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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WARTIME REPORT

ORIGINALLY ISSUED

January 1945 as
Memorandum Report L5A16

DITCHING BEHAVIOR OF MILITARY AIRPLANES

AS AFFECTED BY DITCHING AIDS

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NACA

WASHINGTON

MR No. L5A16

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

MEMORANDUM REPORT

for the

Army Air Forces, Air Technical Service Command

DITCHING BEHAVIOR OF MILITARY AIRPLANES

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By Margaret F. Steiner

SUMMARY

Planing devices such as hydroflaps and hydrofoils were installed on several dynamically scaled models of military airplanes, and their effectiveness in improving ditching characteristics was determined from tests covering a number of ditching conditions.

In general, these ditching aids were found to be of value. The ditching aids tested caused a reduction in the maximum longitudinal (along the fore and aft axis) decelerations and kept the forward part of the fuselage clear of the water during most of the run. In the case of a full-scale ditching this probably would result in less damage to the fuselage bottom and less flooding of the airplane, thus reducing the hazard to the crew.

As a background to the model tests, this report presents general information regarding ditching aids and some experimental data obtained during tests on a hydroflap in the impact basin at the Langley Laboratory.

Extensive tests with dynamic models were conducted at the Langley Laboratory in tank no. 2 and at an outdoor catapult to investigate the ditching characteristics of military airplanes.

It was found in these earlier tests that, in some instances, violent decelerations occurred because of the high hydrodynamic drag of protuberances such as turrets, wing flaps, and nacelles, because of the general shape of the fuselage bottom, or because ~~of~~ the effect of damage to various parts of the fuselage. Also, reports of full-scale ditchings had indicated that damage to the fuselage bottoms and the flooding of the fuselage led to quick sinking of the airplane after a ditching.

The earlier tests were accordingly extended to investigate the performance of dynamic models of several military airplanes equipped with ditching aids. These devices were designed to dissipate vertical and angular momentum, prevent the nose and nacelles from digging into the water, and deflect the water so as to reduce loads on the bomb-bay area.

This report presents data from tests which were made at an outdoor catapult to investigate the effectiveness of ditching aids.

GENERAL REQUIREMENTS OF DITCHING AIDS

On the basis of the previous model tests and actual experience a ditching aid to be effective should dissipate the vertical and angular momentum, prevent the nose of the airplane from digging into the water, and deflect the water away from the bottom of the fuselage so as to reduce loads under the pilot's compartment and on the bomb-bay doors during a ditching.

The above general requirements can be met by any one of several types of aids but to be practical the ditching aid should offer very little air drag, be simple, and require only slight modification to the airplane structure. The ditching aid may be placed at a point which is already reinforced to take landing loads, such as the nose wheel location or main landing-gear location. If this is done, the additional weight of a complete retractable ditching-aid installation for a large bomber should not exceed a few hundred pounds.

A device, which immediately suggests itself, is some sort of a planing surface in either the form of a hydroflap or a hydrofoil.

Hydroflaps.- The hydroflap, as used in these tests, is a long inclined plate installed beneath the forward portion of the fuselage or under the nacelles of an airplane. It serves as a shock absorber as it enters the water and, if of adequate size, it is able to absorb the landing impact and allow the aircraft to plane along the water with the nose, nacelles, and forward part of the fuselage bottom clear of the water.

Although the wake properties of a hydroflap are not too well established, it is thought that considerable area of the fuselage bottom will be afforded protection by the hydroflap wake.

The attitude of the longitudinal axis of the airplane during a ditching is usually of the order of 3° to 12°. To protect the nose, a hydroflap should be narrow laterally to limit the initial loading and should project a considerable distance, vertically, beneath the nose so that contact with the water of the flap and the rear of the fuselage would occur at about the same time. The flap should tend to hold the nose out of the water while the rear of the fuselage tends to sink into the hydroflap wake so that there should be little change in fuselage attitude during the early stages of a smooth-water ditching.

Hydrofoils.- Another ditching aid, which may accomplish the same purpose as a hydroflap but in a slightly different manner, is a V-type hydrofoil. This device, as used in these tests, is a plate having a span of several feet and a chord of about one-sixth to one-eighth of the span. It is suspended below the nose of an airplane by struts, has a slight dihedral in the spanwise direction, and has a cross section of an airfoil.

As the hydrofoil contacts, it acts as a planing plate; however, its small chord length and low positive angle of incidence with the water surface permit it to immerse into the water. At a depth of 4 or 5 chord lengths the hydrofoil is not influenced by the surface of the water and except for cavitation airfoil conditions prevail. As the hydrofoil again approaches the surface, reduction in the mass of water flowing above the hydrofoil causes reduction in the negative pressures on the upper surface and as it leaves the water, it again acts as a very wide hydroflap.

If the nose hydrofoil has a negative attitude at any time during a ditching, it will cause a downward force which will be hazardous. In order to eliminate this danger it may be desirable to have the hydrofoil operate at a high angle of attack. If this is done, complete cavitation should occur throughout the immersion and the hydrofoil will act similar to a wide hydroflap rather than an airfoil.

APPARATUS AND PROCEDURE

The apparatus used and the general procedure followed at the outdoor catapult in conducting model tests are described in references 1 and 2.

Dynamic models of the Army B-26, B-25, B-17F, B-24, and A-20A airplanes were used in the tests. All of the models except that of the B-17F airplane were altered to simulate damage of such parts as the bomb doors, nose-wheel door, bottom hatches, and bombardier's window as described in reference 1. The B-17F model was tested with bomb doors intact and with the belly turret rigidly fastened in place and with simulated damage of nose window and bottom hatches since the most unfavorable ditching performance was obtained in this condition. Models of the B-25, B-26, and A-20A airplanes were tested with bomb doors in place which were designed to fail on direct contact with the water as in a full-scale ditching. Ditchings were made with and without ditching aids to determine roughly the extent of protection afforded to the weak bomb door by an aid.

The general specifications of the ditching aids, which were installed on the various models, are presented in table I.

Typical installations of the nose hydroflap, nacelle hydroflaps, and a nose hydrofoil are presented in figures 1, 2, and 3.

RESULTS

Hydroflap test in the impact basin.- As a background to the model tests, a preliminary test was made in the impact basin to obtain the general characteristics and pressure distribution that might be expected of a hydroflap. The apparatus and general procedure used are described in reference 3. One run was made with a model hydroflap of 9-inch width inclined at an angle of 30° to the water surface and with a weight of 2400 pounds loading the model. The velocity parallel to the water surface was 92.5 feet per second while the velocity normal to the water surface was 9.25 feet per second. (See fig. 4.)

This run may be considered as representative of a full-scale ditching at 90 miles per hour by scaling all values according to the laws of similitude. The corresponding values for the full-scale condition are a velocity normal to the water of 13.2 feet per second, a hydroflap width of 13.5 inches, and a load on the hydroflap of 20,600 pounds.

In a normal tail-down ditching attitude the tail of the fuselage and the hydroflap each carry part of the inertia loads. This run may be considered as representative of the different military airplanes being investigated (having gross weights ranging from 20,000 to 50,000 lb) if different proportions of the water load are considered to be acting on the hydroflap and on the tail of the fuselage.

Figure 5 is a sketch which specifies a possible ditching condition approximately represented by the experimental run.

Figure 6 presents the results obtained in the above run in the form of time histories of pressures, acceleration, vertical velocity, and vertical displacement. Two accelerometers were used to measure the impact acceleration. The instrumentation used to obtain the other variables is described in reference 3. The pressure gages were of the diaphragm type with a strain gage installed to indicate electrically the time histories of the pressure occurring at two points along the hydroflap.

The general shape of the pressure time histories at all immersed points along the center line of the hydroflap is indicated by the time-history plots of the recorded pressures occurring at the location of the two pressure instruments.

As a point entered and left the water it experienced a peak pressure approximately equal in magnitude to the maximum dynamic pressure for the effective velocity at which the point was traveling relative to the water. During the rest of the immersed period, the value of the pressure was about one-half of the peak value.

The peak values would have been slightly less at points farther up on the hydroflap than they were at the locations of the pressure gages used in the tests. For the over-all hydroflap design a uniformly distributed sustained pressure of one-half the peak value could be assumed while the peak pressure values could be used in the local design of the hydroflap.

The hydroflap immersed about 25 inches vertically (full scale) before vertical motion was dissipated. This depth would have required a hydroflap inclined at 30° to the fuselage bottom and approximately 6 feet in length to keep the nose of the fuselage clear at the test speed.

Dynamic model tests at the outdoor catapult.- To allow for variations in seaway, wind, or testing technique several runs were usually made with a model holding the attitude, speed, and structural damage constant.

Table II summarizes the observed general performance of the various models with and without a ditching aid. The number of runs considered and the conditions of seaway are indicated.

Table III presents values of maximum longitudinal decelerations (along the fore and aft axis) obtained in ditchings of various models with and without ditching aids. Typical runs made under similar conditions are compared to demonstrate the effect of ditching aids on maximum longitudinal decelerations.

Table IV presents data which roughly indicate the extent that ditching aids protect the bomb doors.

Figure 7 is a plot of time histories of longitudinal decelerations obtained in typical ditchings of several dynamic models with and without a ditching aid.

Figures 8 through 13 are photographic sequences comparing the ditching performance of the various models with and without ditching aids. The runs were selected to demonstrate the need for a ditching aid in particular instances and to show the effectiveness of the ditching aid in satisfying this need. All of the runs are typical with the exception of the B-26 model ditched without an aid. This was the worst run that occurred with the model ditched in either smooth water or across swells. It is presented inasmuch as it clearly indicates that a need may exist for improving the ditching performance of an airplane which normally has good ditching characteristics (reference 1).

DISCUSSION OF MODEL RESULTS

<u>Effect of ditching aids on ditching performance.</u>- In high-altitude ditchings the most effective nose hydroflap tested was a long slender one which contacted at about the same time as the tail of the fuselage.

In the lower initial attitudes tested, this type of ditching aid caused skipping. In the worst cases, the airplane pitched in the air, stalled, and re-entered the water with a slightly negative attitude. Since the hydroflap angle was decreased, the nose of the airplane was not always held clear during the rest of the run.

The hydrofoil used was always effective in smooth water in holding the nose and nacelles clear and long smooth runs resulted. In the ditchings made at high speeds the model skipped but maintained its trim and the nose and forward part of the fuselage was held clear until late in the run. However, from the previous discussion it is clear that care must be taken to prevent the hydrofoil from operating at a level or negative angle of attack.

On the low-wing airplane upon which the nacelle hydroflaps were tested, they were effective in smooth water. They reduced the drag of the nacelles and at the same time kept the nose clear when the angle of the hydroflaps with respect to the water was such as to keep the resultant force forward of the center of gravity.

The nacelle hydroflaps were successful in preventing violent turns in wing-low landings by reducing the nacelle drag and therefore the high yawing moment.

Effect of ditching aids upon deceleration. - In every instance the maximum longitudinal deceleration (along the fore and aft axis) was decreased when an aid was used. In most runs the deceleration was greatly decreased over that experienced in runs without an aid, although, in a few instances, there was much benefit offered by an aid.

Protection of fuselage bottom. - In landings in smooth water and parallel to the waves, there was an indication that some protection to the fuselage bottom would be accomplished by the nose hydroflap. The hydrofoil also afforded some protection to the forward half of the fuselage bottom insofar as that portion was held clear of the water until late in the run.

Effectiveness of ditching aids in rough water. - The nose hydroflap and hydrofoil were installed in models which were ditched in smooth and rough water. Both devices were most effective in smooth water but appeared to be of considerable value in moderate seaway when landing paralled to the waves.

The hydroflap usually succeeded in holding the mose clear in ditchings made across the waves except in a few cases when the model skipped and re-entered in a nose-down attitude so that the hydroflap trim angle was very small.

The hydrofoil was effective in landing across swells but was not tested in rough breaking waves.

The nacelle hydroflaps used were too small and provided insufficient pitching moment to be of much value in a ditching across the waves but longer and wider hydroflaps would probably have improved ditching performance in rough water.

General observations. - Judging from model tests it would be best to have a nose-ditching aid in conjunction with aids under each of the inboard nacelles.

If hydroflaps are used, they should be trapezoidal in plan form and it would be desirable for the nacelle flaps to have a V-type cross section (dihedral) in order to introduce appropriate forces for reducing the yaw that accompanies a slightly wing-low ditching.

It would be preferable to have all hydroflaps contact the water at about the same time as the tail of the airplane in order to minimize pitching.

If a hydrofoil is used it would be desirable for it to be installed so that it will have little opportunity to operate at a level or negative attitude.

Retractable ditching aids should have negligible effect upon the top speed of the airplane.

CONCLUSIONS

The following conclusions are based on tests made with dynamic models of military airplanes landed in calm and rough water at an outdoor catapult.

1. Ditching aids would be an asset to airplanes which are forced to operate extensively over seaway because of the following beneficial effects in event of a ditching:

a. Decreased deceleration.

b. Protection of forward fuselage bottom.

c. Reduction of diving tendency.

d. Reduction of yawing tendency during wing-low ditchings.

2. Ditching aids placed under the nose and under the nacelles, which house the main landing gear, would be practical means of improving the ditching behavior of military airplanes.

Langley Memorial Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., January 16, 1945

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2. Jarvis, George A., and Steiner, Margaret F.: Ditching Tests with a 1/11-Size Model of the Army B-25 Airplane in NACA Tank No. 2 and on an Outdoor Catapult. NACA MR No. L4J11, 1944.

3. Batterson, Sidney A.: The NACA Impact Basin and Water Landing Tests of a Float Model at Various Velocities and Weights. NACA ACR No. L4H15, 1944.

L-647

TABLE I

DITCHING AID SPECIFICATIONS

(All values are full-scale)

	B-17F	B-24	B-25	B-26	A-20A
Hydrofoil - V-type, 2 strut support					
Span, in.	96			96	
Chord length, in.	16			16	
Foil section, plano convex	R = 19 in. Lower surface flat			R = 14.25" Lower surface flat	
Distance below fuselage reference line, approx. in.	64			81	
Angle made with fuselage reference line, approx. deg	+5			+5	
Longitudinal location with reference to most forward part of fuselage, approx. in.	-87			-87	
Angle of dihedral of hydrofoil, deg	15			15	
Nose hydroflap - Long					
Location with reference to most forward part of fuselage, approx. in.	-72		-74	-65	-65
Length, in.	60		77	72	84
Width, in.	24		22	24	20
Angle of inclination with fuselage reference line, deg	30		30	30	50
Shape of lower surface	Flat		Fuselage bottom curvature approximated.	Fuselage bottom curvature approximated.	Flat
Nose hydroflap - Short					
Location with reference to most forward part of fuselage, approx. in.	-72	-72	-74	-65	-65
Length, in.	36	36	64	66	50
Width, in.	24	24	22	24	20
Angle of inclination with fuselage reference line, deg	15	15	30	50	30
Shape of lower surface	Flat	Flat	Fuselage bottom curvature approximated.	Fuselage bottom curvature approximated.	Flat
Nacelle Hydroflaps (inboard nacelles)					
Location	On leading edge of cowling				
Length, in.	20				
Width, in.	8				
Angle of inclination with thrust line, deg	20				

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE II

EFFECT OF DITCHING AIDS ON PERFORMANCE OF DYNAMIC MODELS OF MILITARY AIRPLANES

(All values are full-scale)

Model	Attitude deg	Airspeed mph	Weight lb	Type of sea and character of approach	Type of loading	Performance of model: Without aid	With nose hydroflap	With hydrofoil	With nacelle hydrofoils	Number of runs considered: with aid	no aid
B-17F	10	90	57,000	Smooth	N	Porpoised, nacelles dug in deeply.	Skipped, nose clear	Smooth run, nose held clear	Forward part of fuselage clear	4a 4b 3a	6
					TL	Turned sharply	Smooth run	Smooth run			
				Along the waves	N	Short run, nacelles and nose dug in deeply.		Same as in smooth water		4b	6
				Across the waves	N	Ploughed deep into waves in a dive.			Nacelles dug into high waves	3a	3
	7	110	57,000	Smooth	N	Similar to 10° attitude runs.	Planed on hydroflap during most of run.	Smooth run resulted with nose clear.	Similar to 10° attitude runs.	3a 3b 3a	4
					TL	Similar to 10° attitude runs.			Turn resulted but no dive accompanied it.		
				Along the waves	N	Similar to 10° attitude runs.		Smooth run resulted. Nose held clear.		3b	4
				Across the waves					Rode over the waves. Nacelles dug in slightly.	3a	3
	3½	126	57,000	Smooth	N	Smooth runs resulted, nacelles dug in early in run.	Planed on hydroflap during most of run.	Long smooth run. Porpoised slightly.	Tended to porpoise or skip with nose held clear.	3a 4b 3a	6
					TL	Diving turn resulted.	Turns resulted with nose held clear.	Turn resulted, nacelles dug in deeply.	Low wing held clear, smooth run resulted.		
				Along the waves	N	Behaved similarly to smooth water run.		Similar to smooth water runs.		3b	6
				Across the waves	N	Skipped, then either rode over or dived into the water	Skipped, nose held clear.		Porpoised or skipped. Nacelles dug in slightly	1a 3a	3

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

TABLE II (Continued)

Model	Attitude deg	Airspeed mph	Weight lb	Type of economy and character of approach	Type of landing	Performance of Model: Without aid	With nose hydroflap	With hydrofoil	With nacelle hydrofoils	Number of runs considered: with aid	no aid
	0	145	37,000	Smooth	N	Nacelles dug in deeply immediately after contact in a shallow dive.	Skipped, nose held clear.	Skipped, nose clear until late in run.	Similar to 3½° attitude runs.	3a 4b 1c	3
					TL	Diving turns occurred.	Nose held clear of water during turn.				
				Along the waves.	N	Similar to 3½° attitude runs.		Similar to smooth water run.		1b	2
D-86	12	105	26,000	Smooth	N	Pitched up and down in water	Nose held clear until end of run.	Planed on hydrofoil until late in run.		4a 2b	3
				Across the waves	N	Approached a shallow dive as it ploughed through the swell	Porpoised slightly			3a	3
	6	140	28,000	Smooth	N	Usually porpoised or skipped and in one run re-entered in a dive.	Skipped slightly, trimmed very high with small portion of hydroflap immersed during most of run.			3a	4
				Along the waves.	N	Similar to smooth water run.	Similar to smooth water run.			3a	3
D-88	13	80	22,000	Smooth	N	Porpoised, raised considerable spray	Skipped with nose held clear.			2a	3
				Along the waves	N	Nose & nacelles dug in deeply.	Behaved similar to smooth water			2a	3
	9	90	22,000	Along the waves	N	Turned in all runs, nosed in during two runs	Planed on hydroflap and tail during 2 runs, thrown clear of water and re-entered in a dive in 1 run.			3a	3

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TABLE II (Concluded)

Model	Attitude deg	Airspeed mph	Weight lb	Type of nearby and character of approach	Type of landing	Performance of model				Number of runs considered	
						Without aid	With nose hydroflap	With hydrofoil	With nacelle hydrofoils	with aid	no aid
A-20A	13	90	17,400	Smooth	N	Low hanging nacelles raised considerable spray. Nose usually clear until end of run.	Planed on end of lower portion of hydroflap			1a	3
				Along the waves	N	Similar to smooth water runs.	Similar to smooth water runs.			2a	3
	4	115	17,400	Smooth	N	Porpoised, nacelles dug in during run.	Nose held clear during run.			2a	3
B-24D	9	96	45,000	Smooth	N	Pitched up after contact then nose dug in - fuselage rode low in water	Tended to porpoise			2a	4
	5	110	45,000	Smooth	N	Similar to 9° attitude run.	Smooth run usually resulted with nose held clear.			2a	3
	1	125	45,000	Smooth	N	Pitched up and down in water. Nose & nacelles dug in deeply at end of run	Skipped after first impact. Re-entered and porpoised.			2a	3

a - nose hydroflap
h - hydrofoil
n - nacelle hydroflaps
WL - wing low landing
N - normal landing

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TABLE III

EFFECT OF DITCHING AIDS ON MAXIMUM LONGITUDINAL DECELERATIONS

OF DYNAMIC MODELS OF MILITARY AIRPLANES

(All values are full-scale)

Model	Attitude fus.ref.line deg	Air Speed mph	Type of ditching aid	Type of seaway [1]	Maximum Deceleration without aid g	Maximum Deceleration with aid g
A-20A	13	90	hydroflap	rough water	5.81	3.54
	13	90	hydroflap	calm	5.38	3.77
	13	90	hydroflap	calm	4.92	3.44
	4	115	hydroflap	rough water	7.54	5.57
	4	115	hydroflap	rough water	7.70	4.60
B-26	12	110	hydrofoil	rough water	4.43	3.61
	12	110	hydrofoil	rough water	6.00	2.95
	12	110	hydroflap	calm	4.92	4.00
	12	110	hydroflap	calm	5.69	3.85
	12	110	hydroflap	calm	4.31	3.00
	8	120	hydrofoil	rough water	4.92	3.93
	4	140	hydroflap	calm	4.59	4.00
B-25	13	90	hydroflap	rough water	4.62	4.59
	13	90	hydroflap	rough water	5.08	4.59
	13	90	hydroflap	calm	4.62	3.61
	13	90	hydroflap	calm	4.62	4.10
	9	108	hydroflap	rough water	5.08	1.48
	9	108	hydroflap	rough water	6.29	2.30
	9	108	hydroflap	calm	7.38	3.40

1. Ditchings in rough water made parallel to the wave crests.

NATIONAL ADVISORY
COMMITTEE FOR AERONAUTICS

L-647

TABLE IV

PROTECTION OF BOMB DOORS BY DITCHING AID

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Model	Attitude fus.ref.line deg.	Air speed mph	Type of seaway 1	Type of ditching aid	With aid	Without aid
A-20A	13	90	rough water	30° hydroflap	Rear half of bomb doors failed.	Bomb doors designed to fail.
	13	90	rough water	30° hydroflap	Skin failed in rear one-quarter in 3 runs.	
	10	98	rough water	30° hydroflap	Later one-third of bomb doors failed.	
	4	115	rough water	30° hydroflap	Bomb doors remained intact in 2 runs	Bomb doors demolished
	2	120	rough water	30° hydroflap	Bomb doors intact in 2 runs	Bomb doors demolished
B-25	13	90	rough water	30° hydroflap	Bomb doors remained intact in 4 runs	Bomb doors demolished
	9	108	rough water	30° hydroflap	Bomb doors remained intact in 3 runs	
B-26	12	110	swells	30° hydroflap	Bomb doors protected in 4 runs	Bomb doors pulled out of airplane
	12	110	rough water	hydrofoil	Bomb doors protected in 2 runs	
	8	120	smooth	30° hydroflap	Bomb doors intact in 3 runs	Bomb doors designed to fail
	8	120	smooth	hydrofoil	Bomb doors intact in one run	Bomb doors demolished

1. Ditchings in rough water made parallel to the wave crests.

L-647

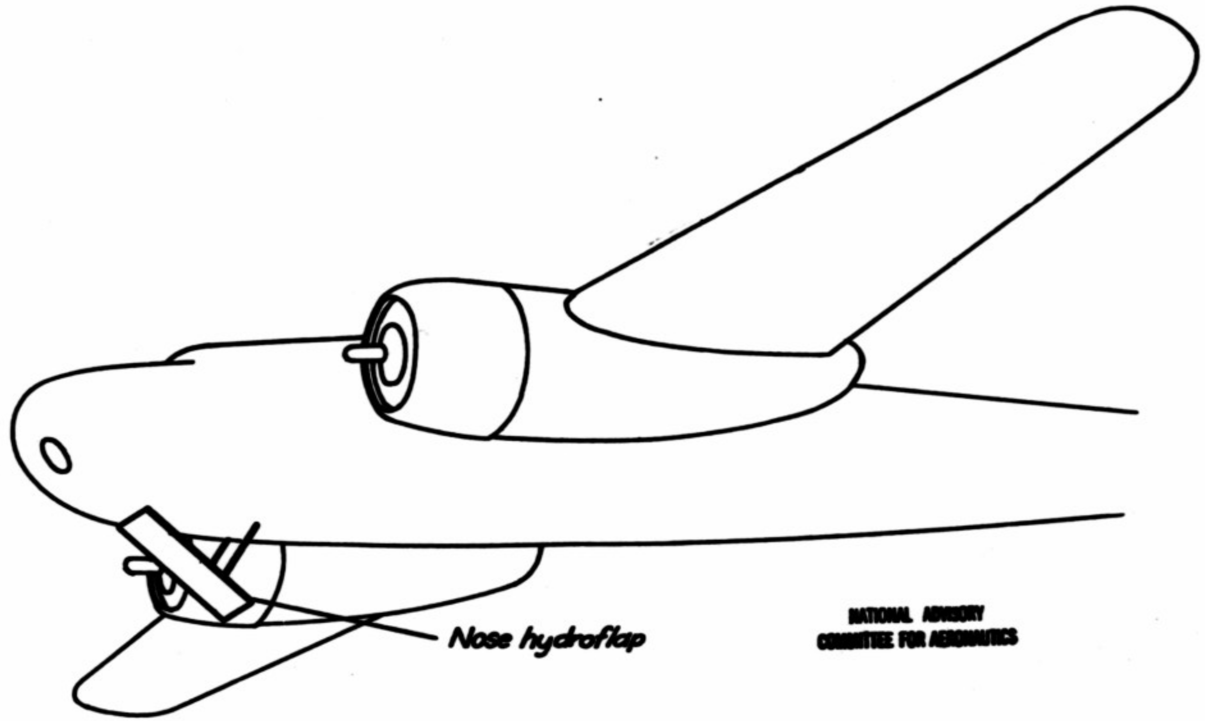

Figure 1.- Sketch showing installation of nose hydroflap on model of Army B-25 airplane.

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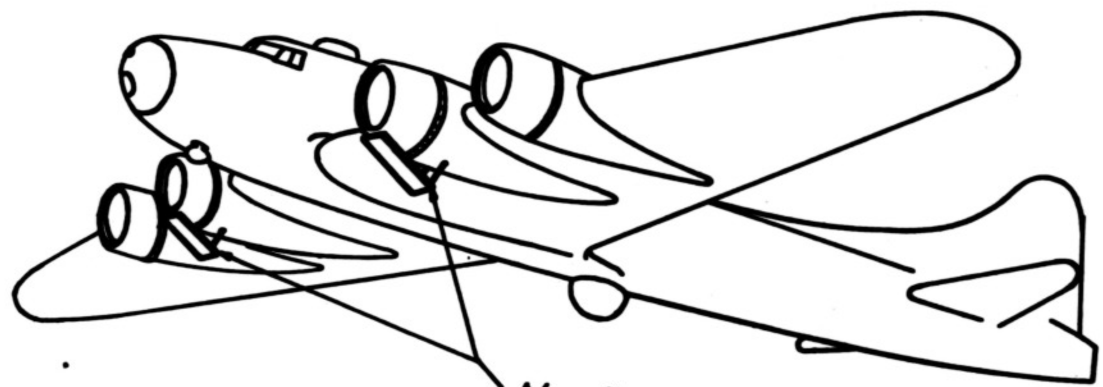

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Figure 2.- Sketch showing installation of nacelle hydroflaps on model of Army B-17F airplane.

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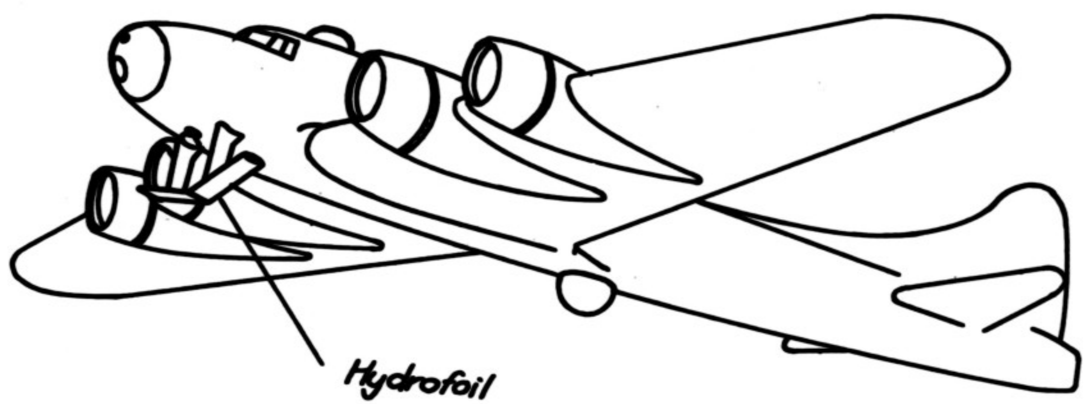

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Figure 3- Sketch showing installation of hydrofoil on model of Army B-17F airplane.

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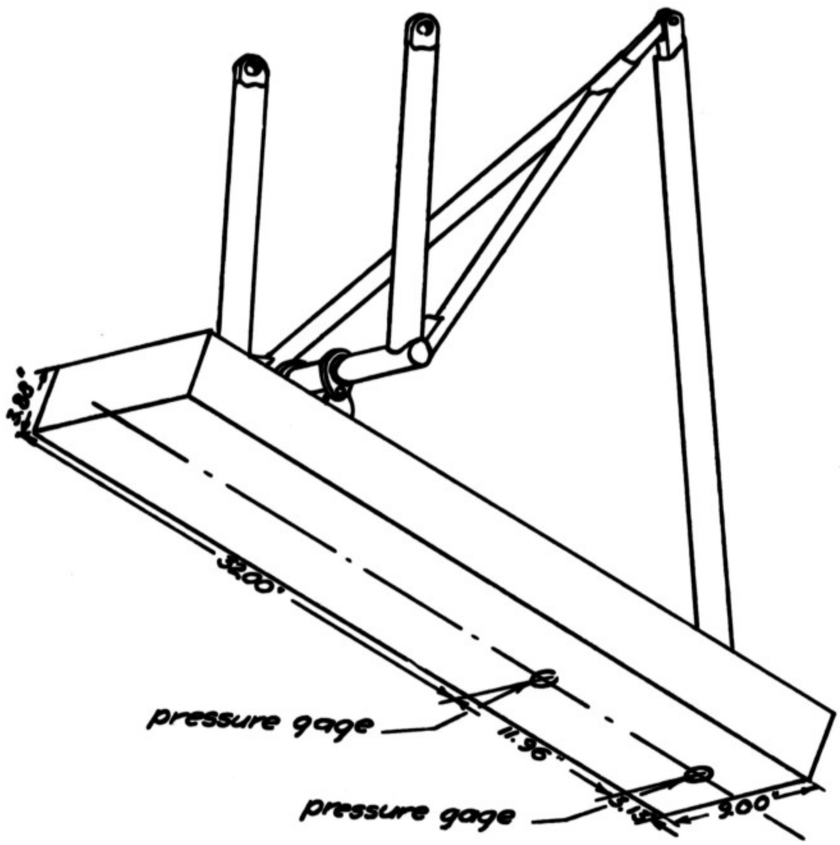

Figure 4.-Sketch of hydroflap tested in Impact Basin.

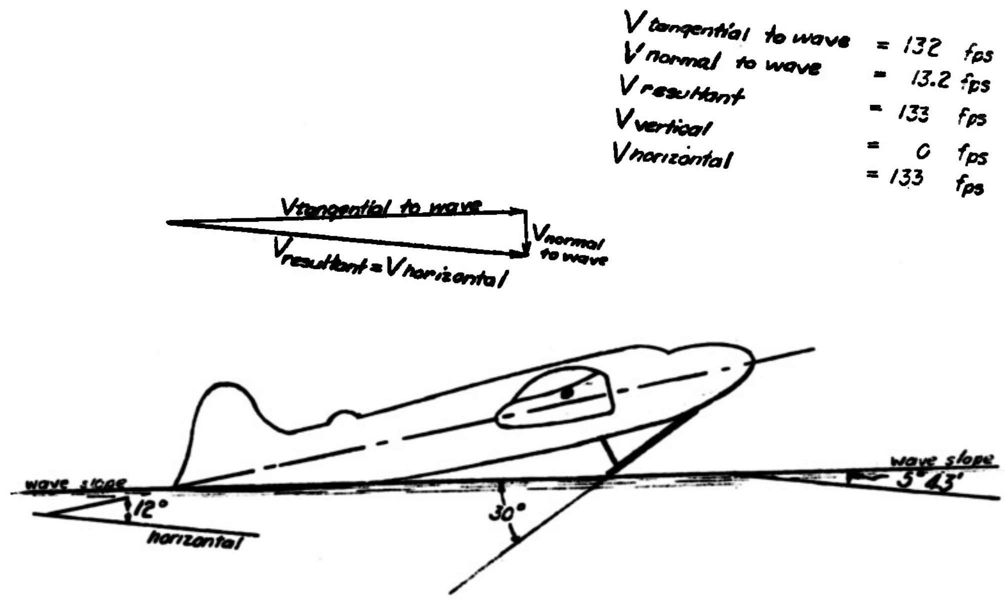

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Figure 5.- Full-scale ditching condition approximately represented by hydroflap test.

L-647

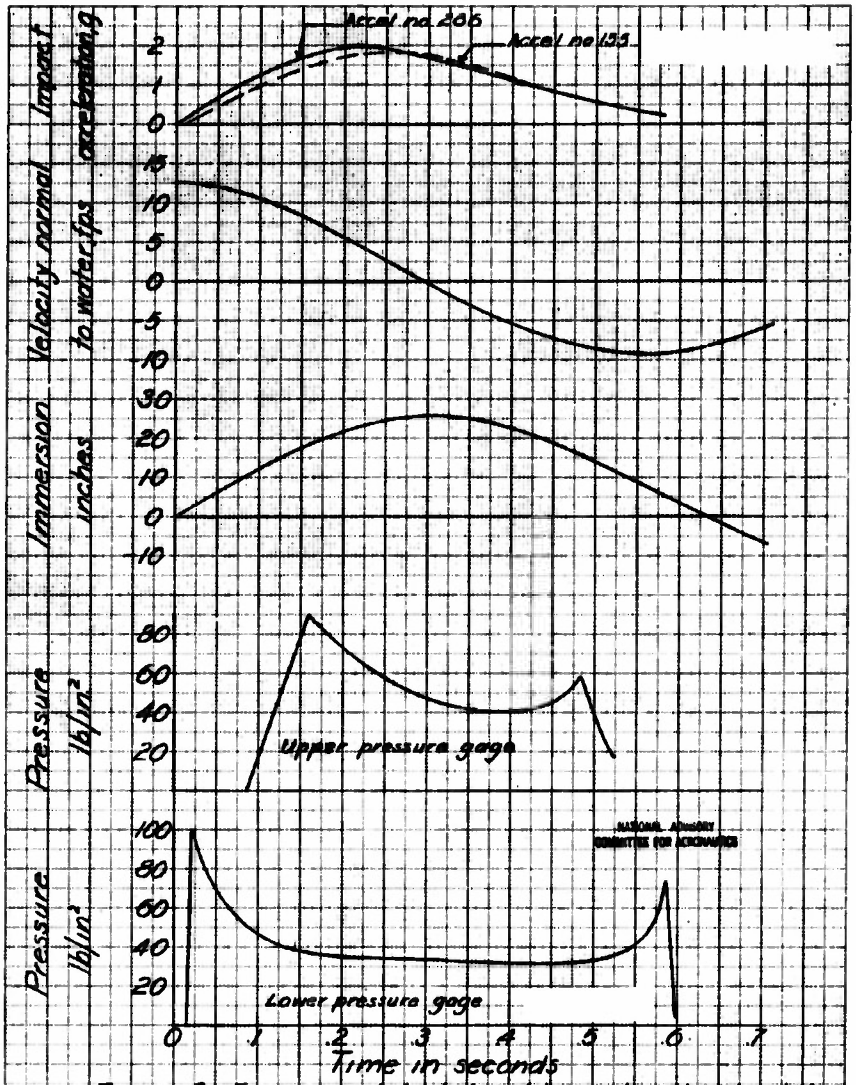

Figure 6.- Experimental data obtained with a model hydroflap at the Impact Basin. All values are full-scale.

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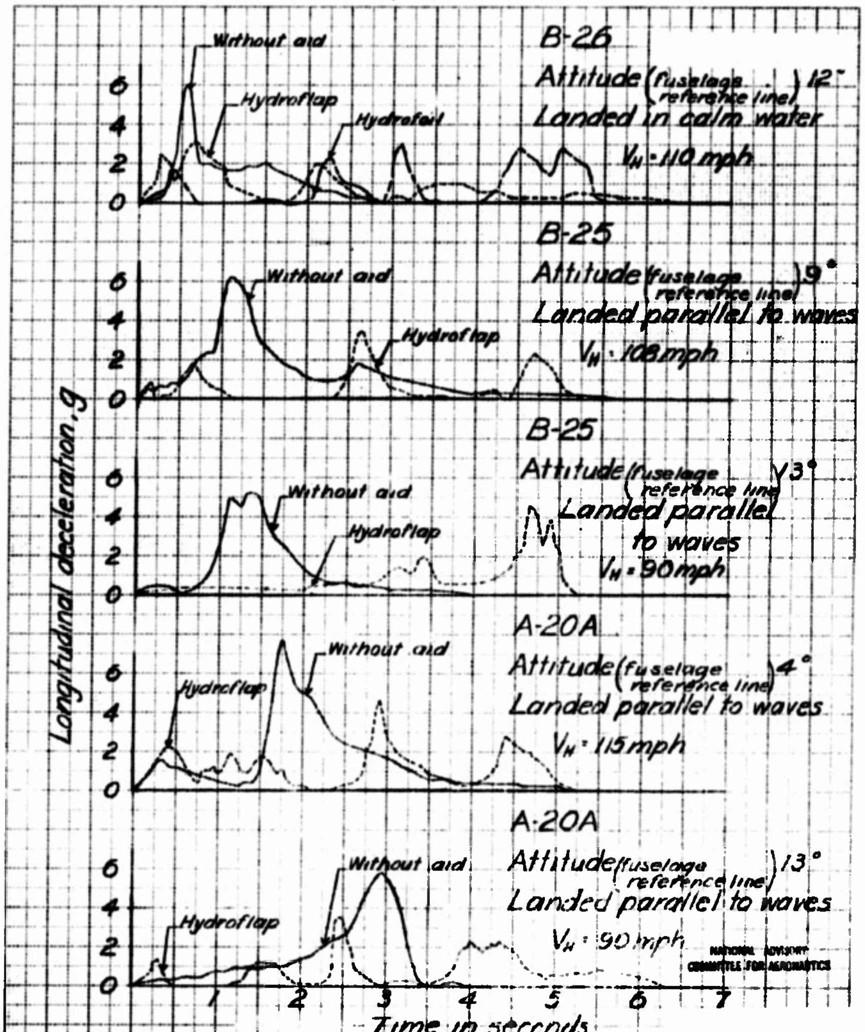
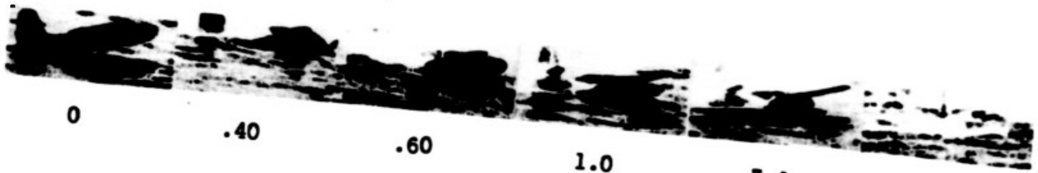


Figure 7.- Comparison of time histories of longitudinal decelerations of dynamic models of military airplanes with and without ditching aids. All values are full-scale.



Time in seconds.

(a) Without aid.

Time in seconds.

(b) With hydroflap.

Figure 8.- Photographs of a 1/10-size model of the Army A-20A airplane ditched along the waves with and without a ditching aid.

Attitude, fuselage reference line, 13°; airspeed, 90 mph.
Bomb-bay doors, bombardier's sighting window, and lower rear gun hatch were removed.

All values are full-scale.

L-647

0 .30 .35 .60 1.05 3.85

Time in seconds.

(a) Without ditching aid.
Attitude, fuselage reference line, 9°; airspeed, 108 mph.

0 .15 .40 .70 2.00 4.18

Time in seconds.

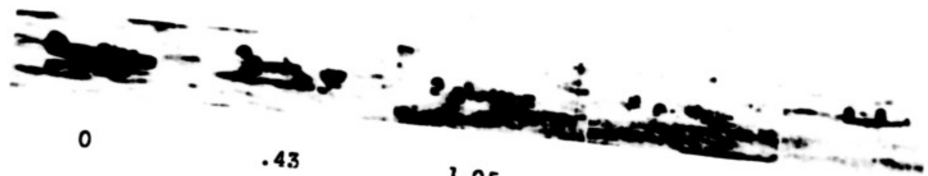
(b) With hydroflap.
Attitude, fuselage reference line, 13°; airspeed, 90 mph.

Figure 9.- Photographs of a $\frac{1}{11}$-size model of the Army B-25 airplane ditched along the waves with and without a ditching aid.

Bomb-bay and wheel doors, bombardier's windows, camera hatch, and bulkhead at after end of the bomb bay were all removed.

All values are full-scale.

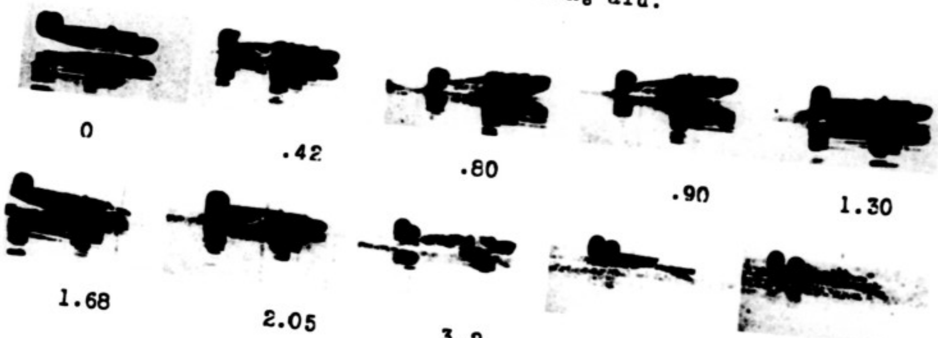
L-647



0 .43 1.05 1.80 4.42

Time in seconds.

(a) Without ditching aid.



Time in seconds.

(b) With hydroflap.

Figure 10.- Photographs of a $\frac{1}{16}$-size model of the Army B-24D airplane ditched with and without a ditching aid.

Attitude, fuselage reference line, 1°; airspeed, 125 mph. Bomb doors out, nose wheel door and bombardier's sighting window were covered with "doped" silkspan.

All values are full-scale.

L-647

0 .30 .40 .70 1.1 4.03

Time in seconds.

(a) Without ditching aid.

0 1.30 2.26 3.55 3.90 5.20

Time in seconds

(b) With hydroflap. (Second impact, attitute greater than 12°)

Figure 11.- Photographs of a $\frac{1}{12}$-size model of the Army B-26 airplane ditched across swells with and without a ditching aid.

Attitude, fuselage reference line, 12°; airspeed, 105 mph.
Bomb-bay doors, waist gun doors were removed, and partial damage to the wheel doors was simulated.

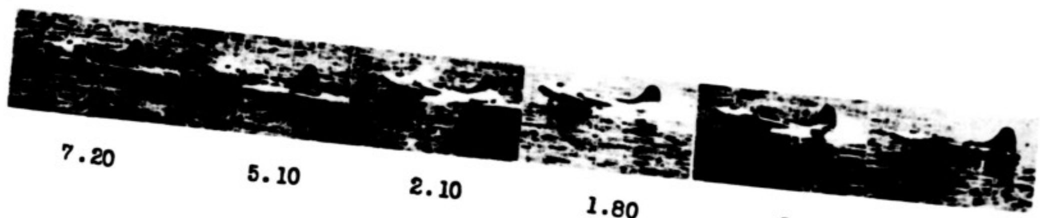
All values are full-scale.

L-647

3.87 2.91 2.00 1.60 1.10 0

Time in seconds.

(a) Without ditching aid.



7.20 5.10 2.10 1.80 .55 0

Time in seconds.

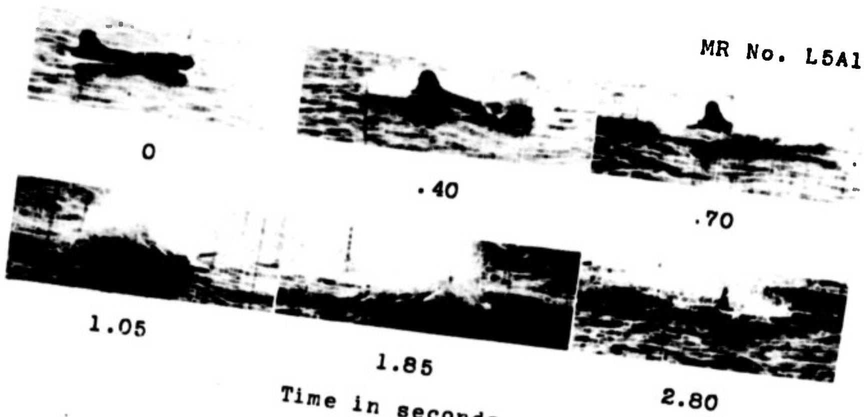
(b) With hydrofoil.

Figure 12.- Photographs of a $\frac{1}{16}$-size model of the Army B-17F airplane ditched along the waves with and without a ditching aid.

Attitude, fuselage reference line, 7°; airspeed, 110 mph. Bomb-bay doors in; gun turret on. Nose window, camera hatch, rear entrance hatch, tail wheel well, and rear gunner's entrance door were omitted to simulate their failure.

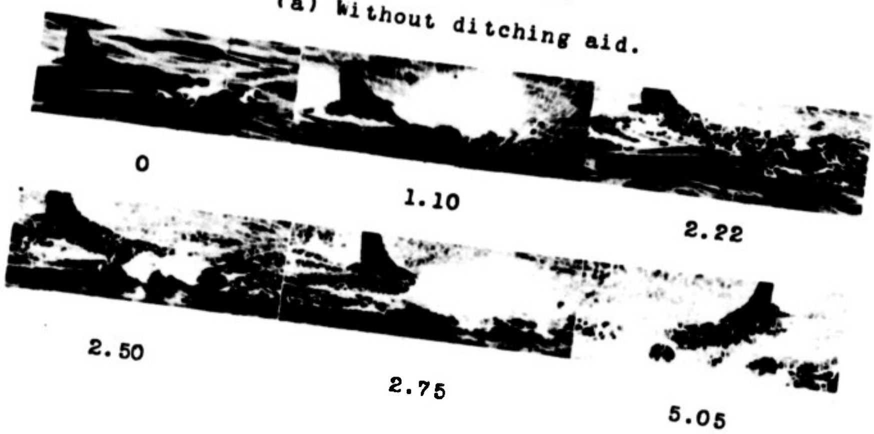
All values are full-scale.

L-647



Time in seconds.

(a) Without ditching aid.



Time in seconds.

(b) With nacelle hydro flaps on inboard motors.

Figure 13.- Photographs of a $\frac{1}{16}$-size model of the Army B-17F airplane ditched across the waves with and without a ditching aid.

Attitude of fuselage reference line, 7°; airspeed, 110 mph. Bomb doors in, gun turret on. Nose window, camera hatch, rear entrance hatch, tail wheel well, and rear gunner's entrance door were omitted to simulate their failure.

All values are full-scale.

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16139

TITLE: Ditching Behavior of Military Airplanes as Affected by Ditching Aids AUTHOR(S): Steiner, M. ORIGINATING AGENCY: National Advisory Committee for Aeronautics, Washington, D. C. PUBLISHED BY: (Same)	ATI- 16139 REVISION (None) ORIG. AGENCY NO. M.R.-L5A16 PUBLISHING AGENCY NO.

DATE	DOC. CLASS.	COUNTRY	LANGUAGE	PAGES	ILLUSTRATIONS
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