NACA RM L9K23

RESEARCH MEMORANDUM

MODEL DITCHING INVESTIGATIONS OF THREE AIRPLANES EQUIPPED WITH HYDRO-SKIS

By Lloyd J. Fisher

Langley Aeronautical Laboratory
Langley Air Force Base, Va.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

WASHINGTON
April 25, 1950

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

RESEARCH MEMORANDUM

MODEL DITCHING INVESTIGATIONS OF THREE AIRPLANES EQUIPPED WITH HYDRO-SKIS

By Lloyd J. Fisher

SUMMARY

Model investigations were made to determine the ditching characteristics of three typical multiengine airplanes equipped with possible arrangements of hydro-ski ditching gear.

The behavior of the models was determined from visual observations, acceleration records, and motion pictures of the landings. Data are presented in tabular form and sequence photographs.

It was concluded that a ditching gear of one or more hydro-skis would afford very satisfactory water landings as compared with landings without skis. The best landing with a hydro-ski ditching gear could be made in a near-level (slightly nose-up) attitude although any normal landing attitude would be satisfactory. It is possible that critical damage could be eliminated from ditching by using a hydro-ski ditching gear, thus greatly increasing the chances of survival and rescue.

INTRODUCTION

As part of a hydrodynamic research program on methods of water-basing high-speed airplanes without undue impairment of flight performance, the NACA has investigated the use of retractable planing surfaces called hydro-skis (reference 1). During water take-offs and landings, the hydro-skis are extended on struts so that the main body of the airplane is not subject to high water loads at planing speeds. In flight they are retracted flush with the surrounding surface.

The concept of hydro-ski landing gears also appears of interest as a positive means of eliminating the hazardous motions and structural damage associated with the ditching of landplanes. This would be of particular interest for transport airplanes. In this case, the gear would be used in a landing only once and a manual arrangement for extending it would be sufficient, hence its weight should be small as compared to that of a normal installation.

A preliminary investigation was made in Langley tank no. 2 to determine the ditching characteristics in calm water of three typical multiengine airplanes equipped with possible arrangements of hydro-ski ditching gears. The purpose of the investigation was to demonstrate generally the characteristics that could be expected from such gear as an incentive for more detailed design studies of specific installations. The optimum number, size, and location of the hydro-skis for a given application will depend on the airplane concerned and the degree of effectiveness desired.

APPARATUS AND PROCEDURE

Description of Models

The models were those used in previous ditching investigations of the Lockheed Constellation (reference 2), the Lockheed P2V-1 (reference 3), and the Douglas DC-4 (reference 4). The Constellation model was $\frac{1}{18}$-scale size and the remaining two were $\frac{1}{16}$-scale size. The models were constructed of balsa and spruce and were ballasted internally to obtain scale weights and moments of inertia. Since the hydro-skis were intended to support the models clear of the water at high speeds, structural damage was not simulated except on the Constellation model which was also tested with scale-strength bottom sections below the passenger floor. (See fig. 1.)

Three-view drawings of the models showing the hydro-ski arrangements arrived at for each are given in figures 2, 3, and 4. The most feasible arrangement for the Constellation was considered to be a single ski retracting into the bottom of the fuselage; for the P2V-1, twin skis retracting into the sides of the fuselage; and for the DC-4, twin skis retracting into the under side of the wing. The location of the skis in the retracted positions, which determine their shape, is shown in figure 5.

The size, plan form, and extended locations shown in figures 2, 3, and 4 were determined from the present tests and previous experience with hydro-skis as being suitable for the purpose of the investigation. Alternate configurations to satisfy detail design requirements better would probably be equally suitable.

Test Methods and Equipment

The models were launched by catapulting them from the Langley tank no. 2 monorail so that they would glide freely onto calm water. The models were attached to the launching carriage at the desired landing attitude and the control surfaces were set so that the models would glide onto the water at approximately this attitude. The results of the investigation were obtained by visual observations, from acceleration records, and motion pictures.

Test Conditions

All values given refer to the full-scale airplanes.

Gross weight.- The model weights corresponded to the following values:

Constellation	85,500 pounds
P2V-1	48,000 pounds
DC-4	72,500 pounds

Location of the center of gravity.- The horizontal and vertical locations of the center of gravity were:

Constellation - 25 percent mean aerodynamic chord and 23 inches above the thrust line of the inboard engines

P2V-1 - 29.3 percent mean aerodynamic chord and 3.6 inches below the thrust line

DC-4 - 28 percent mean aerodynamic chord and 9 inches above the thrust line of the inboard engines

Landing attitude.- Various landing attitudes were investigated as listed in table I. Attitude is defined as the angle between the smooth-water surface and the fuselage reference line.

Landing speeds.- The speeds used in the tests were computed from lift curves for the various airplanes and are listed in table I. The models were airborne in all landings and the speeds were held within ±10 miles per hour of the computed speeds.

Flap settings.- Each model was tested with flaps full down.

RESULTS AND DISCUSSION

General

A summary of the results of the investigation is presented in table I. The symbols used in the table are defined as follows:

h ran smoothly – the model traveled through the water with no apparent oscillation about any axis, settling in the water as the forward velocity decreased

p porpoised – the model traveled through the water with an undulating motion about the lateral axis with some part of the model always in contact with the water

Sequence photographs of the models landing with the hydro-skis installed are shown in figure 6.

In the near-level landings the runs were about a quarter-mile long (full scale) and very smooth. In the high-attitude landings, the lengths of runs were shorter and in the tests of the Constellation, slight porpoising was obtained. Any normal landing attitude was satisfactory. The motions were gentle and longitudinal accelerations were small as compared to the ditching behavior without skis. (See references 2, 3, and 4.)

When landed at the 4° attitude, the Constellation model usually ran at an attitude of about 4° or 5° with the model trimming up and the aft fuselage entering the water near the end of the run. When landed at 9°, the model trimmed up slightly at the beginning of the run and usually ran at about 10° with some porpoising. The ends of the runs at either attitude were characterized by a slight nose-down pitching motion probably caused by a loss of suction on the aft fuselage when speed was lost. This pitching motion is not considered of importance.

The P2V-1 model when landed at the 2° attitude generally trimmed at about 1° or 2° during the landing run. The runs were very smooth. The nose-down pitching motion, as mentioned for the Constellation, was present at the end of the run. In this case it appeared that the pitching motion was caused by the drag on the skis when they sank into the water. In a 6° landing the model trimmed down soon after contact and ran at an attitude of about 1° or 2° making a run very much like that of the 2° landing. In a 10° landing the aft fuselage and tail hit the water about the same time that the ski did, and the model made the entire run at a high attitude with the tail in the water.

The DC-4 model made very good runs at either landing attitude. It trimmed up slightly on landing and then trimmed down making the run at approximately the landing attitude. The nose-down pitching motion at the end of the runs was present in the DC-4 landings.

Longitudinal and vertical accelerations were measured in landings of the Constellation at 4° attitude and the P2V-1 at 10° and 2° attitudes. The increment of vertical accelerations due to landing for both models and longitudinal accelerations for the Constellation were less than $\frac{1}{2}$g. The maximum longitudinal acceleration for the P2V-1 was about 1 g measured in a landing at 2°. (See table I.) By comparing these values with those listed in table I of references 2 and 3, it can be seen that the acceleration forces were reduced considerably when the skis were installed. In the test of the Constellation without a ski, the accelerations were about 4g as compared with $\frac{1}{2}$g with the ski. The accelerations of the P2V-1 were about 4 to 8 times greater, depending on condition of damage, without the ski than with the ski.

The speed at which the skis settled into the water deep enough for the fuselage to be in solid water was determined to be about one-fourth the landing speed. Consequently, the scale-strength bottom of the Constellation model was not damaged during the tests. The skis, therefore, offer the possibility of eliminating damage during ditching with the result that passengers would not be injured by onrushes of water and the airplane could be made to float indefinitely. This feature together with the low accelerations obtained would greatly increase the probabilities of survival and rescue.

Ski Size, Shape, and Location

The ratio of gross weight of the airplane to total area of the ski for the Constellation model was increased progressively during the investigation to 1000 pounds per square foot (full scale). The areas of the P2V-1 and DC-4 skis were selected so that the ratios were 1000 pounds per square foot and 850 pounds per square foot, respectively. These ratios appeared satisfactory. It is possible that the loadings could be increased further without significant deterioration in behavior.

The amount of lateral curvature of the skis caused no noticeable difficulties; consequently, the skis could be retracted flush with the outside of the airplane. In other investigations it has been found that if the curvature was too great the arrangement would be unstable.

The aft edge of the ski used on the Constellation was progressively made more pointed during the investigation. This procedure was used to eliminate porpoising by causing less pitching moment on landing. Such a need is not always necessary, as was illustrated by the DC-4 which made very smooth runs with rectangular skis.

Vertical location of the ski was found to depend on the ski shape, number of skis, fuselage shape, and landing flap position. In general, the amount of spray and the surfaces hit by spray from the skis were important. These characteristics were different for each airplane. The locations given herein proved best for the particular installation. The skis should be far enough below the airplane so that at the desired landing attitude they would contact the water before any other part of the airplane. If the skis are too close to the fuselage, the fuselage will come in contact with the water too soon which would partially nullify the effects of the ski. When this was the case, the models porpoised and the runs were much shorter.

Various longitudinal locations of the skis were investigated and it was found that the best location was such that the center of gravity of the airplane was from 50 to 60 percent of the distance from the aft end to the center of area of the ski. If the ski is too far forward, porpoising will occur; if too far aft, there will be a tendency to dive. The ski settings shown in figures 2, 3, and 4 were best for the particular arrangements shown. Another longitudinal or vertical location or ski shape might require a different angular setting.

CONCLUSIONS

Conclusions based on the model ditching investigations of three airplanes equipped with hydro-skis are as follows:

1. A ditching gear consisting of one of more hydro-skis will afford very satisfactory water landings as compared with landings without skis.

2. The best landing with a hydro-ski ditching gear can be made in a near-level (slightly nose-up) attitude although any normal landing attitude is satisfactory.

3. It is possible that critical damage can be eliminated from ditchings by using a hydro-ski ditching gear, thus greatly increasing the chances of survival and rescue.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

REFERENCES

1. Dawson, John R., and Wadlin, Kenneth L.: Preliminary Tank Tests of NACA Hydro-Skis for High-Speed Airplanes. NACA RM L7I04, 1947.

2. Fisher, Lloyd J., and Morris, Garland J.: Ditching Tests of a $\frac{1}{18}$-Scale Model of the Lockheed Constellation Airplane. NACA RM L8K18, 1948.

3. Fisher, Lloyd J., and Tarshis, Robert P.: Ditching Tests with a $\frac{1}{16}$-Size Model of the Navy XP2V-1 Airplane at the Langley Tank No. 2 Monorail. NACA RM L50C23, 1947.

4. Fisher, Lloyd J., and Hoffman, Edward L.: Model Ditching Investigation of the Douglas DC-4 and DC-6 Airplanes. NACA RM L9K02a, 1949.

[redacted]

TABLE I

SUMMARY OF RESULTS WITH HYDRO-SKIS

[Landing flaps full down, all values full scale]

Landing attitude (deg)	Landing speed (mph)	Length of run (ft)	[1]Motion	Longitudinal acceleration (g)	Vertical acceleration (g)
Constellation with single ski					
9	91	720	h, p	---	---
4	105	1220	h	1/2	1/2
P2V-1 with twin skis					
10	82	480	h	1/2	1/2
6	90	960	h	---	---
2	102	1360	h	1	1/2
DC-4 with twin skis					
7	101	770	h	---	---
2	110	1280	h	---	---

[1]Motions of the model denoted by the following symbols:

h ran smoothly
p porpoised

[redacted]

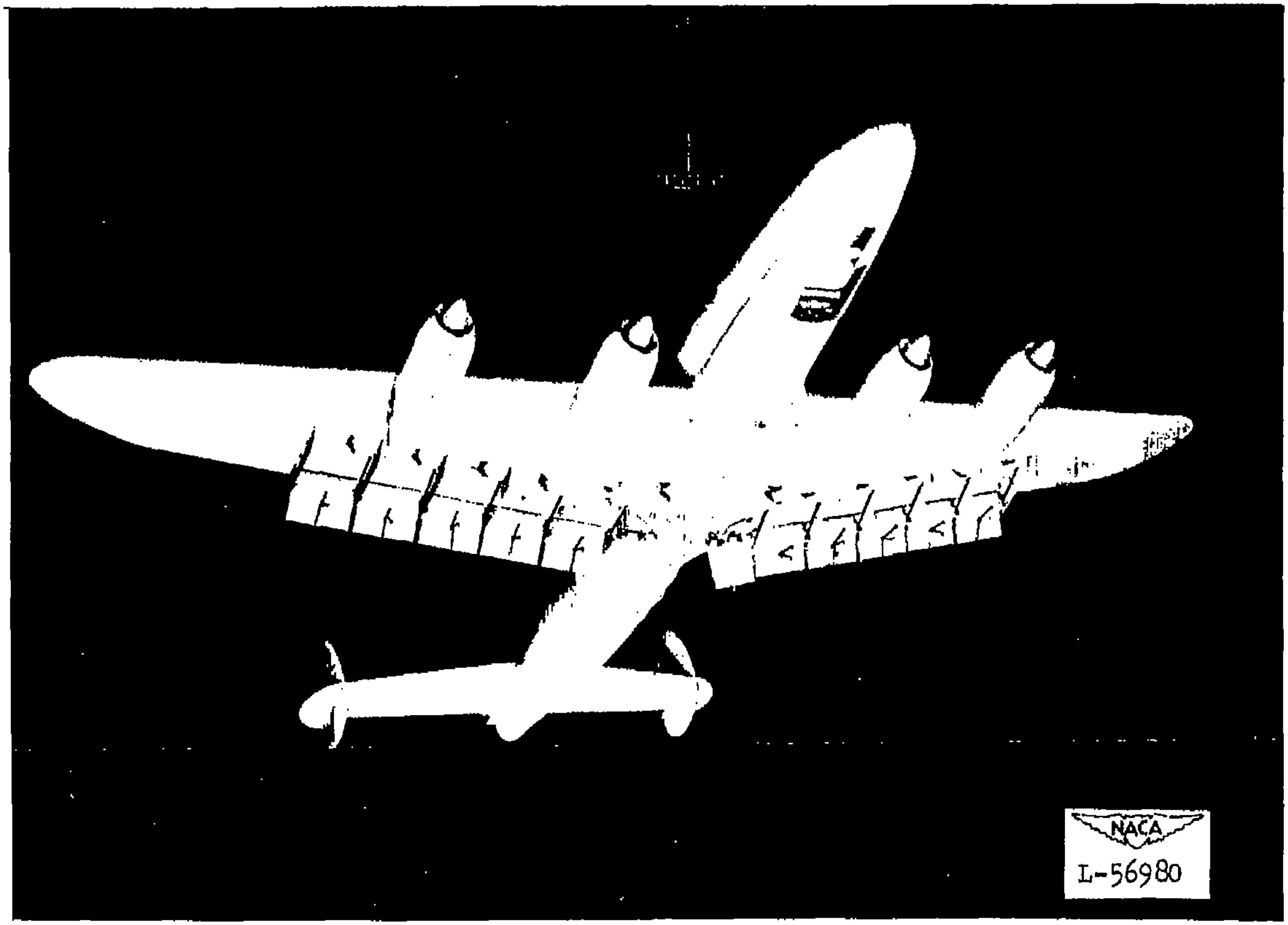
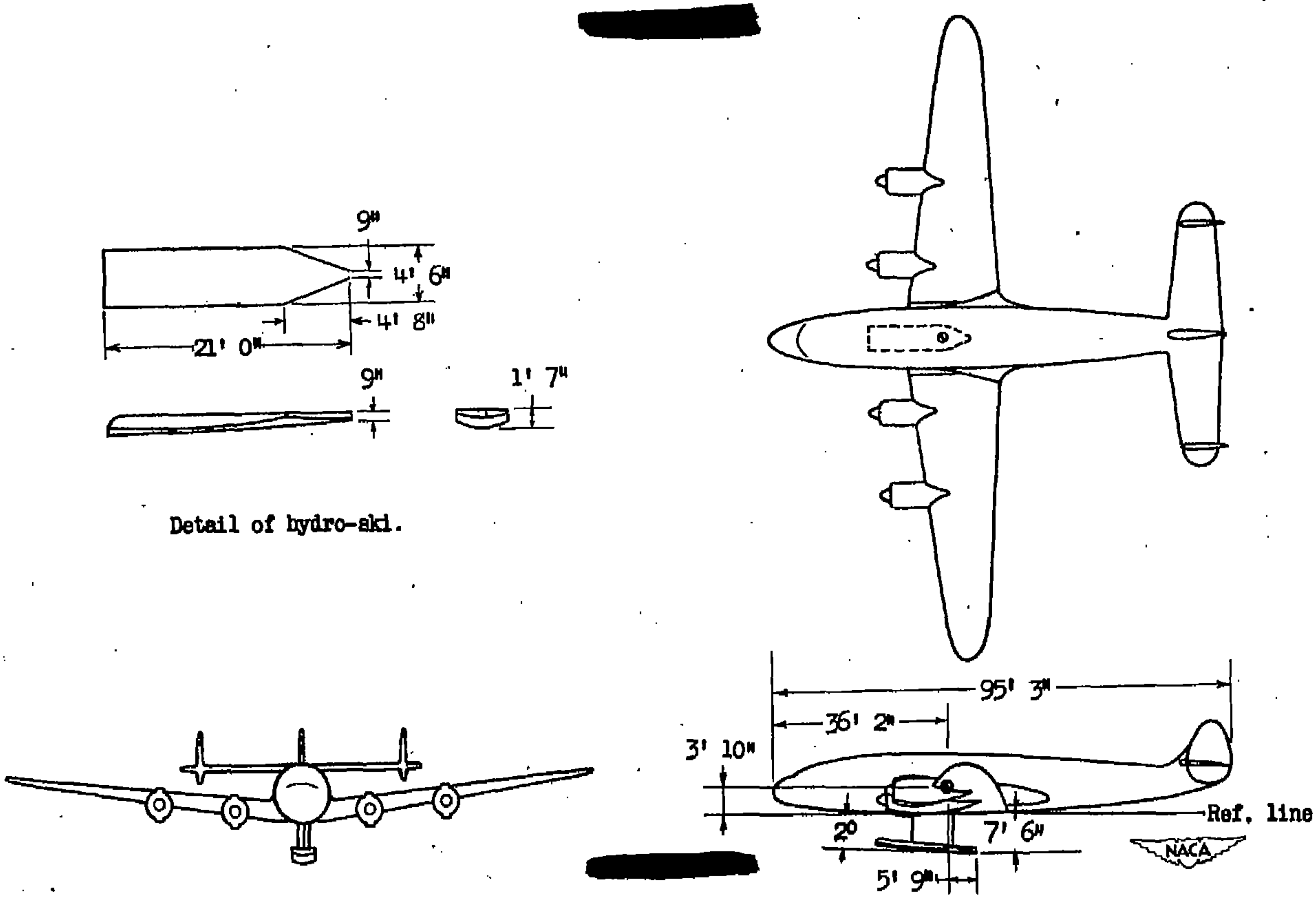


Figure 1.- Constellation model with scale-strength bottom installed.

[redacted]

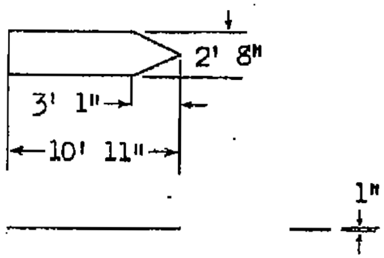
[redacted]



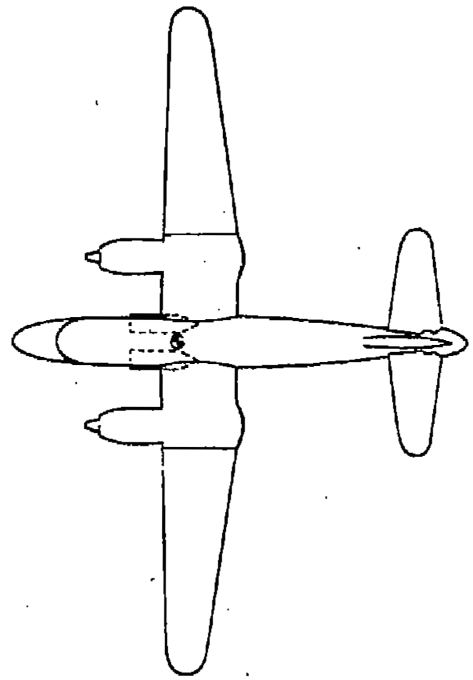
[redacted]

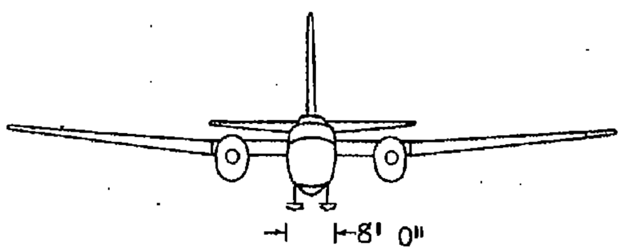
Figure 2.- Hydro-ski installation tested on Constellation model. (Dimensions are full size.)

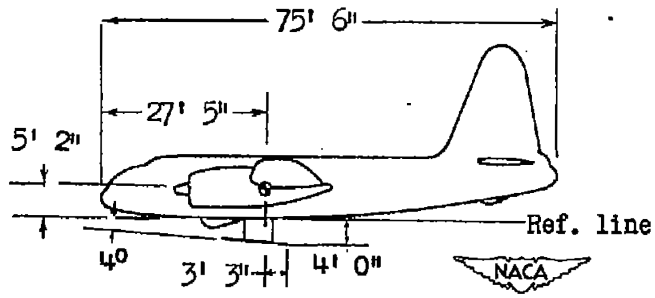
[redacted]



Detail of hydro-ski.



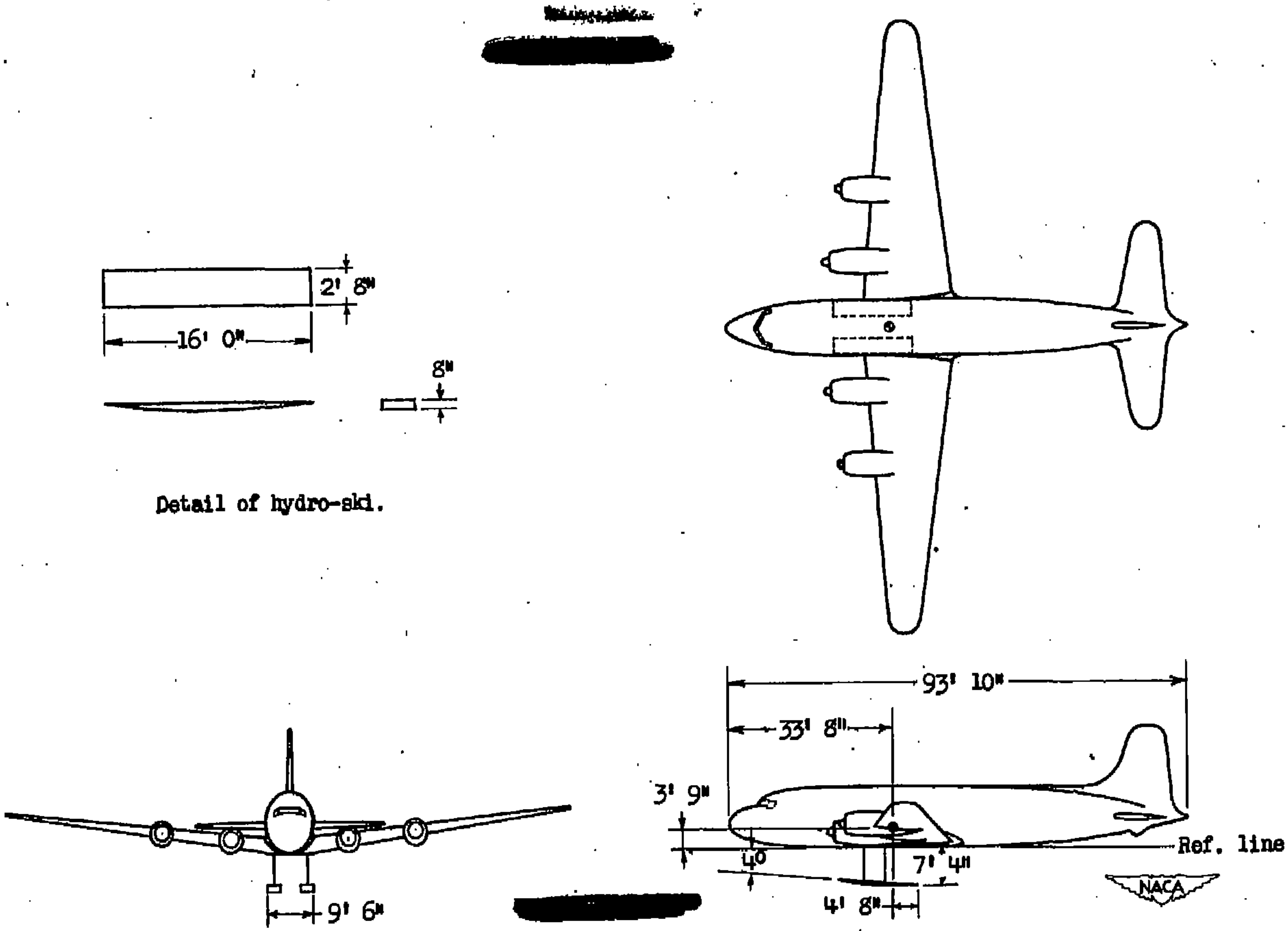




[redacted]

Figure 3.- Hydro-ski installation tested on P2V-1 model. (Dimensions are full size.)

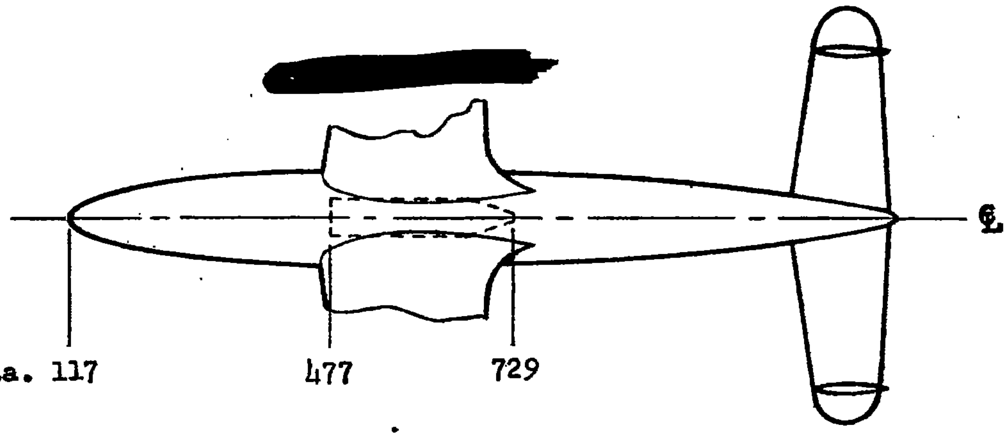
[redacted]



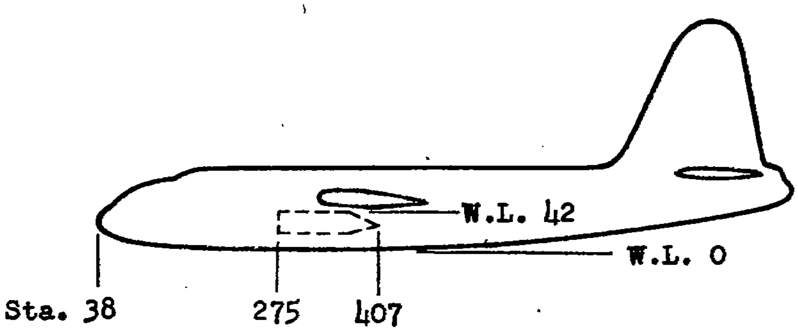
[redacted]

Figure 4.- Hydro-ski installation tested on DC-4 model. (Dimensions are full size.)

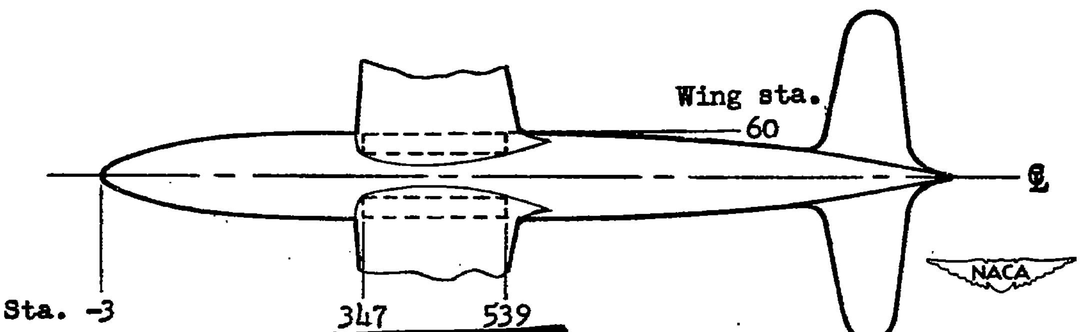
[redacted]



(a) Constellation.



(b) P2V-1.



[redacted]

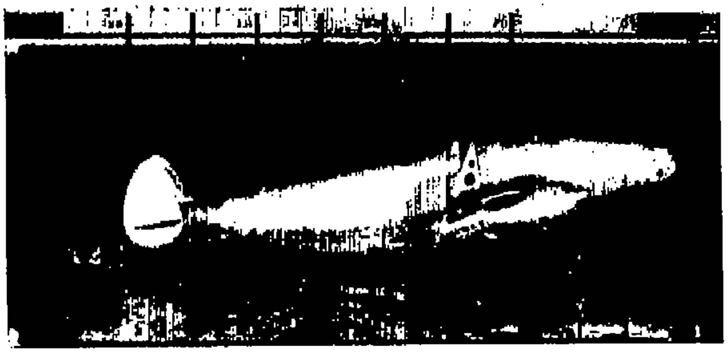
(c) DC-4.

Figure 5.- Location of the area which defined the longitudinal and lateral curvature of the various skis. (Stations are inches, full size.)

[redacted]

Near contact

662 feet



1132 feet

1255 feet

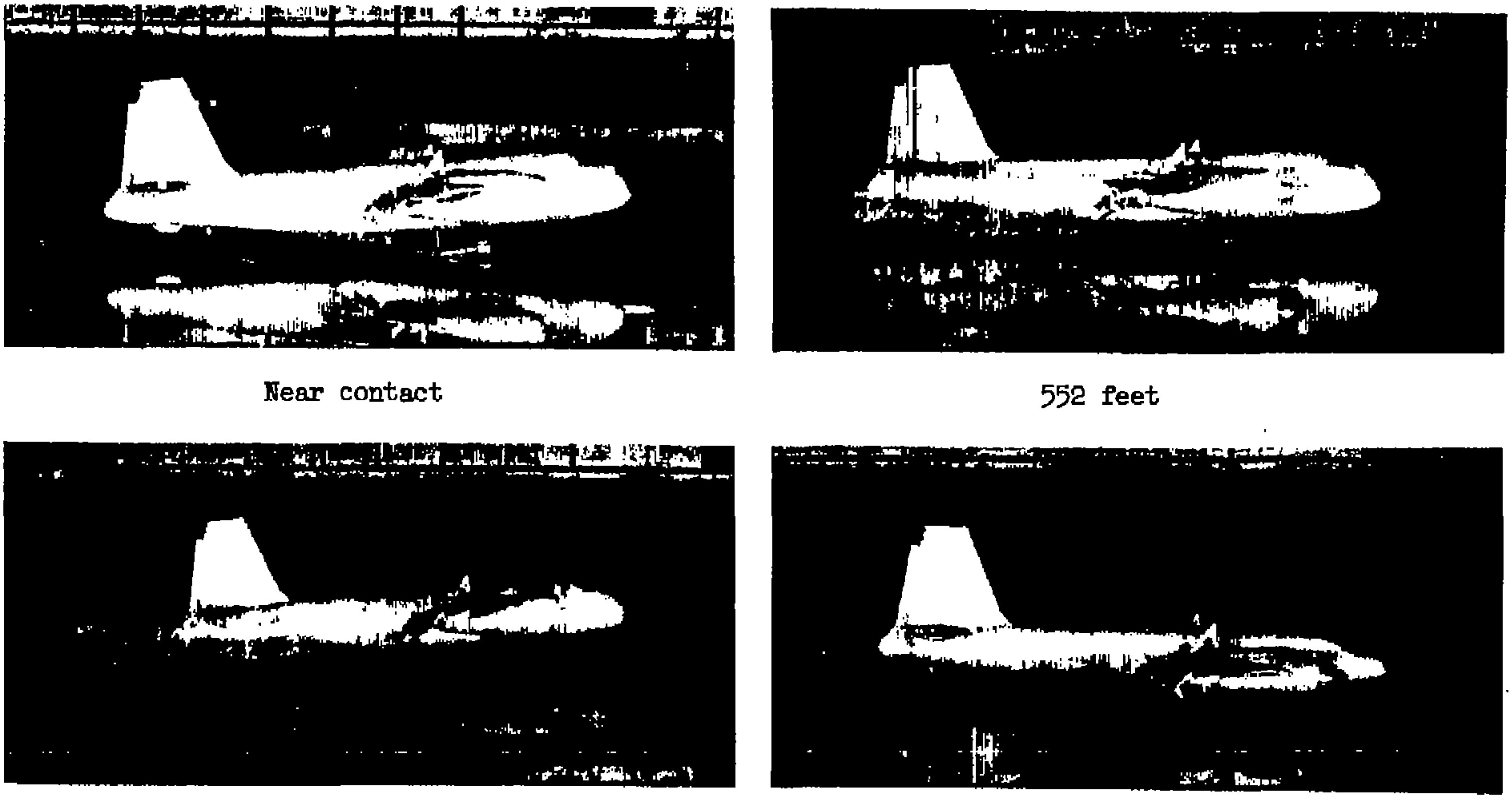
(a) Constellation; landing attitude 4°.

L-63049

Figure 6.- Sequence photographs of model landings on hydro-skis. Distance after contact indicated in feet, full scale.

[redacted]

[redacted]



Near contact

552 feet

1310 feet

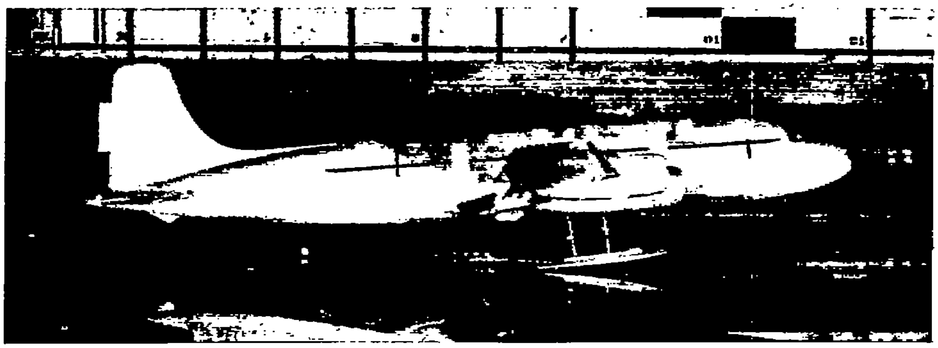
1400 feet

L-63050

(b) P2V-1; landing attitude 2°.

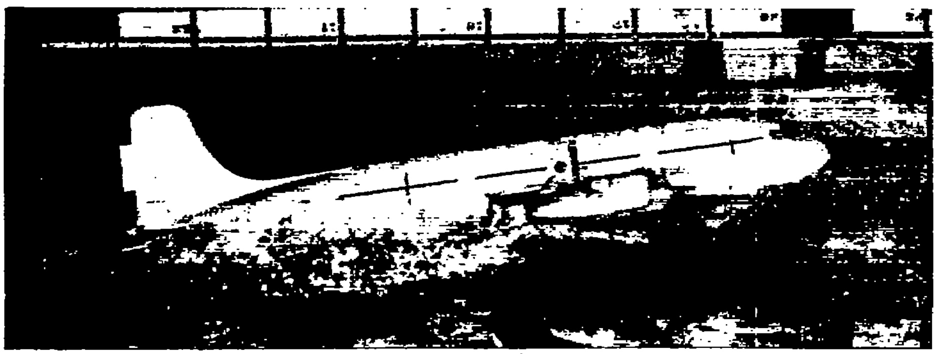
Figure 6.- Continued.

[redacted]



Near contact

640 feet



1136 feet

(c) DC-4; landing attitude 2°.

L-63051

Figure 6.- Concluded.