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RESEARCH MEMORANDUM

for the

Bureau of Aeronautics, Department of the Navy

DITCHING TESTS OF A $\frac{1}{10}$-SCALE MODEL OF THE

NORTH AMERICAN XFJ-1 AIRPLANE

TED NO. NACA 314

By

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SUMMARY

Tests were made of a $\frac{1}{10}$-scale dynamically similar model of the North American XFJ-1 airplane to study its behavior when ditched. The model was landed in calm water at the Langley tank no. 2 monorail. Various landing attitudes, speeds, and conditions of damage were simulated.

The behavior of the model was determined from visual observations, by recording the accelerations, and by taking motion pictures of the ditchings. Data are presented in tabular form, sequence photographs, and time-history acceleration curves.

From the results of the tests it was concluded that the airplane should be ditched at the near-stall, tail-down landing attitude of 12°. The flaps should be fully extended to obtain the lowest possible landing speed. The wing-tip tanks should be jettisoned if any appreciable load of fuel remains; if empty, they should be retained for additional buoyancy. In a calm-water ditching the airplane will probably run about 600 feet. Maximum longitudinal decelerations of about $2\frac{1}{2}g$ and maximum vertical acceleration of about 2g will be encountered. The nose-intake duct will be clear of the water until practically all forward motion has stopped.

INTRODUCTION

Model tests were conducted in calm water at the Langley tank no. 2 monorail to determine the probable ditching performance of the North American XFJ-1 airplane and to determine the best way to land it on water. This airplane was also of interest as a typical jet-powered fighter incorporating a nose-inlet duct. Tests have previously been reported on a jet-powered fighter incorporating wing-inlet ducts in reference 1. A three-view drawing of the XFJ-1 airplane is given as figure 1.

The effect of probable damage in a calm-water ditching was investigated by testing the model undamaged and with a simulated crumpled bottom.

The tests were requested by the Bureau of Aeronautics, Department of the Navy, in their letter of November 12, 1946. Design information on the airplane was furnished by North American Aviation, Inc.

APPARATUS AND PROCEDURE

Description of Model

A $\frac{1}{10}$-scale dynamic model of the XFJ-1 airplane, shown in figure 2, was furnished by the Bureau of Aeronautics according to NACA specifications. It was constructed of balsa wood and spruce and was ballasted internally to obtain scale weight and moments of inertia. The model had a wing span of 3.83 feet and an over-all length of 3.33 feet.

The flaps were hinged and held in the down position by a strand of thread of the required strength. When a load of 138 pounds per square foot (full scale) was applied to the flaps the thread would break and the flaps would rotate to the neutral position.

The hydrodynamic effect of probable bottom damage was investigated by installing the crumpled bottom shown in figure 3. The crumpled bottom was constructed of balsa wood and dented to conform with damage estimates based on the strength of the various fuselage panels replaced by the bottom.

Test Methods and Equipment

The model was launched by catapulting it from the tank no. 2 monorail. The model left the launching carriage at scale speed and at the desired landing attitude, and the control surfaces were set so that the attitude did not change appreciably in flight. The behavior of the model was recorded from visual observations and by a high-speed motion-picture camera. The longitudinal and vertical accelerations were measured by a single-component time-history accelerometer placed in the pilot's cockpit. To obtain the two components of acceleration, the accelerometer was rotated and the tests repeated.

Test Conditions

(All values given refer to the full-scale airplane.)

<u>Gross weight</u>.- Tests were made with the model weight corresponding to the full-scale gross weight of 12,151 pounds.

<u>Location of the center of gravity</u>.- The center of gravity was located at 22.8 percent mean aerodynamic chord and 11.12 inches below the fuselage reference line.

<u>Landing attitude</u>.- The model was ditched at attitudes of 2°, 8°, and 12°. The 2° attitude is close to the three-wheel landing attitude. The 8° attitude is an intermediate landing attitude. The 12° attitude is near the stall angle and the maximum tail-down angle. The attitude angle was measured between the fuselage reference line and the water surface.

<u>Flap deflection</u>.- Tests were made with flaps up and with flaps extended 40° fastened at scale strength.

<u>Landing speed</u>.- The speeds were such that the model was air-borne within ± 4 knots of the landing speed calculated from the power-off lift curves obtained from North American Aviation, Inc.

<u>Landing gear</u>.- All tests simulated ditchings with the landing gear retracted.

<u>Condition of simulated damage</u>.- Structural ultimate strengths of the doors and panels on the underside of the fuselage in pounds per square inch are given in figure 4. On the basis of this structural information the nose-wheel door will probably be torn completely away in a ditching. The portion of the skin from station 82 to station 232 will probably be pushed in but will be partially supported by the catapult tow structure and fuel cells. The section aft of station 232 is of such strength that it may remain undamaged in a calm-water ditching. To simulate these conditions the crumpled bottom shown in figure 3 was developed.

The model was tested with the following configuration:

(a) No damage

(b) Simulated failure of the nose-wheel door

(c) Simulated failure of the nose-wheel door and simulated crumpled bottom from station 82 to station 232

(d) Same as (c) but with empty wing-tip tanks installed

RESULTS AND DISCUSSION

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

d_1 violent dive - a dive in which the wings are submerged and the angle between the water surface and the thrust line is greater than 15°

h smooth run - no apparent oscillation about any axis

p porpoising - an undulating motion about the transverse axis in which some part of the model is always in contact with the water

s skipping - an undulating motion about the transverse axis in which the model clears the water completely

u trimmed up - a rotation about the transverse axis in which the angle subtended by the fuselage reference line and the surface of the water increases as the model runs through the water

Typical time histories of longitudinal and vertical decelerations are given in figures 5, 6, and 7. Photographs showing the characteristic motions of the model are shown as figure 8.

Effect of Attitude and Damage

When tested in the undamaged condition the model exhibited a tendency to skip at all three attitudes tested. The magnitude of this skipping increased with increasing landing speed. At the 12° attitude (flaps 40°) the model was clear of the water for about 100 feet (full scale) during the skip. At the 8° attitude the model made two skips, the first was about 200 feet and was followed immediately by another shorter skip of about 50 feet. At the 2° attitude the skip was of such violence (about 450 ft long) that the model stalled while in the air resulting in the model recontacting the water at a nose-down attitude, causing a violent dive.

The time histories of longitudinal decelerations in figure 5 show that, except for the 12° attitude (flaps 40°) where the skip was comparatively mild, the maximum deceleration occurred upon recontact of the model with the water following the skin. This deceleration increased with the length of the skip.

When the model was tested with the nose-wheel door removed, some difference from the undamaged condition was noted in the results.

After the initial impact, the nose-wheel door was never in the water because of the high attitude at which the model ran. However, the slight change in hydrodynamic forces occurring during the initial impact improved the behavior slightly. This resulted in the elimination of the second skip at the 8° attitude and the dive at the 2° attitude.

When tested with the crumpled bottom, the model showed considerable improvement in ditching behavior. The maximum longitudinal decelerations remained about the same at the 12° attitude but were considerably reduced at the 8° and 2° attitudes. The skip was completely eliminated at the 12° attitude and greatly reduced at 8° and 2°. This improvement in behavior can be seen by comparing the time histories of longitudinal decelerations in figures 5 and 6.

From the preceding results it can be seen that the motions of the model were least violent at the 12° attitude at all three conditions of simulating damage. This and the lower landing speeds and lower decelerations make 12° the preferable ditching attitude. The low decelerations, about $2\frac{1}{2}g$ longitudinal and 2g vertical, the structure of the underside of the fuselage, and the rather smooth motions indicate that in most ditchings only slight bottom damage will occur when ditched in calm water at the 12° attitude. The airplane will run about 600 feet in the water.

From the sequence photographs in figure 8 and the time histories of vertical accelerations in figure 7 the differences in ditching behavior at the 12° attitude caused by fuselage bottom damage can be seen.

Effect of Flaps

At all three of the attitudes tested the landing flaps were the first part of the model to contact the water. The flaps always failed but imparted a slight nose-down pitching moment to the model. This effect was quickly overcome and the model trimmed up when the fuselage bottom contacted the water. When tested with flaps full up, the landing speed was higher and caused the model to skip more violently than when tested with flaps down. For this reason the use of full-down flaps would be advantageous in a ditching.

Effect of Nose-Intake Duct

The nose-intake duct had no effect on the ditching behavior of the model. The model ran at a high enough attitude to keep the duct clear of the water until practically all forward motion had stopped. In both this investigation and that of reference 1 the motions of the model were such that the hydrodynamic effect of jet-intake ducts was of little consequence.

Effect of Wing-Tip Tanks

Previous model tests (reference 1) have indicated that the increased landing speed resulting when the wing-tip tanks are loaded with fuel is detrimental to ditching behavior.

However, when tested at the empty weight, the XFJ-1 tanks did not enter the water until practically all forward motion had stopped. Therefore no change in ditching behavior was noted. In a full-scale ditching the tanks should be retained if empty because of the additional buoyancy that will be realized. If any appreciable load of fuel remains, the tanks should be jettisoned.

CONCLUSIONS

From the results of the tests with a $\frac{1}{10}$-scale model of the North American XFJ-1 airplane the following conclusions were drawn:

1. The airplane should be ditched at the near-stall, tail-down attitude of 12°. The flaps should be fully extended to obtain the lowest possible landing speed. The wing-tip tanks should be jettisoned if any appreciable load of fuel remains; if empty, they should be retained for additional buoyancy.

2. In a calm-water ditching the airplane will probably run about 600 feet. Maximum longitudinal decelerations of about $2\frac{1}{2}$g and maximum vertical acceleration of about 2g will be encountered.

3. The nose-intake duct will be clear of the water until practically all forward motion has stopped.

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Approved: John B. Parkinson
John B. Parkinson
Chief of Hydrodynamics Division

AMS

REFERENCE

1. Fisher, Lloyd J., Jr., and McBride, Ellis E.: Ditching Tests of a $\frac{1}{8}$-Scale Model of the Chance Vought XF6U-1 Airplane - TED No. NACA DE319. NACA RM No. SL8F28, Bur. Aero., 1948

[redacted]

TABLE I

SUMMARY OF RESULTS OF DITCHING TESTS IN CALM WATER OF A $\frac{1}{10}$-SCALE MODEL OF THE NORTH AMERICAN XFJ-1 AIRPLANE

[All values full scale; landing flaps down 40° unless otherwise specified; gross weight, 12,151 lb]

Landing attitude (deg)	12					8				2			
Configuration	Landing speed (knots)	Maximum deceleration (g) Longitudinal	Maximum deceleration (g) Vertical	Length of run (ft)	Motions of model (a)	Landing speed (knots)	Maximum longitudinal deceleration (g)	Length of run (ft)	Motions of model (a)	Landing speed (knots)	Maximum longitudinal deceleration (g)	Length of run (ft)	Motions of model (a)
No damage; flaps up	118.2	6.0		900	$us_{350}s_{150}p$								
No damage	93.9	2.5	3.6	700	$us_{100}ph$	104.3	4.0	1000	$us_{200}s_{50}h$	128.7	9.7	650	$us_{450}d_1$
Simulated failure of nose-wheel door	93.9	2.6	2.8	650	$us_{100}ph$	104.3	4.0	800	$us_{200}h$	128.7	9.0	1000	$us_{250}s_{50}ph$
Simulated failure of nose-wheel door and simulated crumpled bottom	93.9	2.3	1.8	600	huph	104.3	3.0	700	$us_{100}ph$	128.7	5.0	900	$us_{200}uh$
Same as above with wing-tip tanks installed	93.9	2.2		600	huph	104.3	3.1	700	$us_{100}ph$				

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[a]Motions of the model are denoted by the following symbols:
- d_1 - dived violently
- h - ran smoothly
- p - porpoised
- s - skipped (subscript denotes length of skip in feet)
- u - trimmed up

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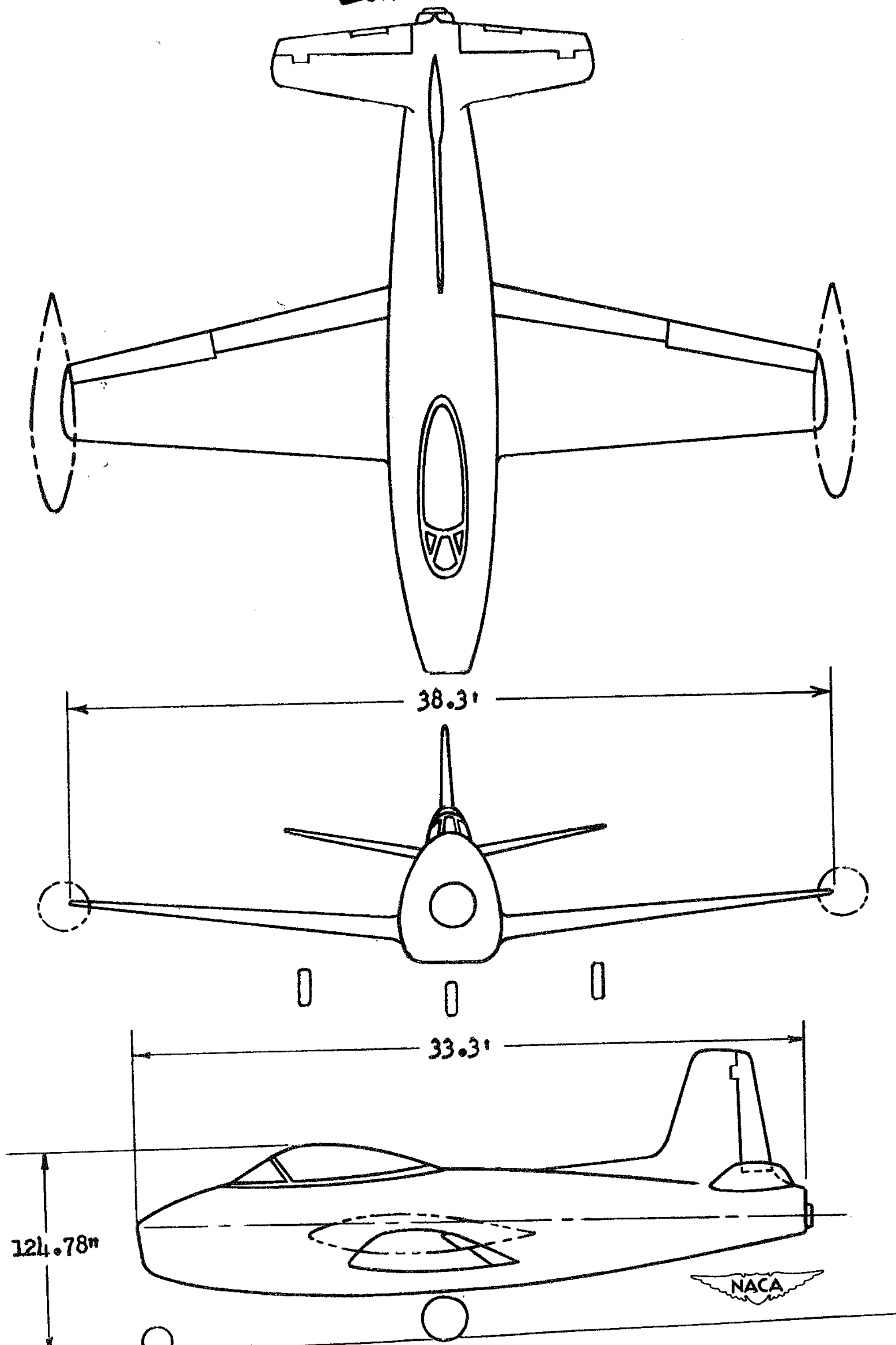

Figure 1.– Three-view drawing of the XFJ-1 airplane.

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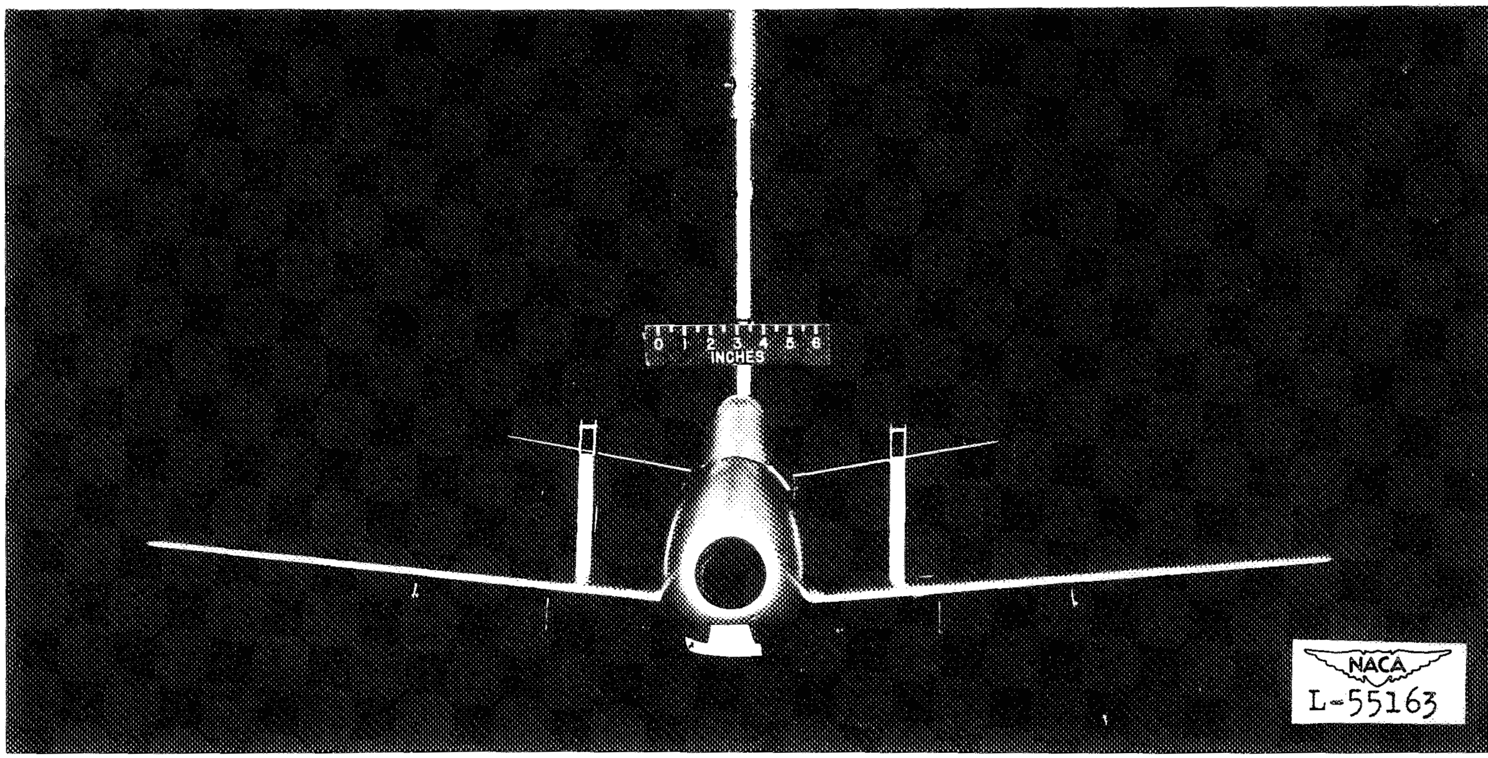

(a) Front view.

Figure 2.- The $\frac{1}{10}$-scale dynamic model of the North American XFJ-1 airplane.

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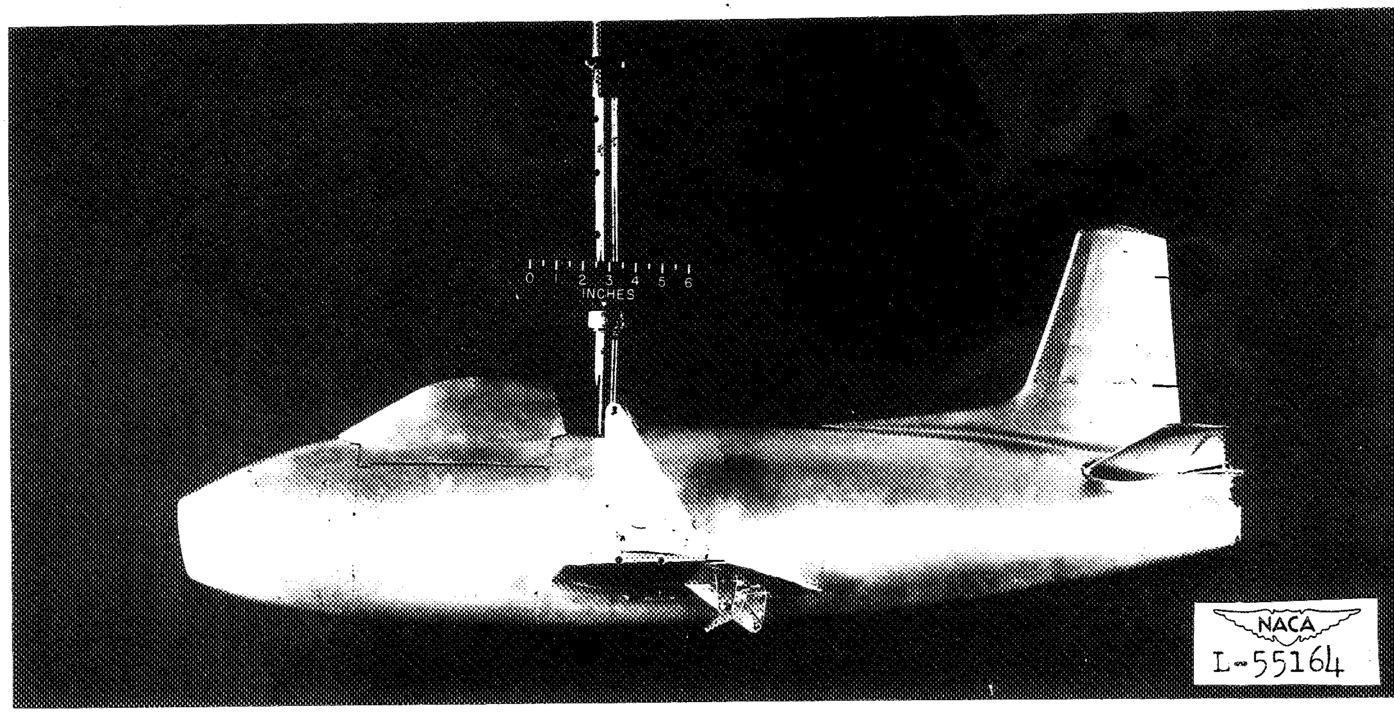

(b) Side view.

Figure 2.– Continued.

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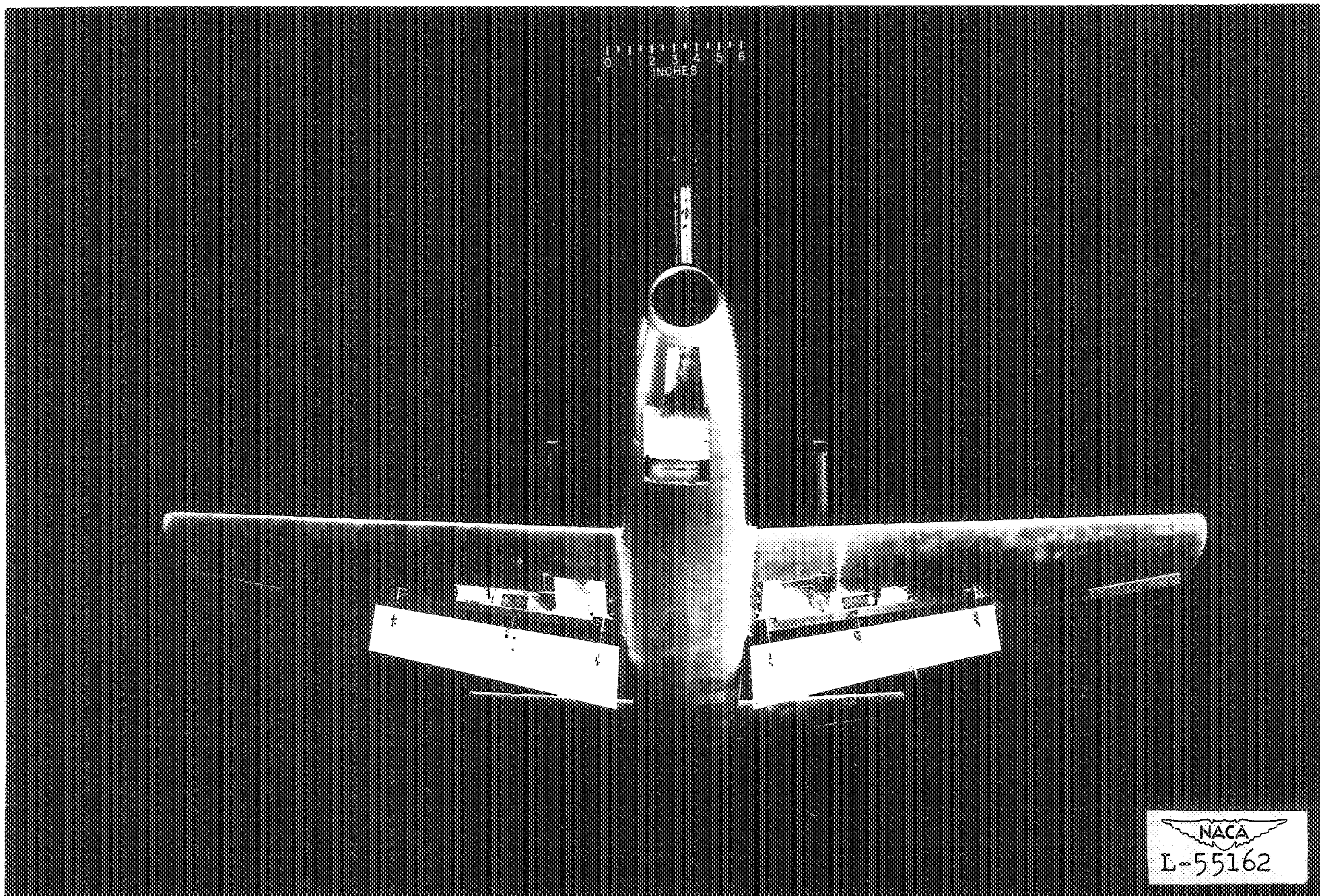

(c) Bottom view.

Figure 2.— Concluded.

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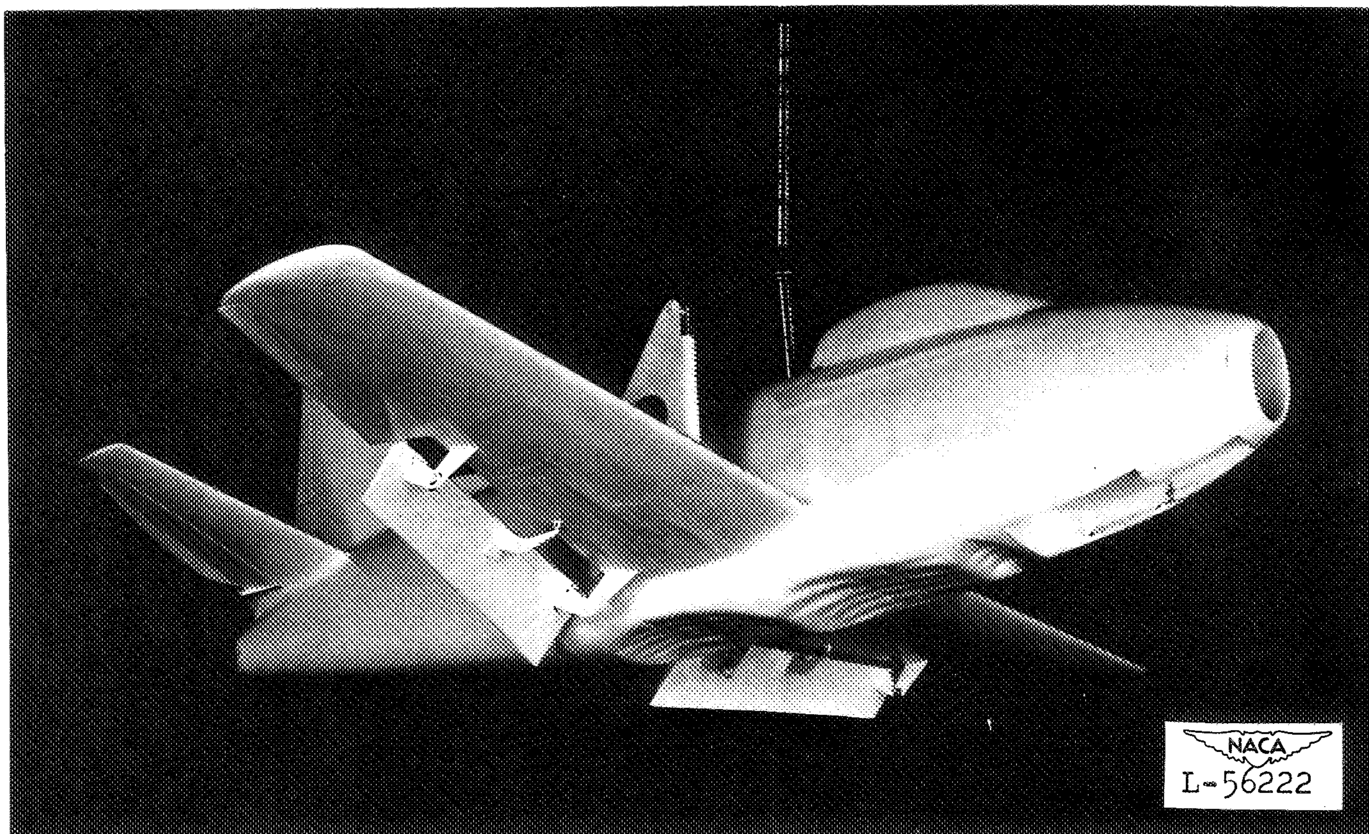

Figure 3.— Installation of the crumpled bottom.

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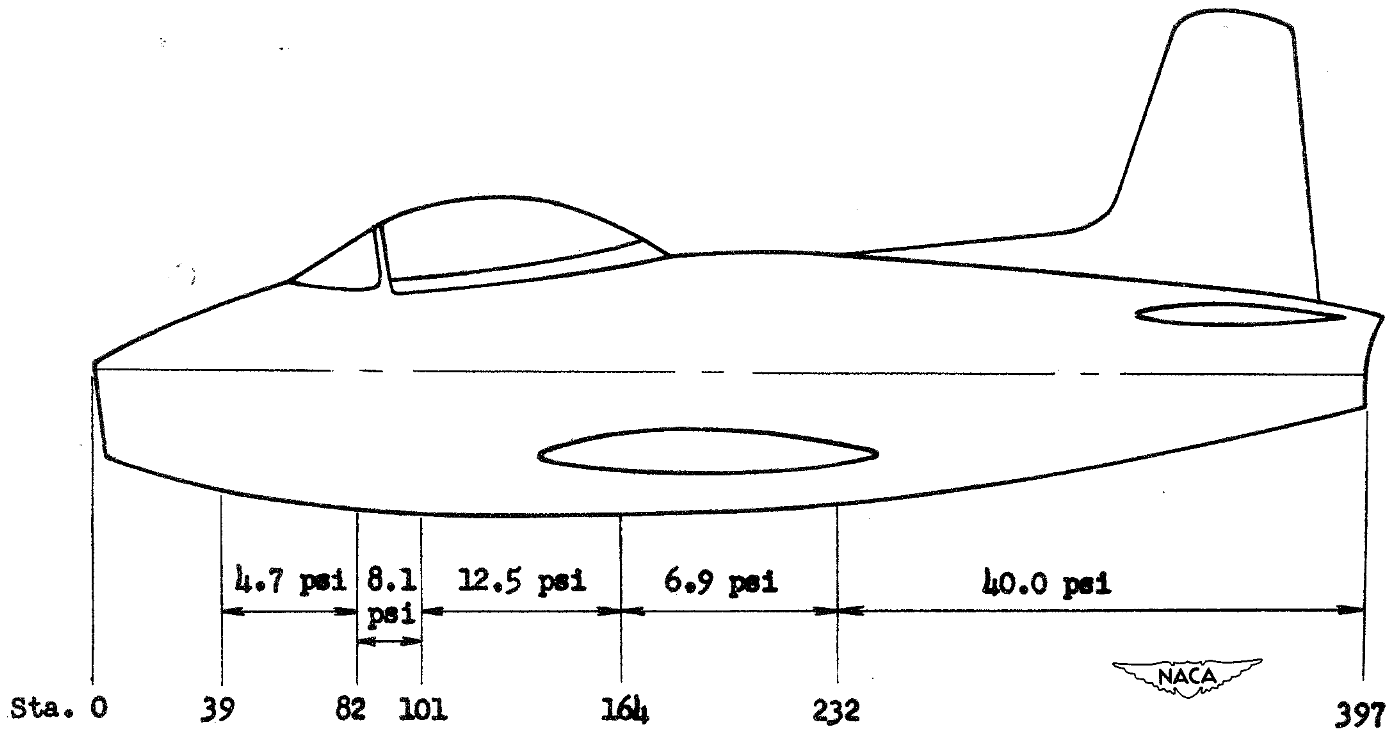

Figure 4.– Structural strengths of the underside of the fuselage.

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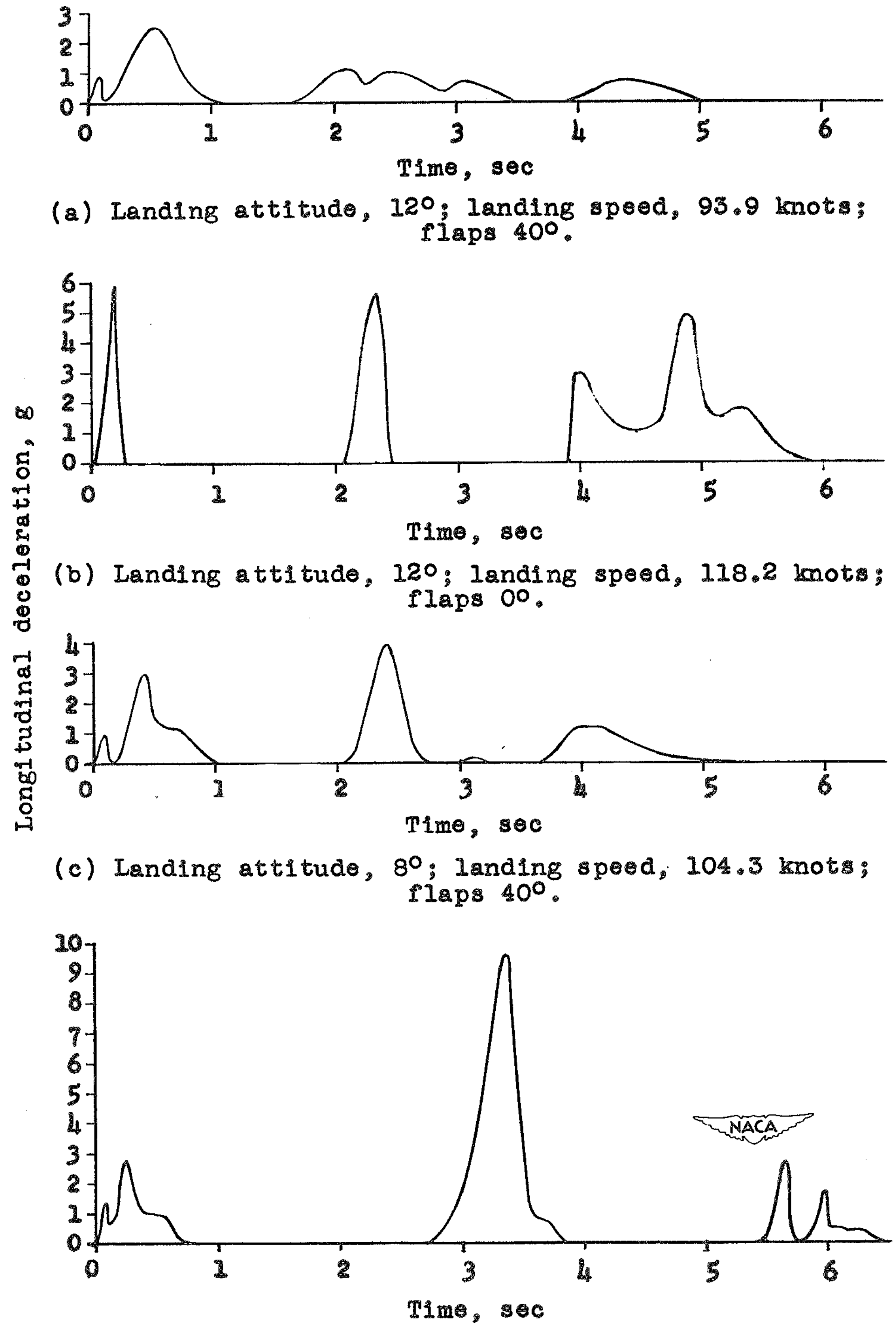

(a) Landing attitude, 12°; landing speed, 93.9 knots; flaps 40°.

(b) Landing attitude, 12°; landing speed, 118.2 knots; flaps 0°.

(c) Landing attitude, 8°; landing speed, 104.3 knots; flaps 40°.

(d) Landing attitude, 2°; landing speed, 128.7 knots; flaps 40°.

Figure 5.– Typical time histories of longitudinal deceleration for ditching tests of undamaged model. (All values are full-scale.)

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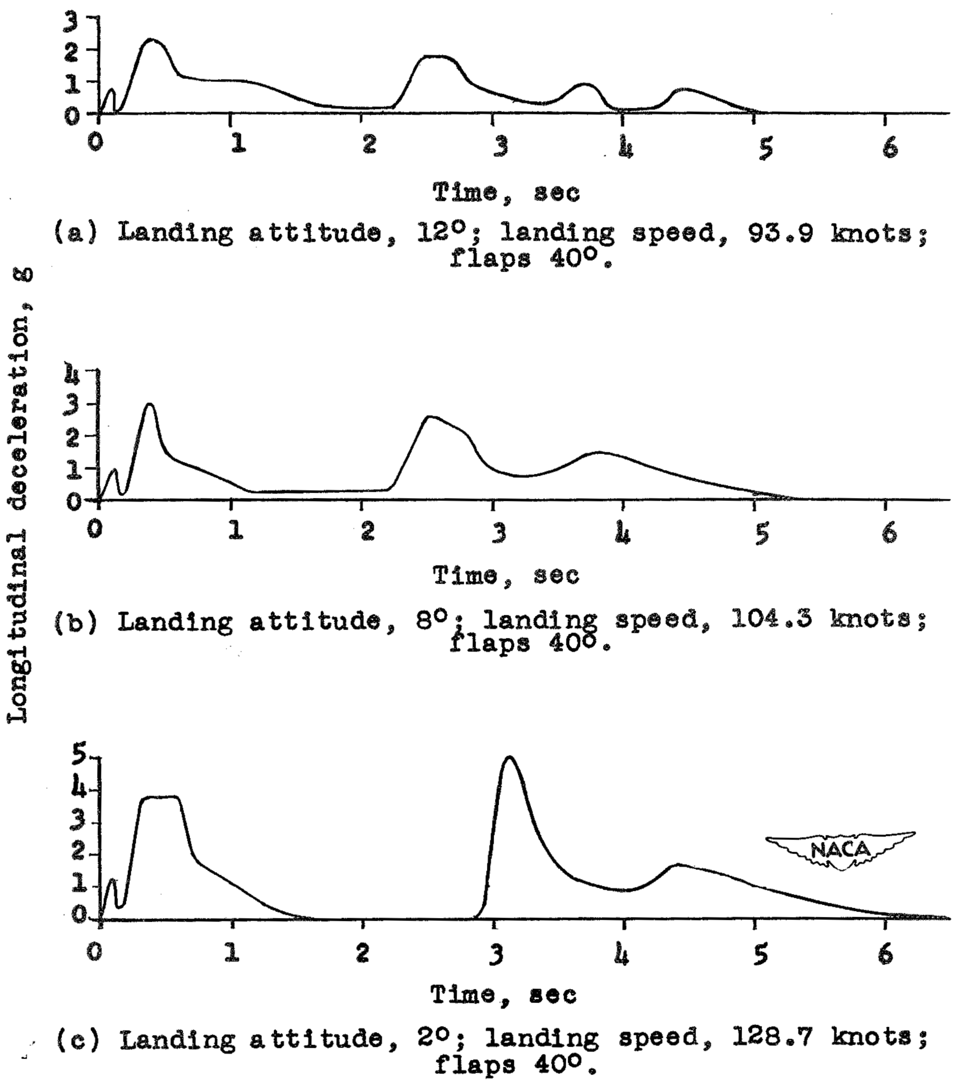

(a) Landing attitude, 12°; landing speed, 93.9 knots; flaps 40°.

(b) Landing attitude, 8°; landing speed, 104.3 knots; flaps 40°.

(c) Landing attitude, 2°; landing speed, 128.7 knots; flaps 40°.

Figure 6.– Typical time histories of longitudinal decelerations for ditching tests of the model with simulated failure of the nose-wheel door and simulated crumpled bottom. (All values are full-scale.)

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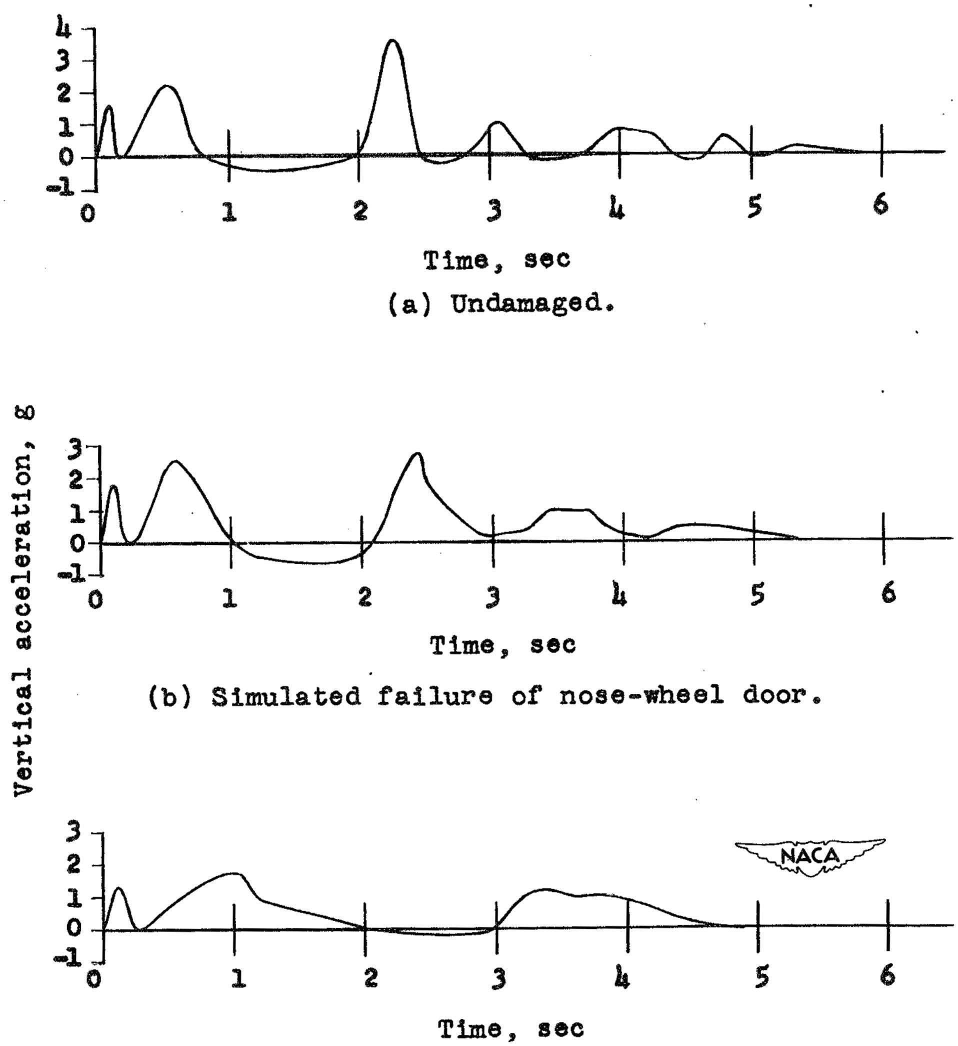

(c) Simulated failure of nose-wheel door and simulated crumpled bottom.

Figure 7.– Typical time histories of vertical accelerations at the 12° landing attitude; landing speed, 93.9 knots; flaps full down. (All values are full-scale.)

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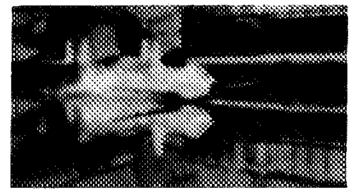
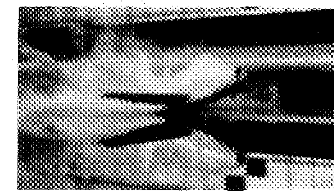
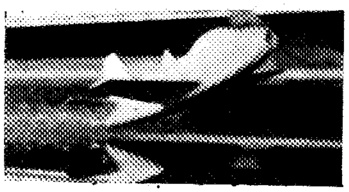
0.35 second



0.87 second



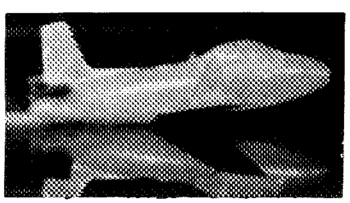
1.39 seconds



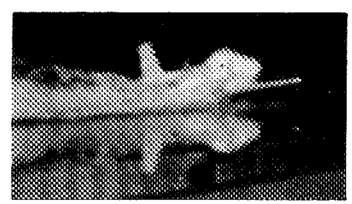
1.91 seconds

2.43 seconds

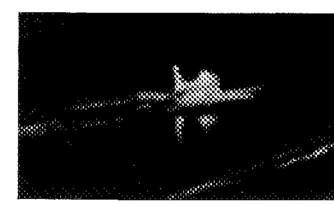
2.95 seconds



3.47 seconds



4.51 seconds



7.21 seconds

(a) Undamaged.

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Figure 8.– Sequence photographs at indicated time after contact of model ditchings at the 12° landing attitude. Landing speed, 93.9 knots. (All values full-scale.)

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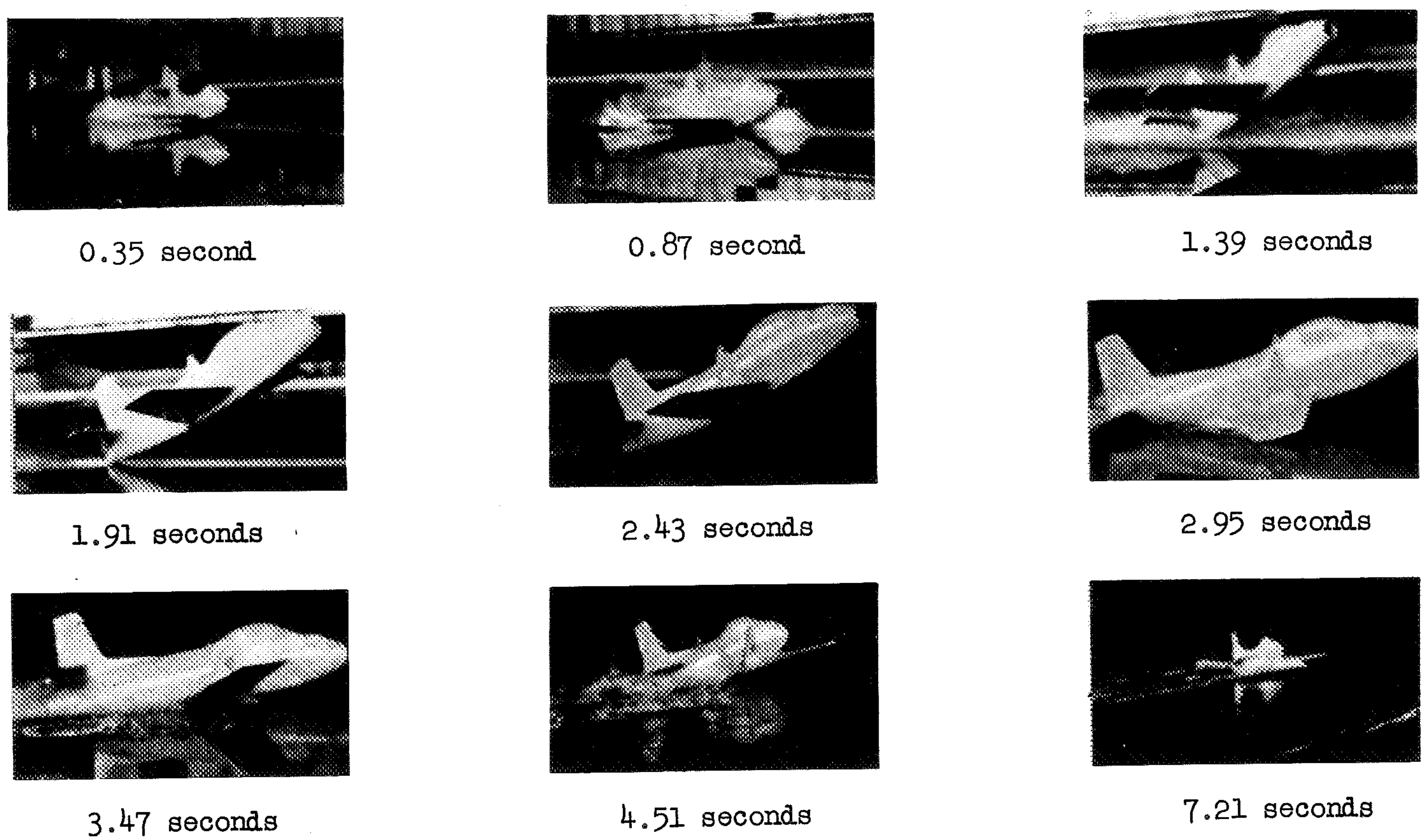

(b) Simulated failure of the nose-wheel door.

Figure 8.- Continued.

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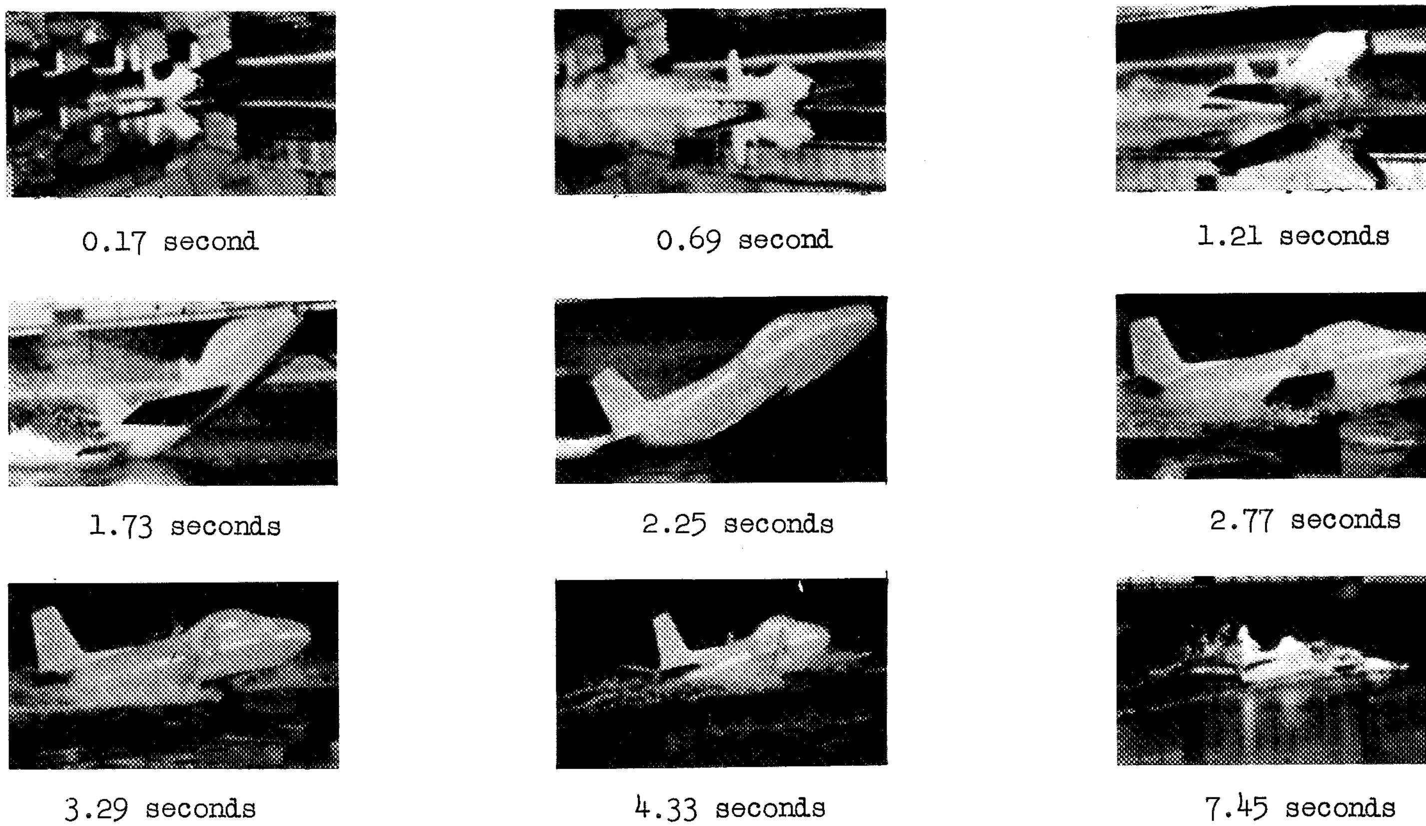

(c) Simulated failure of the nose-wheel door and the installation of the crumpled bottom.

Figure 8.– Concluded.

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