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RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

DITCHING INVESTIGATION OF A $\frac{1}{10}$-SCALE MODEL OF THE NORTH AMERICAN F-86 AIRPLANE

By Lloyd J. Fisher and Ellis E. McBride

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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SUMMARY

An investigation was made of a $\frac{1}{10}$-scale dynamically similar model of the North American F-86 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, acceleration records, and motion-picture records of the ditchings. Data are presented in tabular form, sequence photographs, and time-history acceleration curves.

From the results of the investigation it was concluded that the airplane should be ditched at the nose-high, 14° attitude to avoid the violent dive which occurs at the 4° attitude. The flaps and leading-edge slats should be fully extended to obtain the lowest possible landing speed. The wing tanks should be jettisoned to avoid the undesirable behavior which occurs with the tanks attached. In a calm-water ditching under these conditions the airplane will run smoothly for about 600 feet. Maximum longitudinal and vertical decelerations of about 3g will be encountered.

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INTRODUCTION

An investigation was conducted in calm water at the Langley tank no. 2 monorail to determine the probable ditching behavior of the North American F-86 airplane and to determine the best way to land it on water. This airplane was of interest as a typical swept-wing jet-powered fighter incorporating a nose-intake duct. A three-view drawing of the F-86 airplane is given in figure 1.

The investigation was requested by the Air Materiel Command, U. S. Air Force. Design information on the airplane was furnished by North American Aviation, Inc.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{10}$-scale model of the F-86 airplane is shown in figure 2. 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 3.72 feet and an over-all length of 3.75 feet.

The flaps were hinged and held in the down position by a strand of thread of the required strength. When a load equivalent to the ultimate failing load of 173 pounds per square foot (full scale) was applied to the flaps the thread would break and the flaps would rotate to the neutral or full-up 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 that part of the underside of the fuselage replaced by the bottom.

The effect on ditching behavior of the nose-intake duct was determined by plugging the intake duct as shown in figure 4.

The 207-gallon-size auxiliary wing tanks are shown installed on the model in figure 5.

Test Methods and Equipment

The model was launched by catapulting it from the Langley tank no. 2 monorail. The control surfaces were set so that the model did not yaw or change attitude 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. In order to obtain the two components of acceleration, the accelerometer was rotated and the tests repeated. The accelerometer had a natural frequency of about 20 cycles per second. It was damped to about 65 percent of critical dampening. The reading accuracy of the instrument was about $\pm\frac{1}{2}g$.

Test Conditions

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

Gross weight.– Tests were made with the model weight corresponding to the full-scale weight of 13,311 pounds.

Location of center of gravity.– The center of gravity was located at 22.1 percent mean aerodynamic chord and 11.30 inches below the fuselage reference line.

Landing attitude.– The model was ditched at attitudes of 14°, 9°, and 4°. The 14° attitude is near the maximum tail-down angle. The 9° attitude is an intermediate landing attitude. The 4° attitude is a near-level landing attitude. The attitude angle was measured between the fuselage reference line and the water surface.

Flap deflection.– Tests were made with flaps up and with flaps extended 38° fastened at scale strength.

Leading-edge-slat position.– All tests were made with the leading-edge slats fully extended.

Landing speed.– The landing speeds were calculated from lift curves obtained from North American Aviation, Inc. The model was airborne and flying when released from the launching carriage at approximately these speeds.

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

Condition of simulated damage.— The structural ultimate strength of the rear portion of the underside of the fuselage was given by the manufacturer as 2 pounds per square inch from station 236 to station 327 and 2.5 pounds per square inch from station 327 to station 400. On the basis of this information and since the results of the undamaged tests showed that this portion of the fuselage would contact the water first, the crumpled bottom shown in figure 3 was used to simulate what might happen in a full-scale ditching.

The model was tested with the following configurations:

(a) No damage

(b) Simulated crumpled bottom installed from station 236 to station 400

(c) Same as (b) but with the 207-gallon-size wing tanks installed at empty weight

RESULTS AND DISCUSSION

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

b deep run; model travelled through water partially submerged exhibiting a tendency to dive, although attitude of model was nearly level

d violent dive; wings were submerged and angle between water surface and fuselage reference line was greater than 15°

h smooth run; no apparent oscillation about any axis

p porpoising; an undulating motion about transverse axis in which some part of model was always in contact with water

s skipping; an undulating motion about transverse axis in which model cleared water completely

Effect of Damage and Attitude

When tested at the 14° and 9° landing attitudes in both the undamaged and damaged condition, the behavior of the model was practically the same. The aft end of the fuselage contacted the water first and the model ran very smoothly with the nose well clear of the water and the wing tips barely skimming the water surface. As the speed fell off during the run the trim decreased and the wing tips were clear of the water.

The principal result of simulating damage was to increase the decelerating forces recorded and to shorten the landing runs. By comparing figures 6 and 7, the change in deceleration can be seen. In the undamaged configuration the maximum decelerations were about 1g and in the damaged configuration the maximum decelerations were about 3g. At the 14° attitude the length of run was changed from about 640 feet in the undamaged configuration to about 580 feet in the damaged configuration. At the 9° attitude the length of run was changed from about 800 feet in the undamaged configuration to about 620 feet in the damaged configuration.

The vertical acceleration records for the damaged configuration are shown in figure 8. The maximum value of about 3g was recorded at the initial contact of the model with the water surface.

A photographic comparison of the motions of the model can be seen in figure 9. As is shown by the photographs, the motions are only slightly different when landed at the 14° and 9° attitudes. In the landing at the 14° attitude the model trimmed down slightly after the picture at contact and had returned to approximately the contact trim in the picture at 170 feet. Between the picture at 170 feet and the pitcture at 400 feet the model trimmed down gradually to an almost level attitude and remained at this attitude for the rest of the run which lasted 60 feet past the picture at 520 feet. In the landing at 9° the model had trimmed down at 180 feet. Between the pictures at 180 feet and at 350 feet the model trimmed up to a slightly higher than contact attitude and had returned to a near-level attitude in the picture at 350 feet. The model maintained this near-level attitude for the rest of the run which lasted 60 feet past the picture at 560 feet.

When landed at the 4° attitude in both the undamaged and damaged configuration the model dived violently. The motion of the model when landed at this attitude is shown in figure 9(c). The model after contact gradually trimmed down for about 170 feet, then a violent dive resulted. The length of the run was about 290 feet at the undamaged condition and about 190 feet for the damaged condition. The maximum longitudinal deceleration was about 8g in both conditions (see figs. 6(c) and 7(c)) and the maximum vertical acceleration in a direction tending to throw the pilot out of the cockpit was about 7g. (See fig. 8(c).)

From the preceding results it is believed that the 14° attitude is the safest attitude at which to land this airplane on water. The 14° attitude is chosen rather than 9° because of the slightly lower landing speed and the probability of less structural damage.

Effect of Nose–Intake Duct

When the model was landed at the 14° and 9° attitudes the intake duct did not enter the water at any time during the run. However, when landed at the 4° attitude the model trimmed down gradually for about 170 feet and then dived violently. At about the time that the motion became violent the intake duct entered the water. In order to determine the effect of the intake duct, the duct was plugged and faired to a rounded shape. When tested in this configuration the model trimmed down as before but the resulting dive was less severe, the maximum longitudinal deceleration was reduced from 7g to about 4.5g. From these results it may be concluded that a nose–intake duct is unfavorable for near–level ditchings.

Effect of Wing Sweep

The wing tips were so located that in landings at the 14° and 9° attitudes they contacted the water almost simultaneously with the aft end of the fuselage. This resulted in the wing tips' planing on the surface of the water until the trim angle decreased enough to raise the tips above the water surface. If the wing had been straight in plan form rather than swept back, the wing tips would have been located farther forward and clear of the water. However, the swept wing did not seem to affect the ditching behavior.

Effect of Flaps

When the model was tested with the landing flaps 38° down and fastened at scale strength, the flaps always failed shortly after the model contacted the water surface and no appreciable diving or nose–down pitching moment was imparted to the model. When tested with the flaps in the up position, the model skipped and made a more violent run than with flaps down, probably because of the additional landing speed. For this reason, landing flaps extended 38° would be advantageous in a ditching.

Effect of Wing Tanks

When the model was tested with the wing tanks attached, a deep run resulted at all three attitudes. Upon contacting the water surface the tanks seemed to suck under rapidly, dragging the model down and causing a rather sudden decrease in speed.

When landed at the 14° attitude, the length of run was about 200 feet accompanied by a maximum longitudinal deceleration of about 5.5g.

The length of run when landed at the 9° attitude was about 280 feet and the maximum longitudinal deceleration was about 6g. At the 4° attitude the landing was not as severe, the length of run being about 300 feet and the maximum deceleration about 4.5g. A time-history deceleration plot of a 14° landing with the tanks attached is shown in figure 7(e) and by comparing this with figure 7(a) the effect of wing tanks can be seen.

From these results it is recommended that the wing tanks be jettisoned to avoid the undesirable behavior which occurs with the tanks attached.

CONCLUSIONS

From the results of the investigation of a $\frac{1}{10}$-scale model of the North American F-86 airplane the following conclusions were drawn:

1. The airplane should be ditched at the nose-high, 14° attitude to avoid the violent dive which occurs at the 4° attitude. The flaps and leading-edge slats should be fully extended to obtain the lowest possible landing speed. The wing tanks should be jettisoned to avoid the undesirable behavior which occurs with the tanks attached.

2. In a calm-water ditching under these conditions the airplane will run smoothly for about 600 feet. Maximum longitudinal and vertical decelerations of about 3g will be encountered.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

Lloyd J. Fisher
Lloyd J. Fisher
Aeronautical Research Scientist

Ellis E. McBride
Ellis E. McBride
Aeronautical Research Scientist

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

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TABLE I

SUMMARY OF RESULTS OF DITCHING INVESTIGATION OF A $\frac{1}{10}$-SCALE MODEL OF THE NORTH AMERICAN F-86 AIRPLANE

[All values full scale; landing flaps down 38° unless otherwise specified; gross weight, 13,311 lb]

Landing attitude (deg)	14					9					4				
Configuration	Landing speed (knots)	Maximum deceleration (g) Longitudinal	Maximum deceleration (g) Vertical	Length of run (ft)	Motions of model (a)	Landing speed (knots)	Maximum deceleration (g) Longitudinal	Maximum deceleration (g) Vertical	Length of run (ft)	Motions of model (a)	Landing speed (knots)	Maximum deceleration (g) Longitudinal	Maximum deceleration (g) Vertical	Length of run (ft)	Motions of model (a)
No damage; flaps up	113	2.6		690	p s_{180}										
No damage	98	1.6		640	h	109	1.0		800	h	132	8.2		290	d
Simulated crumpled bottom installed	98	3.0	3.0	580	h	109	3.0	3.2	620	h	132	7.6	7.0	190	d
Same as above with empty wing tanks installed	98	6.0		200	b	109	6.0		280	b	132	4.5		300	b

(a) Motions of the model are denoted by the following symbols:
- b deep run
- d violent dive
- h smooth run
- p porpoising
- s skipping (subscript denotes length of skip in feet)

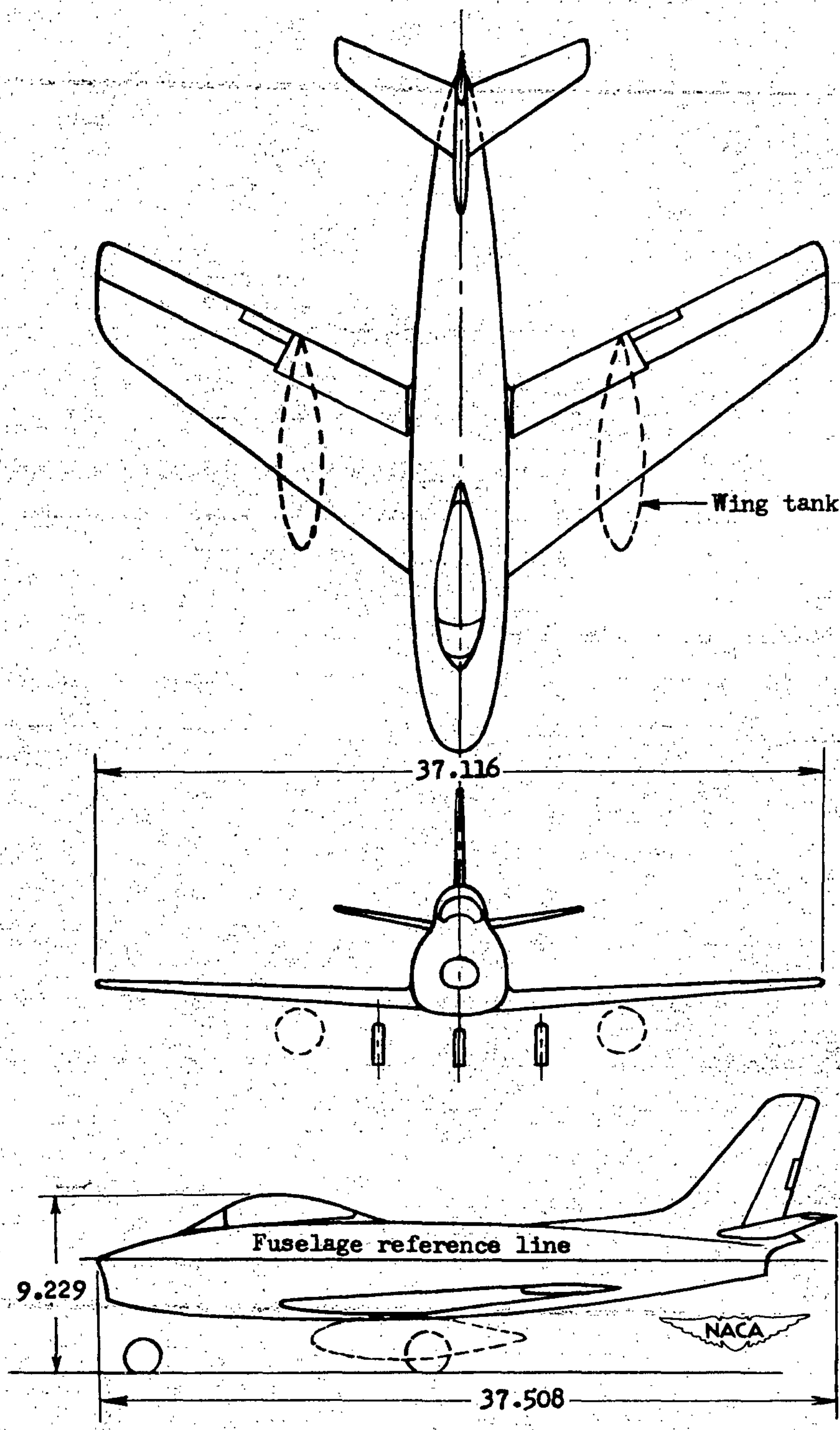
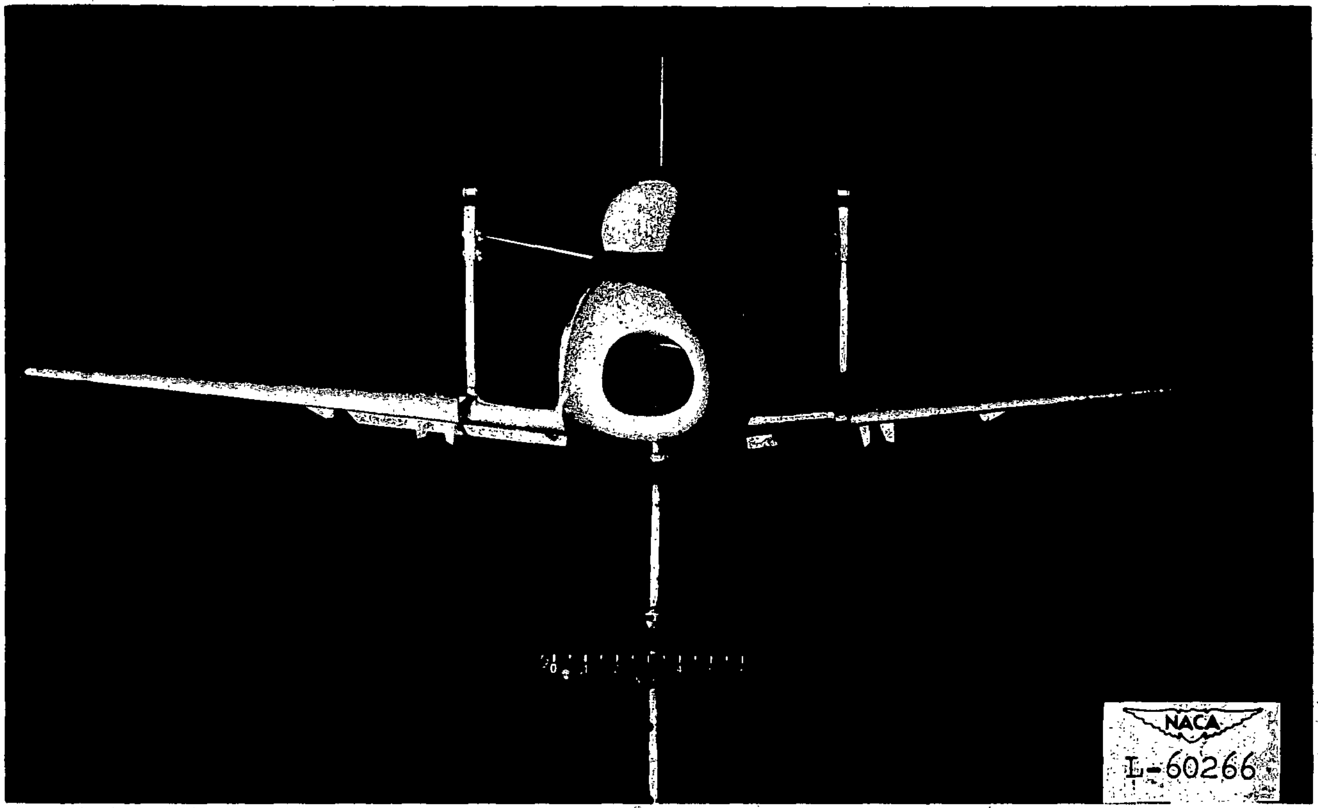
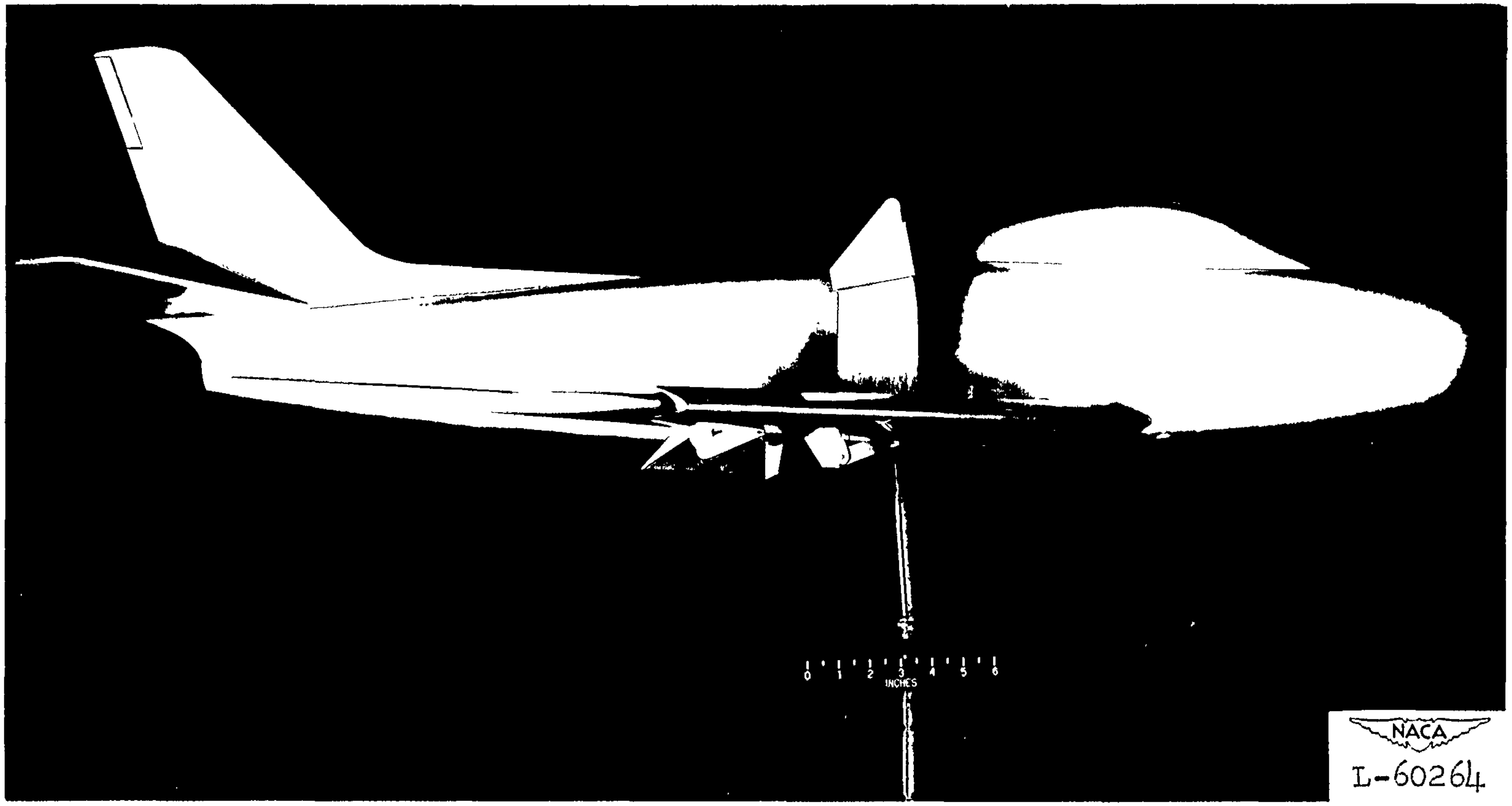


Figure 1.– Three–view drawing of the F–86 airplane.



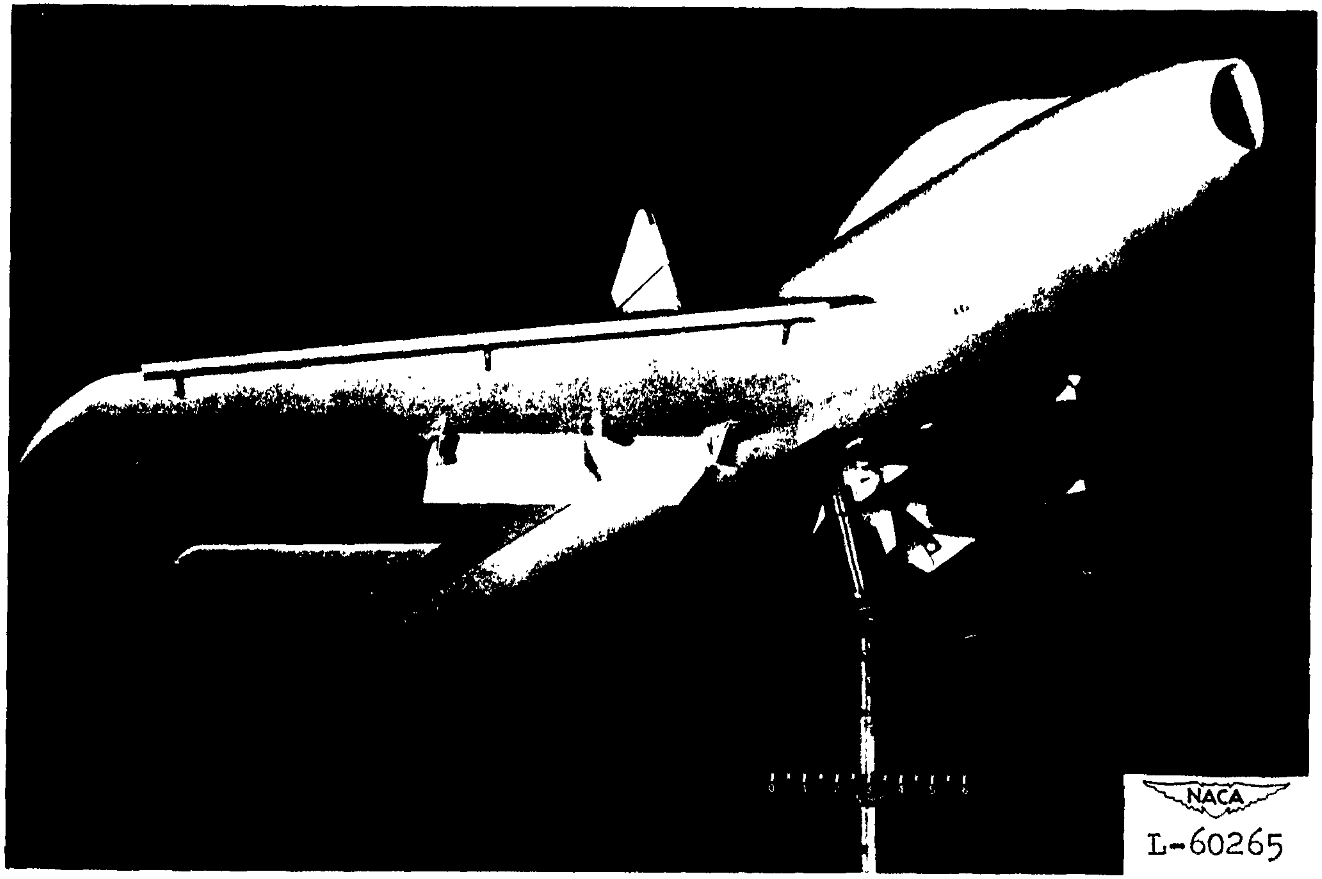
(a) Front view.

Figure 2.– The $\frac{1}{10}$–scale dynamic model of the North American F-86 airplane.



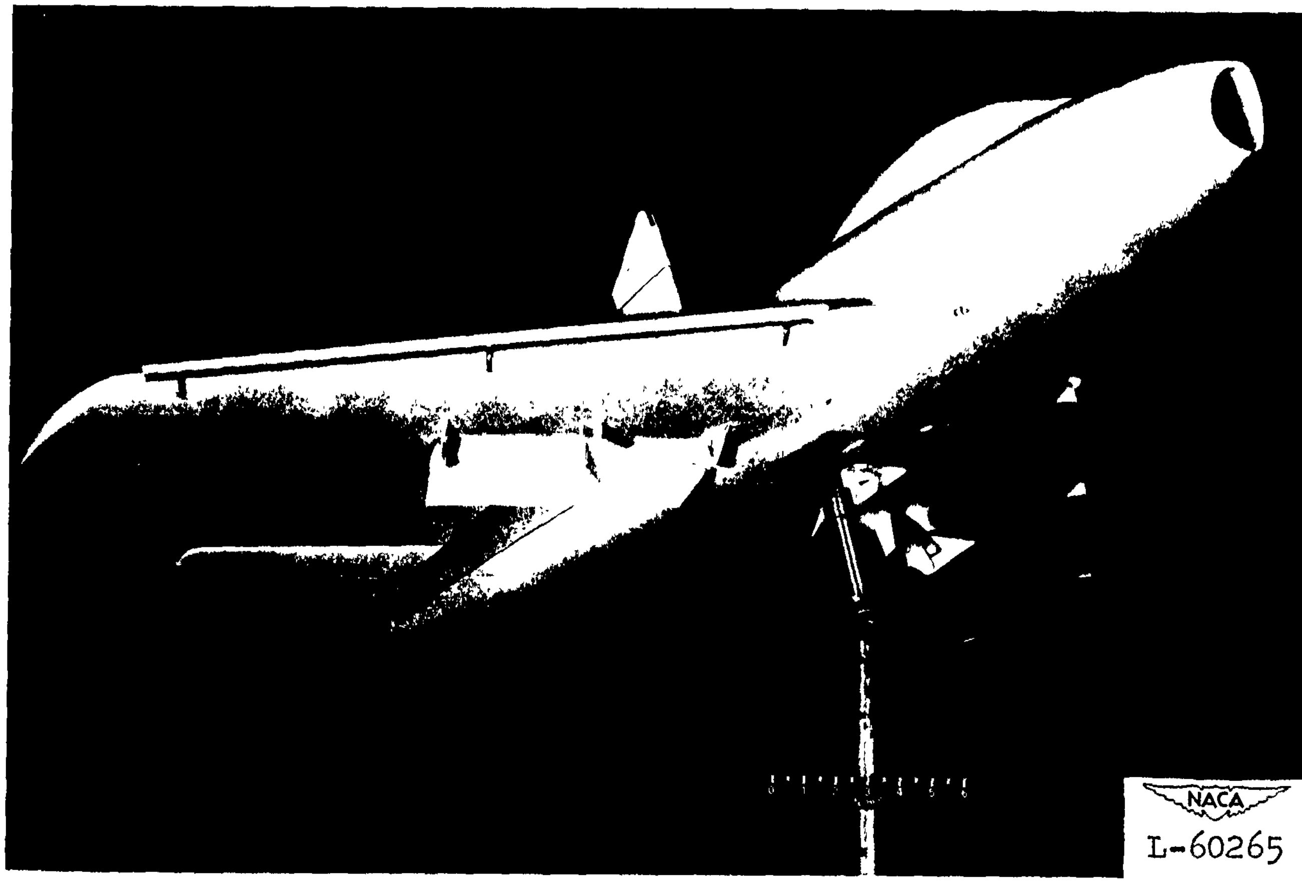
(b) Side view.

Figure 2.– Continued.



(c) Three-quarter bottom view.

Figure 2.- Concluded.



(c) Three-quarter bottom view.

Figure 2.— Concluded.

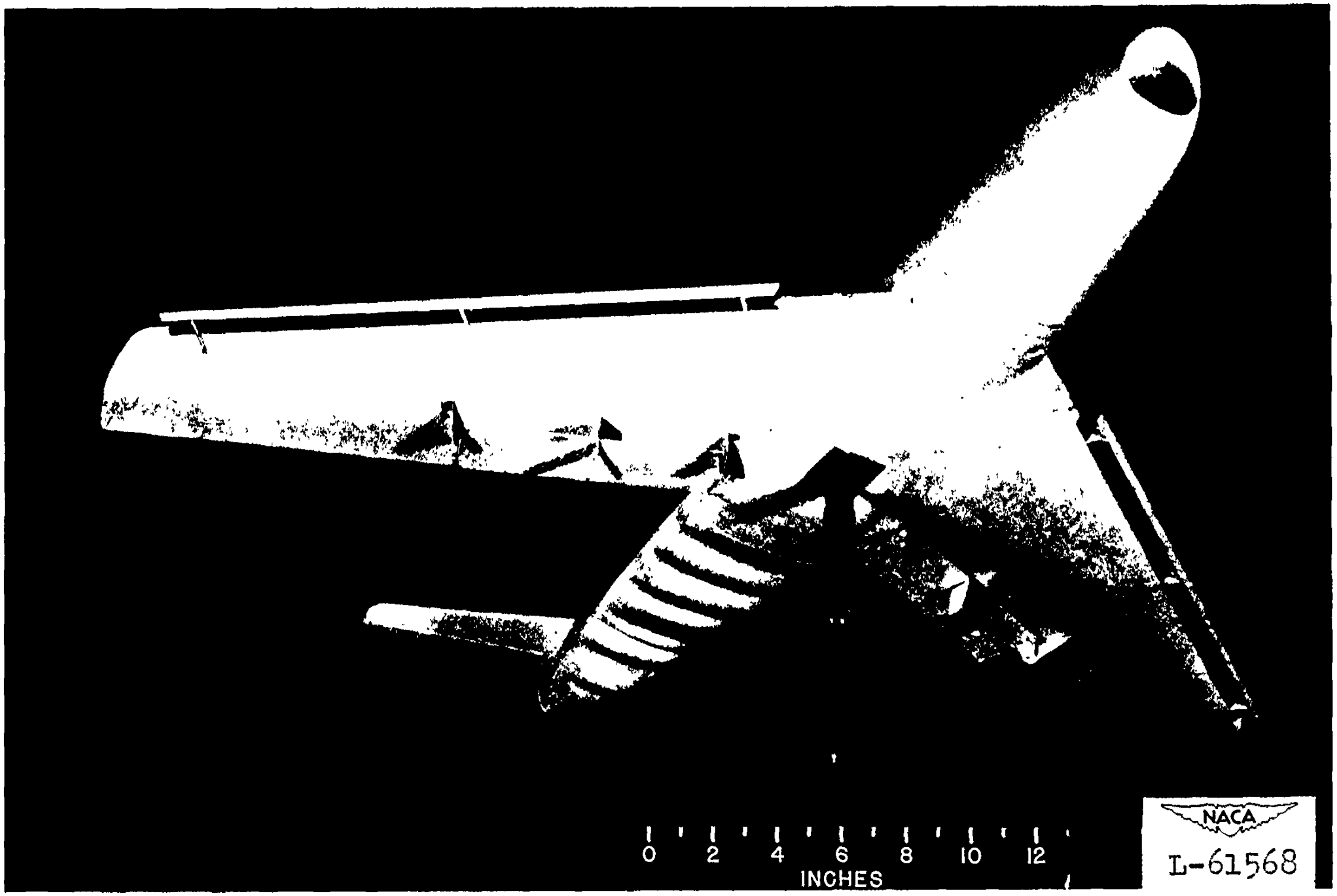


Figure 3.– Installation of the crumpled bottom.

Solid lines show original outline.
Dashed lines show outline of duct plug.

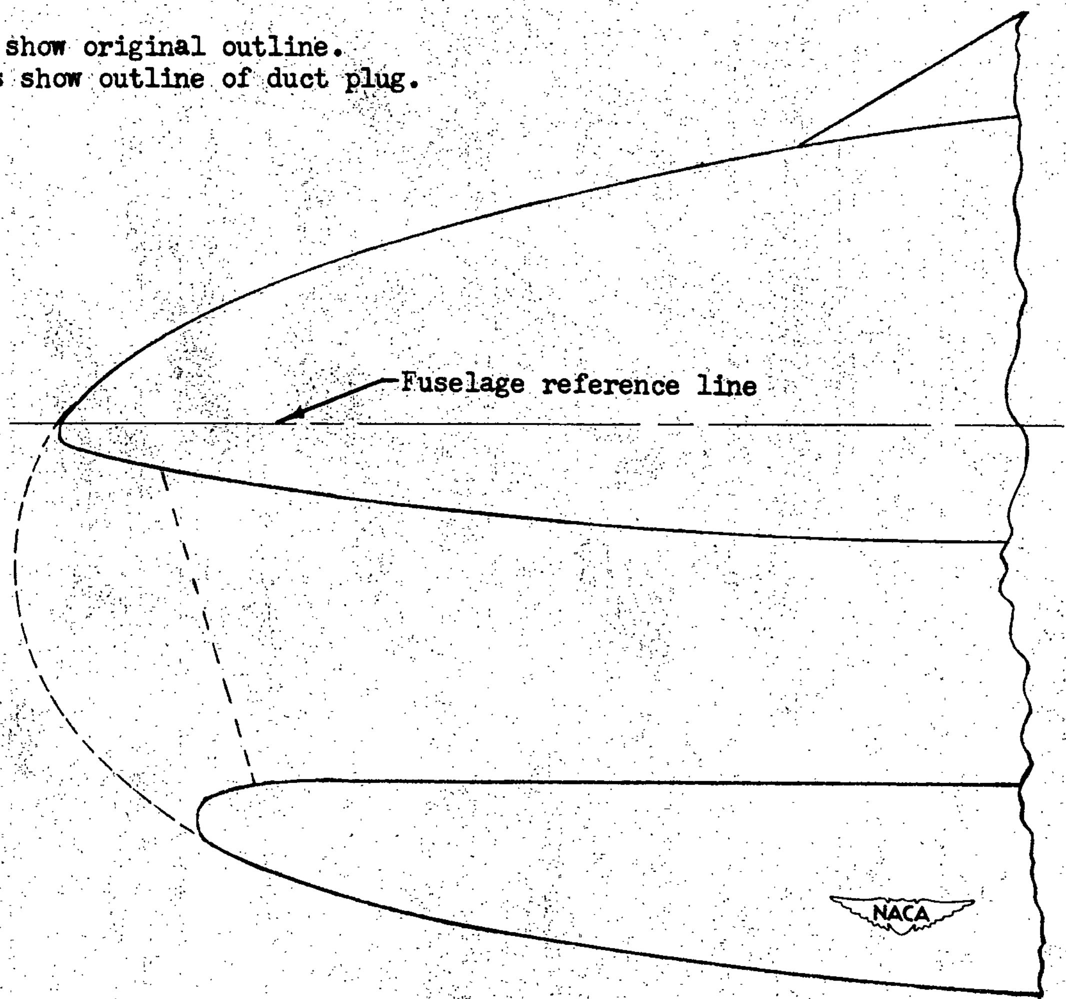


Figure 4.– Approximate outline of the nose after plugging the intake duct.

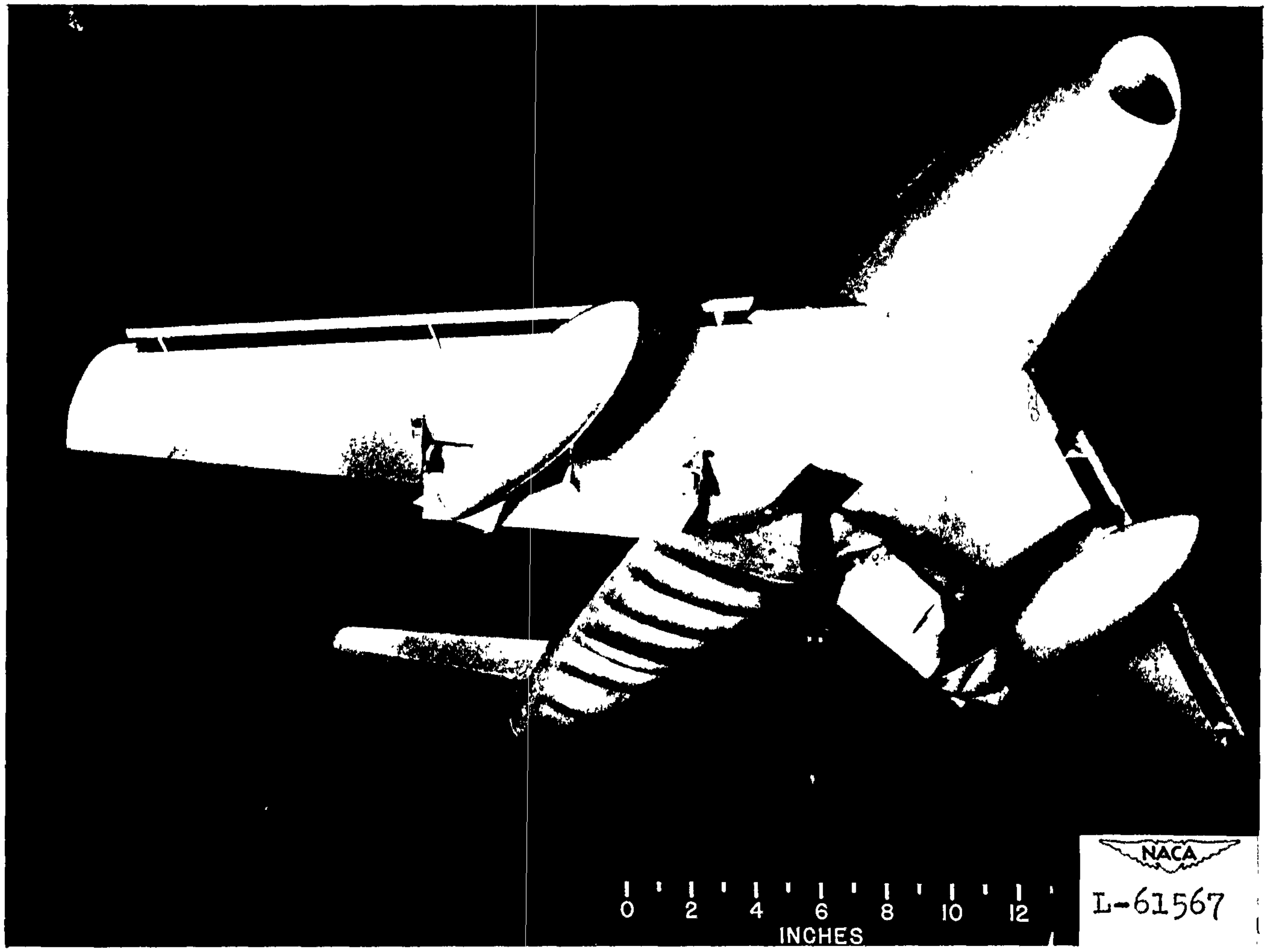
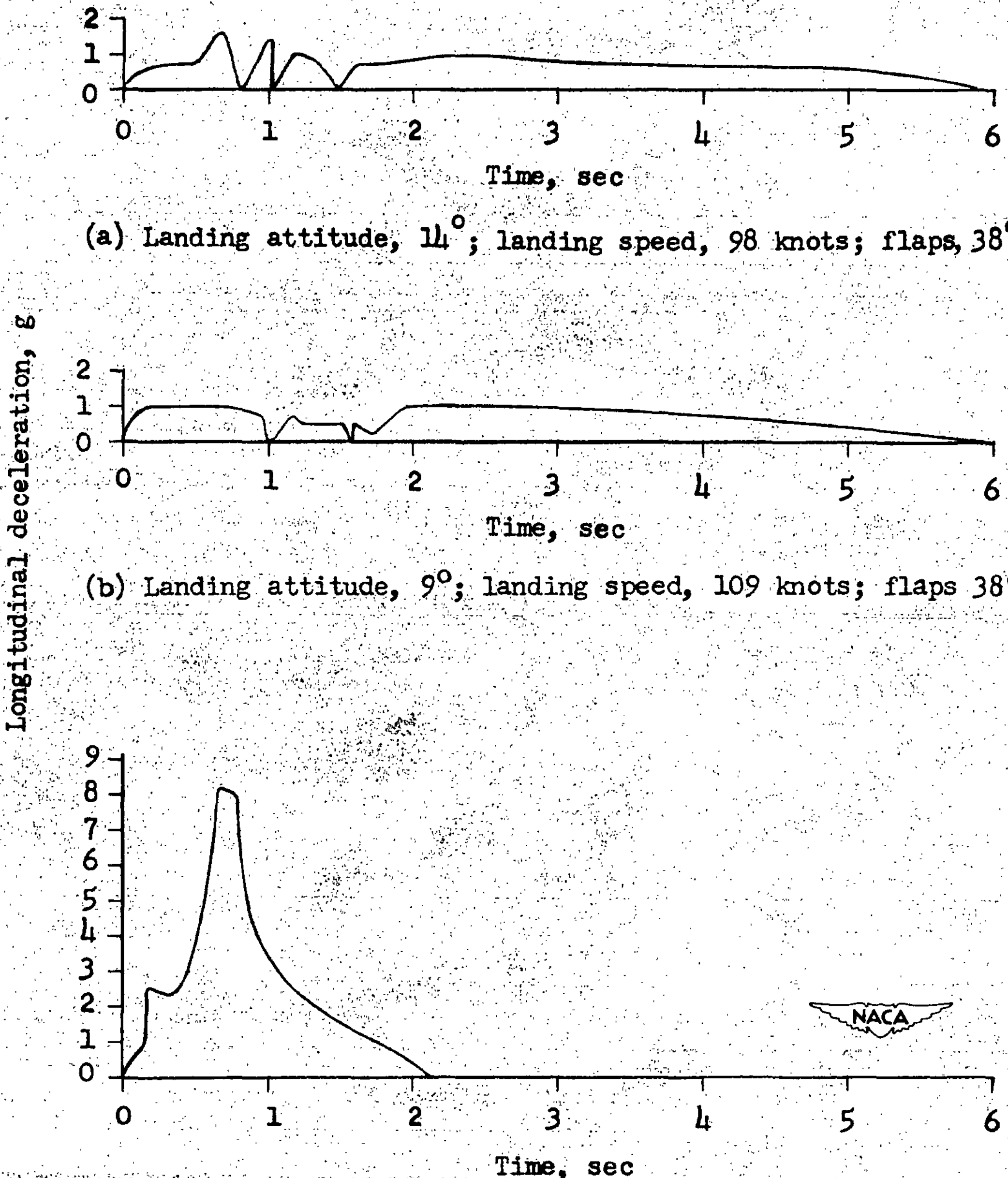


Figure 5.- Installation of the wing tanks.

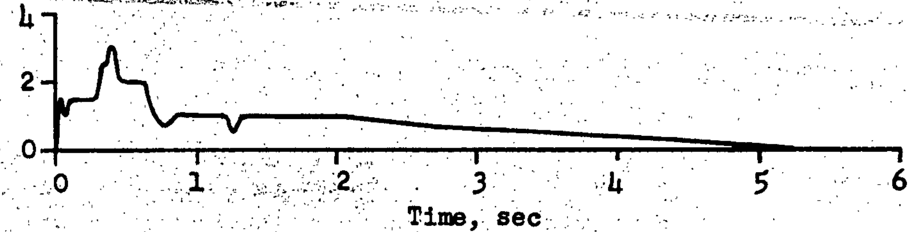


(a) Landing attitude, 14°; landing speed, 98 knots; flaps, 38°.

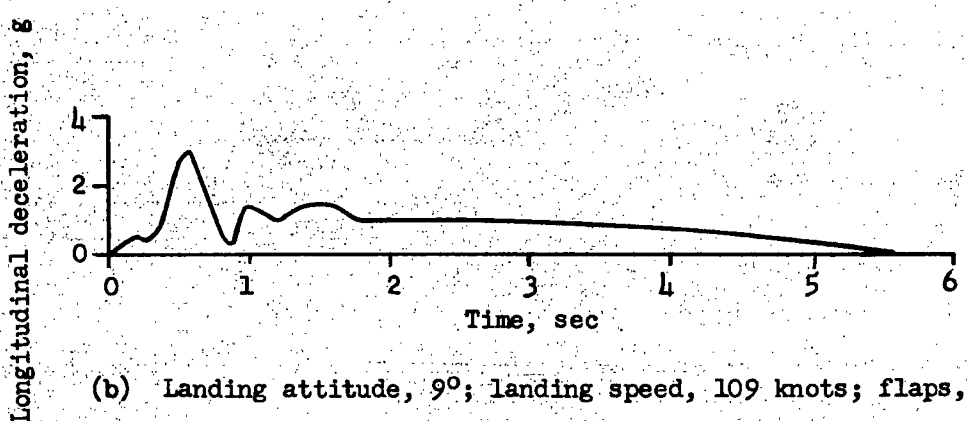
(b) Landing attitude, 9°; landing speed, 109 knots; flaps 38°.

(c) Landing attitude, 4°; landing speed, 132 knots; flaps 38°.

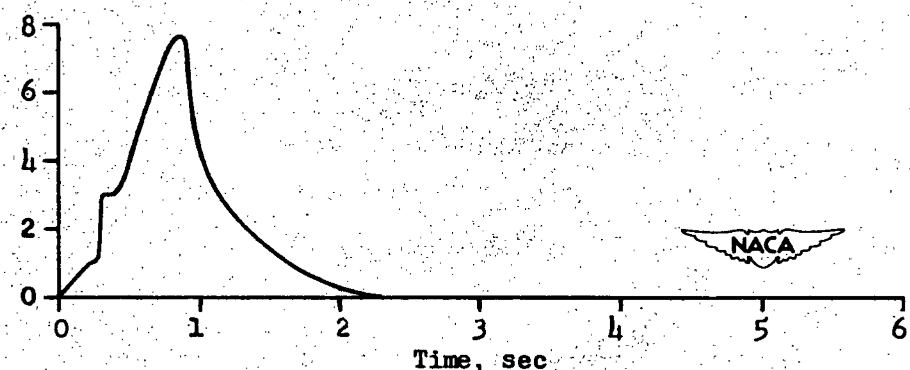
Figure 6.– Typical time histories of longitudinal deceleration for ditching tests of the undamaged model. (All values are full scale.)



(a) Landing attitude, 14°; landing speed, 98 knots; flaps, 38°.

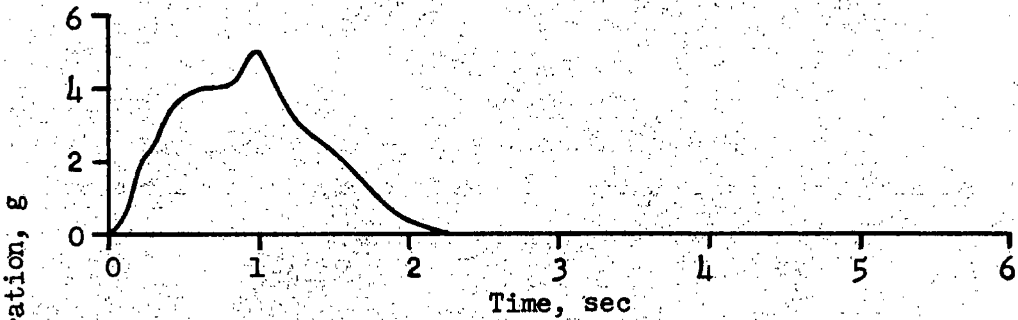


(b) Landing attitude, 9°; landing speed, 109 knots; flaps, 38°.

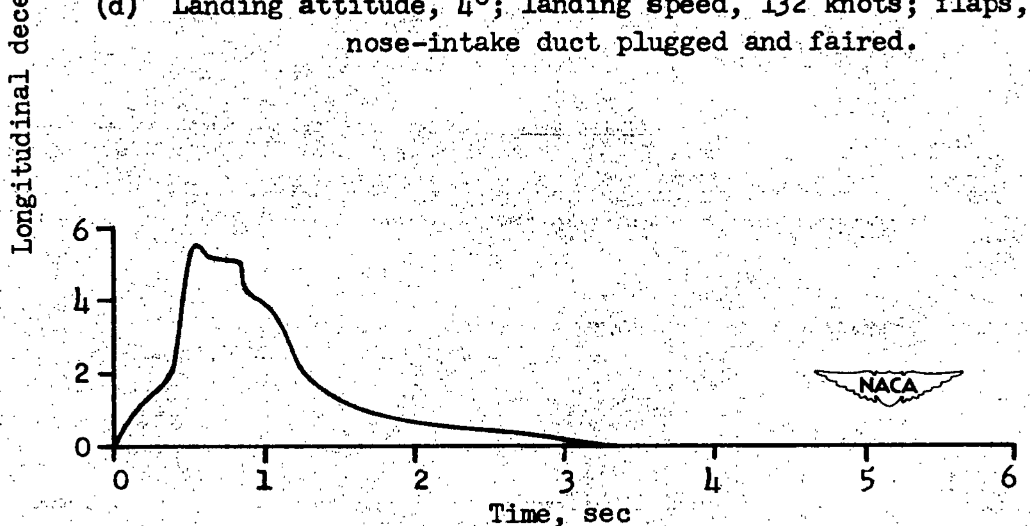


(c) Landing attitude, 4°; landing speed, 132 knots; flaps, 38°;

Figure 7.– Typical time histories of longitudinal deceleration for ditching tests of the model with the simulated crumpled bottom installed. (All values are full scale.)

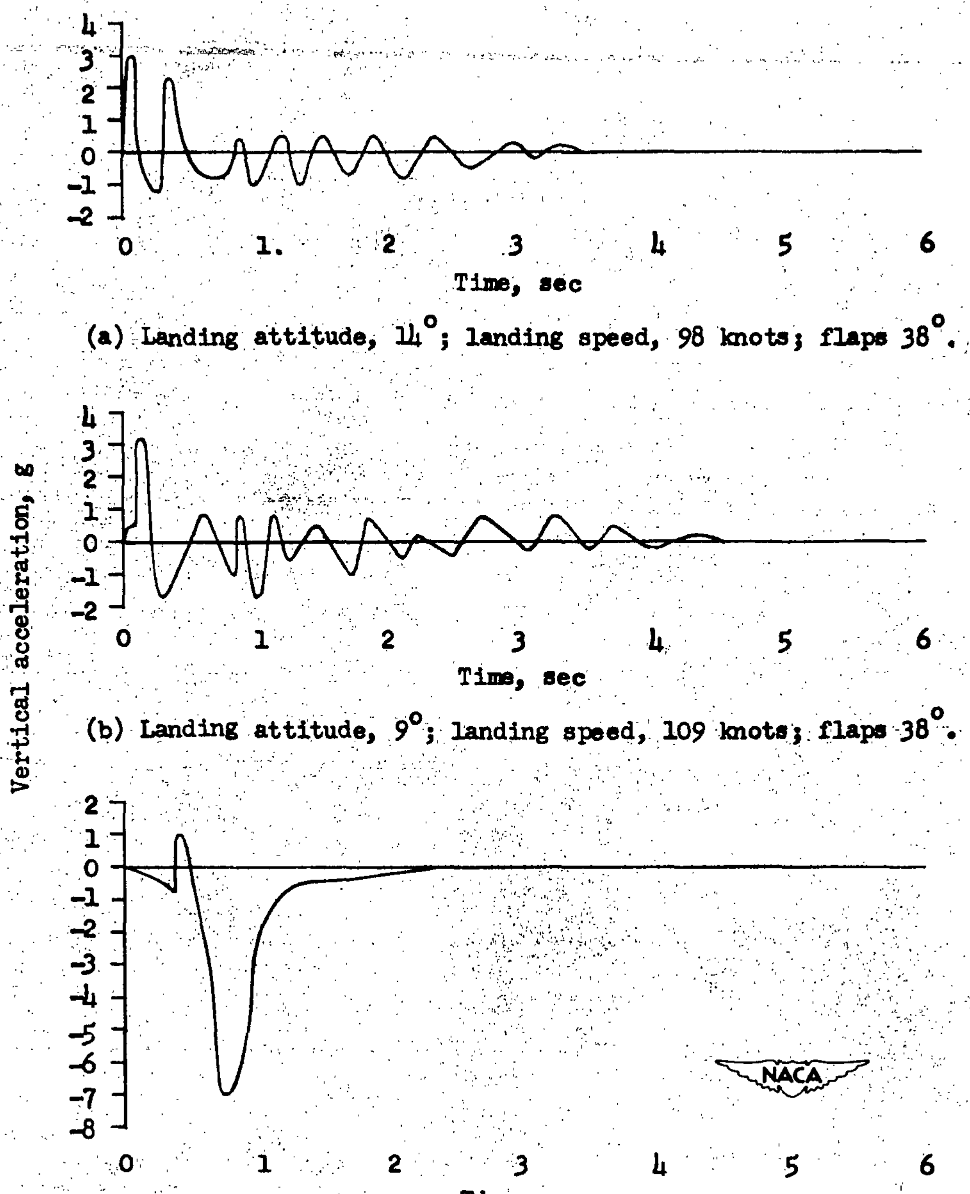


(d) Landing attitude, 4°; landing speed, 132 knots; flaps, 38°; nose-intake duct plugged and faired.



(e) Landing attitude, 14°; landing speed, 98 knots; flaps, 38°; 207-gallon size wing tanks installed at empty weight.

Figure 7.– Concluded.

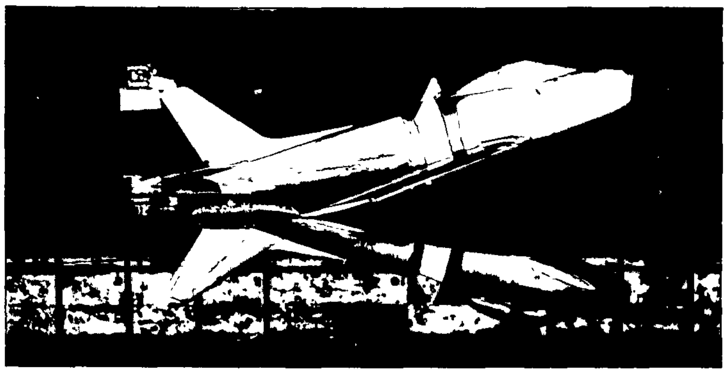


(a) Landing attitude, 14°; landing speed, 98 knots; flaps 38°.

(b) Landing attitude, 9°; landing speed, 109 knots; flaps 38°.

(c) Landing attitude, 4°; landing speed, 132 knots; flaps 38°.

Figure 8.– Typical time histories of vertical accelerations for ditching tests of the model with the simulated crumpled bottom installed. (All values are full scale.)



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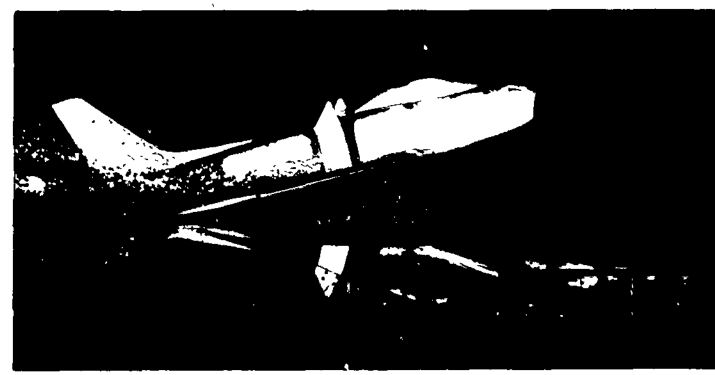
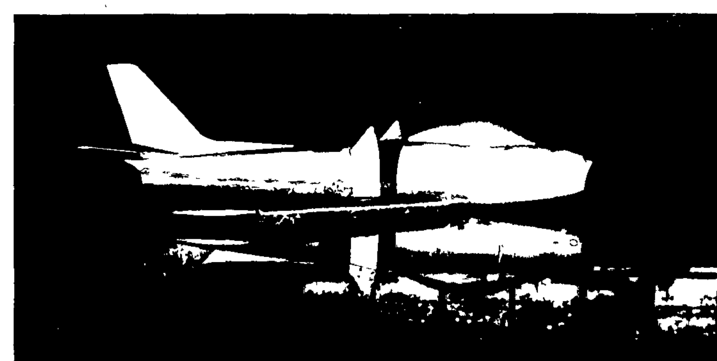


170 feet

400 feet



520 feet

L-62161

(a) Landing attitude, 14°; landing speed, 98 knots.

Figure 9.- Sequence photographs of model ditchings with the simulated crumpled bottom installed. Distance after contact is indicated. (All values full scale.)

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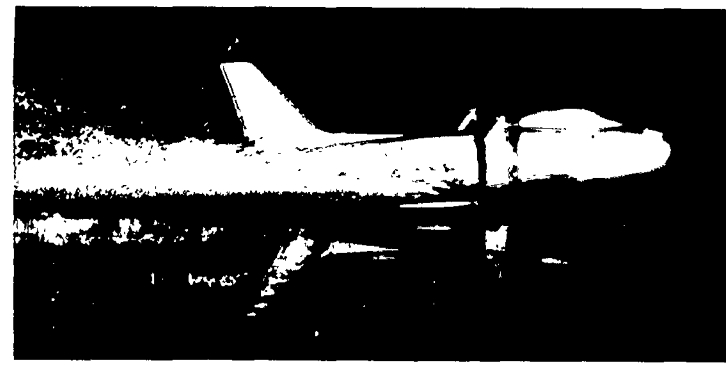
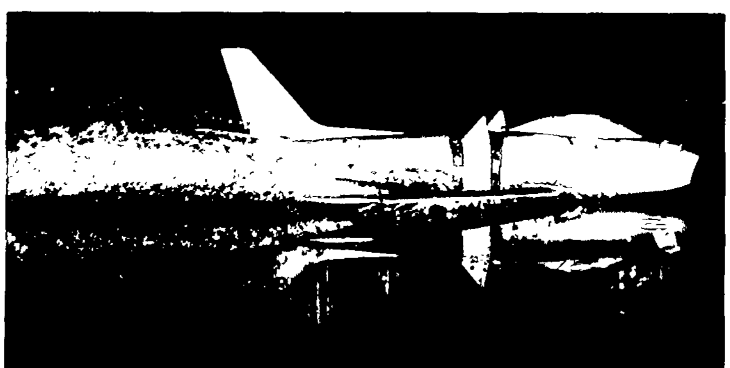
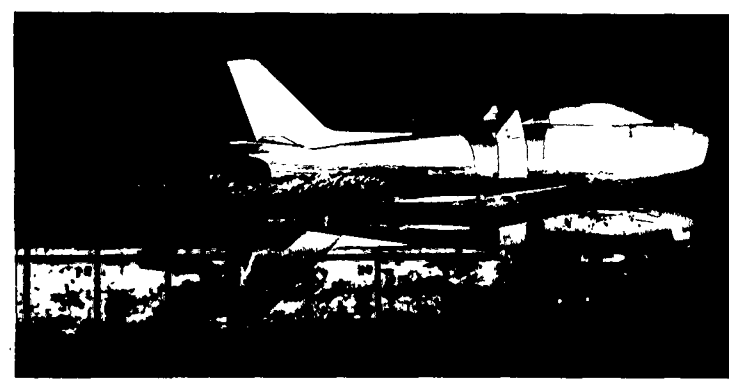


180 feet



350 feet



560 feet

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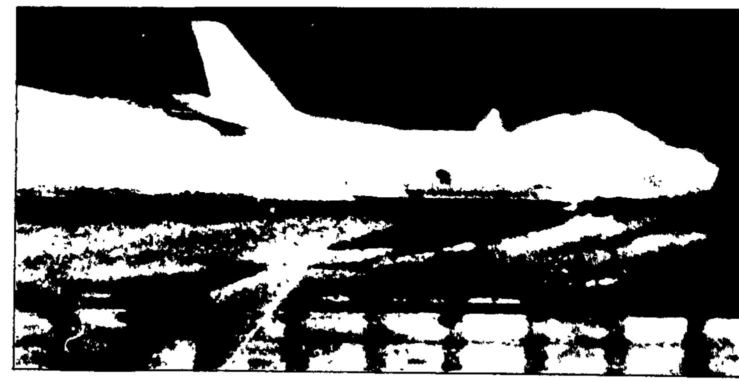
L-63029

(b) Landing attitude, 9°; landing speed, 109 knots.

Figure 9.– Continued.

Contact



90 feet

170 feet

190 feet

L-63030

(c) Landing attitude, 4°; landing speed, 132 knots.

Figure 9.– Concluded.