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RESEARCH MEMORANDUM

for the

Air Materiel Command, Army Air Forces

DITCHING TESTS OF A 1/9-SIZE MODEL OF THE ARMY P-38 AIRPLANE IN LANGLEY TANK No. 2 AND AT THE OUTDOOR CATAPULT

By

George A. Jarvis and Gibson A. Cederborg

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Langley Field, Va.

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON

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DITCHING TESTS OF A 1/9-SIZE MODEL OF THE ARMY P-38 AIRPLANE IN LANGLEY TANK NO. 2 AND AT THE OUTDOOR CATAPULT

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SUMMARY

A dynamically similar model of the Army P-38 airplane was tested to determine the best way to land this airplane on the water and to determine its probable ditching performance. The tests consisted of ditching the model at various landing attitudes, flap settings, speeds, weights, and conditions of simulated damage. The model was ditched in calm water from the tank towing carriage and a few ditchings were made in both calm and rough water at the outdoor catapult. The performance of the model was determined by making visual observations, by recording lengths of run and time histories of decelerations, and by taking motion pictures of the ditchings.

From the results of the tests, the following conclusions were drawn:

1. The airplane should be landed at a tail down attitude (thrust line at 9° to 13°) with flaps full down.

2. When ditched in calm water at the 9° attitude the airplane will probably heave with a high deceleration at the first contact with the water.

3. The landing should be made with the wing laterally level, otherwise a violent turn or an oscillation in yaw may result.

4. The airplane should be landed at the lightest weight possible.

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5. Hydroflaps will improve the ditching performance of the airplane by making the ditching run longer and smoother with lower decelerations.

6. In rough water with wind speeds less than 25 miles per hour the airplane should be ditched at the 9° attitude with the flight path parallel to the wave crests; the airplane will probably heave or turn. If ditched across the waves, the airplane will probably heave or dive. In winds over 25 miles per hour the ditching should be made into the wind and across the waves.

INTRODUCTION

Tests were conducted in Langley tank no. 2 and on an outdoor catapult in order to determine the best way to land the P-38 airplane in calm and rough water and to determine its probable ditching behavior. The tests were requested by the Army Air Forces, Air Materiel Command, in their letter of March 26, 1943, WEL:AW:50.

FULL-SCALE EXPERIENCE

A report of only one full-scale ditching was available. In this ditching an approach was made into the swell with full flap, at an airspeed of about 80 miles per hour. The sea was rough, with a deep swell and a 35 mile per hour wind. The airplane was ditched over the crest of a roller and into the trough. The deceleration was not too severe. The flotation time was approximately 25 seconds. The ditching was considered successful and the pilot, who had his Sutton harness secured, sustained no injuries. The low touch-down speed of 40 to 45 miles per hour together with the bouyancy furnished by the empty gas tanks were given as the main reasons for the successful ditching.

PROCEDURE

Description of Model

A 1/9-size dynamic model of the P-38, shown in figure 1, was used in the tests. The type of construction used in building the model was similar to that described in reference 1; the model was of tissue covered balsa construction reinforced with hardwood at points of high stress. The model had a wing span of 5.78 feet and an over-all length of 4.20 feet.

Scale strength flaps like those described in reference 2 were used on the model. The aluminum brackets used for this purpose can be seen in figure 1.

Test Methods and Equipment

The apparatus and test procedure were similar to those described in references 1 and 2.

Test Conditions

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

Gross weight.- The gross weights tested were 14,900 pounds (normal weight) and 16,100 pounds (overload weight).

Location of center of gravity.- The center of gravity was located at 27.7 percent of the mean aerodynamic chord and 4.6 inches below the thrust line. A few runs were made with the center of gravity at a higher vertical location (0.10 inch above the thrust line) but no noticeable difference in behavior was observed.

Attitude.- The attitudes (of the thrust line) at which the model was tested were 13° (near stall), 9°, 5° (three point landing attitude), and 2°.

Landing gear.- No landing gear was provided on the model and all tests simulated ditchings with the landing gear retracted.

Flaps.- Three flap deflections were used in the tests: up, half down, and full down. In the two extended positions the flaps were fixed at scale strength. The Lockheed Aircraft Corporation indicated that, on each flap, a uniformly distributed load of 3000 pounds would cause failure.

Speeds.- The range of air speeds covered in the tests was from 91 miles per hour to 140 miles per hour. Most of the tests were made at speeds higher than those calculated from the lift curve furnished by the Lockheed Aircraft Corporation because the wing lift of the unpowered model, even with leading edge slats added, was insufficient at the calculated speeds. The correct wing lift was obtained by increasing the speed until the model was air-borne or actually glided into the water after its release. Table I, with one exception, gives two speeds for each attitude and flap setting; the lower speed is the calculated speed and the higher one is the air-borne speed. The exception is the 5° attitude,

20° flap setting, where only the air-borne speed is recorded since it was found to be less than the calculated speed.

Conditions of simulated damage.- Two conditions of simulated damage were used:

(a) No damage, (fig. 1).

(b) Three landing wheel doors removed, (fig. 2).

Ditching aid.- Some tests were made with two rectangular hydroflaps installed on the model, one on the undersurface of each boom or nacelle. Three sets of hydroflaps as shown in figure 3 were tested.

Condition of seaway.- A few runs were made in calm and rough water at the catapult to check the tank results and to give an indication of rough water performance.

RESULTS AND DISCUSSION

General

Summaries of the results of the tests in Langley tank no. 2 are presented in tables I, II, and III. Table IV gives the results of individual ditching runs at the outdoor catapult. The symbols used in the tables are defined as follows:

b deep run - a run in which the model travels through the water partially submerged and exhibits a tendency to dive although the attitude of the model is nearly level

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

e heave - a bouncing motion in which the model strikes the water and noses in slightly, rebounds or clears the water surface while remaining at nearly the same attitude, then strikes the water again

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

o oscillation in roll and yaw - an oscillating motion in roll combined with an oscillating motion in yaw caused by the nacelles of the model "digging in" alternately

p porpoising - an undulating motion about the transverse axis in which some part of the model is always in contact with the water surface

s skipping - an undulating motion about the transverse axis in which the model clears the water surface completely

t sharp turn - a violent angular motion about a vertical axis

In the tables, some of the behaviors are defined by two symbols, indicating combined behavior. For example, "eo" means that during the heave one nacelle dug in at the first contact with the water, and at the second contact the other nacelle dug in, thus giving a yawing motion to the ditching. Similarly, "et" means the model turned sharply at first contact in the heave and then landed at a different heading.

In a heave, the deceleration of the model at the first impact with the water was considerably higher than that at the second. This initial deceleration was comparatively high; as much as 11g was recorded.

Photographs showing characteristic behaviors of the model are shown in figures 4 and 5. Time histories of longitudinal decelerations are shown in figure 6.

The landing speed was the most important variable affecting performance. The highest decelerations as well as the most violent behaviors were encountered at the high speeds. There was no appreciable difference in behavior between the air-borne and lift-curve speeds.

Effect of Attitude

The profile of the P-38 is such that the rudder and vertical stabilizer extend some distance below the boom. Consequently, regardless of how high the attitude was when the tail of the airplane first contacted the water, the attitude fell to about 4° before the lower fuselage surfaces came in contact with the water. Since the fuselage came in contact with the water at approximately the same attitude in all ditchings, the primary effect of attitude was to change the landing speed. High-attitude, low-speed ditchings resulted in a mild form of heave, that is, the "nosing-in" tendency

was small and after the first impact the model did not rebound from the water to any great extent, (figs. 4(a) and 4(b)). Low-attitude, high-speed ditchings resulted in a violent rebound from the water and the model sometimes turned sharply. Also, there was a strong nosing-in tendency, and the model occasionally dived, (fig. 4(c)). Lower decelerations were obtained in the high-attitude ditchings than in the low-attitude ditchings, (fig. 6).

Effect of Flaps

The scale strength flaps seldom failed except when the model landed with one wing low. The flaps failed more often at the catapult (table IV) than in the tank, probably because of the additional impact of the waves. As indicated in table I and figures 4(a) and 4(b), the model with flaps up generally made a deep run, and with flaps down it usually heaved. Flaps half down caused behavior intermediate between those with flaps up and full down, that is, that was more of a tendency to heave with flaps half down than with flaps up. Figure 4 also indicates that flaps full down scale strength caused a slight pitching down moment. However, this effect appeared secondary in importance to the speed reduction obtainable with flaps down.

Effect of Simulated Damage

The maximum decelerations of the model when ditched with simulated failure of the landing wheel doors averaged 3g greater than the maximum decelerations occurring in ditchings of the undamaged model (table I). The tendency to heave and rebound from the water seemed greater in ditchings of the damaged model. When the nose wheel door was removed, the fuselage undersurface aft of the door opening occasionally tore off in a ditching, necessitating reinforcement of the model at this section.

Effect of Weight

Although the performance at both weight conditions was essentially the same (tables I and II), the deceleration and heaving action appeared greater at the overload weight condition than at the normal weight condition. This was probably caused by the higher landing speeds necessary at the higher wing loading.

Effect of Ditching Aids

The hydroflaps helped in counteracting the nosing in tendency, so that the model, when ditched, made longer and smoother runs, table III. Porpoising or skipping was the usual behavior. The large hydroflaps were more effective than the smaller ones. Change in the longitudinal location of the hydroflaps within the limits indicated on figure 3 caused no appreciable difference in behavior.

Effect of Seaway

In table IV the landing attitudes listed for the rough water ditchings are not exact because gusts of wind sometimes caused the model to change attitude after it left the launching carriage.

The wave height obtained in the open sea for a given wind velocity as given in the "Wind and Sea Prediction Table" in reference 3 is greater than the wave height obtained at the catapult for the same wind velocity. Consequently the behavior of the model in rough water may be somewhat optimistic since in upwind ditchings the wave heights were lower than they should have been for the ground speeds at which the model was ditched.

In ditchings across the waves, and at high attitudes, the model showed a tendency to be pitched down by a wave striking the tail. In ditchings along the waves, there appeared a tendency to turn. For both wave conditions, however, the heaving motion was predominant (fig. 5).

Since diving is such a severe motion, the airplane should generally be ditched parallel to the waves to reduce the possibility of a dive occurring from the tail striking a wave crest. The model tests were not made at wind speeds high enough to indicate whether the behavior in ditchings across the waves would improve in very strong winds. However, in winds of about 25 miles per hour or greater, a considerable reduction in speed could be obtained by landing into the wind, so in winds of this magnitude it would probably be advantageous to land into the wind. The success of the full-scale ditching mentioned earlier in this report is in agreement with this conclusion.

CONCLUSIONS

From the results of the tests of a 1/9-size model the following conclusions were drawn:

1. The airplane should be landed at a tail down attitude (thrust line at 9° to 13°) with flaps full down.

2. When ditched in calm water at the 9° attitude the airplane will probably heave with a high deceleration at the first contact with the water.

3. The landing should be made with the wing laterally level, otherwise a violent turn or an oscillation in yaw may result.

4. The airplane should be landed at the lightest weight possible.

5. Hydroflaps will improve the ditching performance of the airplane by making the ditching run longer and smoother with lower decelerations.

6. In rough water with wind speeds less than 25 miles per hour the airplane should be ditched at the 9° attitude with the flight path parallel to the wave crests; the airplane will probably heave or turn. If ditched across the waves, the airplane will probably heave or dive. In winds over 25 miles per hour the ditching should be made into the wind and across the waves.

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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.

2. Jarvis, George A., and Tarshis, Robert P.: Ditching Tests with 1/20-Size Models of the Army B-29 Airplane in Langley Tank No. 2 and from an Outdoor Catapult. NACA MR No. L6B04, Army Air Forces, 1946.

3. Anon.: Landplane Ditching Manual Prepared. Air Sea Rescue Bull. No. 4, Air Sea Rescue Agency (Washington), Oct. 1944, pp. 4-8.

TABLE I.- SUMMARY OF RESULTS OF DITCHING TESTS OF A 1/9-SIZE MODEL OF THE ARMY P-38 AIRPLANE AT THE NORMAL WEIGHT CONDITION IN CALM WATER IN LANGLEY TANK NO. 2

[All values are full scale]

Attitude, thrust line (deg)			13						9					5			2	
Damage	Speed (mph) / Flaps	(1)	91	102	110	115	117	130	101	116	123	133	140	115	132	135	130	140
No damage simulated	Up	Run				7		11				6	7					
		Max				8		8				---	---					
		Rmk				b		e				b	b					
	Down 20°	Run		6			6			5	5					10		
		Max		---			---			---	---					---		
		Rmk		e			b			e	b					e		
	Down 37°	Run	5		7				5	7				7	10			
		Max	--		5				4	5				6	5.2			
		Rmk	e		e				eo	eo				e	e			
Simulated failure of the three landing wheel doors	Up	Run				5		5				4	9					
		Max				---		11				---	11					
		Rmk				b		b				e	e					
	Down 37°	Run	6		5				5	7				5	5		3	6
		Max	--		8.2				---	8				---	9		---	10
		Rmk	e		e				e	eo				e	eo		ed	et

[1]Column notations are explained as follows:

Run - Length of run, given in multiples of the length of the airplane

Max - Maximum deceleration, given in multiples of the acceleration of gravity

Rmk - Notations under this heading have the following meaning:

b - ran deeply
d - dived slightly
e - heaved
o - oscillated in roll and yaw
t - turned sharply

TABLE II.- SUMMARY OF RESULTS OF DITCHING TESTS OF A 1/9-SIZE MODEL OF THE ARMY P-38 AIRPLANE AT THE OVERLOAD WEIGHT CONDITION IN CALM WATER IN LANGLEY TANK NO. 2

[All values are full scale]

Attitude, thrust line (deg)			13		9		5	2
Damage	Speed (mph) / Flaps	(1)	117	135	129	140	138	140
No damage simulated	Up	Run		9		9		
		Rmk		e		b		
	Down 37°	Run	5		10		8	8
		Rmk	e		et		e	et
Simulated failure of the three landing wheel doors	Up	Run		9		6		
		Rmk		e		db		
	Down 37°	Run	7		9		5	5
		Rmk	e		e		e	et

[1] Column notations are explained as follows:

Run - Length of run, given in multiples of the length of the airplane

Rmk - Notations under this heading have the following meaning:

b - ran deeply
d - dived slightly
e - heaved
o - oscillated in roll and yaw
t - turned quickly

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TABLE III.- SUMMARY OF RESULTS OF DITCHING TESTS OF A 1/9-SIZE MODEL OF THE ARMY P-38 AIRPLANE WITH HYDROFLAPS AT THE NORMAL WEIGHT CONDITION IN CALM WATER IN LANGLEY TANK NO. 2

[All values are full scale]

Damage	Attitude, thrust line (deg)			13		9	5
	Speed (mph)			110	130	116	132
	Hydroflap (2)	Flaps	(1)				
Simulated failure of the three landing wheel doors	1	Up	Run		10		
			Rmk		hb		
		Down 37°	Run	10		11	17
			Rmk	p		sb	sh
	2	Down 37°	Run	8			
			Rmk	pb			
	3	Down 37°	Run	5		8	17
			Rmk	h		sb	sb

[1]Column notations are explained as follows:

Run - Length of run, given in multiples of the length of the airplane

Rmk - Notations under this heading have the following meaning:

b - ran deeply
h - ran smoothly
p - porpoised
s - skipped

[2]Hydroflap designation is explained in figure 3.

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TABLE IV.- DITCHING TESTS OF A 1/9-SIZE MODEL OF THE ARMY P-38 AIRPLANE AT THE NORMAL WEIGHT CONDITION IN CALM AND ROUGH WATER AT THE OUTDOOR CATAPULT.

[All values are full scale]

	Attitude, thrust line (deg)	Air-speed (mph)	Flap setting (deg)	(1)	Wave height (in.)	Wind velocity (mph)	Behavior
Across waves, into wind	13	114	37	B	18	27	Turned sharply, one wing low, one flap failed
	13	107	37	B	18	29	Heaved, turned sharply, one flap failed
	9	125	0	A	13	17	Heaved
	9	137	0	A	13	27	Heaved, pitched down by wave striking tail
	9	140	0	A	13	23	Heaved violently, turned
Along waves, across wind	13	105	37	B	9	17	Heaved, turned sharply
	13	110	37	B	9	17	Heaved, two flaps failed
	9	100	37	B	13	24	Heaved, one flap failed
	5	122	37	B	9	12	Heaved, dived deeply, three flaps failed
	5	116	37	B	9	12	Dived slightly, heaved, three flaps failed
	5	115	37	B	9	14	Heaved, turned sharply, one flap failed
Smooth water	13	108	37	B			Dived slightly, one flap failed
	13	105	20	B			Ran deeply
	13	101	0	B			Ran deeply
	13	120	0	A			Heaved
	9	136	0	A			Oscillated in yaw, one wing low
	5	138	37	B			Heaved

[1]Condition of damage: "A" designates no simulated damage.
"B" designates simulated failure of the three landing wheel doors.

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FIGURE LEGENDS

Figure 1.- Photograph of a 1/9-size model of the Army P-38 airplane.

(a) Front view.

Figure 1.- Continued.

(b) Side view.

Figure 1.- Concluded.

(c) Bottom view.

Figure 2.- Photograph of a 1/9-size model of the Army P-38 airplane with the nose landing gear door and main landing gear doors removed.

Figure 3.- Installation of hydroflaps on model.

Figure 4.- Photographs of ditchings of a 1/9-size model of the Army P-38 airplane (0.563 seconds interval full scale). Simulated failure of the three landing wheel doors.

(a) Attitude of thrust line 13°; flaps down 37° scale strength; speed 110 miles per hour full scale.

Figure 4.- Continued.

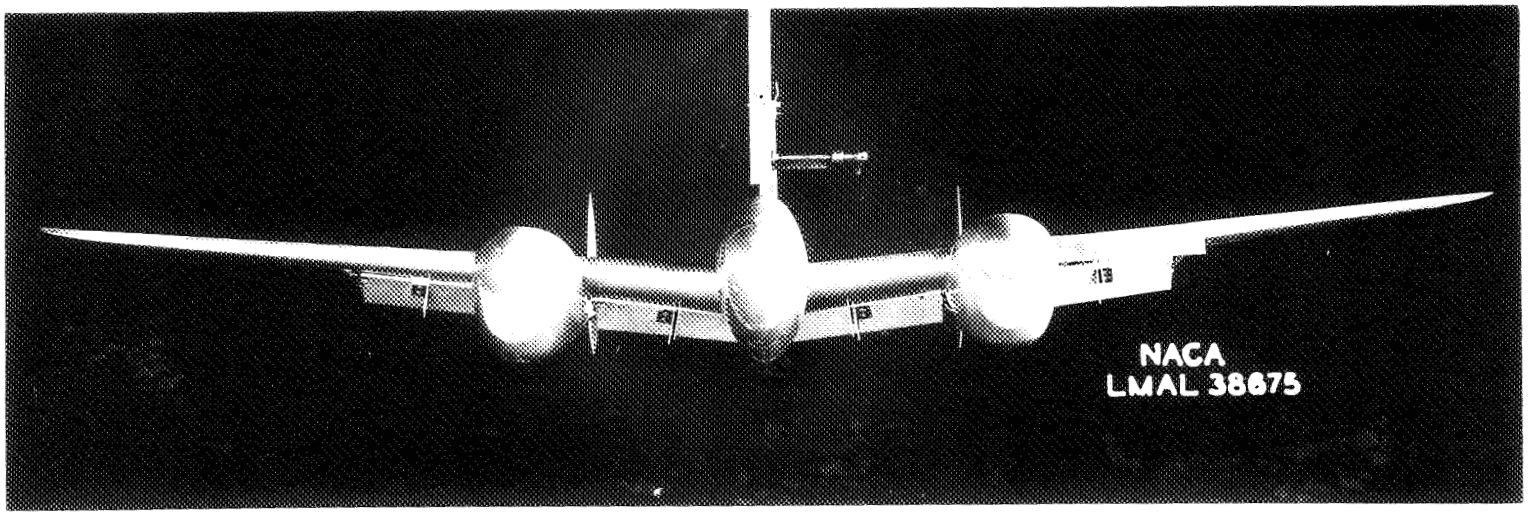
(b) Attitude of thrust line 13°; flaps up; speed 130 miles per hour full scale.

Figure 4.- Concluded.

(c) Attitude of thrust line 2°; flaps 37° scale strength; speed 140 miles per hour full scale.

Figure 5.- Photographs of a ditching of a 1/9-size model of the Army P-38 airplane. (Full scale time intervals indicated in seconds). Attitude 9°, flaps down 37°, speed 100 miles per hour, full scale. Simulated failure of landing wheel doors.

Figure 6.- Time histories of longitudinal decelerations for ditching tests of a 1/9-size model of an Army P-38 airplane at 14,900 pounds gross weight in calm water with flaps full-down. (All values are full scale.)



(a) Front view.

Figure 1.- Photograph of a 1/9-size model of the Army P-38 airplane.

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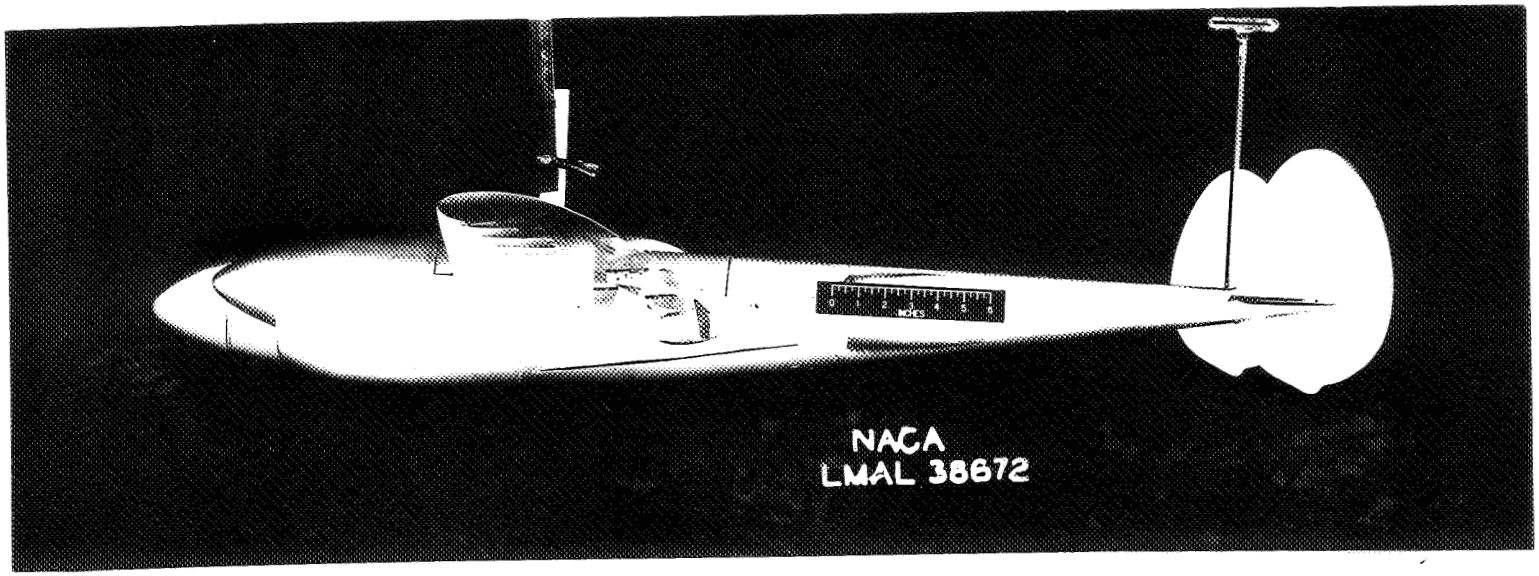

(b) Side view.

Figure 1.- Continued.

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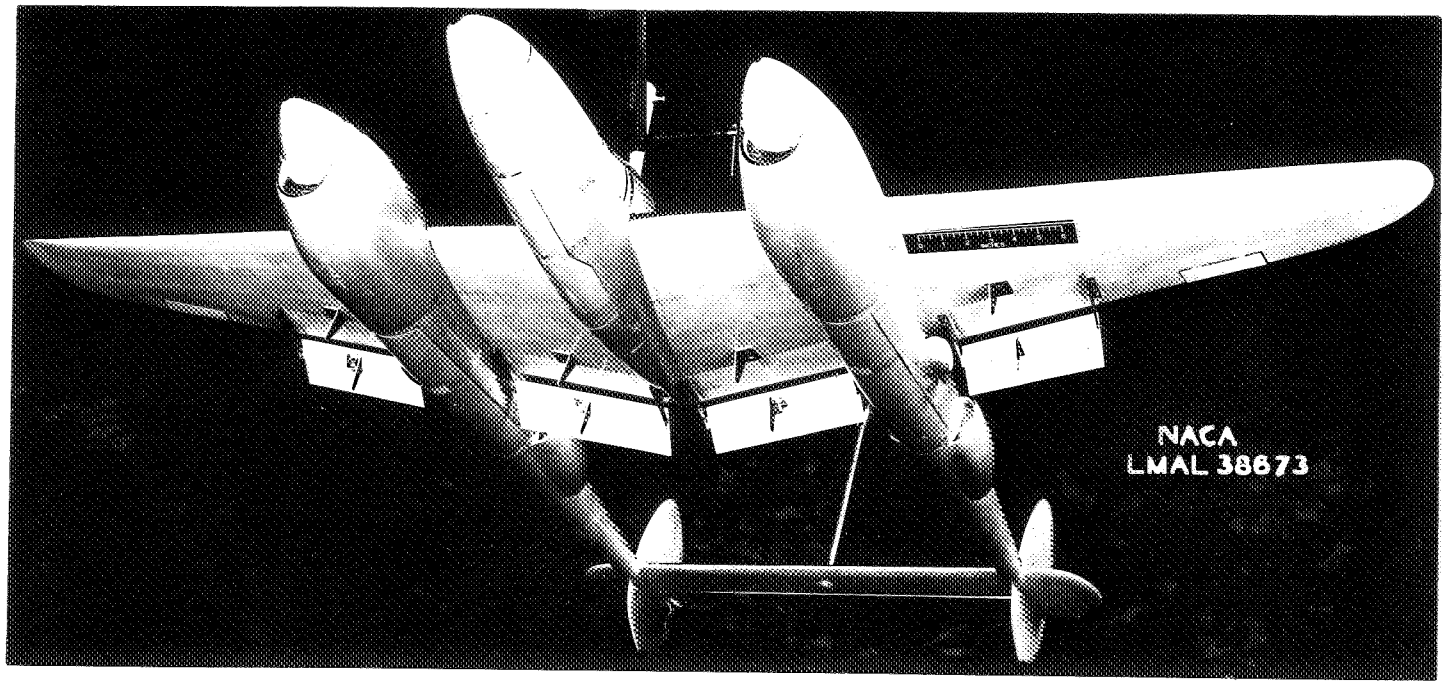

(c) Bottom view.

Figure 1.- Concluded.

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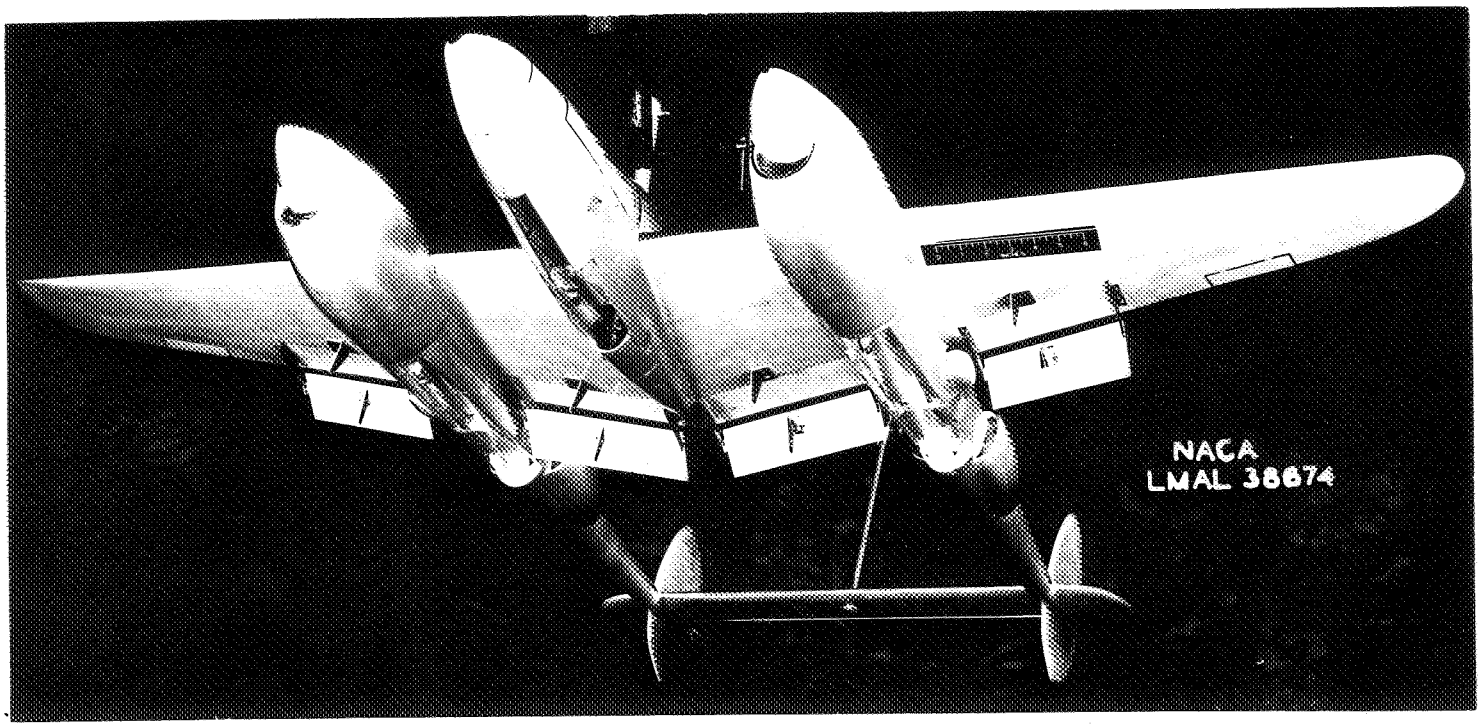

Figure 2.- Photograph of a 1/9-size model of the Army P-38 airplane with the nose landing gear door and main landing gear doors removed.

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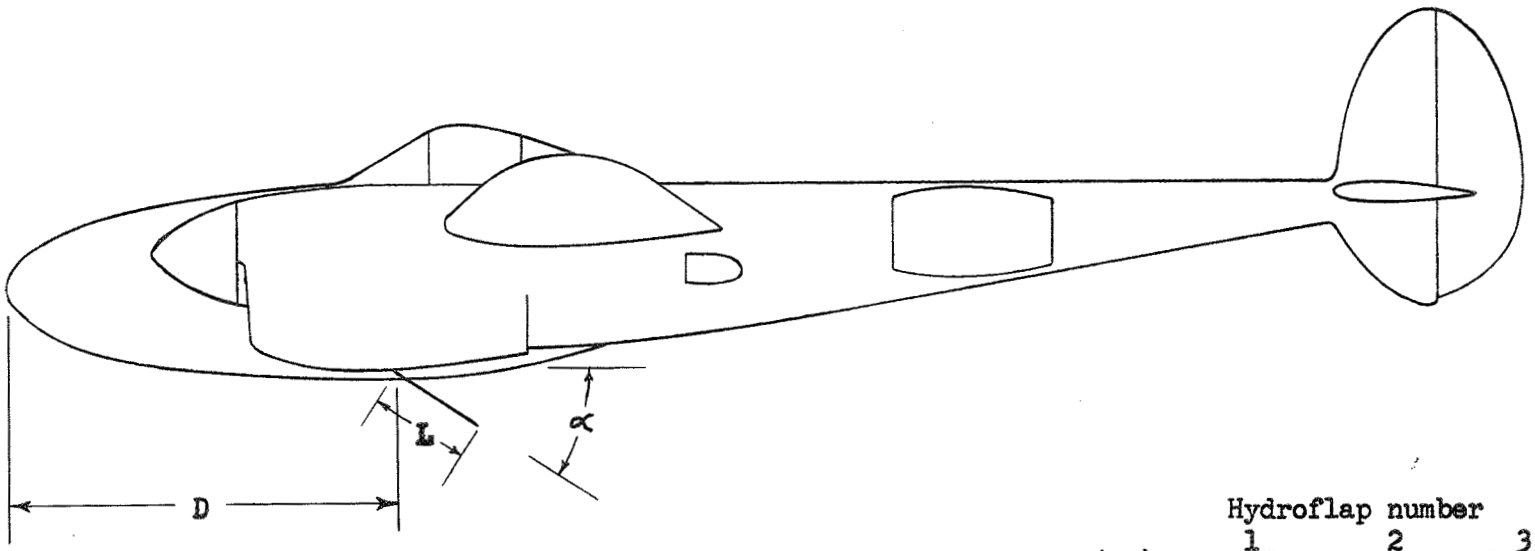

All linear dimensions in inches, full scale

	Hydroflap number		
	1	2	3
Angle with thrust line (α)	30°	30°	30°
Length (L)	27	27	18
Width (W)	9	9	9
Distance aft of nose (D)	114	97	97

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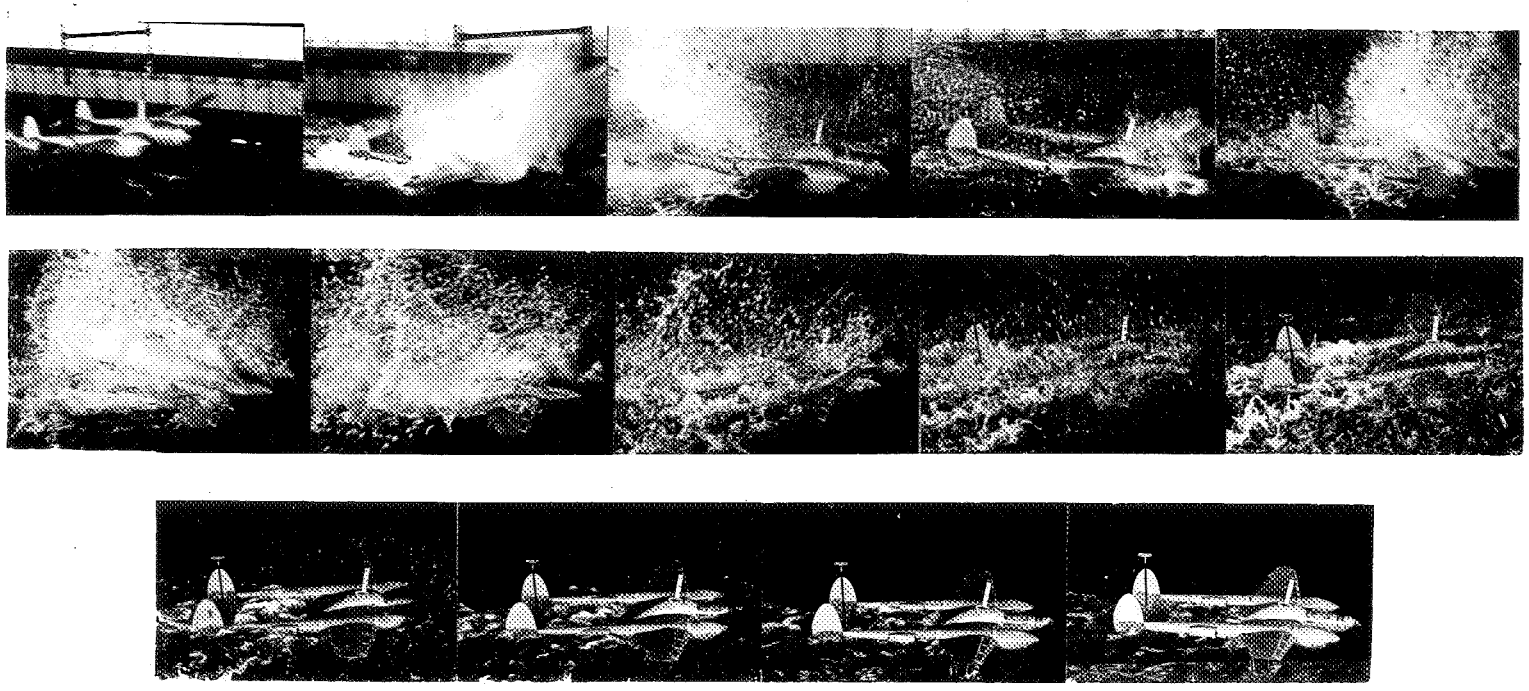
Figure 3.- Installation of hydroflaps on model.



(a) Attitude of thrust line 13°; flaps down 37° scale strength; speed 110 miles per hour full scale.

Figure 4.- Photographs of ditchings of a 1/9-size model of the Army P-38 airplane (0.563 seconds interval full scale). Simulated failure of the three landing wheel doors.

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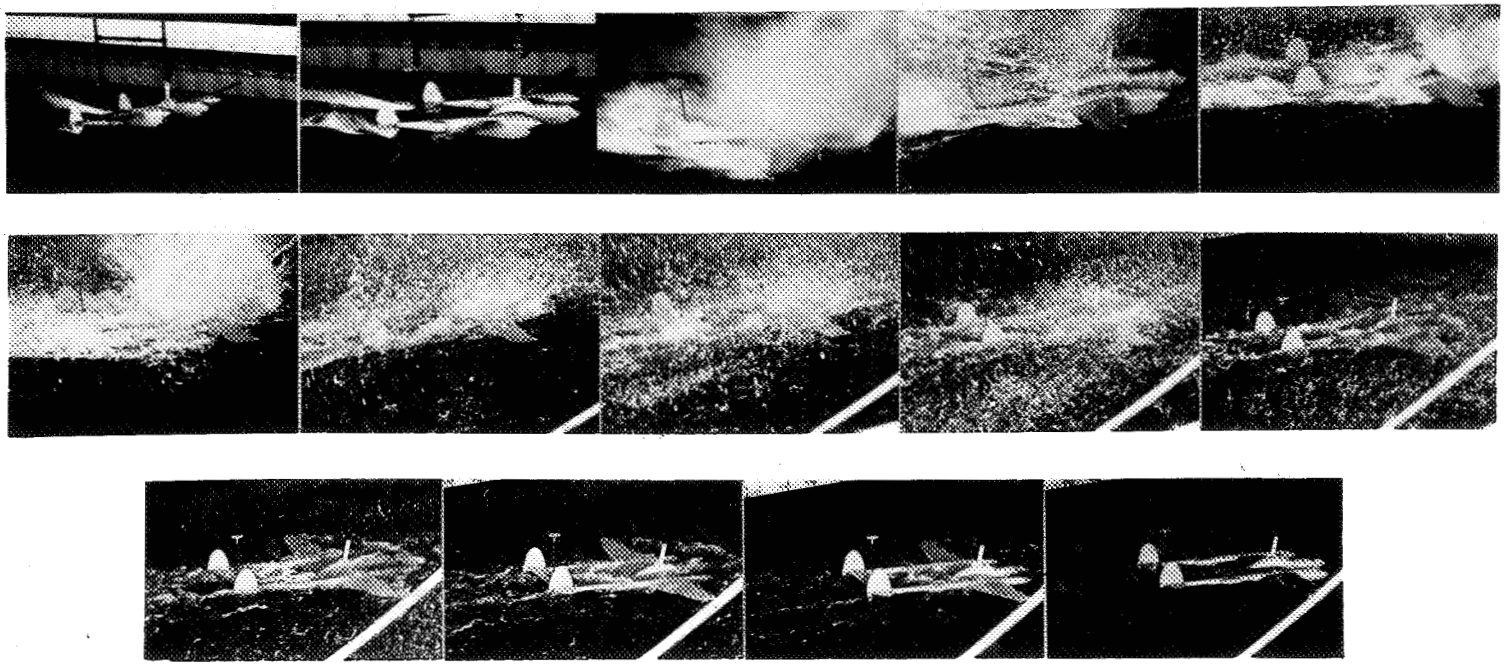

(b) Attitude of thrust line 13°; flaps up; speed 130 miles per hour full scale.

Figure 4.- Continued

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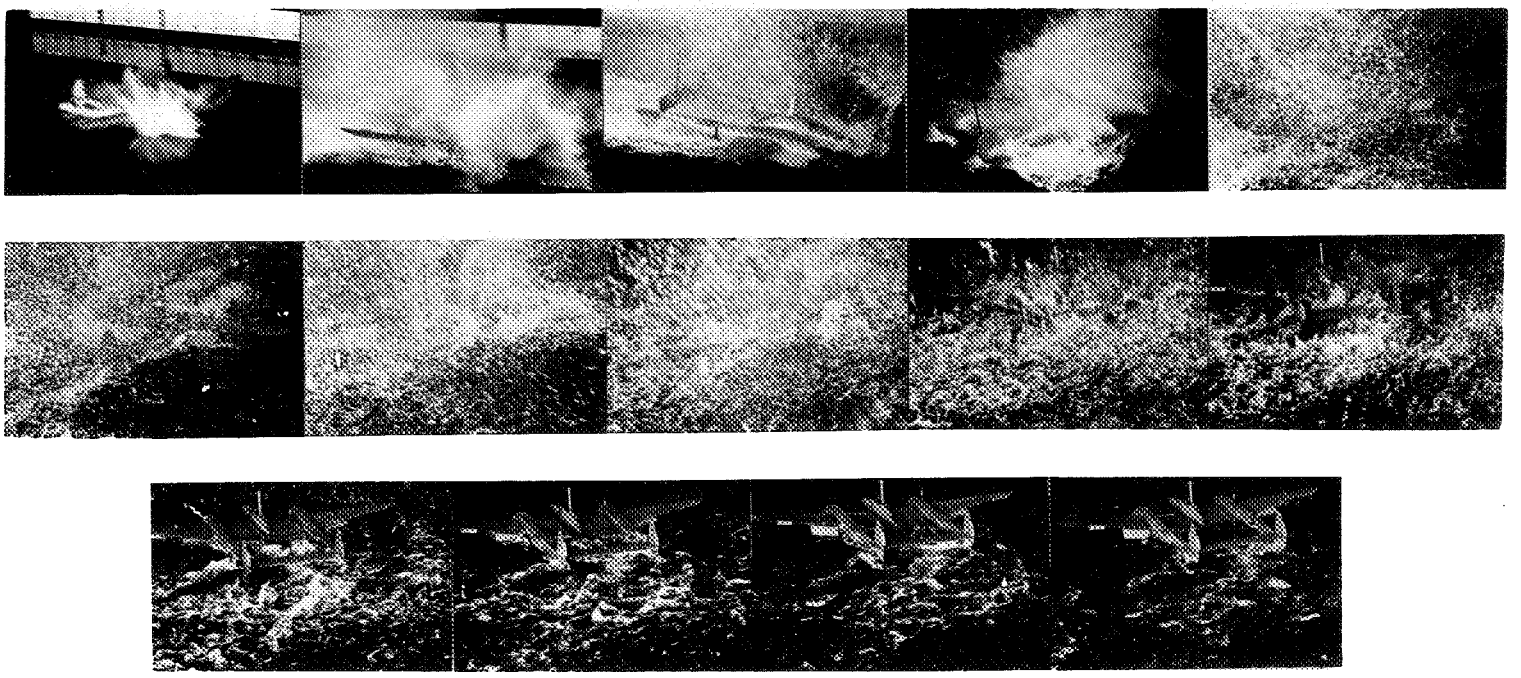

(c) Attitude of thrust line 2°; flaps 37° scale strength; speed 140 miles per hour full-scale.

Figure 4.- Concluded

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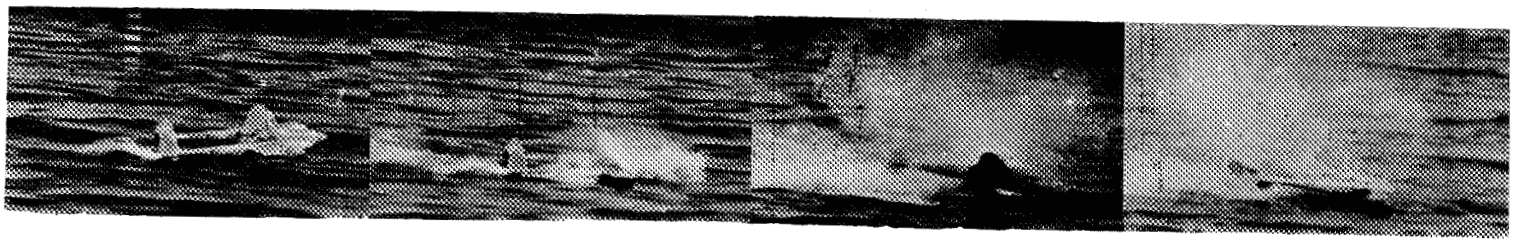

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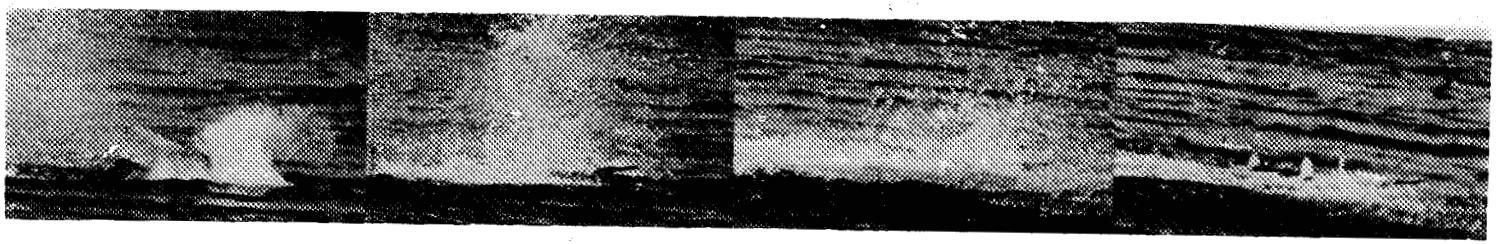

1.88 2.82 4.22 5.63

Figure 5.- Photographs of a ditching of a 1/9-size model of the Army P-38 airplane. (Full scale time intervals indicated in seconds). Attitude 9°, flaps down 37°, speed 100 miles per hour, full scale. Simulated failure of landing wheel doors.

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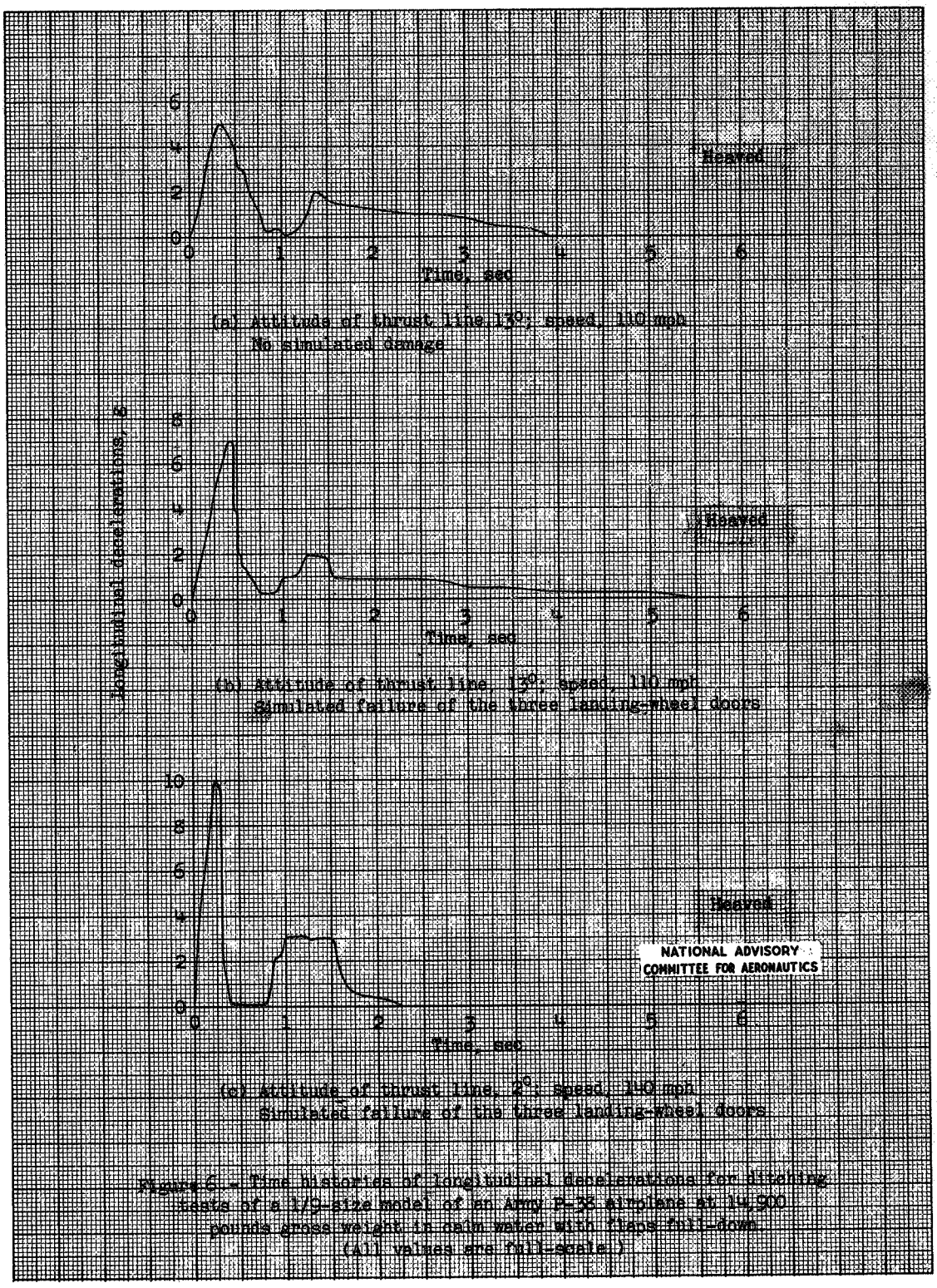

Figure 6.- Time histories of longitudinal decelerations for diving tests of a 1/9-size model of an Army P-38 airplane at 14,900 pounds gross weight in calm water with flaps full-down. (All values are full-scale.)