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DITCHING TESTS WITH A $\frac{1}{12}$-SIZE MODEL OF THE ARMY B-26 AIRPLANE IN NACA TANK NO. 2 AND ON AN OUTDOOR CATAPULT

By Lloyd J. Fisher and Margaret F. Steiner

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Langley Field, Va.

WASHINGTON

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MEMORANDUM REPORT

DITCHING TESTS WITH A $\frac{1}{12}$-SIZE MODEL OF THE ARMY B-26 AIRPLANE IN NACA TANK NO. 2 AND ON AN OUTDOOR CATAPULT

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SUMMARY

In accordance with a request by the Army Air Forces, Materiel Command, tests were made at the Langley Memorial Aeronautical Laboratory, Langley Field, Va. with a $\frac{1}{12}$-size dynamic model of the Army B-26 airplane to determine its behavior when landed on water.

Landings were made in calm and rough water. Various conditions of damage, landing attitude, speed, and flap setting were simulated. Maximum longitudinal decelerations and the lengths of landing runs were recorded, and the general behavior of the model was observed. Motion pictures were taken of some of the landings in both smooth and rough water.

The conclusions based on tests of the model are

(1) The B-26 airplane should be landed in a laterally level position at as light a weight as possible with flaps down and at a slow speed in a medium-high attitude with the fuselage center line at an angle of 6° to 10° with the horizontal (not too near the stalling region).

(2) When appreciable wind exists, this airplane should be landed into the wind and across the waves in order to land at the lowest possible speed. When the wind is light and the waves are regular, landing along the swells is preferable to landing across the swells.

(3) Structural failure of parts such as the bomb-bay doors or waist-gun doors will not seriously affect the dynamic behavior of the airplane.

(4) The crew should brace themselves with the expectation of withstanding fairly high decelerations (4g to 7 g)

INTRODUCTION

Tests were made with a $\frac{1}{12}$-size dynamic model of the Army Air Forces B-26 airplane to determine its behavior when it is ditched. (The forced descent of landplanes on water is called "ditching.") These tests are part of a series of tests requested by the Army Air Forces, Material Command, on March 26, 1943. The tests were made in NACA tank no. 2 in September 1943 and on an outdoor catapult on Back River operated by personnel of the NACA impact basin in December 1943. Tests were made with the model at various conditions of speed, attitude, and flap setting; with various degrees of simulated damage; and with two gross loads. Mr. Hans Bebie, structures representative from the Glenn L. Martin Company, was present during most of the tests at the tank.

DESCRIPTION OF MODEL

The model used in the tests was dynamically similar to the full-size airplane. The test weights of the model did not vary more than $2\frac{1}{2}$ percent from the nominal values, and the moments of inertia about all three axes were approximately correct.

The model was constructed of balsa with pieces of spruce at points of concentrated stress. The fuselage was of a hollowed-out construction, but the wings and tail were built up of ribs and spars and were covered with paper. The model was equipped with movable tabs on the wings and vertical tail and with movable elevators so that it could be balanced for the various conditions tested. Metal parts used for the quadrants, hinges, and assembly fittings were made of aluminum, brass, or dural.

Photographs of the model are shown in figure 1. The hydrostatic characteristics of the model were different from those of the full-size airplane because the model was of wooden construction and would therefore float indefinitely; whereas the metal airplane might sink at once. Structural failures on the model were simulated by completely removing the parts, but corresponding failures on the airplane probably would result in denting, tearing, and dangling parts. However, the length of runs and general behavior of the model, such as diving, turning, or skipping, could reasonably be expected to be about the same as those of the full-size airplane.

I - T A N K T E S T S

METHOD OF TESTING

When the model had been statically balanced, it was attached to a launching gear on the front of the towing carriage in NACA tank no. 2. This gear is provided with an attachment that will permit freeing the model in roll, pitch, and yaw as desired. With the model supported at the center of gravity, it was towed in the air at the speeds at which it was to be ditched, and tabs were set to balance the model aerodynamically in roll and yaw. The elevator settings to balance the model in pitch for the various attitudes and conditions of structural damage used in the tests were then determined. The model, now ready for ditching, was attached to the launching gear as shown in figure 2.

The launching gear in the tank is so arranged that the model can be set up at various attitudes and heights above the water. When the model was to be ditched, the towing carriage was run at a constant speed and the model was released from the front and rear hooks simultaneously. The model glided into the water at approximately the attitude at which it was released. Each ditching occurred at about the same location in the tank.

Two observers at the ditching station determined the length of runs and noted the behavior of the model, and a photographer took motion pictures of some of the ditchings. The attitude of the model at contact with the water and its vertical speed were determined for a few representative ditchings by measurements from motion-picture photographs made with a camera that was attached to the towing carriage.

The maximum longitudinal decelerations under various conditions were measured with an NACA V-G recorder altered to fit the model. This accelerometer was located near the pilot's compartment as shown in figure 3. Some vertical decelerations were obtained by mounting the accelerometer vertically.

SCOPE OF TESTS

All the ditching tests performed in NACA tank no. 2 were made in calm water. The center of gravity of the model was located at 14.2 percent of the mean aerodynamic chord and 3.8 inches (full size) above the center line of the fuselage. The tests were made at two gross loads, 31,000 pounds and 25,000 pounds (full size), and three different landing attitudes. These attitudes (measured with respect to the fuselage center line) were -1° (three-wheel landing), 13° (three-point, tail-down landing), and 6° (an intermediate attitude). The landing speeds corresponding to these attitudes may vary considerably depending on the conditions of wind, power, and flaps. A range of landing speeds comparable with a reasonable variation in power, wind, and flap conditions was covered in the tests (80 to 140 mph, full size). At speeds comparable with power-on landings or landings into the wind, however, the lift from the aerodynamic surfaces of the model was insufficient because neither power nor wind was present. Because of the low Reynolds number of the tests, the stall angle was below that of the airplane, and at high attitudes there was consequently a further increment of lift missing in the tests. A few tests were made with slats added to the wing in order to determine the effect of increasing the lift.

Four flap conditions were used. They were up, down 30° semifixed, and down 55° fixed and semifixed. When the flaps were semifixed, they were held in place by friction clips so that they could be torn from the model by the water forces of the ditching. When the flaps were fixed, they were rigidly held in place and did not move when the model was ditched. Most of the tests were made with the flaps down 55° fixed because the tests indicated that the strength and positions of the flaps did not have much effect on the hydrodynamic behavior of the model and the airplane could be landed at slower speeds with flaps down.

Measurements of the vertical velocities of the model showed that they varied from about 3 to 7 feet per second (full size), a range that might be expected in actual landings.

Structural failures of portions of the airplane were simulated by cutting out corresponding portions on the model. In the case of the wheel doors, partial failure was simulated by indenting the surface of the model for the nose-wheel door and removing only the aft portion of the main-wheel doors.

The following conditions of simulated failure were tested: (1) no failure (see fig. 1), (2) partial failure of the wheel doors and complete failure of the waist-gun doors (see fig. 4), (3) partial failure of the wheel doors and complete failure of the waist-gun and bomb-bay doors (see fig. 5).

It is believed that the relatively weak plastic lugs holding the waist-gun doors in place will readily fail in a ditching. Because of the proximity of the supporting structure of the wheels, it appears unlikely that more than partial failure (similar to that simulated in the tests) will occur to the wheel doors. Tests have been made at the NACA structures laboratory which indicate that the bomb-bay doors will support static loads of about 1200 pounds per square foot before the deflection begins to increase rapidly with load. It seems probable that the bomb-bay doors might not fail in a relatively calm sea but could not withstand the bottom loads caused by rough water.

Tests were made to determine the effect of windmilling propellers on the ditching characteristics of the model. Tests made of other models with propellers over scale strength and under scale strength did not show any violent behaviors caused by the propellers; however, the decelerations were increased. The tests of this report were made with propellers that were not at scale strength. The propellers used were of

$\frac{1}{16}$-inch-thick aluminum. (See fig. 6.) The condition of structural failure used in these tests was that of partial failure of the wheel doors and complete failure of the waist-gun doors.

The majority of the tests in the tank were made at a gross load of 31,000 pounds (full size). In order to determine the effect of a lighter load on the ditching of the airplane, tests were made at a gross load of 25,000 pounds (full size). The landing speeds would actually be about 10 percent less for the lighter load condition at similar conditions of flaps, power, and attitude, but they were not changed because the significant speeds for the lower weight model were bracketed by the original speeds and the comparison of data was facilitated by not changing these speeds.

RESULTS

The results of the tests are given in tables I to III. Maximum and average longitudinal decelerations are given in table I for gross loads of 31,000 pounds and 25,000 pounds. Maximum vertical decelerations are given in table II. Average longitudinal decelerations obtained when the leading-edge slats were added to the wing are given in table III.

General Behavior

When ditched at a low attitude, the model usually trimmed up to a high attitude soon after it touched the water. This characteristic was most pronounced when the model was ditched without any simulated failure. The model generally made a straight run until a fairly low speed was reached and the nacelles had sunk low in the water; then it sometimes turned to the side but, because of the low speed, the turns were not considered severe. Some skipping occurred at each condition tested. Figure 7 shows typical ditching runs for the model.

Dives at high attitudes and low speeds are recorded in table I. These dives were eliminated when the stall angle of the model was increased by adding a leading-edge slat to the wing. (See table III.) The diving is not believed to be typical for this airplane because the tests with the wing lift increased by the addition of the slat more nearly simulate full-size conditions.

Effect of Flaps

The tests indicate that the setting of the flaps had a negligible effect on the hydrodynamic performance of the model. The wing was high, the area of the flaps was small, and the model was moving at low speeds when it sank deep enough for solid water to hit the flaps.

Effect of Landing Attitude and Speed

The landing attitude had little effect on the maximum decelerations except for the tests with simulated damage to the wheel doors, waist-gun doors, and bomb-bay doors. For these tests the maximum decelerations increased as the attitude increased. The model skipped at most conditions tested, but the skipping was somewhat more violent during low-attitude, high-speed landings.

Tests with Undamaged Model

The average decelerations for the ditching of the undamaged model, as indicated by the lengths of landing runs, tended to increase with increasing speed but generally were less than $1\frac{1}{2}g$. The maximum longitudinal decelerations were highest (about $2\frac{1}{2}g$) at the lower landing attitude. (See tables I and III.) When ditched at a low attitude, the model usually trimmed up to a higher attitude soon after it touched the water. Apparently a suction near the tail caused the model to trim up to a higher attitude. The magnitude of this suction is not known, but it is possible that it might be large enough to tear off the skin of the fuselage. The effect of a failure of this type was not investigated in the tests.

Tests with Simulated Damage

Wheel doors and waist-gun doors.- When ditched with simulated partial failure of the wheel doors and complete failure of the waist-gun doors, the model skipped, leaving the water one or more times during the first part of the landing runs. The tendency for the model to trim up in low-attitude landings was reduced when damage was simulated. This difference apparently was caused by the ventilation obtained when the holes representing the waist-gun openings were cut; these holes tended to relieve the suction that appeared to be created on the undamaged model near the tail. The maximum decelerations were about $\frac{1}{2}$g greater for the damaged model than for the undamaged model and the decelerations increased with increasing speed. Because of the skipping, the lengths of runs were slightly longer than those for the undamaged model. (See tables I and III.)

Bomb-bay doors, wheel doors, and waist-gun doors.- The results of ditching the model with bomb-bay doors out, waist-gun doors out, and with partial damage to the wheel doors are shown in tables I and III. There was little tendency for the model to trim up when landed at this damaged condition. The maximum deceleration recorded was 6g at the 13° attitude. The maximum deceleration recorded at the -1° attitude was 3g. (See table I.) There was not much difference in decelerations at the low-attitude landings between this condition and the other conditions tested. The corresponding lengths of landing runs were usually somewhat shorter than the lengths obtained in the other conditions, except that the runs at a full-size speed of 140 miles per hour and the low landing attitude were unusually long (13 and 18 lengths). The diving at the 13° attitude that is recorded in table I was eliminated when the wing lift was increased by adding a leading-edge slat to the wing. (See table III.) When the model dived, the fuselage was at an angle of about 25° with the surface of the water and the nose and wing were submerged.

Tests with Propellers

When the model was ditched with wind-milling propellers and with damage to the wheel doors and the waist-gun doors simulated, the maximum decelerations were generally greater by $\frac{1}{2}$g to 1g than for the same condition without propellers. The lengths of the landing runs with propellers were about one length less than those of the model with similar failures and no propellers. (See table I.) In the course of the ditchings, the propellers were bent back around the nacelles. The propellers used in the tests were not scale strength, however.

Vertical Decelerations

The results of measuring maximum vertical deceleration at the condition of simulated failures of the wheel doors and waist-gun doors are given in table II. The greatest vertical deceleration measured was 3g and there was no consistent variation with either speed or attitude.

Effect of Weight

The results of tests made at a load corresponding to 25,000 pounds (full size) with the waist-gun doors removed and partial damage of the wheel doors simulated are given in table I. The maximum decelerations were smaller and the lengths of landing runs were greater at the high-attitude landings when the gross load was reduced. At low-attitude landings, there was little difference in results between the two gross loads tested.

II - OUTDOOR CATAPULT TESTS

APPARATUS

Catapult

The catapulting apparatus is shown in figure 8. The carriage is attached to a rubber shock cord which furnished the power, the cord being stretched as the carriage is brought to starting position by an electrically operated winch. It is released by pulling a trigger and is stopped by a shock cord that serves as an arresting gear.

Instruments

Accelerometer.- For some of the landings a time-history accelerometer was mounted in the model just forward of the center of gravity in the pilot's compartment in such a manner as to record longitudinal decelerations. This was an undamped instrument with a natural frequency of 100 cycles per second. Decelerations were recorded on super-X film wrapped around a spring-driven drum that started revolving the instant the model was released from the carriage and made a single revolution in 3 seconds.

Wind- and seaway-measuring devices.- A vane-type anemometer was used to measure wind velocity, and a wind vane was mounted over a protractor arrangement in order that the direction of the wind relative to the path of the model might easily be noted. The wave height was determined by observing the vertical displacement of the water from crest to trough on a stationary graduated pole.

Chronoscope.- A Remington Arms Chronoscope (type G-A-2) was used to measure the average of the catapulting speed over a fixed distance. Two contacts, which were placed on the catapult frame, were broken at the end of the catapult run by a knife edge mounted on the carriage. The time elapsing between the breaking of these contacts was indicated on the galvanometer dial. The velocity was readily determined by use of this value.

METHOD OF TESTING

Before the tests were begun, the initial carriage position was determined by means of a previous calibration of the shock cord, the trigger was clamped into position and engaged with the carriage, and a safety block was placed over the trigger arm to avoid any chance of premature release. The chronoscope circuits were tested and the two contacts on the track were wired and made ready for measuring the speed at the end of the catapulting stroke.

Wind readings were taken and the direction relative to the track was noted. In order to obtain the proper airspeed required for the model, any components of wind along the catapult had to be taken into account. Any existing head component of wind was subtracted from the desired airspeed, and the model was catapulted at a reduced ground speed. When a tail component of wind existed, the model was catapulted at correspondingly increased ground speeds to give the required airspeed.

A few trial runs were made to determine the correct tail settings to keep the model in trim along its glide path at various speeds and attitudes. The control surfaces of the model were then set in the position required and the model was placed upon the carriage for the test. A 16-millimeter camera located on a platform some 60 feet from the track took a profile pictorial history of the catapulting and the landings during the tests. After each test the model was retrieved in a boat and was drained and dried. This general procedure was followed throughout the tests.

SCOPE OF TESTS

Test Conditions

The model was ballasted to represent two weight conditions. The first, 35,000 pounds, was a heavy-weight condition that might occur if the airplane were forced to ditch shortly after take-off and before any load could be jettisoned; and the second, 25,000 pounds, was a light-weight condition that represented the airplane with half-fuel and no bomb load. The center-of-gravity position was at 16.9 percent of the mean aerodynamic chord in these tests. The flaps were in the full-down position. The speeds, which in most cases represented flaps-down power-off landings, are tabulated for the two weights in table IV.

The catapult was fixed in a level position and was not adjustable in either height or direction; therefore, the waves were not usually exactly parallel or perpendicular to the path of the model. The location of the catapult in the lee of several large buildings caused the wind to be variable both in strength and direction. When this condition prevailed, ditching was extremely difficult because of the resulting erratic action of the model.

The structural parts of the model that were believed likely to fail in full-scale ditchings were altered in most of the landings. These alterations simulated partial failure of wheel doors and complete failure of waist-gun and bomb-bay doors.

Variables

In the test program the main factors that varied from test to test were forward velocity (airspeed), vertical velocity, attitude of fuselage reference line, and model weight. The forward velocity and attitude were predetermined from performance data supplied by the Army. The weight was set and remained fixed for any one condition, except for that due to the accumulation of water which did not at any time exceed 2 percent of the total model weight.

When the model was in perfect trim and the airspeeds were correct, the glide paths varied little from flight to flight for any one condition regardless of the distance of the model from the water when released. In some of the flights in which the model was released at an appreciable distance off the water, the forward speed had decreased enough to allow a steeper glide path. When the speed was less than the correct value, it was accompanied by a lift smaller than the weight of the airplane, and the nose usually dropped before contact. These landings were not considered to be of much practical value as they were believed to be out of the possible flight range.

DISCUSSION OF RESULTS

Condition of Seaway

A normally loaded airplane shows no marked directional instability or adverse behavior whether landed across the waves or along the waves. The overloaded airplane lands in a reasonably satisfactory manner along the waves across the wind; however, if the overloaded airplane is landed across the waves into the wind, it has a tendency to dive through the wave or to be thrown off the water into attitudes that result in nose-down or wing-low second contacts.

When a stiff wind exists, there are usually white caps and breaking waves. Since a reduction in water speed, and therefore a decrease in bottom loads, occurs when the airplane is landed into the wind, the best ditching practice for the normally loaded airplane appears to be to land into an appreciable wind regardless of wave direction. When there is little or no wind and the waves are regular, or even when the seaway is confused, it appears that the best procedure is to land along the waves or along the smoothest water available.

Effect of Attitude and Speed

It is well recognized that bottom loading increases with the vertical velocity and with the trim angle. In the low-attitude high-speed landings there was a tendency to porpoise; whereas in high-attitude low-speed landings there was more tendency to dive. At intermediate speeds and attitudes, the landings seemed to be free of both these tendencies. At all attitudes and speeds the model turned violently when it landed with one wing low. Since an extremely high-attitude landing might easily pass beyond the stall, it seems advisable to compromise and land at a moderately high attitude and at a correspondingly moderate speed.

Effect of Weight

The heavy-weight condition with the correspondingly increased speed appeared to increase the porpoising tendencies in the low-attitude landings. The heavier airplane was also observed to sustain greater longitudinal deceleration and to throw greater spray. It was concluded from these observations that the heavier airplane had immersed to a somewhat greater depth. These test results indicate that, from the standpoint of performance, the airplane should be made as light as possible before ditching. From the standpoint of loads, also, the airplane should be made as light as possible since the water loads will be less with the lower speeds.

General Observations

The following comments may be made with regard to the full-scale ditching of the B-26 airplane as interpreted from action of the model in open seaway:

If a cross-wind landing is made, the airplane should be flown along the wave until contact is made. It should be recognized, however, that the chances of dropping a wing and causing violent turns would be great in high cross winds. If no appreciable wind exists, a good landing along the wave could probably be made with resulting good performance.

In model landings along the waves, occasionally the airplane nosed into a cross wave. Since the speed was higher than it would have been if the airplane had been landing into the wind, the performance was worse than in any landing into the wind and across the waves. Also, the wave crests were not always straight lines and, whereas the airplane was flying along the crest just before contact, it entered part of the same wave crest that had curved over into the path of the model. These irregular crests were usually choppy and breaking. When the airplane is landing into the wind, therefore, the danger of simultaneously subjecting the whole of the fuselage bottom to a wave is reduced, and any highly concentrated loads will probably cause local failures only.

Since the B-26 fuselage has a fairly narrow stern, it runs well in rough water and is not likely to be thrown off the water in a tail-down landing. A suction is apparently created which pulls the tail down and aids in keeping the nose clear until appreciable forward motion has ceased.

CONCLUSIONS

The following conclusions are based on tank and catapult tests of a model in both calm and rough water:

1. The safest ditchings of the B-26 airplane can be made at a medium-high attitude with the fuselage center line at an angle of 6° to 10° with the horizontal (not too near the stalling region). The flaps should be down and the airplane should be landed at the lowest speed possible.

2. When appreciable wind exists, this airplane should be landed into the wind and across the waves in order to land at the lowest possible speed. When the wind is light and the waves are regular, landing along the swells is preferable to landing across the swells.

3. Calm-water tests indicate that the flaps will have no effect on the dynamic behavior of the airplane.

4. Structural failure of parts, such as the bomb-bay doors or waist-gun doors, will not seriously affect the dynamic behavior of the airplane.

5. The airplane should be ditched at the lightest weight condition possible.

6. The airplane should be landed in a laterally level position because it will turn violently if a wing dips into the water.

7. Because of the danger of partly entering a wave, even when landing parallel to the crests, the crew should brace themselves with the expectation of withstanding fairly high decelerations (4g to 7g).

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., August 15, 1944

TABLE I.- MAXIMUM AND AVERAGE LONGITUDINAL DECELERATIONS AND LENGTH OF RUNS ON DITCHING TESTS OF A 1/12-SIZE MODEL OF THE ARMY B-26 AIRPLANE

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[Decelerations are given in multiples of the acceleration of gravity. Length of runs are given in multiples of the length of the airplane.]

Attitude of fuselage center line				13° Tail-down landing											
Speed (full-size), mph				80				100				120			
See note				Max.	Av.	Run	Rmk.	Max.	Av.	Run	Rmk.	Max.	Av.	Run	Rmk.
Model without openings and with no structural failure simulated	Flaps up	No propellers	31,000 pounds (full-size) gross load		1.2	3			1.4 1.1	4 5			1.5	5	
Model without openings and with no structural failure simulated	Flaps down 55° semifixed	No propellers	31,000 pounds (full-size) gross load		1.2 .8	3 4			1.1 1.9 1.1	5 3 5			1.5 1.3	5 6	t
Model without openings and with no structural failure simulated	Flaps down 30° semifixed	No propellers	31,000 pounds (full-size) gross load		1.2	3	t		1.4 1.4 1.4	4 4 4			1.3 1.5	6 5	
Model without openings and with no structural failure simulated	Flaps down 55° fixed	No propellers	31,000 pounds (full-size) gross load	1.7 1.5 1.3	0.8 1.2 .8 .8	4 3 4 4		1.2 1.7 1.4	1.4 1.4 1.1 1.1 1.1	4 4 5 5 5		1.6 3.5 1.5	1.5 1.1 1.3 1.1	5 7 6 7	
Waist-gun doors removed and partial failure of wheel doors simulated	Flaps down 55° fixed	No propellers	31,000 pounds (full-size) gross load	1.4 1.5	1.8 1.2 .8 1.2	2 3 4 3		2.0	1.1 1.1 1.1	5 5 5		3.0 3.0	1.3 1.3 1.1 1.1	6 6 7 7	s s s s
Waist-gun doors removed and partial failure of wheel doors simulated	Flaps down 55° fixed	Windmilling propellers	31,000 pounds (full-size) gross load	2.0	1.2	3		2.0	1.4	4		1.6	1.3	6	
Waist-gun doors removed and partial failure of wheel doors simulated	Flaps down 55° fixed	No propellers	25,000 lb (full-size) gross load	1.6	0.8	4		1.0 1.1	0.9 .9	6 6		0.9 3.0	1.0 1.1	8 7	
Bomb-bay doors and waist-gun doors removed, and partial failure of wheel doors simulated	Flaps down 55° fixed	No propellers	31,000 lb (full-size) gross load	4.4 4.5 4.0			d d d	5.9 4.1 6.0			d d d	5.0 5.7 6.0 6.0 6.2	1.3 1.9 1.5	6 4 5	s st t s

Attitude of fuselage center line				6°												−1° 3-wheel landing			
Speed (full-size), mph				100				120				140				140			
See note				Max.	Av.	Run	Rmk.	Max.	Av.	Run	Rmk.	Max.	Av.	Run	Rmk.	Max.	Av.	Run	Rmk.
Model without openings and with no structural failure simulated	Flaps up	No propellers	31,000 pounds (full-size) gross load		0.9	6			1.3	6							1.5	7	
Model without openings and with no structural failure simulated	Flaps down 55° semifixed	No propellers	31,000 pounds (full-size) gross load														1.5	7	
Model without openings and with no structural failure simulated	Flaps down 30° semifixed	No propellers	31,000 pounds (full-size) gross load		0.9 1.1	6 5			1.5 1.3	5 6	s s		1.5	7					
Model without openings and with no structural failure simulated	Flaps down 55° fixed	No propellers	31,000 pounds (full-size) gross load						1.3 1.5 1.1 1.3	6 5 7 6	s s s s					1.7 2.3 2.7			
Waist-gun doors removed and partial failure of wheel doors simulated	Flaps down 55° fixed	No propellers	31,000 pounds (full-size) gross load	1.8	1.1 1.1	5 5	s	3.8 2.0	1.3 1.5 1.0	6 5 8	s s s	1.8 2.3	1.3 1.5	8 7	s s s	2.5 3.0	1.3 1.5 1.3	8 7 8	st s
Waist-gun doors removed and partial failure of wheel doors simulated	Flaps down 55° fixed	Windmilling propellers	31,000 pounds (full-size) gross load													4.0	1.5	7	
Waist-gun doors removed and partial failure of wheel doors simulated	Flaps down 55° fixed	No propellers	25,000 lb (full-size) gross load	2.5 2.5	1.1 1.1	5 5		3.2 3.0	1.3 1.5 1.1 1.0	6 5 7 8	s s s s					3.0	1.5	7	
Bomb-bay doors and waist-gun doors removed, and partial failure of wheel doors simulated	Flaps down 55° fixed	No propellers	31,000 lb (full-size) gross load	3.5 3.8 4.0	1.4 2.8 1.9	4 2 3		4.2 4.1	1.5 1.5 1.3 1.1	5 5 6 7	s s s s	4.2 4.0	2.2 2.2	5 5		2.4 3.0	0.6 .8	18 13	s s

Note:

Max. - Maximum deceleration
Av. - Average deceleration
Run - Length of run
Rmk. - Remark: d - dived, s - skipped or porpoised, t - turned

TABLE II - MAXIMUM VERTICAL DECELERATIONS ON DITCHING TESTS OF A 1/12-SIZE MODEL OF THE ARMY B-26 AIRPLANE

Gross weight (full-size), 31,000 lb; flaps down 55° fixed; no propeller; waist gun doors removed and partial damage of wheel doors simulated. Decelerations are given in multiples of the acceleration of gravity.

Attitude of fuselage center line	13° Tail-down landing		6°	
Speed (full-size), mph	100	120	100	120
Maximum vertical deceleration	2.0 1.7	1.9 2.5	2.0 2.4	2.5 3.0

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TABLE III - AVERAGE LONGITUDINAL DECELERATIONS AND LENGTH OF RUNS ON DITCHING TESTS OF A 1/12-SIZE MODEL OF THE ARMY B-26 AIRPLANE

Gross weight (full-size), 31,000 lb; flaps down 55° fixed; additional lift provided by attaching leading-edge slat to regular wing. Decelerations are given in multiples of the acceleration of gravity; length of runs are given in multiples of the length of the airplane.

Attitude of fuselage center line	13° Tail-down landing						6°		
Speed (full-size), mph	80			100			120		
See note	Av.	Run	Rmk.	Av.	Run	Rmk.	Av.	Run	Rmk.
Model without openings and with no structural failure simulated							1.1 1.1 1.0	7 7 8	st st st
Waist gun doors removed and partial failure of wheel doors simulated							0.9 .8 .9	9 10 9	st s s
Bomb-bay doors and waist gun doors removed and partial failure of wheel doors simulated	1.8	2		1.4 1.4	4 4		1.5 1.5	5 5	s s

<u>Note</u>:

Av. - Average deceleration
Run - Length of run
Rmk.- Remark: s - skipped or porpoised, t - turned

TABLE IV

FLIGHT AIR SPEEDS USED AT OUTDOOR CATAPULT

Flaps down, power off.

Weight, (lb)	Attitude, fus. ref. line, (deg)	Airspeed, (mph)
35,000	13	118
26,200	12	105
26,200	8	110
35,000	6	140
26,200	4	130

Note: These speeds were determined from performance data obtained from Glenn L. Martin Company.

TABLE V - DITCHING PERFORMANCE OF THE ARMY B-26 AIRPLANE

All values are full-scale.

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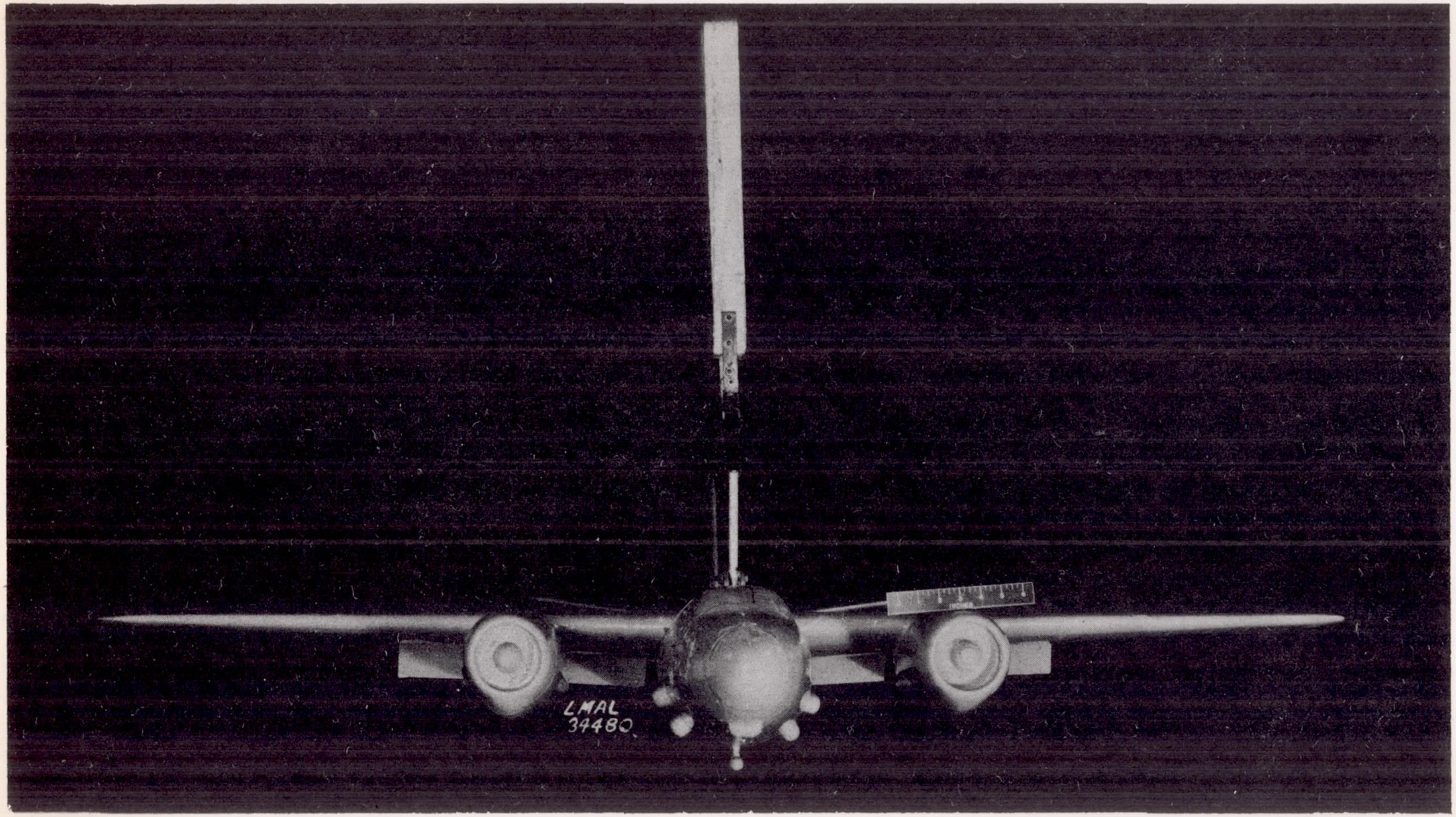
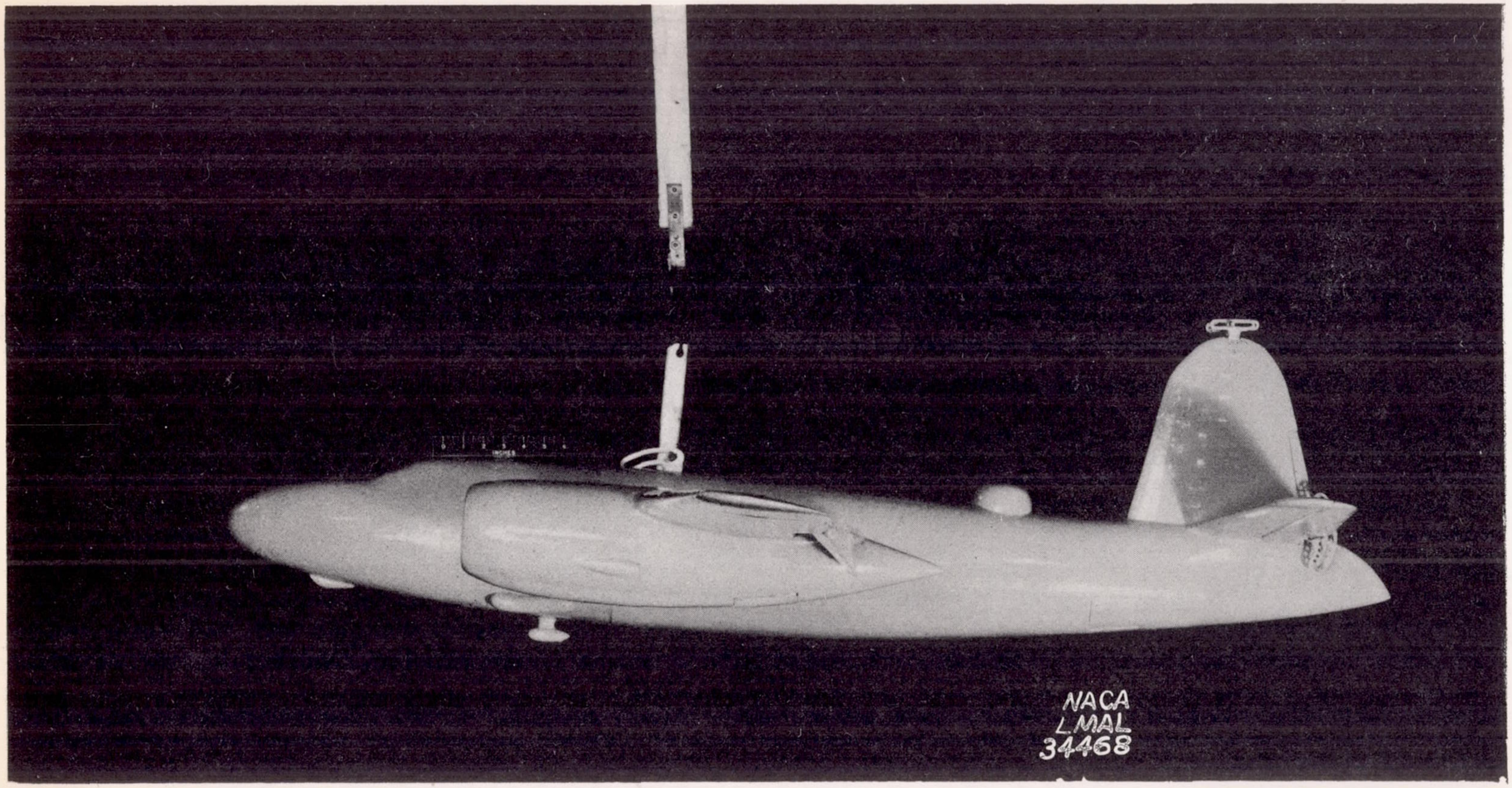
Water Condition	Attitude, fus. ref. line	Weight, (lb)	Range tested of wave heights, (in.)	Range tested of wind velocity, (mph)	Range max. recorded long. decel.	Performance
	Tail down, 12°	26,200	0	0	4.3 - 5.7g	Nacelles dug in, then pitched up and down in water.
Smooth	8°	26,200	0	0	3.7 - 3.9g	Pitched up and down during first impact.
	6°	35,000	0	0-7		
	Medium low, 4°	26,200	0	0-7	4.6 - 4.7g	Skipped or porpoised.
	Tail down, 12°	26,200	48	40	4.4 - 6.4g	Nacelles dug in, approached a shallow dive.
Parallel waves.	8°	26,200	48	35	4g	Pitched up and down slightly during run.
	6°	35,000	27-72	20-50		
	Tail down, 12°	26,200	36	12-5	4.4 - 7g	Nacelles dug in, approached a shallow dive.
Perpendicular to waves.	8°	26,200	24-36	15	3.1 - 5.4g	Tended to porpoise.
	6°	35,000	24-36	20-30		
	Medium low, 4°	26,200	36-48	25	4.0 - 7.2g	Porpoising intensified.



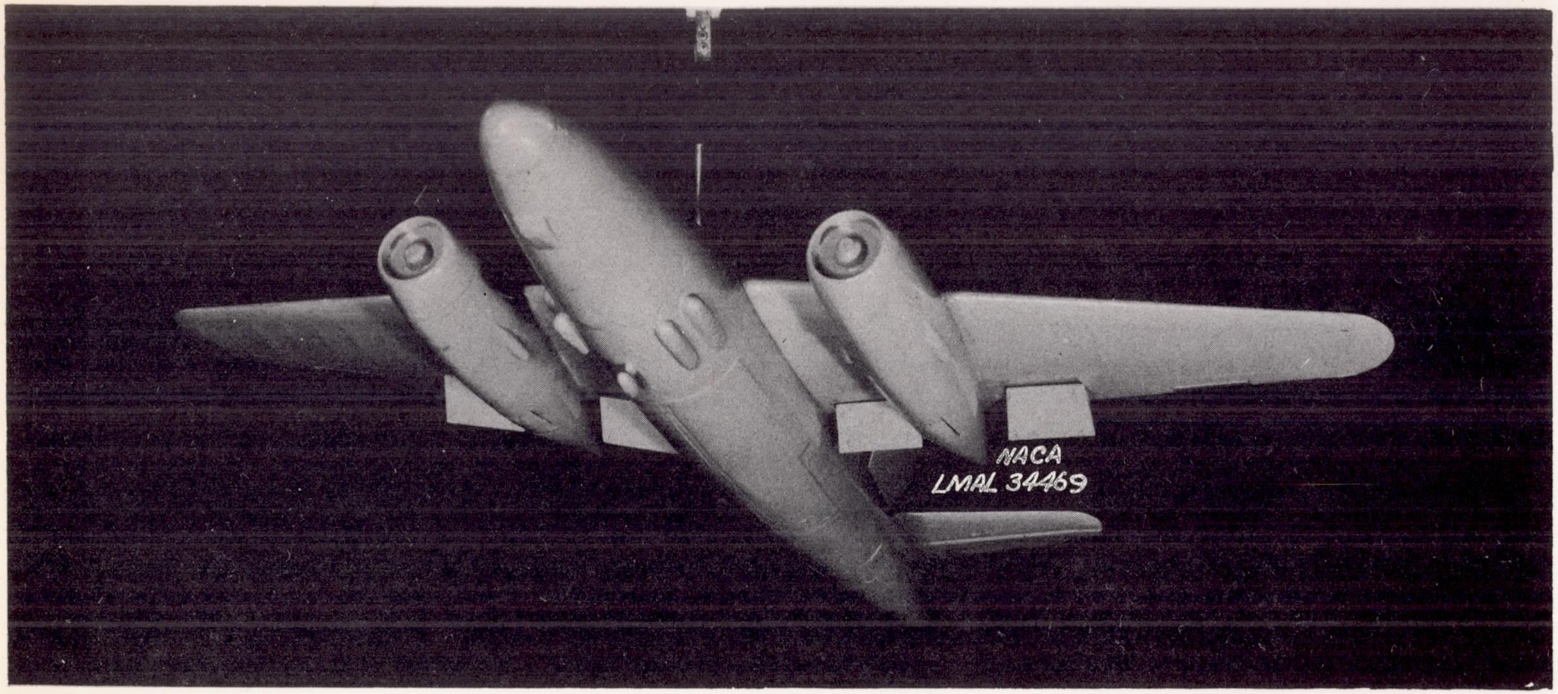
(a) Front view.

Figure 1.- Photograph of a $\frac{1}{12}$-size model of an Army B-26 airplane.



(b) Side view.

Figure 1.- Continued.



(c) Front three-quarter bottom view.

Figure 1.- Concluded.

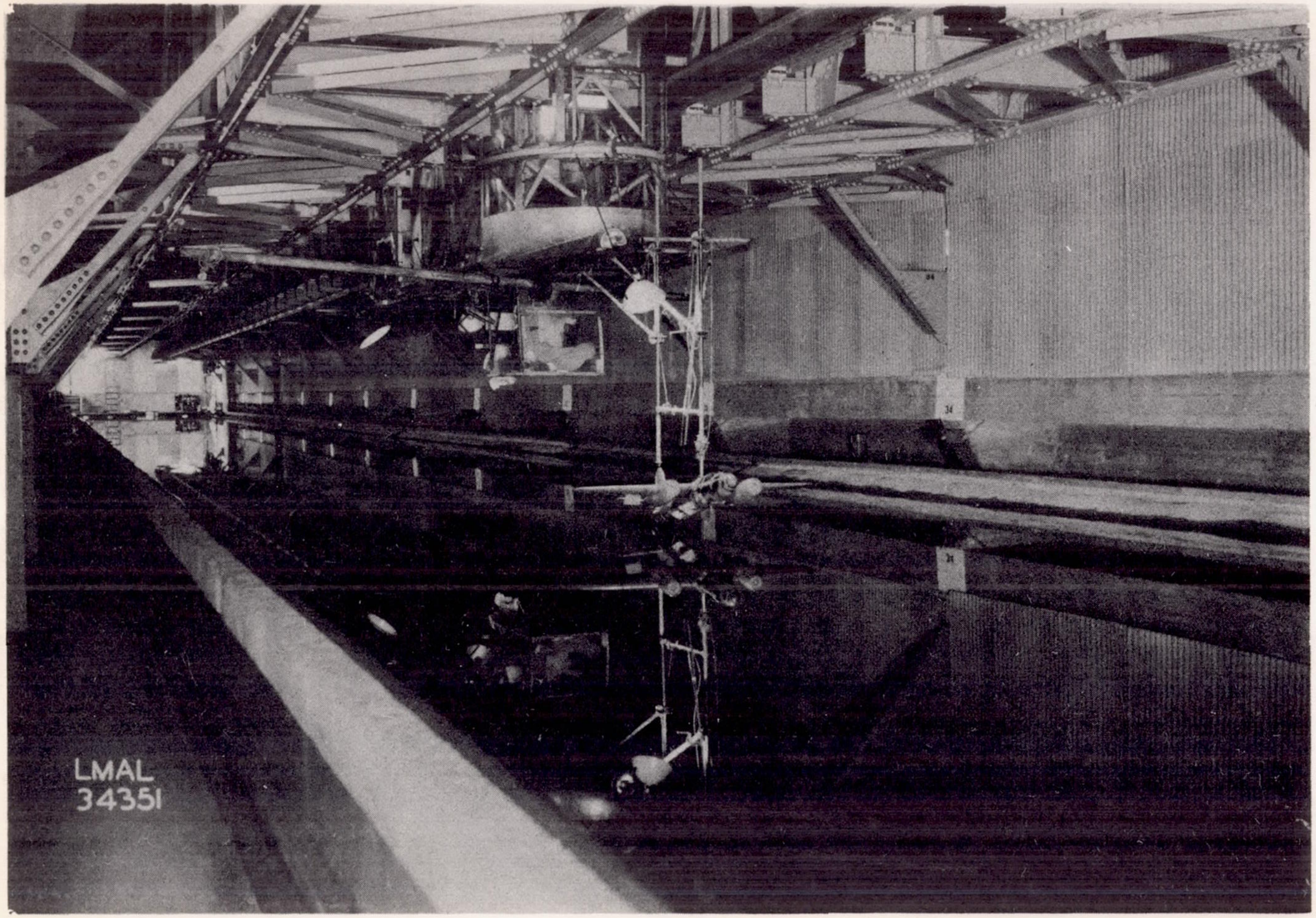


Figure 2.- Photograph of a $\frac{1}{12}$-size model of an Army B-26 airplane attached to the launching gear at the front of the towing carriage.

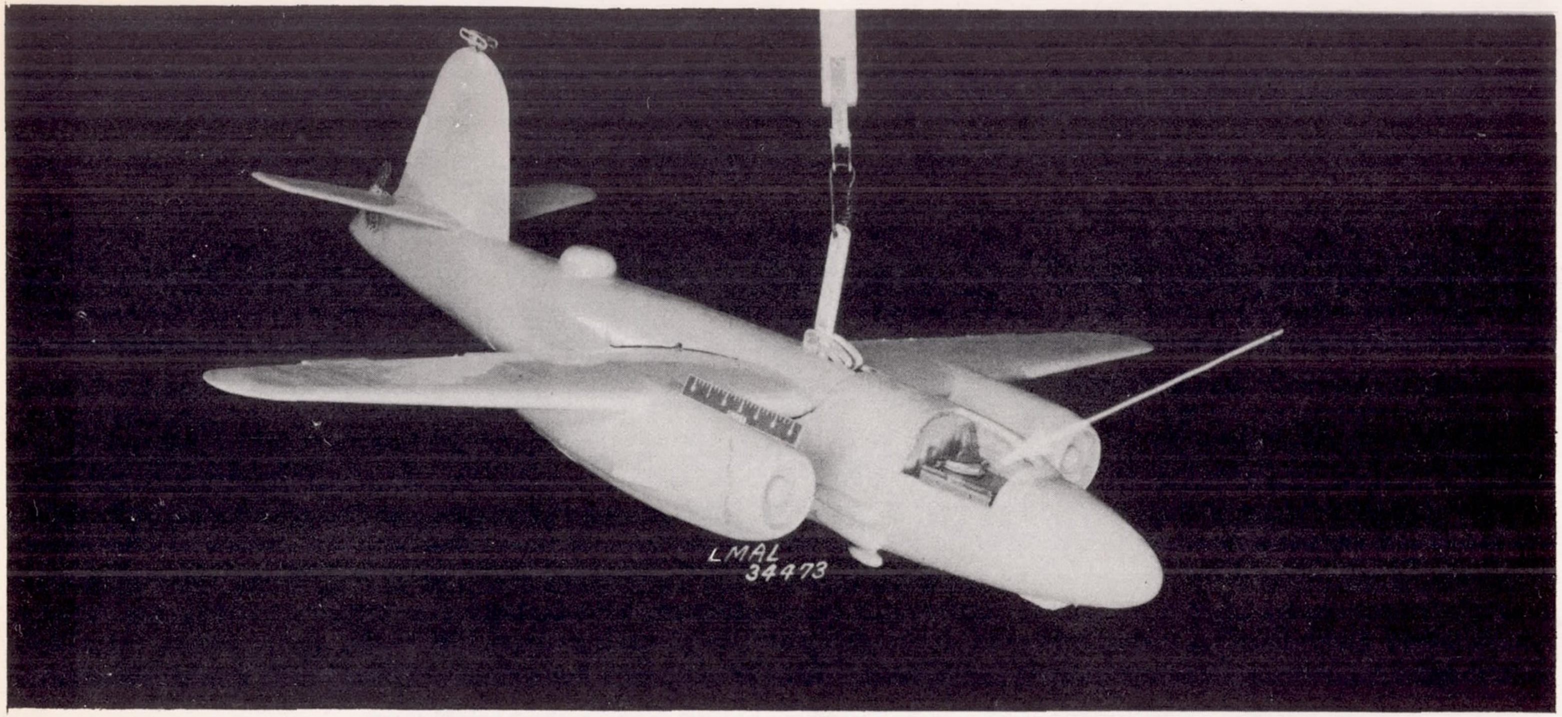


Figure 3.- Photograph of a $\frac{1}{12}$-size model of an Army B-26 airplane showing the location of the accelerometer.

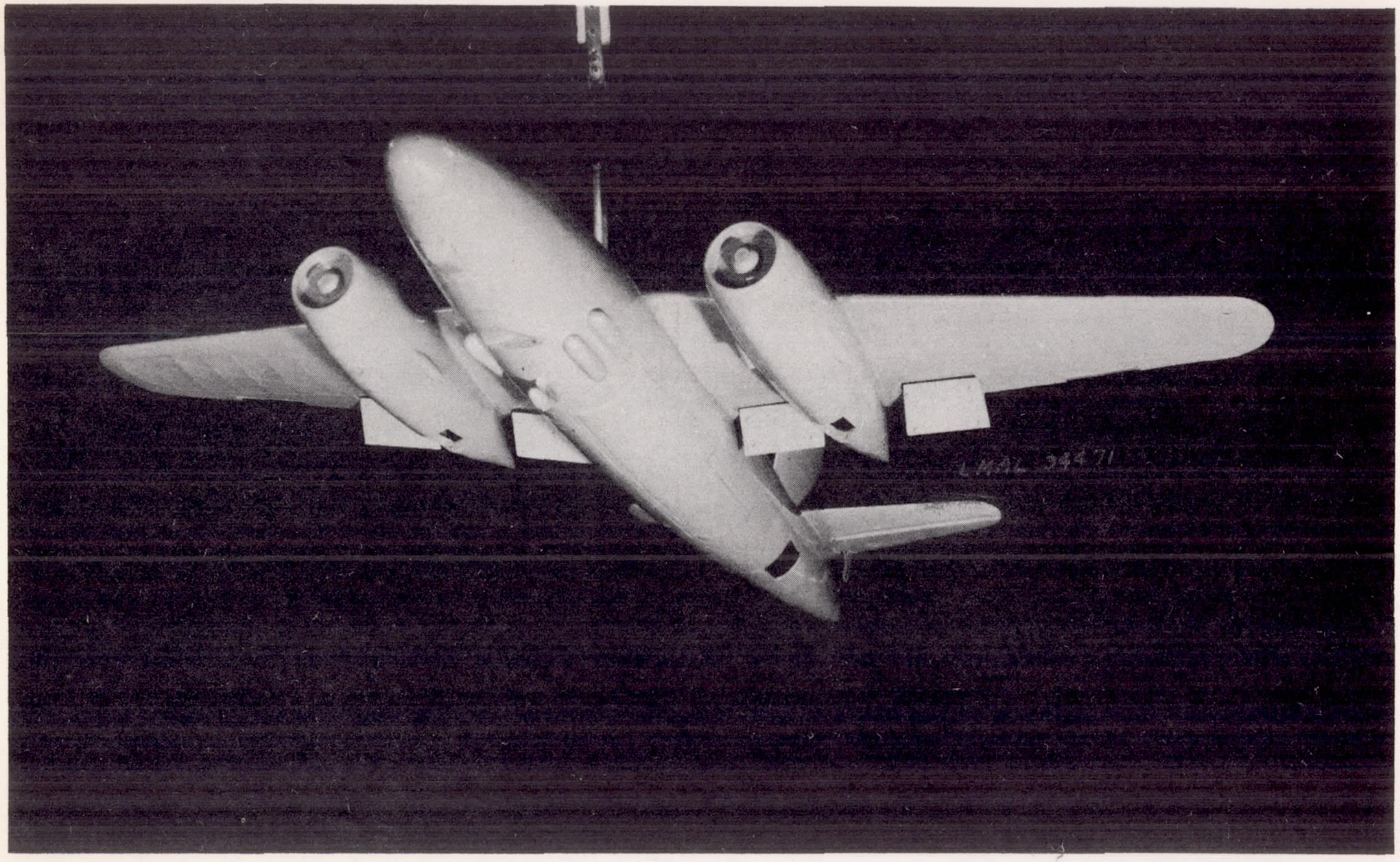


Figure 4.- Photograph of a $\frac{1}{12}$-size model of an Army B-26 airplane with waist gun doors removed and partial failure of wheel doors simulated.

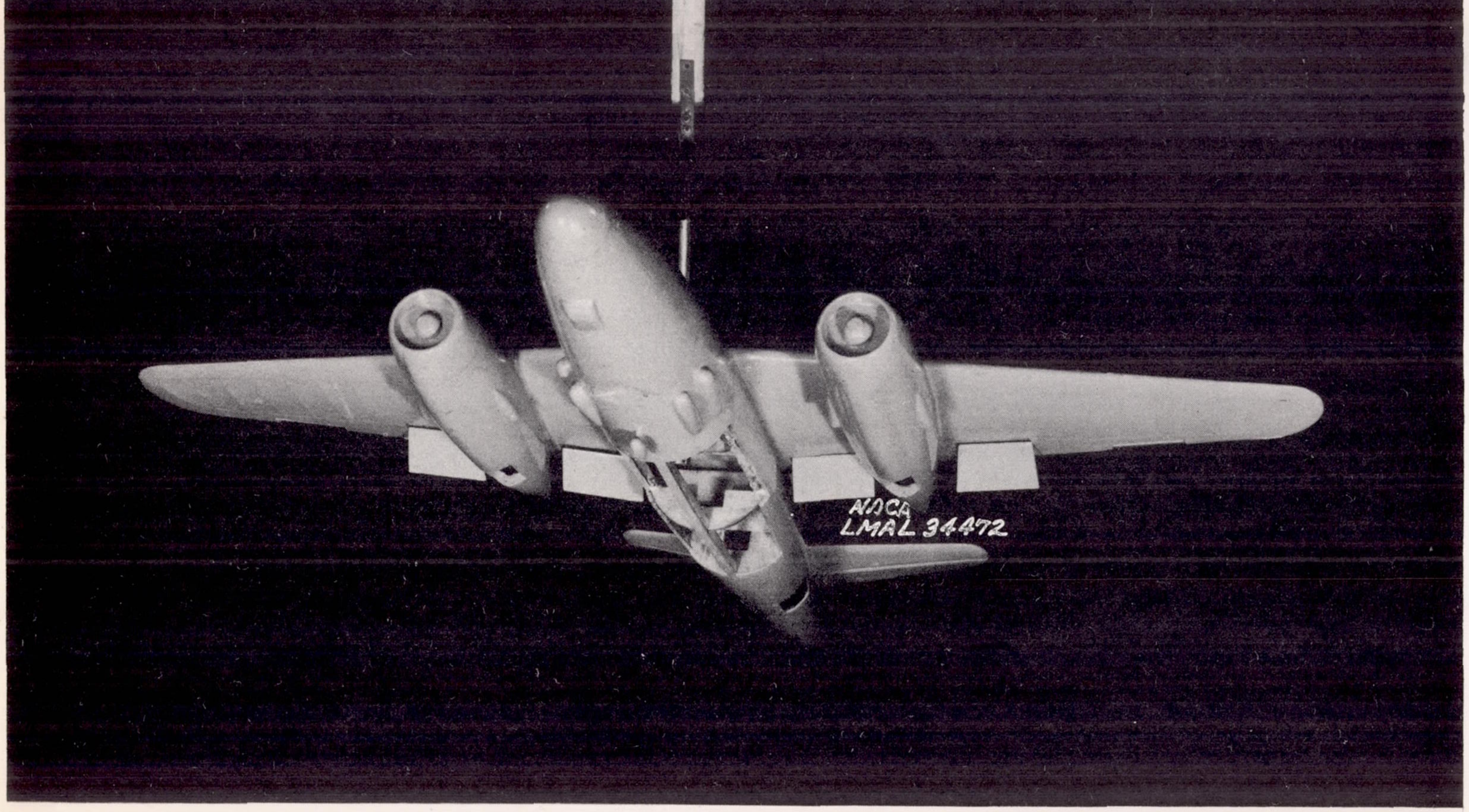


Figure 5.- Photograph of a $\frac{1}{12}$-size model of an Army B-26 airplane with waist gun doors and bomb-bay doors removed and partial failure of wheel doors simulated.

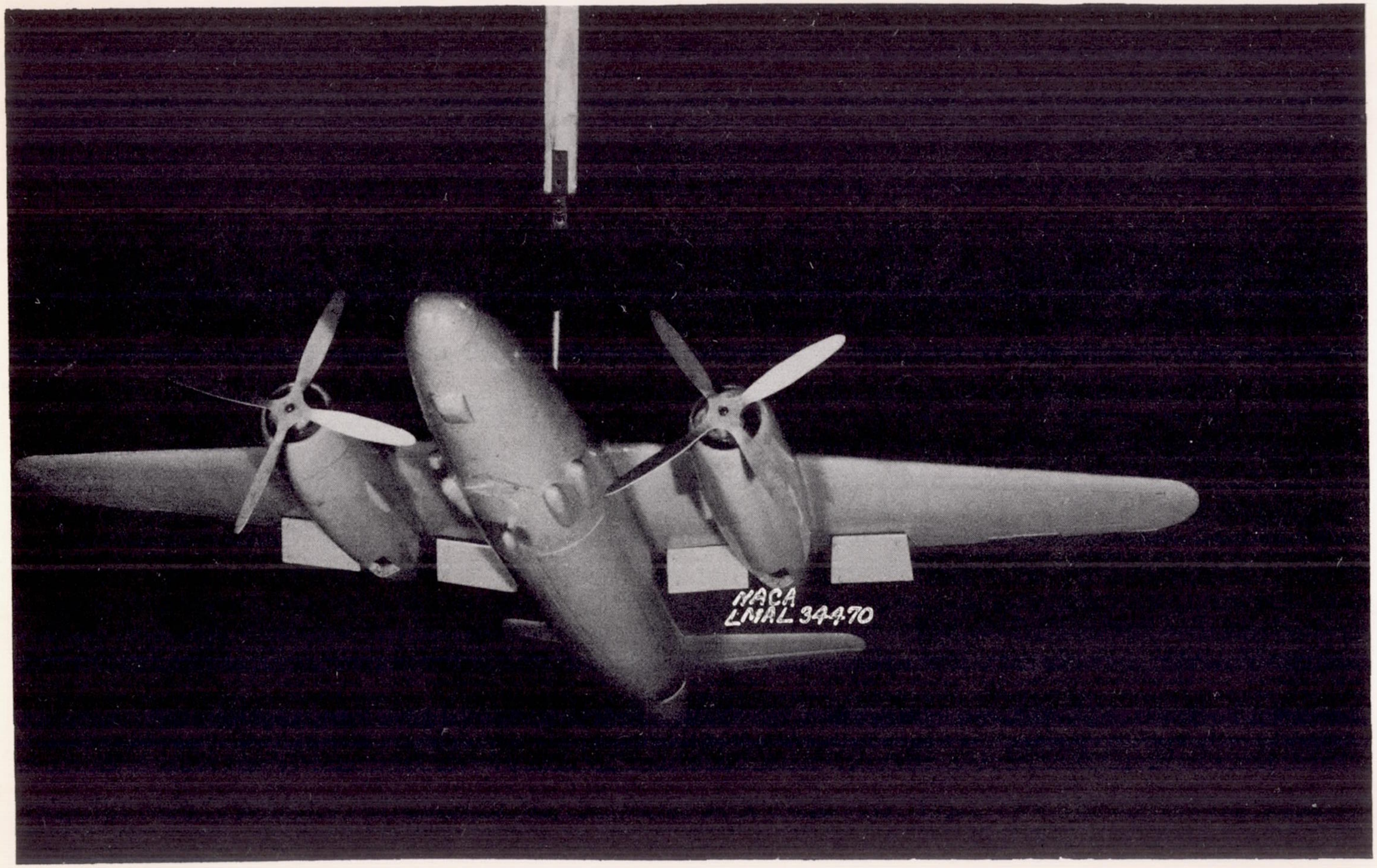
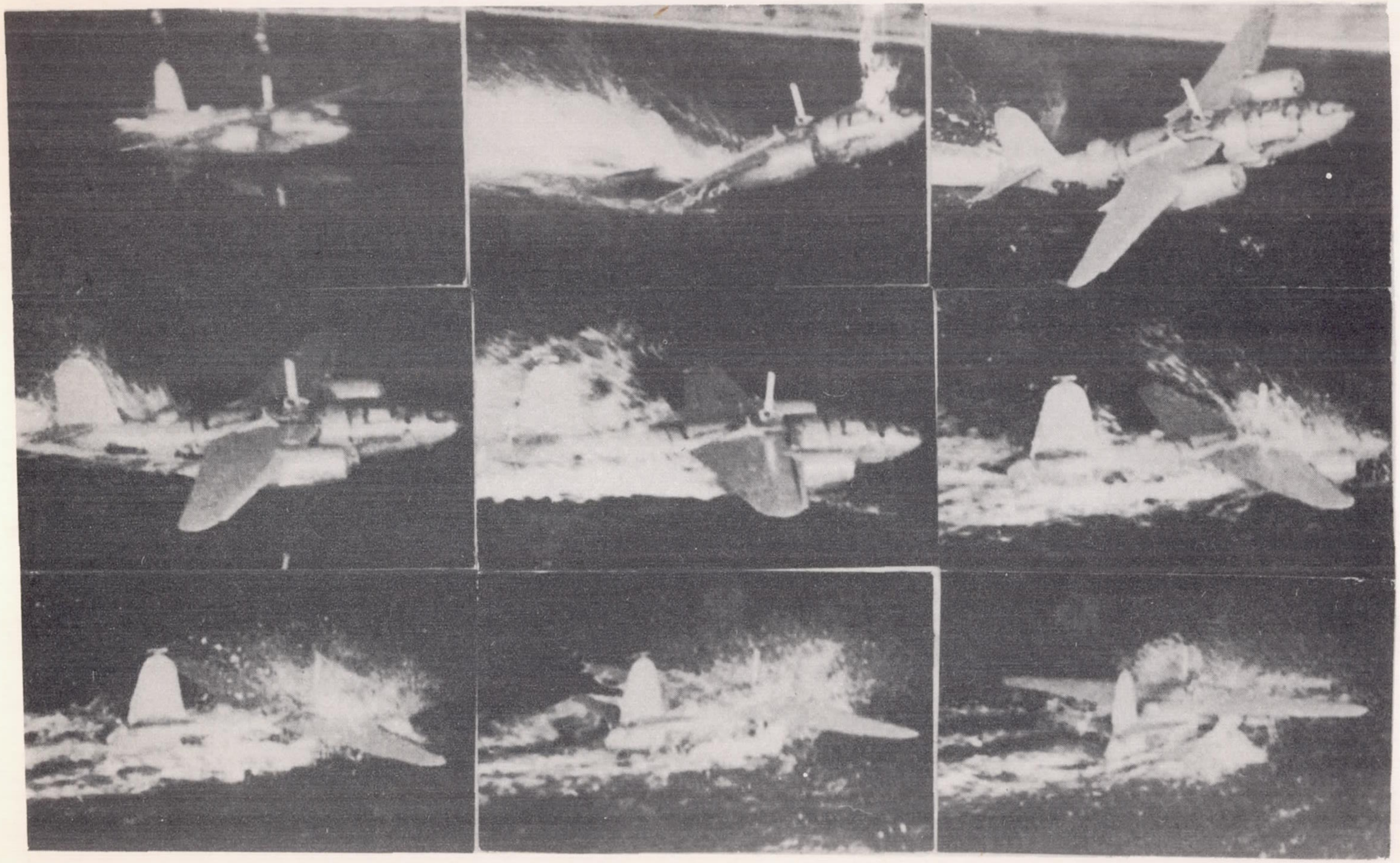


Figure 6.- Photograph of a $\frac{1}{12}$-size model of an Army B-26 airplane showing windmilling propellers with waist gun doors removed and partial failure of wheel doors simulated.



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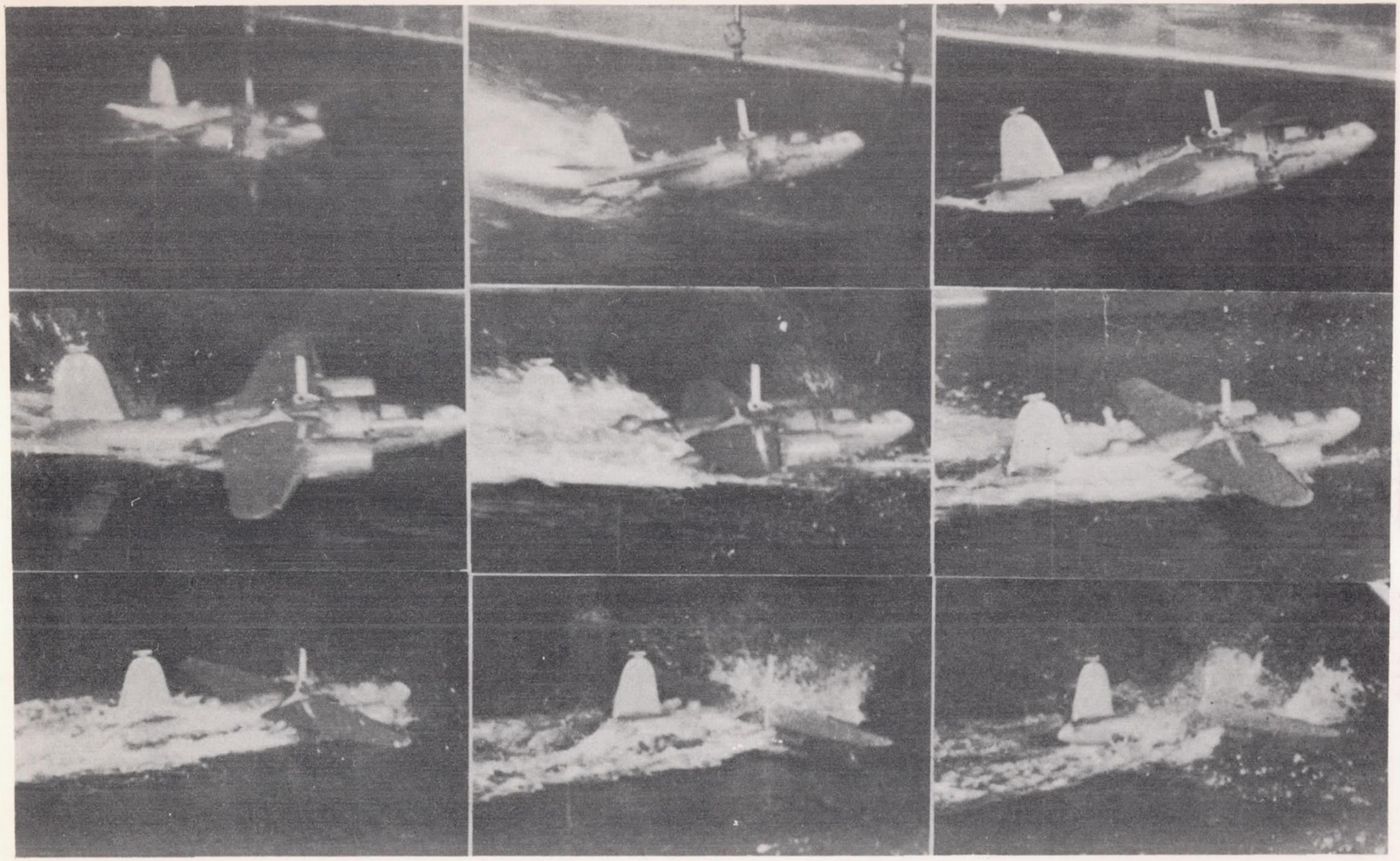
(a) Model undamaged.

Figure 7.- Photographs of ditchings of a $\frac{1}{12}$-size model of an Army B-26 airplane (0.866-second intervals, full size). Attitude of fuselage reference line is 6° at contact; flaps down 55° fixed; speed 120 miles per hour, full size.



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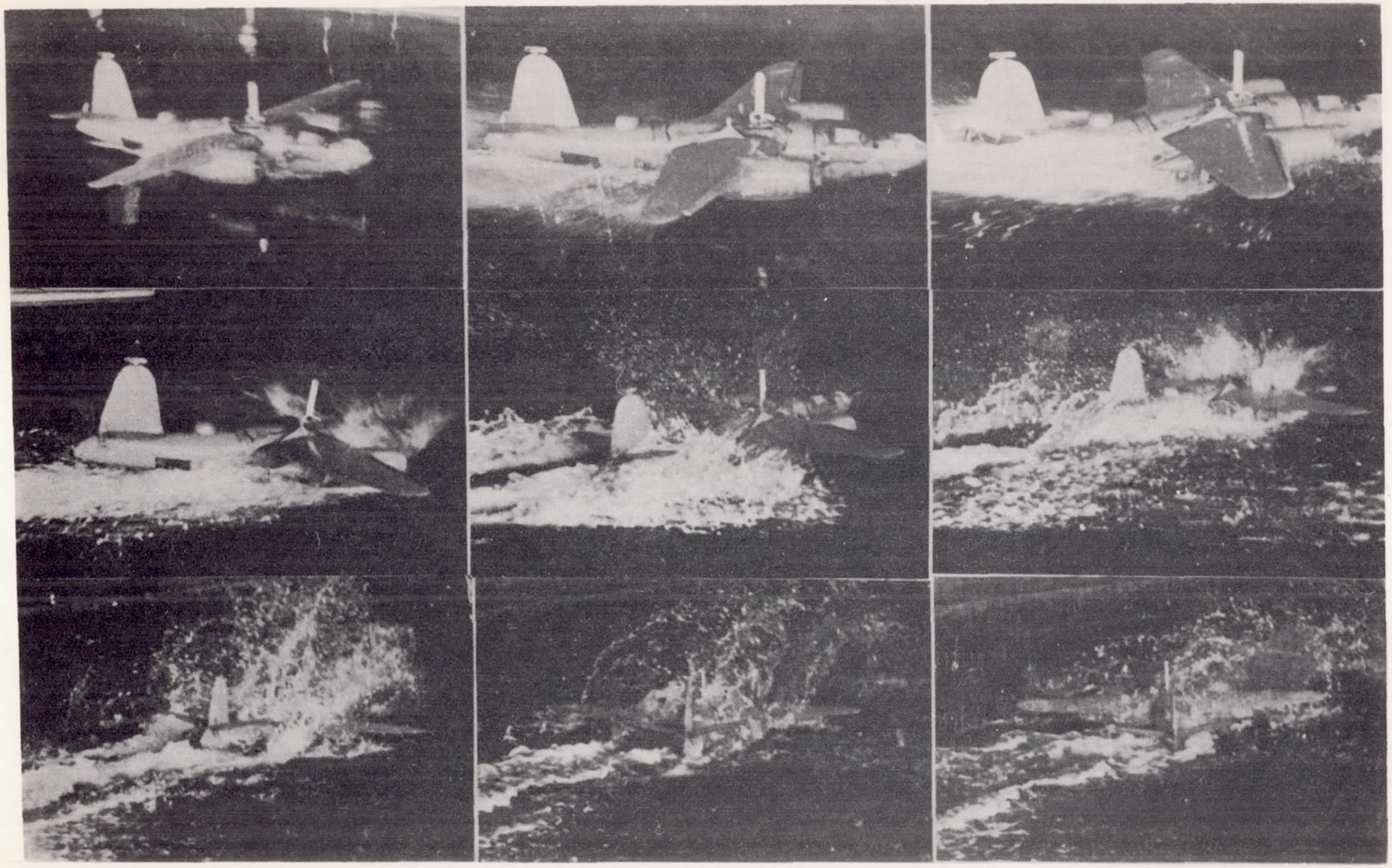
(b) Model with waist gun doors removed and partial failure of wheel doors simulate

Figure 7.- Continued.



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(c) Model with waist gun doors and bomb-bay door removed and partial failure of wheel doors simulated.

Figure 7.- Concluded.

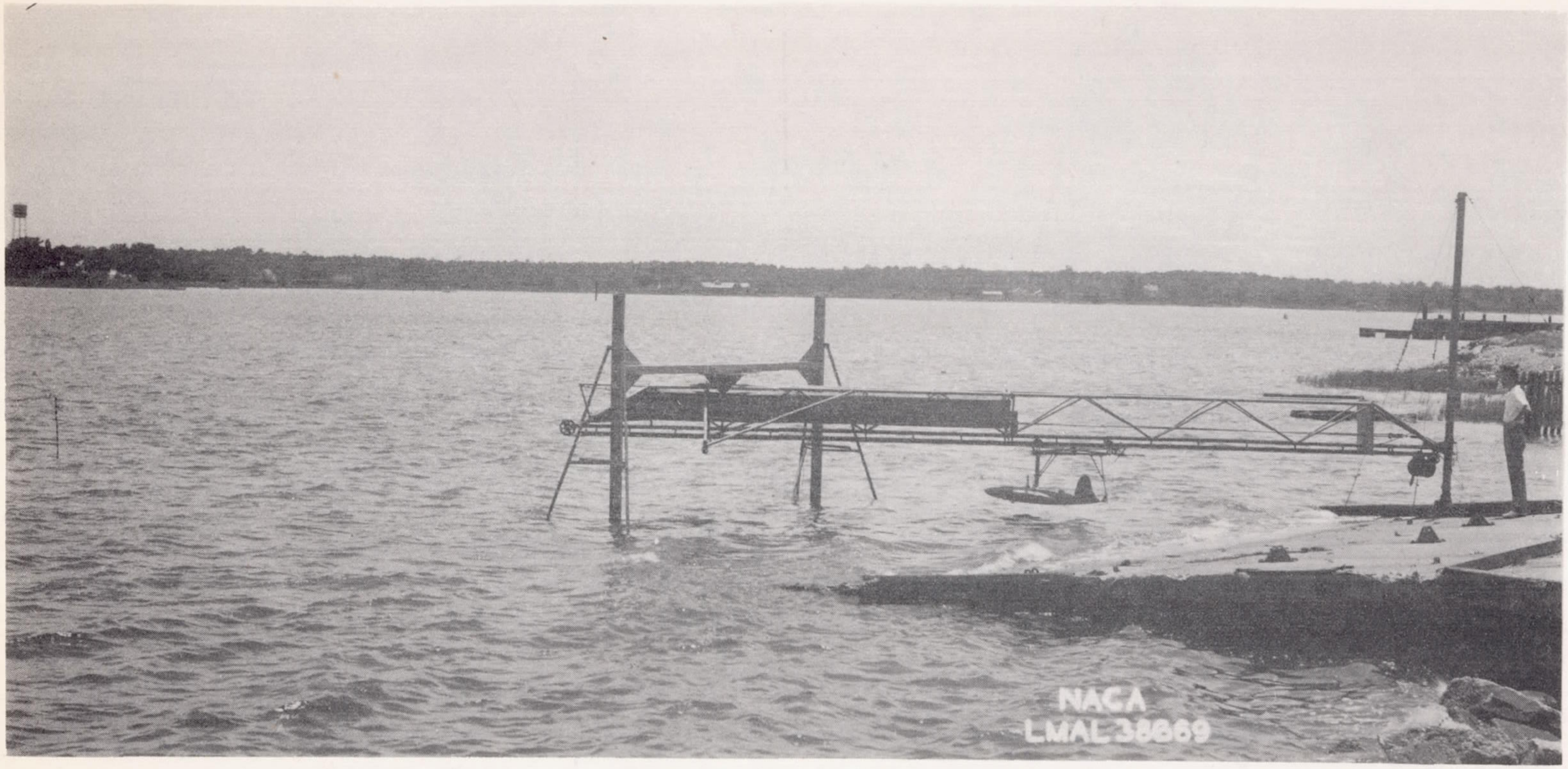


Figure 8.- Photograph of the outdoor ditching catapult.

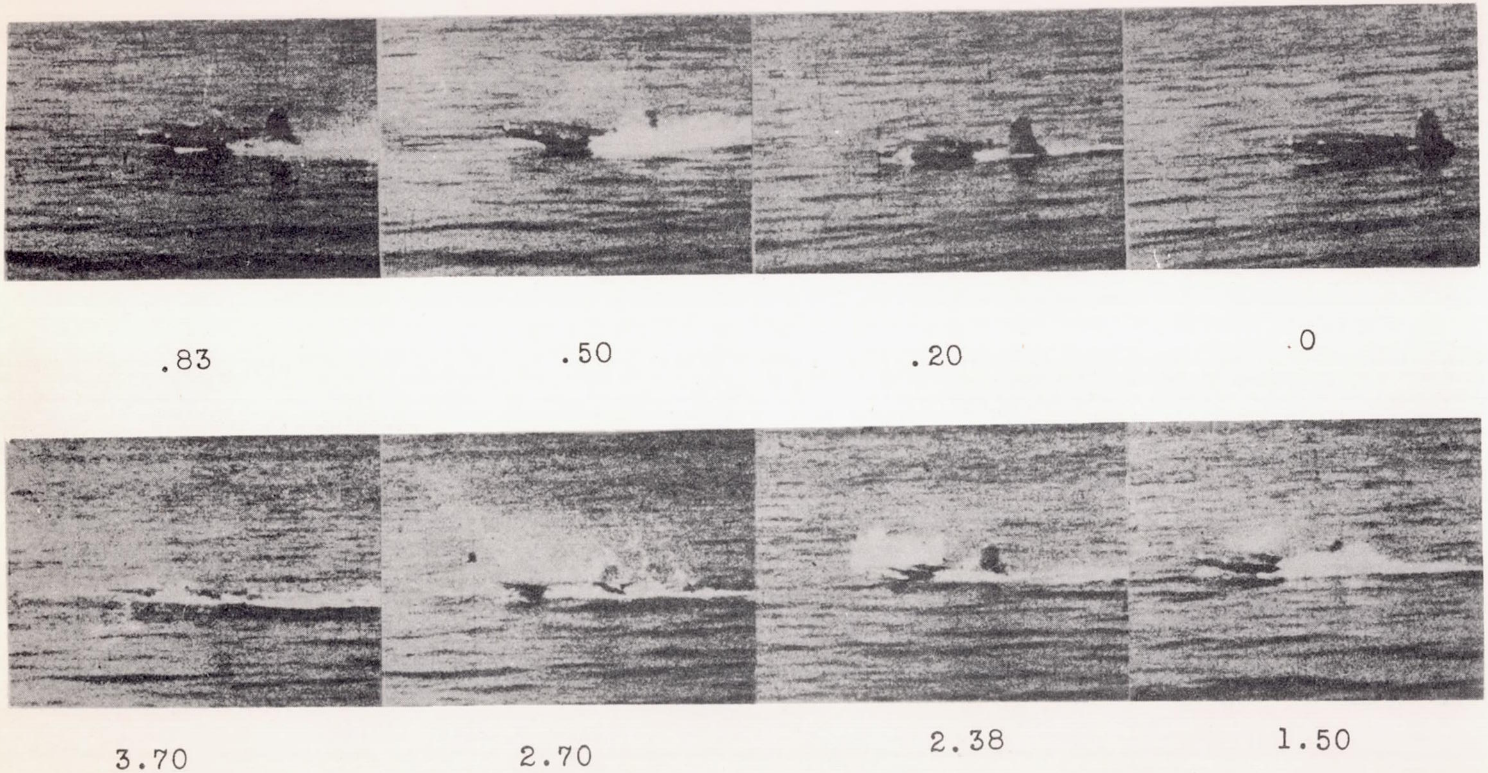
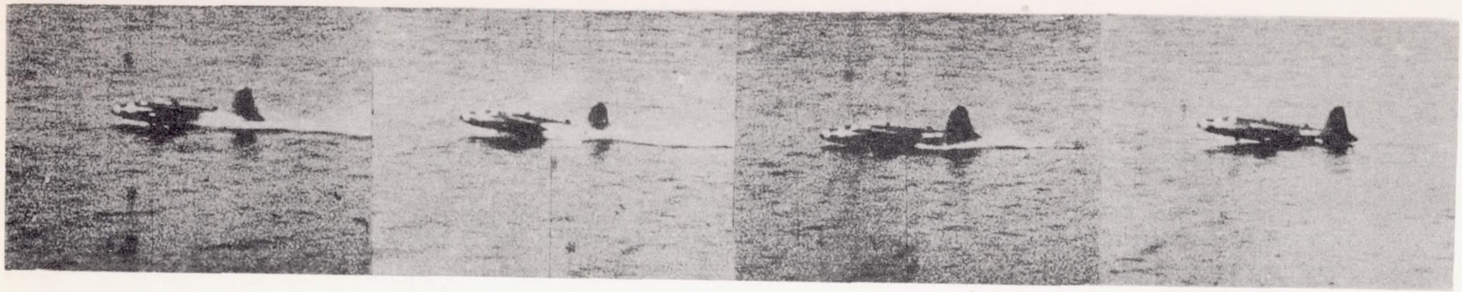
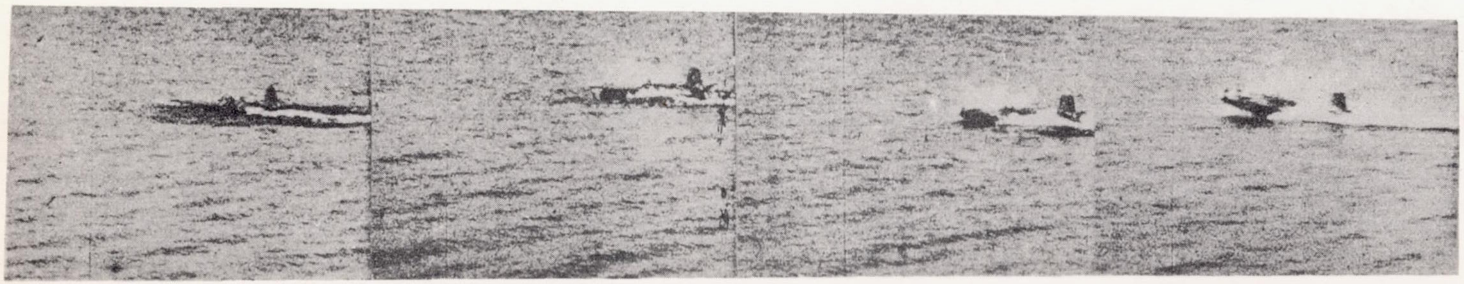


Figure 9.- Photographs of a ditching of a $\frac{1}{12}$-size model of an Army B-26 airplane. A medium-attitude landing, along the waves, in the overload condition. (Full-scale time in seconds listed under each picture.)

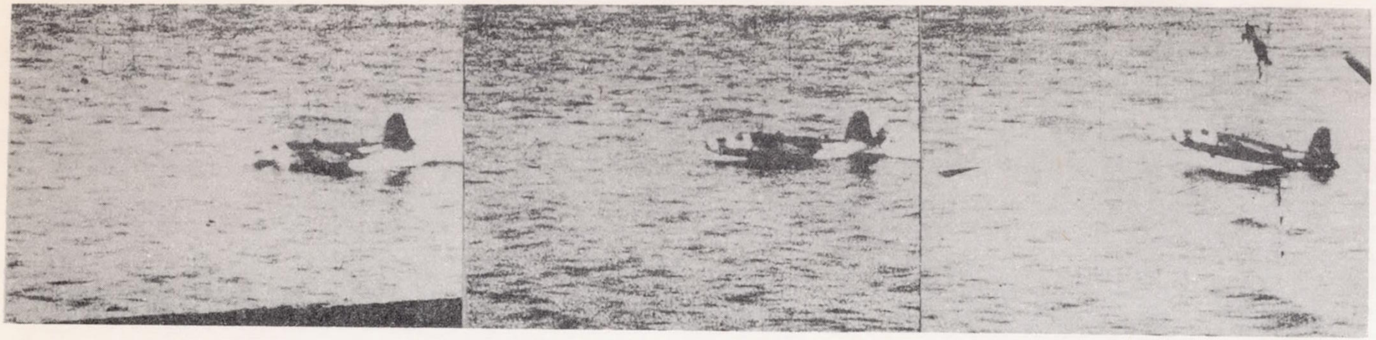


1.05 .50 .30 0

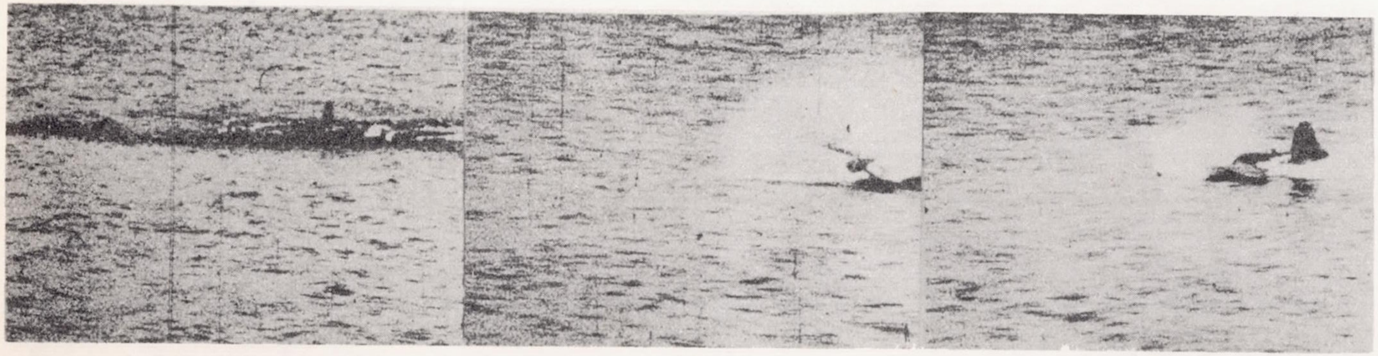


4.30 3.00 2.73 1.80

Figure 10.- Photographs of a ditching of a $\frac{1}{12}$-size model of an Army B-26 airplane. A medium-attitude landing, across the waves, in the light-weight condition. (Full-scale time in seconds listed under each picture.)



.50 .40 0



4.20 1.30 .70

Figure 11.- Photographs of a ditching of a $\frac{1}{12}$-size model of an Army B-26 airplane. A high-attitude landing, across the waves, in the light-weight condition. (Full-scale time in seconds listed under each picture.)

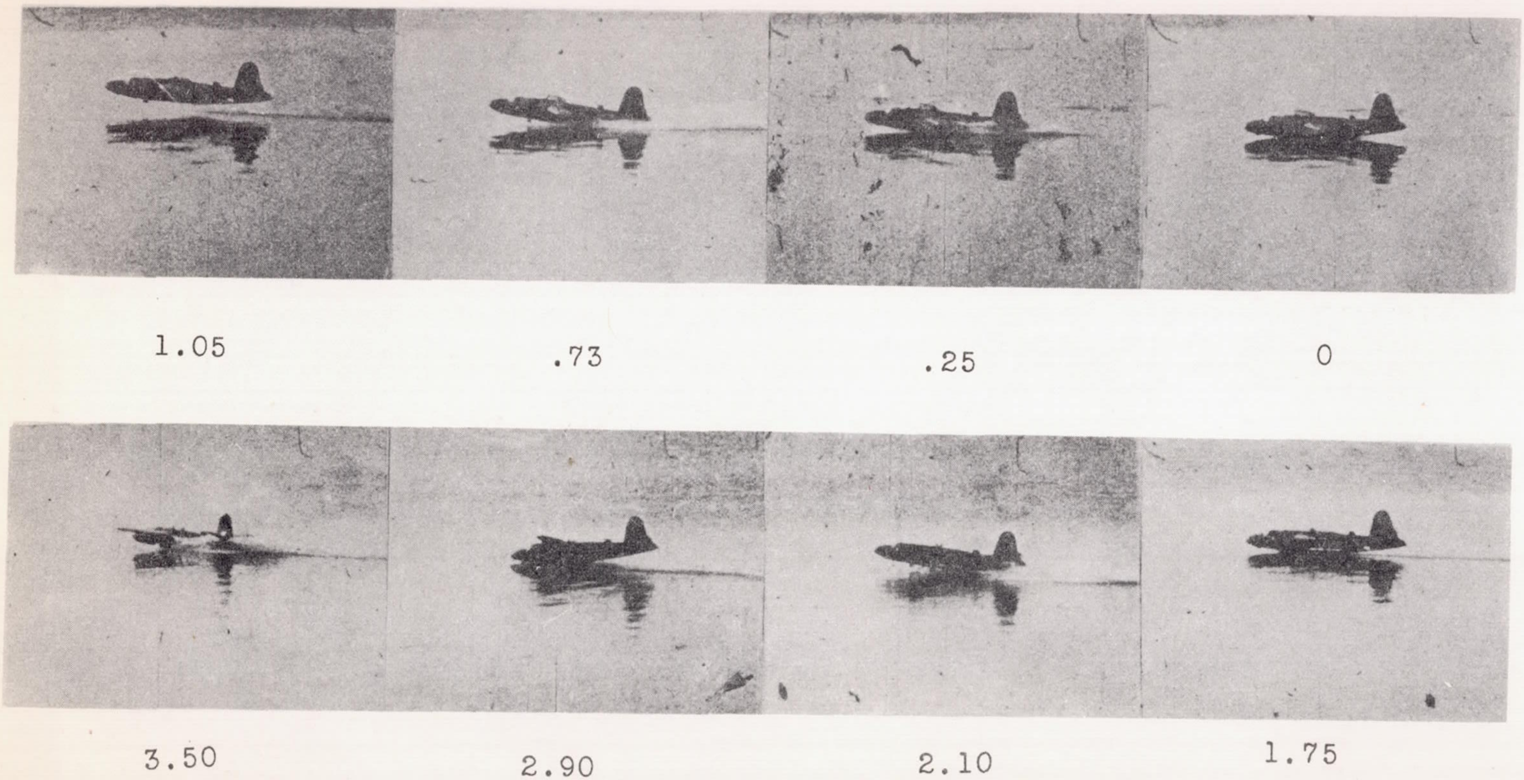


Figure 12.- Photographs of a ditching of a $\frac{1}{12}$-size model of an Army B-26 airplane. A low-attitude landing in smooth water in the light-weight condition. (Full-scale time in seconds listed under each picture.)

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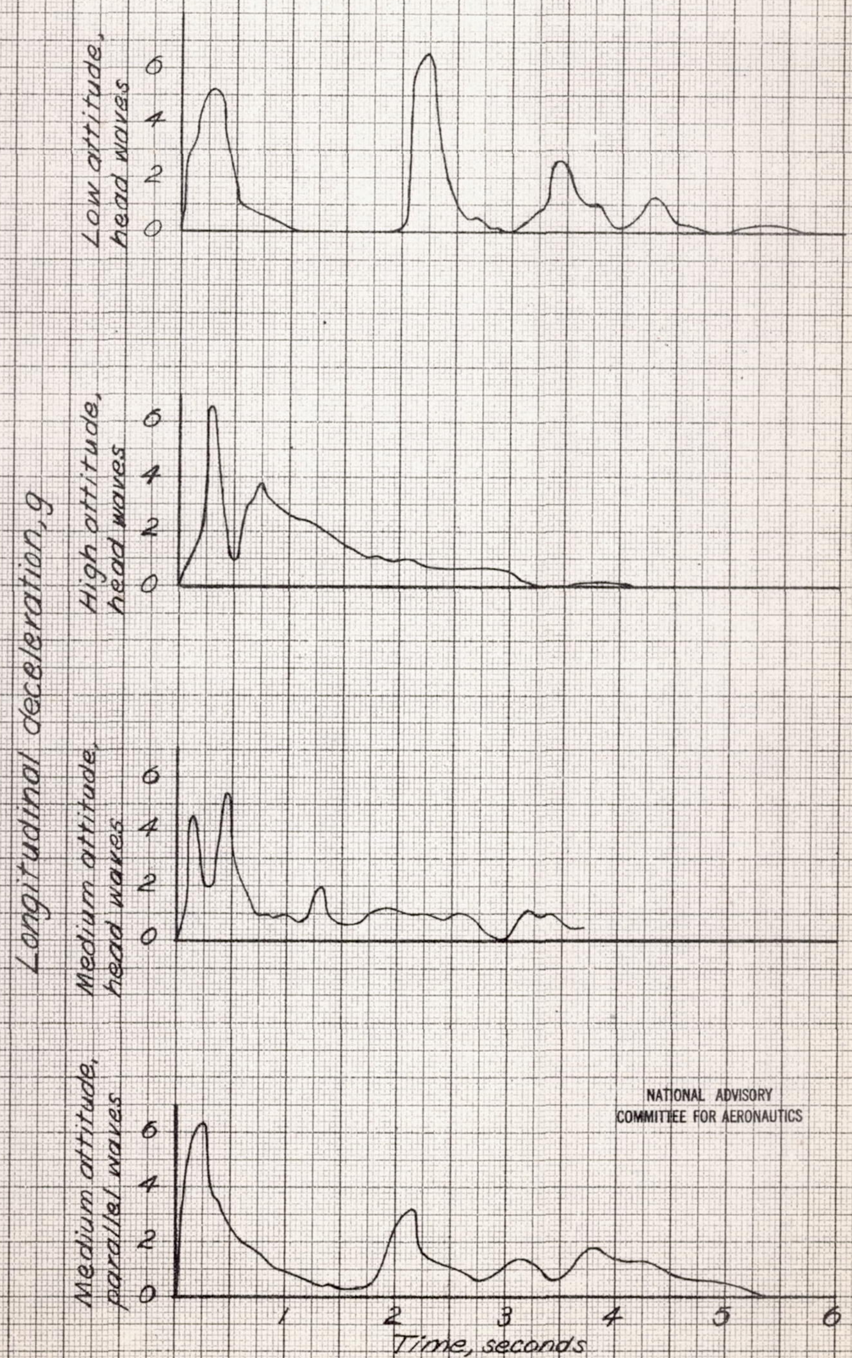

Figure 13a.- Time history of longitudinal decelerations for ditchings of a $\frac{1}{12}$-size model of an Army B-26 Airplane. Gross weight - 26,200 pounds (full size)

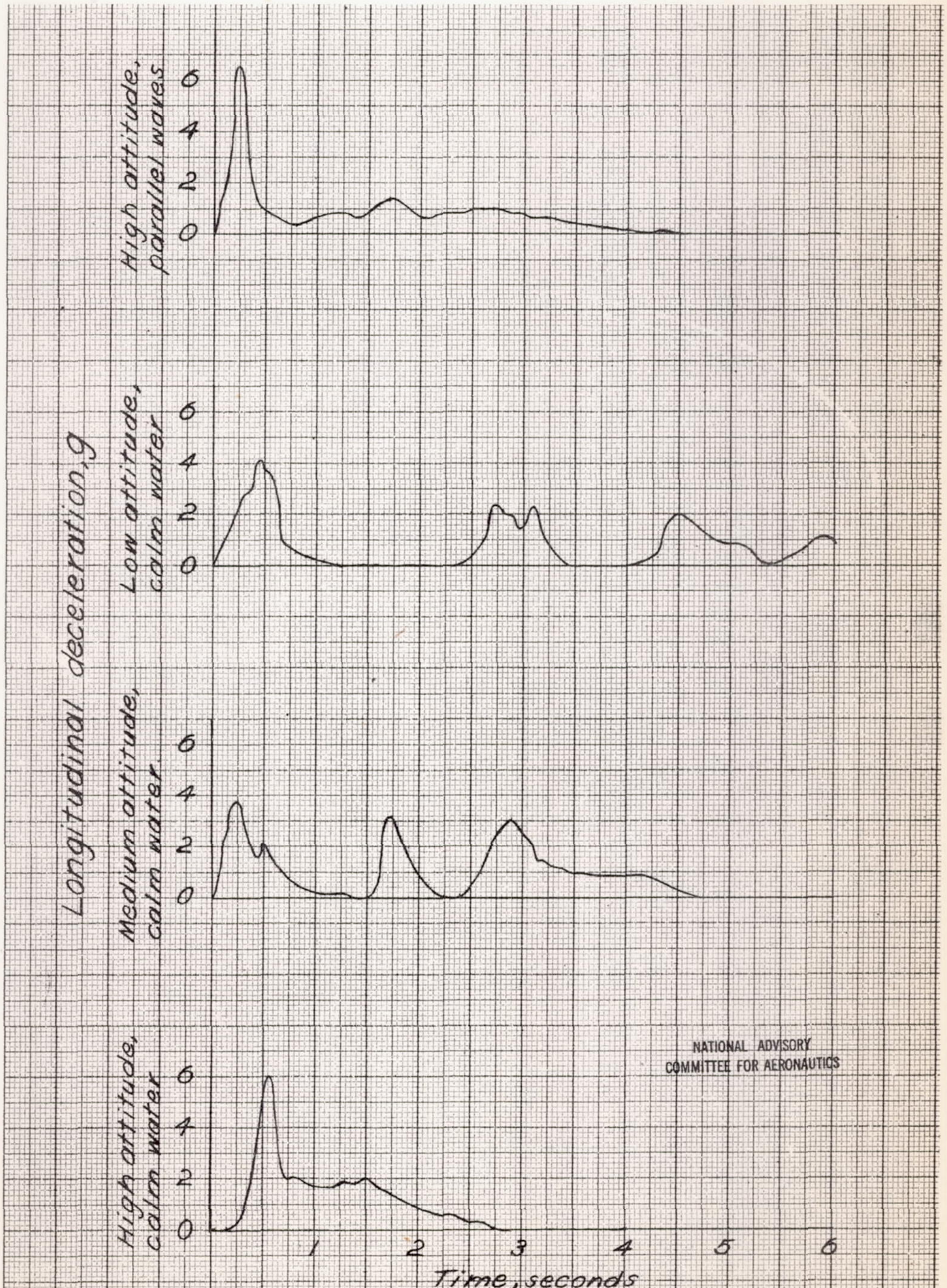

Figure 13b - Time history of longitudinal decelerations for ditchings of a $\frac{1}{12}$-size model of an Army B-26 Airplane. Gross weight - 26,200 pounds (full size)