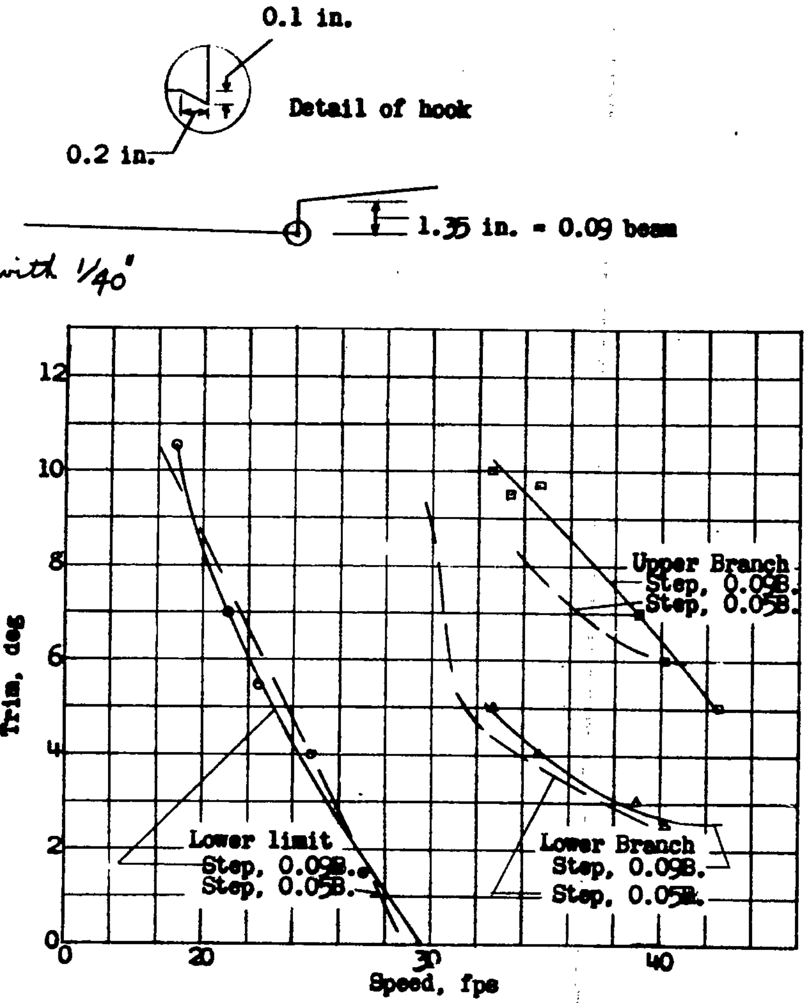


Figure 4 .- Trim limits of stability for model with wedge-shaped hook and depth of step 9 percent beam. Faired curves for 5 percent step shown for comparison.

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*Step

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