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RESEARCH MEMORANDUM

for the

Air Materiel Command, U. S. Air Force

DITCHING INVESTIGATION OF A $\frac{1}{24}$-SCALE MODEL OF THE BOEING B-47 AIRPLANE

By Lloyd J. Fisher and John O. Windham

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NATIONAL ADVISORY COMMITTEE
FOR AERONAUTICS
WASHINGTON
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SUMMARY

An investigation of a $\frac{1}{24}$-scale dynamically similar model of the Boeing B-47 airplane was made to determine the ditching characteristics and proper ditching technique for the airplane. Various conditions of damage, landing attitude, flap setting, and speed were investigated. The behavior of the model was determined from visual observations, motion-picture records, and time-history deceleration records. The results of the investigation are presented in table form, photographs, and curves.

The airplane should be ditched at the lowest speed and highest attitude consistent with adequate control; the flaps should be full down. The airplane will probably make a deep but fairly smooth run. The fuselage bottom will be damaged and partially filled with water; consequently, crew members should be assigned ditching stations near an exit in the upper or forward part of the fuselage. The nacelles may be expected to be torn away from the wing. In calm water the maximum decelerations will be about 3g and the landing run will be about 6 fuselage lengths.

INTRODUCTION

At the request of the Air Materiel Command, U. S. Air Force, an investigation of a model of the Boeing B-47 airplane was made to determine the probable ditching characteristics and proper ditching technique for the airplane. The model and data pertaining to the strength of the fuselage bottom, the flaps, and the nacelles were furnished by the

Air Materiel Command, U. S. Air Force. The tests were made in calm water at the Langley tank no. 2 monorail. A three-view drawing of the airplane is shown in figure 1.

APPARATUS AND PROCEDURE

Description of Model

The $\frac{1}{24}$-scale model had a wing span of 4.83 feet, a fuselage length of 4.5 feet, and a gross weight of 9 pounds. Photographs of the model are shown in figure 2. The model was constructed principally of balsa wood with spruce or mahogany at areas of concentrated stress. Internal ballast was used to obtain scale weight and moments of inertia.

The landing flaps were installed so they could be held in the down position at approximately scale strength (230 pounds per square foot full-scale ultimate failing load). A calibrated thread was fastened between a wing bracket and a corresponding flap bracket so that loads on the flaps greater than the scale design load would break the thread and disengage the flaps from the wing. The strengths of the calibrated thread mentioned in this report were within ±10 percent of the desired values.

To investigate the effects of damage, the model was constructed so that sections representing the bomb-bay and main landing-gear doors could be removed and various conditions of damage simulated. To simulate a condition where the bomb-bay and main landing-gear doors had completely failed, the model was tested with these doors removed (fig. 3). To determine points of concentrated pressure, effect of partial failure of these doors, and amount of damage sustained, the bomb-bay and main landing-gear doors were replaced by an 0.001-inch-thick aluminum-foil covering. The aluminum covering was reinforced by bulkheads located at both the forward and aft end of the bomb bay. The tested strength of this covering was slightly greater than the scale strength of the doors. The full-scale strength of the doors was 200 pounds per square foot.

The nacelles were constructed so they could be attached to the wing by a calibrated thread in such a manner that they would break off when a load greater than the scale design load was applied (fig. 4). The full-scale ultimate loads for the engine mounts (applied through the thrust line) were 15,000 pounds for inboard nacelles and 6,500 pounds for outboard nacelles.

TEST METHODS AND EQUIPMENT

The test methods and equipment used were similar to those used in previous ditching investigations. The model was attached to a launching carriage on the Langley tank no. 2 monorail at the desired attitude with the control surfaces set to hold this attitude in flight. The model was then catapulted into the air and the preset control surfaces kept the model at approximately the desired attitude during the glide from release to landing.

The results of the investigation were obtained from visual observations, motion-picture records, and time-history deceleration records. The decelerations were measured with a single-component accelerometer located slightly forward of the center of gravity of the model. The natural frequency of the accelerometer was 20 cycles per second and it was damped to about 65 percent of the critical dampening. The accuracy with which the instrument could be read was estimated to be about $\pm\frac{1}{2}g$.

TEST CONDITIONS

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

Gross weight.- The design gross weight of 125,000 pounds was simulated in the tests.

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

Pitch, slug-feet^2	1,380,262
Roll, slug-feet^2	1,099,896
Yaw, slug-feet^2	2,480,159

Location of the center of gravity.- The center of gravity was located at 20 percent of the mean aerodynamic chord and 54 inches below the top of the fuselage (top of fuselage is parallel to the reference line).

Landing attitude.- Ditchings were made at three attitudes: 5° (near static), 10° (intermediate), and 15° (near lift-curve stall). The attitude was measured between the fuselage reference line and the smooth-water surface.

Landing flaps.- Tests were made with landing flaps up and full down (35°).

Landing speed.- The landing speeds are listed in table I. They are speeds computed from power-off lift curves furnished by the manufacturer.

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

Fuselage condition.- The model was tested in the following conditions:

(a) No damage
(b) Bomb-bay and main landing-gear doors removed
(c) Bomb-bay and main landing-gear doors replaced with aluminum covering
(d) Bomb-bay and main landing-gear doors replaced with aluminum covering and nacelles attached at scale strength

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 ran deeply – the model settled deeply into the water at contact and traveled through the water partially submerged with little change in attitude

h ran smoothly – the model made no apparent oscillation about any axis and gradually settled into the water as the forward speed decreased

p porpoised slightly – the model undulated about the lateral axis with some part always in contact with the water

s skipped – the model undulated about the lateral axis, intermittently completely clearing the water

u trimmed up – the attitude of the model increased immediately after contact with the water

Typical damage to the aluminum-covered doors is shown in figure 5. Figures 6 to 9 present longitudinal deceleration curves as influenced by damage, flap setting, and landing attitude. Sequence photographs of ditchings at various attitudes are shown as figure 10.

EFFECT OF DAMAGE

The undamaged model usually made straight smooth runs. A tendency to trim up after contact with the water was evident at the lower attitude. In some of the runs this tendency to trim up was enough to cause the model to skip slightly. The landing runs were about 6 fuselage lengths with maximum decelerations of about 2g with flaps full down and 3g with flaps up.

When the model was tested with the bomb-bay and main landing-gear doors replaced with the aluminum covering, some damage always occurred (fig. 5). The model generally made deep but fairly smooth runs with or without the covering and the behavior was about the same at all conditions of damage. The landing runs were between 4 and 6 fuselage lengths with maximum decelerations of about 3g. Damage to the aluminum coverings, even though they were overstrength, indicates that, in a full-scale ditching, the fuselage would be damaged and partially filled with water. Because of the expected inrush of water, crew members should be assigned ditching stations near an exit in the top or forward part of the fuselage and should abandon the airplane quickly.

EFFECT OF NACELLES

When the nacelles were attached at scale strength, they were usually torn off. In tearing away, the inboard nacelles appeared to cause a slight porpoising motion. Tests with the nacelles removed resulted in longer runs and lower decelerations than did the tests with the nacelles attached rigidly or at scale strength.

The nacelle installation was not unduly detrimental to the ditching behavior of the B-47 airplane. An installation similar to that of the inboard nacelles might be detrimental to behavior on another airplane.

EFFECT OF FLAPS

When the model was tested with full-down flaps, the flaps failed consistently and had no detrimental effect on behavior. The flaps-up position resulted, in general, in slightly higher decelerations and slightly more severe behavior. Much greater damage occurred to the aluminum-covered doors when the flaps were up. These differences in behavior and damage were probably caused by the higher landing speed associated with a flaps-up landing. The results indicate that it would be best for the flaps to be full down in a ditching.

EFFECT OF LANDING ATTITUDE AND SPEED

The effect of landing attitude and speed was most apparent in the amount of damage to the aluminum-covered doors. With flaps down, more damage occurred at the 5° attitude than at the 10° and 15° attitudes. Longitudinal decelerations were about the same at all attitudes. Since the most damage with flaps down occurred in the 5° landings, a low attitude should be avoided. The tests indicated very little difference between the 10° and 15° attitude landings; but, because of better flight control, a medium nose-high landing attitude (near 10°) would probably be better in a ditching than a near-stall attitude.

CONCLUSIONS

From the results of the investigation of a $\frac{1}{24}$- scale dynamically similar model of the Boeing B-47 airplane, the following conclusions are drawn:

1. The airplane should be ditched at the lowest speed and highest attitude consistent with adequate control; the flaps should be full down.

2. The airplane will probably make a deep but fairly smooth run.

3. The fuselage will probably be damaged and partially filled with water and the nacelles will probably be torn away. Crew members should be assigned ditching stations near an exit in the upper or forward part of the fuselage.

4. When the airplane is ditched as recommended, the maximum longitudinal deceleration in calm water will be about 3g and the landing run will be about 6 fuselage lengths.

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TABLE I.- SUMMARY OF RESULTS OF DITCHING INVESTIGATION IN CALM WATER OF A $\frac{1}{24}$- SCALE MODEL

OF THE BOEING B-47 AIRPLANE

[Gross weight, 125,000 lb; all values are full scale]

Landing attitude (deg)		15			10						5		
Landing speed (mph)		132			178			138			154		
Configuration	Flap setting	Maximum longitudinal deceleration (g)	Length of landing run (ft)	Motions of the model (1)	Maximum longitudinal deceleration (g)	Length of landing run (ft)	Motions of the model (1)	Maximum longitudinal deceleration (g)	Length of landing run (ft)	Motions of the model (1)	Maximum longitudinal deceleration (g)	Length of landing run (ft)	Motions of the model (1)
Undamaged	Up	---	---	---	3	686	h	---	---	---	---	---	---
	Down	$1\frac{1}{2}$	566	h	---	---	---	2	648	h	2	674	u,s,p
Bomb-bay and main landing-gear doors removed	Up	---	---	---	3	593	b	---	---	---	---	---	---
	Down	$2\frac{1}{2}$	485	b	---	---	---	2	569	h	2	634	b
Aluminum section replacing bomb-bay and main landing-gear doors	Up	---	---	---	$2\frac{1}{2}$	622	b	---	---	---	---	---	---
	Down	3	470	b	---	---	---	$2\frac{1}{2}$	545	h	3	648	b
Scale strength nacelles with aluminum section replacing bomb-bay and main landing-gear door	Down	---	---	---	---	---	---	2	564	p,h	---	---	---

[1]Motions of the model denoted by following symbols:

b ran deeply
h ran smoothly
p porpoised slightly
s skipped
u trimmed up

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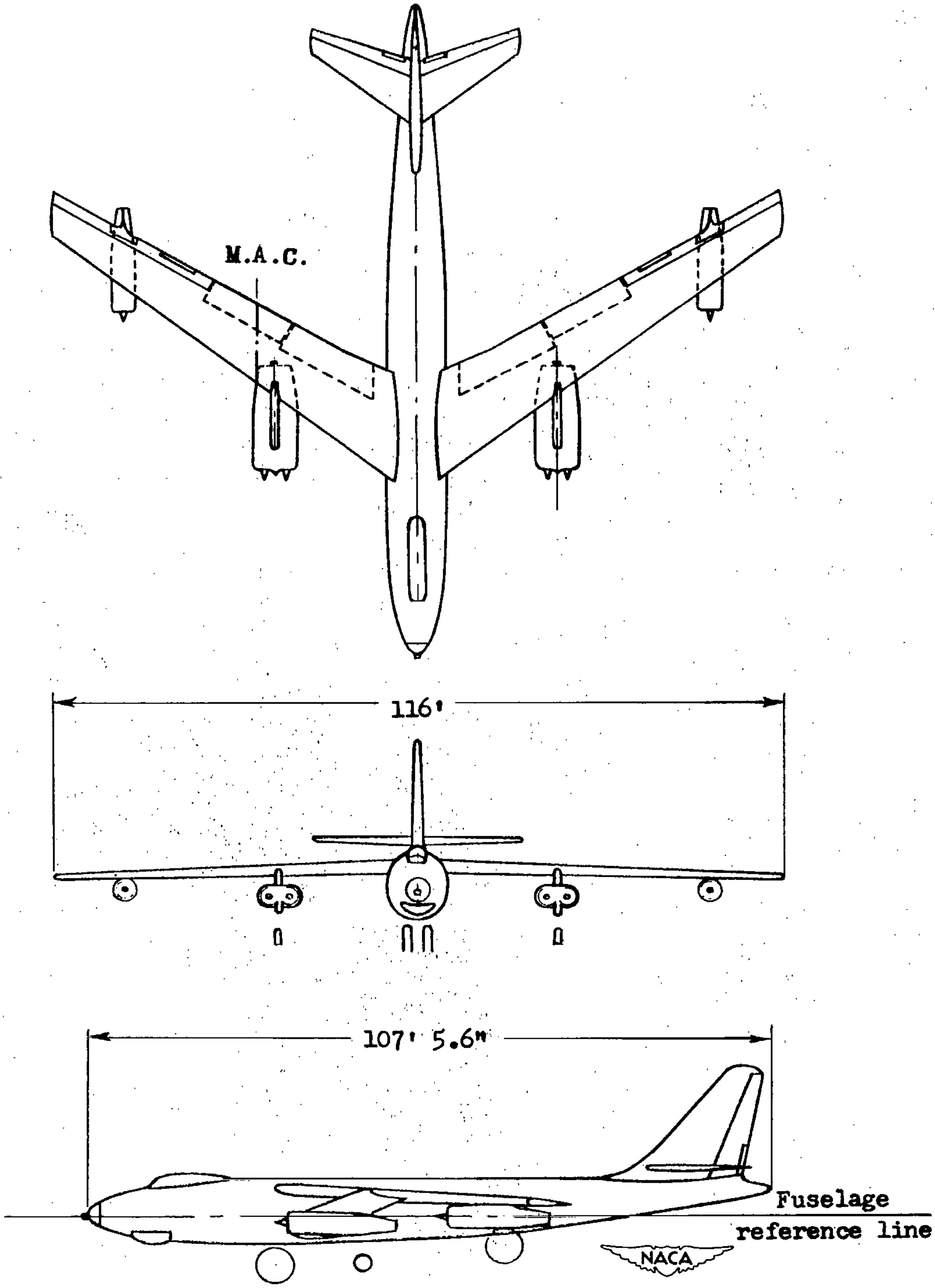
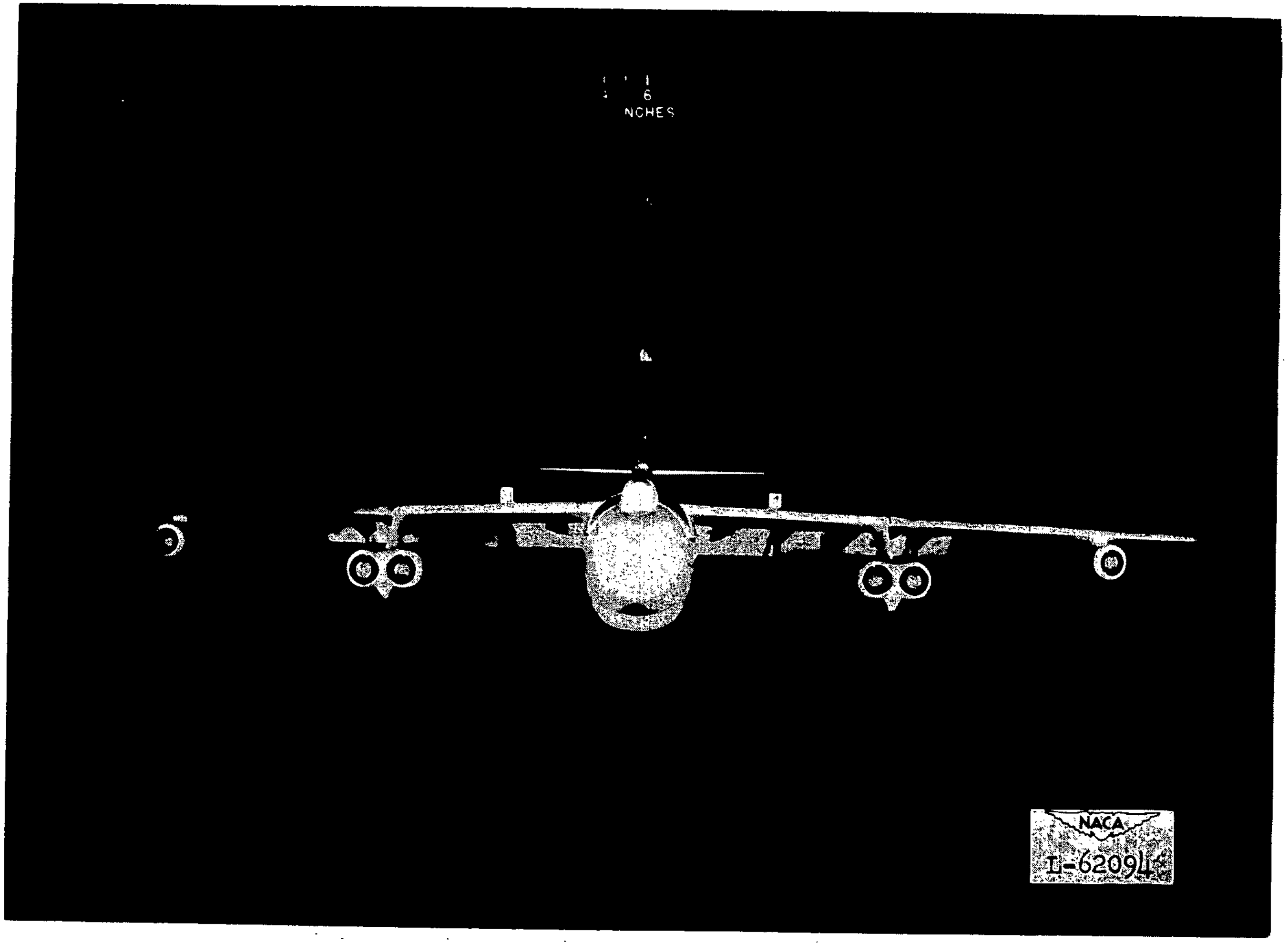
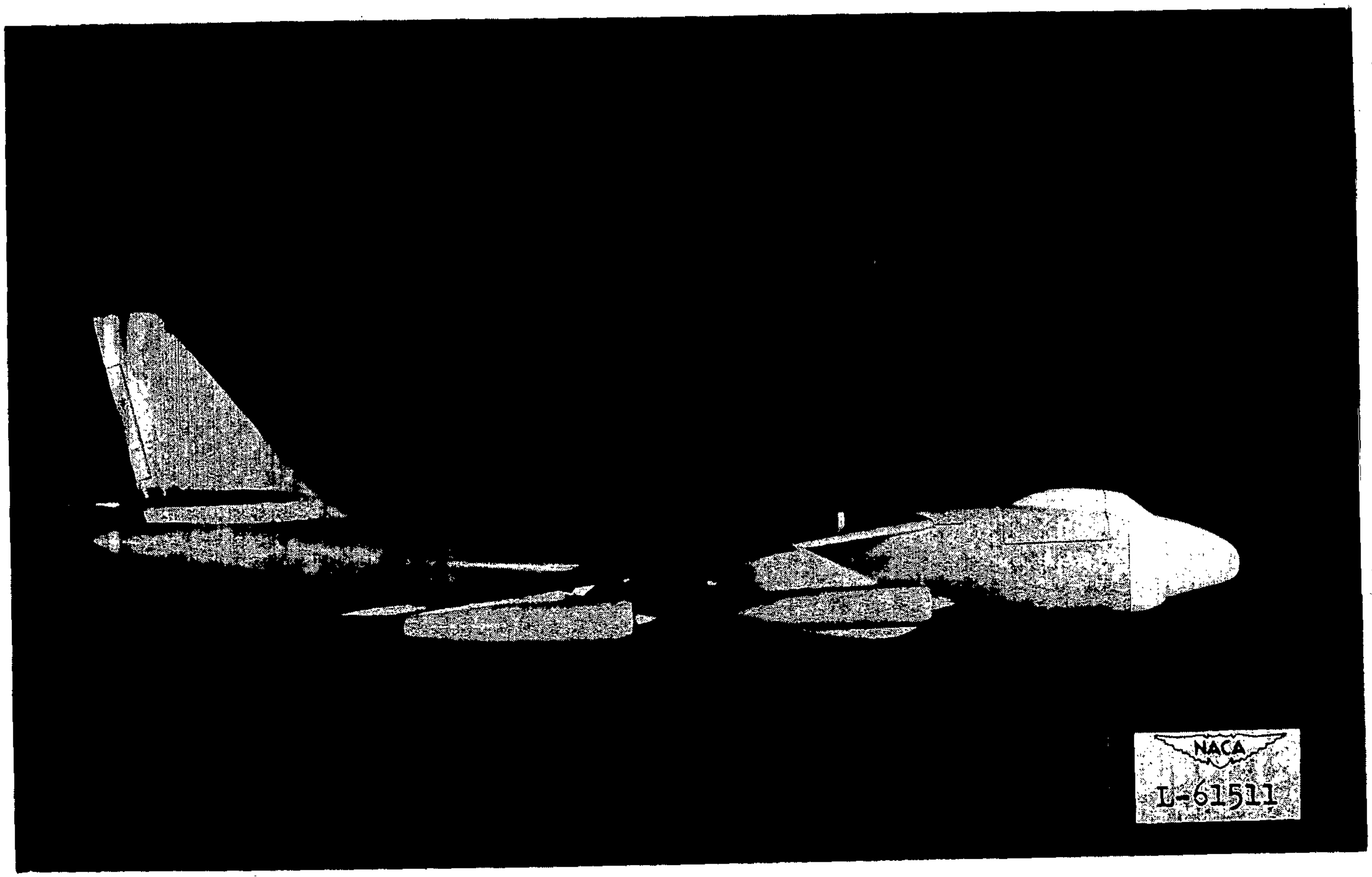


Figure 1.- Three-view drawing of Boeing B-47 airplane.



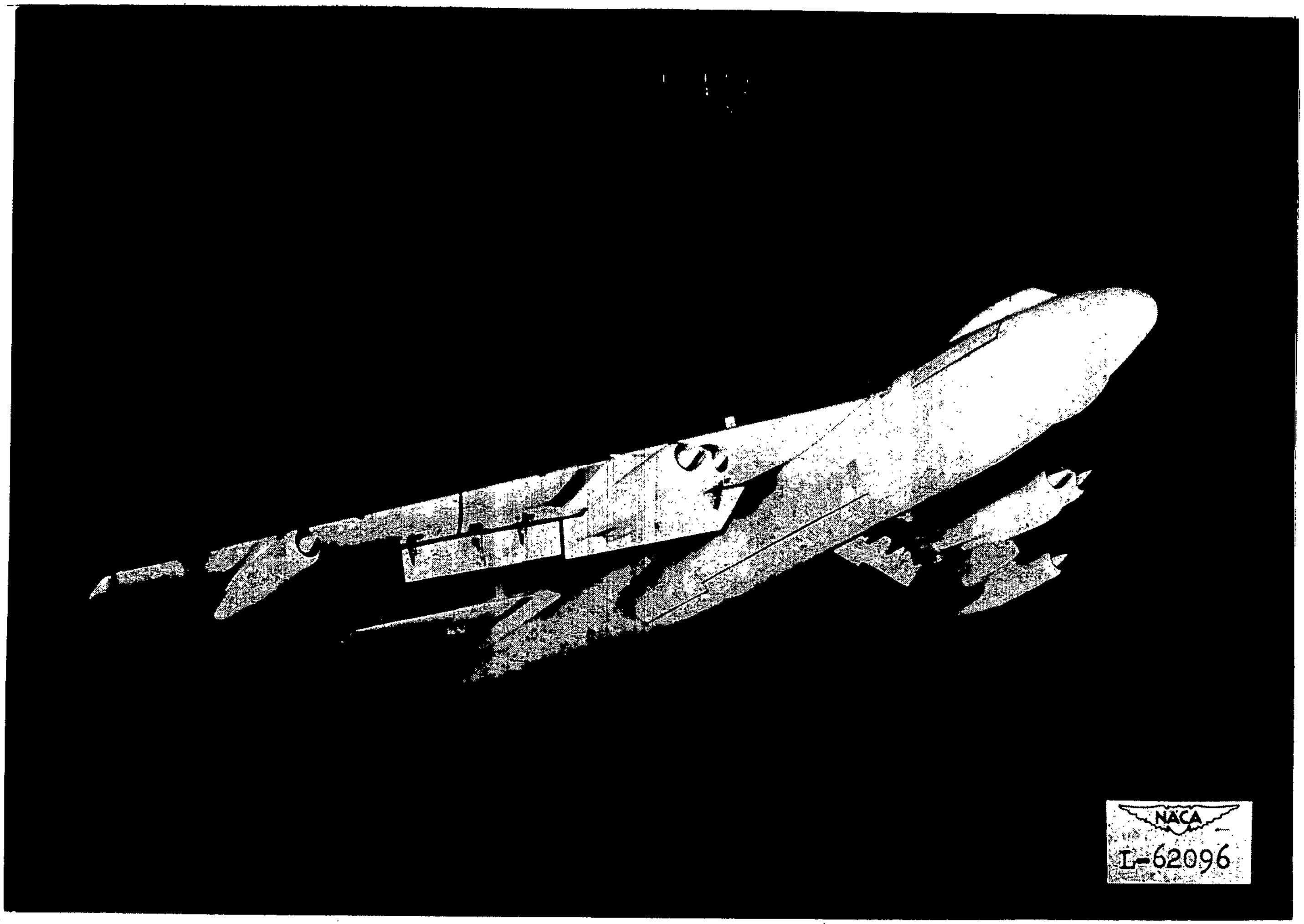
(a) Front view.

Figure 2.- Model of the Boeing B-47 airplane.



(b) Side view.

Figure 2.- Continued.



(c) Three-quarter bottom view.

Figure 2.- Concluded.

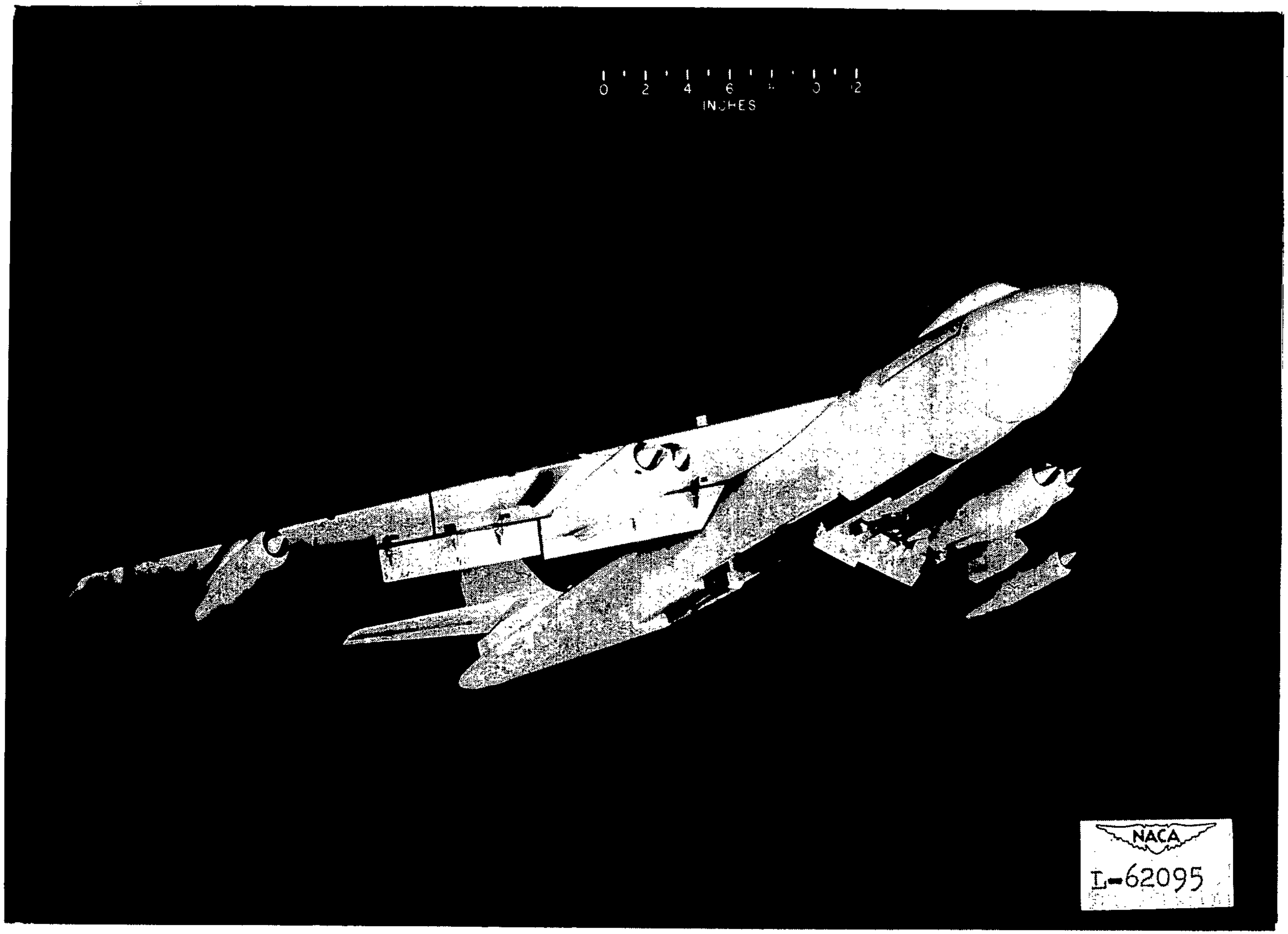


Figure 3.- Model with bomb-bay and main landing-gear doors removed.

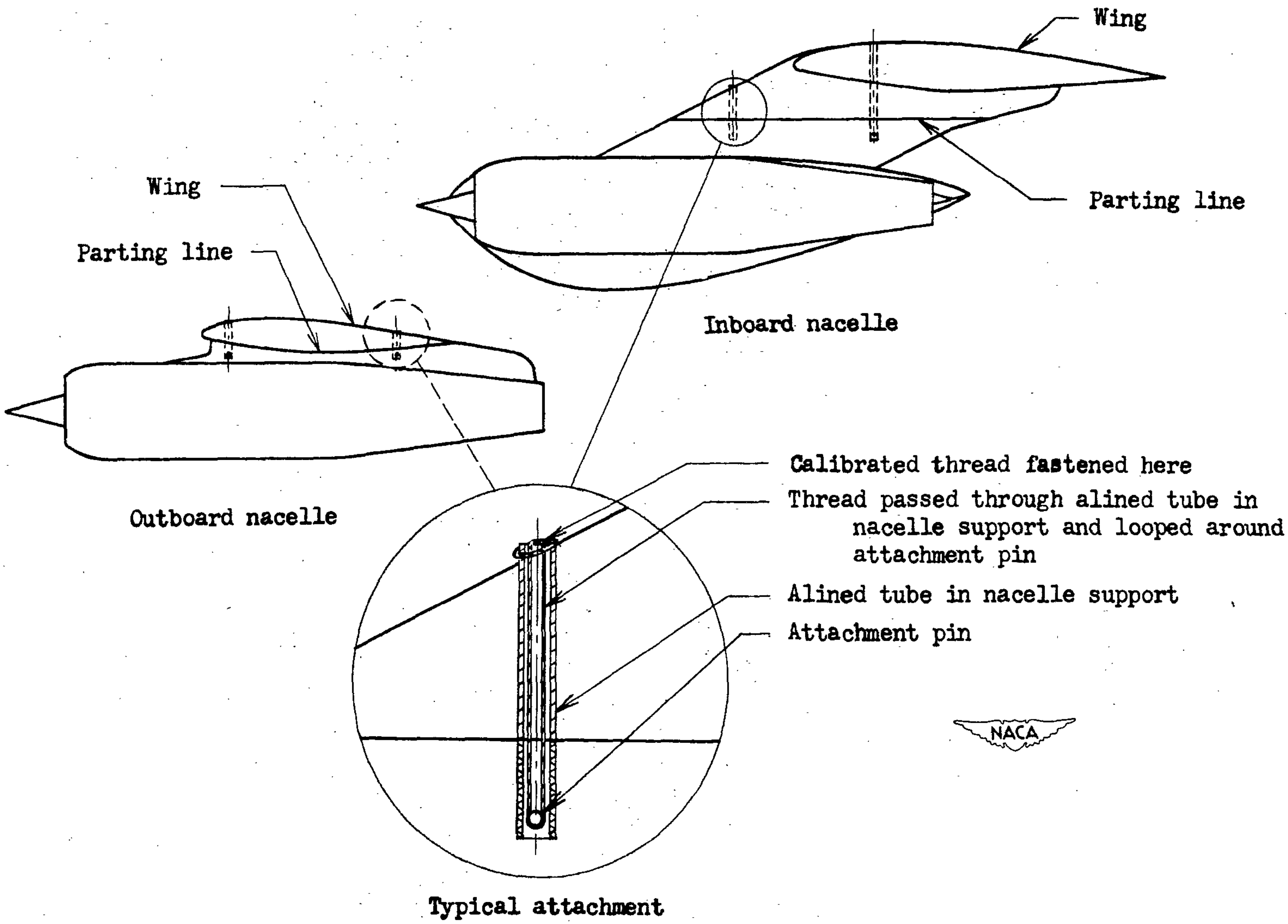
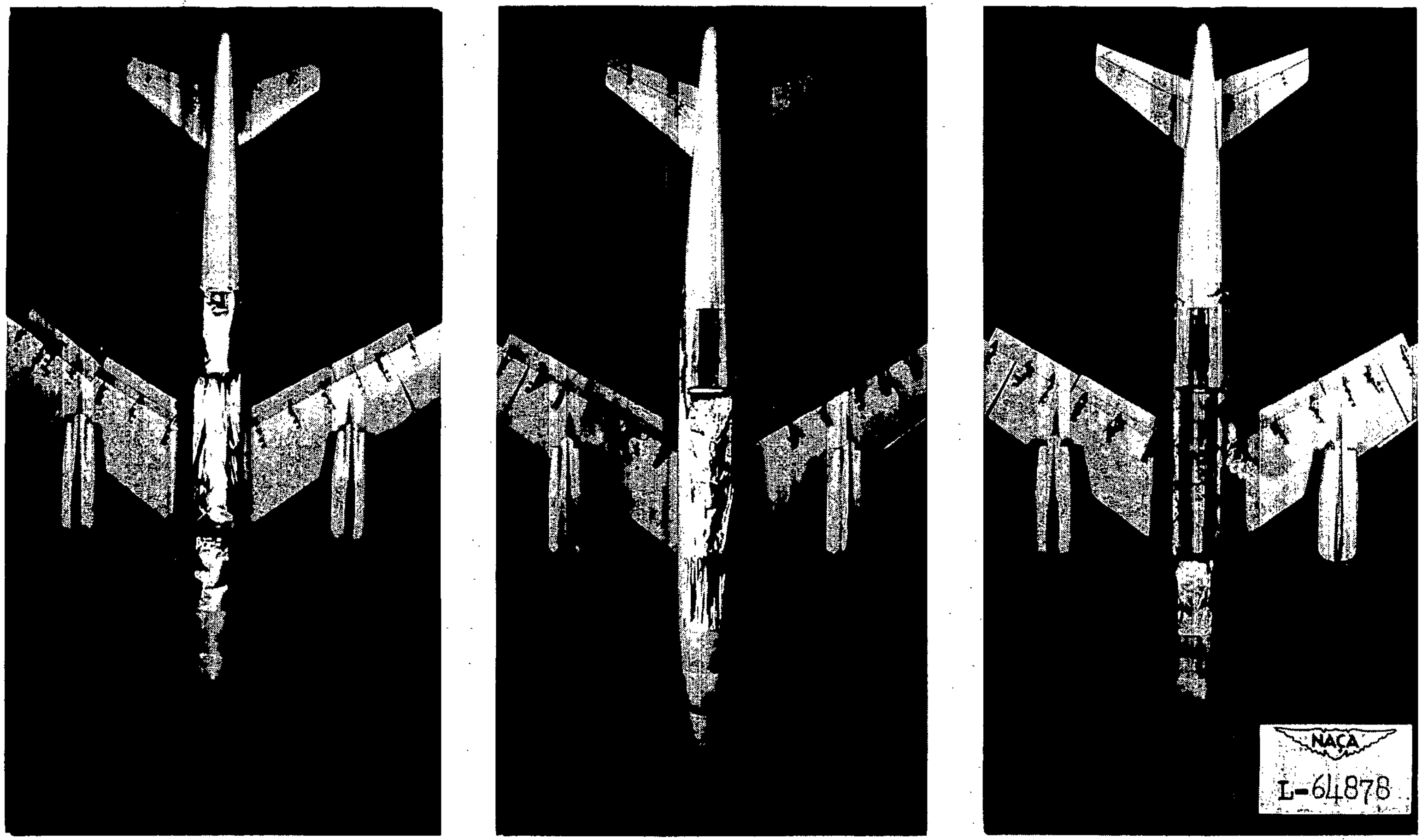


Figure 4.- Details of scale-strength attachment of nacelles to wing.

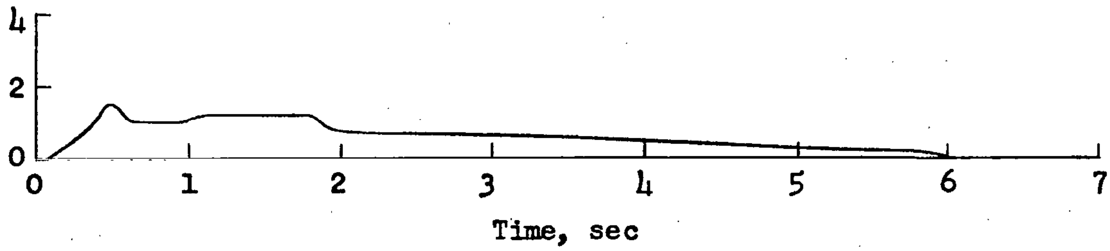


(a) 15° attitude.

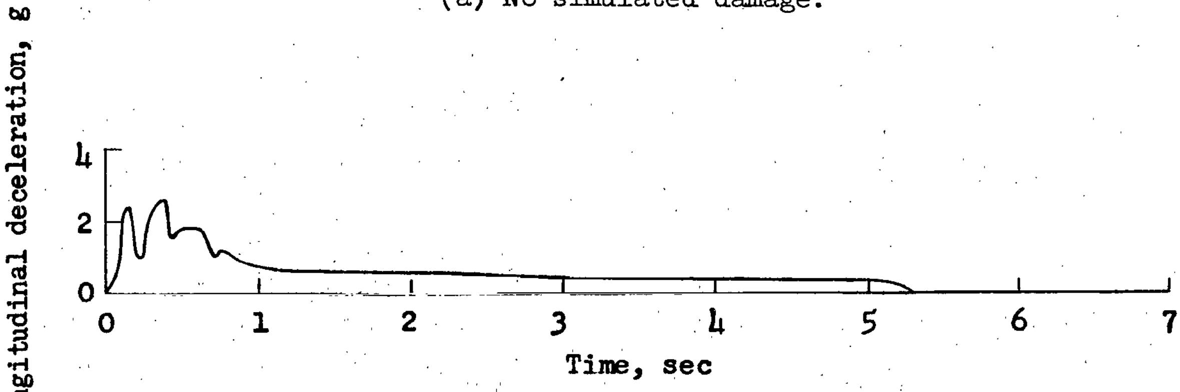
(b) 10° attitude.

(c) 5° attitude.

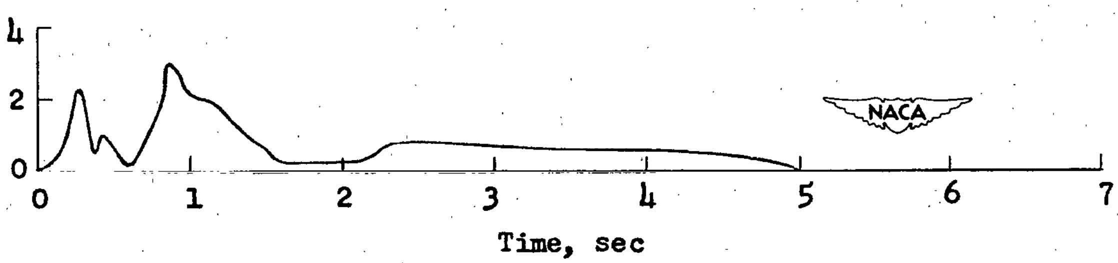
Figure 5.- Damage sustained by aluminum covering replacing the bomb-bay and main landing-gear doors; flaps are full down.



(a) No simulated damage.

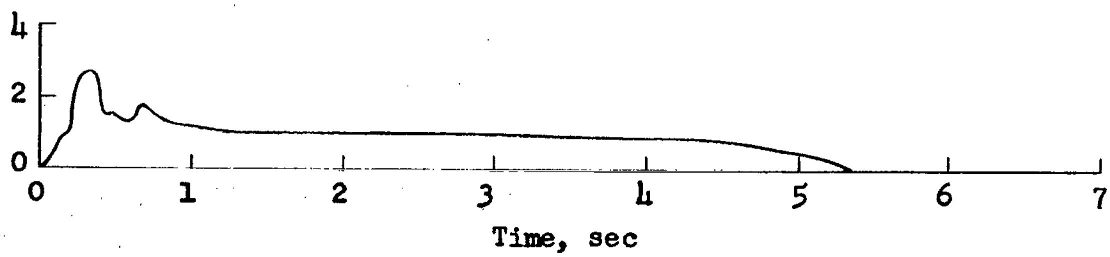


(b) Bomb-bay and main landing-gear doors removed.

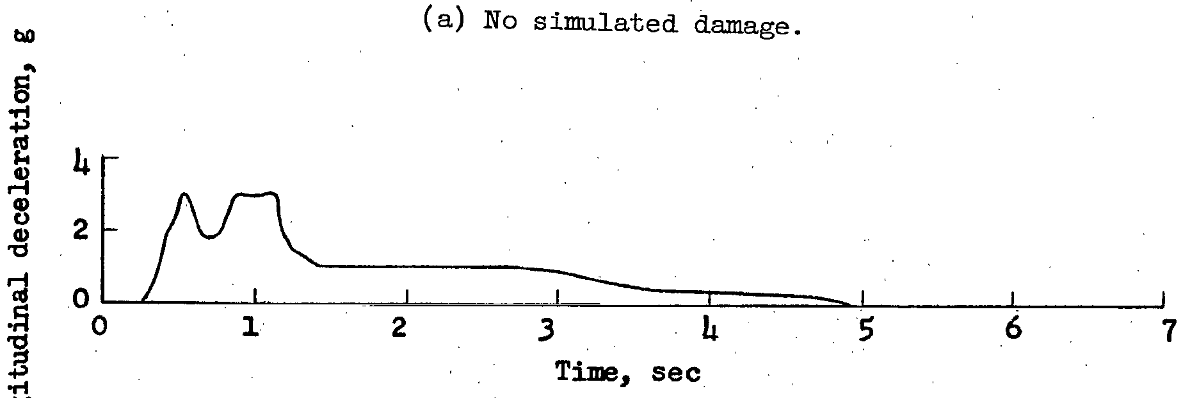


(c) Bomb-bay and main landing-gear doors replaced by aluminum covering.

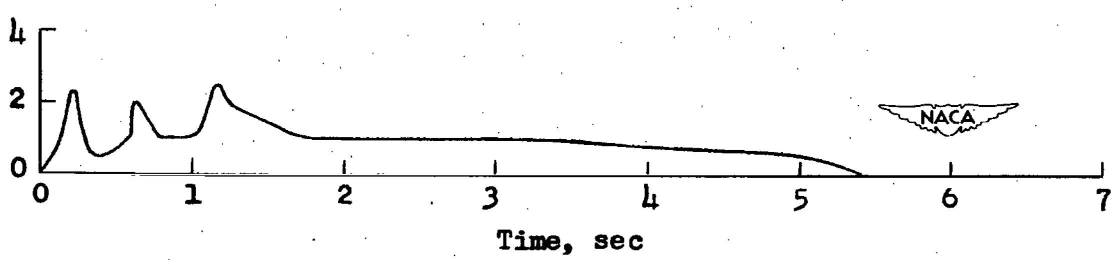
Figure 6.- Longitudinal decelerations at 15° landing attitude; flaps are full down; landing speed is 132 miles per hour. (All values are full scale.)



(a) No simulated damage.

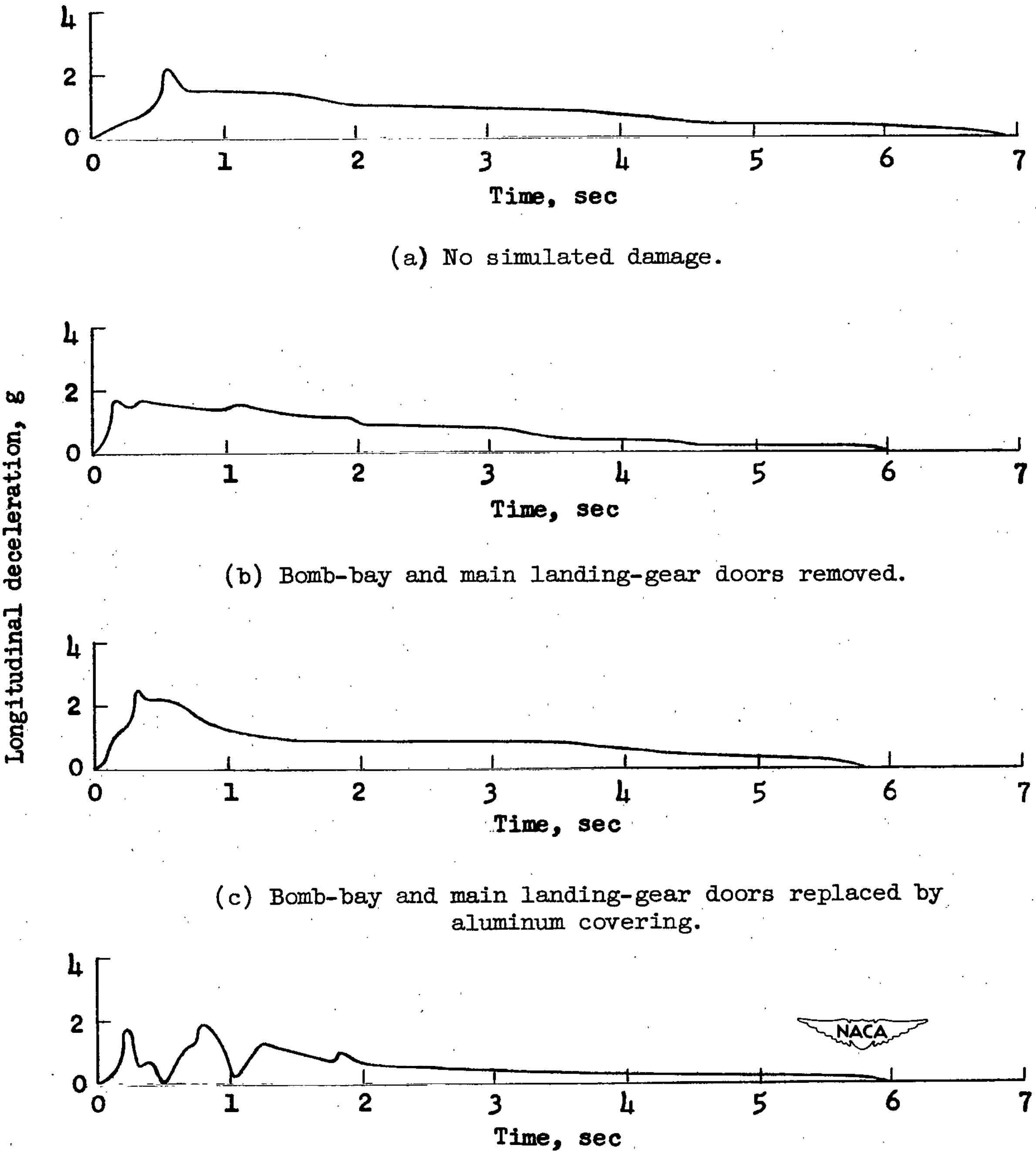


(b) Bomb-bay and main landing-gear doors removed.



(c) Bomb-bay and main landing-gear doors replaced by aluminum covering.

Figure 7.- Longitudinal decelerations at 10° landing attitude; flaps are full up; landing speed is 178 miles per hour. (All values are full scale.)



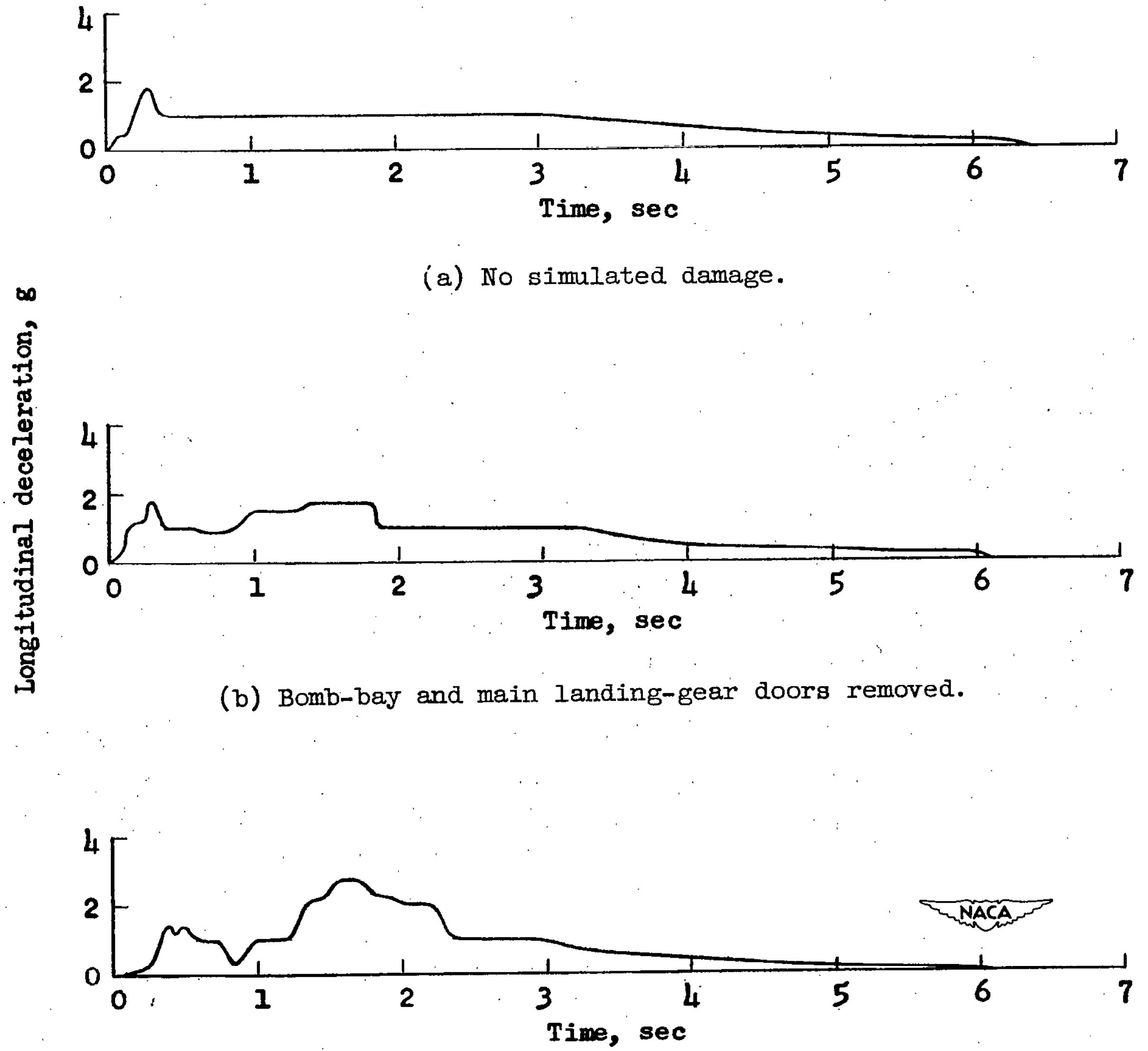
(a) No simulated damage.

(b) Bomb-bay and main landing-gear doors removed.

(c) Bomb-bay and main landing-gear doors replaced by aluminum covering.

(d) Bomb-bay and main landing-gear doors replaced by aluminum covering and nacelles attached at scale strength.

Figure 8.- Longitudinal decelerations at 10° landing attitude; flaps are full down; landing speed is 138 miles per hour. (All values are full scale.)



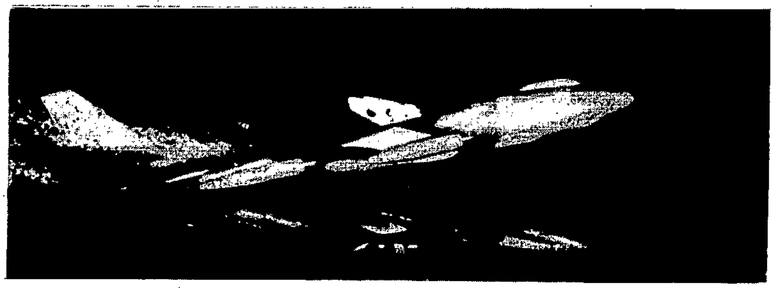
(a) No simulated damage.

(b) Bomb-bay and main landing-gear doors removed.

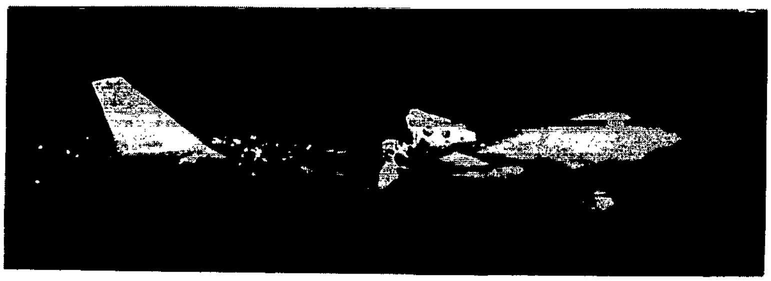
(c) Bomb-bay and main landing-gear doors replaced by aluminum covering.

Figure 9.- Longitudinal decelerations at 5° landing attitude; flaps are full down; landing speed is 154 miles per hour. (All values are full scale.)

Near contact



216 feet



504 feet

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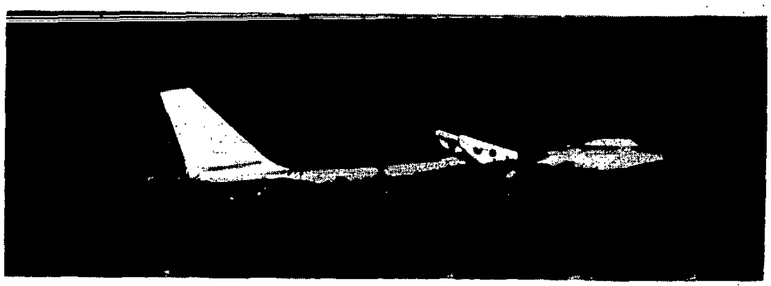
(a) No simulated damage.

Figure 10.- Sequence photographs of model ditchings at the 10° attitude with flaps full down. Distances after contact are indicated. (All values are full scale.)

Near contact

321 feet



457 feet

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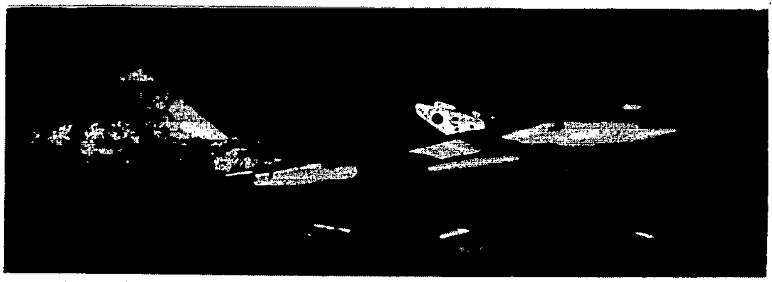
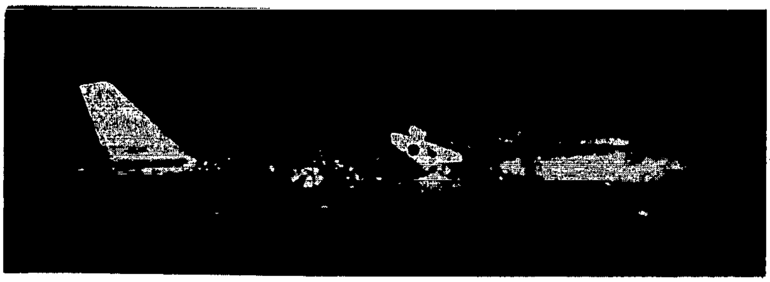
(b) Bomb-bay and main landing-gear doors removed.

Figure 10.- Continued.

Near contact



245 feet



469 feet

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(c) Bomb-bay and main landing-gear doors replaced by an aluminum covering.

Figure 10.- Concluded.