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TECHNICAL MEMORANDUM

SX-626

for

Bureau of Naval Weapons, Department of the Navy

DITCHING INVESTIGATION OF A DYNAMIC MODEL OF A HU2K-1 HELICOPTER

TED NO. NASA AD 3142, COORD. NO. N-AM-42

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON

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ABSTRACT

Various configurations and approach conditions were investigated in order to determine the ditching behavior and the best ditching procedure. When ditchings were made without the float bags, the model rolled over on its side; when ditchings were made with the float bags inflated, the model remained upright. Late-flare and early-flare ditchings gave the same general behavior. Slight damage to the bottom surface of the scale-strength fuselage resulted for all test conditions.

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SUMMARY

An investigation was conducted with a dynamic model of a HU2K-1 helicopter to determine the probable ditching behavior and the best ditching procedure. Various configurations and approach conditions were investigated. Data were obtained from visual observations, acceleration records, and motion pictures.

When ditchings were made without the float bags, the model rolled over on its side; when ditchings were made with the float bags inflated, the model remained upright. Late-flare and early-flare ditchings gave the same general behavior. Slight damage to the bottom surface of the scale-strength fuselage resulted for all test conditions.

INTRODUCTION

A helicopter ditching is unlike an airplane ditching in that a helicopter may, under ideal conditions, contact the water at nearly zero horizontal and vertical velocity. In an actual ditching the pilot will try to approach this condition as nearly as practicable. The ditching problem arises when the pilot misjudges the altitude in either a positive or a negative direction. The manufacturer suggested that an early flare for the HU2K-1 helicopter might result in a vertical velocity of about 14 knots and no horizontal velocity, whereas a late flare

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might result in a vertical velocity of about 7 knots and a horizontal velocity of about 30 knots. These approach conditions were used for the ditching investigation reported herein.

The general arrangement of the HU2K-1 helicopter is shown in figure 1. A ditching investigation of a 1/9-scale dynamic model was conducted at the monorail apparatus of the Langley impacting structures facility. Tests were made in calm and rough water with various model configurations and landing attitudes and at various speeds. Certain portions of the model were made approximately scale-strength to determine the probable ditching behavior and to some extent the resultant damage. Data were obtained from visual observations, acceleration records, and motion pictures.

DESCRIPTION OF MODEL

The 1/9-scale dynamic model of the HU2K-1 helicopter (fig. 2) was furnished by the U.S. Navy. The model was constructed principally of glass cloth impregnated with plastic. Internal ballast was used to obtain scale weight and scale moments of inertia. The scale relationships used in this investigation are shown in table I. Pertinent characteristics of the model and full-scale helicopter are given in table II.

The model was constructed so that portions of the fuselage bottom could be removed and replaced with approximately scale-strength sections. The scale-strength bottoms (ultimate strength of 15 pounds per square inch, full scale) were constructed of cardboard bulkheads and balsa-wood stringers and were covered with aluminum foil. Scale-strength bottoms were used to indicate the location and extent of damage which might occur in a ditching.

The rotor blades were constructed of a wooden core covered with one layer of fiber-glass cloth. Steel rods were inserted throughout the length of each blade in order to obtain the correct weight and balance. Two rotor-hub designs were used in the investigation; one hub was constructed so that the blades had flapping-angle freedom and adjustable angle of attack, and the other was a simple hub with no adjustments. The adjustable hub proved to be very fragile during the tests. The simple hub was satisfactory for the model tests since horizontal and vertical velocity components were obtained by towing the model down an inclined track. Further details of these tests are given in the section entitled "Test Procedure."

The main landing gear of the model was designed so that it could be held in the down position at approximately [redacted] strength shearpin was used to hold the landing-gear drag link so that loads within 0 to -20 percent of the ultimate design load (16,000 pounds for each main gear) applied at the axle and perpendicular to the main strut caused the shearpin to fail.

The float bags shown on the model in figure 3 (stored condition simulated in fig. 2) are a part of the original helicopter design and are to be inflated when a ditching is imminent.

TEST PROCEDURE

Methods and Equipment

A special test setup was used in this investigation in order to have the model enter the water as a free body at controlled attitudes and speeds with the rotor turning. Figure 4 shows the launch track set at an angle to give the model the desired horizontal and vertical velocity components to simulate a condition in which a pilot flared the vehicle too late. The launch track was not required for the tests in which the model had only vertical velocity (simulating a condition in which the pilot flared the vehicle too early). For the tests with only vertical velocity, the model was suspended above the water at the desired landing attitude and was allowed to fall freely into the water. For all tests a motor drive unit was located just above the rotor hub and was used to bring the rotor up to the desired speed of rotation (scaled tip speed). The motor drive unit was disengaged just prior to launching the model, and the rotor autorotated during the ditching.

Accelerations were measured by single-component strain-gage accelerometers installed in the pilot's compartment. The natural frequencies of the accelerometers and the recording galvanometers were 160 and 150 cycles per second, respectively. Both were damped to about 70 percent of critical damping, and the reading accuracy of the instrument was ±0.1g. The longitudinal decelerations and the normal accelerations were measured parallel and perpendicular, respectively, to the fuselage reference line (fig. 1). The static normal-accelerometer reading was 1 g.

Test Conditions

<u>Landing parameters</u>.- The following conditions, believed to be those most likely to occur in an actual ditching, were used in the investigation (all values are full scale):

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	Early flare	Late flare
Landing attitude (angle between fuselage reference line and calm-water surface), deg	10	17
Horizontal landing speed, knots	0	30
Vertical landing speed, knots	14	7
Angle of yaw, deg	0	0, 30

Water conditions.- Tests were made in calm water and into both oncoming and following waves 3 feet high by 75 feet long (crest to crest).

Fuselage conditions.- The model was tested with the following fuselage conditions:

(a) Nonscale-strength fuselage bottom

(b) Scale-strength fuselage bottom

Model configurations.- The following configurations were used in the investigation:

(a) Float bags stored, landing gear retracted

(b) Float bags inflated, landing gear retracted

(c) Float bags stored, landing gear extended

RESULTS AND DISCUSSION

A motion-picture film supplement showing some of the tests discussed in this paper is available on loan. A request card form and a description of the film will be found at the back of this paper on the page immediately preceding the abstract page.

A summary of the results of the investigation is presented in table III. Sequence photographs of the general behavior of the model are shown in figures 5 and 6. Representative damage to the scale-strength fuselage bottoms is shown in figure 7 and typical acceleration curves are shown in figure 8. All data presented herein have been converted to full-scale values.

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Late-Flare Ditchings

The late-flare ditchings of the model were fairly smooth operations. The model without the float bags penetrated the water deeply soon after initial contact, and then surfaced and rolled over on its side. The distance of the run was about 100 feet from initial water contact to roll-over. Typical sequence photographs of this behavior are shown in figure 5. Scale-strength fuselage bottoms showed considerable skin buckling, but there were only minor ruptures. An illustrative photograph of the damage is shown in figure 7(a). The maximum normal acceleration was about 7.3g and the average maximum longitudinal acceleration was about 1.6g (table III). Typical acceleration curves are shown in figure 8(a).

Ditchings with the main landing gear extended resulted in about the same behavior as ditchings with the main gear retracted. The total length of landing run was about 75 feet, or about 25 percent less than with the gear retracted. The scale-strength landing-gear drag links did not fail in any of the ditching tests.

When the model was ditched with the float bags inflated, the aft portion of the fuselage penetrated the water much more deeply than the nose portion. The model came to a stop about 150 feet after initial water contact and remained upright in a near-level attitude. This sequence of events is illustrated in figure 6. The average maximum normal acceleration was about 6.8g and the average maximum longitudinal acceleration was about 1.6g (table III). With the float bags inflated, damage to the scale-strength fuselage bottom consisted principally of buckled skin with only slight ruptures. Typical damage is illustrated in figure 7(b).

Late-flare ditchings at a 30° yaw angle resulted in much the same behavior as the ditchings without yaw, except that very shortly after initial contact with the water the forward motion of the model changed to approximately the 30° yaw direction. The model without float bags rolled over on its side after a run of about 100 feet. The average maximum normal acceleration was 10.4g. With the float bags inflated the model remained upright and made a ditching run of about 150 feet. The average maximum normal acceleration was 9.6g. The normal acceleration was about 40 percent greater in the ditchings with yaw than in the ditchings with no yaw.

There was no noticeable difference in the amount of damage to the scale-strength fuselage bottom whether the vehicle was yawed or not or whether the float bags were inflated or not.

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Early-Flare Ditchings

Early-flare ditchings without the float bags resulted in almost complete submergence of the model before the vertical

8 [redacted]

TABLE I.- SCALE RELATIONSHIPS

[λ = Scale of model]

Quantity	Full size	Scale factor	Model size
Weight	W	λ^3	$\lambda^3 W$
Moment of inertia	I	λ^5	$\lambda^5 I$
Length	l	λ	λl
Speed	V	$\sqrt{\lambda}$	$\sqrt{\lambda} V$
Time	t	$\sqrt{\lambda}$	$\sqrt{\lambda} t$
Acceleration	a	1	a

[redacted]

TABLE II.- PERTINENT CHARACTERISTICS OF THE MODEL

AND FULL-SCALE HU2K-1 HELICOPTER

	1/9-scale model	Full scale
General:		
Gross weight, lb	10.15	7,400
Moment of inertia, slug-ft^2:		
Roll	0.057	3,400
Pitch	0.237	14,000
Yaw	0.191	11,300
Overall length, ft	5.798	52.18
Overall height, ft	1.630	14.67
Fuselage length, ft	4.380	39.42
Center-of-gravity location, ft:		
Distance from nose	1.286	11.57
Height above fuselage bottom	0.509	4.58
Rotor diameter, ft:		
Main	4.489	44
Tail	0.889	8
Float bag dimensions, ft:		
Diameter	0.417	3.75
Length	0.693	6.24
Landing conditions:		
Late flare:		
Attitude, deg	17	17
Horizontal speed, knots	10	30
Vertical speed, knots	2.333	7
Early flare:		
Attitude, deg	10	10
Horizontal speed, knots	0	0
Vertical speed, knots	4.667	14

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TABLE III.- SUMMARY OF RESULTS OF DYNAMIC MODEL DITCHING OF A HU2K-1 HELICOPTER

[Landing gear retracted unless otherwise indicated. Static normal accelerometer reading, 1 g. All values are full scale.]

Water condition	Fuselage bottom	Model configuration	Number of test runs	Average maximum acceleration, g units		Comments
				Normal	Longitudinal	
Late-flare ditching with 0° yaw (attitude, 17°; horizontal speed, 30 knots; vertical speed, 7 knots)						
Calm	Nonscale strength	Float bags stored	8	7.3	1.6	Rolled over on side
		Float bags inflated	20	6.8	1.6	Remained upright
		Landing gear extended; float bags stored	8	8.1	1.8	Rolled over on side; landing gear did not fail
	Scale strength	Float bags stored	8	7.5	1.6	Rolled over on side; some damage to bottom
		Float bags inflated	8	11.6	2.2	Remained upright; some damage to bottom
Waves 3' by 75'	Nonscale strength	Float bags stored	9	9.2	1.4	Rolled over on side
		Float bags inflated	8	6.4	2.1	Remained upright
	Scale strength	Float bags stored	3	----	1.6	Rolled over on side; some damage to bottom
		Float bags inflated	4	10.2	1.9	Remained upright; some damage to bottom
Late-flare ditching with 30° yaw (attitude, 17°; horizontal speed, 30 knots; vertical speed, 7 knots)						
Calm	Nonscale strength	Float bags stored	3	10.4	0.7	Same behavior as for corresponding conditions above except that model runout was in direction of yaw
		Float bags inflated	4	9.6	1.0	
	Scale strength	Float bags stored	3	8.4	0.6	
		Float bags inflated	4	12.6	1.4	
Waves 3' by 75'	Nonscale strength	Float bags stored	6	8.5	1.9	
		Float bags inflated	3	11.4	2.0	
	Scale strength	Float bags stored	2	8.7	1.9	
		Float bags inflated	6	11.0	2.1	
Early-flare ditching with 0° yaw (attitude, 10°; horizontal speed, 0; vertical speed, 14 knots)						
Calm	Nonscale strength	Float bags stored	13	6.4	---	Behavior similar to that for corresponding late-flare conditions except that there was no forward motion
		Float bags inflated	21	7.9	---	
	Scale strength	Float bags stored	3	6.8	---	
Waves 3' by 75'	Nonscale strength	Float bags stored	3	4.1	---	

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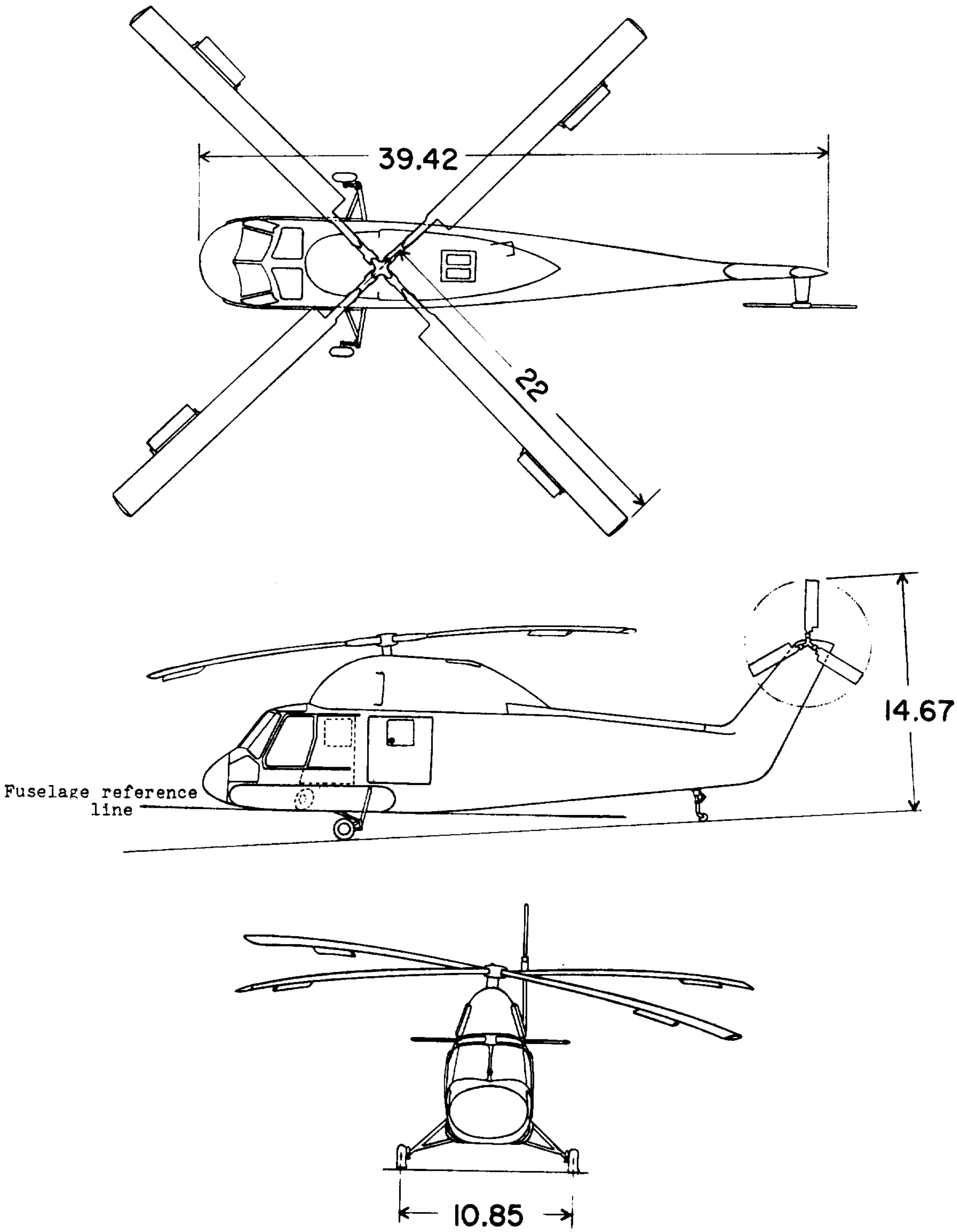

Figure 1.- Three-view drawing of the HU2K-1 helicopter. Dimensions are in feet, full scale.

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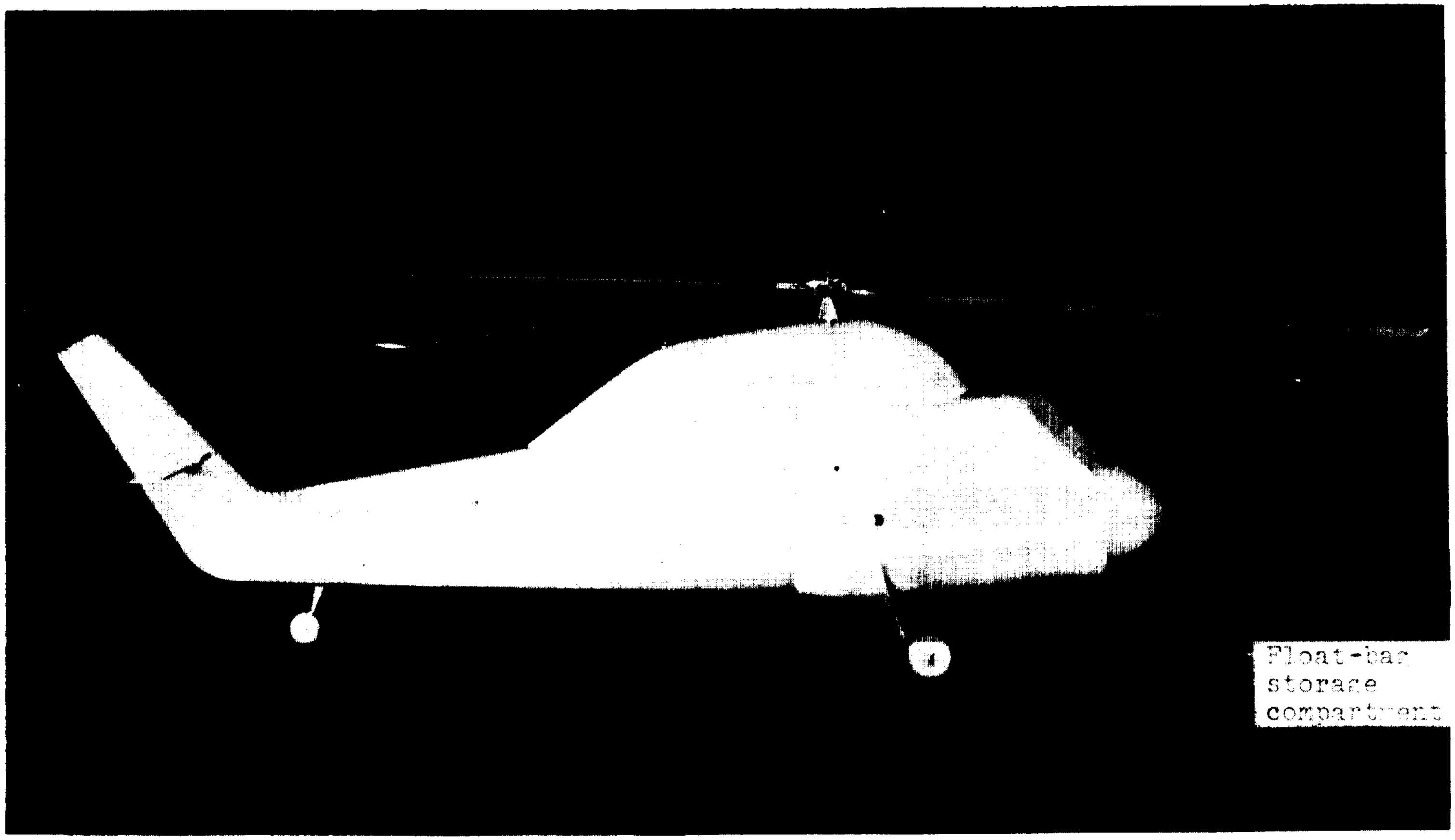
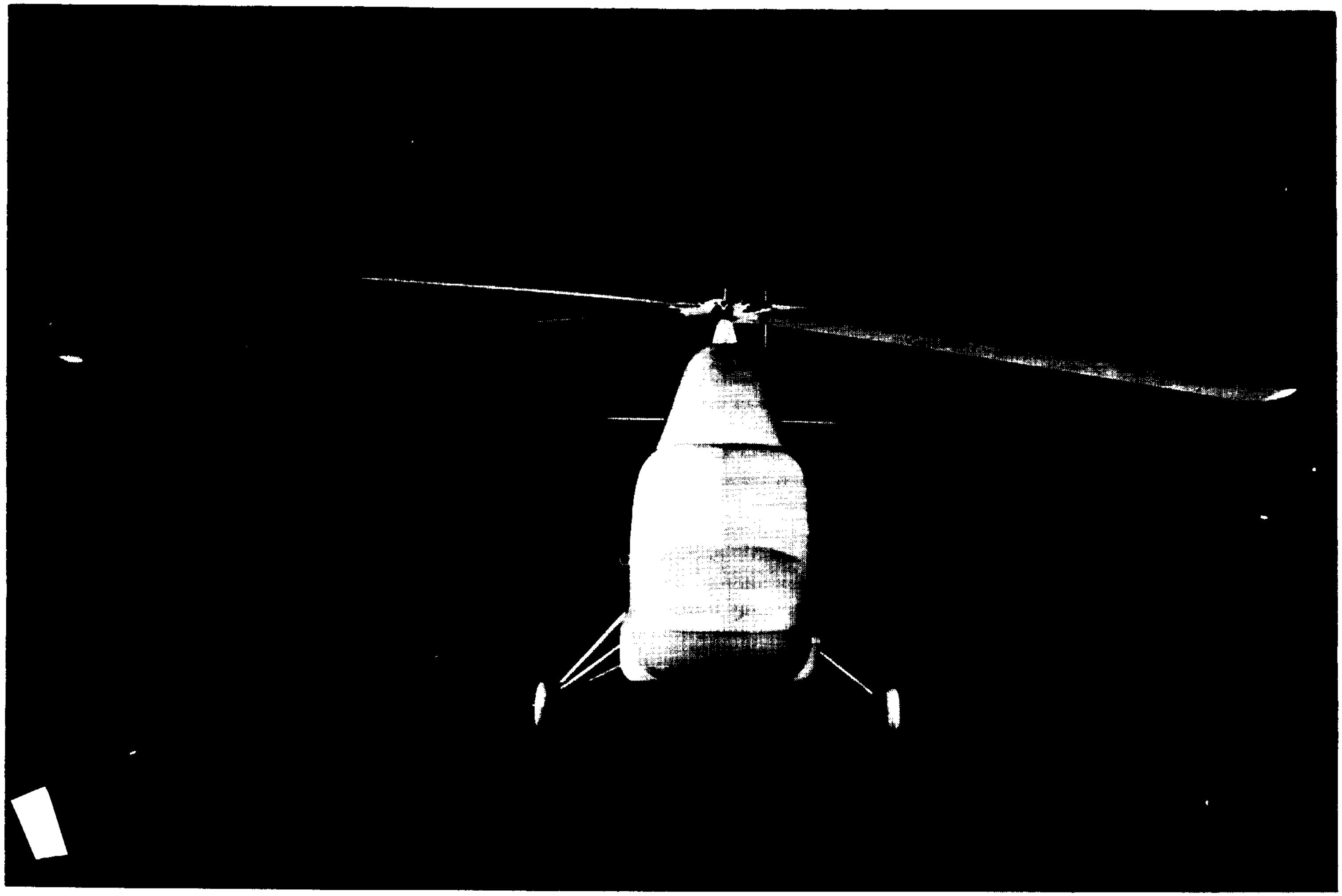


(a) Side view. L-61-7706

Figure 2.- Model with landing gear extended.

[redacted]



(b) Front view. L-58-440a

Figure 2.- Continued.

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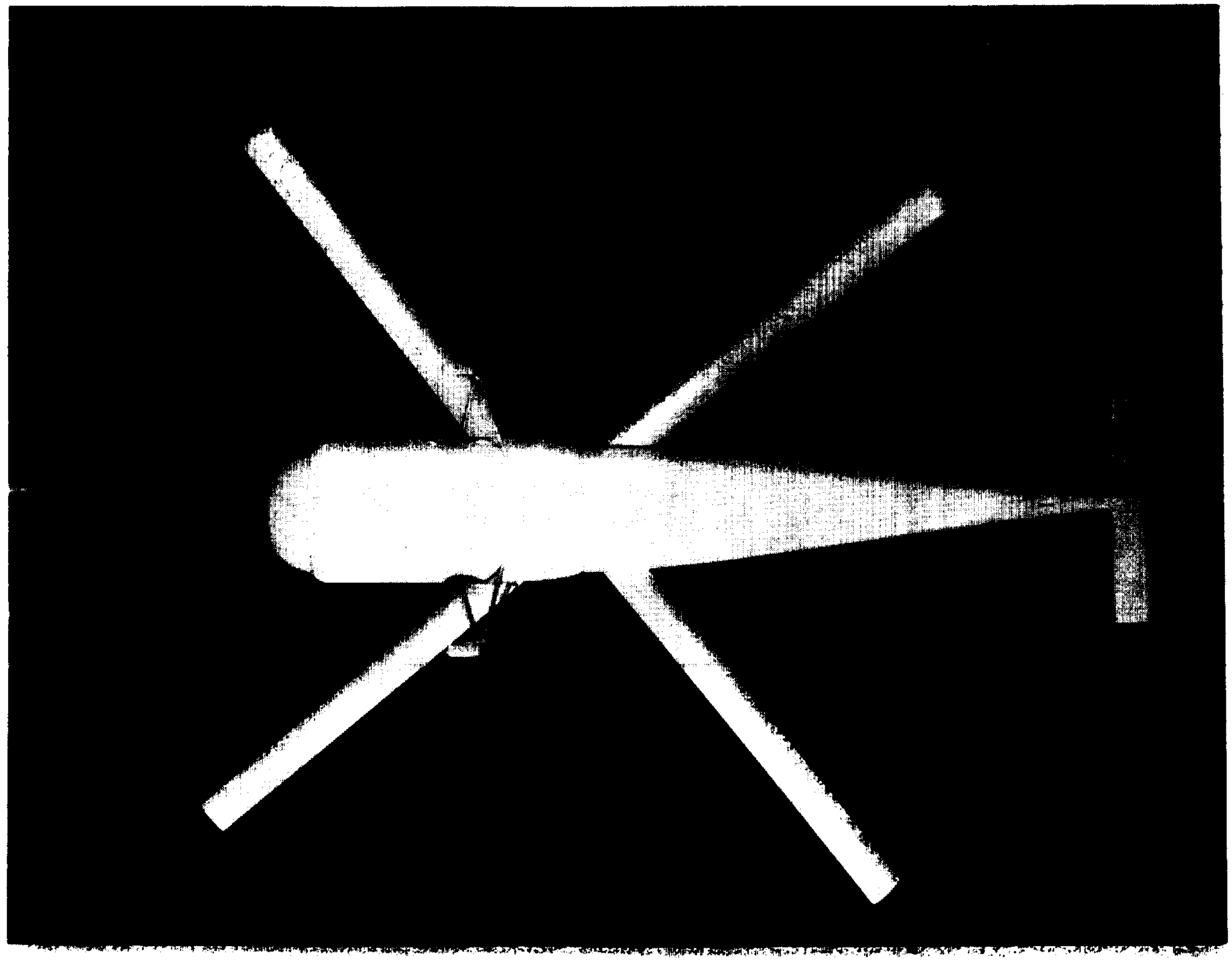

(c) Bottom view. L-58-439a

Figure 2.- Concluded.

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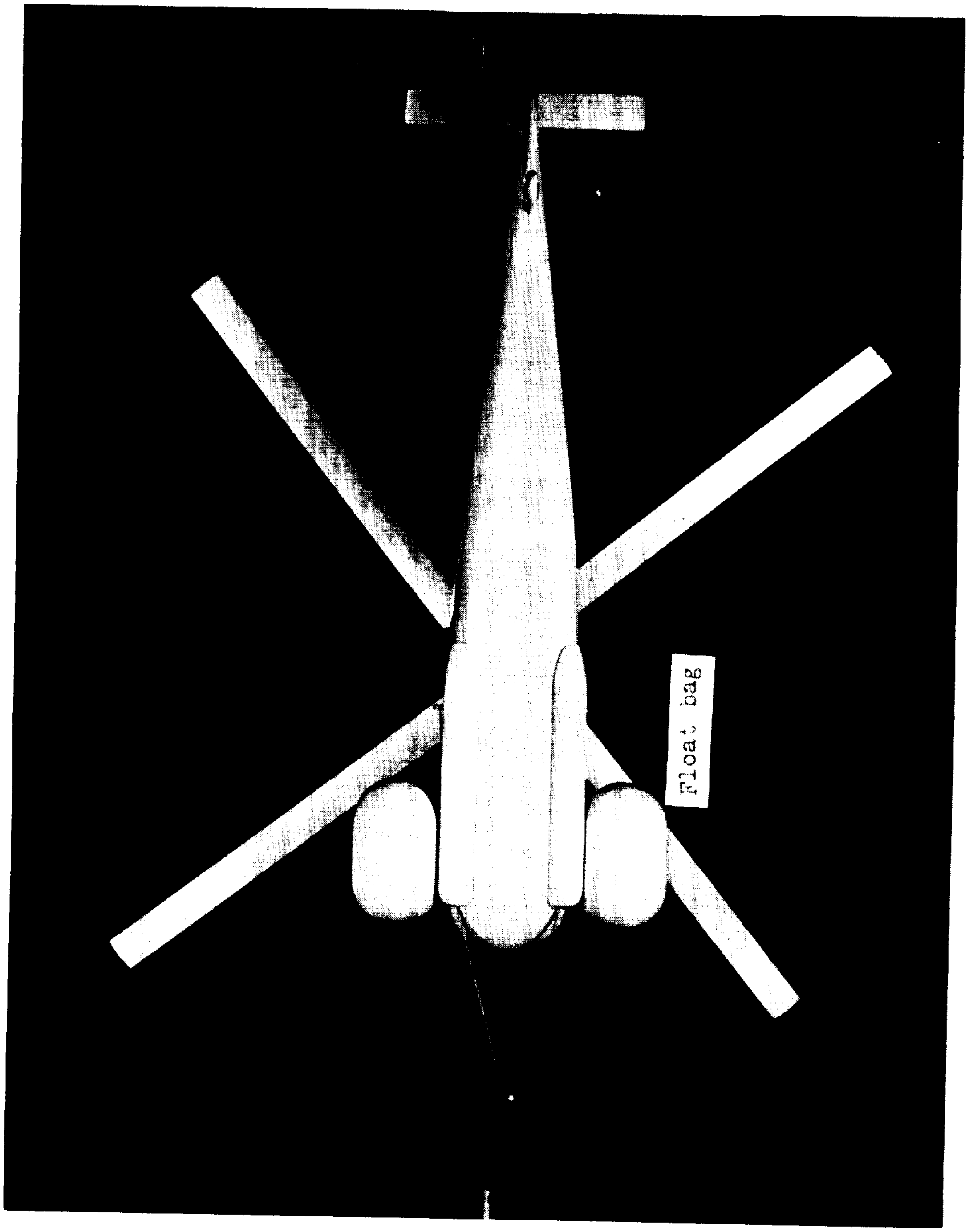

Figure 3.- Model with float bags inflated. L-61-7707

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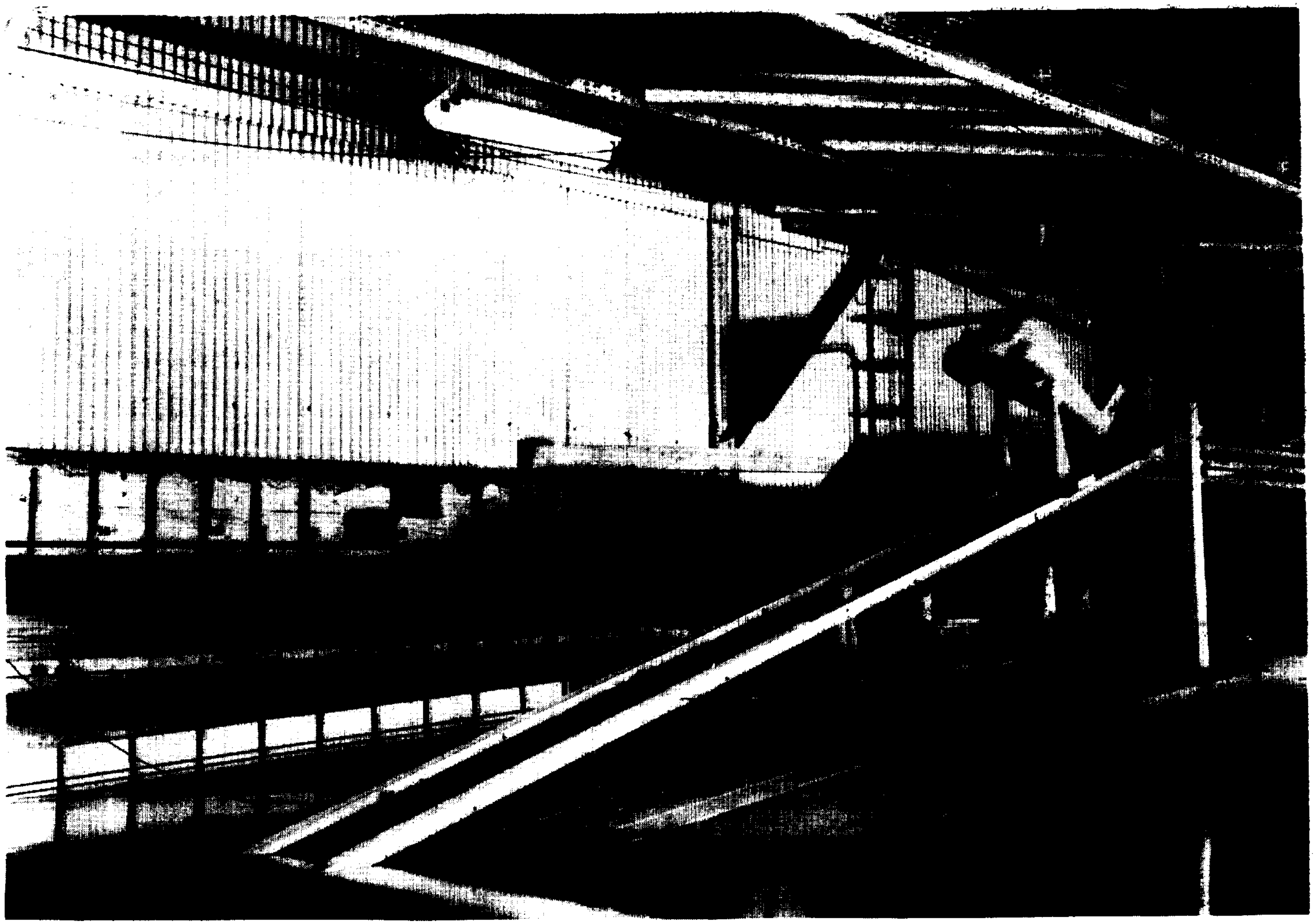

L-59-3373

Figure 4.- Setup for helicopter model ditching tests at the monorail apparatus.

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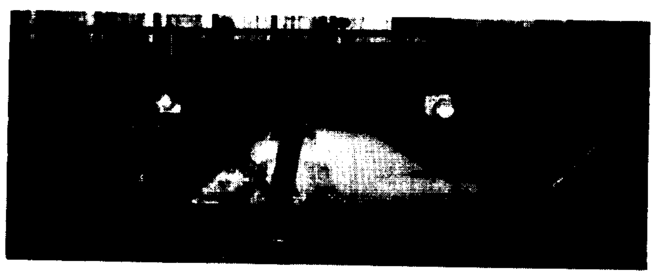
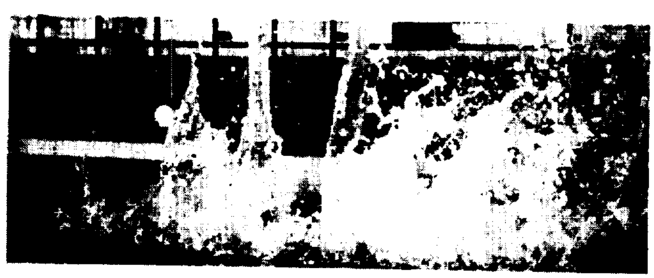
(a) Near contact.

(b) Rear fuselage sank.



(c) Model pitched forward.



(d) Rolled 90°, remained on side.

L-61-7708

Figure 5.- General behavior sequence for a model ditching without float bags.

(a) Near contact.

(b) Rear fuselage sank.

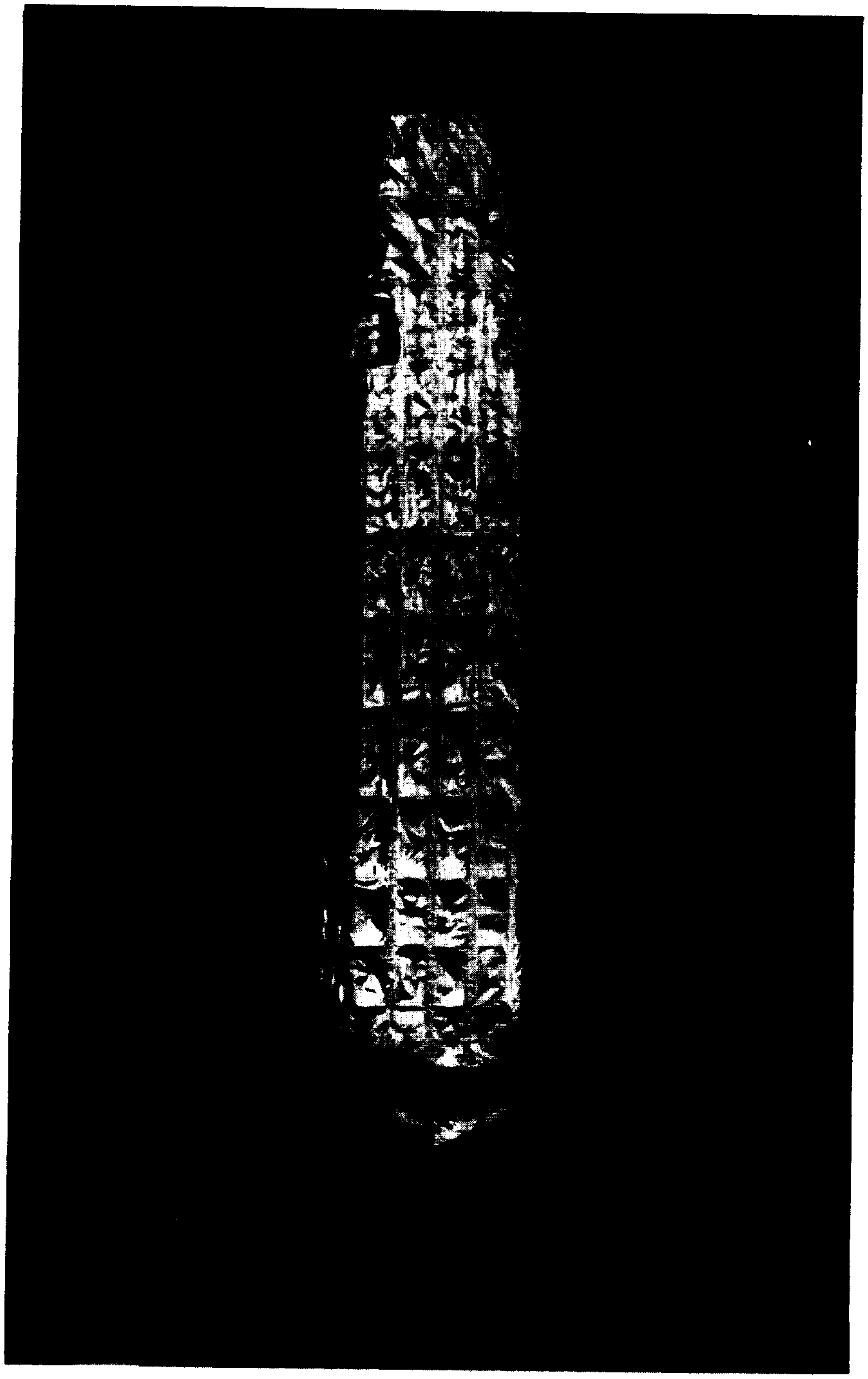
(c) Float bags support forward fuselage.

(d) Model remained upright.

L-61-7709

Figure 6.- General behavior sequence for a model ditching with float bags inflated.

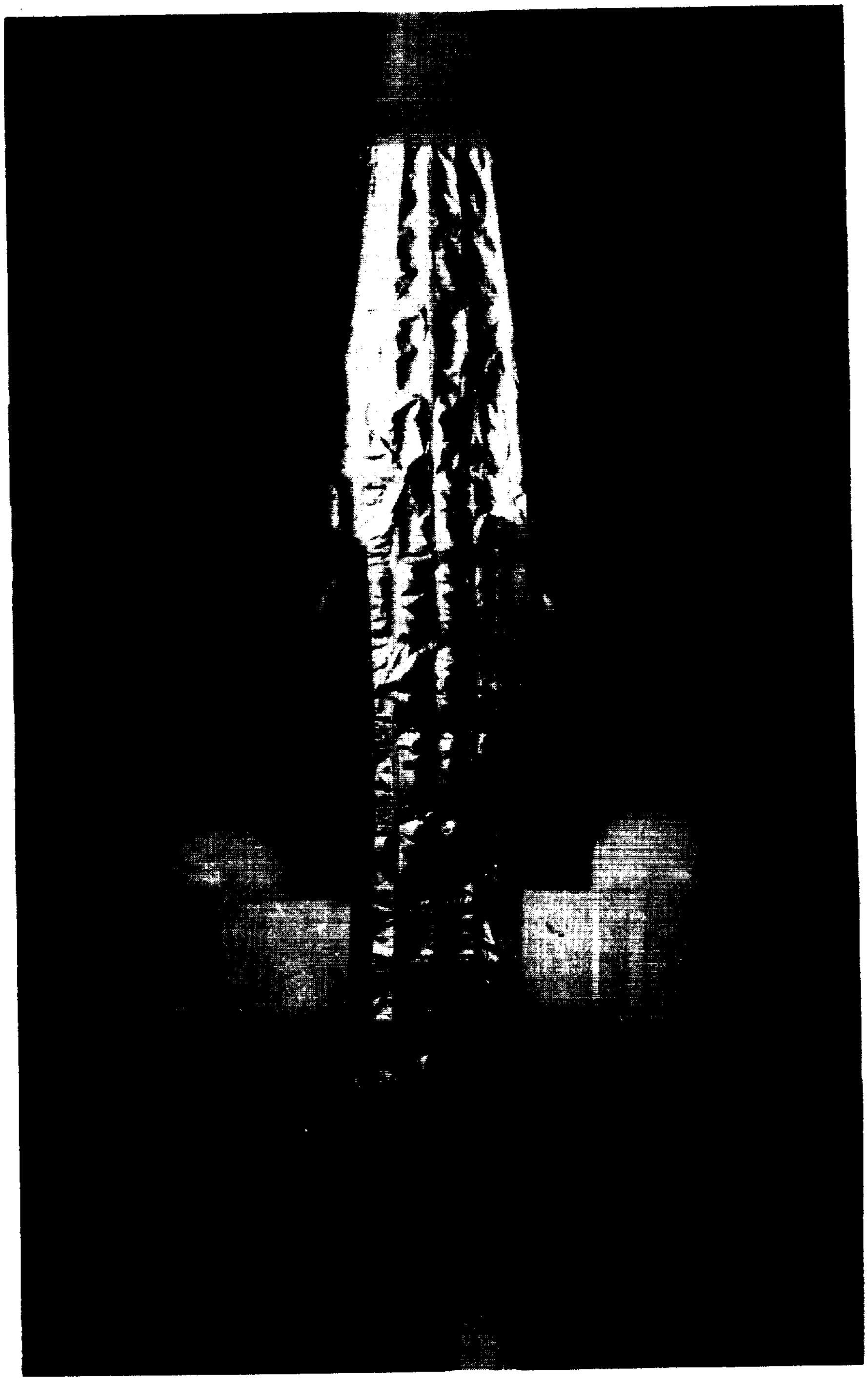
[redacted]



(a) Without float bags. L-61-7710

Figure 7.- Representative damage to scale-strength fuselage bottom.

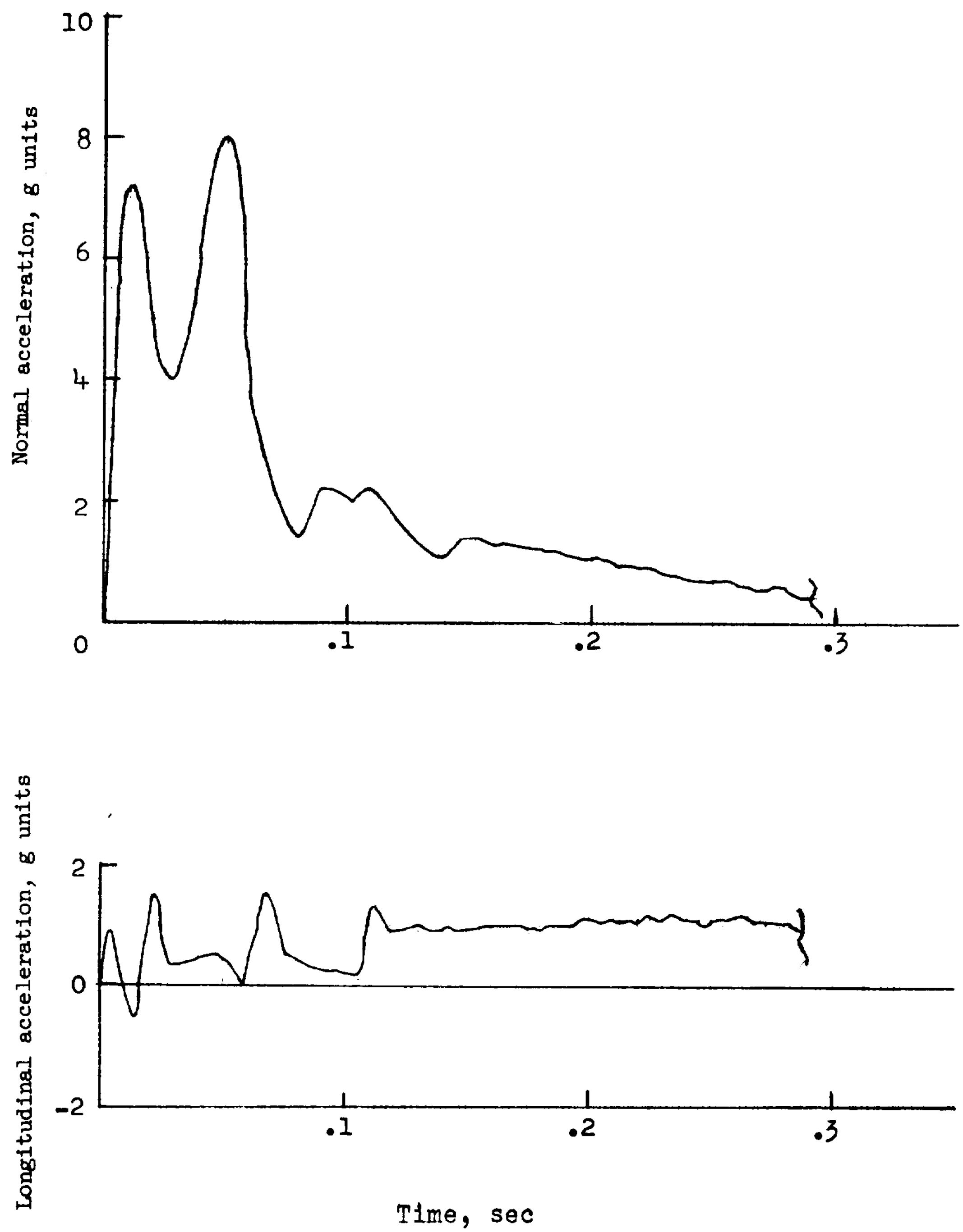
[redacted]



(b) With float bags inflated. L-61-7711

Figure 7.- Concluded.

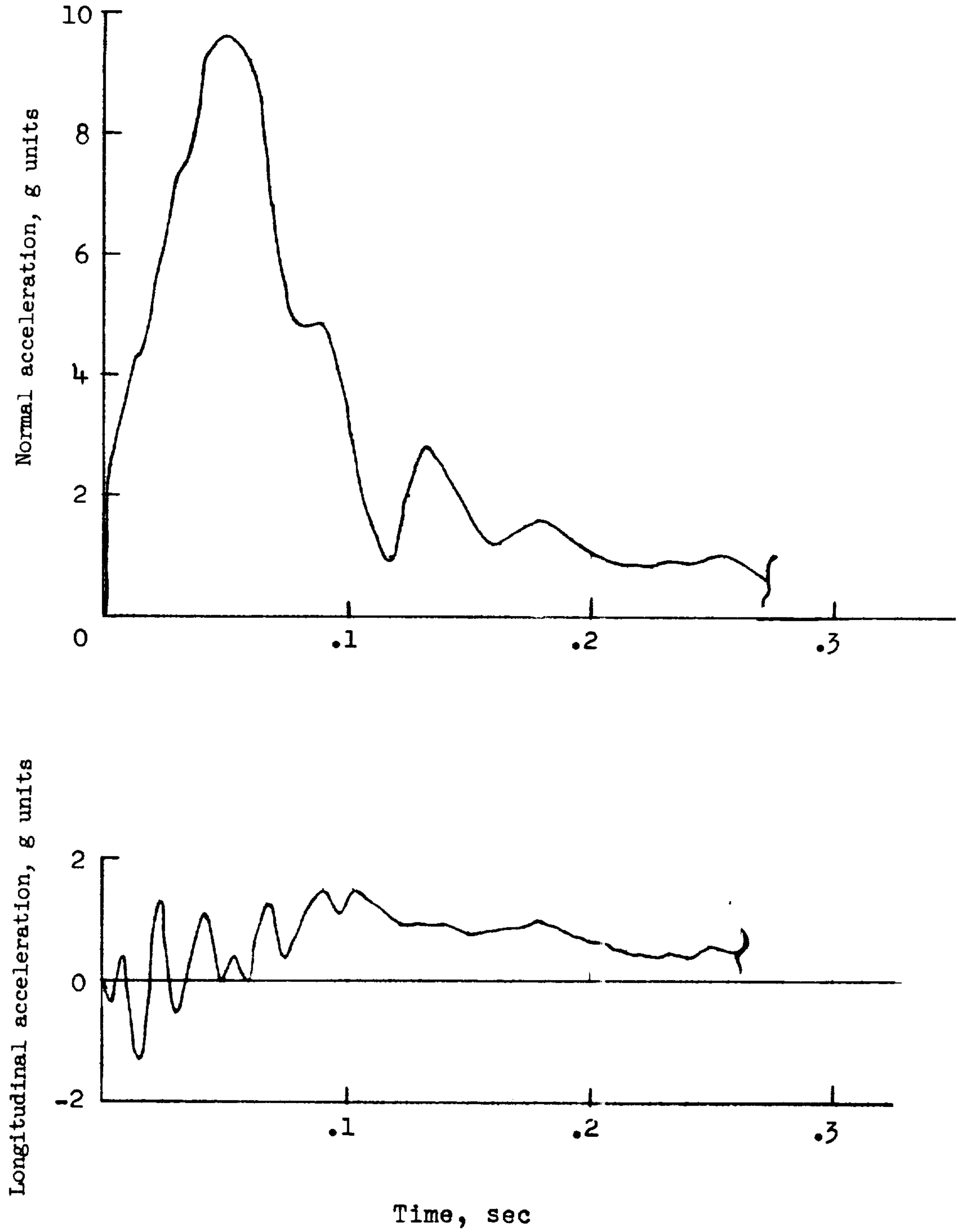
[redacted]



(a) Without float bags.

Figure 8.- Typical touchdown acceleration curves for late-flare ditchings in calm water. Scale-strength fuselage bottom installed on model. All values are full scale.

[redacted]



(b) With float bags inflated.

Figure 8.- Concluded.

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