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NACA

RESEARCH MEMORANDUM

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Bureau of Aeronautics, Navy Department

DITCHING TESTS WITH A 1/16-SIZE MODEL OF THE NAVY XP2V-1 AIRPLANE AT THE LANGLEY TANK NO. 2 MONORAIL

By

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Langley Field, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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SUMMARY

Tests were made with a 1/16-size dynamically similar model of the Navy XP2V-1 airplane to study its performance when ditched. The model was ditched in calm water at the Langley tank no. 2 monorail.

Various landing attitudes, speeds, and conditions of damage were simulated. The performance of the model was determined and recorded from visual observations, by recording time histories of the longitudinal decelerations, and by taking motion pictures of the ditchings.

From the results of the tests with the model the following conclusions were drawn:

1. The airplane should be ditched at the normal landing attitude. The flaps should be fully extended to obtain the lowest possible landing speed.

2. Extensive damage will occur in a ditching and the airplane probably will dive violently after a run of about 2 fuselage lengths. Maximum longitudinal decelerations up to about 4g will be encountered.

3. If a trapezoidal hydroflap 4 feet by 2 feet by 1 foot is attached to the airplane at station 192.4, diving will be prevented and the airplane will probably porpoise in a run of about 4 fuselage lengths with a maximum longitudinal deceleration of less than 3.5g.

INTRODUCTION

Tests were made to determine the probable ditching performance of the Navy XP2V-1 airplane and to determine the best way to ditch the airplane. The investigation was requested by the Bureau of Aeronautics, Navy Department in a letter dated April 6, 1945, Aer-E-23-WSD and was made in calm water at the Langley tank no. 2 monorail.

APPARATUS AND PROCUDERE

Description of Model

A three-view drawing of the Navy XP2V-1 airplane is given in figure 1. A 1/16-size dynamically similar model with a wing span of 6.25 feet and with a fuselage length of 4.72 feet was used in the tests. Photographs of the model are shown in figure 2. The type of construction used on the model was similar to that described in reference 1. Data on the full-scale airplane were obtained from the Lockheed Aircraft Corporation.

Test Methods and Equipment

A photograph of the Langley tank no. 2 monorail is shown in figure 3. In ditching tests at the monorail, the model is attached to a small carriage that runs on a single overhead rail and is accelerated to the desired speed by a rubber shock cord. The carriage is stopped abruptly when it reaches the desired speed, and the model is catapulted into the air. The model then glides freely onto the water.

The test procedure is similar to that described in reference 1. The performance of the model is recorded from visual observation and by a high-speed motion-picture camera. The longitudinal decelerations are measured by a time-history accelerometer placed in the model near the pilot's cockpit.

Test Conditions

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

Gross weight.- The normal gross weight of 45,000 pounds was simulated in the test.

Location of the center of gravity.– The center of gravity was located at 29.3 percent of the mean aerodynamic chord and 3.1 inches above the thrust line.

Attitude.– Attitude was measured with respect to the fuselage reference line which is the attitude of the thrust line plus 3 degrees. The model was ditched at 10°, 6°, and 2° attitudes. The attitude is 10° when the main wheels and the tail skid touch the ground. This is near the stall angle. The attitude is 2° when the main wheels and the nose wheel touch the ground. The 6° attitude is an intermediate attitude and is approximately the normal landing attitude.

Landing Gear.– The tests simulated ditching with the landing gear retracted.

Flaps.– Tests were made with the flaps up and full-down. The flaps, when extended, were fixed at scale strength as shown in figure 4. This strength was based on an ultimate loading normal to the undersurface of the flap of 180 pounds per square foot.

Condition of simulated damage.– Structural strengths of the bottom of the fuselage and of the doors on the underside of the airplane are as follows:

Doors	
Nose-wheel doors, lb/sq ft	150
Main-wheel doors, lb/sq ft	150
Bomb-bay doors, lb/sq ft	100
Rear entrance door, lb/sq ft	70
Fuselage	
Stations 55 to 274, lb/sq ft	100
Stations 484 to 764, lb/sq ft.	70
Stations 764 to 942, lb/sq ft.	120

These values are probably less than the water pressures that will occur on the bottom of the airplane in a ditching. Since the underside of the fuselage is very weak and will probably fail in some parts, a rectangular section from station 500 to station 558, 48 inches wide, and a trapezoidal section from station 644 to 754, 56 inches wide at station 644 and 48 inches wide at station 754 were made so that they could be removed to simulate their failure. The radar turret on the underside of the fuselage was also considered weak enough to be torn away in a ditching.

The model was tested at the following conditions of simulated damage:

(a) No damage (fig. 2).

(b) Nose-wheel doors, main-wheel doors, radar turret, bomb-bay doors, rear entrance door and two sections of the fuselage aft of the bomb-bay doors removed to simulate their failure (fig. 5 and 6). This is the probable condition of damage.

(c) Same as condition (b) above but with the nose-wheel doors in place and a trapezoidal hydroflap 4 feet by 2 feet by 1 foot set at 30° to the fuselage reference line placed at the forward edge of the nose-wheel door, station 114 (figs. 6 and 7).

(d) Same as condition (c) above but with the hydroflap moved back to the aft part of the nose-wheel doors, station 192.4 (figs. 6 and 7).

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 fuselage reference line is greater than 15°

d_2 slight dive - a dive in which the wings are not completely submerged and the angle between the water surface and the fuselage reference line is less than 15°

h smooth run - a run in which there is no apparent oscillation about any axis and during which the model settles in the water as the forward velocity decreases

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

Photographs showing the characteristics behaviors of the model are shown in figures 8 and 9.

Typical time histories of longitudinal decelerations are given in figures 10 to 13.

Effect of Attitude and Simulated Damage

The model made a smooth run when ditched with no damage simulated. The landing attitude had little effect on the ditching characteristics except that at the 2° attitude there was a tendency for the model to trim up after striking the water. The lengths of runs and the maximum decelerations were about the same at all three attitudes tested. Figure 10 shows the time-history deceleration curves for tests with no damage simulated, with the flaps up and also full down. The hump at the beginning of each curve was caused by the initial contact of the model with the water. The model generally made a smooth run after the initial contact but the hump in the curves of figure 10(c) at about 1.2 seconds and figure 10(e) at about 0.4 second occurred during a porpoising motion.

When failure of the nose-wheel doors, main-wheel doors, radar turrent, bomb-bay doors, rear entrance door, and two sections of the bottom of the fuselage was simulated, the model dived violently after a run of about 2 fuselage lengths (fig. 8). The length of run remained about the same for all three landing attitudes, however, the maximum deceleration increased as the attitude decreased. Figure 11 shows time-history deceleration curves obtained during dives caused by damage to the bottom of the fuselage. The initial contact produced the hump at the beginning of each curve. The initial decelerations are larger than those shown in figure 10, because in this case damage was present at the time of contact. In an actual airplane the initial deceleration could be expected to be somewhat less since damage would not occur until after the contact. The dive developed soon after contact and that part of the curves of figures 11(a), (b), and (c) from about 0.5 second to about 3.0 seconds was obtained during the dive.

Since for either condition of damage tested there is little difference in ditching behavior caused by landing attitude, the normal landing attitude is recommended for a ditching because it appears best not to change normal procedure unless a substantial improvement in behavior can be assured.

Effect of Flaps

The flaps usually failed and had little hydrodynamic effect on the ditching characteristics of the model. However, the lower air-speeds obtained with the use of flaps would be advantageous in a ditching.

Effect of Ditching Aid

When the hydroflap was attached at the aft part of the nose-wheel doors (sta. 192.4, full scale) and failure of the main-wheel doors, radar turret, bomb-bay doors, rear entrance door and two sections of the fuselage aft of the bomb-bay doors was simulated, the diving usually caused by this damage was prevented. The model porpoised soon after it first contacted the water and then made a smooth straight run (fig. 9). Figure 12 shows the time-history deceleration curves for the tests of this hydroflap installation. The first hump in each curve was caused by the initial contact. It should be noted that the hydroflap influences the initial contact only in the 2° attitude landing because at 6° and 10° the hydroflap does not touch the water until after the rear part of the fuselage has struck. Figure 12(c) shows a marked decrease in initial deceleration as compared with figure 11(c) where no hydroflap was used. With the hydroflap installation, the model porpoised and the hump that begins in the curves of figures 12(a) and (b) at about 1 second and figure 12(c) at about 2 seconds was caused by the nose going deep into the water during the porpoising motion.

Although the ditching behavior at all three landing attitudes was about the same when the hydroflap prevented diving, the 10° attitude landings resulted in the highest maximum decelerations and the shortest runs, and the 2° attitude landings resulted in the lowest maximum decelerations and the longest runs. However, the average decelerations were better at 10° and 6° than at 2° (see fig. 12) and there is a greater possibility of damage to the fuselage bottom in a landing at 2° than in a higher attitude landing due to the increased speed at the lower attitude. Therefore, the normal landing attitude is recommended for a ditching if a hydroflap is added. This is the same attitude recommended for a ditching without a hydroflap.

The location of the hydroflap is critical because when the hydroflap was attached at the forward edge of the nose-wheel doors (sta. 114, full scale) it did not stop the diving caused by damage. Figure 13 shows the time-history deceleration curves for the tests with the hydroflap installation that did not prevent diving. The initial landing impact resulted in the usual hump at the beginning of each curve. The model then made one skip and dived at the end of the skip. That part of the curves of figures 13(a) and (b) from about 0.5 second to about 2.8 seconds shows the decelerations and their duration in the dive.

CONCLUSIONS

From the results of the tests with a 1/16-size model of the Navy XP2V-1 airplane the following conclusions were drawn:

1. The airplane should be ditched at the normal landing attitude. The flaps should be fully extended to obtain the lowest possible landing speed.

2. Extensive damage will occur in a ditching and the airplane probably will dive violently after a run of about 2 fuselage lengths. Maximum longitudinal decelerations up to about 4g will be encountered.

3. If a trapezoidal hydroflap 4 feet by 2 feet by 1 foot is attached to the airplane at station 192.4 diving will be prevented and the airplane will probably porpoise in a run of about 4 fuselage lengths with a maximum longitudinal deceleration of less than 3.5g.

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BUB

REFERENCE

1. Fisher, Lloyd J., and Steiner, Margaret F.: Ditching Tests with a 1/12-Size Model of the Army B-26 Airplane in NACA Tank No. 2 and on an Outdoor Catapult. NACA MR, Army Air Forces, Aug. 15, 1944.

TABLE I.- Summary of results of ditching tests in calm water with a 1/16-size model of the Navy XP2V-1 airplane at the Langley Tank No. 2 Monorail.

[Gross weight 45,000 pounds
All values are full scale]

Attitude fuselage reference line, deg		10						6						2		
Speed, knots		71			102			78			121			89		
Condition of damage (2)	Flap Setting (1)	Max	Run	Rmk	Max	Run	Rmk	Max	Run	Rmk	Max	Run	Rmk	Max	Run	Rmk
(A)	Up				1.4	7	h				2.0	9	h			
	Full down	2.0	4	h				2.0	4	h				2.0	5	uh
(B)	Full down	3.3	1	d,				4.0	2	d,				5.9	2	d,
(C)	Full down	4.3	1	sd,				4.0	2	sd,						
(D)	Full down	4.0	3	ph				3.5	4	ph				2.9	6	ph

(1) Column headings are explained as follows:

Max – The maximum deceleration in multiples of the acceleration of gravity

Run – Length of run in multiples of the length of the airplane

Rmk – Notations under this heading have the following meaning:

d, – dived violently
h – ran smoothly
p – porpoised
s – skipped
u – trimmed up

(2) Condition of damage

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A – no damage simulated

B – nose-wheel door, main-wheel doors, bomb-bay doors rear entrance door, radar turret and two sections of the fuselage aft of the bomb-bay doors removed to simulate their failure

C – same as "B" above but with the nose-wheel door in and with a hydroflap 4 ft by 2 ft. by 1 ft. at the forward edge of the nose-wheel door

D – same as condition "C" above but with the hydroflap moved to the aft end of the nose-wheel door

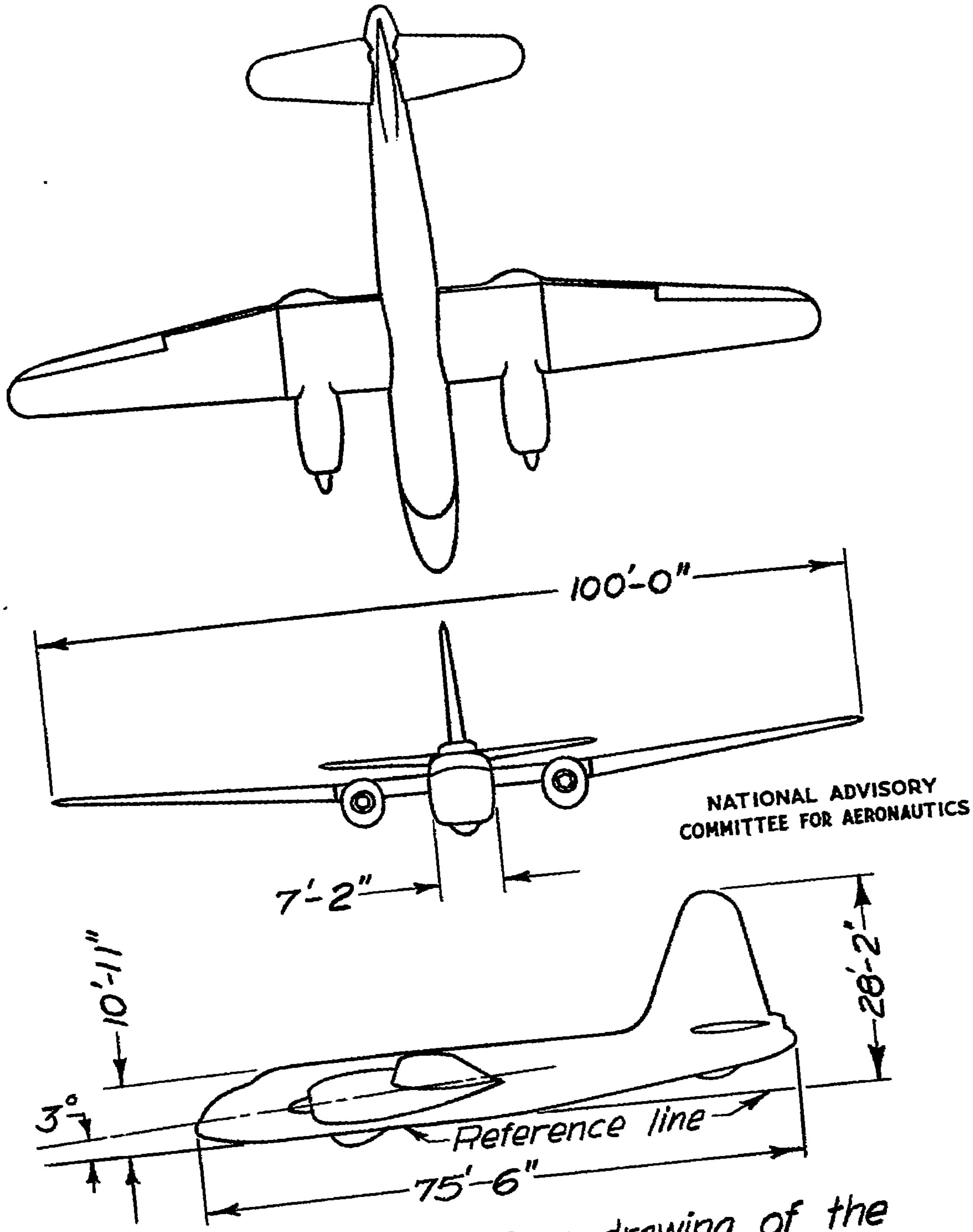
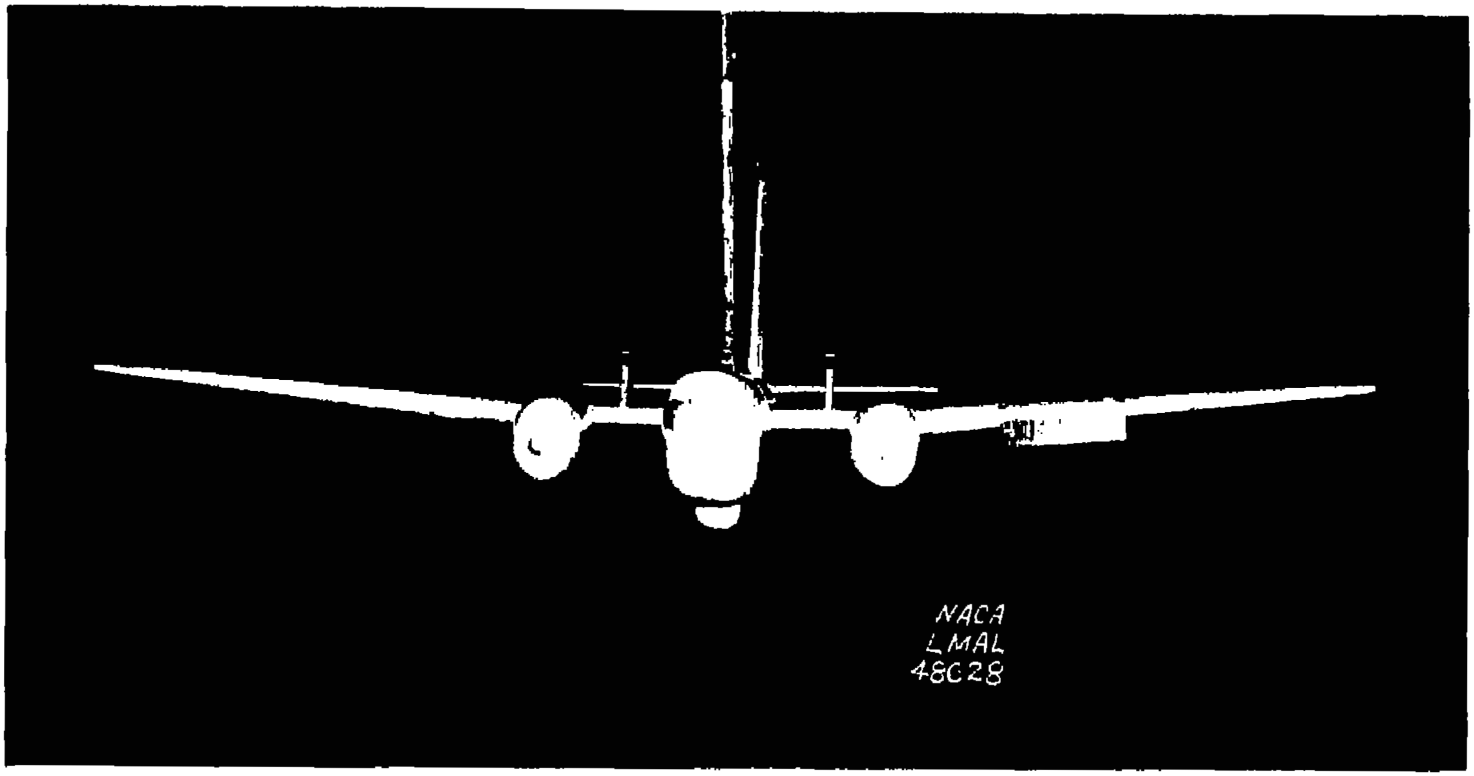
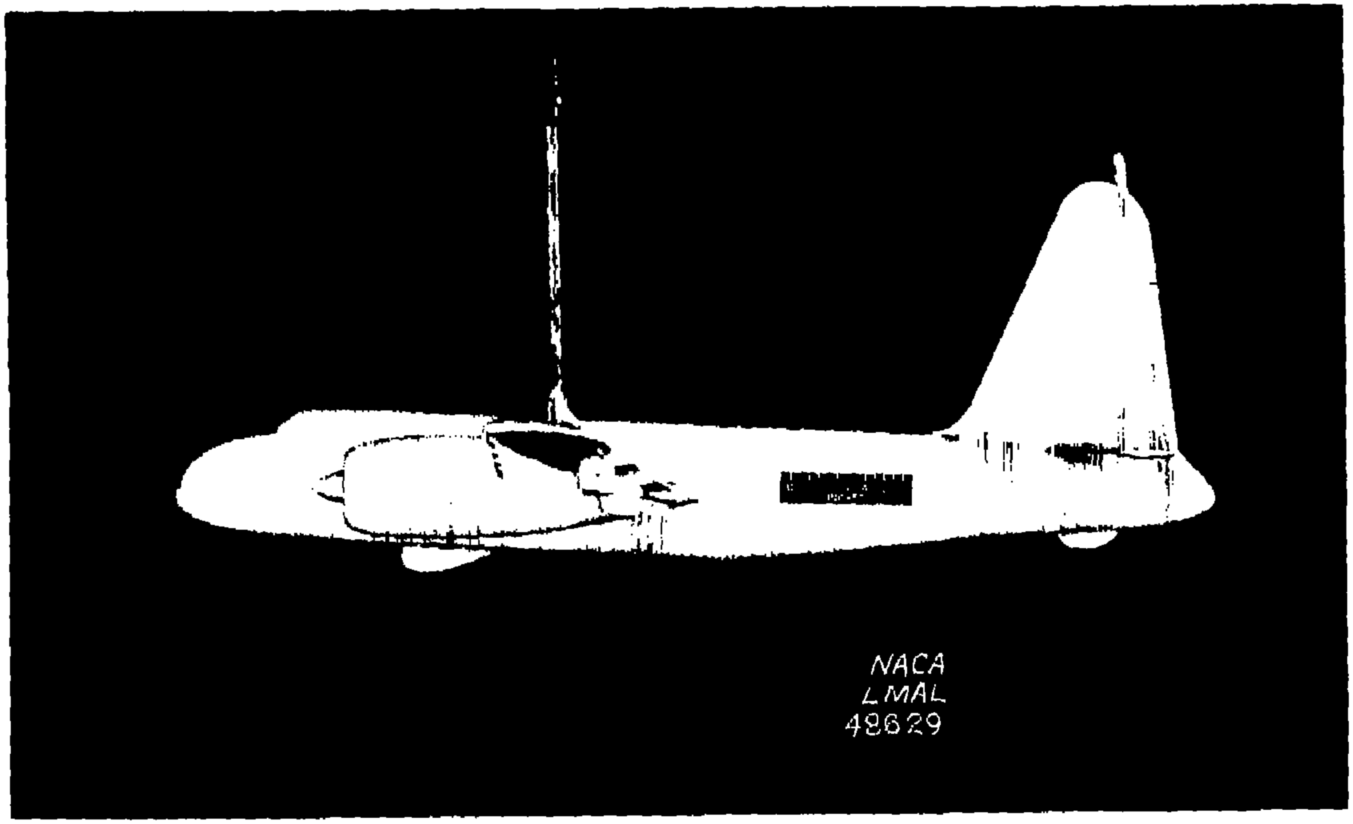


Figure 1 .- Three-view drawing of the Navy XP2V-1 airplane.



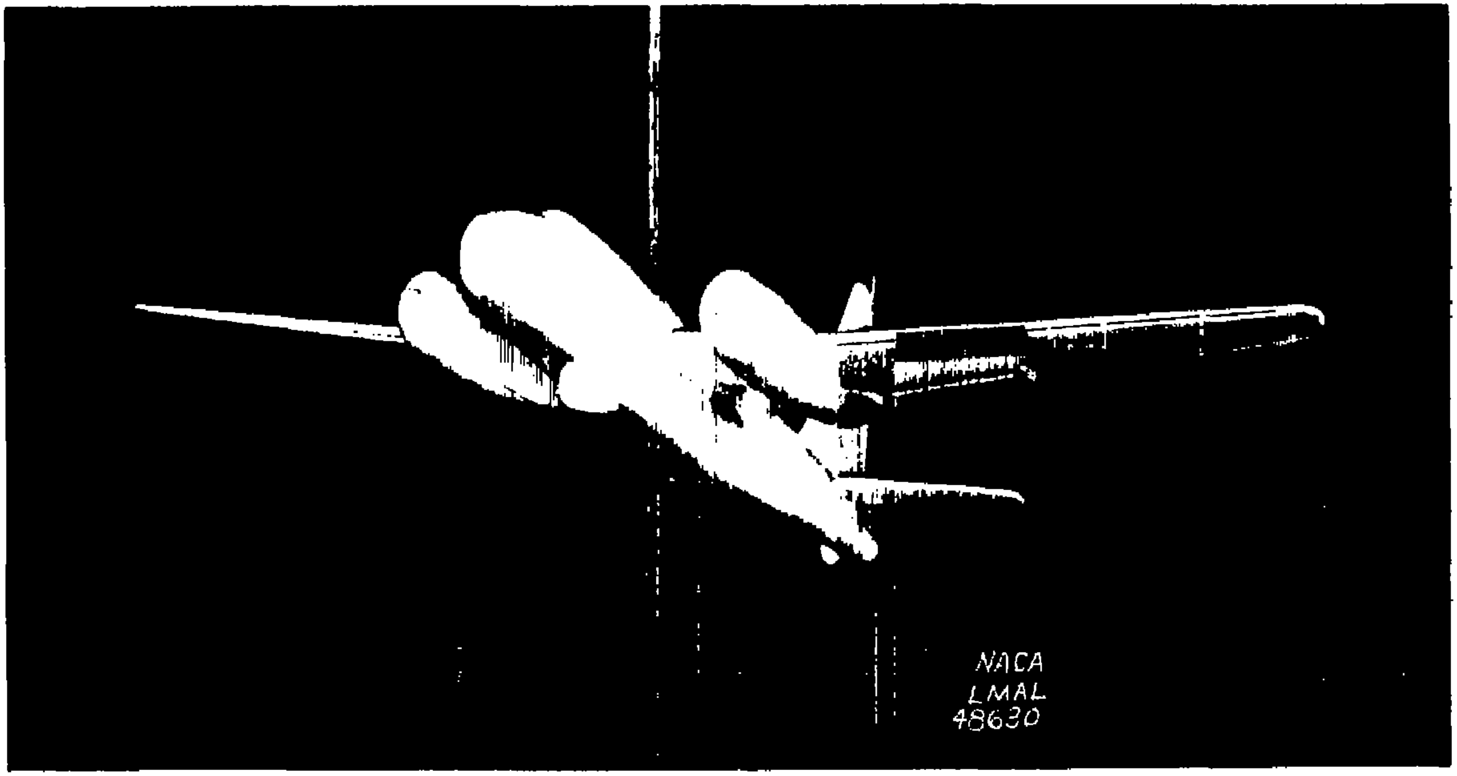
(a) Front view.

Figure 2.- Photograph of the model with no damage simulated.



(b) Side view.

Figure 2.- Continued.



(c) Three-quarter bottom view.

Figure 2.- Concluded.

Figure 3.- Photograph of the Langley tank No. 2 monorail.

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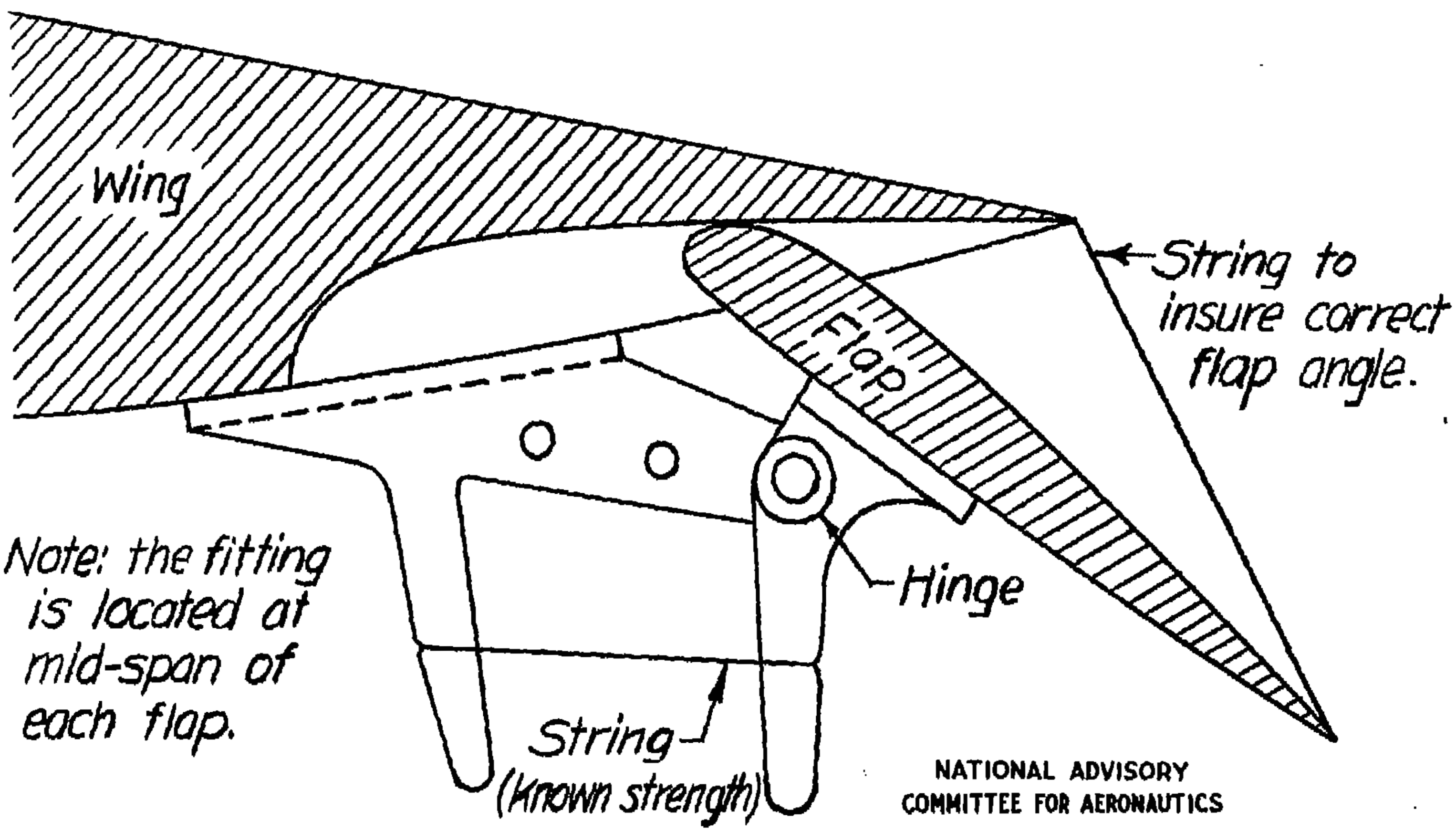


Figure 4.– Drawing showing method used to obtain scale strength flaps.

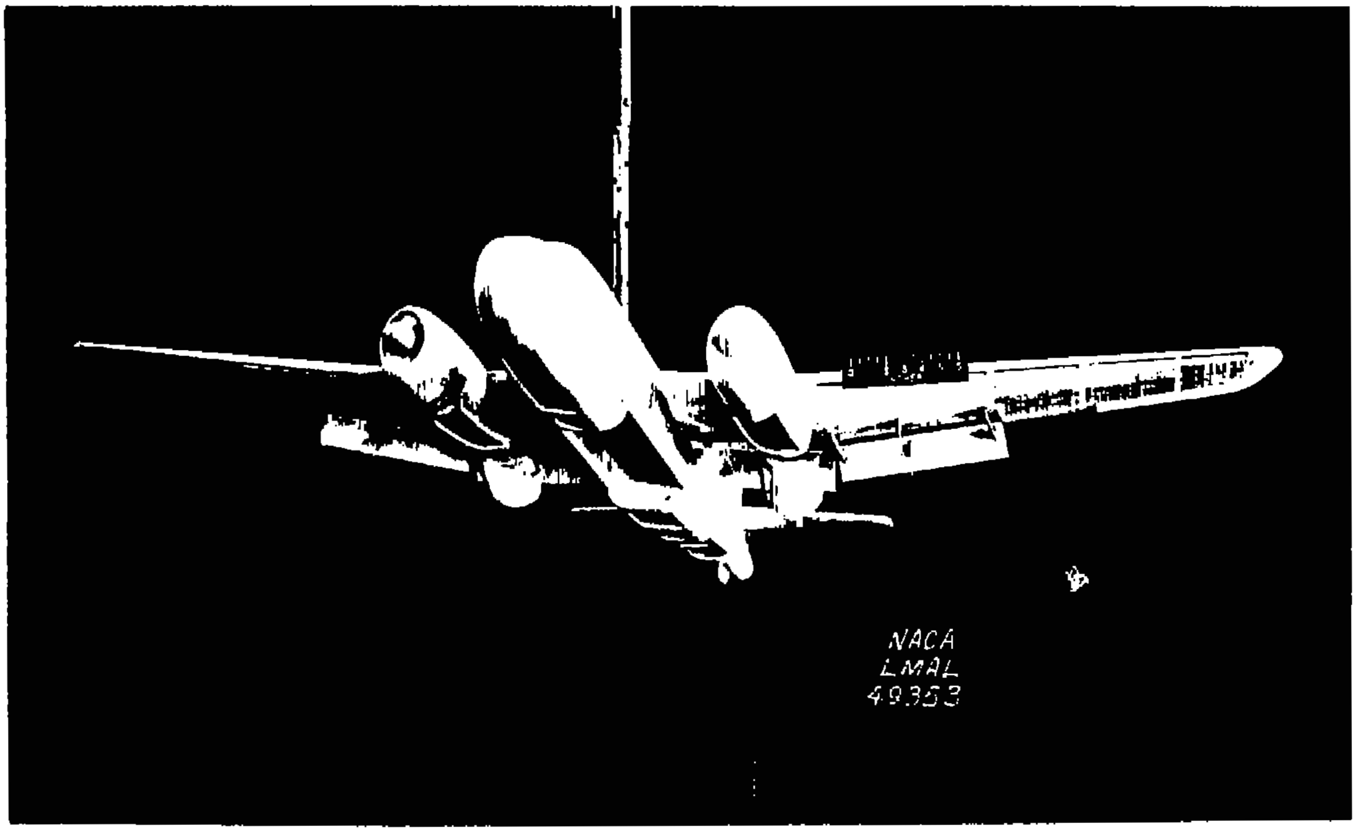


Figure 5.- Photograph of the model with the nose-wheel doors, radar turret, bomb-bay doors, main-wheel doors, rear entrance hatch and the two sections of the fuselage aft of the bomb-bay doors removed to simulate their failure.

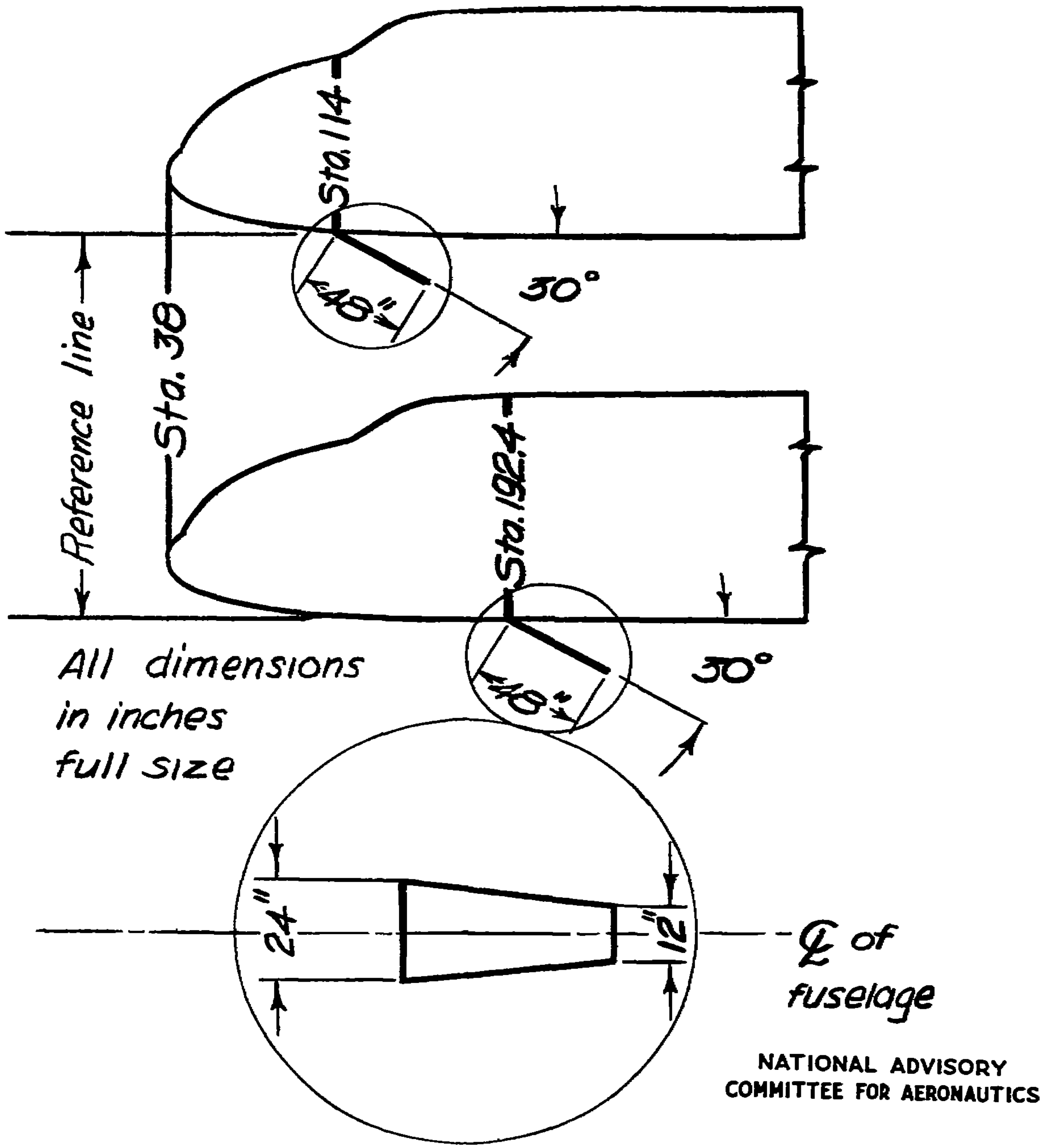


Figure 7 .– Drawing showing locations and size of hydroflap.

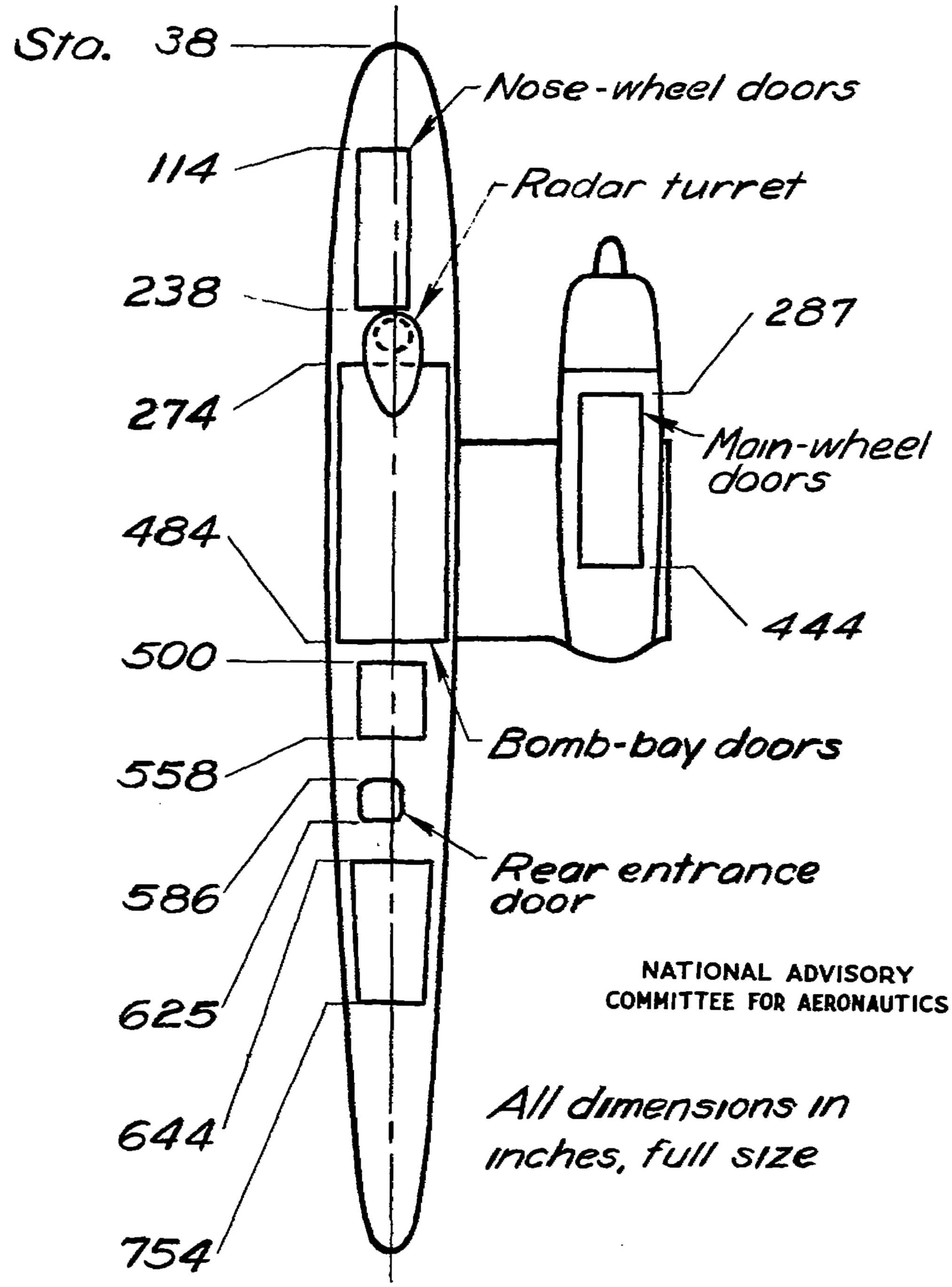
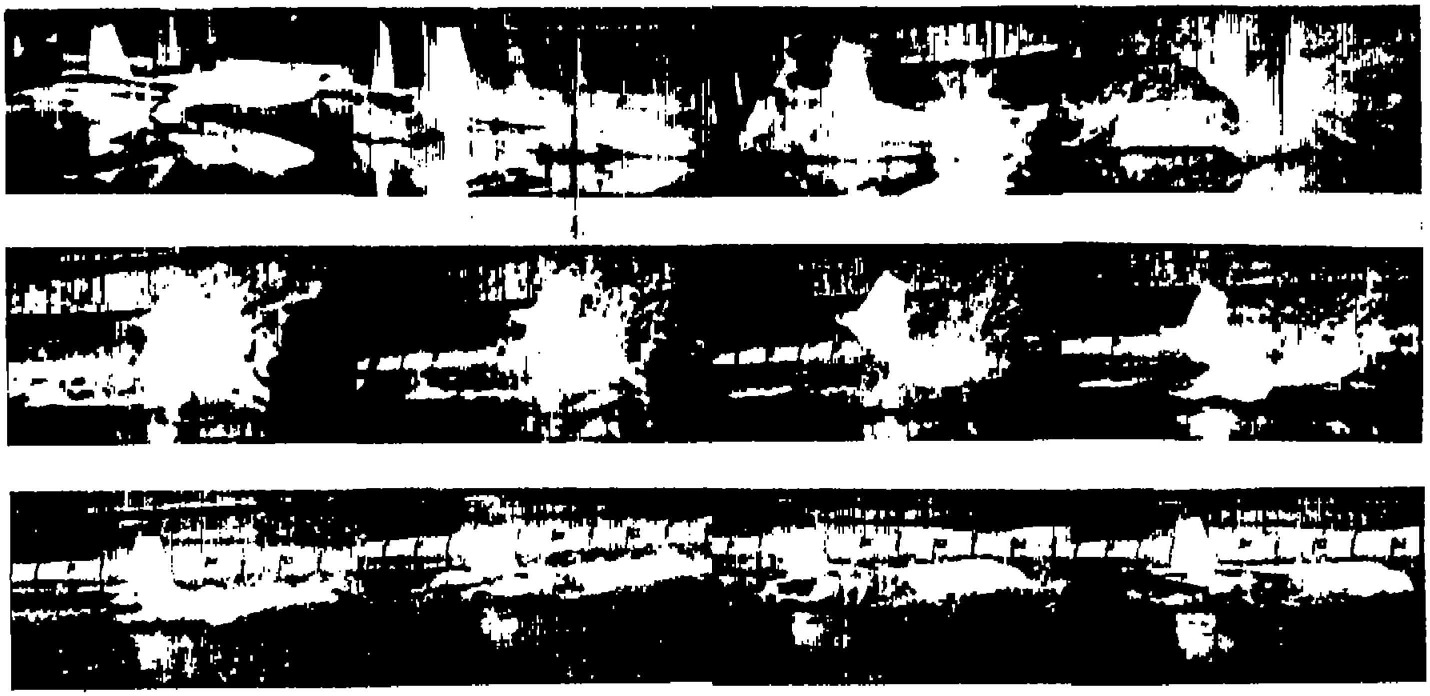


Figure 6.- Drawing showing the locations of components removed to simulate their failure.



(a) Attitude 10°. Speed 71 knots.

Figure 8.- Photographs at 0.5 second intervals of a ditching of the model with flaps full down with simulated failure of the nose-wheel door, radar turret, bomb-bay doors, main-wheel doors, rear entrance door and two sections of the fuselage aft of the bomb-bay doors. All values are full scale.

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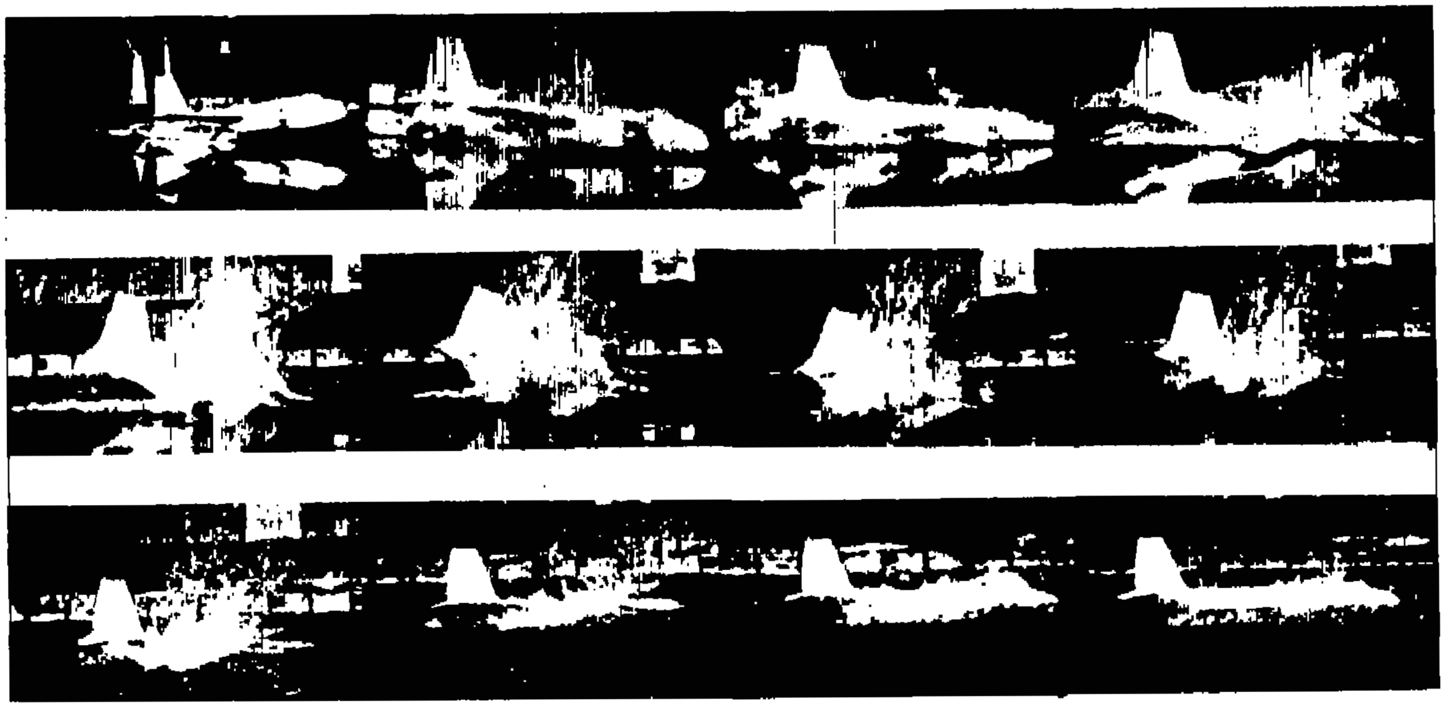

(b) Attitude 6°. Speed 78 knots.

Figure 8.- Continued.

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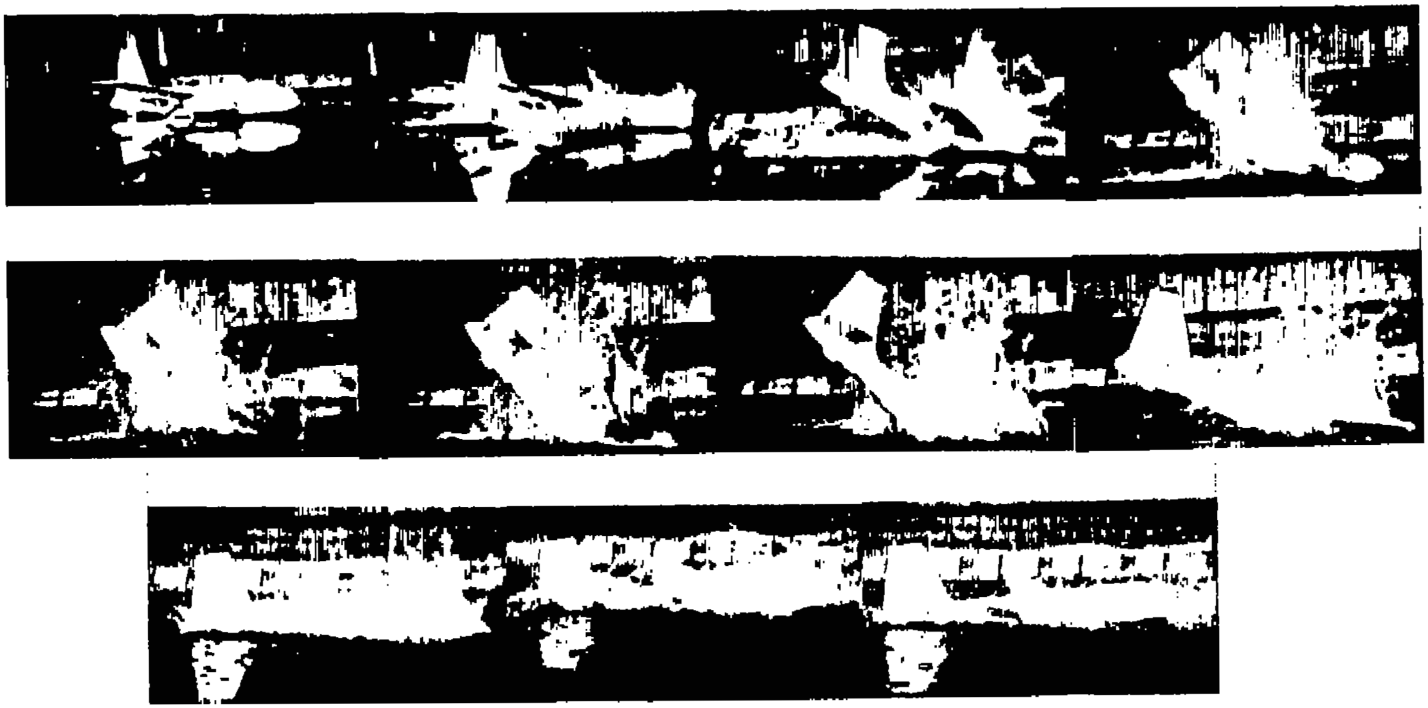
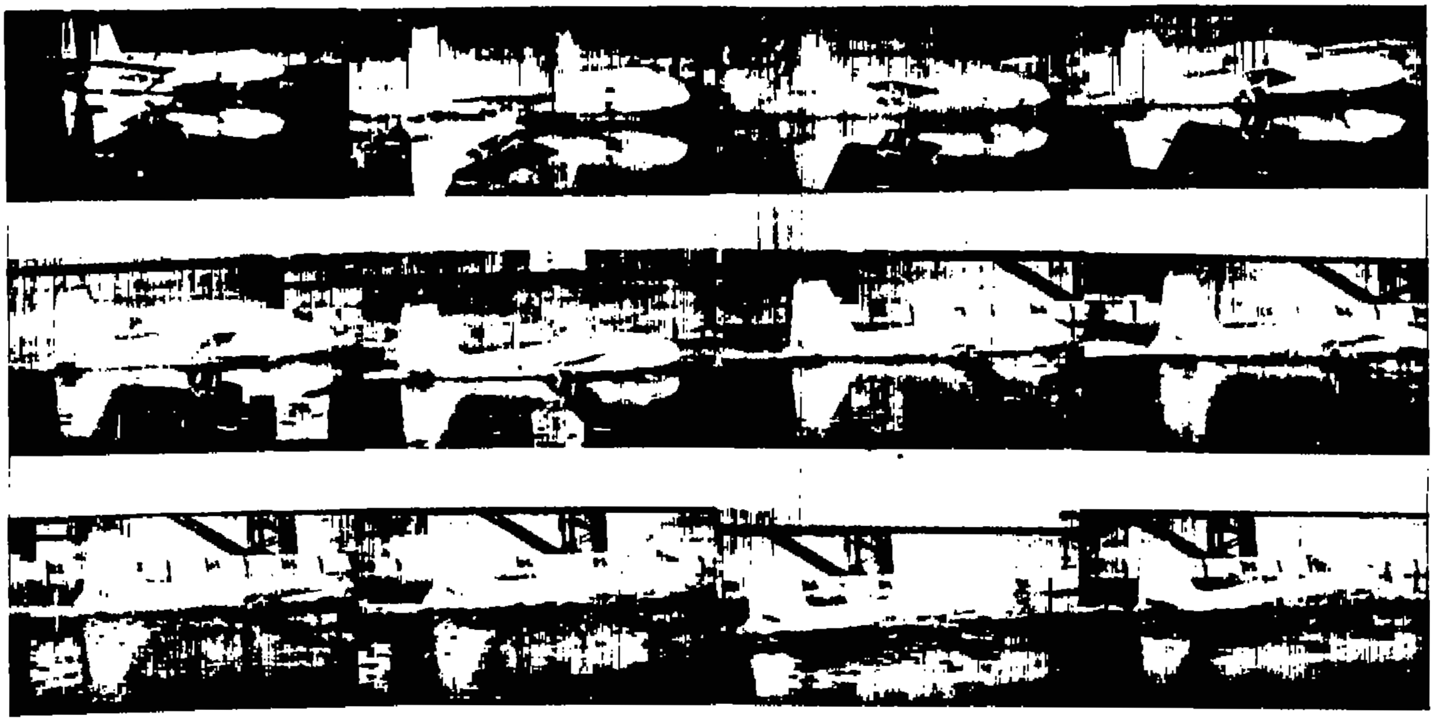


(c) Attitude 2°. Speed 89 knots.

Figure 8.- Concluded.



(a) Attitude 10°. Speed 71 knots.

Figure 9.- Photographs at 0.5 second intervals of a ditching of the model with flaps full down with simulated failure of the radar turret, bomb-bay doors, main-wheel doors, rear entrance door and two sections of the fuselage aft of the bomb-bay doors. A hydroflap 4 feet by 2 feet by 1 foot was attached at station 192.4. All values are full scale.

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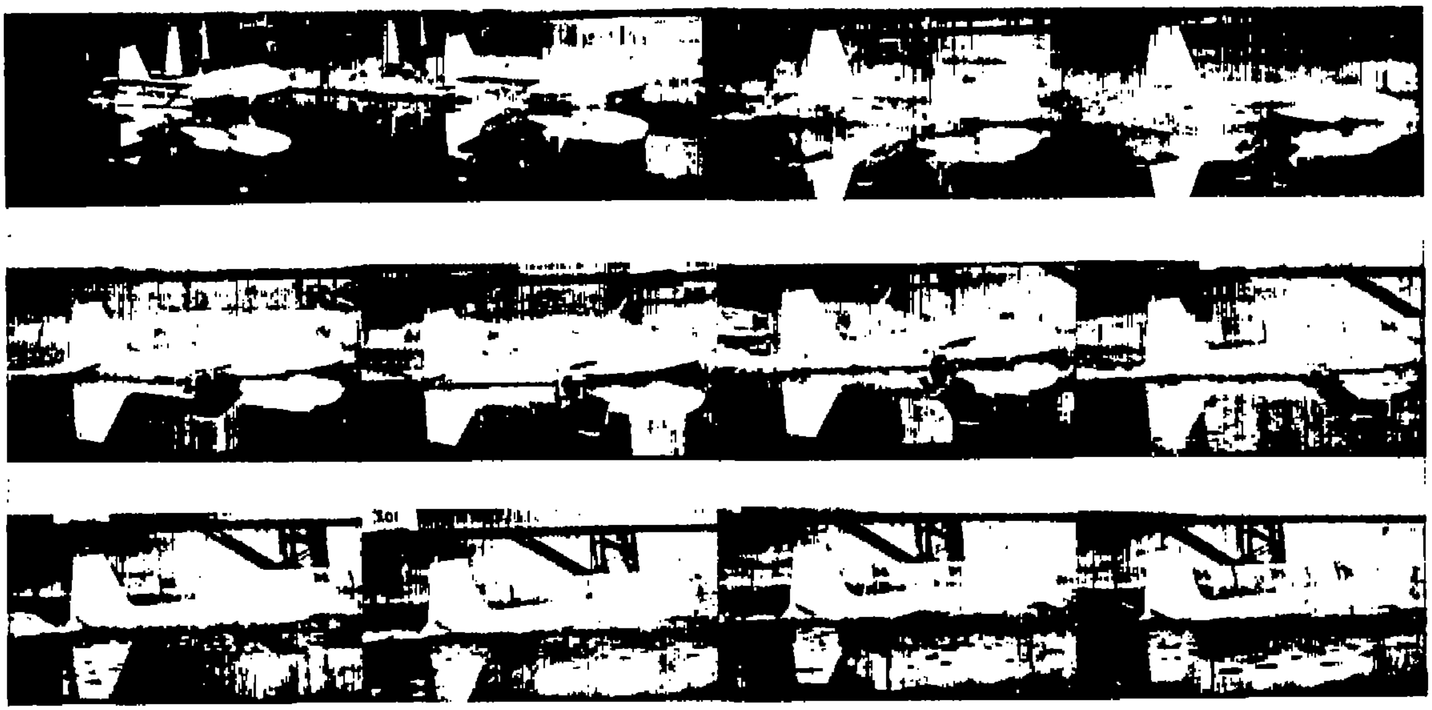

(b) Attitude 6°. Speed 78 knots.

Figure 9.- Continued.

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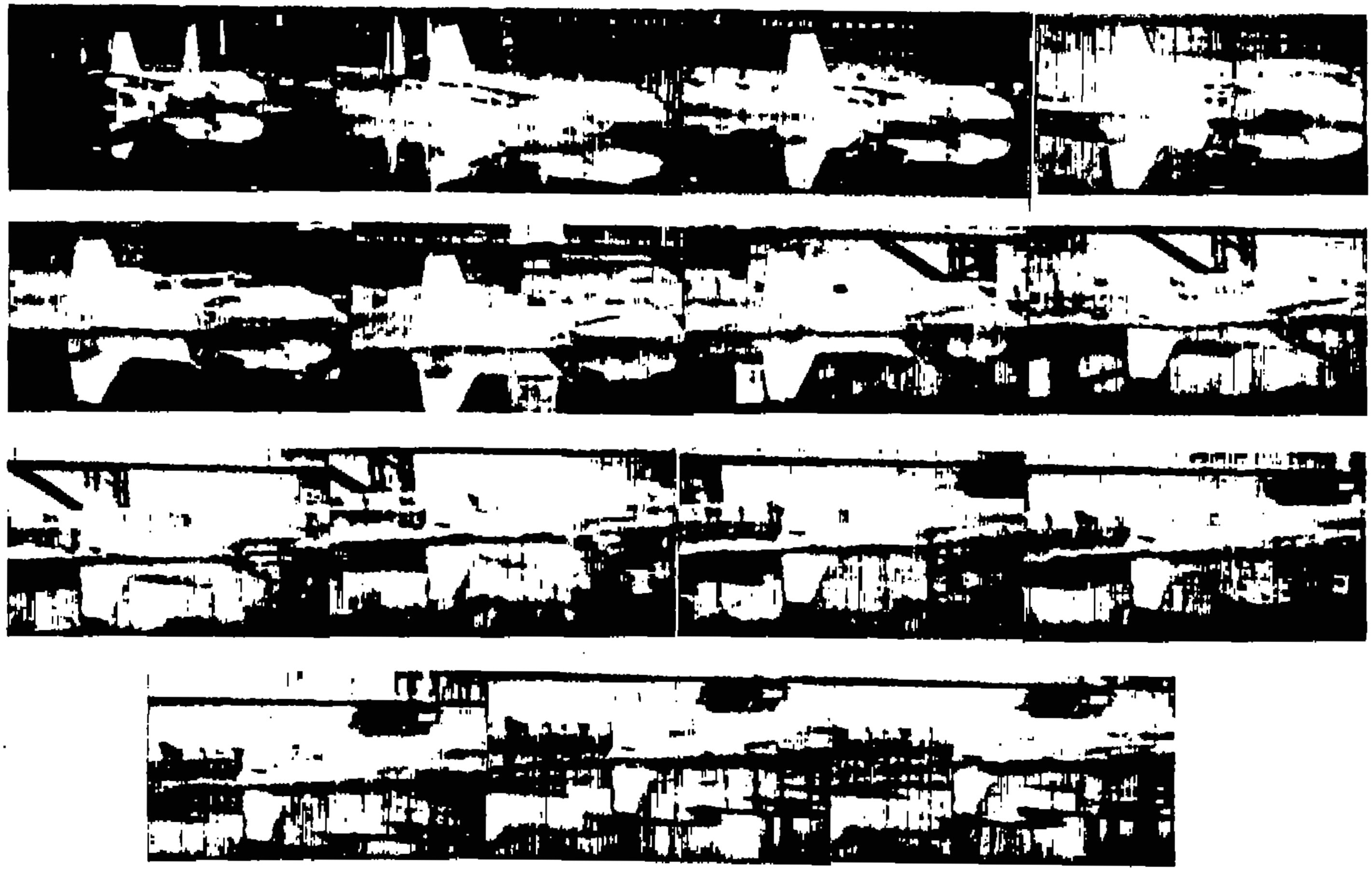

(c) Attitude 2°. Speed 89 knots.

Figure 9.- Concluded.

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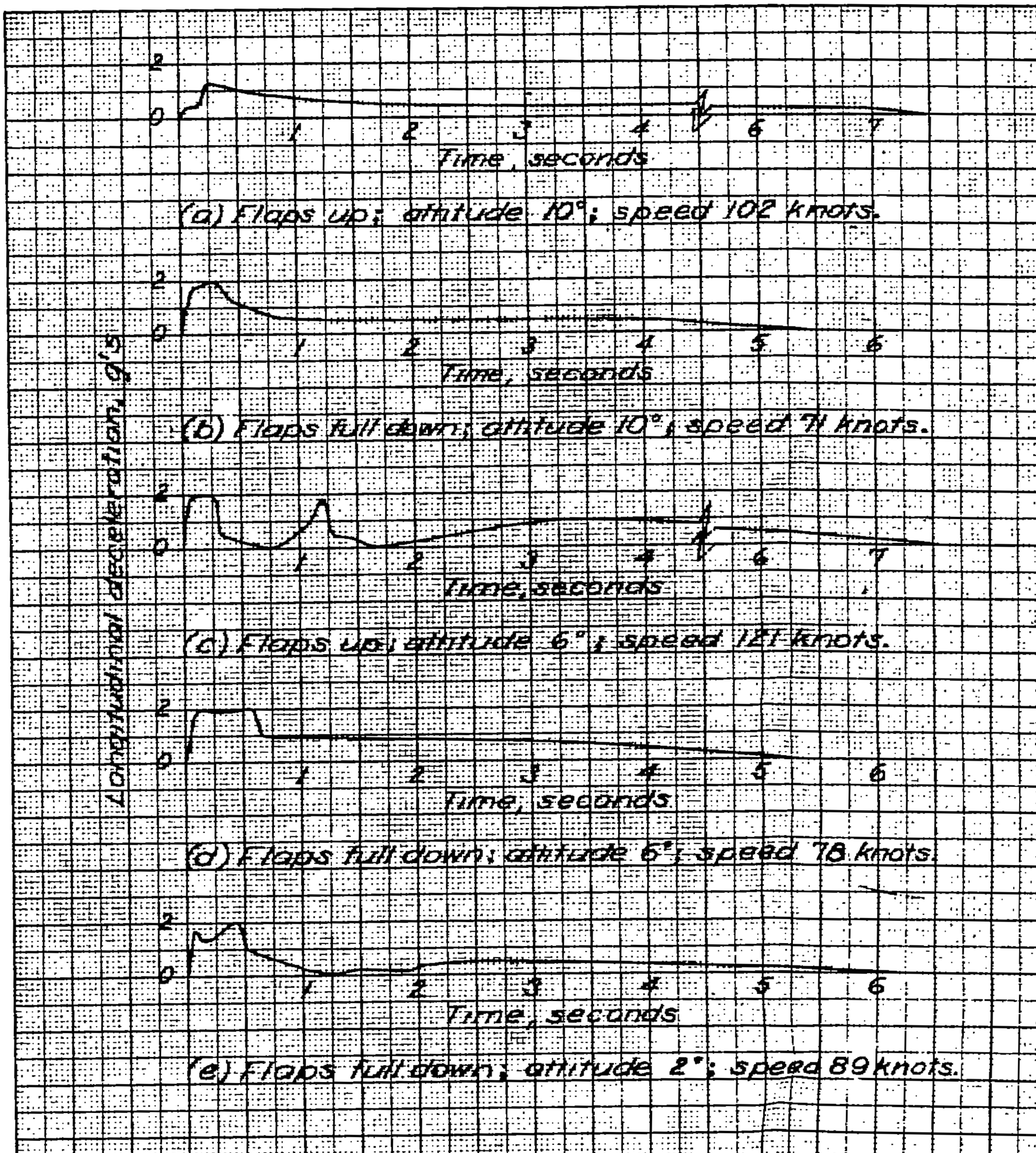
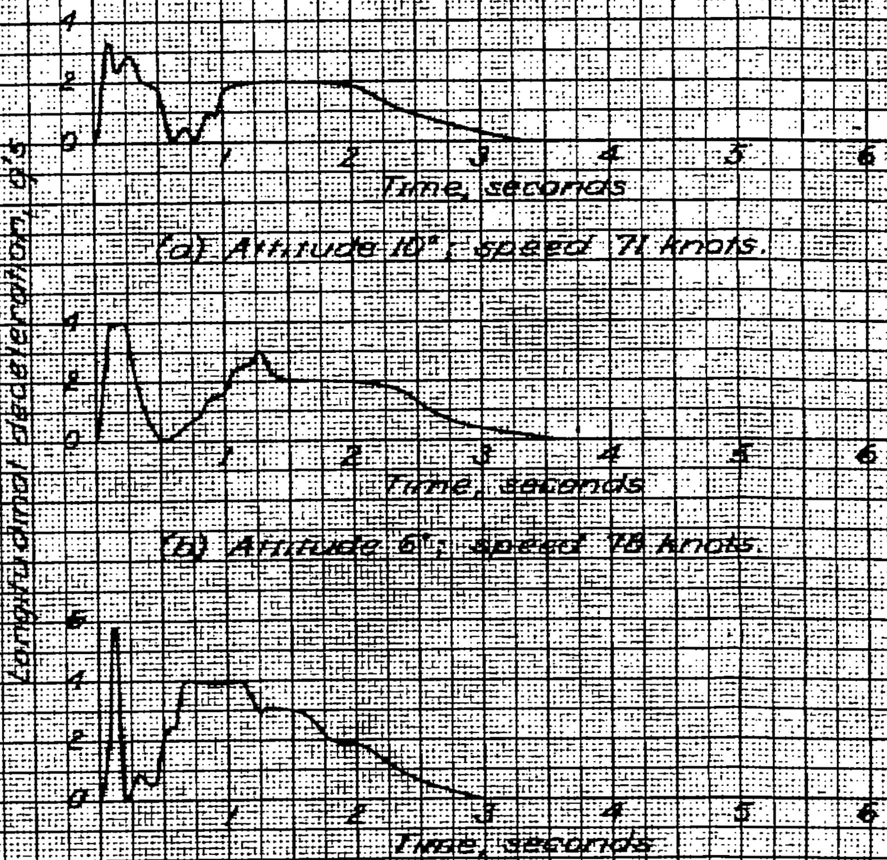


Figure 10.- Typical time-histories of longitudinal decelerations for ditching tests of the model with no damage simulated.
(All values are full scale.)



(a) Attitude 10°; speed 71 knots.

(b) Attitude 6°; speed 78 knots.

(c) Attitude 2°; speed 89 knots.

Figure 11.- Typical time-histories of longitudinal decelerations for ditching tests of the model with flaps full down and with simulated failure of the nose-wheel door, radar turret, bomb-bay doors, main-wheel doors, rear entrance door, and two sections of the fuselage aft of the bomb-bay doors.

(All values are full scale.)

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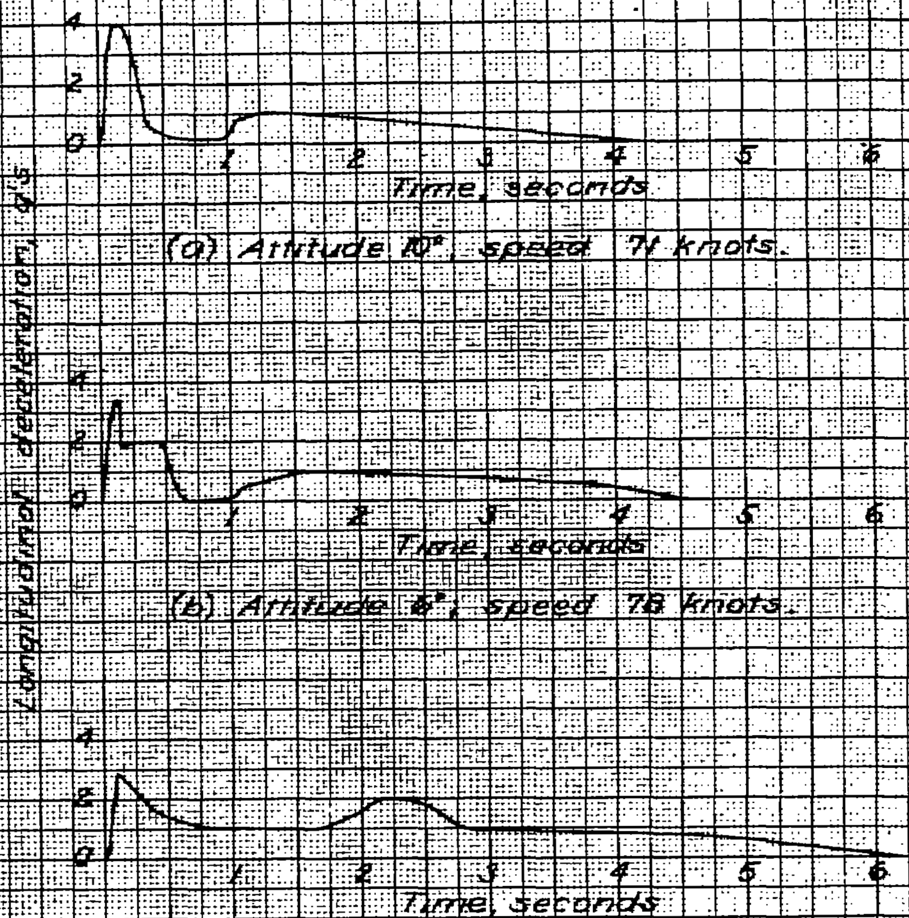

(a) Attitude 10°; speed 71 knots.

(b) Attitude 6°; speed 78 knots.

(c) Attitude 2°; speed 89 knots.

Figure 12.- Typical time-histories of longitudinal decelerations for ditching tests of the model with flaps full down and with simulated failure of the radar turret, bomb-bay doors, main-wheel doors, rear entrance door and two sections of the fuselage aft of the bomb-bay doors and with a trapezoidal hydroflap 4 feet by 2 feet by 1 foot set at 30° with the fuselage reference line at the aft part of the nose-wheel door (station 192.4). (All values are full scale.)

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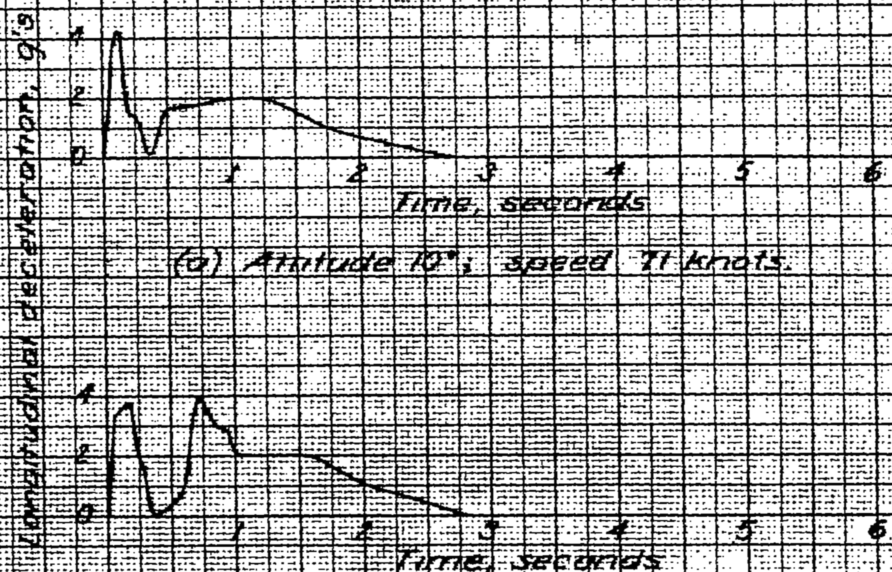

(a) Attitude 10°; speed 71 knots.

(b) Attitude 6°; speed 78 knots.

Figure 13.– Typical time-histories of longitudinal decelerations for ditching tests of the model with flaps full down and with simulated failure of the radar turret, bomb-bay doors, main-wheel doors, rear entrance door, and two sections of the fuselage aft of the bomb-bay doors and with a trapezoidal hydroflap 4 feet by 2 feet by 1 foot set at 30° with the fuselage reference line at the forward edge of the nose-wheel doors (station 114). (All values are full scale.)

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