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RESEARCH MEMORANDUM

LIMITED HYDRODYNAMIC INVESTIGATION

OF A $\frac{1}{15}$ - SIZE MODEL OF A MODIFIED NOSE-INLET

MULTIJET WATER-BASED AIRCRAFT

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FOR AERONAUTICS

WASHINGTON
February 3, 1956

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RESEARCH MEMORANDUM

LIMITED HYDRODYNAMIC INVESTIGATION OF A $\frac{1}{15}$-SIZE MODEL OF A MODIFIED NOSE-INLET MULTIJET WATER-BASED AIRCRAFT

By Robert E. McKann and Claude W. Coffee

SUMMARY

An investigation was conducted to determine the effect on the low-speed resistance and spray characteristics and static transverse stability of a modification which extended the bow of a $\frac{1}{15}$-size model of a nose-inlet transonic seaplane configuration. The investigation was made with and without tip floats.

An increase in bow length of 0.6 beam decreased the hump resistance approximately 50 percent and improved the low-speed spray characteristics. Removal of the wing-tip floats reduced the resistance prior to hump speed but had little effect on the hump resistance. A roll angle of 8° with the tip floats off resulted in a static righting moment equal to that provided by full submergence of the tip float, which occurred at a roll angle of $4\frac{1}{2}°$.

INTRODUCTION

The results of an investigation of the aerodynamic and hydrodynamic characteristics of models of two transonic, multijet, water-based aircraft were reported in reference 1. The transonic area rule (ref. 2) was used as a guide in shaping these bodies. In an attempt to achieve minimum transonic drag rise and low wave drag at supersonic speeds, these hulls were given high fineness ratios and small hull cross-sectional area. In the interests of aerodynamic cleanness, previous hydrodynamic design criteria were deliberately violated. For the nose-inlet configuration the bow height was kept low, engine inlets were placed close to the water, forebody vertical chine strips were faded out short of the bow, and the hull sides were bulged above the chines by engine ducting.

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Wing-tip floats were retained for both configurations, although they were known to add appreciable drag at transonic speeds.

As would be expected, some undesirable hydrodynamic characteristics were encountered. As shown in reference 1, the hump resistance of the nose-inlet configuration was high, the clearance of the nose inlet at low speed was marginal, and the low-speed spray and flow on the forebody were heavy.

The present paper deals with a modification of the nose-inlet configuration to improve the low-speed, free-to-trim resistance as well as the low-speed spray characteristics. Included in this investigation was the effect of wing-tip floats on the low-speed resistance. The static transverse stability (righting moment at rest) of the hull and wing with and without tip floats was also determined.

SYMBOLS

δ_e elevator deflection referred to stabilizer chord, positive when trailing edge is down, deg

δ_f flap deflection, referred to wing chord, positive when trailing edge is down, deg

δ_s stabilizer deflection referred to forebody keel at step, positive when leading edge is up, deg

Δ_o gross load, lb

DESCRIPTION OF MODEL

The 1/15-size dynamic model of the basic nose-inlet configuration of reference 1 was altered so as to increase the forebody length by 0.6 beams, with no increase in the maximum cross-sectional area of the hull. The fineness ratio of the equivalent body was thus increased to 12.9 from 12.5 for the basic configuration. The forebody chines were extended all the way forward on the modified configuration. The duct inlet was raised and extended forward but the upper portion of the duct and the altered canopy were not completely simulated for the tank tests. Photographs of the basic- and the extended-bow configurations are shown in figure 1. The general-arrangement and hull-lines drawings of the two configurations are shown in figures 2 and 3, respectively. All dimensions are given in full size.

The longitudinal distribution of cross-sectional area was maintained smooth and fair for the altered body as shown in figure 4. The modification was faired out at approximately 65 feet (full size) behind the original bow.

APPARATUS AND PROCEDURE

A description of Langley tank no. 1 and the towing carriage is given in reference 3. The model was free to trim and free to rise but was otherwise restrained for these tests. Trim and rise were taken as zero when the forebody keel at the step was tangent to the undisturbed water surface.

The free-to-trim resistance of the complete model, including air drag of the model and towing staff, was determined for various stabilizer and elevator deflections over a range of constant speeds with 0° flap deflection. The air drag of the towing staff was subtracted as a tare from the total resistance. Spray observations and photographs were obtained during these runs.

Trim and static rolling moment were recorded with the tip floats on and off. The model was mounted free-to-trim on a dynamometer fixed to the towing staff which measured the rolling moment for a range of setting of the roll angle.

RESULTS AND DISCUSSION

All values as presented are full size.

The total resistance and the corresponding trim and rise of the extended-bow configuration and the basic configuration for various elevator and stabilizer deflections are shown in figure 5 with 0° flaps and a gross load of 160,000 pounds up to a speed of approximately 100 knots. The hump resistance of the extended-bow configuration was approximately 50 percent less than that of the basic configuration, increasing the hump gross-load-total-resistance ratio from 2.3 to 4.5. The speed at which hump resistance occurred increased from 48 to 55 knots when the bow was extended. At speeds above 100 knots the modified portion of the hull was not wetted and no significant difference in results would be expected.

Increases in both trim and rise occurred prior to hump speed as a result of the bow extension and were accompanied by elimination of flow above the chine and over the bulge of the forward engines that had been present on the basic configuration. The decreased resistance resulted from the higher trim angle, the lesser wetted area, and the elimination of the flow along the transverse curvature of the forward engines. Improvement was also marked in the greater clearance of the engine inlets from the bow spray.

The total resistance, trim, and rise for a gross load of 200,000 pounds (25-percent overload) and 0° flaps are presented in figure 6. The speed for hump resistance remained about 55 knots. The gross-load—hump-resistance ratio is about 3.3 as compared with 4.5 at a gross load of 160,000 pounds. Spray at this overload condition was still acceptable, although little reserve clearance of the engine inlets is available for operation in waves.

The effect of removing tip floats on resistance, trim, and rise is shown in figure 7. Prior to hump speed (approximately 55 knots) a slight increase in trim resulted from the removal of the tip floats and a decrease in resistance was noted. The decrease in resistance was approximately 20 percent at 40 knots and 11 percent at 55 knots. There was little change in the hump resistance. Without the displacement of the tip floats, the hull rides slightly deeper in the water at low speeds but rises somewhat faster as the model trims higher at hump speed without the restraining negative moment of the floats.

Spray photographs of the basic and the extended-bow configurations are shown in figures 8 and 9(a), respectively. At 22.9 knots the greater clearance of the engine inlets of the extended bow ahead of and above the bow spray is visible. Also evident is the effectiveness of the bow extension in preventing flow above the chines and over the ducts. Approximately a 22-percent reduction in resistance was found at this speed.

At 40.1 knots the extended bow configuration had greater engine-inlet clearance and less spray on the sides and wing. At this speed there was a reduction in resistance of 56 percent. At 57.2 knots little difference in the spray patterns is noted.

The effect on the spray of removal of the tip floats may be observed by comparing figures 9(a) and 9(b). As a result of the removal of the tip floats there appears to be heavier flow along the sides of the afterbody prior to hump speed. This difference in flow might be expected from the slightly higher trims and hull loads resulting when the tip floats are removed.

The static rolling moment for a range of roll angles and the corresponding trim with the tip floats on and off are presented in figure 10 for three gross loads. With the tip floats off, the upsetting moment resulting from the negative metacentric height is not balanced by the wing righting moment until a roll angle of 4° is reached at the normal-load condition. The righting moment of the tip float fully submerged at a roll angle of $4\frac{1}{2}^{\circ}$ is equaled by the moment due to the wing buoyancy with the float off at an angle of roll of 8° in the normal-load condition. At heavier gross-load conditions the righting moment with or without tip floats increases with load for a given angle of roll. The trims are the same or slightly greater with the tip floats off as the model is rolled.

CONCLUDING REMARKS

A modification extending the bow and vertical chine strips of the nose-inlet transonic seaplane configuration was found to result in a 50-percent reduction in the hump resistance, increased engine-inlet clearance, reduced low-speed spray and hull-side flow, and acceptable spray and resistance at 25-percent overload. Removal of the wing-tip floats was found to reduce the resistance prior to hump speed, but to have little effect on the hump resistance. The static righting moment provided by full submergence of the tip floats at a roll angle of $4\frac{1}{2}^{\circ}$ was equaled by the moment due to the wing buoyancy with floats off at a roll angle of 8° in the normal-load condition.

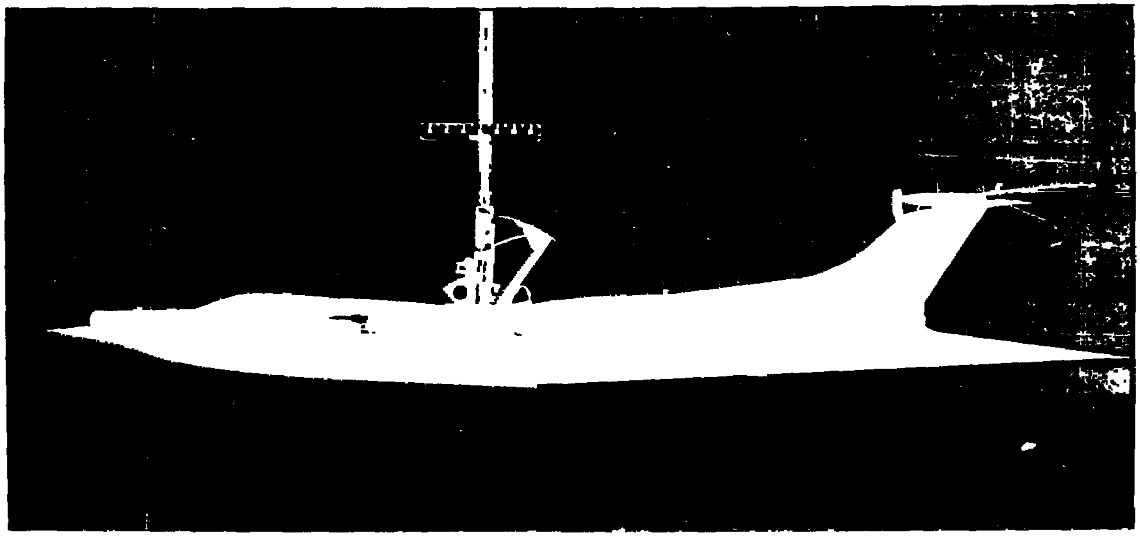
Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., October 21, 1955.

REFERENCES

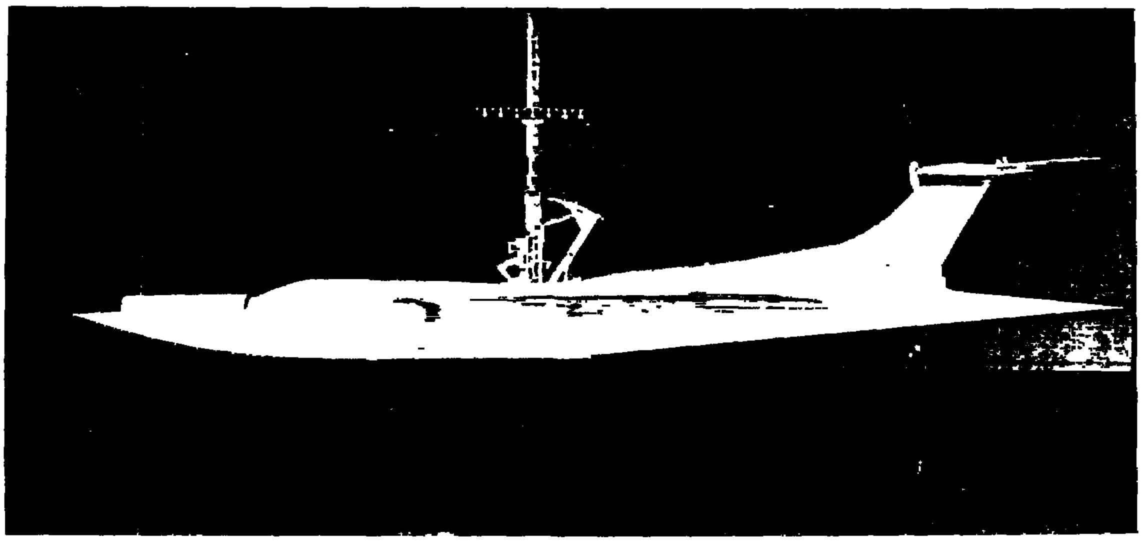
1. Olson, Roland E., and Bielat, Ralph P.: An Aerodynamic and Hydrodynamic Investigation of Two Multijet Water-Based Aircraft Having Low Transonic Drag Rise. NACA RM L55A11a, 1955.

2. Whitcomb, Richard T.: A Study of the Zero-Lift Drag-Rise Characteristics of Wing-Body Combinations Near the Speed of Sound. NACA RM L52H08, 1952.

3. Truscott, Starr: The Enlarged N. A. C. A. Tank and Some of Its Work. NACA TM 918, 1939.



(a) Basic-bow configuration.



(b) Extended-bow configuration. L-90530

Figure 1.- Photographs of the nose-inlet model (Langley tank model 323).

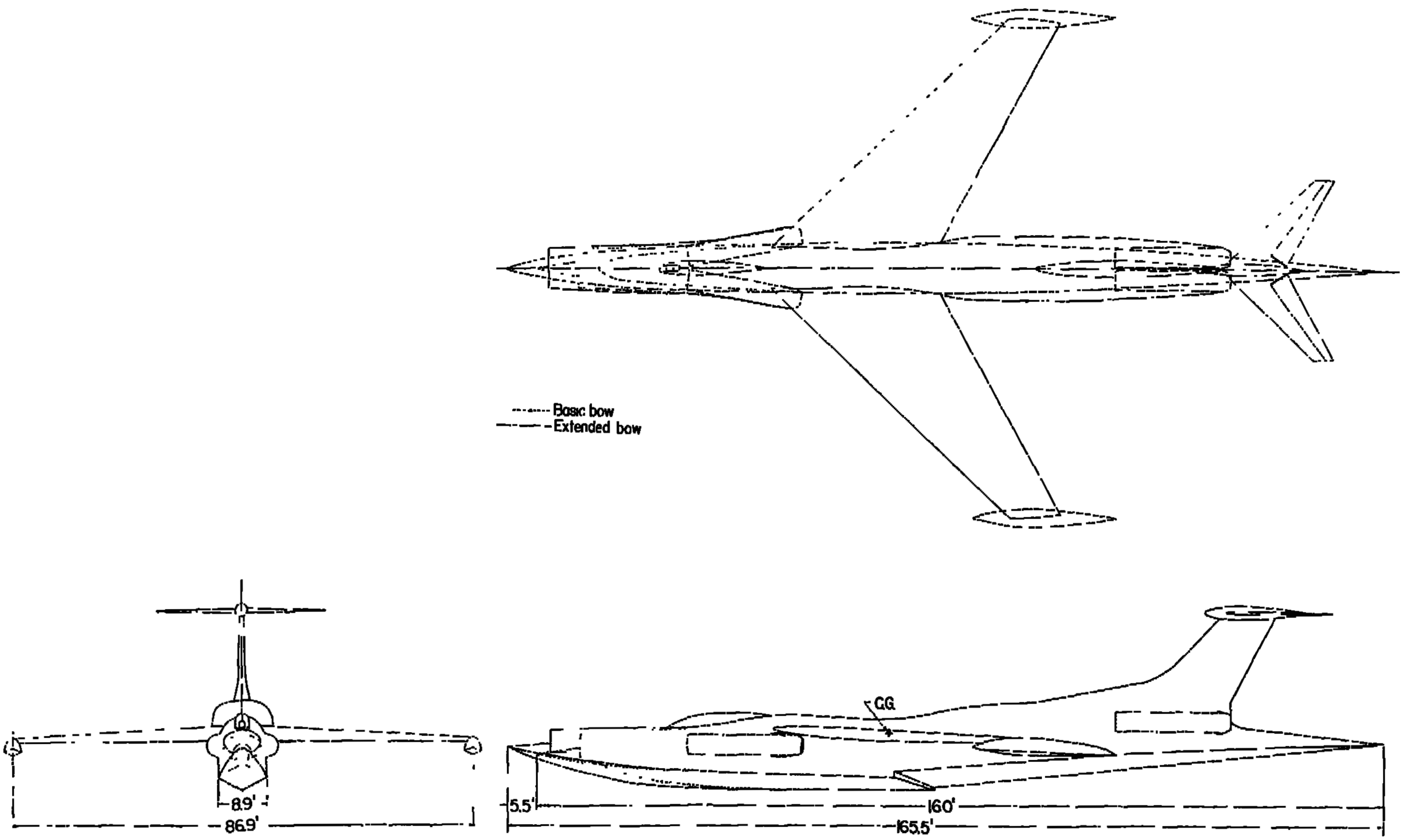


Figure 2.- General arrangement of nose inlet configuration.

[redacted]

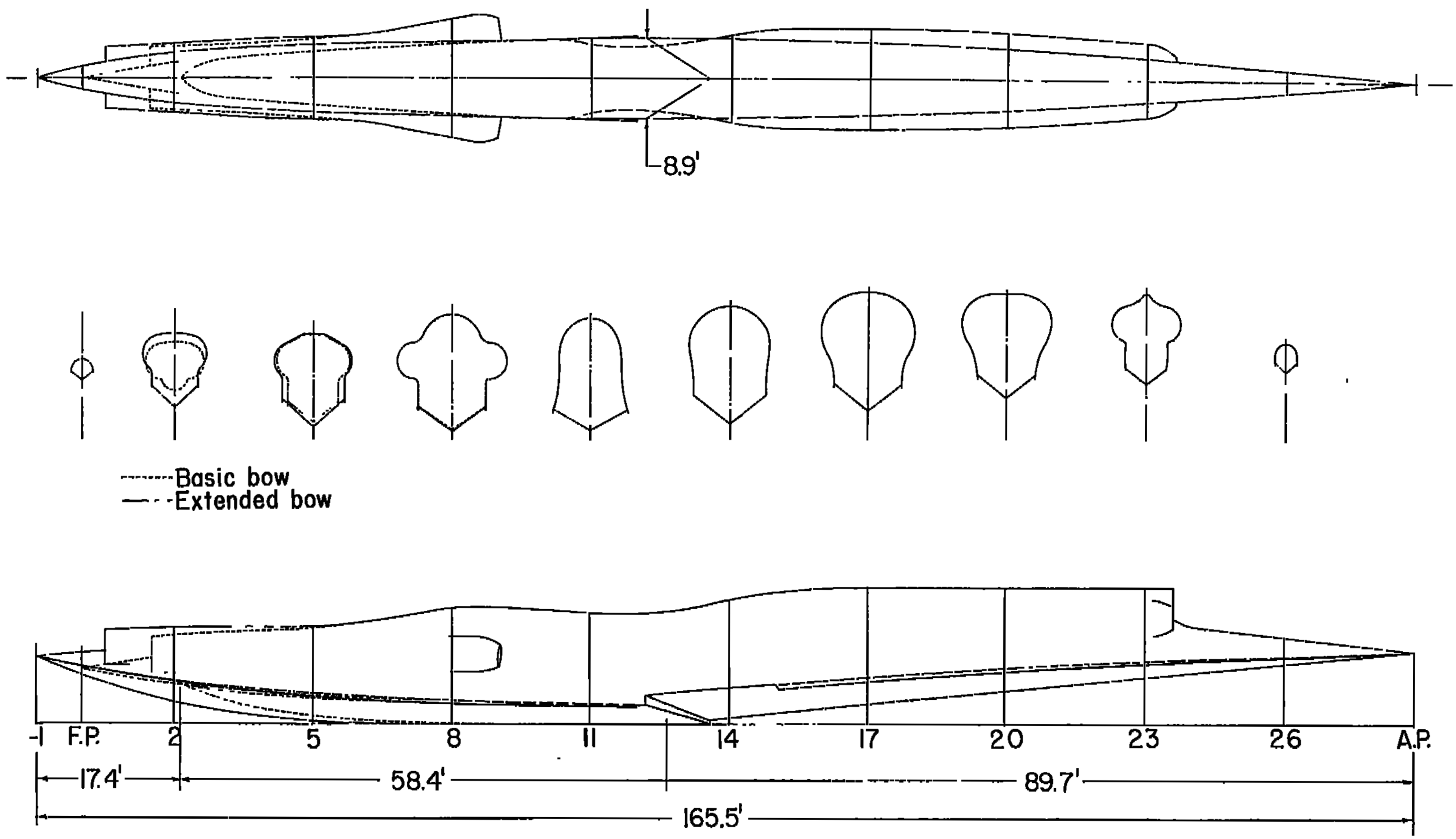


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Figure 3.- Hull lines of nose inlet configuration.

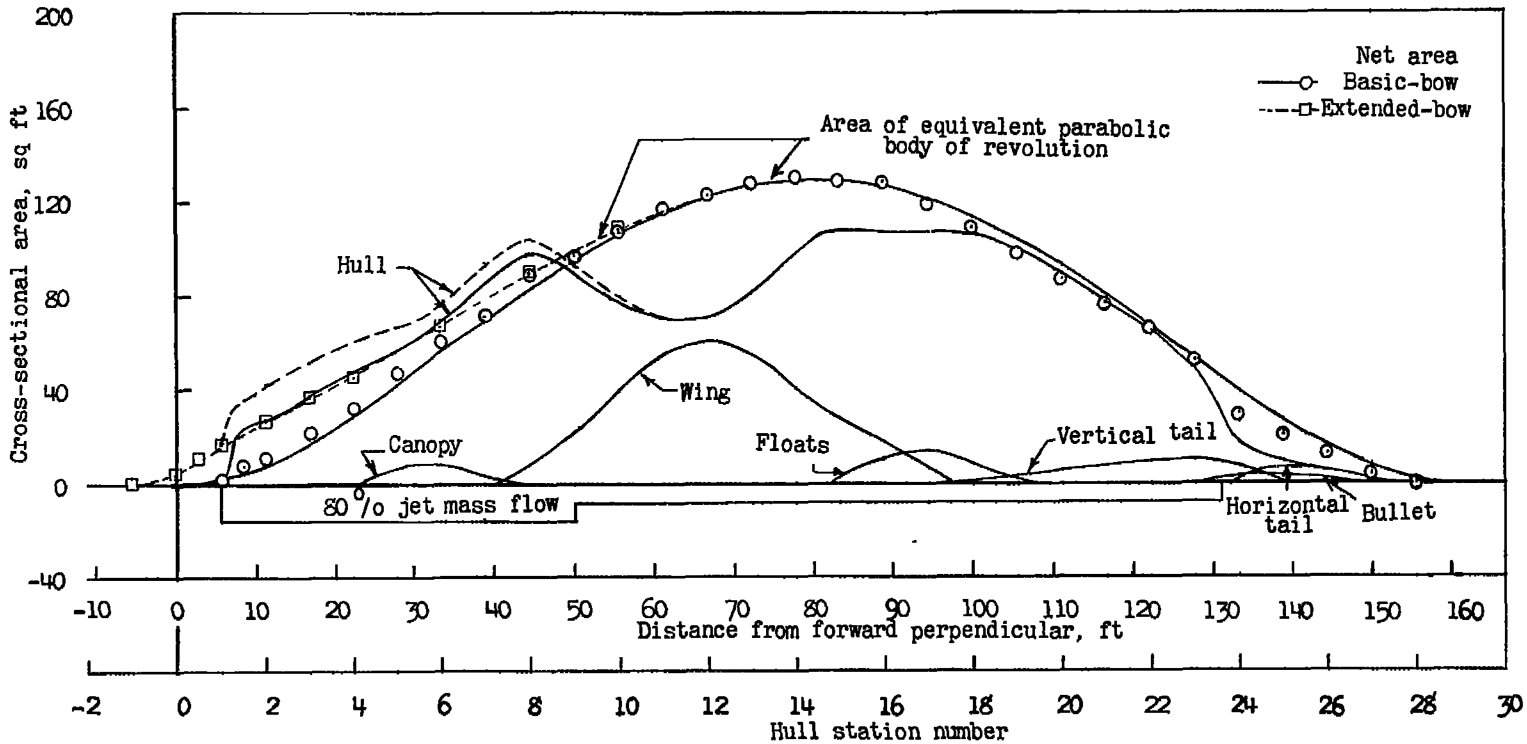


Figure 4.- Area distribution of nose-inlet configuration. (All dimensions are full size.)

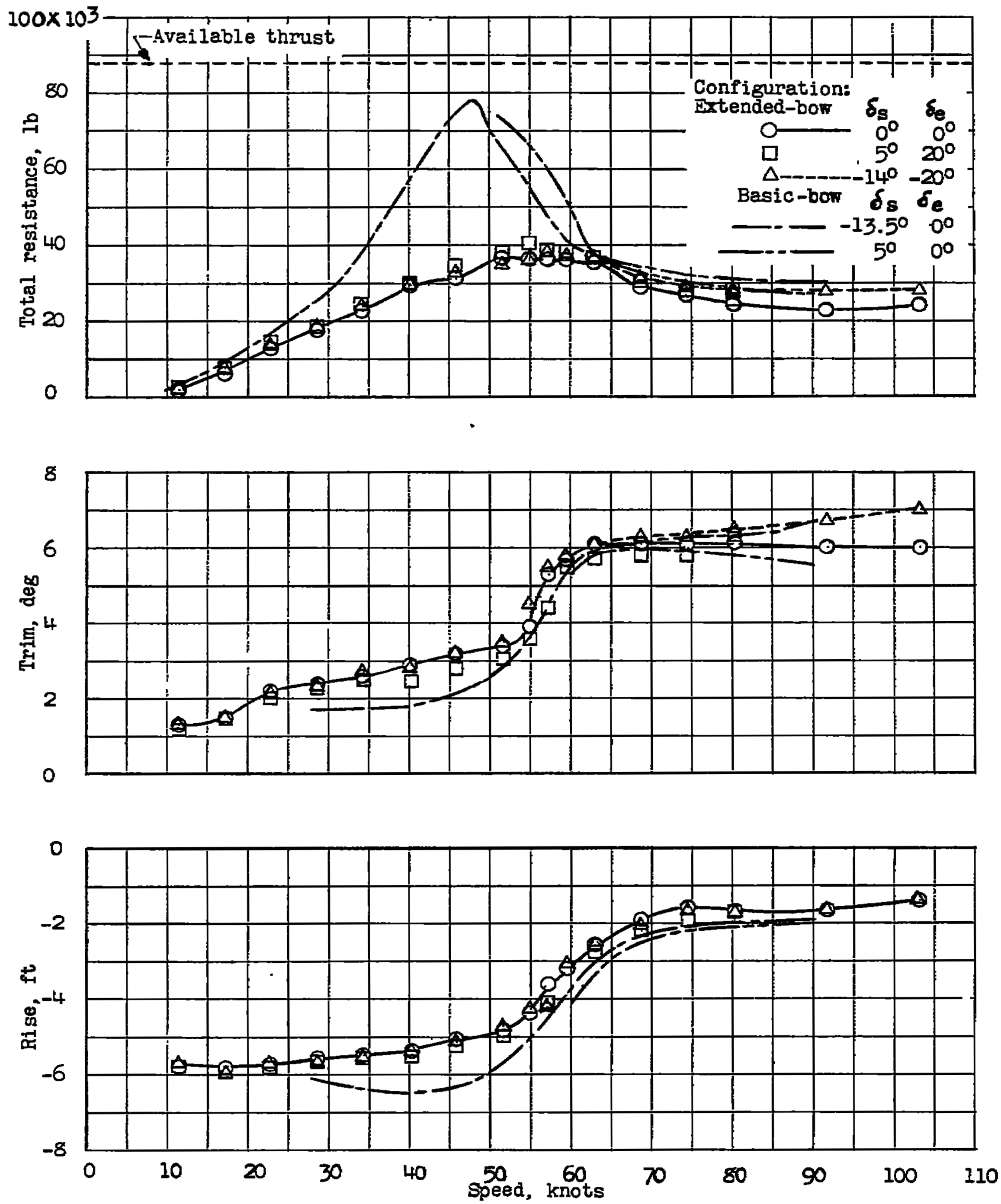


Figure 5.- Variation of total resistance, trim, and rise with speed. Tip floats on; Δ_0 = 160,000 lb; $\delta_f = 0^\circ$.

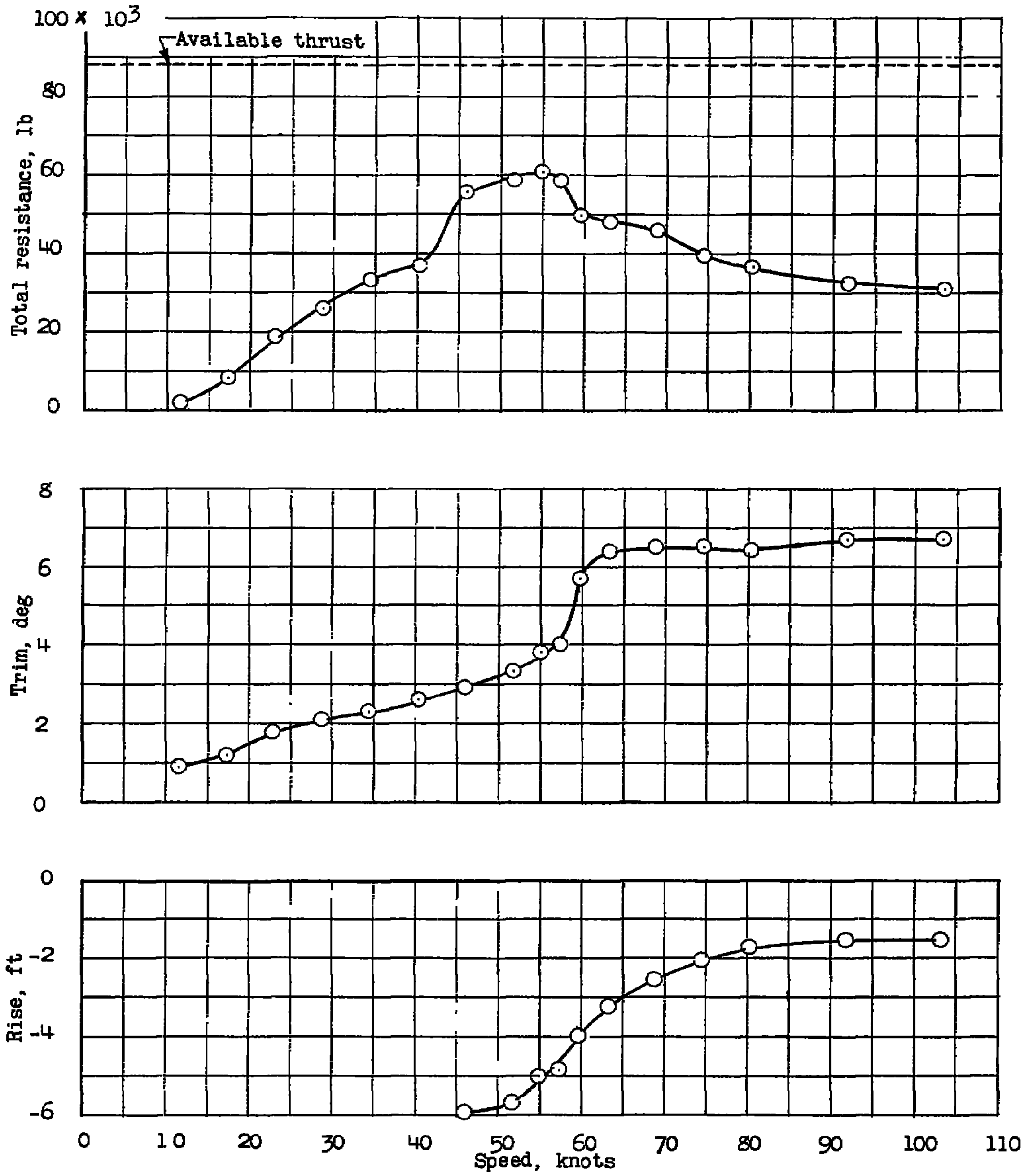


Figure 6.- Variation of total resistance, trim, and rise with speed of the extended-bow configuration. Tip floats on; Δ_0 = 200,000 lb; $\delta_s = 0^\circ$; $\delta_e = 0^\circ$; $\delta_f = 0^\circ$.

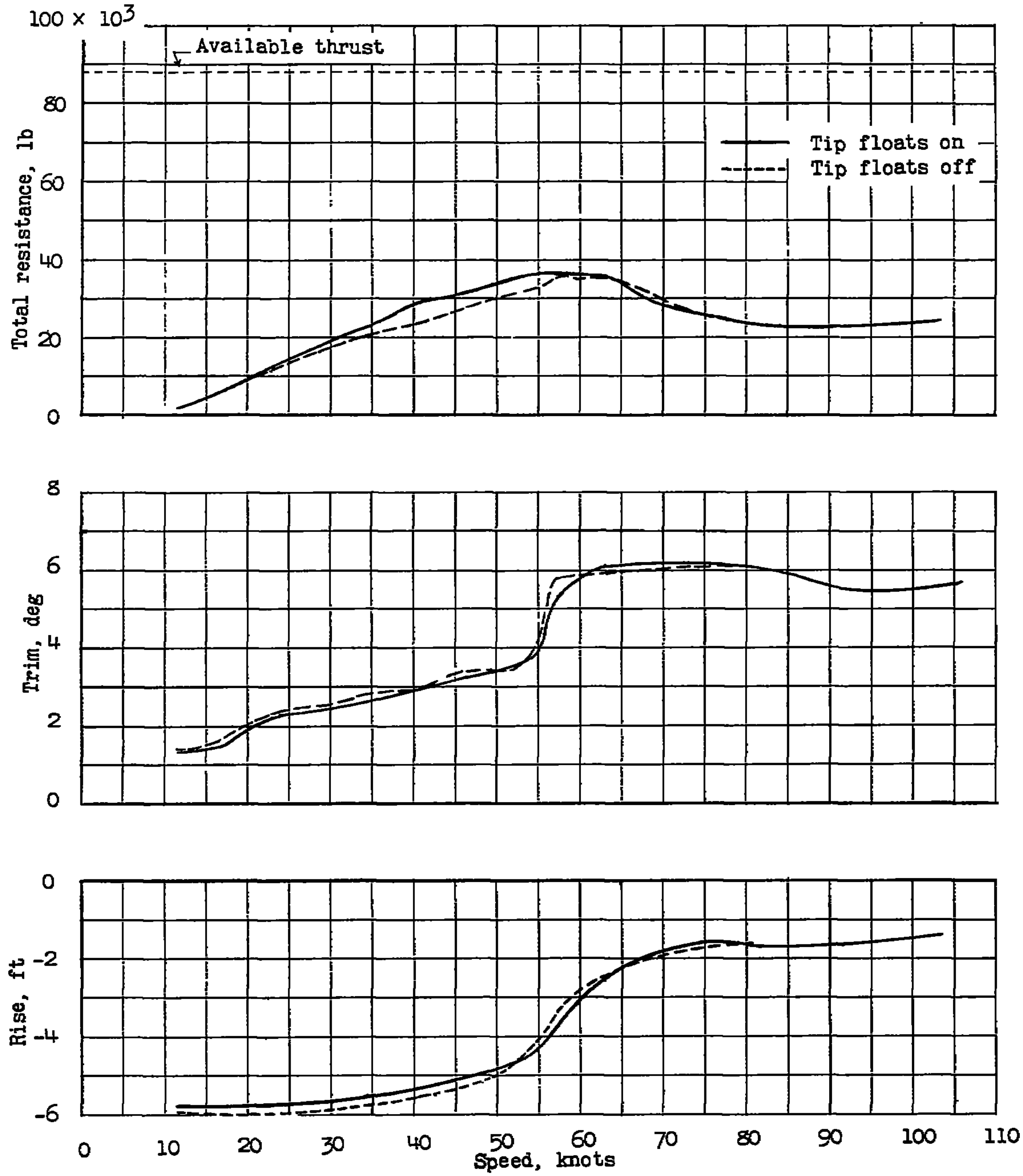
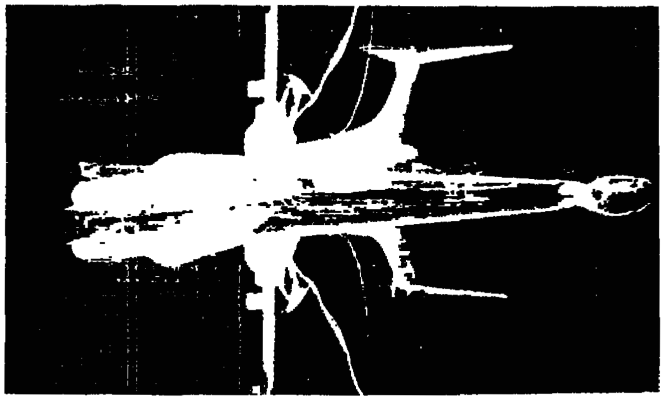
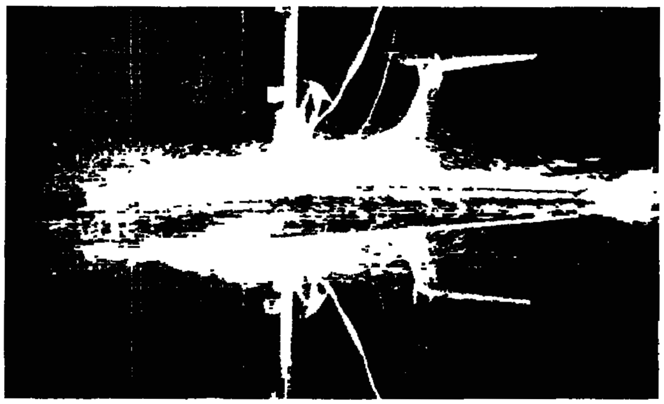


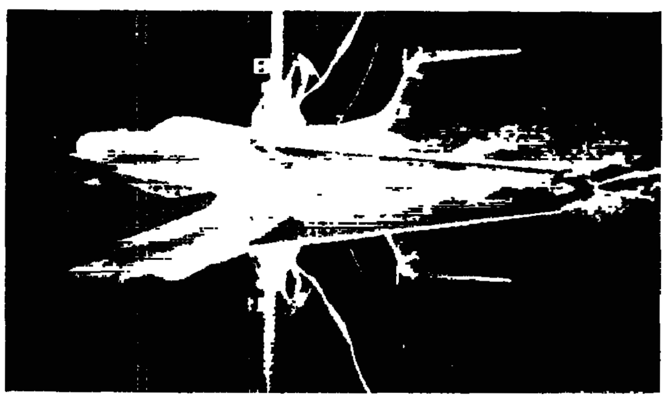
Figure 7.- Effect of tip floats on the total resistance, trim, and rise of the extended-bow configuration. Δ_0 = 160,000 lb; $\delta_f = 0^{\circ}$.



22.9 knots
$\tau = 1.8^\circ$



40.1 knots
$\tau = 2.0^\circ$



57.2 knots
$\tau = 5.4^\circ$

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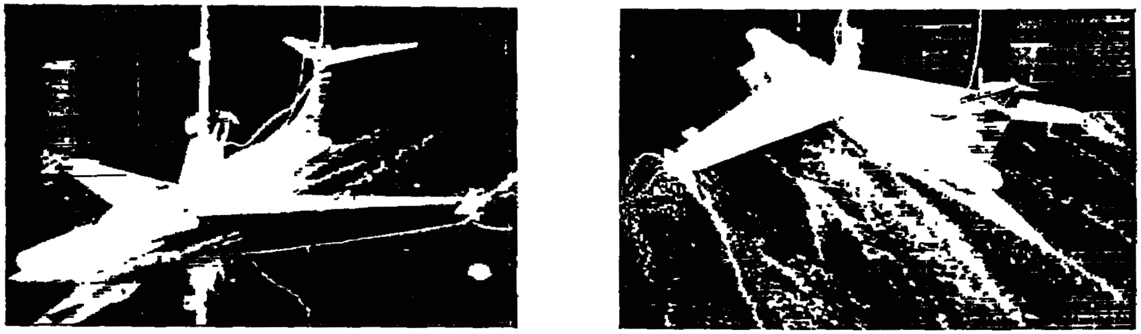
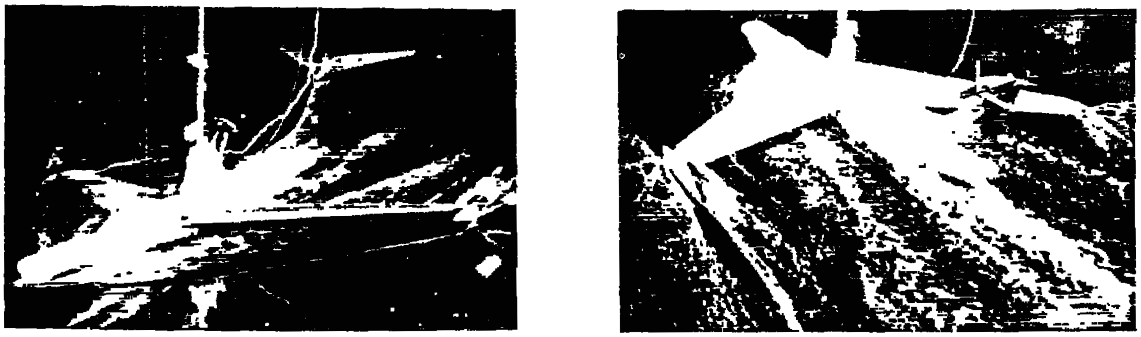
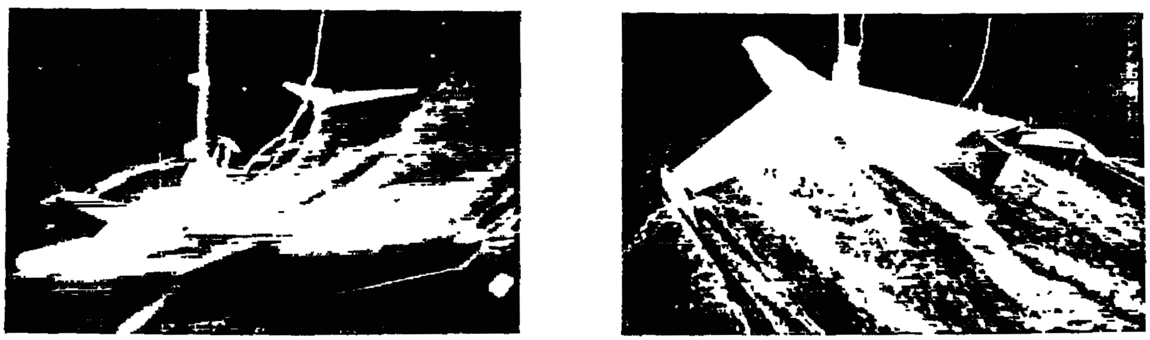
Figure 8.- Spray photographs of basic-bow configuration. Δ_0 = 160,000 lb; $\delta_f = 0^\circ$.



Speed, 22.9 knots; trim, 2.1°



Speed, 40.1 knots; trim, 2.8°.



Speed, 57.3 knots; trim, 5.5°.

(a) Tip floats on.

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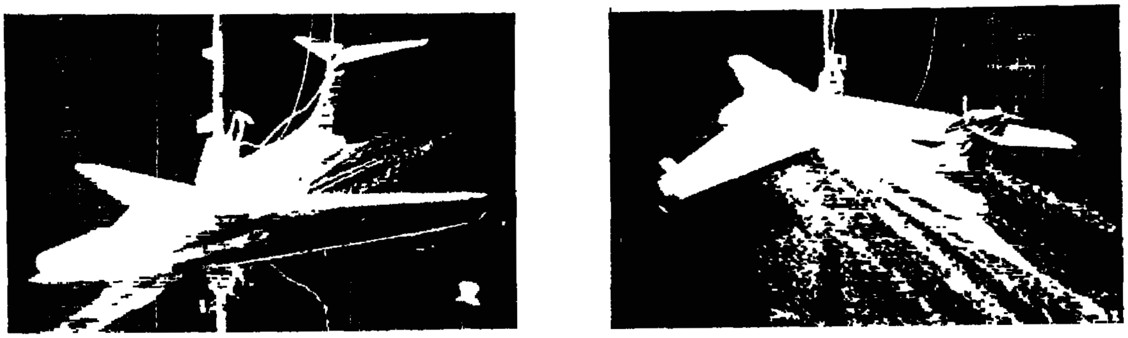
Figure 9.- Spray photographs of extended-bow configuration. Δ_o = 160,000 lb; $\delta_f = 0^\circ$.



Speed, 22.9 knots; trim, 2.3°

Speed, 40.1 knots; trim, 2.9°

Speed, 57.3 knots; trim, 5.8°

(b) Tip floats off.

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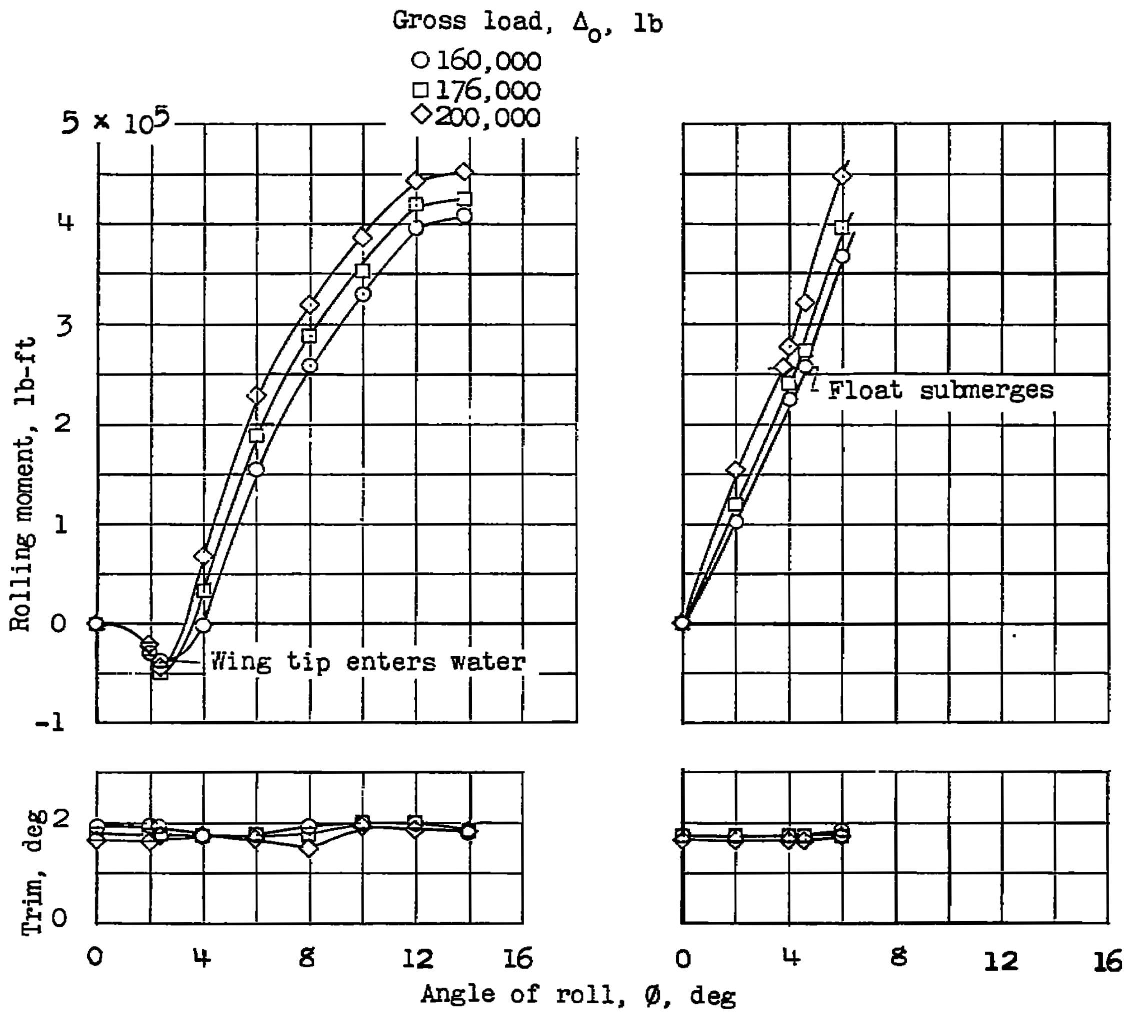
Figure 9.- Concluded.



(a) Tip floats off. (b) Tip floats on.

Figure 10.- Static properties of extended-bow configuration.

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