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RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

DITCHING INVESTIGATION OF A $\frac{1}{18}$-SCALE MODEL OF THE NORTH AMERICAN B-45 AIRPLANE

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NATIONAL ADVISORY COMMITTEE
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SUMMARY

An investigation of a $\frac{1}{18}$-scale dynamically similar model of the North American B-45 airplane was made to observe the ditching behavior and determine the proper landing technique to be used in an emergency water landing. Various conditions of damage were simulated to determine the behavior which probably would occur in a full-scale ditching. The behavior of the model was determined from high-speed motion-picture records, time-history acceleration records, and visual observations.

It was concluded that the airplane should be ditched at the maximum nose-high attitude with the landing flaps full down for minimum landing speed. During the ditching, the nose-wheel and bomb-bay doors probably will be torn away and the rear of the fuselage flooded. A violent dive will very likely occur. Longitudinal decelerations of approximately 5g and vertical accelerations of approximately -6g (including gravity) will be experienced near the pilots' compartment. Ditching braces installed in the bomb bay will tend to improve the behavior slightly but will be torn away along with the bomb-bay doors. A hydroflap installed ahead of the nose-wheel doors will eliminate the dive and failure of the nose-wheel doors, and substantially reduce the motions and accelerations.

INTRODUCTION

A ditching investigation of a model of the North American B-45 airplane was made to observe the behavior and determine the proper technique to be used in an emergency water landing.

The B-45 ditching model and information pertinent thereto were furnished by the Air Materiel Command, U. S. Air Force. A three-view drawing of the B-45 airplane is shown in figure 1. The investigation was made in calm water at the Langley tank no. 2 monorail.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{18}$-scale dynamic model of the B-45 airplane shown in figure 2 was used in the investigation. It was constructed of balsa wood and white cedar, and was ballasted internally to obtain scale weight and moments of inertia. The model had a wing span of 4.95 feet and an over-all length of 4.19 feet.

The flaps were installed so that they could be held in the down position at approximately scale strength. They were hinged and held down by thread of such strength that when a model load corresponding to the full-scale ultimate load was applied to the flaps, the thread would break and the flaps would rotate to the up position. The full-scale ultimate strength of each inboard flap was 9,640 pounds and of each outboard flap was 10,300 pounds.

To investigate the effect of damage, the bomb-bay doors and nose-wheel doors were removed, as shown in figure 3, and replaced by approximately scale-strength sections. The bomb-bay section was made in one piece of thin aluminum foil and no bulkheads or stringers were used. The full-scale ultimate strength of the bomb-bay doors as determined from static load tests was 1.4 pounds per square inch. The scale-strength nose-wheel section was made in one piece of thin aluminum foil glued on a balsa-wood frame. The full-scale ultimate strength of the nose-wheel doors was 1.6 pounds per square inch.

The airplane is equipped with a number of ditching braces to reinforce the bomb-bay doors at the locations shown in figure 4. These braces are designed to take vertical loads but no fore-and-aft loads. Their effect on the ditching performance was investigated by simulating them on the model with scale-strength bomb-bay doors. Details of the model braces are shown in figure 5.

In order to improve the ditching characteristics of the model, a hydroflap was installed ahead of the nose-wheel doors as shown in figure 6. The hydroflap on the model was a flat surface of $\frac{1}{16}$-inch aluminum sheet and was not shaped to retract flush into the fuselage bottom.

Test Methods and Equipment

The model was ditched by catapulting into the air to permit a free glide onto the water. The model left the launching carriage at scale speed and at the desired landing attitude. The control surfaces were set so that the attitude did not change appreciably in flight. The behavior was recorded by a motion-picture camera, a single-component time-history accelerometer, and from visual observations.

The accelerometer had a natural frequency of 20 cycles per second and was damped to about 65 percent of critical. The reading accuracy of the instrument was $\pm\frac{1}{2}g$. It was installed in the pilots' compartment and both vertical and horizontal components of acceleration were measured by rotating the instrument and repeating the runs.

Test Conditions

(All values are full scale.)

Weight.- The design gross weight of 82,600 pounds was simulated in the investigation.

Moments of inertia.- The moments of inertia corresponding to the design gross weight were specified as follows:

Roll, slug-feet^2	540,000
Pitch, slug-feet^2	310,000
Yaw, slug-feet^2	830,000

At the start of the tests the model was ballasted to obtain these values.

Center of gravity.- The center of gravity was located at 28.8 percent of the mean aerodynamic chord and 18.5 inches above the thrust line of the engines.

Landing attitude.- Two attitudes were used in the investigation. The 6° attitude is near the stall angle and the 2° attitude is approximately the static ground attitude. The attitude was measured between the fuselage reference line and the smooth-water surface.

Flaps.- All tests were made with the landing flaps in the down position attached at scale strength. The model was not tested with flaps up because of the correspondingly higher landing speed.

Landing speed.- The landing speeds as computed from design lift curves are listed in table I. The model was airborne when launched and within ±10 miles per hour of these speeds.

Landing gear.- All tests simulated ditchings with the landing gear retracted.

Model configurations.- The model was tested in the conditions listed below:

(a) No damage simulated.

(b) Nose-wheel doors and bomb-bay doors approximately scale strength.

(c) Nose-wheel doors and bomb-bay doors approximately scale strength and ditching braces installed in the bomb bay.

(d) Nose-wheel doors and bomb-bay doors approximately scale strength and the hydroflap installed.

RESULTS AND DISCUSSION

A summary of the results of the investigation is presented in table I. The notations used in the table are defined as follows:

Dived violently - the entire model submerged in the water with the angle between the water surface and the fuselage reference line greater than 20°.

Ran smoothly - made no apparent oscillation about any axis with the model gradually settling into the water as the forward velocity decreased.

Porpoised - made an undulating motion about the transverse axis in which some part of the model remained in contact with the water.

Skipped - made an undulating motion about the transverse axis in which the model cleared the water completely.

Trimmed up - the attitude of the model increased immediately after contact with the water.

Photographs showing characteristic behavior are given in figure 7. Typical time histories of longitudinal and vertical accelerations are shown in figures 8, 9, 10, and 11. A photograph of representative damage to the scale-strength sections is shown in figure 12.

Effect of Landing Flaps

The inboard flaps always failed on contact with the water and the outboard flaps failed intermittently. There was no noticeable difference in behavior when the outboard flaps failed and when they did not. Since the flaps had no apparent detrimental effect on behavior it is therefore desirable that they be used in a ditching in order to provide the minimum landing speed.

Effect of Damage and Attitude

When the model was ditched with no damage simulated it trimmed up immediately after contact and made a smooth run; the trim decreased as the forward velocity decreased. The model made the same type of run at both the 6° and 2° landing attitudes.

When the model was tested with scale-strength bomb-bay doors and nose-wheel doors it usually dived violently. At the 6° landing attitude (fig. 7(a)) the dive occurred about 300 feet (full scale) after contact. The maximum longitudinal deceleration was almost 5g, as shown in figure 8(a). The maximum vertical acceleration was about -6g as shown in figure 11(a). (Vertical acceleration is 1g due to gravity when the airplane is at rest. Negative vertical acceleration is in a direction tending to throw the pilots out of their seats.) At the 2° landing attitude the behavior was similar but the dives were more violent and usually occurred about 200 feet (full scale) after contact. At this attitude the maximum longitudinal deceleration was about $9\frac{1}{2}$g, as shown in figure 8(b). At both attitudes the scale-strength bomb-bay doors and nose-wheel doors were usually torn away (fig. 12).

With ditching braces installed in the scale-strength bomb bay the model continued to dive, although the length of run before the dive was increased and the deceleration was slightly less (fig. 9). The doors and ditching braces were nevertheless usually torn away.

The maximum nose-high attitude resulted in lower accelerations and less violent motions than did the near-level attitude. Diving occurred with or without the ditching braces; however, the braces tended to make the dives less violent. It was observed from the model investigation that the aft part of the fuselage filled with water before there was appreciable loss of motion. Personnel in this section of the airplane probably would not have sufficient time to escape safely.

Effect of Hydroflap

With the hydroflap installed, the model usually made one skip and a continued porpoising run; hence the dive was eliminated. Sequence photographs of typical runs are shown in figures 7(b) and 7(c). The scale-strength bomb-bay doors were usually torn away completely. The scale-strength nose-wheel doors, however, remained intact.

A maximum longitudinal deceleration of about $3\frac{1}{2}$g for both attitudes was obtained as compared with about 5g at the 6° attitude and about $9\frac{1}{2}$g at the 2° attitude without the hydroflap. These values are shown on the time-history deceleration curves in figures 10 and 8. The maximum vertical acceleration with the hydroflap was about +3g to -1g and without the hydroflap was about +3g to -6g. These values are shown in figure 11. Although the ditching behavior with the hydroflap was about the same at both the 6° and 2° attitudes, the maximum nose-high attitude would be preferable because of the slower landing speed.

CONCLUSIONS

From results of the investigation of a $\frac{1}{18}$-scale model of the North American B-45 airplane, the following conclusions were drawn:

1. The airplane should be ditched at the maximum nose-high attitude with the flaps down for minimum landing speed.

2. During the ditching, the nose-wheel and bomb-bay doors probably will be torn away and the rear of the fuselage flooded. A violent dive will very likely occur. Longitudinal decelerations of approximately 5g and vertical accelerations of approximately -6g (including gravity) will be experienced near the pilots' compartment.

3. Ditching braces installed in the bomb bay will tend to improve the behavior slightly but will be torn away along with the bomb-bay doors.

4. A hydroflap installed ahead of the nose-wheel doors will eliminate the dive and failure of the nose-wheel doors and substantially reduce the motions and accelerations.

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TABLE I.- SUMMARY OF RESULTS OF DITCHING INVESTIGATION IN CALM WATER OF A $\frac{1}{18}$-SCALE DYNAMIC MODEL OF THE NORTH AMERICAN B-45 AIRPLANE

[Gross weight, 82,600 lb; landing flaps, full down; all values, full scale.]

Landing attitude, (deg)	6				2			
Landing speed, (mph)	137				151			
Configuration \ Behavior	Maximum horizontal decelerations, (g)	Maximum vertical accelerations, (g)	Length of run (ft)	Motions of model	Maximum horizontal decelerations, (g)	Maximum vertical accelerations, (g)	Length of run (ft)	Motions of model
Undamaged model	1	$3\frac{1}{2}$	865	Trimmed up; ran smoothly	$1\frac{1}{2}$	$3\frac{1}{2}$	935	Trimmed up; ran smoothly
Scale-strength bomb-bay doors and nose-wheel doors	5	-6	300	Dived violently	$9\frac{1}{2}$		200	Dived violently
Ditching braces installed with scale-strength bomb-bay doors and nose-wheel doors	$4\frac{1}{2}$		400	Dived violently				
Hydroflap installed with scale-strength bomb-bay doors and nose-wheel doors	$3\frac{1}{2}$	3 -1	540	Skipped; porpoised	$3\frac{1}{2}$		720	Skipped; porpoised

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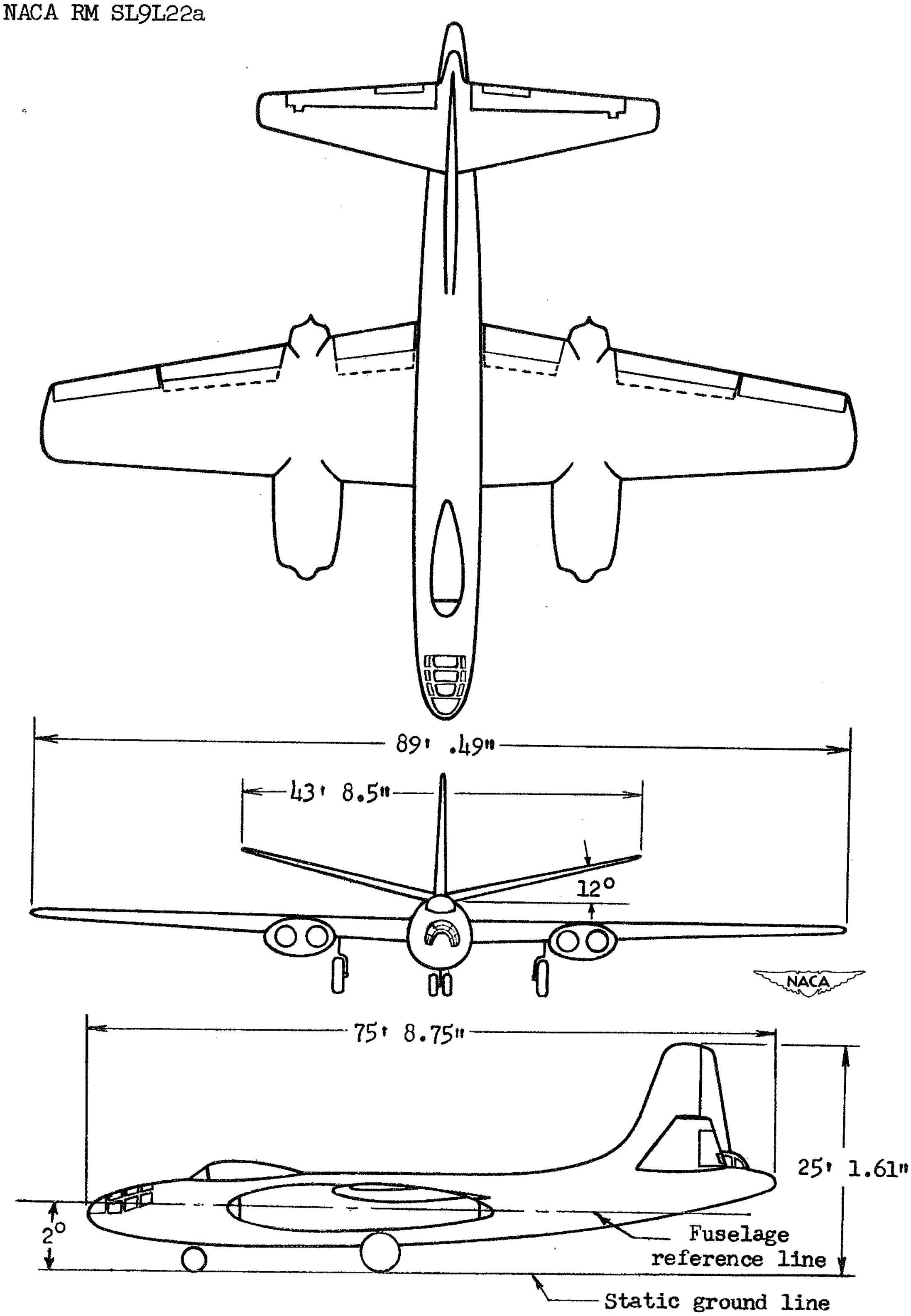
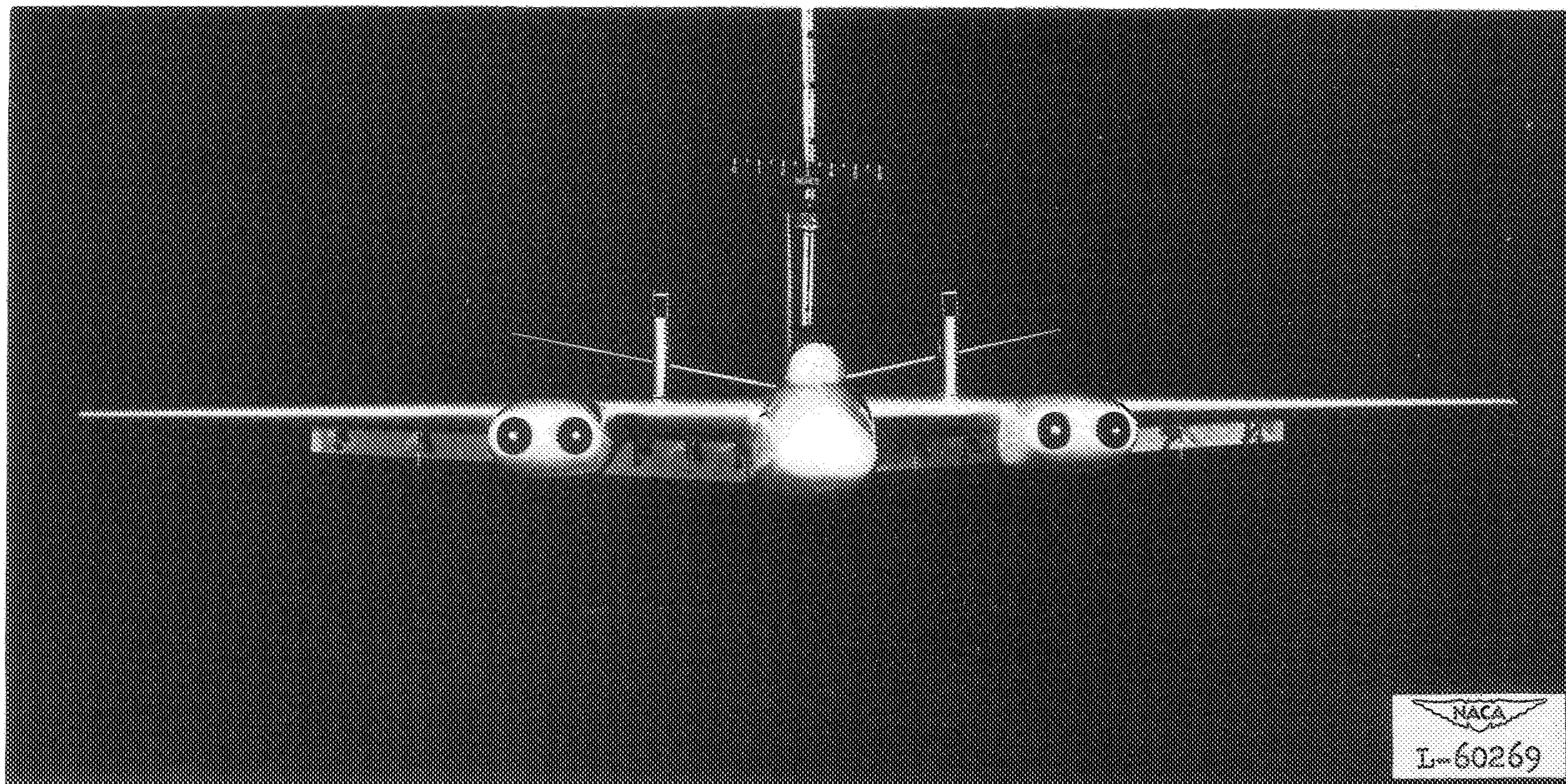
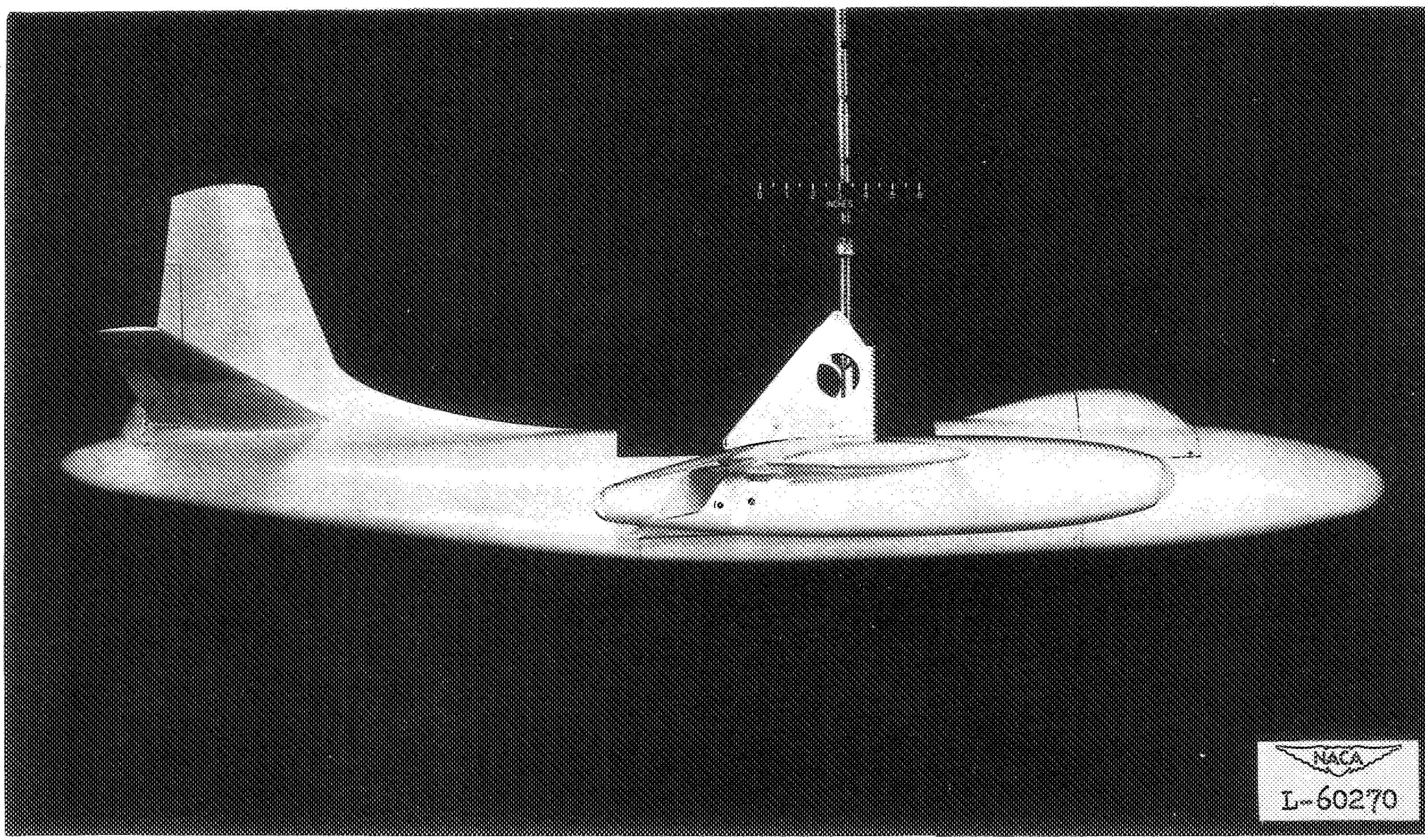


Figure 1.- Three-view drawing of the North American B-45 airplane.



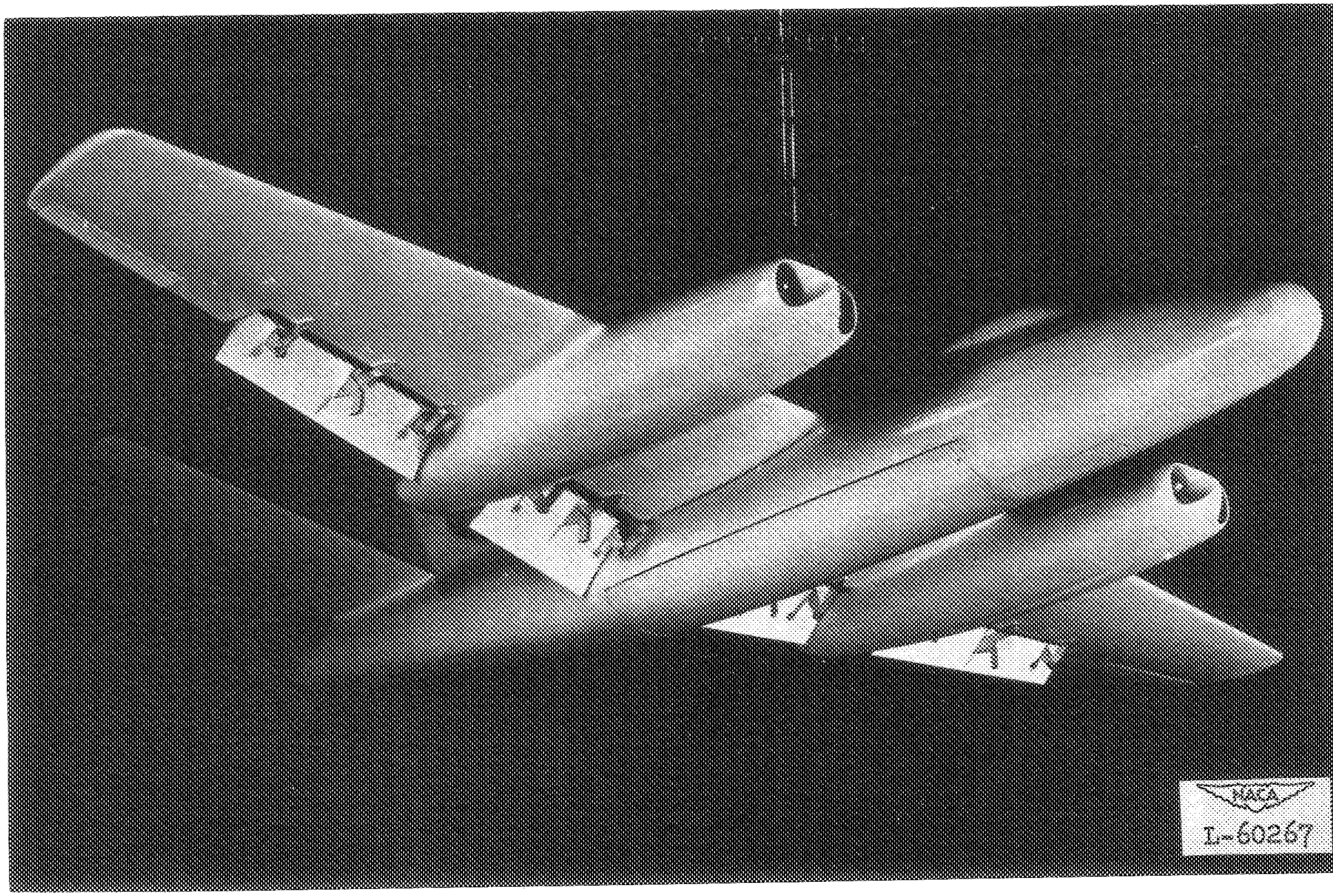
(a) Front view.

Figure 2.- The B-45 ditching model.



(b) Side view.

Figure 2.- Continued.



(c) Three-quarter bottom view.

Figure 2.- Concluded.

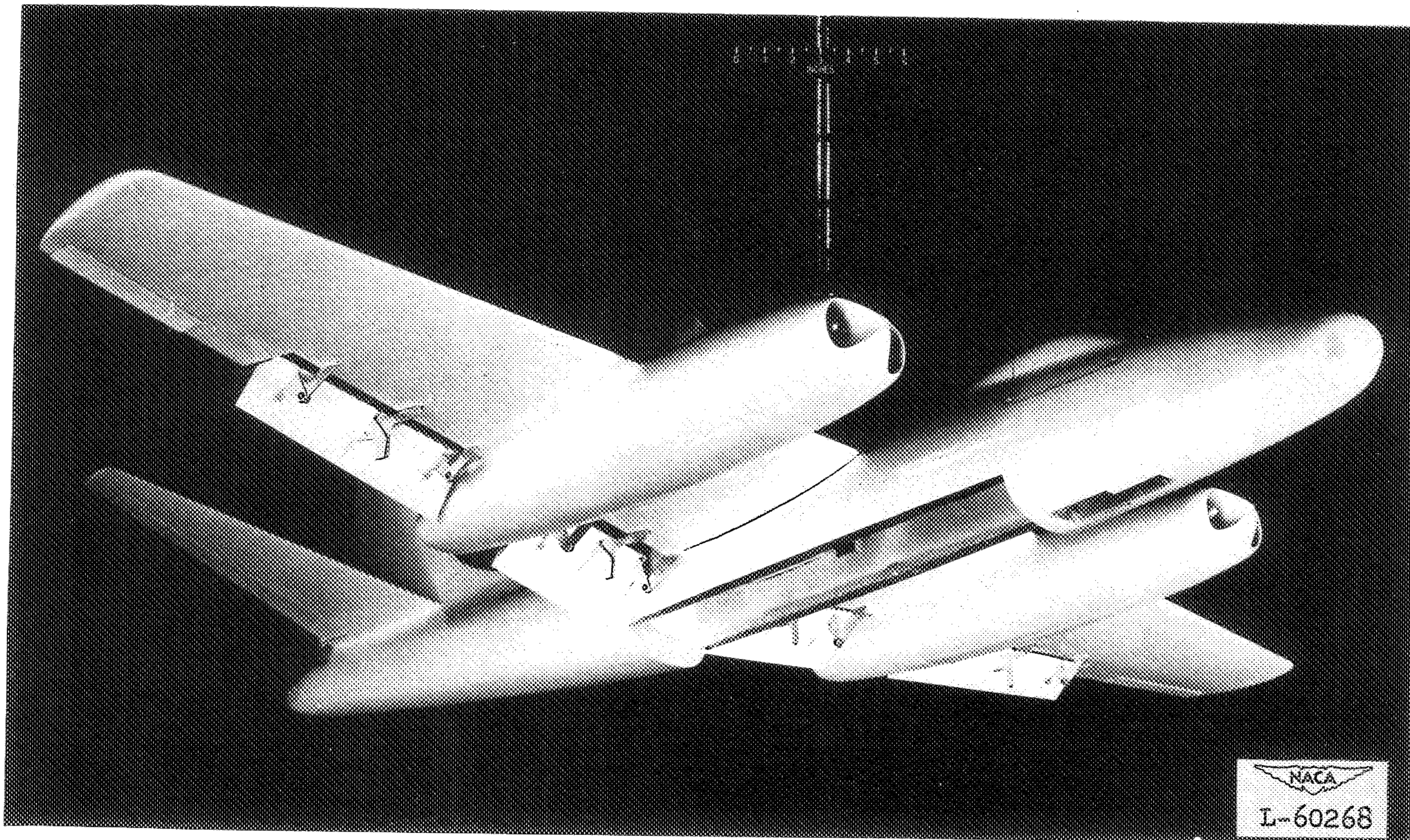


Figure 3.- Model with bomb-bay doors and nose-wheel doors removed.

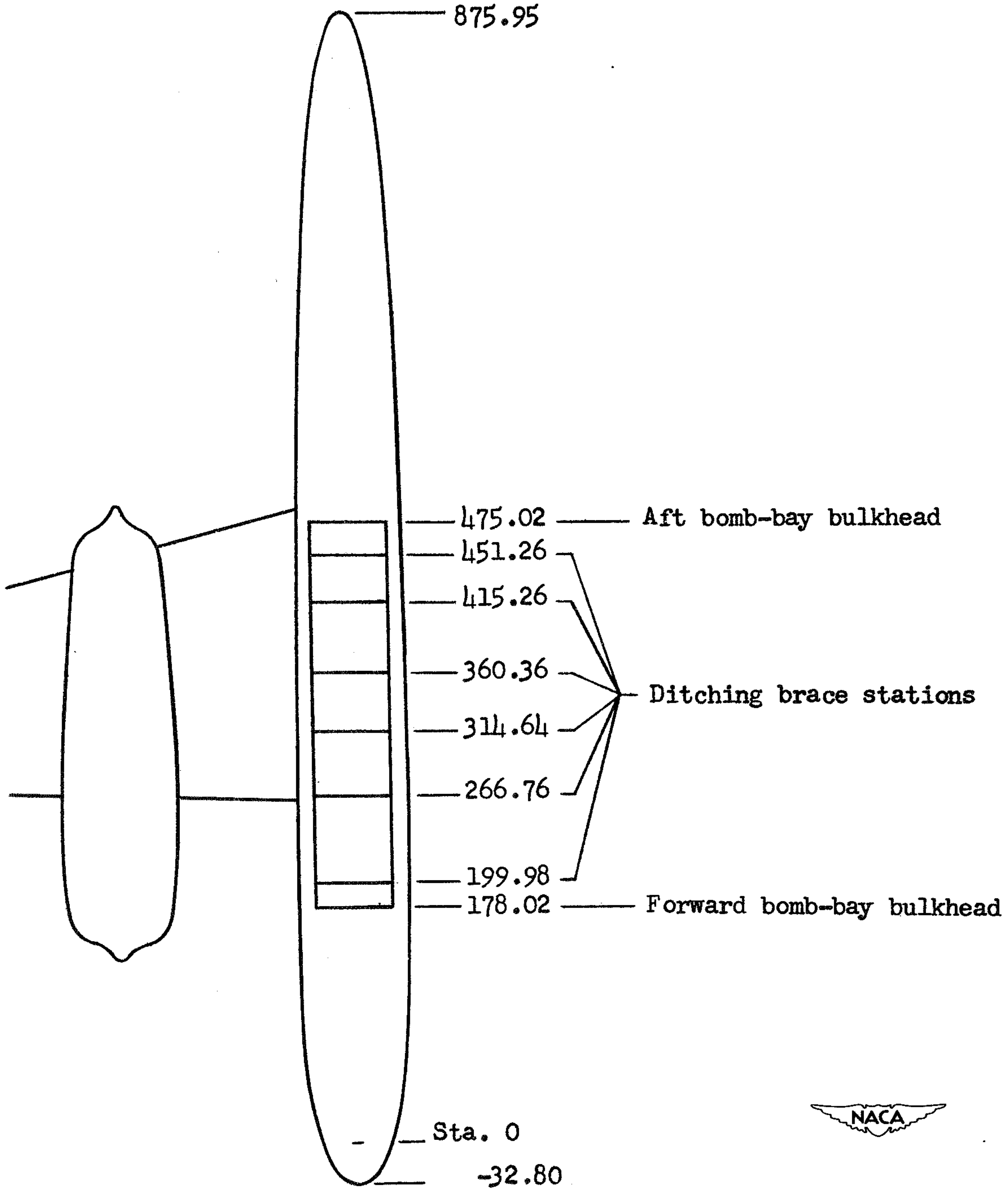


Figure 4.- Bottom view of fuselage showing locations of ditching braces in the bomb bay. Dimensions are in inches; all values are full scale.

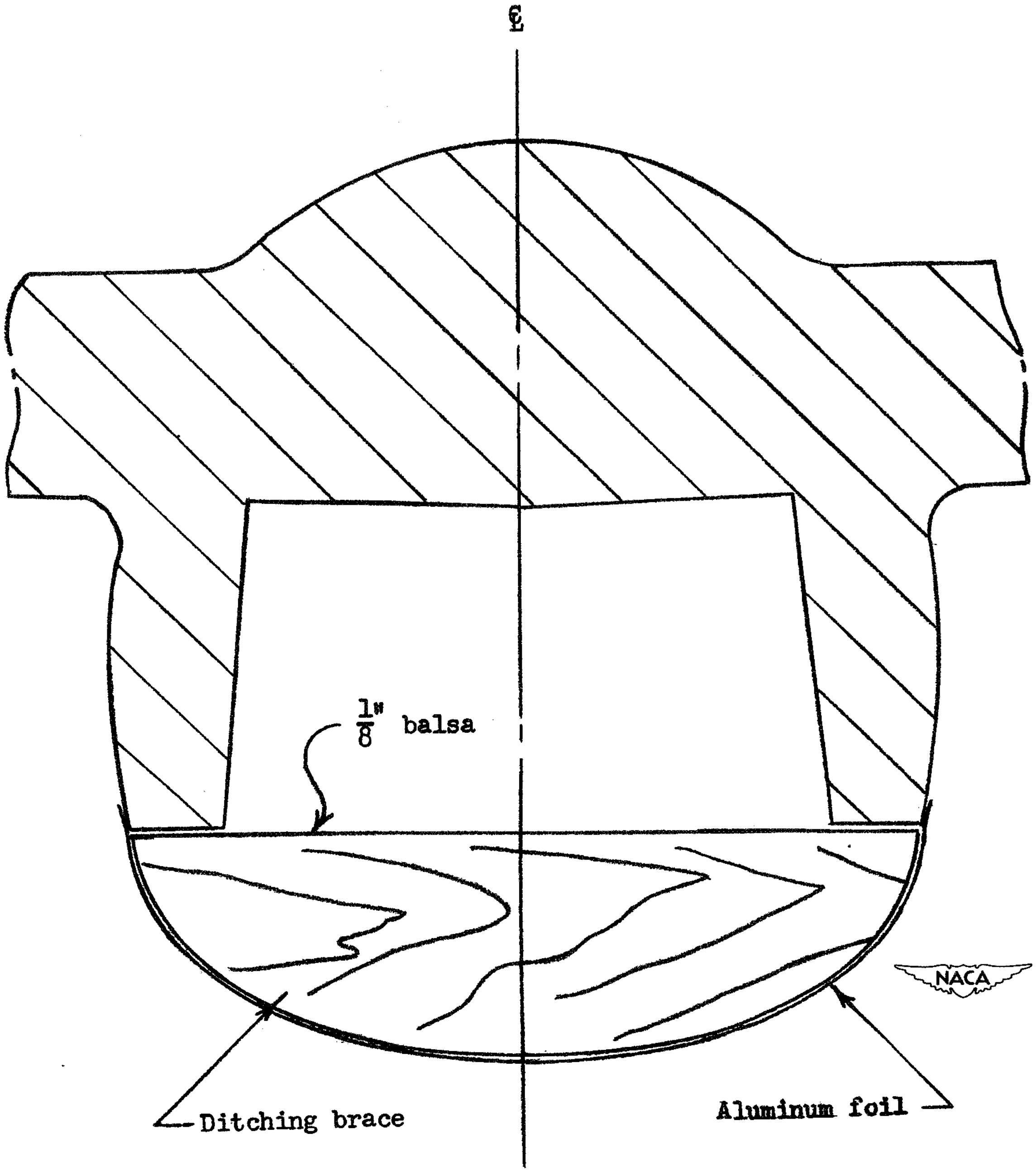


Figure 5.- Cross section of model fuselage showing typical ditching brace.

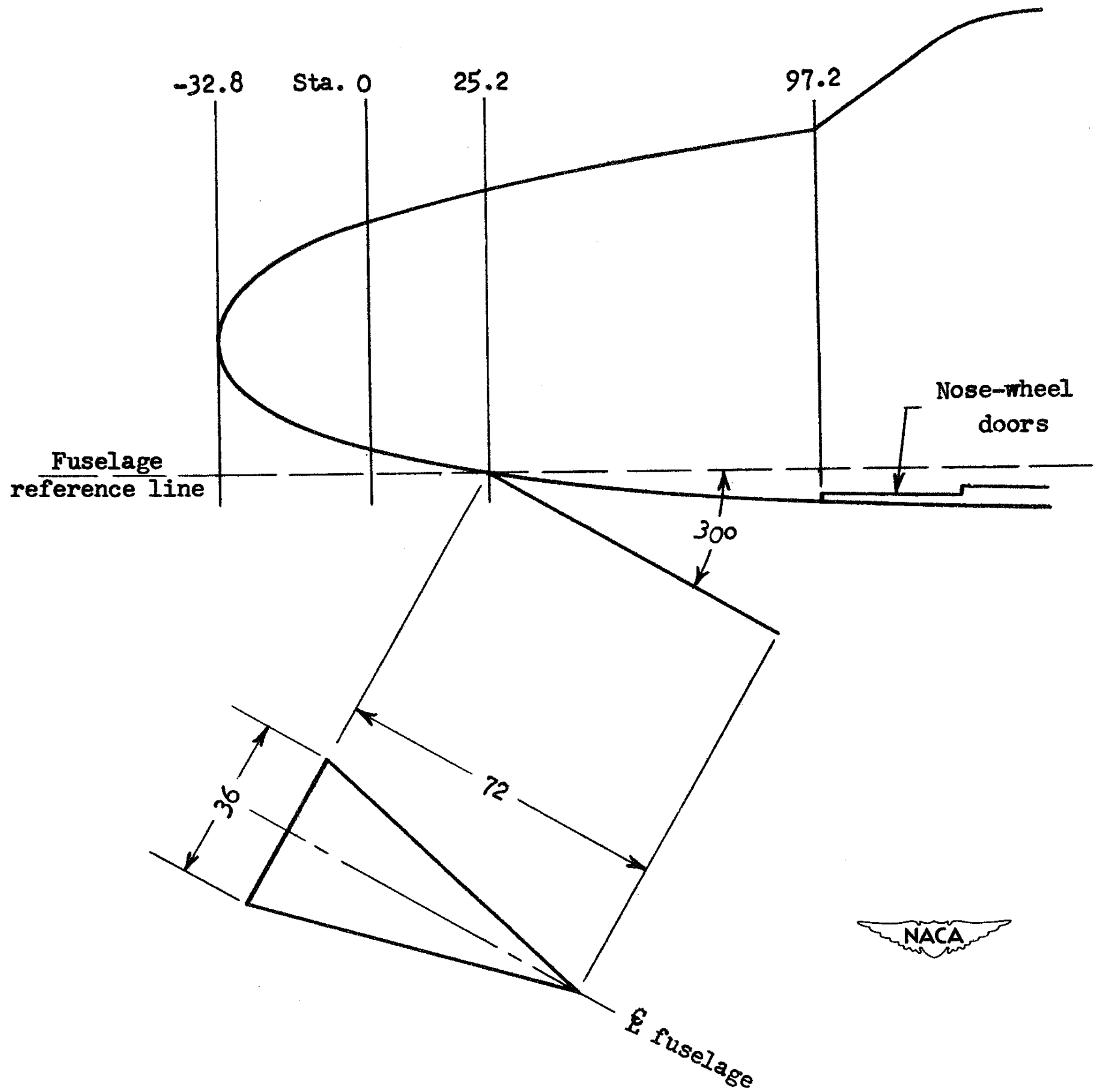
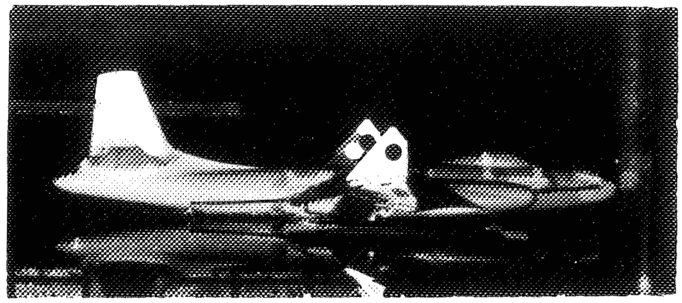
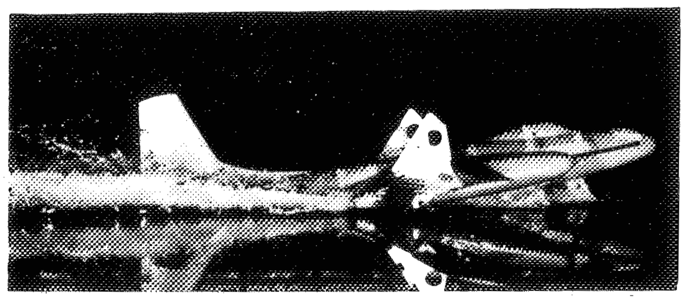


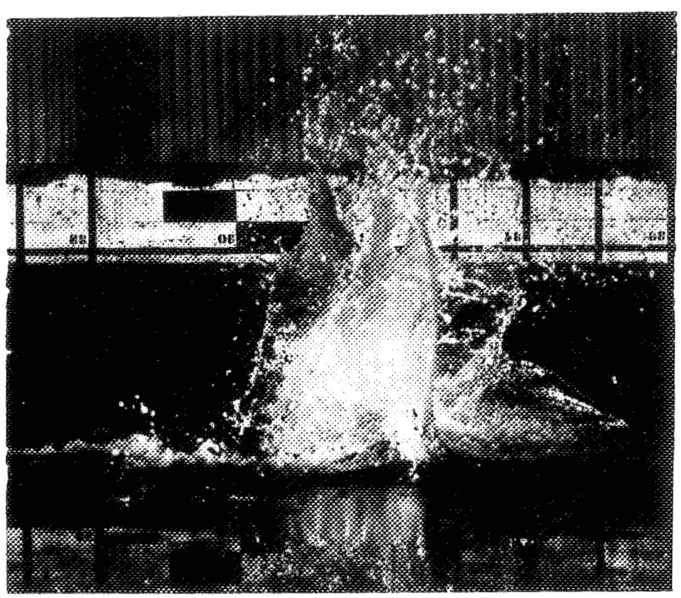
Figure 6.- Side view of nose section showing location and size of hydroflap. Dimensions are in inches; all values are full scale.



Near contact



150 feet



300 feet

(a) Landing attitude, 6°.

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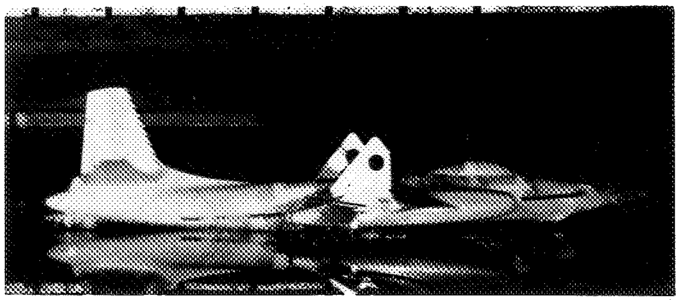
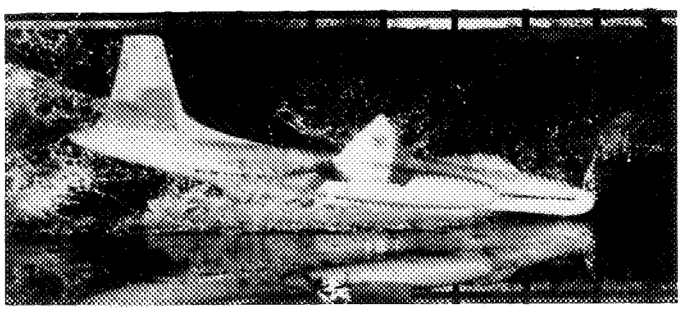
Figure 7.- Sequence photographs of model pitching with scale-strength bomb-bay doors and nose-wheel doors installed. All values are full scale.

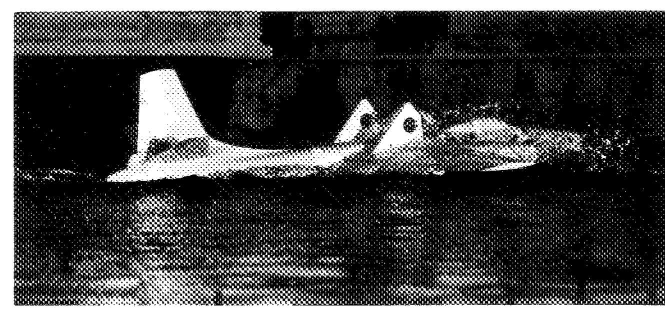


Near contact

150 feet



350 feet



540 feet

(b) Landing attitude, 6°; hydroflap installed.

Figure 7.- Continued.

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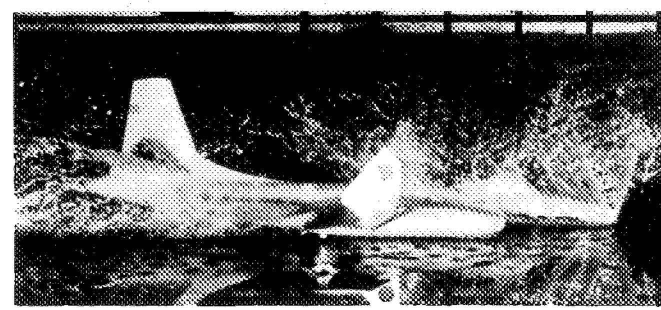
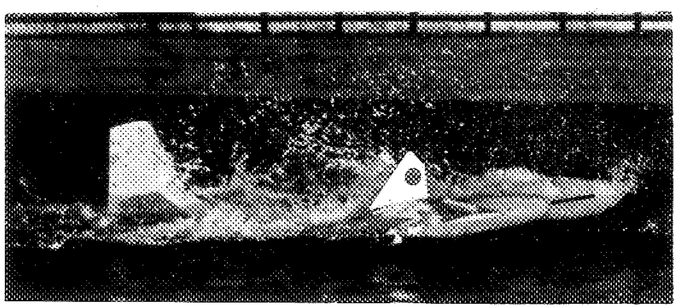
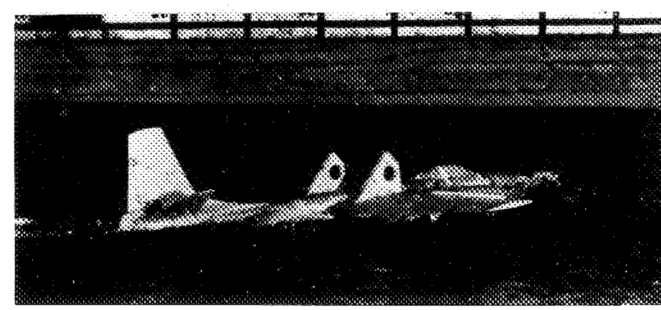
Near contact



200 feet



400 feet



720 feet

(c) Landing attitude, 2°; hydroflap installed.

Figure 7.- Concluded.

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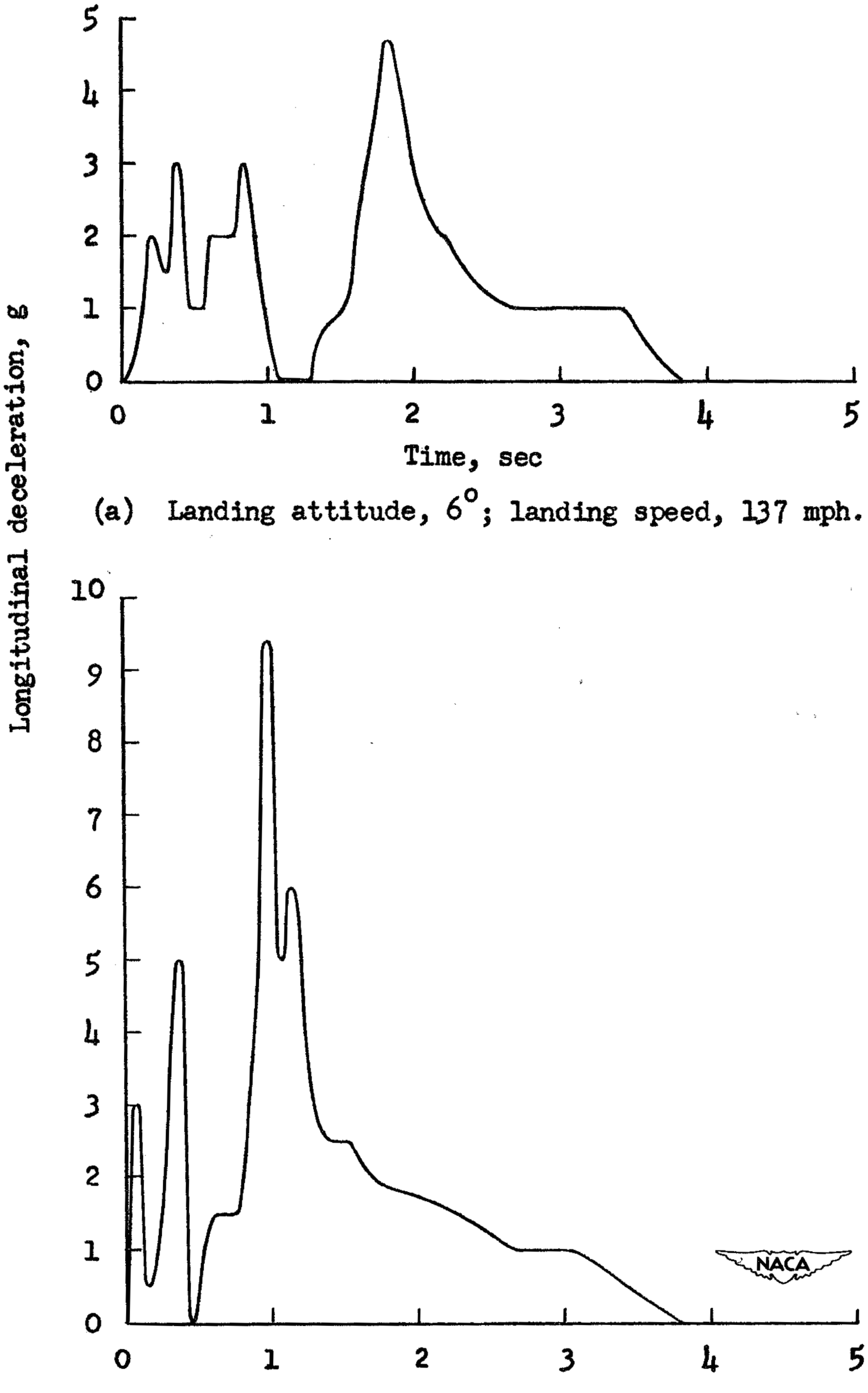

(b) Landing attitude, 2°; landing speed, 151 mph.

Figure 8.- Longitudinal decelerations for typical ditchings with scale-strength bomb-bay doors and nose-wheel doors installed. All values are full scale.

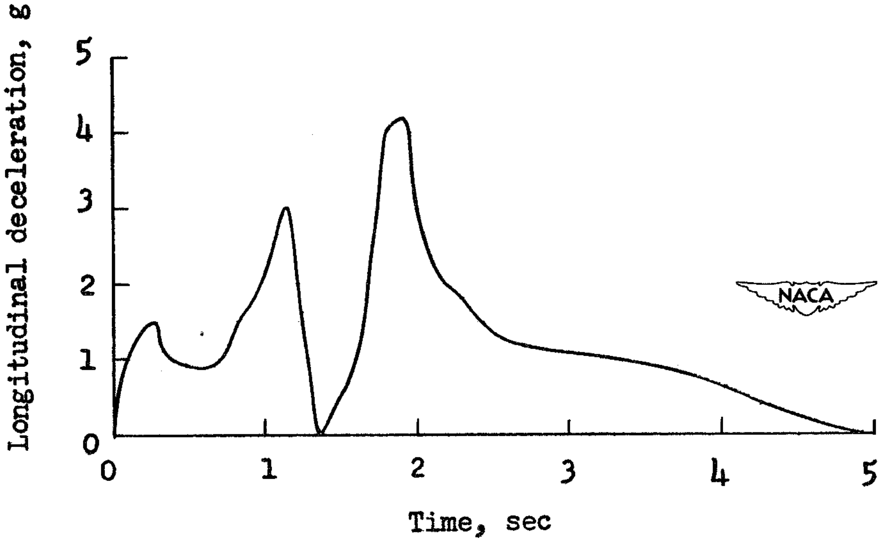

Figure 9.- Longitudinal decelerations for typical ditchings with ditching braces, scale-strength bomb-bay doors and nose-wheel doors installed. Landing attitude, 6°; landing speed, 137 mph. All values are full scale.

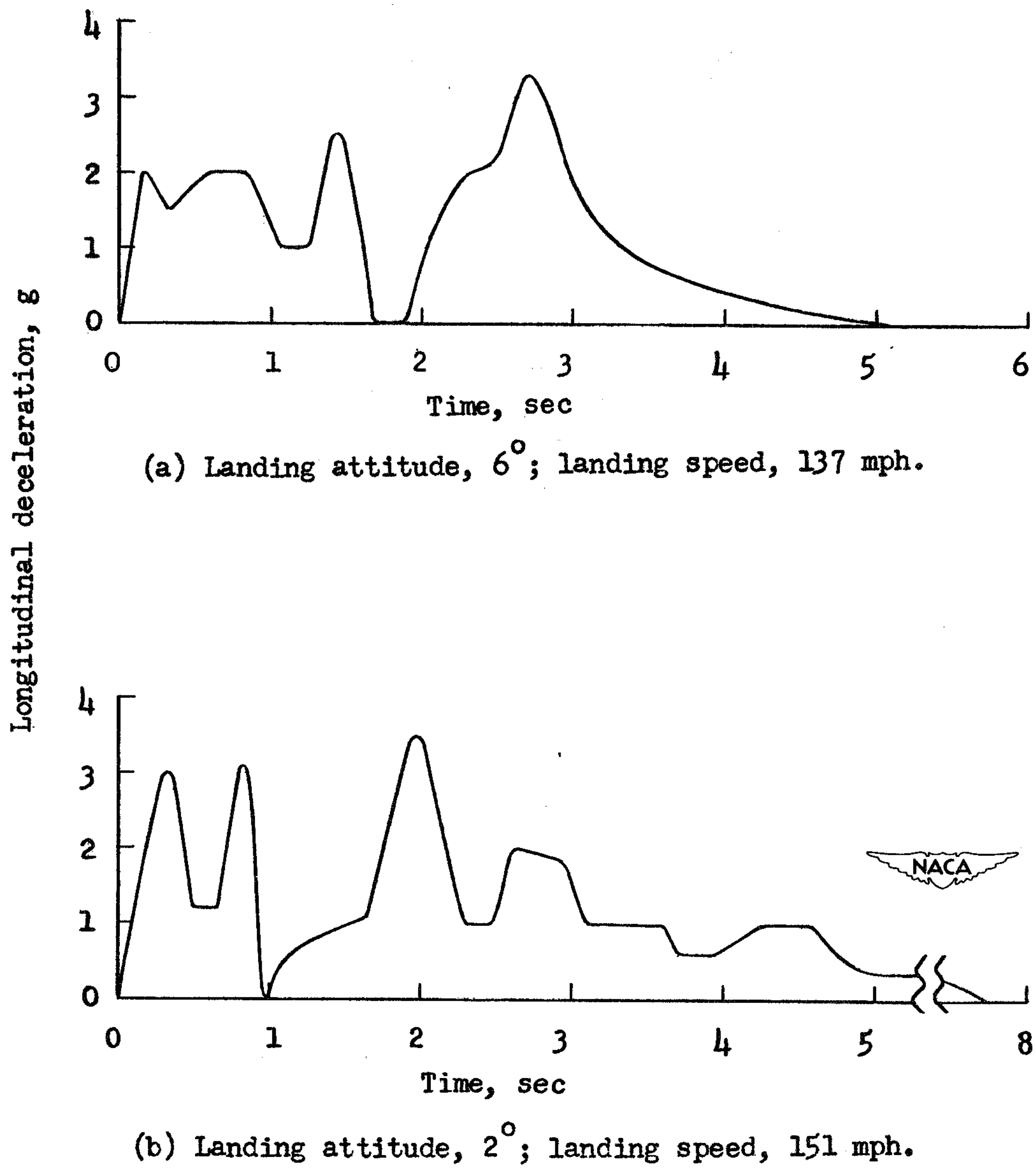

Figure 10.- Longitudinal decelerations for typical ditchings with hydroflap, scale-strength bomb-bay doors and nose-wheel doors installed. All values are full scale.

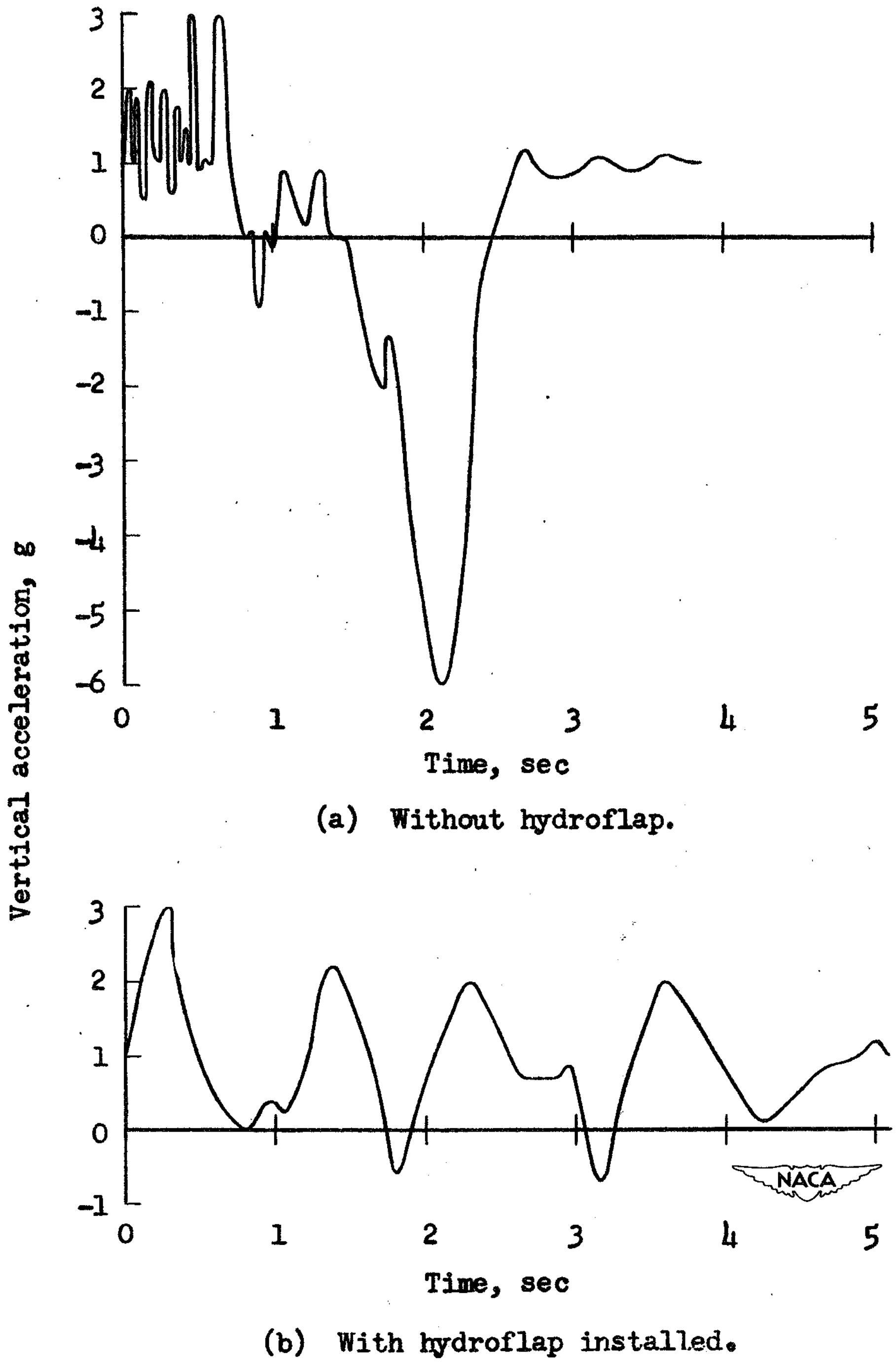

Figure 11.- Vertical accelerations for typical ditchings with scale-strength bomb-bay doors and nose-wheel doors installed. Landing attitude, 6°; landing speed, 137 mph. All values are full scale.

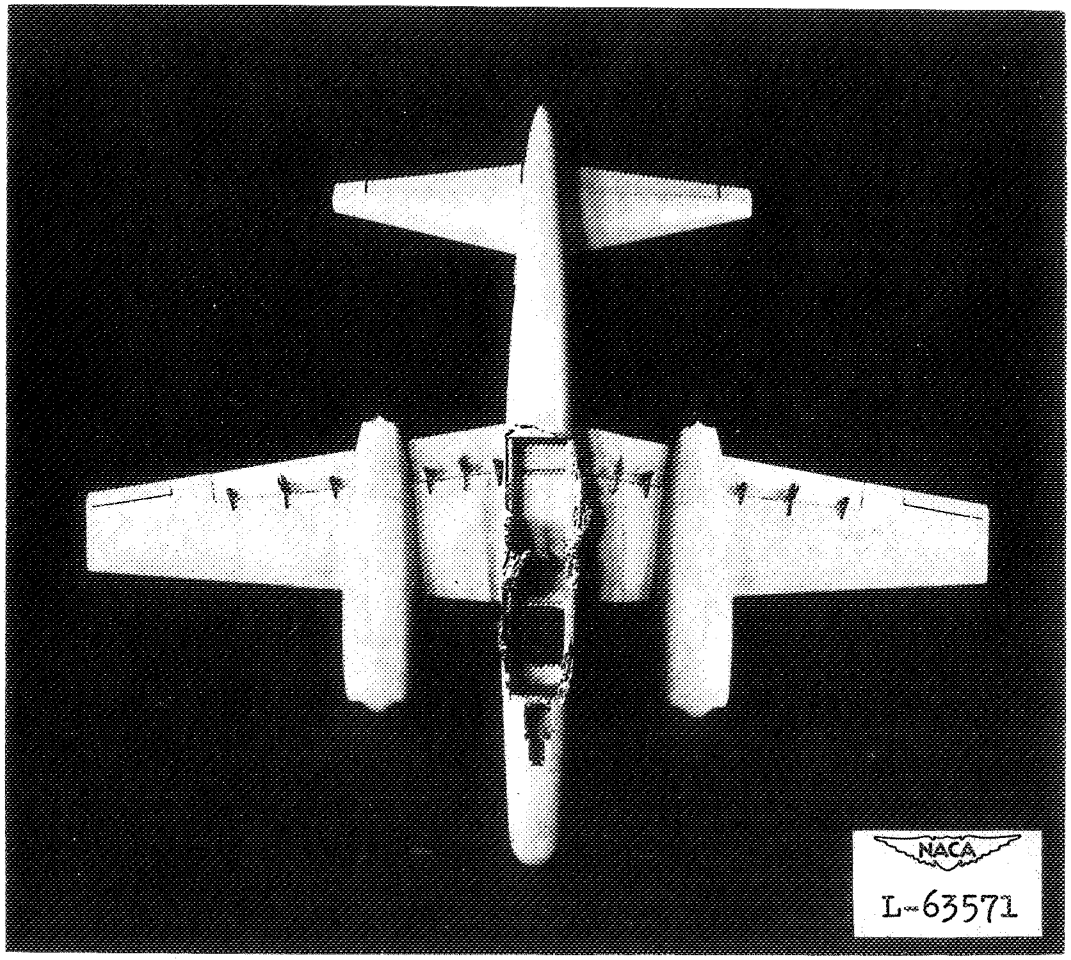

Figure 12.- Representative damage to the scale-strength bomb-bay doors and nose-wheel doors.